ICES HAWG REPORT 2013

ICES ADVISORY COMMITTEE

ICES CM 2013/ACOM:06

Report of the Herring Assessment Working Group for the Area South of 62 N (HAWG)

12–21 March 2013

ICES Headquarters, Copenhagen

ICES
International Council for the Exploration of the Sea
CIEM
Conseil International pour l'Exploration de la Mer

International Council for the Exploration of the Sea
Conseil International pour l'Exploration de la Mer

H. C. Andersens Boulevard 44–46
DK-1553 Copenhagen V
Denmark
Telephone (+45) 33 38 67 00
Telefax (+45) 33 93 42 15
www.ices.dk
info@ices.dk

Recommended format for purposes of citation:

ICES. 2013. Report of the Herring Assessment Working Group for the Area South of 62 N (HAWG), 12-21 March 2013, ICES Headquarters, Copenhagen. ICES CM 2013/ACOM:06. [illegible] pp.

Contents

Executive Summary

The ICES herring assessment working group (HAWG) met for eight days in March 2013 to assess the state of six herring stocks and four sprat stocks/populations. The working group conducted update assessments for five of the herring stocks. No analytical assessments were carried out for herring in VIaS although available survey and/or fishery data were examined. An assessment was performed for North Sea sprat and explorative assessments were carried out for English Channel sprat and IIIa sprat.

The **North Sea autumn spawning herring** SSB in 2012 was estimated at 2.35 m tonnes while mean F2-6 in 2012 was estimated at approximately 0.17, which is below the management agreement target F, while mean F0-1 is 0.03, below the agreed ceiling. Year classes since 2002 onwards are estimated to be among the weakest since the late 1970s. ICES considers that the stock is still in a low productivity phase. The **Western Baltic spring spawning herring** was assessed using new revised data and methods, based on the recent benchmark process. The use of a different assessment model, as well as the revision of the data sources and the addition of new observations, resulted in a new perception of the WBSS stock. In particular, SSB has been revised downward by approximately 20% in 2010-2011, with a consequent significant increase of the F estimate of about 40%. The SSB in 2012 was estimated to be around 87 900 t and has declined substantially in the last three years. Fishing mortality has been estimated at 0.33, and it is now above the revised estimate of Fmsy (0.28). Recruitment has significantly decreased since the late 1990s to values below 2 x 106, and remained at very low levels during the last 8 years. No sign of recovery is found in the estimated 2012 recruitment. The **Celtic Sea autumn and winter spawning stock** has increased considerably in recent years with the highest estimate in the time series recorded in 2012 (159 776 t), well above the B_{pa} reference of 61 000 t. Several strong year classes have recruited since 2005. The 2012 SSB of **West of Scotland autumn spawning** herring has been estimated at approximately 102 000 t (+24% from 2011) with a mean fishing mortality ($F_{3\text{-}6}$) of 0.16 which continues to be below the F_{target} of the management plan (0.25). **West of Ireland (Division VIaS and VIIb,c) autumn- and winter/spring-spawning stock** cannot be assessed analytically because no tuning data are yet available. The current levels of SSB and F are unknown, however, there are indications that the stock is on a historically low level. F is estimated to have declined considerably in the past three years, concomitant with declining landings . **Irish Sea autumn spawning herring** assessment showed an increase in SSB, estimated at 21 500 t in 2012, and a continued high recruitment in recent years, with $F_{4\text{-}6}$ =0.25 in 2012.Catches have been relatively stable since the 1980s, and close to TAC levels in recent years. Based on the most recent estimates the stock is being harvested sustainably and below F_{MSY}. **North Sea sprat** was assessed using new revised data and methods, based on the recent benchmark process. To undertake the assessment and fit with the natural life cycle of sprat the assessment model is shifted by six months so that an assessment year and advice runs from July 1st to June 31st each year, and thus provide in-year advice. The sprat stock seems to be increasing. The stock appears to have been well above B_{pa} (142 000t) since 2005, with the exception of 2007 where SSB was approximately at B_{pa}. Since 2009 SSB has remained more or less stable around 300 000t and fishing mortality has been relatively low (0.5 – 0.7). **Sprat in Division IIIa** This stock was benchmarked in 2013 (WKSPRAT) but an analytical assessment is not presented. Short term projections are to be based on a combination of indices providing in year advice for IIIa based on the ICES approach for data lim-

ited stocks (Category 3 / 4). Since this methodology is based on catches and the TAC has not been reached in a number of years the resultant advice provides catch options which are much lower than 2013 TAC. **Catch advice for sprat in the English Channel (VIId,e)** was based on criteria for data limited stocks. Data available are landings, a time series of lpue (1988 – 2012) and two acoustic surveys that were carried out in 2011 and 2012 in the area where the fishery occurs. A surplus production model was fitted to data but the benchmark WKSPRAT advised that an analytical assessment was premature. Quantitative advice was provided for **Sprat in the Celtic Sea (spr-irls)** . Data on landings are available from as early as the 1970s for some areas (i.e., VIa and VIIa) but biological data were not collected. Some acoustic estimates of biomass exist but do not cover the entire area where sprat are distributed; the estimates show high inter-annual variability. No analytical assessment is available for sprat in the Celtic Sea eco-region and the state of the stock is uncertain;.

The HAWG reviewed the assessments performed on seven sandeel stocks and the related advice of these stocks. The sandeel assessment report is a separate document, but a brief summary is given in the HAWG report (section 11).

There were no special requests to address in 2013. The working group also commented on the quality and availability of data, the problems with estimating the amounts of discarded fish, the use of the data system INTERCATCH, and provided an overview of some of the roles of herring in the ecosystem and of the existing knowledge about herring habitat. HAWG reiterated that activities that have a negative impact on the spawning habitat of herring, such as extraction of marine aggregates and construction on the spawning grounds, should not occur, and encouraged further research into the matter.

1 Introduction

1.1 Participants

Valerio Bartolino	Sweden
Lotte Worsøe Clausen	Denmark (Co-Chair)
Anne Cooper	ICES Secretariat
Mikael van Deurs	Denmark
Afra Egan	Ireland
Sasha Fässler	The Netherlands
Tomas Gröhsler	Germany
Emma Hatfield	UK/Scotland
Niels Hintzen	The Netherlands
Susan Mærsk Lusseau	UK/Scotland
Cecilie Kvamme	Norway
Henrik Mosegaard	Denmark
Marta Moyano	Germany (Guest)
Richard Nash	Norway
Cormac Nolan	Ireland
Mark Payne	Denmark
Anna Rindorf	Denmark
Beatriz Roel	UK/England & Wales (Co-Chair)
Norbert Rohlf	Germany
Pieter-Jan Schon	Northern Ireland
Claus R. Sparrevohn	Denmark (Bona Fide Scientist)
Yves Verin	France

Contact details for each participant are given in Annex 1.

1.2 Terms of Reference

2012/2/ACOM06: The Herring Assessment Working Group for the Area South of 62ºN (HAWG), chaired by Lotte Worsøe Clausen, Denmark and Beatriz Roel*, UK will meet at ICES Headquarters, 12–21 March 2013, incorporating an extra day for benchmark preparation to:

a) compile the catch data of North Sea and Western Baltic herring on 12–13 March
b) address generic ToRs for Regional and Species Working Groups 14–21 March (see table below)
c) prepare for benchmark of Celtic Sea herring, planned for 2014.

The assessments will be carried out on the basis of the Stock Annex in National Laboratories, prior to the meeting. This will be coordinated as indicated in the table below.

Material and data relevant for the meeting must be available to the group no later than 3 weeks prior to the starting date.

HAWG will report by 3 February (on sandeel), and by 8 April 2013 (all stocks except sandeel) for the attention of ACOM

Fish Stock	Stock Name	Stock Coord.	Assesss. Coord. 1	Assess. Coord. 2	Advice
san-ns1	Sandeel in the Doggerbank area (SA 1)	Denmark	Denmark	Norway	Update
san-ns2	Sandeel in the South Eastern North Sea (SA 2)	Denmark	Denmark	Norway	Update
san-ns3	Sandeel in the Central Eastern North Sea (SA 3)	Denmark	Denmark	Norway	Update
san-ns4	Sandeel in the Central Western North Sea (SA 4)	Denmark	Denmark	Norway	Update
san-ns5	Sandeel in the Viking and Bergen Bank area (SA 5)	Denmark	Denmark	Norway	Update
san-ns6	Sandeel in Division IIIa East (Kattegat, SA6)	Denmark	Denmark	Norway	Update
san-ns7	Sandeel in the Shetland area (SA 7)	Denmark	Denmark	Norway	Update
her-3a22	Herring in Division IIIa and Subdivisions 22–24 (Western Baltic Spring spawners)	Denmark	Germany	Denmark	Update
her-47d3	Herring in Subarea IV and Division IIIa and VIId (North Sea Autumn spawners)	Germany	NL	UK (Scot-land)	Update
her-irls	Herring in Division VIIa South of 52° 30′ N and VIIg,h,j,k (Celtic Sea and South of Ireland)	Ireland	Ireland		Update
her-irlw	Herring in Divisions VIa (South) and VIIb,c	Ireland	Ireland		Update
her-nirs	Herring in Division VIIa North of 52° 30′ N (Irish Sea)	UK (North-ern Ireland)	UK (Northern Ireland)		Update
her-vian	Herring in Division VIa (North)	UK (Scot-land)	UK S		Update
spr-kask	Sprat in Division IIIa (Skagerrak - Kattegat)	Norway	Denmark	-	Update
spr-nsea	Sprat in Subarea IV (North Sea)	Denmark	Denmark	Norway	Update
spr-ech*	Sprat in Division VIId,e	Norway	-	-	Update
spr-celt*	Sprat in the Celtic Seas	UK			Update

***Stock identity** to be **updated as decided at the 2013 benchmark (WKSPRAT).**

The following ToRs apply to: AFWG, HAWG, NWWG, NIPAG, WGWIDE, WGBAST, WGBFAS, WGNSSK, WGCSE, WGDEEP, WGHMM, WGEF and WGHANSA.

The working group should focus on:

For all stocks:

a) If no stock annex is available this should be prepared prior to the meeting, based on the previous year advice basis or on the data limited advice basis proposed as the basis for advice this year.

b) Audit the assessments and forecasts carried out for each stock under consideration by the Working Group and write a short report.

c) Propose specific actions to be taken to improve the quality and transmission of the data (including improvements in data collection).

d) Propose indicators of stock size (or of changes in stock size) that could be used to decide when an update assessment is required and suggest threshold % (or absolute) changes that the EG thinks should trigger an update assessment on a stock by stock basis.

e) Consider target categories for stocks in the medium term as proposed and revise as needed

f) Consider ecosystem overviews where available, and propose and possibly implement incorporation of ecosystem drivers in the analytical basis for advice

g) For the ecoregion or fisheries considered by the working group, produce a brief report summarising for the stocks and fisheries where the item is relevant:

h) Mixed fisheries overview and considerations;

   a. Species interaction effects and ecosystem drivers;

   b. Ecosystem effects of fisheries;

   c. Effects of regulatory changes on the assessment or projections;

i) Prepare planning for benchmarks next year, and put forward proposals for benchmarks of integrated ecosystem, multi or single species for 2015

j) Draft the required elements of the Popular Advice for each stock.

k) In the autumn, where appropriate, check for the need to reopen the advice based on the summer survey information and the guidelines in AGCREFA (2008 report). The relevant groups will report on the AGCREFA 2008 procedure on reopening of the advice before 14 October and will report on reopened advice before 29 October.

For update advice stocks:

l) Produce a first draft of the advice on the fish stocks and fisheries under considerations according to ACOM guidelines and implementing the generic introduction to the ICES advice (Section 1.2). If no change in the advice is needed, one page 'same advice as last year' should be drafted.

m) For each stock , when possible prior to the meeting:

n) Update, quality check and report relevant data for the stock:

   a. Load fisheries data on effort and catches (landings, discards, bycatch, including estimates of misreporting when appropriate) in the INTERCATCH database by fisheries/fleets, either directly or, when relevant, through the regional database. Data should be provided to the data coordinators at deadlines specified in the ToRs of the individual groups. Data submitted after the deadlines can be incorporated in the assessments at the discretion of the Expert Group chair;

   b. Abundance survey results;

   c. Environmental drivers.

o) Produce an overview of the sampling activities on a national basis based on the INTERCATCH database or, where relevant, the regional database,

p) Update the assessment using the method (analytical, forecast or trends indicators) as described in the stock annex.

q) Produce a brief report of the work carried out regarding the stock, summarising for the stocks and fisheries where the item is relevant:

   a. Input data (including information from the fishing industry and NGO that is pertinent to the assessments and projections);

   b. Where misreporting of catches is significant, provide qualitative and where possible quantitative information and describe the methods used to obtain the information;

c. Stock status and catch options for next year;

d. Historical performance of the assessment and brief description of quality issues with the assessment;

e. In cooperation with the Secretariat, update the description of major regulatory changes (technical measures, TACs, effort control and management plans) and comment on the potential effects of such changes including the effects of newly agreed management and recovery plans. Describe the fleets that are involved in the fishery.

r) On basis of the outcomes of WKMSYREF calculate Fmsy for stocks where the information exists but the calculations have not been done yet, resolve inconsistencies between Fmsy and MSY Btrigger/Blim and if possible, fill in the Precautionary Approach reference points where they are missing

The TORs are addressed in the sections shown in the text table below.

Stock	Addressed in Section
Herring in Subarea IV and Division IIIa and VIId (North Sea Autumn spawners)	Section 2
Herring in Division IIIa and Subdivisions 22–24 (Western Baltic Spring spawners)	Section 3
Herring in Division VIIa South of 52° 30′ N and VIIg,h,j,k (Celtic Sea and South of Ireland)	Section 4
Herring in Division VIa (North)	Section 5
Herring in Divisions VIa (South) and VIIb,c	Section 6
Herring in Division VIIa North of 52° 30′ N (Irish Sea)	Section 7
Sprat in Subarea IV (North Sea)	Section 8
Sprat in Division IIIa (Skagerrak - Kattegat)	Section 9
Sprat in the Celtic Seas	Section 10
Sandeel assessment summary	Section 11
Sprat in Division VIId,e	Section 12
Stocks with limited data	Section 12

1.3 Working Group's response to special requests

There were no special requests in 2013.

1.4 Reviews of groups or projects important for the WG

HAWG was briefed throughout the meeting about other groups and projects that were of relevance to their work. Some of these briefings and/or groups are described below.

1.4.1 Meeting of the Chairs of Assessment Related Expert Groups [WGCHAIRS]

HAWG was informed about the WGCHAIRS meeting in January 2012. A wide array of initiatives being led by the ACOM leadership was communicated to working group chairs. The presentation focused on the following main outcome relevant for HAWG:

Table of Contents for EG reports: The table of content of assessment EG report was briefly discussed. A few new standard sections have been added to the report format. A key addition is to develop the ecosystem section to provide information on, and plans to provide for, ecosystem drivers for fisheries advice. Under this section, the ecosystem overviews available to HAWG should be evaluated in order to propose and possibly implement incorporation of ecosystem drivers in the analytical basis for advice

Advice format: Few changes have been proposed for the advice sheets for 2013, a major change is the implementation of the RACMS in which the advice should be uploaded. Also the addition of the Popular advice implicates work for HAWG.

Expert group workload: ACOM has made a series of proposals for changing current practice for the Expert working groups with the purpose of reducing the workload for the attending scientists.

The first step in reducing workload is to eliminate the "audit type" review groups for standard fisheries advice. The main purpose of this step is to verify that the stock annex had been correctly applied or that the assessment method and data used are similar to those used in previous years when a stock annex is not available. In discussions with ACOM and with EG chairs, it has been concluded that the time devoted to this activity by ICES' network of experts could be used more fruitfully in other areas, particularly in advice drafting groups and to answer special requests. Expert groups have been asked to fulfil this audit type task by assigning this responsibility to experts not directly involved in the assessment being audited.

HAWG questions if this initiative really will reduce the workload. Given that the review quality should not be reduced by this change, the work of producing a critical review simply just shifts from one group to another. HAWG feels uneasy of the 'circular' process inherent in the internal review and encourages ICES to facilitate a persistence of the critical review of assessment and advice, not reverting to just checkmarks on a list.

A larger time saving measure is that EGs will not be asked to complete the data tables for reporting on the DCF. This activity was found to be very time consuming for both EGs and the Secretariat, and the evaluation is that the results were not very reliable. In the future, it is expected that this reporting will be streamlined when formal data calls are issued for most stocks. It will then be straightforward to compare what was reported with what was requested.

HAWG certainly welcomes this initiative.

The third initiative, linked with Generic ToR d) *Propose indicators of stock size (or of changes in stock size) that could be used to decide when an update assessment is required and suggest threshold % (or absolute) changes that the EG thinks should trigger an update assessment on a stock by stock basis could lead to substantial workload reductions.* This approach could mean that we would no longer have to agree on how frequent the assessment should be done - we would look at indicators and if the changes are significant, we would update the assessment and the advice. Otherwise, the advice would the same as the previous year (same advice as last year - SALY). This approach may also make it possible to provide users of the advice with an evaluation of the robustness of the assessment. Note that users of the advice have not yet fully realised that the reliability of the advice is not necessarily directly linked with the robustness of the assessment - but this is a different issue.

HAWG's response was positive although a number of concerns were voiced:

- **The frequency of the assessment should take into consideration the life span of the species; i.e. roll over TAC is probably not suitable for a short-lived species that experiences large fluctuations in biomass.**
- **The state of the stock; if a stock is at or below safe biological limits an annual assessment would be preferable.**
- **It may not be appropriate for high value stocks where information on a full assessment is required annually.**
- **If available, the use of more than one indicator would be advisable.**
- **The performance of the indicators would need a full evaluation and so will the rule/threshold triggering the assessment process. This should ideally take place as part of a harvest control rule evaluation, but could also be evaluated separately in an independent study.**

In short, the WG view was that the use of indicators could lighten the workload in the long-term but in the immediate future they may well add to it. Further, the group felt that the explanations given related to reduction of the workload and providing stability to Industry were not sufficient.

The ACOM Vice Chair briefed about a new generic ToR: *On basis of the outcomes of WKMSYREF calculate Fmsy for stocks where the information exists but the calculations have not been done yet, resolve inconsistencies between Fmsy and MSY Btrigger/Blim and if possible, fill in the Precautionary Approach reference points where they are missing.*

During HAWG it was decided that the WG should not follow this ToR to the point.

The software plotMSY was used to estimate reference points for some of the stocks. Some teething problems with the software were identified and the developers were contacted so that they were sorted out. The group addressed the ToR for the stocks were there was clear need of new reference points, for the WBSS in particular plotMSY was implemented. Otherwise, for stocks were Fmsy had been estimated in the context of MSE msy reference points were not revised. In discussion, it was mentioned that plotMSY required input files were not particularly user friendly and that stationarity assumptions in the approach were not appropriate for stocks where parameters such as M were variable. Precautionary reference points were not re-estimated for stocks where they were found not to be operational.

1.4.2 Working Group for International Pelagic Surveys [WGIPS]

The Working Group of International Pelagic Surveys (WGIPS) met at ICES in Copenhagen from 3–7 December 2012, to review larvae and acoustic surveys done in 2012 and co-ordinate the 2013 survey activities on herring and sprat in the North Sea, Irish

Sea and Western Baltic as well as those on herring, blue whiting, sprat, mackerel and boarfish in the Northeast Atlantic.
This meeting was the first of the two merged working groups WGIPS and WGNAPES into one single WGIPS. 14 persons from nine countries participated in the meeting. Results on the specific survey estimates by species and area as well as survey co-ordination are available from the WGIPS report (ICES CM 2012/SSGESST: 22). The following text refers only to the surveys with relevance to HAWG.

Review of larvae surveys in 2012/2013: Six survey metiers were covered in the **North Sea**. The herring larvae sampling period was still in progress at the time of WGIPS meeting, thus sample examination and larvae measurements have not yet been completed. The information necessary for the larvae abundance index calculation will be ready for, and presented at the Herring Assessment Working Group (HAWG) meeting in March 2013.

The larvae survey in the **Western Baltic** was conducted from late February to the end of June, in total a 16 weeks period. On April 26th the new vessel FFS Clupea replaced the retired ship FFK Clupea and the weekly survey period was extended for two weeks of parallel ichthyoplankton fishery investigating potential effects of individual vessels on catch efficiency. This survey resulted in no significant differences of larval numbers due to the change of vessels (working document in preparation). The recruitment index could not be calculated at the time of WGIPS since data validation procedures will not be accomplished until early January 2013.

Results for the 2012 **Irish Sea** herring larvae survey indicate a similar distribution pattern to previous years, with greatest abundance of herring larvae to the east and north of the Isle of Man. Few larvae were caught along the eastern Irish coastline despite evidence from fishing samples of herring spawning in the area. The point estimate of production in the north eastern Irish Sea was the highest in the time series. Many larger larvae (>15mm) were observed in the samples, suggesting a higher survival rate compared to recent years.

North Sea, West of Scotland and Malin Shelf summer acoustic surveys in 2012: Seven surveys were carried out during late June and July covering most of the continental shelf in the North Sea, West of Scotland and the Malin Shelf. The estimate of North Sea autumn spawning herring spawning stock is 7% lower compared to the previous year, at 2.3 million tonnes and 12 668 million herring. The 2008 and 2009 year-classes seem to be relatively strong and still persistent in this year’s estimate.

The estimates of Western Baltic spring-spawning herring SSB were 97 000 tonnes and 777 million herring, which is slightly lower than last year’s estimate, confirming a steady decrease in stock size over the past few years. The stock is dominated by 1 and 2 ring fish. This year’s estimated abundance of 1-ringers is lower than the previous two years.

The West of Scotland estimate (VIaN) of SSB is 375 000 and 1 964 million herring. This is lower than observed in 2011. 3 and 4 winter-ring fish dominate the age composition of the standing stock and immature fish were better represented than in 2011.

The SSB estimate for the Malin Shelf area (divisions VIaN-S and VIIb,c) 427 000 tonnes and 2 321 million fish. The estimate is dominated by 3 and 4 winter ringers. The contribution of immature fish to total abundance was higher than that observed in 2011. The Clyde and Irish Sea survey are not any longer conducted in Summer, but in August and October and thus now reported separately

Sprat: The total abundance of North Sea sprat in 2012 was estimated to be 45,466 million individuals and the biomass 408,859 tonnes (Table5.10). This is a decrease of about 8% in terms of biomass when compared to last year (ICES 2012). It is higher than the average for the period. In terms of abundance, it is the fourth highest estimate (Table 5.11). The amount of immature and mature sprat is about the same. The sprat stock is dominated by 1- and 2-year old fish representing 76% of the biomass.

An age-disaggregated time-series of North Sea sprat abundance and biomass (ICES area IVa-c), as obtained from the acoustic survey, is given in Table 5.11. Note that for 2003, information on sprat distribution is available from one nation only. This year, immature 0-group sprat data were delivered in FishFrame (NL). This probably reflects maturity staging problems, and all 0-group sprat were thus defined as immature as mature 0-group sprat is unlikely.

In Division IIIa, sprat was found in both the Skagerrak and Kattegat area. In 2011, sprat was present in the Kattegat only. The abundance was estimated to be 1 902 mill individuals, a 21% increase compared to 1 574 million individuals in 2011. The biomass was estimated to be 37 596 tonnes, an increase of about 37%. Most sprat were 3+ group (78%), and all were mature.

1.4.3 Study Group on the evaluation of management plan for North Sea herring [WKHELP]

WKHELP evaluated the current Long term Management Plan for North Sea autumn spawning herring given the recent benchmark assessment (ICES 2012/ACOM:47) following the joint request from EC and Norway. Given the revised perception of the stock, the group allocated much effort to the evaluation of the Reference Points.

The group considered two periods of time-series data of SSB and recruitment to extract information that would support the choice of Blim and the results indicated that Blim = 0.8 million t would be appropriate. Bpa was subsequently estimated at 1 000 000 t taking the uncertainty of the stock assessment and a 5% risk into account. The group explored a variety of stock-recruitment functions to estimate Fmsy. The range 0.24 – 0.30 resulting from both Ricker and Beverton and Holt fits was proposed as appropriate Fmsy values.

Eight Harvest Control Rule (HCR) options were examined for Fmsy targets at F=0.24 and F=0.30. The options were the following: 1)The current harvest control rule; 2) The current harvest control rule with no TAC stability mechanism; 3) The current harvest control rule with F 3years TAC stability mechanism; 4) The current harvest control rule with the 50:50 rule TAC stability mechanism; 5) The current harvest control rule with a constraint in F variability as the TAC stability mechanism; 6) The current harvest control rule with a quota flexibility of +10% (banking); 7) The current harvest control rule with a quota flexibility of ±10% (banking and borrowing) and 8) The current harvest control rule changing the target fishing mortality for 0-1 ringers over a range of values from 0.0375 to 0.05.

All eight Harvest Control Rule options tested included precautionary scenarios. WKHELP selected five HCR options for the advice based on an evaluation of the performance of the options in terms of the chosen performance indicators, but also how operational these options will be for management of North Sea autumn spawning herring (NSAS). WKHELP did not recommend implementation of an HCR without a TAC stabilising mechanism.

WKHELP also considered the current evidence and knowledge of density-dependence processes in the biology of NSAS. They concluded that the evidence is not strong enough to justify an increase in the target F at high stock sizes. Density-dependent mechanisms cannot be ruled out at the early larval stages of herring. It may be that the decline in recruitment is purely environmentally driven and the apparent synchrony with spawning biomass is a coincidence.

Following WKHELP an additional request was put forward by the EC and Norway asking for further explorations.

…letter from NH; JS and LAW?

1.4.4 GAP Project

In the GAP2 project (see http://www.gap2.eu/ for information) the creation of a mutually agreed LTMP for the herring fishery in ICES Division IIIa and Sub Divisions 22-24 is the subject for a case-study lead by Lotte Worsøe Clausen DTU Aqua, Denmark. The overarching achievement in the case study has been to lay a common ground for a LTMP for WBSS and the identification of the parts of such a plan, which need particular attention in terms of negotiation and clarification prior to actual MSE for WBSS. A wide range of stakeholders (industry, management, science, NGO's) agreed, that the objectives of a LTMP were that the plan should be Specific, Measureable, Achievable, Realistic and Time-limited (SMART); it needs to be simple to grasp by all stakeholders and the most important objective to aim for is a high and stable yield based on a sensible F.

The division of the catch opportunities between SD 22-24 and Div. IIIa was identified as being of outmost importance for successful implementation and compliance with a suggested LTMP. The decision to divide the catch opportunities was the subject for debate with the BSRAC, PELRAC, fisheries representatives, the Commission and a few representatives from the Governmental bodies. The outcome of this debate gave first of all a confirmation of what is of priority for a LTMP as seen from all stakeholders (in prioritised order):

1. High and stable yield
2. Flexibility between IIIa and North Sea in terms of TAC usage
3. Balanced allocation of fishing opportunities between 22-24 and IIIa
4. Fishing at MSY

Given the high priority of the management measures in relation to TAC share and flexibility the case study then has focused on getting these settled among stakeholders from both MS and Norway. It has been agreed with the ICES working group formulating the advice for the stock and area how to deal with these measures, however, the final step of getting both MS and non-MS to agree in the stakeholder group still remain to be resolved. Initiatives for this are taken through the Fisheries representatives.

A pre-requisite for the MSE modelling exercises following an agreed management set-up is to have a common perception the stocks; their exploitation patterns and their relative importance to the herring fishery and the preservation of biodiversity in a changing climate. During the last 6 months much effort has been put into scrutinising landing data, grey-information from the fishery in terms of misreporting history and catch compositions as collaboration between the Fishermen and the Science partners. This has resulted in the formation of a quality ensured input data on catch compositions regarding the spatial distribution of the major herring stocks. These results have led to the first stages of defined migration pattern for the various lifestages of the major herring stocks based on historical data (10 years). Furthermore, the case study has managed to get a description of the fleet behaviour in relation to the defined migration patterns of the major stock movements and the economical prioritising performed to match these dynamics to optimise the outcome of the fishery. In particular, the degree of mixing between lifestages and stocks in the catch and the resulting economic value hereof has been debated and described in relation to past misreporting of herring catches.

Given the priority to the more politically delicate features of a LTMP for WBSS, the case study is developing results along two lines now; Management and Model as an alternative to the more usual 'first data, then model and then management' approach used when developing LTMPs.

For the Management part; a very significant result is that the common ground and perception of what is to constitute the LTMP (from Workshop 1, November 2011) withstood the test of thorough debate among a wider group of fishery and science stakeholders during the workshop held in February 2013. This workshop also confirmed the importance of the more political related parts of the management defined as the division of the catch opportunities between SD 22-24 and Div. IIIa as identified in Workshop 2, April 2012. As described above under WP1, the fishery stakeholders are taking the lead in reaching a common base for the TAC share and flexibility across management areas, which then can be fed into a stochastic MSE setup.

For the Model part, the case study has now gained a solid knowledge of the biology of the herring and a detailed insight in the data available for the model. The precision of the available data are subject to variability in terms of accuracy and is also at times historically quite patchy. As a high level of precision in the data is a prerequisite for the model, the stakeholders have been involved in the data quality check using historical knowledge, logbooks and 'grey data' and part of this work is still on-going.

1.4.5 Planning Group on commercial catch, discards and biological sampling [PGCCDBS]

PGCCDBS is the ICES forum for planning and co-ordination of collection of data for stock assessment purposes. It coordinates and initiates the development of methods and adopts sampling standards and guidelines. Many activities in this group are closely linked to the activities of the DCF, and DG MARE of the European Commission is a member of PGCCDBS to ensure coordination with the DCF activities. Stock assessment requires data covering the total removal from the fish stocks and the PG serves as a forum for coordination with non-EU member countries where appropriate.

Last year's recommendations and intersessional work were reviewed. Most of them were concluded with success and those not concluded gave rise to developments carried out during this year.

The Group reviewed reports from relevant Expert Groups with respect to recommendations addressed to PGCCDBS. As a feedback mechanism from data users (mainly assessment WGs and benchmark assessment WKs) to the PG, 'data contact persons' have been nominated with a set of tasks to report on data problems and function as link between data collectors and data users. PGCCDBS acts as an advisory group on the further development of InterCatch. It did work best in the cases where the contact person was a member of both the AWG and PGCCDBS, which is the case for HAWG. HAWG 2009 appointed Lotte Worsøe Clausen (DTU Aqua) as contact person for the PGCCDBS and she is continuing this task in 2013. The PGCCDBS focused their approach to the recommendation system this year by underlining the importance of Expert Groups prioritising their recommendations on data issues as being either urgent data problems affecting advice quality or important but not urgent and a scope for longer term strategic studies.

Recent changes in data collection (e.g. through the revised EU DCF) were reviewed and the need for workshops was defined. PGCCDBS provided views on the revision of the Data Collection Framework, focusing on the need for statistically-sound, regional sampling programmes and task-sharing to improve cost effectiveness.

The methodological workshops WKACCU, WKPRECISE and WKMERGE previously initiated by PGCCDBS have provided valuable general knowledge in how catch sampling programs can be designed and the reports are beneficial for countries aiming to improve the current situation. PGCCDBS further stresses the need to establish a methodological support system for catch sampling and suggests that a series of workshops be set up and the findings presented in a reference book, as this is missing at the present time. The main aim with the series of workshops would be to provide countries with enough support to design and implement scientifically sound and transparent sampling programs enabling quality assessment of estimates used for stock assessment.

The WKNARC2 workshop, initiated by PGCCDBS in 2011, will take place in May 2013. One of the expected outputs from the follow-up WKNARC in 2012 will be a review of the means of dealing with uncertainty in relation to age data in assessments, which in turn will be of major interest for assessment working groups.

1.4.6 WKFRAME III and WKLIFE

WKLIFE met in 2012 to consider life history approaches to stock assessment and the provision of advice. WKLIFE formed the basis of an advice drafting group to update the introduction to the ICES advice. A guidance is available from ACOM on how advice will be framed in 203 for stocks without forecasts (ICES DLS Guidance Report 2012, ICES CM 2012/ACOM 68). WKLIFE considered 6 categories of stocks, and classified the stocks within HAWG into these, as follows:

1) **– data rich stocks (quantitative assessments):** North Sea and VIId herring, Celtic Sea herring, IIIa and Sub-division 22-24 herring, VIaN herrig, Sprat in the North Sea, Sandeels SA1 - 3.
2) **– stocks with analytical assessments and forecasts that are only treated qualitatively:** Herring, Irish Sea; Herring VIaS, VIIbc.
3) **– stocks for which survey-based assessments indicate trends:** Sprat in III and Sprat in the English Channel; Herring VIaS, VIIbc, SA4.
4) **– stocks for which reliable catch data are available for short time-series:** None in HAWG.
5) **– data-poor stocks:** Sprat IIIa; Sprat Celtic Seas Ecoregion; Sprat North Sea, SA4; 6.
6) **– negligible landings stocks and stocks caught in minor amounts as by-catch:** Sandeel SA5; 7.
7) HAWG broadly agrees with this categorisation, at the time of WKLIFE writing its report. HAWG has made efforts to move stocks upwards in the

categorisation, and this task will continue. In 2013, VIId,e sprat can now be classified as 3 and North Sea sprat has now become a category 1.

1.5 Commercial catch data collation, sampling, and terminology

1.5.1 Commercial catch and sampling: data collation and handling

Input spreadsheet and initial data processing

Since 1999 (catch data 1998), the Working Group members have used a spreadsheet to provide all necessary landing and sampling data. The current version used for reporting the 2012 catch data was v1.6.4. These data were then further processed with the SALLOC-application (Patterson, 1998). This program gives the required standard outputs on sampling status and biological parameters. It also clearly documents any decisions made by the species co-ordinators for filling in missing data and raising the catch information of one nation/quarter/area with information from another data set. This allows recalculation of data in the future, or storage and analyses in other tools like InterCatch (see section 1.5.4), choosing the same (subjective) decisions currently made by the WG. Ideally, all data for the various areas should be provided on the standard spreadsheet and processed similarly, resulting in a single output file for all stocks covered by this working group. National catch data submission was due by 22th February 2013. All nations generally deliver their data in due time or a few days later. All nations submitted catch and sampling data via the official exchange spreadsheets, and some of them loaded data into the InterCatch database.

More information on data handling transparency, data archiving and the current methods for compiling fisheries assessment data are given in Stock Annex 3. To facilitate a long-term data storage, the group stores all relevant catch and sampling data in a separate "archive" folder on the ICES network, which is updated annually. This collection is supposed to be kept confidential as it will contain data on misreporting and unallocated catches, and will be available for WG members on request. Table 1.5.1 gives an overview of data available and source for the period 2008 to present. Members are encouraged to use the latest-version input spreadsheets if the re-entering of catch data is required. Figure 1.5.1 shows the separation of areas applied to data in the archive.

1.5.2 Sampling

Quality of sampling for the whole area

The level of catch sampling by area is given in the table below for all herring stocks covered by HAWG (in terms of fraction of catch sampled and number of age readings per 1000 t catch). There is considerable variation between areas. Further details of the sampling quality can be found by stock in the respective sections in the report.

Area	Official Catch	Sampled Catch	Age Readings	Age Readings per 1000t
IVa(E)	35351	31221	791	22
IVa(W)	248793	203719	6169	25
IVb	103067	76767	2276	22
IVc	3940	2285	100	25
VIId	33136	24153	606	18
VIIa(N)	5693	5078	1391	244
VIa(N)	21296	9081	300	14
IIIa	48750	4491	11060	227
Celtic, VIIj	21604	21604	1733	80
VIa(S), VIIb,c	6571	6571	960	146

The EU sampling regime

HAWG has recommended for years that sampling of commercial catches should be improved for most of the stocks. The EU directive for the collection of fisheries data was implemented in 2002 for all EU member states (Commission Regulation 1639/2001). The provisions in the "data directive" define specific sampling levels per 1 000 tons catch. The definitions applicable for herring and the area covered by HAWG are given below:

Area	sampling level per 1000 T catch		
Baltic area (IIIa (S) and IIIb-c)	*1 sample of which*	*100 fish measured and*	*50 aged*
Skagerrak (IIIa (N))	*1 sample*	*100 fish measured*	*100 aged*
North Sea (IV and VIId):	*1 sample*	*50 fish measured*	*25 aged*
NE Atlantic and Western Channel ICES Subareas II, V, VI, VII (excluding d) VIII, IX, X, XII, XIV	*1 sample*	*50 fish measured*	*25 aged*

There are some exemptions to the above mentioned sampling rules if e.g. landings of a specific EU member states are less than 5 % of the total EU-quota for that particular species.

The process of setting up bilateral agreements for sampling landings into foreign ports started in 2005. However, there is scope for improvement, and more of these agreements have to be negotiated, especially between EU and non-EU countries, to reach a sufficient sampling coverage of these landings. Besides this, HAWG notes the absence of formal agreements or procedures on the exchange of data collected from samples from foreign vessels landing into different states. HAWG decided that in the absence of guidance, this should be resolved on a case by case basis, but preferred to receive guidance from PGCCDBS (see also Section 1.4.6).

Given the diversity of the fleets harvesting most stocks assessed by HAWG, an appropriate spread of sampling effort over the different metiers is more important to the quality of catch-at-age data than a sufficient overall sampling level. The WG therefore recommends that all metiers with substantial catch should be sampled (including by-catches in the industrial fisheries), that catches landed abroad should be sampled, and information on these samples should be made available to the national laboratories.

1.5.3 Terminology

The WG noted that the use of “age”, “winter rings” and “rings” still causes confusion outside the group (and sometimes even among WG members). The WG tries to avoid this by consequently using “rings” or “ringers” instead of “age” throughout the report. It should be observed that, for autumn spawning stocks, there is a difference of one year between “age” and “rings”. Further elaboration on the rationale behind this can be found in the Stock Annex 3.

1.5.4 Intercatch

“InterCatch is a web-based system for handling fish stock assessment data. National fish stock catches are imported to InterCatch. Stock coordinators then allocate sampled catches to unsampled catches, aggregate to stock level and download the output. The InterCatch stock output can then be used as input for the assessment models". Stock coordinators used InterCatch for the first time at the 2007 Herring Assessment Working Group. Comparisons between InterCatch and conventional used systems (e.g., Salloc and spreadsheets) have been carried out annually since 2007. The comparison is available for a collection of stocks (her_47d3, her_vian, her_irls, her_irlw). Maximum discrepancies between the systems are presented in Table 1.5.2.

For Herring caught in the North Sea, these discrepancies were in general small. Even after splitting the landings into NSAS and WBSS, the overall landings calculated by both procedures for North Sea autumn spawning herring were in very close agreement and differ only by 80 t. For herring caught in VIa (North) the overall landings calculated by both procedures differed by 11 t. There were no differences between the systems for herring in the Celtic Sea and herring in VIaS, VIIbc.

However, for Western Baltic spring spawners in Division IIIa and SD22-24, preliminary results of CATON and CANUM were very close to those compiled by the stock coordinator, but by some reason the weight in the catch showed larger differences to the assessment input data. Due to time constrains this could not be elaborated any further during the meeting.

1.6 Methods Used

1.6.1 ICA

“Integrated Catch-at-age Analysis” (ICA: Patterson, 1998; Needle, 2000) combines a statistical separable model of fishing mortality for recent years with a conventional VPA for the more distant past. Population estimates are tuned by abundance or CPUE indices from commercial fisheries or research-vessel surveys, which may be age-structured or not as required. ICA is run using FLICA which performed the same analysis as the original version but from an FLR platform (Fisheries Library in R). FLICA was used to assess all herring stocks in HAWG with the exception of herring in VIaS and VIIb,c.

1.6.2 FLXSA and FLICA [recent developments of XSA and ICA in R] and SURBA

The FLR (Fisheries Library in R) system (www.flr-project.org) is an attempt to implement a framework for modelling integrated fisheries systems including population dynamics, fleet behaviour, stock assessment and management objectives. The stock assessment tools in FLR can also be used on their own in the WG context. The combination of the statistical and graphical tools in R with the stock assessment aids the exploration of input data and results.

1.6.3 SAM

SAM is a Spate-space stock assessment model. This model has the standard exponential decay equations to carry forth the N's (with appropriate treatment of the plus-group), and the Baranov catch equation to calculate catch-at-age based on the F's. The additional components of SAM are the introduction of process error down the cohort (additional error term in the exponential decay equations), and the random walk on F's. The steps (or deviations) in the random walk process are treated as random effects that are "integrated out", so are not viewed as estimable parameters. The sigma parameter controls how large the random walk deviations are, and this parameter is estimated. SAM provides the option of correlated errors across ages for the random walks on F, where the correlation is an additional parameter estimated to be estimated. This option of SAM was used for Western Baltic Spring Spawning herring.

1.6.4 FLSAM

The assessments of Irish Sea, and North Sea herring were carried out using FLSAM which is an R-platform to run SAM, a Spate-space stock assessment model. This platform was used to assess North Sea herring and Irish Sea herring.

1.6.5 Separable VPA

In situations where no tuning data exist, the WG uses separable VPA, implemented in the Lowestoft Package (Darby and Flatman, 1994). This is a VPA that assumes that fishing mortality can be separated into year and age effects. HAWG screens over terminal fishing mortalities in a realistic range.

1.6.6 SHORT TERM PREDICTIONS

FLR and MFDP

Short-term predictions for the North Sea used a code developed in R. The method was developed in 2009 and intensively compared to the MFDP approach. The Western Baltic Spring Spawner forecast used the standard projection routines developed under FLR package Flash (version 2.0.0 Tue Mar 24 09:11:58 2009). Other short-term predictions were carried out using the MFDP v.1a software and MSYPR that was developed several years ago in the HAWG (Skagen; WD to HAWG 2003).

1.6.7 Medium term projections

Performing medium term projections is no longer viewed as a task for the Herring Assessment Working Group. In the future, medium term projections will be performed during specifically designed working groups.

1.6.8 F_{MSY} management simulations

The HCS10 software was not used this year. Fmsy reference points for Western Baltic Spring were estimated by means of stochastic simulations carried out by means of plotMSY, software developed by Cefas. The software was also used for VIaN herring for verification of the management plan reference points.

1.6.9 Repository setup for HAWG

To increase the efficiency and verifiability of the data and code used to perform the assessments as well as the short term forecasts within HAWG a repository system was set up in 2009. Within this repository, all stocks own a subfolder where they can store their data and code to run the assessments. At the same time, there is one common folder, used by all assessments, that ensures that the FLR libraries used are identical for all stocks, as well as the output generated to evaluate the performance of the assessment.

The repository is public and can be found at: http://code.google.com/p/hawg/. Contributing to the repository is not possible for outsiders as a password is required. Downloading data and code is possible to the public. The repository is maintained by members of the WG.

1.7 Discarding and unaccounted mortality by pelagic fishing vessels

In many fisheries, fish, invertebrates and other animals are caught as by-catch and returned to the sea, a practice known as discarding. Most animals do not survive this procedure. Reasons for discarding are various and usually have economic or operational drivers:

- Fish smaller than the minimum landing size
- Quota for this specific species has already been taken
- Fish of undesired quality, size (high-grading) or low market value
- By-caught species of no commercial value
- Insufficient time for processing in relation to incoming catch

Theoretically, the use of modern acoustic fish finding technology used to detect and identify schools of fish should result in low by-catch. However, if species mixing occurs in pelagic schools (most notable of herring and mackerel), non-target species might be discarded. Releasing unwanted catch from the net (slipping, now generally prohibited in the North Sea) or pumping unsorted catch overboard also results in discarding.

In the area considered by HAWG, three countries conducted observer programmes in 2012: The Netherlands, Germany and Ireland. Only the Netherlands recorded discarding in 2012.

Dutch Observer Programme

The amount of discarded herring for the pelagic Dutch-owned vessels fishing in European waters was estimated for 2012 (van Helmond and van Overzee, 2013, WD). Discard estimates were derived from the Dutch observer programme (Data Collection Framework), and raised to the fishery by trip (Table 1.7.1). In 2012, 12 trips were monitored on board pelagic freezer trawlers (Table 1.7.1; Figure 1.7.1). Herring discards were observed during seven trips; six trips on board Dutch flagged vessels and one trip on board a French flagged vessel (Figure 1.7.2). All trips being treated as belonging to the same fleet.

On board trawlers, unwanted quantities of the catch are removed from the conveyer belt and discarded. During the observer trips biological samples were taken from both the catch and the discards which allowed to estimate the amount of discards per species per trip. Total discard weight per species and trip were then raised to fleet level in that year (Van Helmond & Van Overzee 2009; 2010; Van Overzee & Van Helmond, 2012). The raised herring discards are presented in Table 1.7.2 and Figure

1.7.3. In 2012, the raised herring discards was estimated at about 1 421 tonnes (CV of 62%). This corresponds to 2% of the total catch of the Dutch pelagic freezer trawler fleet.

The data collected by the scientific observers showed that occasionally part of or the whole catch was discarded without sorting. This type of discarding was referred to as "unsampled discards". As no biological samples could be taken from these discards, it was decided not to include these events in the raised species specific discards.

The annual landings of the Dutch pelagic fleet show that this fishery is seasonal. It is therefore not surprising that the discarding of herring differs between fishing season. Discarding of herring was observed during quarters 2, 3 and 4 in 2012. The length frequency shows that there appears to be very little selection by size between landed and discarded herring (Figure 1.7.5). Estimating discards by age was not possible under the current sampling strategy. Similarly, variances were too high when attempting to estimate to stock or area level. Thus, at present only total annual discards of herring can be estimated.

The inclusion of discarded catch is considered to reduce bias of the assessment and thus give more realistic values of fishing mortality and biomass. However, it might also increase the uncertainty in the assessment because the sampling level for discards is usually lower than that for landings (Dickey-Collas *et al*. 2007). This low sampling rate is caused by the large number of different metiers in the pelagic fishery and the difficulty of predicting behaviour of the fisheries (in terms of target species and spatial and temporal distribution). Raising discard estimates to the national landings might result in a higher bias than an area based estimate of discards from the total international fleet, if sampling is insufficient. HAWG therefore recommends that the development of methods for estimating discards should be fleet based, rather than on a national basis.

Table 1.7.1: Overview of the fleet activity and number of trips observed in the Dutch pelagic fleet by year (2003-2012).

	Number trips pelagic Dutch flagged fleet	**Number sampled trips**	**Herring discards**	**Standard Error**
2003	131	5	6350	4452
2004	131	6	2825	2398
2005	142	12	3683	1835
2006	122	12	2747	1448
2007	124	12	2729	1011
2008	110	12	1052	387
2009	93	11 (a)	2173	1136
2010	91	8 (b)	646	417
2011	88#	15 (c)	1019*	286
2012	85	12 (d)	1421	886

(a) This includes 9 trips on board Dutch flagged vessels, 1 trip on board a German flagged vessel and 1 trip on board a British flagged vessel

(b) This includes 5 trips on board Dutch flagged vessels, 1 trip on board a German flagged vessels and 2 trips on board British flagged vessels

(c) This includes 14 trips on board Dutch flagged vessels and 1 trip on board a French flagged vessel

(d) This includes 8 trips on board Dutch flagged vessels, 2 trips on board a French flagged vessels and 2 trips on board German flagged vessels

 # Number of trips have been adjusted

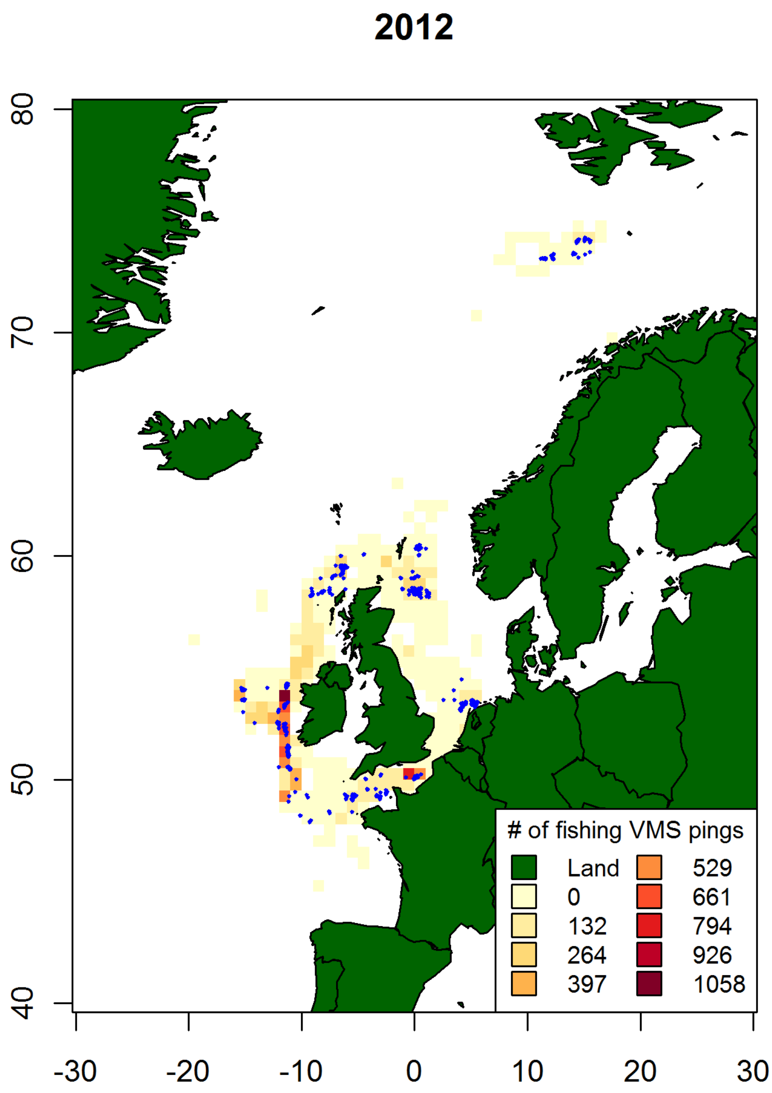


Figure 1.7.1: Distribution of the Dutch pelagic fleet (based on VMS data) and positions of the sampled pelagic discard trips per haul for 2012 (blue points). Discards that were observed in Norwegian waters were not thrown overboard but frozen as waste product.

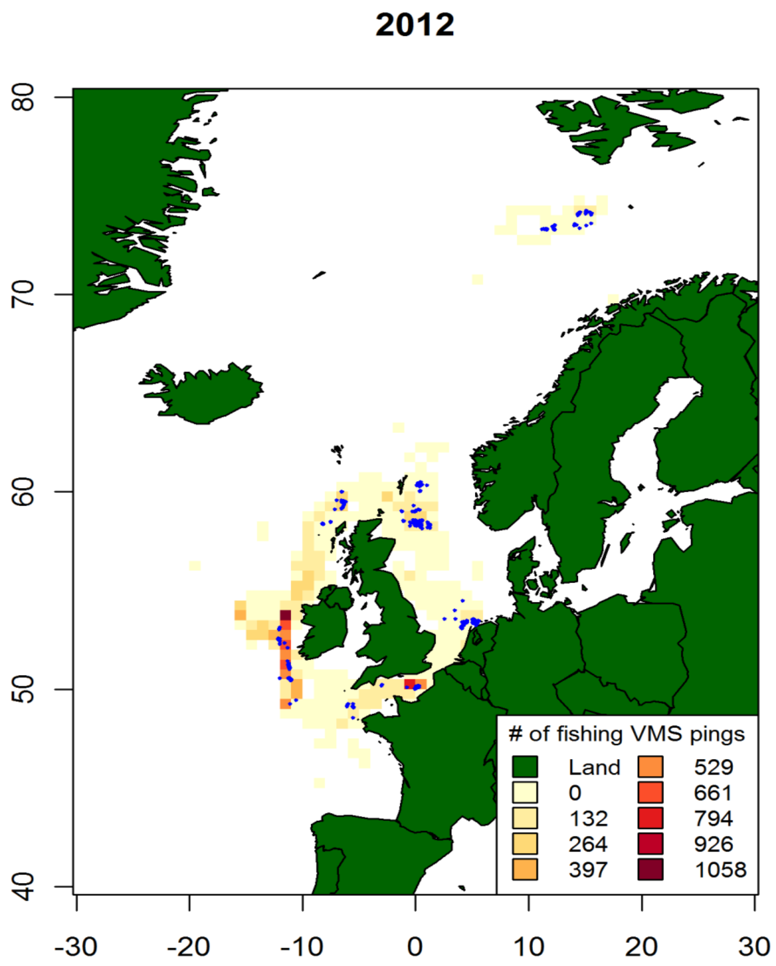


Figure 1.7.2: Distribution of the Dutch pelagic fleet (based on VMS data) and positions of the sampled pelagic discard trips per haul for 2012 where herring discards were observed (blue points).

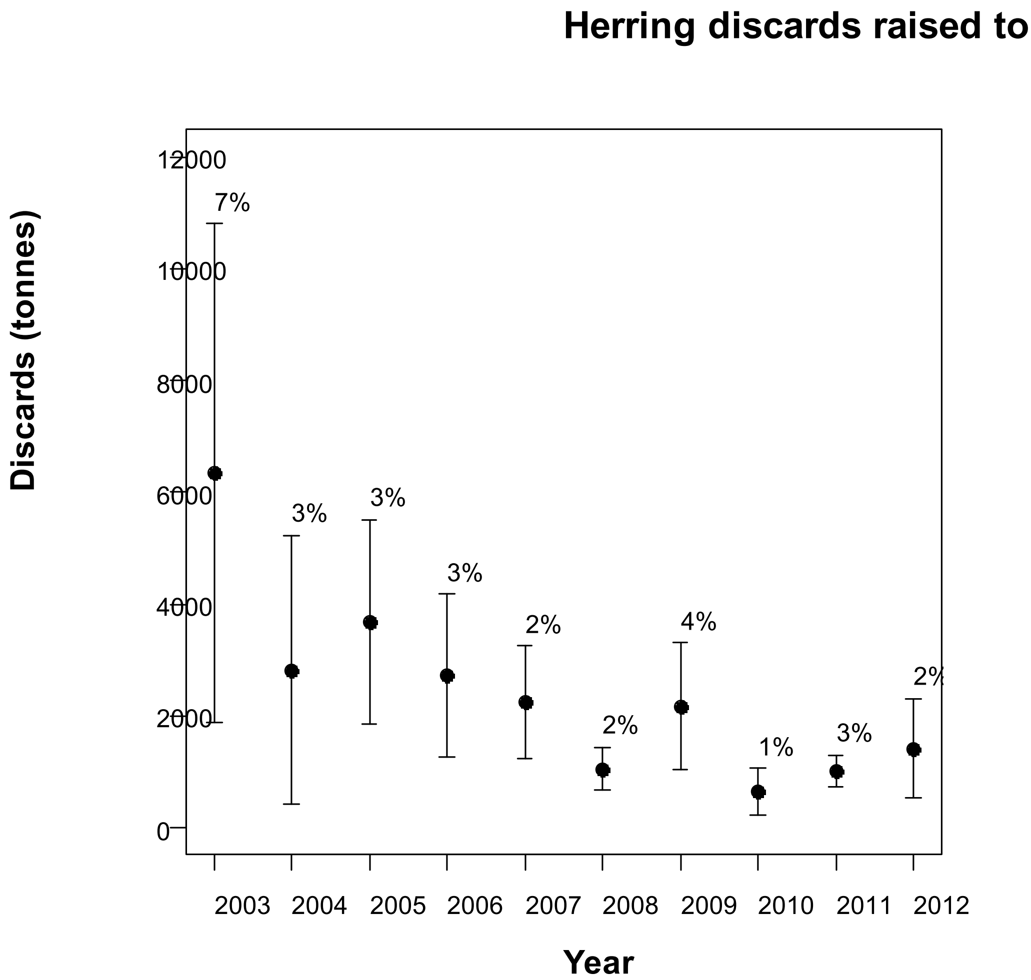


Figure 1.7.3: Raised herring discards (tonnes) by the Dutch pelagic freezer trawler fleet per year (2003-2012) from all ICES areas and corresponding percentage of discards to total catch of the fleet. Error bars denote ± standard error of the estimates of discards

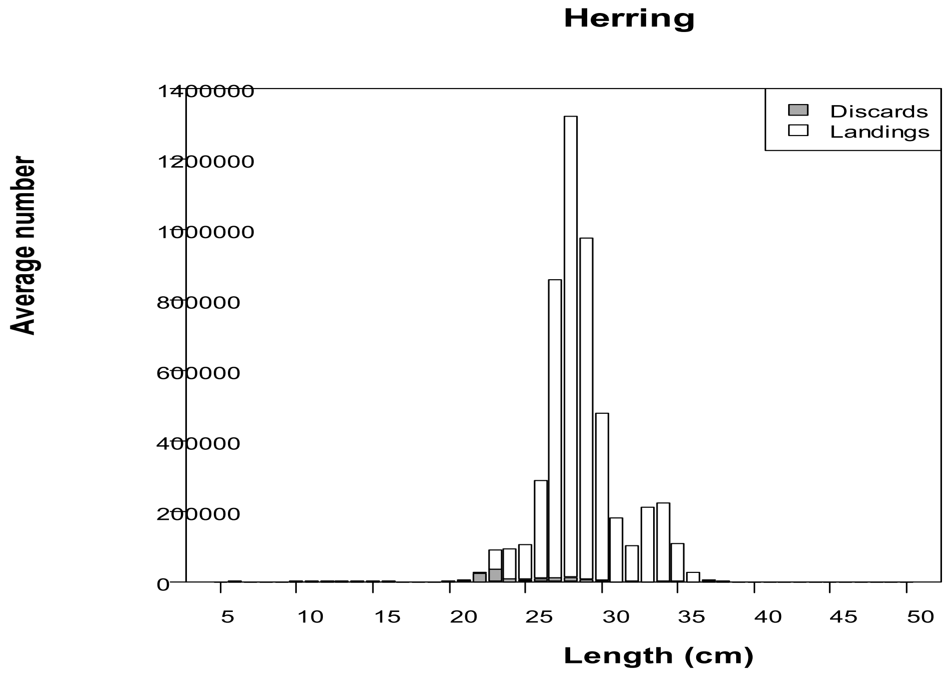


Figure 1.7.4: Average number herring landed and discarded against length (cm) by the sampled Dutch pelagic freezer trawlers for 2012.

1.8 Ecosystem overview and considerations

1.8.1 Ecosystem and environmental drivers for fisheries advice

The traditional ICES approach to fisheries science and management is based on single species dynamics mostly without considering environmental or ecosystem interactions of drivers. The system is generally assumed to be stable and management advices are given based on the assumption of equilibrium in the system and stationarity in the relationships. These assumptions are not appropriate for most fish stocks (ICES 2011), particularly for herring or sprat stocks (Nash *et al.*, 2009). Moreover, very few cause-and-effect relationships have withstood the test of time (Myers, 1998) and ecosystem regime shifts and alternative stable states may hide new relationships within ecosystems.

Although progress has been made towards incorporating ecosystem drivers in advice (e.g., through integrated assessment WGs) work needs to be done on finding appropriate ecosystem drivers for implementation into fisheries advice. This includes gaining more knowledge on the key forces driving ecosystem and fish population dynamics, but also on developing an advice framework able to incorporate ecosystem considerations in both qualitative and quantitative manners, as appropriate.

In principle all life stages of herring and sprat may be affected by environmental drivers. The drivers may be of biotic (predators, inter and intra specific competitors, prey, human exploitation) or abiotic nature (natural or human-induced environmental effects such as hydrographical, climatic, chemical influences, etc.).

North Sea herring has provided clear evidence that the paradigm of a single time-invariant stock–recruitment relationship that has prevailed for the past 60 years (Bailey and Steele, 1992) is clearly invalid. Instead, the interaction of stock and recruitment must be viewed as being more fluid, changing gradually or periodically depending on ecosystem changes. In trying to project the productivity of North Sea herring forward, it is clear that recruitment adds most of the uncertainty to the estimates of future yield and of the potential to reach biomass reference points within a specific time-frame (Dickey-Collas *et al*., 2010a).

Beside broad scale changes, it is obvious that North Sea herring dynamics co-vary with environmental variability (Payne *et al*., 2009; Groeger *et al*., 2010; Dickey-Collas *et al*., 2010). Whilst the direct mechanisms are not known (Nash and Dickey-Collas, 2005; Brunel, 2010) and the spatial and temporal scales of covariance with the environment are still unclear (Petitgas *et al*., 2009; Röckmann *et al*., 2011; Fässler *et al*., 2011) the productivity and distribution of herring have been shown to vary with the environment. Variability in advection from the spawning grounds to the nursery grounds has been thought to be a crucial factor (Corten, 1986; Bartsch *et al*., 1989; Munk and Christensen, 1990), but unequivocal support for this hypothesis has not been forthcoming (Dickey-Collas *et al*., 2009). Physiological modelling of temperature-specific food requirements suggests that the spawning periods utilized are the most favourable ones for larval growth and survival (Hufnagl *et al*., 2009). Indeed, changes in the planktonic system have been suggested as critical for recruitment (Cushing, 1992; Payne *et al*., 2009), but clear evidence is still lacking. Variations in bottom temperature near the spawning grounds (Nash and Dickey-Collas, 2005; Payne *et al*., 2009), predation by jellyfish (Lynam *et al*., 2005), bottom-up processes (Hufnagl *et al*., 2009), cannibalism (Corten 2013) and competition with other species (Corten, 1986) have been proposed as mechanisms that also affect recruitment. Productivity is also correlated with large scale North Atlantic climate indices (Groeger *et al*. 2010). Other factors may also affect growth and survival of larval and juvenile herring (disease, storms, contaminants), but with some exceptions (Tjelmeland and Lindstrom, 2005) it has not been possible to include any environmental factors in recruitment models that can be used in routine assessments.

There is evidence for changes in the growth of North Sea herring. In populations experiencing large changes in abundance, density-dependent regulation of growth might occur, because of reduced competition for food when stock size is smaller (Melvin and Stephenson, 2007). Before and during the collapse (from the late 1940s to the early 1980s), length-at-age increased markedly (approx. 2 cm at age 3) for the Orkney/Shetland, Banks, and Downs components (Dickey-Collas *et al*., 2010a). During the period of stock recovery, weight-at-age decreased and these declines were correlated significantly and inversely with stock size in Downs herring (Shin and Rochet, 1998). In contrast no density dependent growth was detected in the Celtic Sea herring (Lynch, 2010). More generally, strong herring year classes have grown poorly in recent years, suggesting that density-dependent mechanisms are operating.

Whereas most of the variations in size-at-age observed can be explained by density-dependent mechanisms, there are also indications of environmental effects. Modelling the growth of juvenile herring during the period of stock decline (1961–1981), Heath *et al*. (1997) explained the interannual variability in growth rate (superimposed on the main trend of density-dependent growth) by environmental fluctuations (hydrographic conditions and plankton abundance). For juvenile and adult life stages, Brunel and Dickey-Collas (2010) found that temperature significantly explained variations in growth between cohorts of North Sea herring from the mid-1980s. Cohorts experiencing warmer conditions throughout their lifetime attained higher growth rates, but had a shorter life expectancy and smaller asymptotic size. Further research is needed to disentangle the various causes of variability in historical growth.

The environment also influences the spatial distribution of North Sea herring (Dickey-Collas *et al* 2010b; 2010c; Röckmann *et al*., 2011). There are currently no models to help either fully investigate how migration may be impacted by environmental changes, and this may affect the assessment or management of North Sea herring. Likewise the impact of herring on the North Sea ecosystem is difficult to predict (Dickey-Collas *et al*., 2010a). Herring population may impact on cod productivity (Speirs *et al*. 2010; Fauchald, 2010) and simulation studies suggested that the cod stock recovery may be dependent in some extent on the size of the herring population in the North Sea (Speirs *et al*., 2010).

The relative contributions the environmental effect on herring stock-dynamics, however, has implications for the management of these stocks. Brunel *et al*. (2010) suggest that environmental harvest control rules (eHCRs) are beneficial when the environmental signal is strong and the environmental conditions are worsening, but under minor or gradual changes in the environment, the benefits from the implementation of eHCRs are difficult to evaluate. The current North Sea herring rule was adjusted in 2008 to account for the lower productivity of the stock: subsequent evaluations have established the robustness of this rule to the current low productivity observed in this this stock (WKHMP 2008, WKHIAMP 2011, WKHERMP 2011, WKHELP 2012). Nevertheless, the development of these eHCRs (environmental Harvest Control Rules) requires an understanding of the underlying processes, which is currently lacking.

The North Sea herring stock assessment is unique in HAWG in that it incorporates the non-stationary nature of the ecosystem. The assessment of this stock includes time-varying variable estimates of M directly derived from the integrated assessment for the North Sea. Moreover, a spawning-component abundance index (i.e., SCAI) allows estimation of the relevant contribution of the different spawning components to the total stock, and thereby incorporating the effect of environmental heterogeneity on recruitment success. HAWG hopes to extend this approach to other stocks in the future.

In conclusion, numerous studies have greatly improved our understanding on the effects of environmental forcing on the herring stock productivity and dynamics. However, further work is still required to move beyond simple correlative understanding and elucidate the underlying mechanisms. Furthermore, mechanisms to incorporate this understanding into the provision of management advice are limited. ICES could therefore benefit greatly from developments that unify these two aspects of its community.

1.8.2 Environmental overview

HAWG this year was fortunate to be the recipient of the first in a series of "environmental briefing sheets" prepared by the Working Group on Operational Oceanography for Fisheries and the Environment (WGOOFE) (ICES HAWG 2013, WD04). This document was developed in consultation with HAWG, and provided an overview of the physical and biological environment thought to be of relevance to the stocks assessed by HAWG. Outputs from three biogeochemical models (NORWECOM, ECOSMO and ERSEM) were combined with an optimally-interpolated temperature product (OSTIA) to produce an overview of both the large scale variability (annual averages over regions) and the variability on the spawning grounds (averaged over the spawning period). Sea-surface temperature and primary productivity were chosen as the two most important variables.

Sea-surface temperatures on the Malin Shelf, Irish Sea and in the North Sea (Figure 1.8.1) show strong decadal-scale variability. The most recent decades are amongst the warmest in the time-series. There also appears to be a strong degree of synchrony between the regions considered here. However, the last three years have displayed a reduction in the average temperature, relative to the previous decade: in the North Sea this has corresponded to 0.5 C, with smaller reductions in other regions.

Primary productivity in these regions has shown a high-degree of inter-annual variability (Figure 1.8.2). Clear increasing trends in productivity are apparent in the last decade in the Irish Sea and Malin shelf, and to a lesser extent in the North Sea. However, these increases are mainly driven by the NORWECOM model, which is the only data source for the first two regions. The increasing trend seen in NORWECOM does not appear to be supported by ECOSMO and ERSEM. It is therefore difficult to draw conclusions as to the robustness of this observation.

The temperatures on the North Sea Autumn Spawning (NSAS) spawning grounds suggest anomalous warmth since the mid-1990s (Figure 1.8.3). There is also a high degree of synchrony visually apparent between the northern-most components (Orkney-Shetland, Buchan and Banks): this result has been reported elsewhere previously (Fässler *et al*., 2011). The most recent years have, however, suggested a return to temperatures last seen in the 1980s-early 1990s. The Downs component has not shown the same strength or persistency in warming.

Temperatures on the spawning grounds to the west of Great Britain (Figure 1.8.4) show a high degree of synchrony, particularly between the West of Scotland, VIaS and Irish Sea stocks. Consistent warm anomalies are observed since the last 1990s. The most recent years suggest a cooling trend.

1.8.3 Future directions

HAWG was extremely grateful for the environmental briefing sheet generated by WGOOFE and wishes to express their gratitude to the group for producing this extremely useful product.

- HAWG would very much like to continue the collaboration with WGOOFE, with the aim of further refining the briefing sheet concept to improve its utility, both to HAWG and to other working groups. In particular, the following refinements could be considered
  The interpretation of the primary production products proved challenging for the working groups. Expert interpretation of these results in the light of oceanographic processes (particularly with regard to the magnitude of ob-served trends and relative merits of the given models) would be of great use, as HAWG felt it lacked the expertise necessary to interpret these results. Ex-pansion of the number of input products could also be beneficial.
- Expansion of the spatial coverage of the data sources to include the full range of HAWG stocks, particularly the Western Baltic and Celtic Sea herring stocks.
- Understanding of the long-term productivity of small pelagic fish needs to resolve key processes across a range of different spatio-temporal scales. Recent analyses (Payne *et al*., 20xx) showed the relevance of local spawning components to the overall productivity of the North Sea herring stock, and suggest the importance of smaller scales of investigation. Thus, comprehen-sion of those processes influencing the herring population dynam-

ics as a whole is subordinate to understanding the oceanography and productivity of the North Sea at a small scale. In this respect, availability and interpretation of high resolution hydrographic data is certainly needed.

- The incorporation of forecast products was considered to be particularly ben-eficial. In particular, HAWG is aware of recent advances in the predictability of the North Atlantic marine environment (e.g. Matei *et al*., 2012) and could potentially benefit from this type of product with a 0-3 year lead time, where significant forecast skill has been demonstrated.
- HAWG could also benefit greatly from improved insight into the zooplankton community. In particular, changes in the abundance and composition of the zooplankton community in the various regions covered by the group are thought to be important, but little quantitative information is available to the group in this regard. Inclusion of zooplankton indices in the briefing sheet would also be of tremendous use.

The WGOOFE briefing sheet proved to be an excellent and informative product that the group benefited from. However, this represents only one part of the ecosystem/environment picture: the bottom-up one. HAWG would therefore very much like to see the development of a corresponding "top-down" briefing sheet, characterising the current state of predatory and competitive influences of other species on the stock dynamics of small pelagic fish. The Working Group on Multispecies Assessment Models (WGSAM) would be an ideal candidate for the production of such a product, and therefore encourages WGSAM to enter a dialogue about the generation of such an overview.

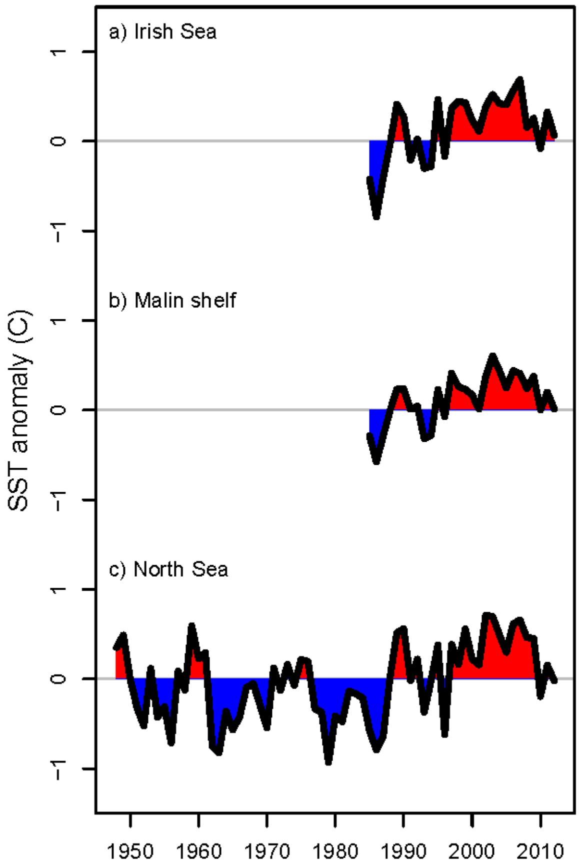


Figure 1.8.1. Anomalies in annually-averaged sea-surface temperatures (SST) for a) the Irish Sea b) the Malin Shelf and c) the North Sea. Anomalies are relative to the arithmetic mean over the period 1985-2000.

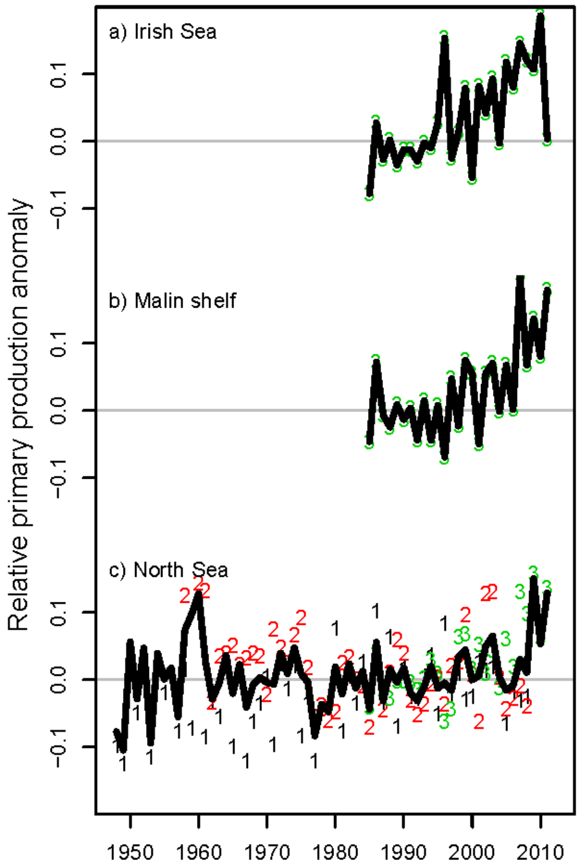


Figure 1.8.2 Relative anomalies in annually-averaged primary productivity for a) the Irish Sea b) the Malin Shelf and c) the North Sea. Points are labelled by data source: 1: ECOSMO 2: ERSEM 3: NORWECOM

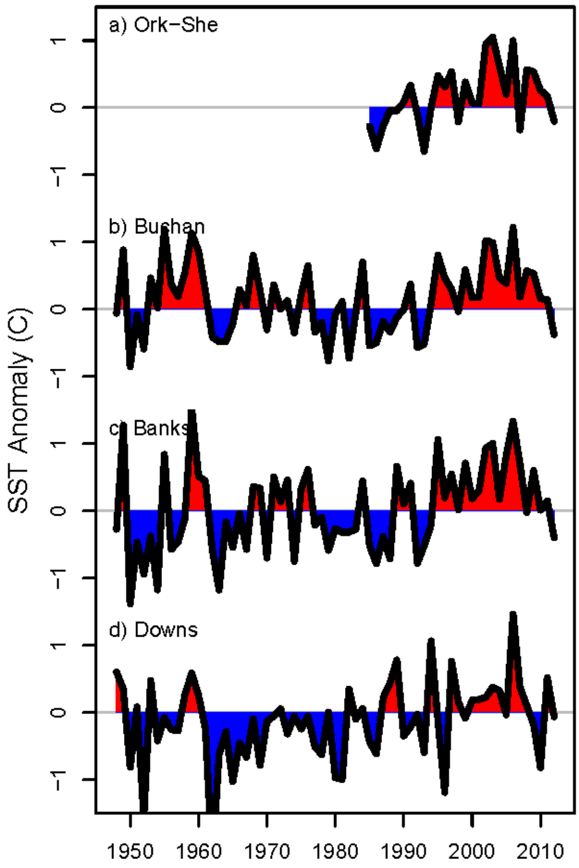


Figure 1.8.3. Anomalies in sea-surface temperatures (SST) averaged over the spawning grounds of the North-Sea Autumn Spawning (NSAS) herring stock during the spawning period. Anomalies are expressed as relative to the period 1985-2000 (inclusive).

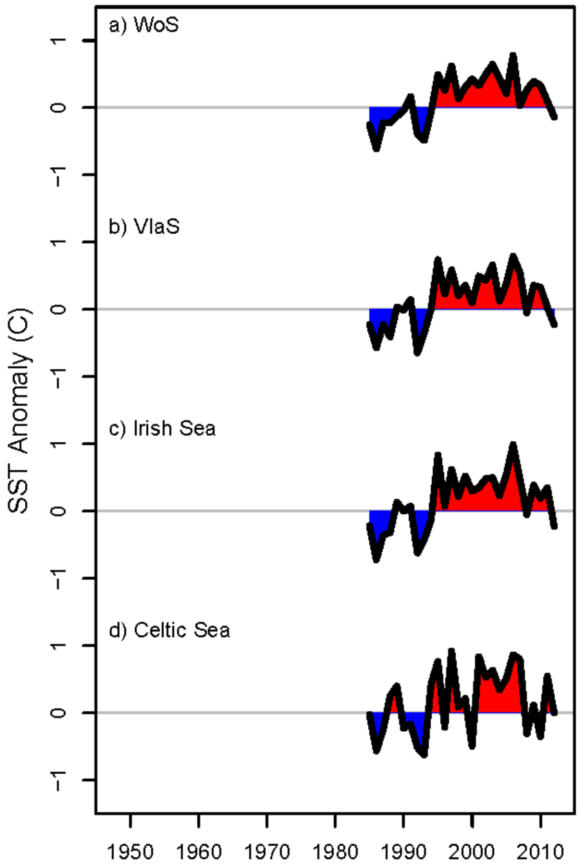


Figure 1.8.4. Anomalies in sea-surface temperatures (SST) averaged over the herring spawning grounds to the west of Great Britain during the spawning period. Anomalies are expressed as relative to the period 1985-2000 (inclusive).

1.9 Pelagic Regional Advisory Council [Pelagic RAC]

Following a good correspondence in previous years, the Pelagic RAC sent a communication to HAWG again concerning advice and work relevant for its members. The Pelagic RAC expressed a need for clarification in relation to the greater emphasis put on the advice related to seabed disturbance on herring spawning grounds put forward in 2012 for most herring stocks. HAWG considered these concerns and incorporated them into the work of the group as specified in below paragraphs.

"…the Pelagic RAC would like to establish what the terms "seabed disturbance activities" and "negative seabed impacts" imply? Our assumption is that ICES is not indicating that traditional fishing methods are being highlighted, but rather the expansion of new technology like the offshore renewable energy sector is causing concern." HAWG appreciated that the previous formulation were too wide and narrowed the sentence in the first paragraph of the Advice to read: *"…that activities that have a negative impact on the spawning habitat of herring, such as extraction of marine aggregates and construction on the spawning grounds, should not occur."* Furthermore, HAWG specified in 'Additional considerations' of the Advice sheet that *"…Gravel substrate is important fish habitat for herring spawning. Herring spawning and nursery areas are sensitive and vulnerable to anthropogenic influences. Activities that have an impact on the spawning habitat of herring, such as extraction of marine aggregates (such as gravel and sand) and construction, can impact spawning. Herring abandon and repopulate spawning grounds and an absence of spawning in any particular year does not mean that the spawning* *ground is not required to maintain a resilient herring population. There is scientific information (Groot, 1979; 1996) to support the advice that no gravel extraction should occur in areas with spawning grounds."* By tightening the sentences to anthropogenic influences other than traditional fishing, HAWG hopes to have clarified this issue in the Advice for 2013. In order to facilitate further clarification, HAWG decided to bring forward a recommendation to the Working Group on the Effects of Extraction of Marine Sediments on the Marine Ecosystem (WGEXT) concerning the evaluation of the effect of gravel extraction and other bottom-disturbing activities on herring spawning grounds for herring spawning success.

"The Pelagic RAC would also like to know whether ICES has information on the exact locations of herring spawning grounds. If not, is this an area where input from the Pelagic RAC could help provide information on where these important areas can be found?" HAWG highly appreciates this approach by Pelagic RAC and it was decided to follow up on this offer by formulating a Working Document holding all known information to the group on spawning sites and then pass this on to the Pelagic RAC enquiring if any additional information could be added based on the observations from members of the Pelagic RAC. The intention is that this document then will form the base for further exploration of hitherto un-described spawning grounds as a collaborative project between the Pelagic RAC and relevant Institutes. *Richard Nash, Mark Payne and Lotte Worsøe Clausen were appointed to lead the work and to report back to HAWG in 2014.*

1.10 Data coordination through PGCCDBS and/or the Regional Coordination Meeting (RCM)

Assessment Working Group (AWG) recommendations

During HAWG 2013, Lotte Worsøe Clausen (DTU Aqua) compiled all issues relevant to PGCCDBS in the table "Stock Data Problems Relevant to Data Collection" (included it in the HAWG 2011 report). The PGCCDBS reviewed AWG reports with respect to recommendations addressed to PGCCDBS. The relevant recommendations from HAWG to the PGCCDBS and the response is listed in the below table.

Stock	Data problem	How to be addressed/ by whom	PGCCDBS Comments
Age estimation of sprat Celtic Sea and West of Scotland	Collation of age-length keys of sprat in the Celtic Sea and West of Scotland should be done. A first step should be to validate the ageing of sprat from this area. HAWG recommends including available material on this part of the sprat stock complex in the upcoming large-scale exchange on Sprat in the North Sea.	"Provision of survey indices (total biomass, numbers at length, and/or numbers at age) for sprat in the Celtic seas eco-region" was removed from the recommendations, and IBTSWG and WGIPS was removed as recipient. The recommendation was forward to Lotte Worsøe Clausen [law@aqua.dtu.dk], the coordinator of the North Sea sprat age reading exchange.	For the collation of ALKS: HAWG should do this. The large-scale North Sea sprat exchange otolith exchange has been extended to include Celtic sea and Western Scotland. Validation of sprat age reading: micro increment (aka daily ring / microstructure) validation exists for NS and Baltic stocks. PGCCDBS advises to wait on the results from this upcoming exchange before evaluating the need for a validation study.

Stock Data Problems Relevant to Data Collection

HAWG identified the following issues for further discussion by the PGCCDBS in relation to stock data problems relevant to data collection. These are listed in the below text-table.

Stock	Data Problem	How to be addressed in DCR	By who
Stock name	***Data problem identification***	***Description of data problem and recommend solution***	***Who should take care of the recommended solution and who should be notified on this data issue.***
All stocks	HAWG is concerned about the lack of information on discarding levels in the herring fisheries.	All efforts should be made to maintain observer coverage across fleets that catch a substantial proportion of pelagic fish and to report on the observed discard levels. The implications of the discard ban on pelagic vessels in the revised CFP should be considered in relation to pelagic observer programmes.	PGCCDBS and RCMs

1.11 Propose specific actions to be taken to improve the quality and transmission of the data (including improvements in data collection).

Catch input data for the North Sea herring assessment are estimated in two runs, one for herring caught in the North Sea and a second one for NSAS and WBSS herring in the North Sea, to which splitting of catches has applied (due to the mixing of WBSS and NSAS in Subdivision IVa(E) and Division IIIa). So far, InterCatch offers only the possibility to keep one final dataset per stock and year. An opportunity should be implemented to store both datasets separately.

Furthermore, InterCatch does not provide the needed output for Division IIIa. Information on CANUM and WECA of North Sea autumn spawning herring is not available for this area. Their amount is summed to Subdivision IVa(E). This is a major concern as these estimates are an essential need as input data for the assessment. Consequently, InterCatch could not be used for NSAS and WBSS solely unless this output is produced.

1.12 Summary of relevant Mixed fisheries overview and considerations, species interaction effects and ecosystem drivers, Ecosystem effects of fisheries, and Effects of regulatory changes on the assessment or projections for all stocks.

Brief summaries are given here, more detailed information can be found in the relevant stock summaries.

North Sea autumn spawning herring (her-47d3):

The North Sea herring fishery is a multinational fish**ery that seasonally targets her**ring in the North Sea and English Channel. An industrial fishery, which catches juvenile herring as a by-catch operates in the Skagerrak, Kattegat and in the central North Sea. Most fleets that execute the fishery on adult herring target other fish at other times of the year, both within and beyond the North Sea (e.g. mackerel, horse mackerel and blue whiting). The fishery for human consumption has mostly single-species catches, although some mixed herring and mackerel catches occur in the northern North Sea, especially in the purse-seine fishery. The bycatch of sea mammals and birds is also very **low, i.e. undetectable using ob**server programmes. There is less information readily available to assess the impact of the industrial fisheries that by-catch juvenile herring. The pelagic fisheries on herring and mackerel claim to be **some of the "cleanest" fish**eries in terms of bycatch, disturbance of the seabed and discarding. Pelagic fish in-teract with other components of the ecosystem, including demersal fish, zooplankton and other predators (sea mammals, elasmobranchs and seabirds). Thus a fishery on pelagic fish may impact on these other components via second order interactions. There is a paucity of knowledge of these interactions, and the inherent complexity in the system makes quantifying the impact of fisheries very difficult.

Another potential impact of the North Sea herring fishery is the removal of fish that could provide other "ecosystem services". The North Sea ecosystem needs a biomass of herring to graze the plankton and act as prey for other organisms. If herring biomass is very low other species, such as sandeel, may replace its role or the system may shift in a more dramatic way. Likewise large numbers of herring can have a predatory impact on species with pelagic egg and larvae stages.

The populations of herring constitute some of the highest biomass of forage fish in the North Sea and are thus an integral and important part of the ecosystem, particularly the pelagic components. The influence of the environment of herring productivity means that the biomass will always fluctuate. North Sea herring has a complex substock structure with different spawning components, producing offspring with different morphometric and physiological characteristics, different growth patterns and differing migration routes. Productivity of the spawning components varies. The three northern components show similar recruitment trends and differ from the Downs component, which appears to be influenced by different environmental drivers. Having their spawning and nursery areas near the coasts, means herring are particularly sensitive and vulnerable to anthropogenic impacts. The most serious of these is the ever increasing pressure for marine sand and gravel extraction and the development of wind farms. Climate models predict a future increase in air and water temperature and a change in wind, cloud cover and precipitation. Analysis of early life stages' habitats and trends over time suggests that the projected changes in temperature may not widely affect the potential habitats but may influence the productivity of the stock

Western Baltic Spring Spawners (her-3a22):

The Western Baltic herring fishery is a multinational fishery that seasonally targets herring in the eastern parts of the North Sea (Eastern IVa,b), the Skagerrak and Kattegat (Division IIIa) and Western Baltic (SD 22–24). The fishery for human consumption has mostly single-species catches, although in recent years some mackerel bycatch can occurred in the trawl fishery for herring. The bycatch of sea mammals and birds is low enough to be below detection levels based on observer programmes. At present there is a very limited industrial fishery in Division IIIa and hence a limited bycatch of juvenile herring. The pelagic fisheries on herring claim to be some of the "cleanest" fisheries in terms of bycatch, disturbance of the seabed and discarding. Pelagic fish interact with other components of the ecosystem, including demersal fish, zooplankton and other predators (sea mammals, elasmobranchs and seabirds). Thus a fishery on pelagic fish may impact on these other components via second order interactions. There is a paucity of knowledge of these interactions, and the inherent complexity in the system makes quantifying the impact of fisheries very difficult. Another potential impact of the Western Baltic herring fishery is the removal of fish that could provide other "ecosystem services." There is, however, no recent research on the multispecies interactions in the foodweb in which the WBSS interact.

Dominant drivers of larval survival and year class strength of recruitment are considered to be linked to oceanographic dispersal, sea temperatures and food availability in the critical phase when larvae start feeding actively. However, research on larval herring survival dynamics indicates that driving variables might not only vary at the population level and by region of spawning but also by larval developmental stage. Since WBSS herring relies on inshore, transitional waters for spawning and larval retention, the suit of environmental variables driving reproduction success potentially differs from other North Atlantic stocks recruiting from coastal shelf spawning areas.

Herring in the Celtic Sea and VIIj (her-irls):

There are few documented reports of by catch in the Celtic Sea herring fishery. Small quantities of non target whitefish species were caught in the nets. Of the non target species caught whiting was most frequent (84% of tows) followed by mackerel (32%) and cod (30%). The only marine mammals recorded were grey seals (*Halichoerus grypus*). The seals were observed on a number of occasions feeding on herring when the net was being hauled and during towing. They appear to be able to avoid becoming entangled in the nets. Occasional entanglement **of cetaceans** may occur but overall incidental catches are thought to be minimal.

Temperatures in this area have been increasing over the last number of decades. There are indications that salinity is also increasing. Herring are found to be more abundant when the water is cooler while pilchards favour warmer water and tend to extend further east under these conditions. However, studies have been unable to demonstrate that changes in the environmental regime in the Celtic Sea have had any effect on productivity of this stock. Herring larval drift occurs between the Celtic Sea and the Irish Sea. The larvae remain in the Irish Sea for a period as juveniles before returning to the Celtic Sea. Catches of herring in the Irish Sea may therefore impact on recruitment into the Celtic Sea stock. The residence of Celtic Sea fish in the Irish Sea may have an influence on growth and maturity rates.

The spawning grounds for herring in the Celtic Sea are well known and are located inshore close to the coast. Spawning grounds tend to be vulnerable to anthropogenic influences such as dredging and sand and gravel extraction. Herring are an important component of the Celtic sea ecosystem. There is little information on the specific diet of this stock. Herring form part of the food source for larger gadoids such as hake. Recent research showed that fin whales *Balaenoptera physalus* are an important component of the Celtic Sea ecosystem, with a high re-sighting rate indicating fidelity to the area. There is a strong peak in sightings in November, and fin whales were observed actively feeding on many occasions, seeming to associate with sprat and herring shoals. There is the suggestion that the peak in fin whale sightings in November may coincide with the inshore spawning migration of herring.

Herring in VIa North (her-vian):

Herring are an important prey species in the ecosystem and also one of the dominant planktivorous fish. Herring fisheries tend to be clean with little bycatch of other fish. Herring represent an important prey item for many predators including cod and other large gadoids, dog-fish and sharks, marine mammals and sea birds. Because of the trophic importance of herring puts its stocks under immense pressure from constant exploitation**.**

The benthic spawning behaviour of herring makes this species vulnerable to anthropogenic activity such as offshore oil and gas industries and gravel extraction. There are many hypotheses as to the cause of the irregular cycles shown in the productivity of herring stocks (weights-at-age and recruitment), but in most cases it is thought that the environment plays a key role (through prey, predation and transport). The VIaN herring stock has shown a marked decline in productivity during the late 1970s and has remained at a low level since then.

Herring in VIa South and VIIbc (her-irlw):

Sea surface temperature**s** from Malin head on the North coast of Ireland since 1958 **indicate that s**ince 1990 sea surface temperatures **have displayed a sustained in-**creasing trend, with winter temperatures >6° and higher summer temperatures during the same period. Environmental conditions can cause significant fluctuations in abundance in a variety of marine species including fish. Oceanographic variation associated with temperature and salinity fluctuations appears to affect herring in the first year of life, probably during the winter larval drift.

Productivity in this region is reasonably high on the shelf but drops rapidly west of the shelf break. This area is important for many pelagic fish species. The shelf edge is a spawning area for mackerel *Scomber scombrus* and blue whiting *Micromesistius potassou*. Preliminary examination of productivity shows that overall productivity in this area is currently lower than it was in the 1980s.

The spawning grounds for herring along the northwest coast are located in inshore areas close to the coast **and** tend to be vulnerable to anthropogenic influences such as dredging and sand and gravel extraction.

Herring in the Irish Sea (her-nirs):

The targeted fishery for herring in the Irish Sea is considered to be clean, with limited bycatch of other species. Herring is a common prey species for many species but at present the extent of this is not quantified. Stock discrimination techniques, tagging, and otolith microstructure and shape show that juveniles originating from the Celtic Sea are present in the Irish Sea. The majority of mixing occurs at ages (rings) 1–2. Over the period 2006 to 2010 interannual variation in the proportion of mixing was large with between 60% and 15% observed in the 1+biomass estimate during the study period. The main fish predators on herring in the Irish Sea include whiting (*Merlangius merlangus*) (mainly 0-1 ring), hake (*Merluccius merluccius*) and spurdog (*Squalus acanthias*) (all age classes). The small clupeids are an important source of food for piscivorous seabirds and marine mammals which occur seasonally in areas where herring aggregate. Whilst small juvenile herring occur throughout the coastal waters of the western and eastern Irish Sea, their distribution overlaps extensively with sprats (*Sprattus sprattus*). There are irregular cycles in the productivity of herring stocks which are probably caused by changes in the environment (e.g. transport, prey, and predation). There has been an increase in water temperatures in this area which has affected the distribution some fish species.

North Sea Sprat (spr-nsea):

Young herring as a bycatch is acknowledged for this fishery with bycatch regulations in force. The Bycatch of marine mammals and birds is considered to be very low (undetectable using observer programs). Sprat is a short-lived forage fish that is predated by a wide range of marine organisms, from predatory gadoids, through birds to marine mammals. Therefore, the dynamics of sprat populations are affected by the dynamics of other species through annually varying natural mortality rates. Because sprat interacts with many other components of the ecosystem (fish, zooplankton and predators) the fishery may impact on these other components via second order interactions. It is uncertain how many sprat migrate in to and out of adjacent management areas i.e. IIIa and the English Channel (VIId,e) or how this may vary annually.

Sprat in IIIa (spr-kask):

Young herring as a bycatch is acknowledged for this fishery with bycatch regulations in force. Sprat is a short-lived forage fish that is predated by a wide range of marine organisms, from predatory gadoids, through birds to marine mammals. Whilst it is acknowledged that the dynamics of the sprat population will be affected by the dynamics of other species through annually varying natural mortality rates there is insufficient information on the predator-prey dynamics in the area for this to be quantified. Because sprat interacts with many other components of the ecosystem (fish, zooplankton and predators) the fishery may impact on these other components via second order interactions. A major source of uncertainty with this stock is whether it actually constitutes a discrete stock and the extent that individuals migrate in and out of adjacent management areas.

Sprat in the English Channel (VIId,e) (spr-ech):

The fishery considered here is primarily in Lyme Bay with small trawlers targeting sprat with very little to no bycatch of other species. The relationship of the sprat in this area to the sprat stock or population in the adjacent areas is unknown. The potential for mixed fisheries, if the fisheries are expanded to cover the whole of the English Channel, is unknown at present. It is acknowledged that sprat is prey for many species and these will affect the natural mortality, however, this has not been quantified in this area. In addition changes in the size of the sprat population through fishing will affect the available prey for a number of commercially exploited species.

Sprat in the Celtic Seas EcoRegion (VI and VII (excluding VIId,e)) (spr-irls):

This ecoRegion currently has fisheries in the Celtic Sea and a variety of Scottish Sea lochs with the possibility of fisheries being revived in the Clyde. Generally, mixed fisheries are not an issue as sprat are targeted with very little to no other species caught as a bycatch. If a fishery was to be prosecuted in the Irish Sea then bycatch of young herring may become an issue due to the overlap in distribution between young herring an sprat. It is acknowledged that sprat is prey for many species and these will affect the natural mortality, however, this has not been quantified in this area. Since sprat preys on e.g. zooplankton and is preyed upon by many species fisheries for sprat can have effects on the ecosystem dynamics.

1.13 Stock overview

The WG was able to perform analytical assessment for 6 of the 9 stocks investigated. Results of the assessments are presented in the subsequent sections of the report and are summarized below and in Figures 1.11.1 - 1.11.3.

North Sea autumn spawning herring (her-47d3) is the largest stock assessed by HAWG. The spawning stock biomass was low in the late 1970s and the fishery was closed for a number of years. This stock began to recover until the mid-1990s, when it appeared to decrease again. A management scheme was adopted to halt this decline. Based on the WG assessment the stock is classified as being at full reproductive capacity and is being harvested sustainably but below F_{MSY} and management plan target. The spawning stock at spawning time in 2012 is estimated at approximately 2.35 million tonnes, which is similar to the 2012 estimate of 2.34 million tonnes forecasted in 2011. Recruitment appears still in the same low regime since 2002. The estimate of 0-wr fish in 2013 (2012 year class) is estimated to be at approximately 22.5 million, just below the long term geometric mean. Mean $F_{2\text{-}6}$ in 2012 is estimated at approximately 0.17, which is below the management agreement target F, while mean $F_{0\text{-}1}$ is 0.03, also below the agreed ceiling. The updated assessment estimated an $F_{2\text{-}6}$ of 0.11 in 2011. From 2012 to 2013, SSB is expected to decline, mainly driven by the higher TAC in 2012 and 2013 which results in an increase in fishing mortality. Under all scenarios SSB is predicted to decline in 2014 and 2015, except under the no-fishing scenario. The SSB is expected to further decline under the management plan in 2014 to 1.8 million tonnes and further in 2015 to approximately 1.5 million tonnes. SSB is expected to be above $B_{trigger}$, and therefore also B_{pa}, in 2013, 2014 and 2015. Under the F_{msy} option F, SSB is expected to decline to 1.8 million tonnes in 2014 and to 1.5 million tonnes in 2015.

Western Baltic Spring Spawners (her-3a22) is the only spring spawning stock assessed within this WG. It is distributed in the eastern part of the North Sea, the Skagerrak, the Kattegat and the Subdivisions 22, 23 and 24. Within the northern area, the stock mixes with North Sea autumn spawners, and recently mixing with Central Baltic herring stock has been reported in the western Baltic area. This stock was benchmarked in February 2013. The previous ICA model for WBSS has been replaced by SAM. The use of a different assessment model, as well as the revision of the data sources and the addition of new observation, resulted in a new perception of the

WBSS stock. In particular, SSB has been revised downward of approximately 20% in 2010-2011, with a consequent significant increase of the F estimate of about 40%. Also the perception of recent recruitment has been changed, and the 2010 year class appears in line with the low recruitment level estimated for the last 8-years period. The most recent assessment shows that the stock has decreased consistently during the second half of the 2000s. SSB has slightly increased from the last year which recorded minimum over the time period of this assessment. Fishing mortality (F_{3-6}) was drastically reduced in 2010 (0.37) and 2011 (0.32), and showed a minor increase in 2012. The estimate of F_{3-6} for 2012 is 0.33 and it is now above the revised estimate of F_{msy} (0.28). The assumptions in the short-term predictions give the expected catch by fleet for IIIa as summing up to a total of 49 732 t WBSS in 2013.

Herring in the Celtic Sea and VIIj (her-irls): The herring fisheries to the south of Ireland in the Celtic Sea and in Division VIIj have been considered to exploit the same stock. For the purpose of stock assessment and management, these areas have been combined since 1982. The stock has increased considerably in size in recent years with the highest estimate in the time series recorded in 2012 (159 776 t), and continue to be above the B_{pa} reference of 61 000 t. Despite the uncertainty in the recent survey estimates, there is evidence that the stock is at a high level. Several strong cohorts (2003, 2005, 2007 and possibly 2008 and 2009) have entered the fishery recently, and as they gain weight, they maintain the stock at a high level. Fishing mortality (F_{2-5}) declined between 2003 and 2009 but started to rise again in 2010 due to increased catches. It is currently estimated to be 0.15, which is below $F_{0.1}$ (0.17) and F_{MSY} (0.25). It seems likely that there has been a reduction in the level of discarding in 2012, but no quantitative evaluation was possible. Short term projections under the rebuilding plan show a rather stable trajectory of the stock for the next year, and all the scenarios show that SSB will be above B_{pa} in 2015.

Herring in VIa North (her-vian): The stock was larger in the 1960s when the productivity of the stock was higher. The stock experienced a heavy fishery in the mid-70s following closure of the North Sea fishery. The fishery was closed before the stock collapsed. It was opened again along with the North Sea. In the mid 1990s there was substantial area misreporting of catch into this area and sampling of catch deteriorated. Area misreporting was reduced to a very low level and information on catch has improved, and in recent years misreporting has remained relatively low. SSB for 2012 has been estimated at approximately 102 000 t (+24% from 2011) and a mean fishing mortality (F_{3-6}) of 0.16 and continues to be below the F_{target} of the management plan (0.25). The 2008 year class is the strongest since 2000. This year class has a high abundance in the catch data. There is insufficient data to evaluate later year classes. The forecast shows that SSB (in 2013) will be approx. 2 times B_{lim}. WG considers that the stock is currently fluctuating at a low level and is currently being exploited below F_{MSY}..

Herring in VIa South and VIIb,c (her-irlw) are considered to consist of a mixture of autumn- and winter/spring-spawning fish. The winter/spring-spawning component is distributed in the northern part of the area. The main decline in the overall stock since 1998 appears to have taken place on the autumn-spawning component, and this is particularly evident on the traditional spawning grounds in VIIb. In 2012 almost all the catches were reported in VIaS with a large part of the catch came from the northern area in the autumn, targeting pre-spawners. Recruitment has continued to be poor in recent years, though there is evidence that the 2008 year class was above the recent average. The current levels of SSB and F are not precisely known, however, there are indications that the stock is on a historically low level. The results of the exploratory assessments continue to suggest that SSB has been low since the mid 1990s, though it has increased since 2010. The absolute level is uncertain but is likely to be below B_{lim}. F is estimated to have reduced considerably in the past 3 years, concomitant with declining landings, however, the absolute levels of F is unknown.

Herring in the Irish Sea (her-nirs) comprises two spawning groups (Manx and Mourne). This stock complex experienced a decline during the 1970s. In the mid-1980s the introduction of quotas resulted in a temporary increase, but the stock continued its declined from the late 1980s up to the early 2000s. During this time period the contribution of the Mourne spawning component declined. An increase in activity on the Mourne spawning area has been observed since 2006. In the past decade there have been problems in assessing the stock, partly as a consequence of the variability in spawning migrations and mixing with the Celtic Sea stock. This assessment indicates an increase in SSB, estimated at 21 500 t in 2012, and a continued high recruitment in recent years, with a relatively stable $F_{4\text{-}6}$ (0.25 in 2012). Catches have been relatively stable at a relatively low level since the 1980s, and close to TAC levels in recent years. Based on the most recent estimates the stock is being harvested sustainably and below F_{MSY}.

North Sea Sprat (spr-nsea) is mainly targeted by the Danish fleet in the North Sea (80% of a total catch) with a catch of 85 656t in 2012. The catches are usually dominated by recruits (age 1) and their contribution was above the average in 2012. The stock is dominated by age 1-2 fish. Due to the short life cycle and early maturation, the majority of the stock consists of mature fish. This stock was benchmarked in 2013 (WKSPRAT) and an analytical assessment (based on an SMS model) was presented for the first time. To undertake the assessment and fit with the natural life cycle of sprat the assessment model is shifted by six months so that an assessment year and advice runs from July 1st to June 31st each year, and thus provide in-year advice. The sprat stock seems to be increasing. The stock appears to have been well above B_{pa} (142 000t) since 2005, with the exception of 2007 where SSB was approximately at B_{pa}. Since 2009 SSB has remained more or less stable around 300 000t and fishing mortality has been relatively low (0.5 – 0.7). In the short term projections an $F_{MSY\text{-}escapement}$ = 2.5 resulting in an SSB_{2014}= 142 000t and a catch of 194 000t whereas an F=M=1.3 would result in an SSB_{2014} = 161 000t and a catch of 144 000t.

Sprat in IIIa (spr-kask) is mostly caught by a small-meshed industrial fishery from Denmark, Sweden and Norway in decreasing order of amount landed. Sprat cannot be fished without by-catches of herring except in years with high sprat abundance or low herring recruitment. For this reason the sprat fishery in IIIa is controlled by sprat TAC (41 600 t in 2013), herring by-catch quota (6 659 t in 2013), and by-catch percentage limits. This stock was benchmarked in 2013 (WKSPRAT) but it was not possible to undertake an analytical assessment for IIIa sprat. Short term projections are to be based on the IBTS Q1 age 1 as an indicator of the incoming year class and IBTSQ1 age 2, IBTSQ3 age 1 the previous year and HERAS age 1 the previous year as indicators of age 2. These should provide in year advice for IIIa based on the ICES data limited stock approach (Category 3 / 4). Since this methodology is based on catches and the TAC has not been reached in a number of years the resultant advice provides catch options which are much lower than the current TAC for the year 2013.

Sprat in the English Channel (VIId,e) (spr-ech) is caught by a small number of small vessels primarily in the vicinity of Lyme Bay, western English Channel. This year ICES has provided catch advice for sprat in divisions VIId,e (primarily in the vicinity of Lyme Bay) based on criteria for data limited stocks. Data available are landings, a time series of lpue (1988 – 2012) and two acoustic surveys that were carried in 2011 and 2012 in the area where the fishery occurs. A surplus production model was fitted to data but the benchmark WKSPRAT advised that an analytical assessment was premature. The stock identity of sprat in the English Channel relative to sprat in the North Sea and Celtic Sea is unknown.

Sprat in the Celtic Sea (spr-irls): The stock structure of sprat populations in this eco-region (Subareas VI and VII (excluding VIId, e)) is not clear, and further work for the identification of management units for sprat is required. Most sprat in the Celtic Seas eco-region are caught by small pelagic vessels that also target herring, mainly Irish and Scottish vessels. This is the second year ICES provides quantitative advice for sprat in this eco-region. The quality and amount of information available for sprat is rather heterogeneous across this composite area. There is evidence from different survey sources of significant inter-annual variation in sprat abundance. Landed biomass, but not biological information on the catch, is available from 1970s in some areas (i.e., VIa and VIIa), while acoustic surveys started in 1991, with some gaps in the time series. The state of the stock is uncertain; no analytical assessment is available for sprat in the Celtic Sea eco-region.

1.14 Benchmark process

HAWG has made some strategic decision regarding the future benchmarking of its stocks (Table 1.12). In 2015, it is proposed to benchmark VIaN and VIaS and VIIbc together. Before this happens it is necessary to successfully split the Malin Shelf survey (MSHAS) according to season of spawning. If this is not possible, then a modelling approach is required to deal with the fact that both stock are relying for tuning on an acoustic survey that covers both stocks. In 2015 it is proposed benchmark the Celtic Sea herring.

Stock	Ass status	Latest benchmark	Benchmark next year	Planning Year +2	Further planning	Comments
NSAS	Update	2012	No	No		Consider mixing with IIIa in 2016
WBSS	Update	2013	No	No		Consider mixing with North Sea in 2016
VIaN	Update	Never	2015	yes	Splitting of VIaN and Malin surveys	Consider stock mixing with VIaS/VIIbc
Celtic Sea	Update	2008	2014	No		Consider stock mixing withVIIaN
VIaS/VIIbc	Exploratory	Never	2015	yes	Splitting of VIaN and Malin surveys	Consider stock mixing with

						VIaS/VIIbc
VIIaN	Update	2012	No	Yes	Consider mixing with Celtic Sea	Consider stock mixing with Celtic Sea
Sprat NS	None	2013	Yes		Consider stock components	
Sprat IIIa	None	2013	Yes		Consider stock components	
Sprat VIId,e	None	2013	Yes			
Sprat Celtic	None	2013	Yes	No		Need to evaluate stock identity

1.14.1 Benchmark planning

Celtic Sea Herring will be dealt with in WKPELA 2014. The Issue List for the benchmark in 2014 is presented in Annex XX to this report.

1.14.2 Long-term benchmark planning

HAWG is also developing a longer-term perspective towards its benchmark process, by identifying issues that should be addressed in the next round of benchmarks, even though they are several years in the future. The following list of issues is intended to focus development work during this inter-benchmark period.

- North Sea Autumn Spawning (NSAS) herring

Development of a component-based assessment model, including:

Incorporation of the IHLS LAI indices and direct estimation of the SCAI index inside the assessment model.

Splitting of catches, where possible, into autumn and winter-spawning components

Refinement of the IBTS0 index calculation to provide component-resolved information

- Splitting of survey information, where possible, into components

Modification of the assessment model to account for reduced precision in catch statistics prior to the 1960s

- West of Scotland (VIaN) herring

Extraction of West of Scotland herring larval abundance estimates from the North Sea IBTS0 survey

- Irish Sea herring

Develop techniques to maximize the information content in the Irish Sea larval survey

1.15 Assessment and forecast auditing process

This year HAWG will carry out internally the review process of individual assessments and forecasts. HAWG stocks subjected to review are shown in the Table below and the designated reviewer is named on the last column. The choice of assessment model, the model configuration and the data used in the assessments are to be checked against the corresponding settings described in the Stock Annex.. Other considerations as in the ICES document **Template for audit of assessments made by EG member** will also be addressed.

Fish Stock	Stock Name	Stock Coord.	Assesss. Coord. 1	Assess. Coord. 2	Advice	Review (SA)
san-nsea	Sandeel in Division IIIa and Subarea IV	Denmark	Denmark	Norway	Update	Niels Hintzen
her-3a22	Herring in Division IIIa and Subdivisions 22–24 (Western Baltic Spring spawners)	Denmark	Germany	Denmark	Update	Subgroup (M.Payne)
her-47d3	Herring in Subarea IV and Division IIIa and VIId (North Sea Autumn spawners)	Germany	NL	UK (Scotland)	Update	PJ Schon
her-irls	Herring in Division VIIa South of 52° 30′ N and VIIg,h,j,k (Celtic Sea and South of Ireland)	Ireland	Ireland		Update	E. Hatfield
her-irlw	Herring in Divisions VIa (South) and VIIb,c	Ireland	Ireland		Update	Henrik Moosegaard
her-nirs	Herring in Division VIIa North of 52° 30′ N (Irish Sea)	UK (Northern Ireland)	UK (Northern Ireland)		Update	Susan Lusseau
her-vian	Herring in Division VIa (North)	UK (Scotland)	UK S		Update	Norbert and Tomas
spr-kask	Sprat in Division IIIa (Skagerrak - Kattegat)	Norway	Denmark	-	Update	Ives and Sasha
spr-nsea	Sprat in Subarea IV (North Sea)	Denmark	Denmark	Norway	Update	Niels Hintzen
spr-celt (VI & VII)*	Sprat in the Celtic Seas and English Ch.	UK			Update	Cecilie Kvamme

The shaded row indicates that, at the time of writing, san-nsea review has been carried out already.

1.16 Structure of the report

The report details the available information on the catch, fisheries and biology of the stocks and then the stock assessments, the projections, the quality of the assessments and management considerations for each stock. This information and analyses are given in chapters for each of the seven major stocks considered by HAWG. Despite

this structure, it is important to realise that there are many links between the stocks and/or areas. (e.g., North Sea and herring caught in IIIa; VIaN herring and the North Sea; VIaS, VIIbc, Irish Sea and VIaN herring and Celtic Sea and Irish Sea herring).
In 2013 HAWG carried out 7 assessments:

(1) Western Baltic spring spawning herring,
(2) North Sea autumn spawning herring,
(3) VIaN autumn spawning herring and
(4) Celtic Sea autumn and winter spawning herring.
(5) Irish sea herring
(6) North Sea sprat
(7) Sandeels

VIaS/VIIbc Sea herring was an exploratory assessment. One stock with poor data (IIIa sprat) is described in Section 9. Section 10 covers sprat in the Celtic Seas ecoregion, including sprat in VIIde. Section 11 covers all sandeel stocks. Section 12 covers with limited data (no catch at age sampling) and no current ongoing research. These are Clyde herring (part of VIaN) and herring in the English/Bristol Channel (VIIe,f) and herring in Subarea VIII.

Medium term predictions have not been performed in 2013. This is because work is now focussing on developing the F_{MSY} approach for the stocks.

1.17 Recommendations

Please see Annex 2. All recommendations have been uploaded to the ICES Recommendation database.

Table 1.5.1: Available disaggregated data for the HAWG per March 2013. X: Multiple spreadsheets (usually .xls); W: WG-data national input spreadsheets (xls); D: Disfad inputs and Alloc-outputs (ascii/txt); I: Intercatch input. Years prior to 2008 are given in the HAWG report 2012.

Stock	Catchyear	Format				Comments
		X	W	D	I	
Western Baltic Sea:						
IIIa and SD 22-24	2008	X	W		I	provided by Lotte Worsøe Clausen, Mar. 2009
(her_3a22)	2009	X	W		I	provided by Lotte Worsøe Clausen, Mar. 2010
	2010	X	W		I	provided by Lotte Worsøe Clausen and Tomas Gröhsler, Mar. 2011
	2011	X	W		I	provided by Lotte Worsøe Clausen and Tomas Gröhsler, Mar. 2012
	2012	X	W		I	provided by Lotte Worsøe Clausen and Tomas Gröhsler, Mar. 2013
Celtic Sea and VIIj						
(her_irls)	2008		W		I	provided by Afra Egan, Mar. 2009
	2009		W		I	provided by Afra Egan, Mar. 2010
	2010		W		I	provided by Afra Egan, Mar. 2011
	2011		W		I	provided by Andrew Campbell, Mar. 2012
	2012		W		I	provided by Afra Egan, Mar. 2013
Irish Sea						
(her_nirs)	2008		W		I	provided by Steven Beggs, Mar. 2009
	2009		W		I	provided by Steven Beggs, Mar. 2010
	2010		W		I	provided by Steven Beggs, Mar. 2011
	2011		W		I	provided by Steven Beggs, Mar. 2012
	2013		W		I	provided by Pieter-Jan Schön, Mar. 2013
North Sea						
(her_47d3, her_nsea)	2008		W	D	I	provided by Norbert Rohlf, Mar. 2009
	2009		W	D	I	provided by Norbert Rohlf, Mar. 2010
	2010		W	D	I	provided by Norbert Rohlf, Mar. 2011
	2011		W	D	I	provided by Norbert Rohlf, Mar. 2012
	2012		W	D	I	provided by Norbert Rohlf, Mar. 2013
West of Scotland (VIa(N))						
(her_vian)	2008		W	D	I	provided by Emma Hatfield, Mar. 2009
	2009		W	D	I	provided by Emma Hatfield, Mar. 2010
	2010		W	D	I	provided by Emma Hatfield, Mar. 2011
	2011		W	D	I	provided by Emma Hatfield, Mar. 2012
	2012		W	D	I	provided by Emma Hatfield, Mar. 2013
West of Ireland						
(her_irlw)	2008		W		I	provided by Afra Egan, Mar. 2009
	2009		W		I	provided by Afra Egan, Mar. 2010
	2010		W		I	provided by Afra Egan, Mar. 2011
	2011		W		I	provided by Andrew Campbell, Mar. 2012
	2012		W		I	provided by Afra Egan, Mar. 2013
Stocks with limited data						
(her_VIIe,f and VIII	2011	X				provided by Yves Verin, Mar. 2012
	2012	X				provided by Yves Verin, Mar. 2013
Sprat in IIIa						
(spr_kask)	2008	X	(W)	D		provided by Lotte Worsøe Clausen, Mar. 2009
	2009		W		I	provided by Cecilie Kvamme, Mar. 2010
	2010		W		I	provided by Cecilie Kvamme, Mar. 2011
	2011		W		I	provided by Richard Nash, Mar. 2012
	2012		W		I	provided by Cecilie Kvamme, Mar. 2013
Sprat in the North Sea						
(spr_nsea)	2008	X	(W)	D	I	provided by Lotte Worsøe Clausen, Mar. 2009
	2009		W		I	provided by Cecilie Kvamme, Mar. 2010
	2010		W		I	provided by Cecilie Kvamme, Mar. 2011
	2011		W		I	provided by Katja Enberg, Mar. 2012
	2012		W		I	provided by Cecilie Kvamme, Mar. 2013
Sprat in VIId & e						
(spr_ech)	2008	X	(W)	D	I	provided by Else Torstensen, Mar. 2009
	2009		W		I	provided by Cecilie Kvamme, Mar. 2010
	2010		W		I	provided by Cecilie Kvamme, Mar. 2011
	2011		W		I	provided by Beatriz Roel, Mar. 2012
	2012		W		I	provided by Beatriz Roel, Mar. 2013

Table 1.5.2 Comparison of CANUM and WECA-estimates from conventional systems and InterCatch, by stock and age-group (winter-rings).

her-vian

2012 data		**canum**		**2012 data**		**weca**	
wr	sallocl	InterCatch	% difference	wr	sallocl	InterCatch	% difference
1	979.53	979	0	1	0.0725	0.072	0
2	14952.63	14952	0	2	0.1469	0.147	0
3	46647.39	46650	0	3	0.1894	0.189	0
4	9704.45	9705	0	4	0.2076	0.207	0
5	8097.3	8098	0	5	0.2161	0.216	0
6	6311.66	6313	0	6	0.2261	0.226	0
7	3873.67	3874	0	7	0.2408	0.241	0
8	1129.8	1130	0	8	0.2817	0.282	0
9+	4013.8	4014	0	9+	0.2467	0.246	0

North Sea (47d3)

2012	CANUM	CANUM	Proportion	2011	WECA	WECA	Proportion
wr	Salloc	IC	Match (%)	wr	Salloc	IC	Match (%)
0	773241	773241	1.00	0	0.011	0.011	1.00
1	284149	282759	1.00	1	0.046	0.046	1.00
2	457028	450666	0.99	2	0.124	0.125	1.00
3	666513	670356	1.01	3	0.170	0.170	1.00
4	408785	408309	1.00	4	0.185	0.185	1.00
5	310527	310691	1.00	5	0.205	0.205	1.00
6	153897	153231	1.00	6	0.221	0.221	1.00
7	104699	104164	0.99	7	0.238	0.238	1.00
8	91725	91653	1.00	8	0.239	0.239	1.00
9+	114308	113137	0.99	9+	0.245	0.245	1.00
Sum	3364873	3358206	1.00				

Table 1.5.2 continued: Comparison of CANUM and WECA-estimates from conventional systems and InterCatch, by stock and age-group (winter-rings).

Her IRLW	**Ring**	**Intercatch**	**WG Exchange**	**% Deviation**
CATON		6570.9	6570.9	0.00
CANUM	1	5141.6	5141.7	0.00
CANUM	2	12843.9	12844.0	0.00
CANUM	3	16386.5	16386.8	0.00
CANUM	4	4042.3	4042.3	0.00
CANUM	5	1775.8	1775.8	0.00
CANUM	6	553.4	553.4	0.00
CANUM	7	540.763	540.772	0.00
CANUM	8	102.554	102.554	0.00
CANUM	9	20.663	20.663	0.00
WECA	1	0.090	0.090	0.00
WECA	2	0.134	0.134	0.00
WECA	3	0.179	0.179	0.00
WECA	4	0.196	0.196	0.00
WECA	5	0.214	0.214	0.00
WECA	6	0.237	0.237	0.00
WECA	7	0.228	0.228	0.00
WECA	8	0.243	0.243	0.00
WECA	9	0.236	0.236	0.00

Her IRLS	Ring	Intercatch	WG Exchange	% Deviation
CATON		21605.3	21604.0	-0.01
CANUM	1	11596.6	11596.0	0.00
CANUM	2	61912.6	61908.9	-0.01
CANUM	3	44377.9	44375.2	-0.01
CANUM	4	37131.2	37129.0	-0.01
CANUM	5	6241.1	6240.7	-0.01
CANUM	6	21038.1	21036.8	-0.01
WECA	1	0.072	0.072	-0.01
WECA	2	0.094	0.094	0.00
WECA	3	0.124	0.124	0.00
WECA	4	0.138	0.138	0.00
WECA	5	0.152	0.152	0.00
WECA	6	0.160	0.160	-0.04

Table 1.8.1. Studies known to HAWG of environmental drivers influencing recruitment, growth, migration, predation by and predation of herring or sprat, the timing of spawning and studies of incorporating environmentally influenced changes in productivity into management.

Stock	recruitment	growth	migration	predation on her/sprat	predation by her/sprat	time of spawning	managing productivity changes
North Sea herring	X	X	X	X	X	X	X
Western Baltic SS herring	X	X		X			
VIaN herring			X				X
VIaS herring		X	X			X	X
VIIaN herring					X		
Celtic Sea herring		X	X	X		X	X
North Sea sprat	X	X		X	X	X	
IIIa sprat							

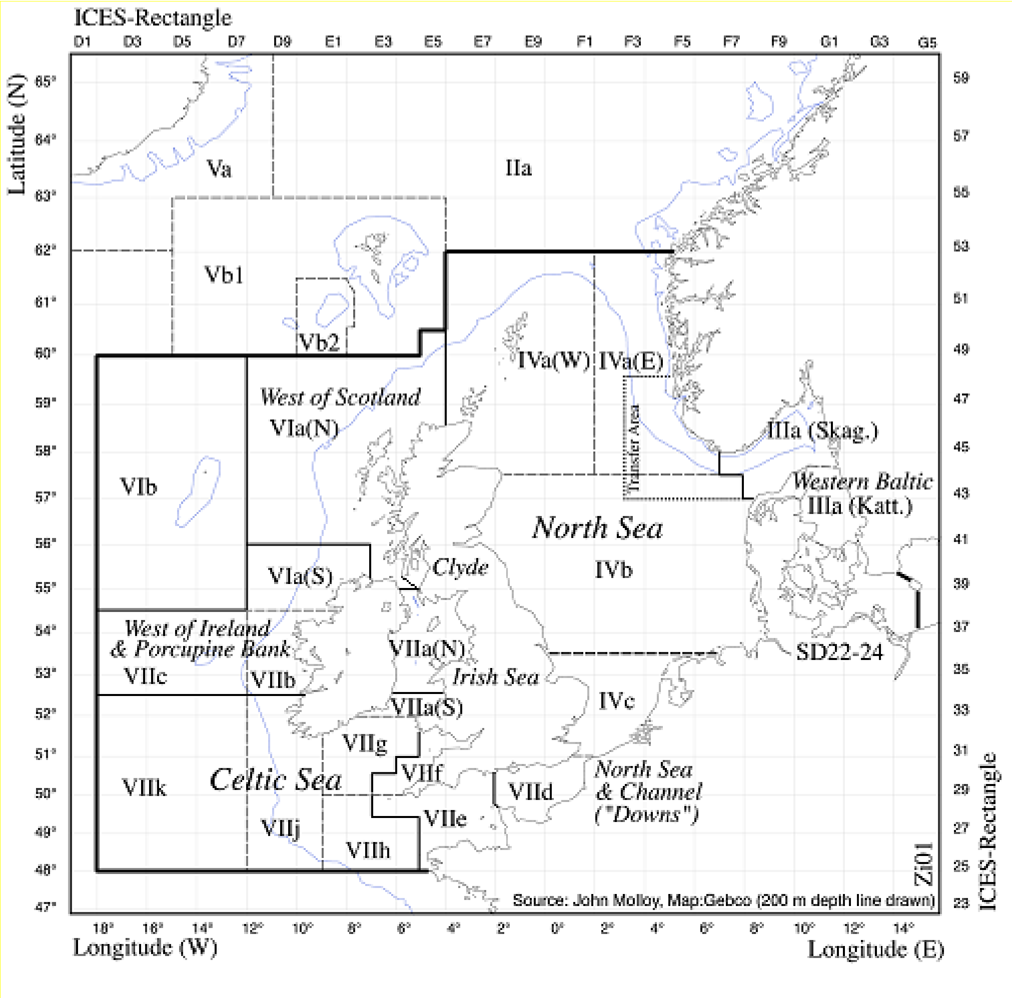


Figure 1.5.1 ICES areas as used for the assessment of herring stocks south of 62°N. Area names in italics indicate the area separation applied to the commercial catch and sampling data kept in long term storage. "Transfer area" refers to the transfer of Western Baltic Spring Spawners caught in the North Sea to the Baltic Assessment.

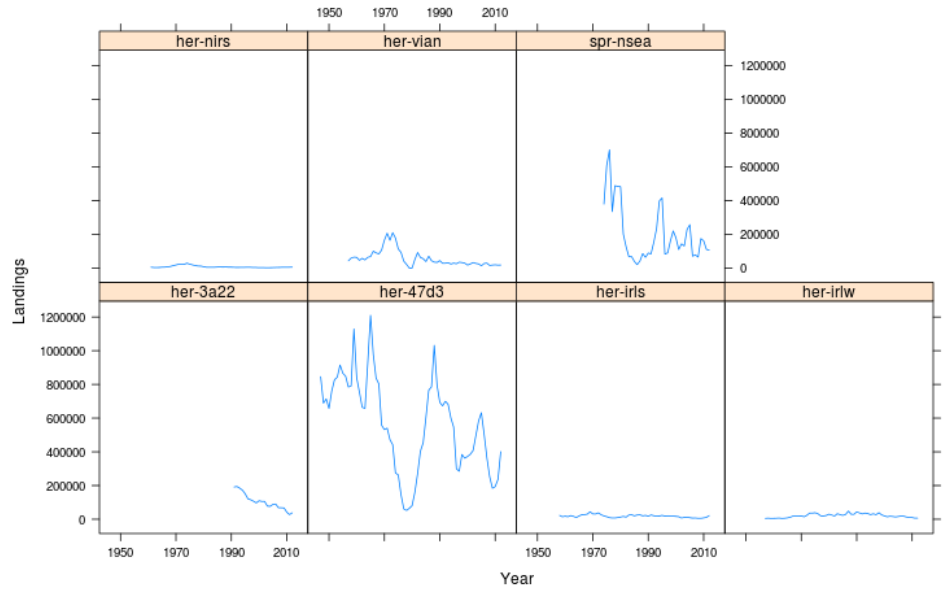


Figure 1.11.1 WG estimates of catch (yield) of the herring and sprat stocks presented in HAWG 2013.

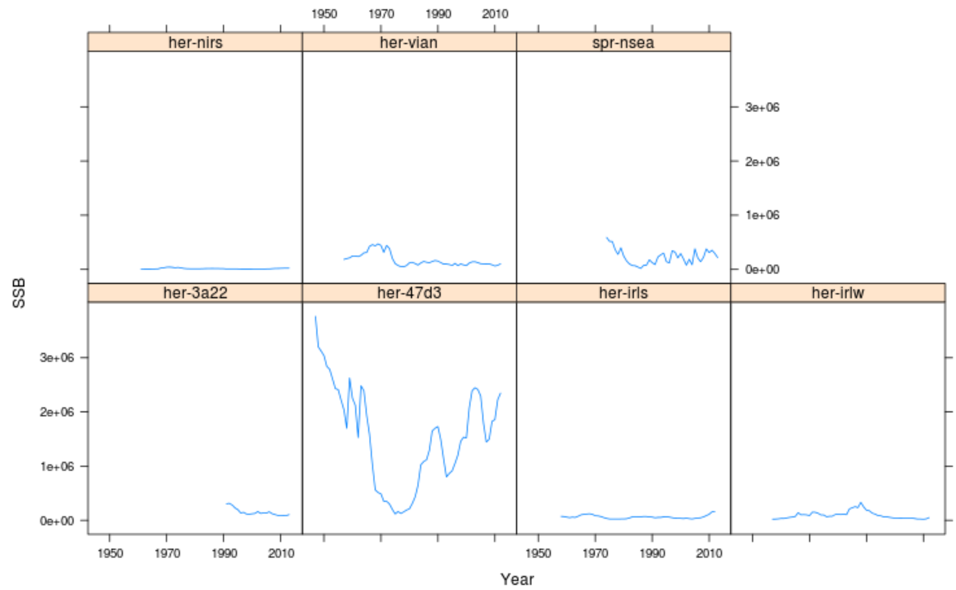


Figure 1.11.2 Spawning stock biomass estimates for the 1 sprat and 5 herring stocks under analytical assessment, and for the exploratory assessment of the her-irlw, presented in HAWG 2013.

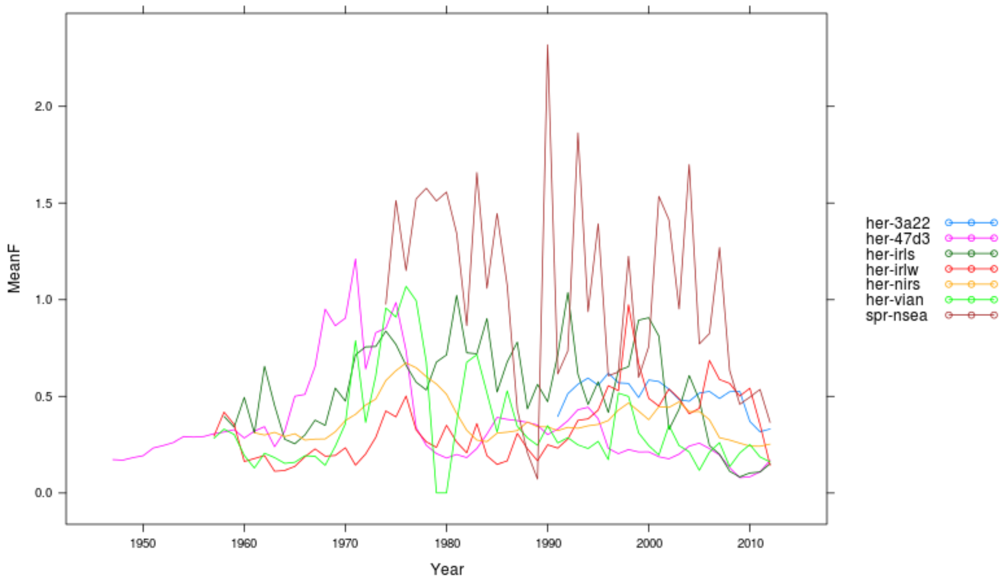


Figure 1.11.3 Estimates of mean F for the 1 sprat stock and 5 herring stocks under analytical assessment, and for the exploratory assessment of the her-irlw, presented in HAWG 2013.

2 North Sea Herring

2.1 The Fishery

2.1.1 ICES advice and management applicable to 2012 and 2013

According to the management plan agreed between the EU and Norway, adopted in December 1997 and amended in November 2007, efforts should be made to maintain the SSB of North Sea Autumn Spawning herring above 800 000 tonnes.

The EU-Norway agreement on management of North Sea herring was updated in 2008, to adapt to the present reduced recruitment, accounting for the results of WKHMP (ICES 2008/ACOM:27). The management plan is given in Stock Annex 3.

The main changes were a reduced target F for juveniles and a higher trigger biomass for reducing the adult F. The revised rule specifies fishing mortalities for juveniles (F_{0-1}) and for adults (F_{2-6}) not to be exceeded, at 0.05 and 0.25 respectively, when the SSB is above 1.5 million tonnes. The current agreement has a constraint on year-to-year change of 15% in TAC, when the SSB is above 800 000 t.

An iterative procedure is needed to find a fishing mortality and a corresponding SSB in the TAC year (see Stock Annex 3).

From January 2009 (EU Council Reg No 43/2009) high-grading and slipping of fish over the minimum landing size (as long as quota still exists) has been banned in EU waters. Discarding is illegal in Norwegian waters.

The EU–Norway agreement called for a review of the current plan until the end of 2011. However, this re-examination was done during WKHELP in 2012, implementing the changes made in the benchmark assessment performed in WKPELA 2012. The benchmark assessment has led to revisions of the perception of the stock and reconsidered F_{msy} as well as a target-F. The harvest control rules for the stock were evaluationed against variations in biology, testing for robustness under varying starting conditions in population size and changes in the North Sea Ecosystem. However, further negotiations are pending and the conclusions of WKHELP are not yet implemented in a new management plan.

The final TAC adopted by the management bodies for 2012 was 422 850 t for Area IV and Division VIId, whereof not more than 44 550 t should be caught in Division IVc and VIId. For 2013, the total TAC was increased by 16% to 492 400 t (478 000 t for the A-Fleet, +18%), including a TAC of 50 266 t for Division IVc and VIId.

The by-catch TAC for the B-Fleet in the North Sea (and Div. IIa) was 17 900 in 2012 and is decreased by almost 20% to 14 400 t for 2013. As North Sea autumn spawners are also caught in Division IIIa, regulations for the fleets operating in this area have to be taken into account for the management of the WBSS stock (see Section 3). Catches of spring spawning herring in the Thames estuary are in general low and not included in the TAC. For a definition of the different fleets harvesting North Sea herring see the Stock Annex and Section 2.7.2.

2.1.2 Catches in 2012

Total landings and estimated catches are given in the Table 2.1.1 for the North Sea and for each Division in Tables 2.1.2 to 2.1.5. Total Working Group (WG) catches per statistical rectangle and quarter are shown in Figures 2.1.1 (a-d), the total for the year in Figure 2.1.1(e). Each nation provided most of their catch data (either official landings or Working Group catch) by statistical rectangle. The catch figures in Tables 2.1.1 - 2.1.5 are mostly provided by WG members and may or may not reflect national catch statistics. These figures can therefore **not** be used for legal purposes.

In line with the rise of the TAC in 2012, the total WG catch of all herring caught in the North Sea increased considerably and amounted to 424 600 t in 2012. Official catches by the human consumption fishery were 413 600 t, corresponding to a slight overshoot of 2% of the TAC for the human consumption fishery (405 000 t). As in previous years, the vast majority of catches are taken in the 3rd quarter in Division IVa(W).

In the southern North Sea and the eastern Channel, the total catch sums to 40 400 t. The separate TAC for this area was 44 500 t, so 10% of the TAC remain in Division IVc and VIId (but due to catch regulation, 50% of the TAC could have been taken in Division IVb). The reduced catches continues to relieve the fishing pressure on the Downs stock component. In 2011, the catches were in good accordance with the TAC, while landings overshot the TAC by 73% in 2010.

Information on by-catches in the industrial fishery is provided by Denmark. While the Norwegian by-catches are included in the A-fleet figure for Norway, catches taken in the small-meshed fishery by Denmark account to a separate EU quota (B-fleet).

Landings of herring as by-catch in the Danish small-meshed fishery in the North Sea have increased by 19% to 10 638 t as compared to last year (Table 2.1.6). These industrial herring catches were much lower than the by-catch TAC set by the EU (17 900 t). Since the introduction of yearly by-catch ceilings in 1996, these ceilings have never been exceeded.

The total North Sea TAC and catch estimates for the years 2007 to 2012 are shown in the table below (adapted from Table 2.1.6).

Year	2007	2008	2009	2010	2011	2012
TAC HC ('000 t)	341	201	171	164	200	405
"Official" landings HC ('000 t)[1]	354	219	157	166	209	414
Working Group catch HC ('000 t)	381	236	156	166	209	414
Excess of landings over TAC HC ('000 t)	40	35	0	1	9	9
By-catch ceiling ('000 t) [2]	32	19	16	14	17	18
Reported by-catches ('000 t) [3]	7	9	10	9	9	11
Working Group catch North Sea ('000 t)	388	245	166	175	218	425

HC = human consumption fishery

1 Landings might be provided by WG members to HAWG before the official landings become available; they may then differ from the official catches and cannot be used for management purposes. Norwegian by-catches included in this figure.

2 by-catch ceiling for EU industrial fleets only, Norwegian by-catches included in the HC figure.

3 provided by Denmark only.

2.1.3 Regulations and their effects

Following the apparent recovery of the NSAS herring, some regulatory measures were amended. A licence scheme introduced in 1997 by UK/Scotland to reduce misreporting between the North Sea and VIaN was relaxed. The minimal amount of target species in the EU industrial fisheries in IIIa has been reduced to 50% (for sprat, blue whiting and Norway pout).

In 2013, half of the EU quota for Division IIIa could be taken in the North Sea (IV). Norway can take up to 50% of its quota for Division IIIa in the North Sea (IV).

In the North Sea, Norway can take up to 50 000 t of its quota in EU-waters in Divisions IVa and IVb. 50 000 t of the EU-quota can be taken within Norwegian waters south of 62°N.

Half of the EU quota for Division VIc and VIId can be taken in Division IVb (notification for IVb is needed in advance to the commission). However, no information on the occurrence of such transfer is available to the HAWG.

2.1.4 Changes in fishing technology and fishing patterns.

There have been no major changes to fish technology of the fleets that target North Sea herring. Fishing pattern have changed slightly. The majority of catches is still taken in Subdivision IVaW (58 %). After a sharp reduction in the catches taken in Division IVb in 2010, the proportion of catch taken in that area have increased again. Since 2011, they contribute roughly 25% to the total catches and are in the same order of magnitude as in the period 2007-2009. In the most recent year, catches in Divisions IVc and VIId contributed 10% to the catch, while it had been in the range of 15% for the period since 2008.

In 2007, the Danish administration introduced an ITQ system to regulate industrial fisheries. This has led to a consolidation of the fleet, resulting in fewer vessels being active. Due to this restructuring of the fleet, pelagic vessels that earlier did not take part in industrial fisheries have now became heavily engaged, while previously the human consumption fleet and industrial fleet had been mostly separate. This allowed vessel owners to be more flexible in weighing the benefits of one fishery against the other, but also put them in a position of being more exposed to the risk of sanctions against them in terms of losing 1/12 of their human consumption quota when not complying with the maximum limits of the amount of herring by-catch that they are allowed to hold on board.

Another change in the NSAS herring fishery was the substantial decline in misreporting of catch in the most recent years. Area misreporting (from IV to VI; and from IV into IIIa) seems to have ceased. Most of the previous unaccounted catches from the stock have been reduced, if not eliminated. Part of this can be explained by newly introduced national legislation in Denmark in 2009.

2.2 Biological composition of the catch

Biological information (numbers, weight, catch (SOP) at age and relative age composition) on the catch as obtained by sampling of commercial catches is given in Tables 2.2.1 to 2.2.5. Data are given for the whole year and by quarter. Except in cases where the necessary data are missing, data are displayed separately by area for herring caught in the North Sea, for Western Baltic spring spawners (only in IVaE), and for the total NSAS stock, including catches in Division IIIa.

Biological information on the NSAS caught in Division IIIa was obtained using splitting procedures described in Section 3.2 and in the Stock Annex 3.

The Tables are laid out as follows:

- Table 2.2.6: Total catches of NSAS (SOP figures), mean weights- and numbers-at-age by fleet

- Table 2.2.7: Data on catch numbers-at-age and SOP catches for the period 1996-2011 (herring caught in the North Sea)
- Table 2.2.8: WBSS taken in the North Sea (see below)
- Table 2.2.9: NSAS caught in Division IIIa
- Table 2.2.10: Total numbers of NSAS
- Table 2.2.11: Mean weights-at-age, separately for the different Divisions where NSAS are caught, for the period 2002-2012.

Note that SOP catch estimates may deviate in some instances slightly from the WG catch used for the assessment.

2.2.1 Catch in numbers-at-age

With regard to the large TAC increase from 2011 to 2012, the total number of herring taken in the North Sea (3.0 billion fish) and the total number of NSAS (3.3 billion fish) have increased by 60% and 54%. 0- and 1-ringers contributed 32% of the total catch in numbers of NSAS in 2012 (Table 2.2.5).

In 2012, catches in numbers of 0-ringers are stable and 1-ringers have increased by 78%, as compared to 2011. However, as a proportion of total catches, an overall reduction of the amount of 0- and 1-ringers has taken place. For herring caught in the North Sea, this proportion has reduced from 37% in 2011 to 25% in 2012. Most of these herring are still taken in the B-Fleet in Division IVb. Here, 0- and 1-ringers amount to 57% of the total catch in numbers (2011: 73%).

The proportion of the 3-ringers or older herring has increased from 45% to 62% of the total catch in numbers taken in the North Sea.

Western Baltic (WBSS) and local Division IIIa spring-spawners are taken in the eastern North Sea during the summer feeding migration (see Stock Annex 3 and Section 3.2.2). These catches are included in Table 2.1.1 and listed as WBSS. Table 2.2.8 specifies the estimated catch numbers of WBSS caught in the North Sea, which are transferred from the North Sea assessment to the assessment of Division IIIa/Western Baltic in 1997-2012. After splitting the herring caught in the North Sea and IIIa between stocks, the total catch of North Sea Autumn spawners amounts to 434 600 tonnes.

Area	Allocated	Unallocated	Discards	Total
IVa West	248 793	-3 416	-	245 377
IVa East	35 351	-	-	35 351
IVb	103 067	411	-	103 478
IVc/VIId	37 076	3 326	-	40 402
	Total catch in the North Sea			424 608
	Autumn spawners caught in Division IIIa (SOP)			12 197
	Baltic spring spawners caught in the North Sea (SOP)			-2 095
	Blackwater spring spawning herring			-63
	Other spring spawners			0
	Total catch NSAS used for the assessment			**434 647**

2.2.2 Other Spring-spawning herring in the North Sea

Norwegian spring-spawners and local fjord-type spring spawning herring are taken in Division IVa (East) close to the Norwegian coast under a separate TAC. These catches are not included in the Norwegian North Sea catch figures given in Tables 2.1.1 to 2.1.6, but are listed separately in the respective catch tables. Along with the increasing biomass of these spring spawning herring, the catches had increased in 2009 and 2010 (to 56 900 t), but decreased since down to 9 619 t in 2012.

Blackwater herring are caught in the Thames estuary under a separate quota and included in the catch figure for England & Wales. This fishery was re-opened in 2012. Total catch was 63 t.

In recent years no larger quantities of spring spawners were reported from routine sampling of commercial catch taken in the west.

2.2.3 Data revisions

No data revisions were applied in this year's assessment.

2.2.4 Quality of catch and biological data, discards

In the most recent year, some nations provided information on misreported and unallocated catches of herring in the North Sea and adjacent areas. However, misreporting and unallocation of catches is meanwhile regarded as a minor issue in the North Sea herring fishery. The **Working Group catch**, which include estimates of all fleets (and discards and misreported or unallocated catches; see Section 1.5), was estimated to be in the same order of magnitude as the official catch.

No information was provided on discard levels in 2012. In recent years quantified discards associated with herring landings were only provided by Scotland. With the cessation of the Scottish pelagic observer programme this source of information is no longer available. The previously reported discards were in the range of 10 to 100's tonnes. Although discards are likely to occur in all national fisheries, and this figure therefore likely was an underestimate, the general level of discarding in this fishery is believed to be low.

Discard data have not been consistently available for the whole time series and are only included in the assessment when reported. Besides discarded catches, considerable loss of herring may also occur during catch processing, e.g. flushing of tanks and slippage from the net. Little information is available about the amount of this loss, but is thought to amount to larger quantities (van Overzee & van Helmond, HAWG 2012, WD03).

The sampling of commercial landings is slightly lower in 2012 and covers 80% of the total catch (2011: 84%). The number of herring weighed and measured has increased by roughly 30% compared to 2011 (Table 2.2.12).

More important than a sufficient overall sampling level is an appropriate spread of sampling effort over the different metiers (here defined as each combination of fleet/nation/area and quarter). Of 88 different *reported* metiers, 37 were sampled in 2012. The recommended sampling level of more than 1 sample per 1 000 t catch has been met for 22 metiers. With regards to age readings, 24 metiers appear to be sampled sufficiently (recommended level >25 fish aged per 1 000 t catch).

On the other hand, some of the metiers yielded very little catch. In 37 metiers the catch is below 1 000 t. The total catch in these metiers sums to 7 748 t, so the remaining 51 metiers represent 416 537 t of the official catch (98%). However, only 32 metiers of these 51 were sampled, and only 17 fulfil the recommended level of more than 1 sample per 1 000 t catch and 19 the criteria of 25 age readings per 1 000 t catch.

Compared to 2011, the amount of metiers sampled in the B-Fleet has improved. Larger quantities of catches are taken by France and Sweden, but no biological information is available from these catches. According to the DCF regulations, some catches of UK (England) were landed into and sampled by other nations.

The WG recommends that all metiers with substantial catch should be sampled (including by-catches in the industrial fisheries), and that catches landed abroad should be sampled based on criteria provided above, and information on these samples should be made available to the national laboratories (see Section 1.5).

2.3 Fishery independent information

2.3.1 Acoustic Surveys in the North Sea (HERAS), West of Scotland VIa(N) and the Malin Shelf area (MSHAS) in June–July 2012

Seven surveys were carried out during late June and July covering most of the continental shelf north of 52°N in the North Sea and to the west of Scotland and Ireland to a northern limit of 62°N. The eastern edge of the survey area was bounded by the Norwegian, Danish, Swedish and German coastline and to the west by the shelf slope between 200 and 400 m depth. The individual surveys and the survey methods are given in the report of the Working Group for International Pelagic Surveys (WGIPS; ICES CM 2012/SSGESST:22). The vessels, areas and dates of cruises are given in Table 2.3.1.1 and in Figure 2.3.1.1.

The global survey results provide spatial distributions of herring abundance by number and biomass-at-age by statistical rectangle and distributions of mean weight- and proportion mature-at-age.

The North Sea autumn spawning herring spawning stock was estimated at 2.3 million tonnes and 12 668 million herring (Table 2.3.1.2). In terms of biomass this is 7 % lower compared to the previous year. The abundance of the 2009 year-class (3-winter ringers this year) is consistent with a strong estimate of 1-wr fish in 2010. The current estimate also confirms the relatively strong 2008 year-class already observed in the previous year.

The spatial distribution of mature and immature autumn spawning herring is shown in Figures 2.3.1.2 and 2.3.1.3 respectively. The distribution of adult herring in the North Sea is still concentrated in the areas east of Scotland close to the Fladen Grounds. The bulk of the distribution seems to stretch out towards the north and northwest, around the Shetland Islands. A few larger concentrations are situated in isolated rectangles at the northwestern boundary of the combined survey area.

The time series of abundance of North Sea autumn spawning herring is given in Table 2.3.1.3.

Trends in acoustic survey catchability from the assessment

For the years 2005-2009, abundances of herring at ages 4-9+ observed in the acoustic survey were associated with large residual patterns in the 2009 ICA assessment model. This situation, however has improved considerably since 2010. Addititionally, survey catchability has been biased positively towards older ages and negatively towards younger ages. That pattern has become less emphasised over the past 10 years though (Figure 2.3.1.4). Irrespective of the improvements seen in both situations, an investigation into possible causes may help to identify any potential shortcomings of the survey design. In the case of the North Sea herring acoustic survey, three major effects may have caused a bias in the abundance estimate over time: (1) age-dependent changes in migration patterns or alterations in either (2) schooling behaviour, or (3) fish target strength (Simmonds and MacLennan, 2005).

Based on the spatial distribution of acoustic herring recordings over the time period in question, survey coverage does not seem to be a problem. Densities observed in the acoustic survey decrease towards the edge of the survey area, which is bounded by the 200 m depth contour at the northern and north-western borders of the North Sea (Figure 2.3.1.2). This pattern is generally observed in the survey (see, e.g., ICES 2012/ACOM:06).

Another potential source of survey bias is the change in schooling behaviour. If herring systematically change their behaviour and disaggregate into very low densities, they may not be sampled to the same extent anymore. Such behavioural changes may typically occur in correlation with changes in population sizes and time of the day (Petitgas and Lévénez, 1996; Beare *et al*. 2002; Muiño *et al*., 2003). No analysis in that respect has been done for the time period after 2000, however based on the observed change in stock size there may be merit in doing so.

There is evidence that fish depth (pressure) modulates the TS of Atlantic herring (Edwards *et al*., 1984; Ona, 2003; Fässler *et al*. 2009) and this dependence may bias acoustic survey results if not taken into account (Løland *et al*., 2007). If herring have changed their distribution systematically over the time period 2005-2009 compared to previous years, this may have caused a bias in abundance estimates. A preliminary analysis of herring depth distributions from the acoustic survey, using a mean sea bed depth per ICES rectangle was done during HAWG 2012. The result did not suggest that there is evidence for such an effect. Nonetheless, the use of an average depth per ICES rectangle assumes a homogeneous distribution of fish, low depth variability within ICES rectangles and close association of schools with the sea bed. There is a high probability that not all of these assumptions are justified and a thorough analysis of the effect should be based on true school depth distributions and locations. WGIPS will be looking into this issue and already presented some preliminary results on the use of a depth-dependent target strength relationship in the latest WGIPS report (ICES, 2012).

An investigation into the centre of gravity in abundance of herring at ages 4-9+ over 2003 -2012 was performed using data from FishFrame (Figure 2.3.1.5). Between 2003-2005, there was a distinct shift in centre of gravity from just east of Shetland towards the south. From 2005 onwards, the centre of gravity remained relatively constant and was concentrated between 59°00′ - 59°30′N and 0° - 1° E. Nonetheless, the centres of gravity observed in these years are all found at similar water depths, which further supports the assumption of negligible changes in vertical distribution over time.

2.3.2 International Herring Larvae Surveys in the North Sea (IHLS)

Herring larvae surveys were conducted in September and December 2012 and in January 2013. They cover stations in the Orkney/Shetland area, Buchan and the central North Sea in the second half of September. The southern North Sea was surveyed on three occasions in December 2012 and January 2013 (Figures 2.3.2.1 – 2.3.2.4). The survey effort in vessel days and numbers of samples taken is comparable to recent years.

As anticipated, newly hatched larvae spatial distributions varied between areas and time periods. Compared to the previous year, the total number of newly hatched larvae has increased markedly in the areas surveyed in September 2012. The estimate in the Orkney/Shetland area is the largest ever observed in the 40 years of IHLS sampling, and the Buchan area also yielded top-ranked numbers. As opposite, the estimate for the central North Sea is very small (and some stations remain uncovered) and less than 1% of last year's estimate (Fig. 2.3.2.1). This shows the large inter-annual variability and the importance of annual larvae surveys.

The overall abundance of newly hatched larvae in the southern North Sea in 2012 has also increased to historical high estimates, but is still in the same order of magnitude as in the last six years, where the proportion of Downs offspring in the total larvae abundance has increased strongly.

However, due to variable survey coverage of the spawning areas and time periods, abundance estimates are not directly comparable. While the Downs component is surveyed three times (covering the whole hatching period), all others areas are in general covered only once a year, and most often during the same time period. This pattern is persistent for most of the last 20 years. It is obvious that these gaps must results in larger levels of uncertainty when calculating larvae abundance indices for the North Sea. To support the quality of larvae abundance estimates as input parameters for statistical models, one approach could be to alternate the survey time period in the Orkney/Shetland, the Buchan and the central North Sea as often as possible.

The Multiplicative Larvae Abundance Index (MLAI) is estimated to obtain an SSB index of North Sea autumn spawning herring. For the most recent year, the MLAI increased drastically (Tab. 2.3.2.1) and correspond to an SSB around 6 million tonnes (!).

During the Benchmark procedure for North Sea herring (ICES, WKPELA 2012), it was decided to replace the MLAI model by the Spawning Component Abundance Index (SCAI) model (Payne 2010), which in addition to the total stock dynamics also monitors dynamics on a component level. The most recent SCAI index corresponds to an SSB of 4.0 million tonnes (Figure 2.3.2.5).

2.3.3 International Bottom Trawl Survey (IBTS-Q1)

The International Bottom Trawl Survey (IBTS) started out as a young herring fish survey in 1966 with the objective of obtaining annual recruitment indices of 1- ringers for the combined North Sea herring stock. The IBTS catches provide recruitment indices not only for herring, but for sprat and demersal species as well. In addition to the 1-ringer abundance, the IBTS catches also indicate abundances of 2-5+ ringer herring. At night-time, additional sampling is carried out using a fine-meshed 2 metre ring net (MIK ring net) and from these catches the abundance of large herring larvae (0-ringers) is estimated. Hence, the sampling during IBTS affords an extended series of herring abundance indices (0 to 5+ ringers). During the latest benchmark of North Sea herring it was decided only to use the indices of 0-ringer and 1-ringer abundance in the assessment (ICES, WKPELA 2012).

2.3.3.1 The 0-ringer abundance (IBTS0 survey)

The total abundance of 0-ringers in the survey area is used as a recruitment index for the stock. This year, 652 depth-integrated hauls were completed with the ring-net. This is less than last year's effort and was due to the severe weather conditions that occurred over a large part of the survey, particularly in the northern North Sea. Despite these impediments, the coverage of the survey area was still excellent with at least 2 hauls in almost all ICES rectangles in the North Sea as well as in Kattegat and Skagerrak. Only very few rectangles could only be sampled once. Index values are calculated as described in detail in the Stock Annex. This year, there were 44 hauls from the area south of 54° N with mean larval length <20mm. These hauls had to be excluded from the index calculation as specified in the calculation procedure and are not illustrated in Figure 2.3.3.1. The calculated index is, thus, calculated from the results of 608 hauls, and 2 rectangles, 39E9 and 39F1, in the Southern Bight are not accounted for in the index calculation. These small larvae in the southern area are thought to be larvae of the Downs component of North Sea herring. The exclusion of these small larvae from the index means that this component is not accounted for in the IBTS0 index. A detailed discussion of North Sea herring components and in particular Downs herring can be found in section 2.11 in this report. The time series of IBTS0 estimates is shown in Table 2.3.3.1. The new index value of 0-ringer abundance of the 2012 year class is estimated at 50.4.

The index estimate is again lower than last year's estimate for the 2011 year class. It is only 46% of the long term mean, and shows a further continuation of the series of relatively low productivity starting from the 2002 year class. The 0-ringers caught in 2012 were predominantly found in 2 distinct areas: one in the western part of the central and northern North Sea with its core close to the Scottish and northern English coast. The other area of high larvae abundance was situated in the southeastern North Sea in the continental waters along the Dutch, German and Danish coasts (Figure 2.3.3.1). Low larval densities were found in the Southern Bight, the Kattegat in the Central North Sea while the Skagerrak and the northern and northeastern parts of the North Sea were virtually devoid of herring larvae. This pattern differs from those of the previous years where the highest concentrations were always close to the Scottish coast. This year 2 cores of abundance could be detected and for the first time since 1992 the abundance of larvae in the eastern part was higher than in the western part of the North Sea (Figure 2.3.3.2). In this figure the relative abundance is given as the number of 0-ringers in the area west of 2°E relative to the total number of 0-ringers in the given year class. In contrast to last year, again high concentrations of smaller Downs herring larvae were found in the ring net catches in the area of the English Channel.

2.3.3.2 The 1-ringer herring abundances (IBTS-1)

The 1-ringer recruitment estimate (IBTS-1 index) is based on trawl catches in the entire survey area. The time series for year classes 1977 to 2011 is shown in Table 2.3.3.2. This year's 1-ringer index for the 2011 year class is 22% higher than the index for the 2010 year class from last year's survey. The index from the 2013 survey of 1651 is at 89% of the long term mean. Figure 2.3.3.3 illustrates the spatial distribution of 1-ringers as estimated by trawling in February 2011, 2012 and 2013. Across years, the main areas of 1-ringer distribution are in the German Bight and south of Dogger Bank. For the 2011 year class, the majority of the 1-ringers were distributed in the eastern part of the North Sea and the Kattegat in line with the distribution in previous years. The distribution was slightly more contracted than previous year but with abundances slightly higher over several rectangles resulting in the slightly higher value of the index this year.

2.4 Mean weights-at-age, maturity-at-age and natural mortality

2.4.1 Mean weights-at-age

Table 2.4.1.1 shows the historic mean weights-at-age (winter ringers, wr) in the North Sea stock during the 3rd quarter in Divisions IV and IIIa from the North Sea acoustic survey (HERAS) as well as the mean weights-at-age in the catch from 1996 to 2012 for comparison. The data for 2012 were sourced from Table 2.3.1.2. and Table 2.2.2. In the third quarter most fish are approaching their peak weights just prior to spawning.

In 2012, almost all age groups had similar mean weights-at-age in the catches when compared to 2011. The mean weights in the acoustic survey were slightly lower for almost all ages apart from the 3-winter ringers.

Generally, mean weight of the older fish (4+wr) in the acoustic survey and to a lesser extent in the catches has been declining slightly since 1996. The general tendency of declining weights-at-age for the older ages seems to have continued in 2011 and 2012 (Figure 2.4.1.1). In contrast to this, both the survey and the catches are showing a slight increase in weight of the 2- and 3-ringers over the same period.

Variations in size-at-age in North Sea herring can to a large extent be explained by density dependent mechanisms but also seem to be affected by environmental effects to some degree (reviewed in Dickey-Collas *et al.*, 2010). In particular, it was noted that the very strong 2000 year class, which was competing with an already large herring stock biomass, grew slower than other year classes throughout.

2.4.2 Maturity ogive

The percentages at age of North Sea autumn spawning herring that were considered mature in 2012 were estimated from the North Sea acoustic survey (Table 2.4.2.1). The method and justification for the use of values derived from a single year's data was described fully in ICES (1996/ACFM:10). Maturities were very high for both 2 and 3-ringers in 2012 at 91 and 99% respectively.

2.4.3 Natural mortality

One of the improvements of the recent benchmark of the North Sea herring stock (ICES, WKPELA 2012) is the integration of fundamental links between the North Sea ecosystem and the NSAS stock dynamics.

From 2012 onwards the assessment of NSAS includes variable estimates of natural mortality (M) at age derived directly from a multispecies stock assessment model, the SMS model, used in WGSAM (Lewy and Vinther 2004, ICES 2011). The input data to the assessment are the smoothed values of the raw SMS model annual *M* values, which are variable both at-age and over the time period 1963 – 2010. Natural mortality in years outside this time-period are filled and estimated for each age as a five year running mean in the forward direction for 2011+ and in the reverse direction for years prior. Detailed explanation regarding the natural mortality estimates can be found in Stock Annex 3.

The M estimates are variable along the time period covered by the assessment and are the result of predator-prey overlap and diet composition (Figure 2.4.3.1). The trends in total M of NSAS are a result of the contribution of each of the predators to the predation mortality of the NSAS stock. Inspection of the trends in the stock size of the main herring predators suggests that the increase in natural mortality of all age groups >1 in the early period, approximately 1963-1978, is likely linked to the gadoid outburst in the late 1960s, in particular predation by cod and saithe. From approximately 1979 onwards, natural mortality decreased again while the gadoid population reduced in size as well. From approximately 1991 onwards, close to the period where a regime shift in the North Sea is thought to have occurred, an increase in natural mortality can be observed again. In the more recent years (2008-2010) natural mortality appears to decrease again. The apparent increase in the two most recent years is an artefact of the forward projection of the timeseries by using the 5 year running mean.

2.5 Recruitment

Information on the development in North Sea herring recruitment comes from the International Bottom Trawl Surveys, from which IBTS0 and the IBTS-1 indices are available. Further, the SAM assessment provides estimates of the recruitment of herring in which information from the catch and from all fishery independent indices is incorporated. The recruitment trends from the assessment are dealt with in section 2.6.

2.5.1 Relationship between 0-ringer and 1-ringer recruitment indices

The estimation of 0-ringer abundance (IBTS0 index) predicts the year class strength one year before the strength is estimated from abundance of 1-ringers (IBTS-1 index). The relationship between year class estimates from the two indices is illustrated in Figure 2.5.1 and described by the fitted linear regression. Over the time series there has generally been very good agreement between the indices in their description of temporal trends in recruitment (Figure 2.5.2), but in recent years (the 2009 and the 2006-2007 year classes) the predicted levels of recruitment has deviated between the two indices. This deviation was observed again for the 2011 year class, which as 0-ringers in 2012 showed a continuation of the decline in recruitment whereas as 1-ringers in 2013 showed a modest increase. Among possible explanations for this deviation is the underestimation of the Downs component by the IBTS0 index as discussed in an earlier report (ICES 2009/ACOM 03, sections 2.3.3.1-2).

2.6 Assessment of North Sea herring

2.6.1 Data exploration and preliminary results

During the course of 2011 and 2012, extensive data analyses and benchmark assessment trials were performed during the WKPELA ICES meetings (ICES, WKPELA 2012), prior to the regular working group meeting in 2012. The benchmark decided on revised input data sources and assessment methods which are thoroughly described in the WKPELA report and in Stock Annex 3. The tool for the assessment of North Sea herring is FLSAM, an implementation of the State-space assessment model (www.stockassessment.org), embedded inside the FLR (Kell et. al 2007) library..

Acoustic (HERAS ages 1-8+), bottom trawl (IBTS-Q1 age 1), IBTS0 and SCAI larval (IHLS) indices are available for the assessment of North Sea autumn spawning herring. The surveys and the years for which they are available are given in Table 2.6.1.1. The input data and the performance of the assessment have been carefully scrutinised to check for potential problems. The proportion mature of 2 and 3-wr in 2012 was high (0.99 and 0.91, respectively) and comparable to the situation observed three years ago (see Figure 2.6.1.1). Proportional catch numbers-at-age are given in Figure 2.6.1.2 and time series of natural mortality-at-age is given in Figure 2.6.1.3.

The SCAI continues its increase, stating another ultimate high of the time series. The IBTS0 shows a decline in 0-wr fish over the past 5 years while the pattern of the IBTS-Q1 1-wr index shows erratic trends with large variation over the years 2007-2012 and indicating a slight increase for 2013 compared to 2012.

The IBTS-Q1 survey index has again been revised in 2013 for a subset of years between 2003-2013. In recent years such revisions to the index have been common and are linked to the upload of revised data from national laboratories. ICES is currently reviewing the processes resulting in these revisions (Reference on the WK). It is not expected that the recent revisions in the IBTS-Q1 1-wr index will affect the results of the assessment significantly.

The numbers at age over all ages in the acoustic survey can still be considered relatively high in the recent time period (see Figure 2.6.1.4). The internal consistency of the acoustic survey remains high, as it has been for a long period (see Figure 2.6.1.5).

The SAM model fits the catch well and residuals are random and small for all ages (Figures 2.6.1.6 to 2.6.1.25). However, in 2013 the catch residuals for all ages where positive while the residuals for all ages in the acoustic survey were negative which indicates a conflict in signal between the catch and the survey. A small block of positive residuals can be observed for age 7 catch data over the years 2000-2006, while at age 8 catch data a similar block of negative residuals can be found. These residuals are small however. They are not considered an issue for the performance of the assessment. The SCAI survey fit shows a clear residual pattern, which can partly be explained by the fact that the SCAI indices in individual years are not independent of each other, but instead are the output of an auto-correlated random-walk model. All other surveys fit well inside the model.

A feature of the assessment model is the estimation of an observation variance parameter for each data set (see Figure 2.6.1.26). Overall, all data sources are associated with low observation variances where the catch at ages 1-5 stands out at the most precise data source while the SCAI index and HERAS 1-wr are perceived to be the noisiest data series. The uncertainty associated with the parameter estimated is low for most data sources where only the CV of the catch at age 0 is somewhat higher (Figure 2.6.1.27). However, the CVs do not indicate a lack of convergence of the assessment model.

The retrospective pattern shows a very similar perception in SSB, F and recruitment for the years 2010 - 2012 (Figure 2.6.1.28), although the most recent perception of SSB was slightly lower than the previous two years. Going back further in time, however, shows consistent underestimation of SSB and overestimation of F over the years by the assessment model. Preliminary analyses suggest that a combination of two effects cause the retrospective bias:

- The 1998 and 2000 year classes are considered strong and are targeted by the fishery up to older ages. This has caused a shift in selection to older ages in the years 2005-2008.
- From 2007 to 2008, fishing mortality has declined from approximately 0.2 to 0.13. Therefore, the contrast in the catch-at-age matrix has likely decreased.

The combination of these effects might have resulted in a persistent perception of higher selection on older ages, even in the years 2007-2009 where, in retrospect, this has been revised downwards. However, the higher selection not only affects the numbers-at-age in the older ages, but also propagates through to the younger ages which results in a different SSB and F perception.

Figure 2.6.1.29 shows the model uncertainty plot, representing the parametric uncertainty of the fit of the assessment model in terminal F and SSB. Further data screening of the input data on mature – immature biomass ratios, survey CPUEs, proportion of catch numbers- and weights-at-age and proportion of IBTS and acoustic survey ages have been executed, as well as correlation coefficient analyses for the acoustic and IBTS survey and assessment parameters (see Figure 2.6.1.30). It was observed that the estimates of weight-at-age in the catch have gone up in the 2012 assessment while weights-at-age in the stock, which are based on a three year running average, have decreased. No further issues were raised by this exercise.

2.6.2 Exploratory Assessment for NS herring

No exploratory assessment was carried out for North Sea herring this year.

2.6.3 Final Assessment for NS herring

In accordance with the settings described in the Stock Annex, the final assessment of North Sea herring was carried out by fitting the state space model (SAM, in the FLR environment). The input data and model settings are shown in Tables 2.6.3.1 – 2.6.3.11, the SAM output is presented in Tables 2.6.3.13 – 2.6.3.26, the stock summary in Table 2.6.3.12 and Figure 2.6.3.1 and model fit and parameter estimates in Table 2.6.3.25. Figure 2.6.3.2 shows the agreed management plan including the biomass trigger points and contains the $F_{2\text{-}6}$ estimates of the past 10 years.

The spawning stock at spawning time in 2012 is estimated at approximately 2.35 million tonnes [1.96, 2.81 million tonnes (95% CI)], which is similar to the 2012 estimate of 2.34 million tonnes forecasted in 2011. The estimate of 0-wr fish in 2013 (2012 year class) is estimated to be at approximately 22.5 million [12.0, 42.3 million (95% CI)], just below the long term geometric mean (see Table 2.6.3.14). Mean $F_{2\text{-}6}$ in 2012 is estimated at approximately 0.17 [0.13, 0.22 yr^{-1} (95% CI)], which is below the management agreement target F, while mean $F_{0\text{-}1}$ is 0.03, also below the agreed ceiling. The updated assessment estimated an $F_{2\text{-}6}$ of 0.11 in 2011.

2.6.4 State of the Stock

Spawning biomass in relation to precautionary limits	Fishing mortality in relation to precautionary limits	Fishing mortality in relation to FMSY target	Fishing mortality in relation to agreed target	Comment
At full reproductive capacity	Harvested sustainably	Below target	Below target	

Based on the most recent estimates of SSB and fishing mortality, ICES classifies the stock as being at full reproductive capacity and is being harvested sustainably but below F_{MSY} and management plan target. The SSB in autumn 2012 was estimated at 2.35 million t [1.96, 2.81 million tonnes (95% CI)], well above B_{pa}. $F_{2\text{-}6}$ in 2012 was estimated at 0.17, below the target $F_{2\text{-}6}$ of 0.25. Both the 2011 and 2012 year class are estimated below the long term geometric mean recruitment.

2.7 Short term predictions

Short term predictions for the years 2013, 2014 and 2015 were done with code developed in R software. In the short term predictions, recruitment is assumed constant for the years 2014 and 2015 following the same recruitment regime since 2002 (geometric mean of 2001 to 2011 year classes). The assessment model provides a recruitment estimate for 2013, based on the information available from the IBTS0 survey in 2013.

For the intermediate year, no overshoot for the A fleet was assumed, as there was minimal deviation from the TAC in 2012. Negotiations between the EU and Norway resulted in the allowance of 50% of the TAC in the Kattegat-Skagerrak area to be taken in the North Sea. The pelagic RAC was requested to estimate the percentage of the IIIa herring TAC to be taken in the North Sea under this regulation. The pelagic RAC estimated it at 40%.Therefore, the expected catches of North Sea herring by the A fleet in 2013 is increased by 40% of 55 000 tonnes. The expected catches of Western Baltic Spring Spawning herring caught under the North Sea TAC are deduced from the expected A fleet catches (amounting to 2095t). For the B-fleet the agreed by-catch ceiling in 2013 has been used but scaled down by the proportion taken as observed in 2012 (59%). For the C and D fleets, the fraction of North Sea Autumn Spawning herring caught in IIIa vs. the fraction of western Baltic Spring Spawning herring in the same area is used to derive C and D fleet catches, based on projected TACs in IIIa for these fleets. See Table 2.7.1 – 2.7.11 for other inputs.

The six scenarios presented (Table 2.7.12) are based on an interpretation of the harvest control rule or other options and are only illustrative:

i) No fishing;
ii) The EU-Norway management plan;
iii) A roll over TAC from 2013 to 2014 of 478 kt for the A fleet;
iv) A 15% increase in the A fleet TAC between 2013 and 2014;
v) A 15% decrease in the A fleet TAC between 2013 and 2014;
vi) A fleet TAC following from fishing at Fmsy.

Since the current management plan only stipulates overall fishing mortalities for juveniles and adults, making fleet-wise predictions for four fleets that are more or less independent provides different options for 2014. The consequence of other combinations of catch options can be explored on request.

For options A to F, the C and D fleets are assumed to have a North Sea autumn spawner catch for 2013 of 11.7 and 2.5 thousand tonnes respectively. In 2014 and 2015 they are assumed to have a North Sea autumn spawner catch of 11.2 and 2.4 thousand tonnes respectively. **All predictions are for North Sea autumn spawning herring only.** The results are presented in Table 2.7.12.

2.7.1 Comments on the short-term projections

From 2012 to 2013, SSB is expected to decline, mainly driven by the higher TAC in 2012 and 2013 which results in an increase in fishing mortality. Under all scenarios SSB is predicted to decline in 2014 and 2015, except under the no-fishing scenario (i). The SSB is expected to further decline under the management plan in 2014 to 1.8 million tonnes and further in 2015 to approximately 1.5 million tonnes. SSB is expected to be above $B_{trigger}$, and therefore also B_{pa}, in 2013, 2014 and 2015. Under the Fmsy option F, SSB is expected to decline to 1.8 million tonnes in 2014 and to 1.5 million tonnes in 2015.

The predicted catch according to the management plan for 2014 implies a decrease in TAC of 2%which is associated with an SSB decline from 2013 to 2014 of 11%.

2.7.2 Exploratory short-term projections

Exploratory short term predictions were run to investigate the utility of stochastic forecasts. The approach and software used were similar to the deterministic setup, but included the ability to vary starting conditions of stock numbers-at-age by sampling from the variance-co-variance matrix a hundred times, and sampling from historic observations on key population parameters like maturity-at-age and stock weight-at-age to populate the hundred replicates. The results of the median of these hundred replicates turned out to be very similar to the deterministic run (with differences explained by the slight difference in assumed maturity-at-age in the deterministic run and the stochastic run). The resulting tables with 5^{th} -95^{th} percentile is given in Table 2.7.2.1.

2.8 Medium term predictions and HCR simulations

WKHELP evaluated the current Long term Management Plan for North Sea autumn spawning herring given the recent benchmark assessment (ICES 2012/ACOM:47) following the joint request from EC and Norway. In total, 99 different scenarios were evaluated with varying TAC stabilizing mechanisms, target fishing mortalities and biomass trigger points (see also Chapter 1).

At the end of 2012, no decision on a preferred management plan design was made during the negotiations between the EU and Norway, and therefore it is likely that ICES will be approached to perform an analyses of an additional set of management plan designs in 2013.

2.9 Precautionary and Limit Reference Points and FMSY targets

The precautionary reference points for this stock were adopted in 1998. The analysis carried out by the 2012 benchmark meeting (ICES, WKPELA 2012) implies that the reference points have shifted under the perception of the stock assessment. Due to this change in perception the EU and Norway formulated a request to ICES to re-evaluate the precautionary and limit reference points as well as to evaluate precautiornary management plan designs (WKHELP, ICES CM 2012/ACOM:72). The sections below describe the applied reference points and FMSY targets for NSAS in the assessment performed in HAWG 2013.

The Blim

The 1998 Study Group on Precautionary Approach to Fisheries Management determined reference points for North Sea herring that were adopted by ICES (ICES CM 1998/ACFM:10). The B_{lim} (800 000 tonnes) was set at a level below which the recruitment may become impaired and was also the formally used MBAL. In 2007, WKREF (ICES CM 2007/ACFM:05) explored limit reference points for North Sea herring and concluded that there is no basis for changing B_{lim}. In 2011, WKHERMP agreed that there was still no basis for changing B_{lim}. A low risk of SSB falling below B_{lim} was therefore the basis of ICES precautionary advice. The evaluation of the lower breakpoint in the benchmark meeting (ICES, WKPELA 2012) showed that the currently used 800 000 tonnes does not seem to have changed under the new perception of the stock. At the WKHELP (ICES CM 2012/ACOM:72) meeting, B_{lim} was re-evaluated following the approach from the benchmark meeting (ICES, WKPELA 2012). A segmented regression stock-recruitment relationship fit to the 1985-2011 pairs as estimated from the 2012 stock assessment gave an estimated breakpoint at about 0.8 million tonnes. When only pairs from 2003 were considered (start of low recruitment survival period), the lowest recruitment observed corresponded to an SSB of 0.8 million tonnes. On this basis B_{lim} was suggested to be at 0.8 million tonnes.

Fpa and Bpa

Under the current management plan Fpa = 0.25 is the F target value in the harvest control rule. The current Bpa = 1.3 million tonnes was the trigger point in the LTMP established in 1998. These targets, used in the management plan (which began in 1997), were recommended by the Study Group on Precautionary Approach to Fisheries Management and adopted by ICES as the precautionary reference points (ICES CM 1998/ACFM:10). This means that the precautionary reference points were taken from the previous management plan. In the management plan, the target fishing mortalities were intended as targets and not as limits. They were based on an investigation of risk to falling below 800 000 t SSB, F_{MSY} and consideration of fisheries on both juvenile and adult herring (ICES CM 1997/ACFM:08).

Since WKHELP (ICES CM 2012/ACOM:72) Fpa is no longer considered a relevant reference point and Bpa has been re-evaluated based on the suggested Blim of 0.8 million tonnes and the uncertainty in the SAM assessment from 2001 to 2011. The assessment indicates that on average, the uncertainty associated with the terminal SSB estimate is in the order of a 10% CV. The assumed risk to fall below Blim while the stock assessment indicates SSB to be at Bpa was set at 5%. The following equation has therefore been used to calculate the value of Bpa: log(Blim) = log(Bpa) – upper confidence limit * CV. This results in an estimate of Bpa, rounded upwards to the nearest 100 000t of 1 000 000t.

Note that in this exercise, retrospective bias in the assessment has not been taken into account. The mechanisms behind, and the dynamics of change in, bias are not sufficiently understood. Although the time series does not indicate any drastic changes in bias pattern from one year to the next, attention should be paid to indications of shifting selection pattern that could be a sign of overestimating SSB.

B trigger

No updated Btrigger value has been agreed based on the findings from WKHELP (ICES CM 2012/ACOM:72).

The B trigger of the management plan ($B_{MGTtrigger}$) was changed in November 2008 from 1.3.million to 1.5 million tonnes after evaluation and consultation with the stakeholders. Thus currently the $B_{MGTtrigger}$ and B_{pa} are different at 1.5 million tonnes and 1.3 million tonnes respectively. **$B_{MGTtrigger}$ is a harvest rule parameter and is not a reference point by which to judge stock status.**

MSY framework for North Sea herring

In 2010 ACOM agreed with HAWG that Fmsy for NSAS was 0.25. This was supported by WKFRAME2. The analyses carried out by the 2012 benchmark suggested that MSY reference points may vary over time. Further, WKPELA 2012 suggested that a minor increase in Fmsy might be appropriate given the increase in SSB resulting from the FLSAM benchmark assessment. An Fmsy around 0.3 was considered.

At WKHELP, the proposed Fmsy analyses, taking uncertainty associated with the assessment results and biological characteristics into account, has been executed. The 'plotMSY' software (ICES, WKFRAME 2010) has been used to perform the stochastic yield per recruit and MSY reference point analyses. Both the Ricker as well as the Beverton & Holt stock-recruitment relationship have been used in the analyses. The difference between the point estimates for Fmsy based on Beverton and Holt and on Ricker functions is small. In addition, the understanding about the nature of the stock and recruitment relationship is still insufficient to support either model's underlying assumptions. Therefore a range of values were proposed for Fmsy. Those correspond to the median of the estimates resulting from the Ricker and the Beverton and Holt fits which are 0.24 and 0.30

In addition, WKMSYREF 2013 met early 2013 and recommended to use the 'plotMSY' software to derive Fmsy values. Each Stock Assessment expert group was requested to derive Fmsy values using this software, specifying, if appropriate, the uncertainty associated with the Fmsy values and express this as a range of potential Fmsy values in their reports. For North Sea herring, this exercise had taken place at WKHELP already. The range that is associated with Fmsy lies between 0.24 and 0.3. As the likelihood of the fits of both the Beverton and Holt and Ricker simulations is nearly idenitical, it was decided to run with a Fmsy point estimate of 0.27 from 2013 onwards.

2.10 Quality of the assessment

The data used within the assessment, the assessment methods and settings were carefully scrutinized during the 2012 benchmark (ICES, WKPELA 2012). A complete overview of the choices made during the benchmark can be found in the ICES WKPELA 2012 report (ICES, WKPELA 2012) and these are described in the North Sea Herring Stock Annex (Annex 3). The 2013 assessment was classified as an update assessment and was carried out following these procedures and settings.

The data used within the assessment, the assessment methods and settings were carefully scrutinized during the 2012 benchmark (ICES, WKPELA 2012) and the assessment has been regarded as relatively consistent. The diagnostics indicate a similar classification for this year. The perception of the SSB over the past three years changed in comparison to last year's assessment. These changes in perception have altered the time series resulting in a slightly lower SSB estimate. Extra attention was given to the estimated selection pattern in 2012 which indicates higher selection at older ages. The information on abundance at age in the catch contrasts with the information in the survey and the stock assessment fits in between. Following the Baranov catch equation, it results that the large catches at older ages are associated with a lower estimate of numbers-at-age in the population (due to pulling down the abundance at age by the acoustic survey) and therefore resulting in the higher selection in older ages.

The information from the IBTS-Q1 survey continues to be noisy but does contribute to the assessment as scrutinized during the WKPELA 2012 meeting.

The IBTS0 index has in recent years begun to exhibit systematic biases. The residuals between the IBTS0 index and the recruitment estimated from the model show a significant time-trend (Figure 2.10.1; upper panel), suggesting that the assessment model is now overestimating the recruitment relative to the signal from the survey index. This trend is most probably related to changes in the composition of the stock, and particularly the increase in the Downs component post-2005 (Figure 2.10.1: lower panel). The calculation of the IBTS0 index actively excludes small larvae in the Downs spawning region, and therefore the index is only representative of the recruitment to the northern components (Buchan, Banks, Orkney-Shetland). This simplification will not introduce biases in situations where the composition of the stock is constant in time (and/or the recruitment to the Downs component follows similar patterns to the others). However, that is clearly not the case in recent years, and may therefore have introduced the observed bias. Further work is therefore required to improve the calculation of the IBTS0 index, to understand its relevance, and to modify the stock-assessment model to take full advantage of the information that it contains.

The data from the 2013 stock summary table is compared with the stock summary from the 2012 assessment and the predicted 2012 values from the 2012 assessment. The source of difference is explained in the previous section.

The projected F2-6 for 2012 for the intermediate year, from HAWG 2012 was 0.18 (see text table below). The estimated F2-6 from this Working Group for 2012 is just below that at 0.17. The difference in expected catches in 2012, also due to the re-allocation of IIIa herring quota to area IV and the catch of North Sea herring in IIIa is very small. The projected biomass of 2012 SSB in 2013 is very similar to the 2012 estimate. A slightly higher maturity of 2 and 3wr fish are the main cause of an elevated estimate of SSB in the 2013 assessment compared to 2012.

	2012 Assessment				**2013 Assessment**				**Percentage change in estimate 2012/2011**			
Year	Rec	SSB	Catch	$F_{2\text{-}6}$	Rec	SSB	Catch	$F_{2\text{-}6}$	Rec	SSB	Catch	$F_{2\text{-}6}$
2010	37095	2004	188	0.078	36873	1858	188	0.084	-0.6%	-7.9%	-	7.1%
2011	31139	2343	226	0.093	33132	2227	226	0.109	6.0%	-5.2%	-	14.7%
2012*	27757	2271	442	0.180	30432	2348	435	0.168	8.8%	3.3%	-1.6%	-7.1%

***projected values from the intermediate year in the short term projection. (Recruits are defined as age 0)**

2.11 North Sea herring spawning components

The North Sea autumn-spawning herring stock is generally understood as representing a complex of multiple spawning components (Cushing, 1955; Harden Jones, 1968; Iles and Sinclair, 1982; Heath *et al*., 1997). Most authors distinguish four major components, each defined by distinct spawning times and sites (Iles and Sinclair, 1982; Corten, 1986; Heath *et al*., 1997). Three of the components spawn in the North Sea in August/September (the Orkney–Shetland, the Buchan and the Banks components). In the English Channel, the Downs component spawns during December and January. Although the different components mix outside the spawning season and are exploited together, each component is thought to have a high degree of population integrity (Iles and Sinclair, 1982) and, therefore, could be expected to have relatively unique population dynamics.

Monitoring and maintaining the diversity of local populations is widely viewed as critical to the successful management of marine fish stocks. Changes in the relative composition of the combined stock can give rise to differences in exploitation rates between the components (Bierman *et al*., 2010) and the associated risk of local depletions (Kell *et al*., 2009). Maintaining such spatial diversity within a stock should provide increased resilience to both anthropogenic and natural stressors (Harden Jones, 1968; McPherson *et al*., 2001; Secor *et al*., 2009).

Here we collate the available information, from a variety of differenct sources, about the individual components.

2.11.1 International Herring Larval Survey

The spawning component abundance index (SCAI: Payne 2010) was developed to characterize the relative dynamics of the individual North Sea spawning components. The SCAI is a statistical model designed to analyze the larval abundance indices (LAIs) generated by the IHLS (see section 2.3.2). Interpretation of these time series is made difficult missing observations (especially since the 1990s), high sampling noise and differences in the spawning intensity between surveys. The SCAI model, however, is robust to these problems, gives a good fit to the data and proves capable of both handling and predicting missing observations well (Payne 2010).

SCAI provides an index of the abundance of early larvae (less than 10-11mm) on the spawning grounds. The abundance of herring early-larvae have been shown to be an appropriate and reliable proxy for the corresponding biomass of spawning adults (Postuma and Zijlstra, 1974; Heath, 1993). The SCAI is also shown to be significantly correlated with the SSB estimated in the stock assessment here (Figure 2.3.2.5). The use of the SCAI as an index of the component spawning biomasses therefore appears justified.

The SCAI model analysis shows that the Downs component appears to have a different set of dynamics from the other three components (Figure 2.11.1). Recovery from the 1970s stock collapse was much slower in this component, and the late 1980s peak displayed by the other three components is relatively weak. In recent times, however, the Downs component has increased consistently to a point where it is the largest component in the stock.

The SCAI indices can also be used to examine the relative composition of the stock (Figure 2.11.2). The composition of the stock has changed appreciably over time. The largest fraction of the total SSB in the past 35 years has generally been represented by the Orkney–Shetland component (on average 50%), but the ratio has ranged between 25 and 80%. The relative contribution of the Downs component to the total stock has increased systematically since the start of the IHLS survey in the early 1970s. During the post-2001 reduced-productivity period, the Downs fraction has increased its proportion further, suggesting that it has been impacted less than the other components.

Since the mid-2000s, the relative contributions of the components has been generally stable. The most recent year suggest some changes in the Buchan component: however, the precision of the terminal year estimate in the SCAI index is reduced and therefore little weight should be placed on this change, pending more years of observations.

2.11.2 IBTS0 Larval Index

The ring net hauls for 0-ringers during the IBTS in the eastern English Channel also include Downs herring larvae and additional sampling in this region has been performed since 2007 (Section 2.3.3.1). In contrast to the 2012 survey, concentrations of smaller larvae which are thought to be of the Downs component were found in the 2013 survey. Nevertheless, these small larvae (separated as <20 mm) have until now been excluded from the standard estimation of 0-ringer recruitment (IBTS0 index). Furthermore, recent studies showed that the daily mortality rates of newly hatched larvae of North Sea herring have increased over the time series and there are uncertainties on the mortality level for these small larvae (Fässler *et al.*, 2011).

2.11.3 IBTS 1 ringer

The proportion of the autumn and winter spawning components in recruiting year classes of North Sea herring can also be inferred through the abundance of different sized fish in the IBTS. The 1-ring fish from Downs spawning sites (winter) are believed to be smaller than those from the more northern autumn-spawning sites, because this component hatches later than the autumn spawned herring and generally appear as a smaller sized group during the 1st quarter IBTS. A recruitment index of small 1-ring fish is calculated based on abundance estimates of herring <13 cm (ICES CM 2000/ ACFM:12 and ICES CM 2001/ ACFM:12). Table 2.3.3.2 includes abundance estimates of 1-ringer herring <13 cm, calculated as the standard index but is in this case for herring <13 cm only. Indices for these small 1-ringers are given both for the total area (North Sea and IIIa) or the area excluding Division IIIa, and their relative proportions are also shown. In the time-series, the proportion of 1-ringers <13 cm (of total catches) is in the order of 22%, and the contribution from Division IIIa to the overall abundance of <13 cm herring varies markedly during the period (Table 2.3.3.2). Both the total abundance and the relative proportion of this smaller size component has, on average, been relatively high for the year classes 1995 to 2002 although there is considerable variation between year classes (Table 2.3.3.2 and Figure 2.11.3) and fluctuates between 7 and 70 % (Figure 2.11.4). The 2012 year class seems to be at a high level with 45% and abundance estimate shows a level comparable to the 2010 year class

2.11.4 IBTS acoustic information

Since 2007, the IBTS 1st quarter survey area has been extended to the eastern English Channel, and both additional GOV hauls and ring-net sampling are carried out in this area to provide more information on Downs herring (ICES CM 2007/ACFM:11). Acoustic data are also recorded and show large herring schools along the French coast. The mean density of these shoals of herring, which were found during the survey in a localized area, can however not be raised to represent the whole area. This is due the nature of the IBTS survey design, which does not adopt systematic area coverage with transects. Furthermore, large schools close to the coast in shallow and inaccessible waters were regularly detected with a horizontal echo sounder between the period 2007-2012. Compared to the previous years less concentrations were found during IBTS 2013. Figure 2.11.5 shows the catch composition (percentage by age) of the pelagic hauls carried out on these schools since 2008. In 2013, the 3wr fish represented 62% of the total catch

2.11.5 Fisheries and TAC in the IVc/VIId

Historically, the TAC for herring in IVc and VIId has been set as a proportion of the total North Sea TAC and this has varied between 6 and 16% since 1986. The proportion has been relatively high, particularly between 2002 and 2005. However, ICES expressed concerns regarding Downs herring in 2005 and recommended that the proportion used to determine the TAC should be set to the long term average of the proportions used since 1986 (around 11%). Since 2005, this proportion fluctuated between 9 to 14%. In 2012 and 2013 this proportion was set respectively at 45 985 tonnes and 50 266 tonnes which represents 11 % and 10.5 % of the total human consumption TAC of Divisions IVa and IVb (Figure 2.11.6).

Except in 2010, the tendency to overfish the Downs TAC has markedly reduced since 2005 (Figure 2.11.7). For 2012, the catches of 40 402 tonnes were set under the TAC.

The Downs herring has been considered highly sensitive to overexploitation (Burd, 1985; Cushing, 1968; 1992). Furthermore, the directed fishery in Q4 and Q1 targets aggregations of spawning herring. Preliminary studies undertaken by HAWG (ICES CM 2006/ACFM:20) based on population profiles suggested that total mortality (Z) was significantly higher for the 1998 and 1999 year classes of Downs herring compared to herring caught in the northern part of the North Sea.

Downs herring is also taken in other herring fisheries in the North Sea and mixes with other components of North Sea herring in the summer whilst feeding. There is also a summer industrial fishery in the eastern North Sea exploiting juvenile Downs and North Sea autumn spawning herring. Otolith microstructure studies of catches from the northern North Sea suggested that the proportion of Downs herring may vary considerably from year to year (26 to 60 %) and may also vary between fleets (Bierman *et al*., 2010).

2.11.6 Conclusions

The Downs TAC is set up to conserve the spawning aggregation of Downs herring. Uncertainties concerning the status of, and recruitment to, this component of the North Sea herring stock are high, and HAWG is not aware of any evidence to suggest that this measure is inappropriate. HAWG therefore recommends that the IVc-VIId TAC be maintained at 11% of the total North Sea TAC (as recommended by ICES). This recommendation should be seen as an interim measure prior to the development of a more robust harvest control rule for setting the TAC for Downs herring. A future harvest control rule will have to be supported by increased research effort into dynamics of the components, with a view to increasing the amount of component-resolved information (*e.g* catch data and survey data split by component, and incorporation of this information into the assessment model). Any new management approach should provide an appropriate balance of F across stock components and be similarly conservative until the uncertainty about contribution of the Downs and other components to the catch in all fisheries in the North Sea is reduced. Possible methods to approach this problem are discussed by Kell *et al*. (2009).

2.12 Management Considerations

Based on the most recent estimates of SSB and fishing mortality, ICES classifies the stock as being at full reproductive capacity and is being harvested sustainably, below target fishing mortality for the management plan.

The stock is managed according to the EU-Norway Management agreement which was updated in November 2008 (see Stock Annex 3). In 2008, WKHMP examined the performance of this management plan and the plan is consistent with the precautionary approach. In 2011, WKHERMP re-examined the management plan. WKHERMP concluded that the management plan appears to operate well in relation to the objectives of consistency with the precautionary approach and a rational exploitation pattern, but not in relation to achieving simultaneous stable and high yield. The main weakness appears to be the 15% Inter Annual Variation limit on TAC change which leads to restricted TACs when the stock is improving and the trade-off between stability and high yield will limit the maximising of yield in some circumstances. WKHERMP recommended that further work on the management plan be carried out in 2011, prior to the December decisions by the EU and Norway, to develop mechanisms that avoid the unwanted side-effects of the present plan.

The analysis carried out by the benchmark in 2012 implies that the reference points for NSAS may have shifted under the perception of the stock assessment and thus a full revision of the existing management plan for NSAS was highly warranted.

In 2012, ICES was requested to re-evaluate reference points and evaluate different management plan designs. During a series of sessions by the Workshop for Revision of the North Sea Herring Long Term Management Plan (WKHELP), ICES evaluated the Blim, Bpa and Fmsy reference points and suggested Btrigger values per individual management plan design. The advice following from WKHELP was put forward by ICES and considered in the EU-Norway negotiations in November / December 2012. No decision on a preferred management plan design was made during these negotiations and the EU-Norway managers to request ICES to evaluate an additional set of management plan designs, to be executed in 2013.

The fishing mortality is reliably estimated by the stock assessment. Fishing mortality is now below the target set by the management plan and based on the most recent estimates of SSB and fishing mortality, the NSAS stock can be classified as being at full reproductive capacity and harvested sustainably, though below Fmsy and the management target.

HAWG still considers the stock to be in a low productivity phase as the survival ratio between newly hatched larvae and recruits is still much lower than prior to 2001 (see section 2.14 and Figure 2.14.3). The management plan has proved to be an effective tool for maintaining sustainable exploitation and conserving the North Sea herring stock in this lower productivity regime.

North Sea herring and western Baltic spring spawning herring are managed under mixed quotas in some areas of the North Sea, Skagerrak and Kattegat. With the decline of the WBSS herring, conservation of this stock needs to be considered when setting TACs. With the mixing of stocks within a fishery, primacy of consideration should be given to protection of the stock most vulnerable to exploitation in the area of overlap. Hence ICES recommended that the TAC setting for IIIa consider the requirements for MSY of western Baltic spring spawners before those of North Sea autumn spawning herring (ACOM and WKWATSUP).

Catches in the transfer area in IVa (east) are generally assumed to be dominated by western Baltic spring spawners. The current method of estimation (vertebral counts) is not considered completely robust.

The options selected for the C- and D-fleets are compatible with the advised exploitation of western Baltic spring spawners.

The North Sea autumn spawning herring stock also includes the Downs herring component (herring in Divisions IVc and VIId). The management of this component is discussed in detail in Section 2.11.

Herring spawning and nursery areas are sensitive and vulnerable to anthropogenic influences. Activities that have an impact on the spawning habitat of herring, such as extraction of marine aggregates (such as gravel and sand) and construction, may impact spawning. Herring abandon and repopulate spawning grounds and an absence of spawning in any particular year does not mean that the spawning ground is not required to maintain a resilient herring population. There is scientific information (Groot, S.J. 1979, 1996) to support the advice that no gravel extraction should occur in areas with spawning grounds.

2.13 Ecosystem considerations

Herring is considered as a major prey item for fish, seabirds and sea mammals in the North Sea area (Dickey-Collas *et al.*, 2010). Trophic interactions were incorporated into the stock assessment of North Sea herring for the first time during the 2012 benchmark assessment, through the adoption of time-varying estimates of natural mortality. These estimates are derived from the Stochastic Multispecies model (SMS) and represent state-of-the-art knowledge about the effect of predation by higher-trophic levels upon herring. The outputs of this model suggest that the natural mortality of herring is dominated by cod and saithe, and that this source of mortality is both variable in time (see e.g. Figure 2.4.3.1) and, in recent years, greater than the fishing mortality. Changes in the dynamics of these two species in particular, due to either anthropogenic or natural processes, can therefore be expected to have a direct impact on the population dynamics of NSAS herring.

Furthermore, herring is also considered to have a major impact on many other fish stocks as an ichthyoplanktivorous predator. Recent work using process-oriented length-based ecosystem modelling (Speirs *et al*., 2010) and correlative approaches (Fauchald, 2010) suggests a link between a large herring biomass and the repression of the North Sea cod recovery. This suggests that through herring predation on cod eggs and larvae, strong cod recruitment is unlikely with the current state of the North Sea ecosystem.

The herring human consumption fisheries are considered to be relatively clean, with little by-catch of other fish, mega-fauna and almost no disturbance of the sea bed: direct ecosystem effects therefore appear to be limited. Juvenile herring are caught as a bycatch of industrial fisheries and these vessels catch a range of fish species. Most of these bycatches are monitored and included in the catch statistics.

Herring spawning and nursery areas, being near the coasts, are particularly vulnerable to anthropogenic influences. The most serious of these are the extraction of marine sand and gravel and the development of coastal wind farms. Herring abandon and then repopulate spawning grounds and a lack of spawning in recent years does not mean that the spawning ground is not required to maintain a resilient herring population.

2.14 Changes in the environment

This stock has, since 2002, produced a decade of below average year classes, a situation which has never been observed before (Payne *et al*., 2009): the most recent year class also appears to represent a continuation of this trend. This low recruitment has occurred in spite of a spawning stock biomass that is well above the B_{lim} of 800 000 tonnes (where impaired recruitment is expected to set in) (Figure 2.14.1).

Stock productivity, as represented by the number of recruits-per-spawner from the assessment, has been low for the last decade (Figure 2.14.2). Although there have been changes during this low-productivity regime, at no point has this metric approached the levels seen during the 1990s. The most recent recruits-per-spawner is amongst the lowest observed during both the recent period and also during the entire time series.

Year-class strength in this stock is determined during the larvae phase (Dickey-Collas and Nash 2005; Payne *et.* al 2009). Updating these analyses with the most recent data sets suggests that the trend of reduced larval survival between the early (as indicated by the SCAI index) and the late- (as indicated by the IBTS0 index) larval stages has continued in the most recent years (Figure 2.14.3). The most recent observation (for the 2012 cohort) represents the lowest larval survival rate to date.

The IBTS0 index is regarded by the working group as not being representative of recruitment to the Downs spawning component, as observations of small larvae in this region are removed from the index calculation. A more appropriate metric is therefore to base the metric of larval survival on the abundance of larvae from the three northern components (ie excluding the Downs). However, this refined metric shows a very similar trend (Figure 2.14.4): larval survival during the most recent decade is an order of magnitude less than during the 1990s, with the most recent observation exhibting the lowest survival on record.

All indicators therefore suggest that the stock remains in the low-productivity regime observed in previous years.

The general reduction in larval survival is generally thought to be associated with changes in the physical and biological environment (ICES SGRECVAP 2008; Payne *et al* 2009). The change in survival rate co-varies with an increase in the mortality rate of the very young larvae (Fassler *et al*., 2011). The specific reasons for this are not known but there appears to be correlations between the mortality trends and the residuals of the stock-recruit relationship, the stock biomass and temperature. WKHELP reviewed the current knowledge of density-dependence processes in the biology of NSAS and concluded the evidence is not strong enough to neither confirm nor rule out density-dependent mechanisms at the early larval stages (WKHELP, ICES CM 2012/ACOM:72).

Furthermore, recent work has show that the reduced survival is also correlated with a reduction in larval growth rate (Payne *et al* 2013). Individual larval growth rates were estimated for 200 larvae captured before and after the onset of reduced productivity period using a model-based analysis of the otolith ring-widths. Hydrographic-backtracking models complemented the otolith analysis by reconstructing the environmental history and spawning origin of each larva. A mixed-modelling approach was then employed to analyse the combined data set. After correcting for the effect of other explanatory variables, a significant reduction in larval growth rate around the time of capture of 8%, concurrent with the reduced larval survival and recruitment, was identified. The authors attributed this result to changes in either the amount or quality of available food. More work, however, is required to understand the mechanisms underpinning these observations in greater detail.

The environment also influences the growth of individual North Sea herring. Temperature significantly explains the variation in growth between cohorts of North Sea herring since the mid-1980s (Brunel and Dickey-Collas, 2010). Cohorts experiencing warmer conditions throughout their lifetime attain higher growth rates, but have shorter life expectancy and smaller asymptotic size, and *vice- versa* for herring experiencing colder conditions. However, recent work in the 2012 benchmark has also suggested that predictions of growth and mortality are currently not feasible (ICES WKPELA 2012).

Table 2.1.1: Herring caught in the North Sea. Catch in tonnes by country, 2003 – 2012. These figures do not in all cases correspond to the official statistics and cannot be used for legal purposes.

Country	2003	2004	2005	2006	2007
Belgium	5	8	6	3	1
Denmark [6]	78606	99037	128380	102322	84697
Faroe Islands	627	402	738	1785	2891
France	31544	34521	38829	49475	24909
Germany	43953	41858	46555	40414	14893
Netherlands	81108	96162	81531	76315	66393
Norway [1]	112481	137638	156802	135361	100050
Poland	-	-	458	-	-
Sweden	4781	5692	13464	10529	15448
USSR/Russia	-	-	99	-	-
UK (England)	18639	20855	25311	22198	15993
UK (Scotland)	40292	45331	73227	48428	35115
UK (N.Ireland)	2010	2656	2912	3531	638
Unallocated landings	31875 [5]	48898 [5]	57788	18764	26641
Total landings	445921	533058	626101	509125	387669
Discards	4125	17059	12824	1492	93
Total catch	**450046**	**550117**	**638925**	**510617**	**387762**
Estimates of the parts of the catches which have been allocated to spring spawning stocks					
WBSS	2821	7079	7039	10954	1070
Thames estuary [2]	84	62	74	65	2
Others [3]	308	0	0	0	0
Norw. Spring Spawners [4]	979	452	417	626	685

Country	2008	2009	2010	2011	2012
Belgium	-	-	-	4	3
Denmark [6]	62864	46238	45869	58726	105707
Faroe Islands	2014	1803	3014	-	-
France	30347	18114	17745	16693	23819
Germany	8095	5368	7670	9427	24515
Netherlands	23122	24552	23872	34708	72344
Norway [1]	59321	50445	46816	60705	119253
Lithuania	-	-	90	-	-
Sweden	13840	5299	4395	8086	14092
Russia	-	-	-	-	-
UK (England)	11717	652	10770	11468	25346
UK (Scotland)	16021	14006	14373	18564	34414
UK (N.Ireland)	331	-	-	17	4794
Unallocated landings	17151	-726	0	0	321
Total landings	244823	165751	174614	218398	424608
Discards	224	91	13	0	0
Total catch	**245047**	**165842**	**174627**	**218398**	**424608**
Estimates of the parts of the catches which have been allocated to spring spawning stocks					
WBSS	124	3941	774	308	2095
Thames estuary [2]	7	48	85	2	63
Others [3]	0	0	0	0	0
Norw. Spring Spawners [4]	2721	44560	56900	12178	9619

1 **Catches of Norwegian spring spawners removed (taken under a separate TAC).**

2 **Landings from the Thames estuary area are included in the North Sea catch figure for UK (England).**

3 **Caught in the whole North Sea, partly included in the catch figure for The Netherlands**

4 **These catches (including some local fjord-type Spring Spawners) are taken by Norway under a separate quota south of 62°N and are not included in the Norwegian North Sea catch figure for this area.**

5 **may include misreported catch from VIaN and discards**

6 **Including any by-catches in the industrial fishery**

Table 2.1.2: Herring caught in the North Sea. Catch in tonnes in Division IVa West. These figures do not in all cases correspond to the official statistics and cannot be used for legal purposes.

Country	2003	2004	2005	2006	2007
Denmark [1]	48358	48128	80990	60462	45948
Faroe Islands	95	-		580	1118
France	11237	10941	13474	18453	8570
Germany	25796	17559	22278	18605	4985
Netherlands	25045	43876	36619	39209	42622
Norway	34443	36119	66232	38363	40279
Poland	-	-	458	-	-
Sweden	2647	2178	8261	4957	7658
Russia	-	-	99	-	-
UK (England)	12030	13480	15523	12031	11833
UK (Scotland)	39970	43490	71941	47368	35115
UK (N. Ireland)	2010	2656	2912	3531	638
Unallocated landings	14115 [2]	28631 [2]	39324 [2]	10981 [2]	22215
Misreporting from VIa North					
Total Landings	215746	247058	358111	253048	220981
Discards	4125	15794	10861	1492	93
Total catch	**219871**	**262852**	**368972**	**254540**	**221074**

Country	2008	2009	2010	2011	2012
Denmark [1]	28426	16550	25092	26523	42867
Faroe Islands	2	288	1110	-	-
France	13068	7067	6412	7885	11131
Germany	498	-	505	2642	13060
Netherlands	11634	11017	13593	15202	46654
Norway	40304	25926	38897	45200	72581
Lithuania	-	-	90	-	-
Sweden	7025	1435	2310	5121	6065
Russia	-	-	-	-	-
UK (England)	8355	578	7384	4555	18289
UK (Scotland)	14727	10249	13567	17909	33352
UK (N. Ireland)	331	-	-	17	4794
Unallocated landings	14952	-977	0	0	-3416
Misreporting from VIa North					
Total Landings	139322	72133	108960	125054	245377
Discards	194	91	13	0	0
Total catch	**139516**	**72224**	**108973**	**125054**	**245377**

[1] **Including any by-catches in the industrial fishery**

[2] **May include misreported catch from VIaN and discards**

Table 2.1.3: Herring caught in the North Sea. Catch in tonnes in Division IVa East. These figures do not in all cases correspond to the official statistics and cannot be used for legal purposes.

Country	2003	2004	2005	2006	2007
Denmark 1	7401	16278	5761	8614	2646
Faroe Islands	359	-	738	975	577
France	-	-	-	-	-
Germany	54	888	-	34	-
Netherlands	-	-	-	-	263
Norway 2	62306	100443	89925	90065	54424
UK (Scotland)	-	-	-	83	-
Sweden	1529	1720	3510	2857	640
Unallocated landings	9988	0	0	0	-96 3
Total landings	81637	119329	99934	102628	58454
Discards	-	-	-	-	-
Total catch	**83640**	**119329**	**99934**	**102628**	**58454**
Norw. Spring Spawners 4	979	452	417	626	685

Country	2008	2009	2010	2011	2012
Denmark 1	1587	499	-	1590	1822
Faroe Islands	400	700	719	-	-
France	-	-	-	-	-
Germany	-	-	-	-	-
Netherlands	-	-	-	-	-
Norway 2	17474	6981	7362	12922	32714
UK (Scotland)	-	-	-	167	
Sweden	-	1735	1505	150	815
Unallocated landings	0	0	0	0	0
Total landings	19461	9915	9586	14829	35351
Discards	-	-	-	-	-
Total catch	**19461**	**9915**	**9586**	**14829**	**35351**
Norw. Spring Spawners 4	2721	44560	56900	12178	9619

[1] Including any by-catches in the industrial fishery

[2] Catches of Norwegian spring spawning herring removed (taken under a separate TAC)

[3] Negative unallocated catches due to misreporting into other areas

[4] These catches (including some fjord-type spring spawners) are taken by Norway under a separate quota south of 62°N and are not included in the Norwegian North Sea catch figure for this area

Table 2.1.4: Herring caught in the North Sea. Catch in tonnes in Division IVb. These figures do not in all cases correspond to the official statistics and cannot be used for legal purposes.

Country	2003	2004	2005	2006	2007
Denmark 1	22574	33857	41423	32277	35990
Faroe Islands	173	402	-	200	1196
France	7918	10592	10205	17385	8421
Germany	12116	13823	14381	14222	2205
Netherlands	19115	23649	10038	13363	8550
Norway	15732	1076	645	6933	5347
Sweden	605	1794	1694	2715	7150
UK (England)	2632	2864	3869	4924	577
UK (Scotland)	322	1841	1286	977	-
Unallocated landings 3	-2401	8300	10233	2364	-203
Total landings	78786	98198	93774	95360	69233
Discards 2		1265	1963		
Total catch	**78786**	**99463**	**95737**	**95360**	**69233**

Country	2008	2009	2010	2011	2012
Denmark 1	32230	29164	19671	30498	60503
Faroe Islands	1612	815	1185	-	-
France	9687	4316	2349	1687	3898
Germany	2415	1061	1994	1778	4187
Netherlands	904	3164	830	7314	9202
Norway	1543	17538	557	2537	13958
Sweden	6815	2129	580	2815	7212
UK (England)	833	2	1577	4748	3045
UK (Scotland)	1293	3757	805	488	1062
Unallocated landings 3	-904	-166	0	0	411
Total landings	56428	61780	29548	51865	103478
Discards 2	30				
Total catch	**56458**	**61780**	**29548**	**51865**	**103478**

[1] Including any by-catches in the industrial fishery
[2] Discards partly included in unallocated landings
[3] Negative unallocated catches due to misreporting into other areas

Table 2.1.5: Herring caught in the North Sea. Catch in tonnes in Division IVc and VIId. These figures do not in all cases correspond to the official statistics and cannot be used for legal purposes.

Country	2003	2004	2005	2006	2007
Belgium	5	8	6	3	1
Denmark	273	774	206	969	113
Faroe Islands				30	-
France	12389	12988	15150	13637	7918
Germany	5987	9588	9896	7553	7703
Netherlands	36948	28637	34874	23743	14958
UK (England)	3977	4511	5919	5243	3583
UK (Scotland)	-	-	-	-	-
Unallocated landings	8170	9963	8231	5419	4725
Total landings	67749	68473	74282	56597	39001
Discards [2]	-	-	-	-	-
Total catch	**67749**	**68473**	**74282**	**56597**	**39001**
Coastal spring spawners included above [1]	84	62	74	65	2

Country	2008	2009	2010	2011	2012
Belgium	-	-	-	4	3
Denmark [3]	621	25	1106	115	515
France	7592	6731	8984	7121	8790
Germany	5182	4307	5171	5007	7268
Netherlands	10584	10371	9449	12192	16488
Norway	-	-	-	46	-
UK (England)	2529	72	1809	2165	4012
UK (Scotland)	1	-	1	-	-
Unallocated landings	3103	417	0	0	3326
Total landings	29612	21923	26520	26650	40402
Discards 2	-				
Total catch	**29612**	**21923**	**26520**	**26650**	**40402**
Coastal spring spawners included above [1]	7	48	85	2	63

[1] **Landings from the Thames estuary area are included in the North Sea catch figure for UK (England)**

[2] **Discards partly included in unallocated landings**

Table 2.1.6 ("The Wonderful Table"): Herring caught in the North Sea. Catch in thousand tonnes in Subarea IV, Division VIId and Division IIIa.

Table 2.1.6 ("The Wonderful Table"): HERRING in Sub-area IV, Division VIId and Division IIIa. Figures in thousand tonnes.

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Sub-Area IV and Division VIId: TAC (IV and VIId)														
Recommended Divisions IVa, b	265	- [15]	- [15]	- [15]	- [15]	- [15]	- [15]	- [15]	- [15]	- [15]	-	-	-	
Recommended Divisions IVc, VIId	- [11]	- [11]	- [11]	- [11]	- [11]	- [11]	- [11]	- [11]	- [11]	- [11]	-	-	-	
Expected catch of spring spawners														
Agreed Divisions IVa,b [1]	240	240	223	340.5	393.9	460.7	404.7	303.5	174.6	147.4	149.0	173.5	360.4	427.7
Agreed Div. IVc, VIId	25	25	42.7	59.5	66.1	74.3	50.0	37.5	26.7	23.6	15.3	26.5	44.6	50.3
Bycatch ceiling in the small mesh fishery	36	36	36	52.0	38.0	50.0	42.5	31.9	18.8	16.0	13.6	16.5	17.9	14.4
CATCH (IV and VIId)														
National landings Divisions IVa,b [2]	261	272	261	354.5	427.7	502.3	439.2	326.8	201.2	145.0	148.1	191.7	387.2	
Unallocated landings Divisions IVa,b	35	2	24	23.7	36.9	49.6	13.3	21.9	14.0	-1.1	0.0	0.0	-3.0	
Discard/slipping Divisions IVa,b [3]	-	-	17	4.1	17.1	12.8	1.5	0.1	0.2	0.1	0.0	0.0	0	
Total catch Divisions IVa,b [4]	296	273	303	382.3	481.6	564.6	454.0	348.8	215.4	143.9	148.1	191.7	384.2	
National landings Divisions IVc, VIId [3]	23	24	43	59.5	56.5	66.1	51.2	34.3	26.5	21.5	26.5	26.7	37.1	
Unallocated landings Divisions IVc,VIId	27	26	7	8.2	12.0	8.2	5.4	4.7	3.1	0.4	0	0	3.3	
Discard/slipping Divisions IVc, VIId [3]	-	-	0	-	-	-	-	-	-	-	-	-	-	
Total catch Divisions IVc, VIId	50	50	50	67.7	68.5	74.3	56.6	39.0	29.6	21.9	26.5	26.7	40.4	
Total catch IV and VIId as used by ICES [4]	**346**	**323**	**353**	**450.0**	**550.1**	**638.9**	**510.62**	**387.8**	**245.0**	**165.8**	**174.6**	**218.4**	**424.6**	
CATCH BY FLEET/STOCK (IV and VIId) [7]														
North Sea autumn spawners directed fisheries (Fleet A)	322	296	323	434.9	529.5	610.0	487.1	379.6	236.3	152.1	164.8	209.2	411.8	
North Sea autumn spawners industrial (Fleet B)	18	20	22	12.3	13.6	21.8	11.9	7.1	8.6	9.8	9.1	8.9	10.6	
North Sea autumn spawners in IV and VIId total	**339**	**317**	**346**	**447.2**	**543.0**	**631.9**	**499.0**	**386.7**	**244.9**	**161.9**	**173.9**	**218.1**	**422.5**	
Baltic-IIIa-type spring spawners in IV	7	6	7	2.8	7.1	7.0	11.0	1.1	0.1	3.9	0.8	0.3	2.1	
Coastal-type spring spawners	0.1	1.2	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.1	0.0	0.1	
Norw. Spring Spawners caught under a separate quota in IV [14]	26	7	4	1.0	0.5	0.4	0.6	0.7	2.7	44.6	56.9	12.2	9.6	
Division IIIa: TAC (IIIa)														
Predicted catch of autumn spawners	53	- [15]	- [15]	- [15]	- [15]	- [15]	- [15]	- [15]	- [15]	- [15]	- [15]	- [15]	-	
Recommended spring spawners	- [12]	- [12]	- [12]	- [12]	- [15]	- [15]	- [15]	- [15]	- [15]	- [15]	- [15]	- [15]	-	
Recommended mixed clupeoids	-	-	-	-	-	-	-	-	-	-	-			
Agreed herring TAC	80	80	80	80.0	70.0	96.0	81.6	69.4	51.7	37.7	33.9	30.0	45.0	55.0
Agreed mixed clupeoid TAC														
Bycatch ceiling in the small mesh fishery	21	21	21	21.0	21.0	24.2	20.5	15.4	11.5	8.4	7.5	6.7	6.7	6.7
CATCH (IIIa)														
National landings	108	90	79	76.0	61.1	90.8	88.9	47.3	38.2	38.8	37.3	20.0	27.7	
Catch as used by ICES	99	82	73	68.1	52.7	69.6	51.2	47.4	38.2	38.8	37.3	20.0	27.7	
CATCH BY FLEET/STOCK (IIIa) [7]														
Autumn spawners human consumption (Fleet C)	36	34	17	24.1	13.4	22.9	11.6	16.4	9.2	5.1	12.0	6.6	7.8	
Autumn spawners mixed clupeoid (Fleet D) [13]	13	12	9	8.4	10.8	9.0	3.4	3.4	3.7	1.5	1.8	1.8	4.4	
Autumn spawners other industrial landings (Fleet E)														
Autumn spawners in IIIa total	**49**	**46**	**26**	**32.5**	**24.2**	**31.9**	**15.0**	**19.8**	**12.9**	**6.5**	**13.8**	**8.4**	**12.2**	
Spring spawners human consumption (Fleet C)	45	33	38	31.6	16.8	32.5	30.2	25.3	23.0	29.4	23.0	10.8	14.5	
Spring spawners mixed clupeoid (Fleet D) [13]	5	3	9	4.0	11.2	5.1	5.9	2.3	2.2	2.9	0.5	0.8	1.0	
Spring spawners other industrial landings (Fleet E)														
Spring spawners in IIIa total	**50**	**36**	**47**	**35.6**	**28.0**	**37.6**	**36.1**	**27.6**	**25.2**	**32.3**	**23.5**	**11.6**	**15.5**	
North Sea autumn spawners Total as used by ICES	**388**	**363**	**372**	**479.7**	**567.2**	**663.8**	**514.6**	**406.5**	**257.9**	**168.4**	**187.6**	**226.5**	**434.6**	

1 IVa,b and EC zone of IIa. 2 Provided by Working Group members. 3 Incomplete, only some countries providing discard information. 4 Includes spring spawners not included in assessment. 5 Based on F=0.3 in directed fishery only; TAC advised for IVc, VIId subtracted. 6 130-180 for spring spawners in all areas. 7 Based on sum-of-products (number x mean weight at age). 8 Status quo F catch for fleet A. 9 The catch should not exceed recent catch levels. 10 During the middle of 1996 revised to 50% of its original agreed TAC. 11 Included in IVa,b. 12 Managed in accordance with autumn spawners. 13 Fleet D and E are merged from 1999 onwards. 14 These catches (including local fjord-type Spring Spawners) are taken by Norway under a separate quota south of 62°N and are not included in the Norwegian North Sea catch figure for this area. 15 See catch option tables for different fleets.

Table 2.2.1: North Sea autumn spawning herring (NSAS), and western Baltic spring spawners (WBSS) caught in the North Sea and Div IIIa in 2012. Catch in numbers (millions) at age (CANUM), by quarter and division.

WR	IIIa NSAS	IVa(E) all	IVa(E) WBBS	IVa(E) NSAS only	IVa(W)	IVb	IVc	VIId	IVa & IVb NSAS	IVc & VIId	Total NSAS	Herring caught in the North Sea
Quarters: 1-4												
0	**145.8**	**0.0**	**0.0**	**0.0**	**0.0**	**619.4**	**8.1**	**0.0**	**619.4**	**8.1**	**773.2**	**627.4**
1	**174.9**	**2.3**	**0.0**	**2.3**	**6.8**	**95.2**	**4.5**	**1.2**	**104.3**	**5.7**	**284.9**	**110.0**
2	**43.7**	**7.6**	**0.0**	**7.6**	**232.3**	**128.1**	**14.0**	**29.4**	**368.1**	**43.5**	**455.2**	**411.5**
3	**1.9**	**52.4**	**0.2**	**52.2**	**402.9**	**194.8**	**1.5**	**19.8**	**649.8**	**21.3**	**673.0**	**671.4**
4	**1.2**	**23.1**	**0.4**	**22.7**	**253.4**	**57.9**	**4.6**	**63.7**	**334.0**	**68.3**	**403.5**	**402.7**
5	**0.2**	**20.2**	**0.0**	**20.2**	**179.0**	**57.3**	**3.0**	**46.4**	**256.6**	**49.5**	**306.2**	**306.0**
6	**0.2**	**19.5**	**1.4**	**18.1**	**91.7**	**32.2**	**0.5**	**7.0**	**142.0**	**7.5**	**149.7**	**150.9**
7	**0.1**	**14.0**	**0.0**	**14.0**	**56.5**	**22.9**	**0.3**	**10.7**	**93.4**	**11.0**	**104.5**	**104.3**
8	**0.0**	**8.0**	**1.1**	**6.9**	**39.1**	**31.5**	**1.1**	**9.7**	**77.5**	**10.8**	**88.4**	**89.5**
9+	**0.0**	**28.5**	**6.3**	**22.2**	**48.7**	**22.4**	**0.6**	**8.5**	**93.2**	**9.0**	**102.2**	**108.5**
Sum	**368.0**	**175.7**	**9.4**	**166.2**	**1310.3**	**1261.7**	**38.2**	**196.5**	**2738.2**	**234.7**	**3341.0**	**2982.4**
Quarter: 1												
0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	**0.0**
1	60.7	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.5	0.0	**61.2**	**0.5**
2	28.9	0.2	0.0	0.2	4.6	19.3	0.1	0.0	24.1	0.1	**53.1**	**24.2**
3	1.0	2.3	0.0	2.2	22.0	113.0	0.6	1.9	137.2	2.5	**140.7**	**139.7**
4	0.0	1.2	0.0	1.2	5.5	15.1	1.0	4.9	21.8	5.9	**27.8**	**27.8**
5	0.0	1.3	0.0	1.3	5.3	7.3	1.1	3.8	13.9	4.9	**18.9**	**18.9**
6	0.0	0.6	0.0	0.6	4.1	9.8	0.4	1.2	14.4	1.6	**16.0**	**16.0**
7	0.0	0.3	0.0	0.3	1.9	1.6	0.3	0.6	3.8	0.9	**4.7**	**4.7**
8	0.0	0.3	0.0	0.3	1.2	1.8	0.6	1.4	3.3	2.0	**5.3**	**5.3**
9+	0.0	0.5	0.0	0.5	1.7	0.0	0.5	2.7	2.2	3.3	**5.5**	**5.5**
Sum	**90.7**	**6.6**	**0.1**	**6.5**	**46.8**	**167.9**	**4.6**	**16.6**	**221.3**	**21.2**	**333.1**	**242.5**
Quarter: 2												
0	0.0	0.0	0.0	0.0	0.0	167.9	0.0	0.0	167.9	0.0	**167.9**	**167.9**
1	29.5	0.0	0.0	0.0	1.2	7.5	0.1	0.0	8.6	0.1	**38.1**	**8.7**
2	1.7	0.2	0.0	0.2	102.9	13.9	0.2	0.0	117.0	0.2	**118.9**	**117.2**
3	0.1	20.4	0.1	20.3	98.7	10.2	0.0	0.0	129.2	0.1	**129.3**	**129.4**
4	0.0	12.4	0.0	12.4	107.4	4.0	0.0	0.1	123.8	0.1	**123.9**	**123.9**
5	0.0	14.0	0.0	14.0	60.8	3.0	0.0	0.1	77.8	0.1	**77.8**	**77.8**
6	0.0	5.9	0.0	5.9	19.3	1.4	0.0	0.0	26.6	0.0	**26.6**	**26.6**
7	0.0	3.6	0.0	3.6	10.0	1.2	0.0	0.0	14.7	0.0	**14.8**	**14.8**
8	0.0	3.3	0.0	3.3	5.5	1.4	0.0	0.0	10.1	0.0	**10.2**	**10.2**
9+	0.0	5.8	0.0	5.8	7.9	1.1	0.0	0.0	14.8	0.0	**14.9**	**14.9**
Sum	**31.2**	**65.7**	**0.1**	**65.6**	**413.6**	**211.5**	**0.3**	**0.2**	**690.7**	**0.5**	**722.4**	**691.3**
Quarter: 3												
0	104.3	0.0	0.0	0.0	0.0	238.0	0.0	0.0	238.0	0.0	**342.3**	**238.0**
1	55.0	0.1	0.0	0.1	1.5	15.5	0.0	0.0	17.1	0.0	**72.1**	**17.1**
2	11.0	0.8	0.0	0.8	86.2	57.8	0.0	0.0	144.8	0.0	**155.8**	**144.8**
3	0.5	3.3	0.0	3.3	252.5	46.6	0.0	0.0	302.4	0.0	**302.9**	**302.4**
4	0.8	2.3	0.0	2.3	129.6	25.4	0.0	0.0	157.3	0.0	**158.1**	**157.3**
5	0.2	1.2	0.0	1.2	102.8	38.3	0.0	0.0	142.3	0.0	**142.5**	**142.3**
6	0.2	0.9	0.0	0.9	56.1	13.3	0.0	0.0	70.4	0.0	**70.5**	**70.4**
7	0.1	0.6	0.0	0.6	36.1	14.0	0.0	0.0	50.8	0.0	**50.8**	**50.8**
8	0.0	0.6	0.0	0.6	29.4	23.3	0.0	0.0	53.3	0.0	**53.3**	**53.3**
9+	0.0	0.3	0.0	0.3	32.1	9.3	0.0	0.0	41.7	0.0	**41.7**	**41.7**
Sum	**172.0**	**10.1**	**0.1**	**10.0**	**726.4**	**481.6**	**0.0**	**0.0**	**1218.0**	**0.0**	**1390.1**	**1218.2**
Quarter: 4												
0	41.5	0.0	0.0	0.0	0.0	213.5	8.1	0.0	213.5	8.1	**263.1**	**221.6**
1	29.7	2.3	0.0	2.3	3.6	72.2	4.4	1.2	78.1	5.7	**113.4**	**83.7**
2	2.2	6.4	0.0	6.4	38.6	37.1	13.7	29.4	82.1	43.1	**127.4**	**125.3**
3	0.3	26.4	0.0	26.4	29.7	24.9	0.9	17.9	81.1	18.8	**100.1**	**99.9**
4	0.3	7.2	0.3	6.8	10.9	13.4	3.6	58.7	31.1	62.3	**93.7**	**93.7**
5	0.0	3.8	0.0	3.8	10.1	8.7	1.9	42.5	22.6	44.4	**67.0**	**67.0**
6	0.0	12.1	1.4	10.7	12.2	7.7	0.2	5.8	30.6	6.0	**36.6**	**38.0**
7	0.1	9.4	0.0	9.4	8.4	6.2	0.0	10.1	24.0	10.1	**34.2**	**34.1**
8	0.0	3.8	1.1	2.7	3.0	5.1	0.5	8.3	10.8	8.8	**19.6**	**20.7**
9+	0.0	21.9	6.3	15.6	6.9	11.9	0.0	5.7	34.4	5.7	**40.1**	**46.4**
Sum	**74.1**	**93.2**	**9.1**	**84.1**	**123.5**	**400.7**	**33.3**	**179.7**	**608.3**	**213.0**	**895.3**	**830.4**

Table 2.2.2: North Sea autumn spawning herring (NSAS), and western Baltic spring spawners (WBSS) caught in the North Sea and Div IIIa in 2012. Mean weight-at-age (kg) in the catch (WE-CA), by quarter and division.

WR	IIIa NSAS	IVa(E) all	IVa(E) WBSS	IVa(W)	IVb	IVc	VIId	IVa & IVb all	IVc & VIId	Total NSAS	Herring caught in the North Sea
Quarters: 1-4											
0	0.013	0.000	0.000	0.000	0.010	0.019	0.000	0.010	0.019	0.011	0.010
1	0.040	0.101	0.000	0.089	0.053	0.058	0.094	0.056	0.065	0.046	0.057
2	0.067	0.146	0.150	0.132	0.131	0.106	0.125	0.132	0.119	0.124	0.130
3	0.124	0.185	0.167	0.184	0.141	0.155	0.165	0.171	0.165	0.171	0.171
4	0.169	0.195	0.183	0.186	0.178	0.184	0.186	0.185	0.186	0.185	0.185
5	0.175	0.203	0.208	0.206	0.209	0.191	0.203	0.207	0.202	0.206	0.206
6	0.200	0.216	0.213	0.226	0.214	0.204	0.213	0.222	0.212	0.222	0.222
7	0.221	0.225	0.211	0.240	0.245	0.197	0.235	0.239	0.234	0.239	0.239
8	0.216	0.225	0.201	0.242	0.250	0.188	0.212	0.243	0.209	0.239	0.239
9+	0.000	0.232	0.230	0.254	0.258	0.218	0.227	0.248	0.226	0.246	0.247
Quarter: 1											
0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1	0.017	0.089	0.089	0.089	0.000	0.000	0.000	0.089	0.000	0.018	0.089
2	0.053	0.119	0.119	0.113	0.088	0.096	0.000	0.093	0.096	0.071	0.093
3	0.105	0.173	0.173	0.133	0.111	0.128	0.127	0.116	0.127	0.116	0.116
4	0.121	0.184	0.184	0.153	0.130	0.153	0.143	0.139	0.145	0.140	0.140
5	0.135	0.196	0.196	0.184	0.155	0.173	0.161	0.169	0.164	0.168	0.168
6	0.208	0.213	0.213	0.184	0.157	0.190	0.184	0.167	0.185	0.169	0.169
7	0.000	0.213	0.213	0.213	0.170	0.198	0.188	0.196	0.191	0.195	0.195
8	0.000	0.217	0.217	0.217	0.180	0.184	0.167	0.197	0.172	0.188	0.188
9+	0.000	0.251	0.251	0.236	0.214	0.218	0.221	0.239	0.220	0.228	0.228
Quarter: 2											
0	0.000	0.000	0.000	0.000	0.004	0.000	0.000	0.004	0.000	0.004	0.004
1	0.022	0.000	0.000	0.076	0.037	0.043	0.000	0.043	0.043	0.027	0.043
2	0.060	0.159	0.159	0.125	0.097	0.075	0.000	0.121	0.075	0.120	0.121
3	0.113	0.187	0.187	0.155	0.151	0.123	0.127	0.160	0.125	0.160	0.160
4	0.127	0.190	0.190	0.161	0.168	0.144	0.143	0.164	0.143	0.164	0.164
5	0.118	0.198	0.198	0.177	0.190	0.158	0.161	0.181	0.160	0.181	0.181
6	0.000	0.219	0.219	0.194	0.218	0.200	0.184	0.201	0.185	0.201	0.201
7	0.156	0.214	0.214	0.198	0.227	0.162	0.188	0.204	0.181	0.204	0.204
8	0.000	0.218	0.218	0.202	0.230	0.183	0.167	0.211	0.168	0.211	0.211
9+	0.000	0.251	0.251	0.200	0.250	0.221	0.221	0.224	0.221	0.224	0.224
Quarter: 3											
0	0.010	0.000	0.000	0.000	0.008	0.035	0.000	0.008	0.035	0.009	0.008
1	0.061	0.090	0.090	0.083	0.057	0.069	0.085	0.059	0.070	0.061	0.059
2	0.097	0.145	0.145	0.144	0.147	0.106	0.140	0.145	0.110	0.142	0.145
3	0.149	0.191	0.191	0.200	0.185	0.182	0.173	0.198	0.177	0.198	0.198
4	0.168	0.196	0.196	0.208	0.197	0.193	0.193	0.206	0.193	0.206	0.206
5	0.178	0.218	0.219	0.226	0.216	0.204	0.207	0.223	0.206	0.223	0.223
6	0.201	0.231	0.231	0.247	0.234	0.219	0.215	0.244	0.217	0.244	0.244
7	0.212	0.244	0.244	0.252	0.248	0.200	0.246	0.251	0.235	0.251	0.251
8	0.224	0.249	0.249	0.252	0.261	0.203	0.216	0.256	0.210	0.256	0.256
9+	0.000	0.239	0.236	0.274	0.250	0.224	0.217	0.268	0.221	0.268	0.268
Quarter: 4											
0	0.019	0.000	0.000	0.000	0.017	0.019	0.000	0.017	0.019	0.017	0.017
1	0.064	0.101	0.101	0.095	0.054	0.058	0.094	0.057	0.066	0.059	0.058
2	0.106	0.146	0.146	0.125	0.142	0.106	0.125	0.135	0.119	0.129	0.129
3	0.149	0.183	0.183	0.178	0.189	0.174	0.169	0.183	0.170	0.180	0.181
4	0.181	0.206	0.206	0.191	0.197	0.193	0.190	0.197	0.190	0.193	0.193
5	0.000	0.221	0.221	0.199	0.231	0.201	0.207	0.215	0.206	0.209	0.209
6	0.193	0.213	0.213	0.196	0.251	0.232	0.219	0.216	0.219	0.216	0.216
7	0.233	0.229	0.229	0.245	0.261	0.000	0.238	0.243	0.238	0.241	0.241
8	0.209	0.228	0.228	0.229	0.229	0.192	0.220	0.228	0.218	0.224	0.224
9+	0.000	0.226	0.226	0.227	0.266	0.000	0.229	0.238	0.229	0.236	0.237

Table 2.2.3: North Sea autumn spawning herring (NSAS), and western Baltic spring spawners (WBSS) caught in the North Sea in 2012. Mean length-at-age (cm) in the catch, by quarter and division.

WR	IIIa NSAS	IVa(E) all	IVa(E) WBSS	IVa(W)	IVb	IVc	VIId	IVa & IVb all	IVc & VIId
Quarters: 1-4									
0	**n.d.**	**0.0**	**n.d.**	**0.0**	**11.7**	**14.6**	**0.0**	**11.7**	**14.6**
1	**n.d.**	**23.6**	**n.d.**	**22.4**	**19.3**	**20.2**	**22.9**	**19.6**	**20.8**
2	**n.d.**	**25.9**	**n.d.**	**24.6**	**24.7**	**23.5**	**24.3**	**24.6**	**24.0**
3	**n.d.**	**27.7**	**n.d.**	**27.3**	**26.5**	**26.3**	**26.3**	**27.1**	**26.3**
4	**n.d.**	**28.2**	**n.d.**	**27.5**	**27.7**	**27.2**	**27.4**	**27.6**	**27.4**
5	**n.d.**	**28.6**	**n.d.**	**28.5**	**28.9**	**28.2**	**28.4**	**28.6**	**28.4**
6	**n.d.**	**29.7**	**n.d.**	**29.5**	**29.4**	**28.7**	**28.7**	**29.5**	**28.7**
7	**n.d.**	**30.3**	**n.d.**	**30.1**	**30.3**	**28.6**	**29.5**	**30.1**	**29.5**
8	**n.d.**	**30.2**	**n.d.**	**30.0**	**30.9**	**28.5**	**29.0**	**30.4**	**29.0**
9+	**n.d.**	**30.7**	**n.d.**	**30.4**	**29.9**	**29.2**	**29.5**	**30.4**	**29.5**
Quarter: 1									
0	n.d.	0.0	n.d.	0.0	0.0	0.0	0.0	0.0	0.0
1	n.d.	24.0	n.d.	23.9	0.0	0.0	0.0	23.9	0.0
2	n.d.	25.9	n.d.	25.7	23.6	23.3	0.0	24.0	23.3
3	n.d.	27.2	n.d.	26.8	25.9	25.1	25.1	26.1	25.1
4	n.d.	27.6	n.d.	28.3	27.4	26.7	26.8	27.6	26.8
5	n.d.	28.1	n.d.	29.5	29.0	27.8	27.9	29.1	27.9
6	n.d.	28.9	n.d.	29.6	29.1	28.2	28.5	29.2	28.4
7	n.d.	29.1	n.d.	30.4	30.0	28.6	28.5	30.1	28.5
8	n.d.	29.5	n.d.	31.7	30.5	28.5	28.7	30.8	28.6
9+	n.d.	29.8	n.d.	31.2	28.9	29.2	29.5	30.9	29.5
Quarter: 2									
0	n.d.	0.0	n.d.	0.0	9.3	0.0	0.0	9.3	0.0
1	n.d.	0.0	n.d.	20.6	16.7	17.7	0.0	17.2	17.7
2	n.d.	25.2	n.d.	23.8	22.4	20.8	0.0	23.6	20.8
3	n.d.	27.2	n.d.	25.6	26.6	24.8	25.1	25.9	24.9
4	n.d.	27.5	n.d.	26.3	27.1	26.4	26.8	26.5	26.7
5	n.d.	28.0	n.d.	27.2	28.6	27.6	27.9	27.4	27.8
6	n.d.	28.8	n.d.	28.1	29.6	28.7	28.5	28.3	28.5
7	n.d.	29.0	n.d.	28.2	30.0	28.2	28.5	28.5	28.4
8	n.d.	29.2	n.d.	28.7	30.5	28.5	28.7	29.1	28.7
9+	n.d.	29.8	n.d.	28.5	29.6	29.3	29.5	29.1	29.5
Quarter: 3									
0	n.d.	0.0	n.d.	0.0	11.1	17.1	0.0	11.1	17.1
1	n.d.	22.9	n.d.	21.9	19.6	21.5	22.8	19.8	21.5
2	n.d.	25.7	n.d.	25.1	25.7	23.5	25.0	25.3	23.7
3	n.d.	28.0	n.d.	28.0	27.6	27.1	26.6	27.9	26.8
4	n.d.	28.2	n.d.	28.4	27.9	27.4	27.6	28.3	27.5
5	n.d.	29.3	n.d.	29.0	28.8	28.3	28.6	29.0	28.5
6	n.d.	29.8	n.d.	30.0	29.7	29.2	28.7	29.9	29.0
7	n.d.	30.4	n.d.	30.3	30.5	28.3	30.1	30.3	29.7
8	n.d.	30.4	n.d.	30.2	31.3	28.8	29.2	30.7	29.0
9+	n.d.	30.4	n.d.	30.6	29.6	28.8	29.6	30.4	29.1
Quarter: 4									
0	n.d.	0.0	n.d.	0.0	14.3	14.6	0.0	14.3	14.6
1	n.d.	23.6	n.d.	23.0	19.5	20.2	22.9	19.8	20.8
2	n.d.	25.9	n.d.	25.4	24.7	23.5	24.3	25.1	24.0
3	n.d.	28.0	n.d.	28.1	27.3	27.2	26.5	27.8	26.5
4	n.d.	29.5	n.d.	28.4	27.9	27.4	27.5	28.5	27.5
5	n.d.	30.5	n.d.	29.8	29.2	28.4	28.4	29.6	28.4
6	n.d.	30.2	n.d.	29.8	29.5	29.8	28.7	29.9	28.8
7	n.d.	30.8	n.d.	31.3	29.8	0.0	29.6	30.7	29.6
8	n.d.	31.0	n.d.	30.2	29.4	28.6	29.1	30.1	29.1
9+	n.d.	31.0	n.d.	31.1	30.1	0.0	29.5	30.8	29.5

Table 2.2.4: North Sea autumn spawning herring (NSAS), and western Baltic spring spawners (WBSS) caught in the North Sea and Div IIIa in 2012. Catches (tonnes) at-age (SOP figures), by quarter and division.

WR	IIIa NSAS	IVa(E) all	IVa(E) WBSS	IVa(E) NSAS only	IVa(W)	IVb	IVc	VIId	IVa & IVb NSAS	IVc & VIId	Total NSAS
Quarters: 1-4											
0	1.8	0.0	0.0	0.0	0.0	6.2	0.2	0.0	6.2	0.2	8.2
1	6.9	0.2	0.0	0.2	0.6	5.1	0.3	0.1	5.9	0.4	13.2
2	2.9	1.1	0.0	1.1	30.6	16.8	1.5	3.7	48.5	5.2	56.6
3	0.2	9.7	0.0	9.6	74.1	27.4	0.2	3.3	111.1	3.5	114.8
4	0.2	4.5	0.1	4.4	47.2	10.3	0.9	11.9	61.9	12.7	74.8
5	0.0	4.1	0.0	4.1	36.9	12.0	0.6	9.4	53.0	10.0	63.0
6	0.0	4.2	0.3	3.9	20.8	6.9	0.1	1.5	31.5	1.6	33.2
7	0.0	3.2	0.0	3.2	13.6	5.6	0.1	2.5	22.3	2.6	24.9
8	0.0	1.8	0.2	1.6	9.5	7.9	0.2	2.1	18.9	2.3	21.2
9+	0.0	6.6	1.4	5.1	12.3	5.8	0.1	1.9	23.3	2.0	25.3
Sum	12.2	35.4	2.1	33.3	245.5	103.8	4.1	36.3	382.6	40.4	435.2
Quarter: 1											
0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1
2	1.5	0.0	0.0	0.0	0.5	1.7	0.0	0.0	2.2	0.0	3.8
3	0.1	0.4	0.0	0.4	2.9	12.5	0.1	0.2	15.9	0.3	16.3
4	0.0	0.2	0.0	0.2	0.8	2.0	0.2	0.7	3.0	0.9	3.9
5	0.0	0.3	0.0	0.3	1.0	1.1	0.2	0.6	2.4	0.8	3.2
6	0.0	0.1	0.0	0.1	0.8	1.5	0.1	0.2	2.4	0.3	2.7
7	0.0	0.1	0.0	0.1	0.4	0.3	0.1	0.1	0.7	0.2	0.9
8	0.0	0.1	0.0	0.1	0.3	0.3	0.1	0.2	0.6	0.3	1.0
9+	0.0	0.1	0.0	0.1	0.4	0.0	0.1	0.6	0.5	0.7	1.3
Sum	2.7	1.3	0.0	1.2	7.1	19.5	0.8	2.7	27.9	3.5	34.0
Quarter: 2											
0	0.0	0.0	0.0	0.0	0.0	0.7	0.0	0.0	0.7	0.0	0.7
1	0.6	0.0	0.0	0.0	0.1	0.3	0.0	0.0	0.4	0.0	1.0
2	0.1	0.0	0.0	0.0	12.8	1.4	0.0	0.0	14.2	0.0	14.3
3	0.0	3.8	0.0	3.8	15.3	1.5	0.0	0.0	20.6	0.0	20.6
4	0.0	2.4	0.0	2.4	17.3	0.7	0.0	0.0	20.4	0.0	20.4
5	0.0	2.8	0.0	2.8	10.7	0.6	0.0	0.0	14.1	0.0	14.1
6	0.0	1.3	0.0	1.3	3.7	0.3	0.0	0.0	5.3	0.0	5.3
7	0.0	0.8	0.0	0.8	2.0	0.3	0.0	0.0	3.0	0.0	3.0
8	0.0	0.7	0.0	0.7	1.1	0.3	0.0	0.0	2.1	0.0	2.1
9+	0.0	1.5	0.0	1.5	1.6	0.3	0.0	0.0	3.3	0.0	3.3
Sum	0.8	13.2	0.0	13.2	64.7	6.2	0.0	0.0	84.1	0.1	84.9
Quarter: 3											
0	1.0	0.0	0.0	0.0	0.0	1.9	0.0	0.0	1.9	0.0	2.9
1	3.4	0.0	0.0	0.0	0.1	0.9	0.0	0.0	1.0	0.0	4.4
2	1.1	0.1	0.0	0.1	12.4	8.5	0.0	0.0	21.0	0.0	22.1
3	0.1	0.6	0.0	0.6	50.6	8.6	0.0	0.0	59.8	0.0	59.9
4	0.1	0.4	0.0	0.4	26.9	5.0	0.0	0.0	32.4	0.0	32.5
5	0.0	0.3	0.0	0.3	23.2	8.3	0.0	0.0	31.7	0.0	31.7
6	0.0	0.2	0.0	0.2	13.9	3.1	0.0	0.0	17.2	0.0	17.2
7	0.0	0.2	0.0	0.2	9.1	3.5	0.0	0.0	12.7	0.0	12.8
8	0.0	0.2	0.0	0.2	7.4	6.1	0.0	0.0	13.6	0.0	13.6
9+	0.0	0.1	0.0	0.1	8.8	2.3	0.0	0.0	11.2	0.0	11.2
Sum	5.8	2.1	0.0	2.0	152.4	48.1	0.0	0.0	202.6	0.0	208.3
Quarter: 4											
0	0.8	0.0	0.0	0.0	0.0	3.6	0.2	0.0	3.6	0.2	4.6
1	1.9	0.2	0.0	0.2	0.3	3.9	0.3	0.1	4.5	0.4	6.7
2	0.2	0.9	0.0	0.9	4.8	5.3	1.5	3.7	11.0	5.1	16.4
3	0.0	4.8	0.0	4.8	5.3	4.7	0.2	3.0	14.8	3.2	18.1
4	0.1	1.5	0.1	1.4	2.1	2.6	0.7	11.2	6.1	11.9	18.0
5	0.0	0.8	0.0	0.8	2.0	2.0	0.4	8.8	4.9	9.2	14.0
6	0.0	2.6	0.3	2.3	2.4	1.9	0.0	1.3	6.6	1.3	7.9
7	0.0	2.2	0.0	2.2	2.1	1.6	0.0	2.4	5.8	2.4	8.3
8	0.0	0.9	0.2	0.6	0.7	1.2	0.1	1.8	2.5	1.9	4.4
9+	0.0	4.9	1.4	3.5	1.6	3.2	0.0	1.3	8.3	1.3	9.6
Sum	3.0	18.8	2.0	16.8	21.3	30.0	3.2	33.6	68.1	36.8	108.0

Table 2.2.5: North Sea autumn spawning herring (NSAS), and western Baltic spring spawners (WBSS) caught in the North Sea in 2012. Percentage age composition (based on numbers, 3+ group summarised), by quarter and division.

WR	IIIa NSAS	IVa(E) all	IVa(E) WBSS	IVa(E) NSAS only	IVa(W)	IVb	IVc	VIId	IVa & IVb NSAS	IVc & VIId	Total NSAS
Quarters: 1-4											
0	39.6%	0.0%	0.0%	0.0%	0.0%	49.1%	21.1%	0.0%	22.6%	3.4%	23.1%
1	47.5%	1.3%	0.0%	1.4%	0.5%	7.5%	11.7%	0.6%	3.8%	2.4%	8.5%
2	11.9%	4.4%	0.2%	4.6%	17.7%	10.2%	36.6%	15.0%	13.4%	18.5%	13.6%
3	0.5%	29.8%	2.3%	31.4%	30.7%	15.4%	4.0%	10.1%	23.7%	9.1%	20.1%
4	0.3%	13.1%	3.8%	13.7%	19.3%	4.6%	12.1%	32.4%	12.2%	29.1%	12.1%
5	0.1%	11.5%	0.0%	12.2%	13.7%	4.5%	7.9%	23.6%	9.4%	21.1%	9.2%
6	0.1%	11.1%	15.2%	10.9%	7.0%	2.6%	1.4%	3.6%	5.2%	3.2%	4.5%
7	0.0%	8.0%	0.0%	8.4%	4.3%	1.8%	0.8%	5.4%	3.4%	4.7%	3.1%
8	0.0%	4.5%	11.7%	4.1%	3.0%	2.5%	2.9%	4.9%	2.8%	4.6%	2.6%
9+	0.0%	16.2%	66.8%	13.3%	3.7%	1.8%	1.4%	4.3%	3.4%	3.8%	3.1%
Sum 3+	1.0%	94.3%	99.8%	94.0%	81.8%	33.2%	30.6%	84.4%	60.1%	75.6%	54.7%
Quarter: 1											
0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
1	67.0%	0.3%	0.0%	0.3%	1.0%	0.0%	0.0%	0.0%	0.2%	0.0%	18.4%
2	31.8%	2.7%	4.0%	2.7%	9.8%	11.5%	3.0%	0.0%	10.9%	0.7%	15.9%
3	1.1%	34.1%	50.9%	33.8%	46.9%	67.3%	12.8%	11.4%	62.0%	11.7%	42.2%
4	0.0%	18.3%	7.4%	18.4%	11.7%	9.0%	21.6%	29.6%	9.9%	27.9%	8.3%
5	0.0%	19.2%	0.0%	19.5%	11.4%	4.4%	24.0%	23.2%	6.3%	23.4%	5.7%
6	0.0%	8.5%	8.4%	8.5%	8.7%	5.8%	7.6%	7.3%	6.5%	7.4%	4.8%
7	0.0%	4.9%	0.0%	5.0%	4.1%	0.9%	6.6%	3.3%	1.7%	4.1%	1.4%
8	0.0%	4.7%	11.4%	4.6%	2.6%	1.0%	12.3%	8.6%	1.5%	9.4%	1.6%
9+	0.0%	7.3%	17.8%	7.2%	3.6%	0.0%	11.9%	16.6%	1.0%	15.6%	1.6%
Sum 3+	1.2%	97.0%	96.0%	97.0%	89.1%	88.5%	97.0%	100.0%	88.9%	99.3%	65.7%
Quarter: 2											
0	0.0%	0.0%	0.0%	0.0%	0.0%	79.4%	0.0%	0.0%	24.3%	0.0%	23.2%
1	94.3%	0.0%	0.0%	0.0%	0.3%	3.5%	17.6%	0.0%	1.2%	10.1%	5.3%
2	5.4%	0.4%	1.2%	0.4%	24.9%	6.6%	54.0%	0.0%	16.9%	31.0%	16.5%
3	0.2%	31.1%	98.8%	30.9%	23.9%	4.8%	8.5%	11.4%	18.7%	9.7%	17.9%
4	0.0%	18.9%	0.0%	19.0%	26.0%	1.9%	10.6%	29.6%	17.9%	18.7%	17.2%
5	0.0%	21.3%	0.0%	21.4%	14.7%	1.4%	6.0%	23.2%	11.3%	13.3%	10.8%
6	0.0%	9.0%	0.0%	9.0%	4.7%	0.6%	0.6%	7.3%	3.8%	3.4%	3.7%
7	0.0%	5.5%	0.0%	5.5%	2.4%	0.6%	0.9%	3.4%	2.1%	1.9%	2.0%
8	0.0%	5.0%	0.0%	5.0%	1.3%	0.6%	0.5%	8.6%	1.5%	3.9%	1.4%
9+	0.0%	8.8%	0.0%	8.8%	1.9%	0.5%	1.5%	16.6%	2.1%	7.9%	2.1%
Sum 3+	0.2%	99.6%	98.8%	99.6%	74.8%	10.5%	28.4%	100.0%	57.5%	59.0%	55.0%
Quarter: 3											
0	60.6%	0.0%	0.0%	0.0%	0.0%	49.4%	3.3%	0.0%	19.5%	2.1%	24.6%
1	32.0%	0.6%	0.0%	0.6%	0.2%	3.2%	9.2%	0.6%	1.4%	6.2%	5.2%
2	6.4%	8.0%	11.9%	8.0%	11.9%	12.0%	46.6%	10.4%	11.9%	33.9%	11.2%
3	0.3%	32.6%	47.7%	32.5%	34.8%	9.7%	4.4%	12.3%	24.8%	7.2%	21.8%
4	0.5%	22.5%	8.9%	22.6%	17.8%	5.3%	16.3%	34.6%	12.9%	22.7%	11.4%
5	0.1%	11.7%	0.0%	11.8%	14.2%	8.0%	13.1%	27.6%	11.7%	18.2%	10.3%
6	0.1%	9.2%	9.1%	9.2%	7.7%	2.8%	1.9%	3.1%	5.8%	2.4%	5.1%
7	0.0%	6.2%	0.0%	6.2%	5.0%	2.9%	0.7%	4.1%	4.2%	1.9%	3.7%
8	0.0%	6.1%	14.6%	6.0%	4.0%	4.8%	2.5%	5.0%	4.4%	3.4%	3.8%
9+	0.0%	3.0%	7.9%	3.0%	4.4%	1.9%	2.0%	2.2%	3.4%	2.1%	3.0%
Sum 3+	1.0%	91.4%	88.1%	91.4%	87.9%	35.4%	41.0%	89.0%	67.2%	57.8%	59.0%
Quarter: 4											
0	56.1%	0.0%	0.0%	0.0%	0.0%	53.3%	24.2%	0.0%	35.1%	3.8%	29.4%
1	40.1%	2.4%	0.0%	2.7%	2.9%	18.0%	13.3%	0.7%	12.8%	2.7%	12.7%
2	2.9%	6.9%	0.0%	7.6%	31.2%	9.3%	41.1%	16.4%	13.5%	20.3%	14.2%
3	0.4%	28.3%	0.0%	31.4%	24.1%	6.2%	2.7%	10.0%	13.3%	8.8%	11.2%
4	0.4%	7.7%	3.8%	8.1%	8.8%	3.3%	10.8%	32.7%	5.1%	29.3%	10.5%
5	0.0%	4.0%	0.0%	4.5%	8.1%	2.2%	5.7%	23.7%	3.7%	20.9%	7.5%
6	0.1%	13.0%	15.5%	12.7%	9.9%	1.9%	0.5%	3.2%	5.0%	2.8%	4.1%
7	0.1%	10.1%	0.0%	11.2%	6.8%	1.5%	0.0%	5.6%	3.9%	4.8%	3.8%
8	0.0%	4.0%	11.9%	3.2%	2.4%	1.3%	1.6%	4.6%	1.8%	4.1%	2.2%
9+	0.0%	23.5%	68.8%	18.6%	5.6%	3.0%	0.0%	3.2%	5.7%	2.7%	4.5%
Sum 3+	0.9%	90.7%	100.0%	89.7%	65.9%	19.4%	21.4%	82.9%	38.6%	73.3%	43.7%

Table 2.2.6: Total catch of herring caught in the North Sea and Div. IIIa: North Sea autumn spawners (NSAS). Catch in numbers (millions) at mean weight-at-age (kg) by fleet, and SOP catches ('000 t). SOP catch might deviate from reported catch as used for the assessment.

2010	**Fleet A**		**Fleet B**		**Fleet C**		**Fleet D**		**TOTAL**	
Total Winter rings	Numbers	Mean Weight	Numbers	Mean Weight	Numbers	Mean Weight	Numbers	Mean Weight	**Numbers**	**Mean Weight**
0	0.0	0.000	594.7	0.007	0.1	0.028	48.6	0.007	**643.3**	**0.007**
1	49.1	0.086	34.5	0.051	120.5	0.072	76.6	0.016	**280.6**	**0.057**
2	237.4	0.139	6.6	0.086	39.4	0.080	4.0	0.040	**287.3**	**0.128**
3	229.6	0.167	3.8	0.184	0.3	0.122	0.0	0.114	**233.7**	**0.167**
4	123.1	0.192	1.1	0.143	0.1	0.149	0.0	0.000	**124.4**	**0.192**
5	79.8	0.222	3.6	0.205	0.1	0.191	0.0	0.000	**83.5**	**0.222**
6	57.5	0.222	5.6	0.191	0.0	0.221	0.0	0.000	**63.1**	**0.219**
7	34.2	0.217	0.0	0.000	0.1	0.216	0.0	0.000	**34.3**	**0.217**
8	59.4	0.234	0.0	0.000	0.0	0.205	0.0	0.000	**59.4**	**0.234**
9+	56.0	0.245	0.0	0.000	0.0	0.000	0.0	0.000	**56.0**	**0.245**
TOTAL	926.0		649.9		160.5		129.1		1,865.5	
SOP catch	**164.6**		**9.1**		**12.0**		**1.8**		**187.5**	

Figures for A fleet include 4 451 t unsampled bycatch in the industrial fishery

2011	**Fleet A**		**Fleet B**		**Fleet C**		**Fleet D**		**TOTAL**	
Total Winter rings	Numbers	Mean Weight	Numbers	Mean Weight	Numbers	Mean Weight	Numbers	Mean Weight	**Numbers**	**Mean Weight**
0	0.0	0.000	575.1	0.008	2.3	0.021	201.5	0.007	**778.9**	**0.008**
1	11.0	0.112	113.1	0.036	19.4	0.053	16.0	0.013	**159.5**	**0.041**
2	306.2	0.141	0.0	0.000	59.7	0.085	1.7	0.045	**367.7**	**0.132**
3	270.9	0.160	0.0	0.000	3.1	0.115	0.2	0.071	**274.1**	**0.159**
4	217.6	0.183	0.0	0.000	0.3	0.134	0.0	0.000	**217.9**	**0.183**
5	129.5	0.197	0.0	0.000	0.2	0.191	0.0	0.000	**129.7**	**0.197**
6	62.7	0.217	0.0	0.000	0.1	0.193	0.0	0.000	**62.8**	**0.217**
7	51.8	0.221	0.0	0.000	0.1	0.234	0.0	0.000	**51.9**	**0.221**
8	59.8	0.223	0.0	0.000	0.0	0.248	0.0	0.000	**59.8**	**0.223**
9+	65.3	0.240	0.0	0.000	0.0	0.000	0.0	0.000	**65.3**	**0.240**
TOTAL	1,174.8		688.3		85.1		219.5		2,167.6	
SOP catch	**207.2**		**8.8**		**6.6**		**1.8**		**224.4**	

Figures for A fleet include unsampled bycatch in the industrial fishery

2012	**Fleet A**		**Fleet B**		**Fleet C**		**Fleet D**		**TOTAL**	
Total Winter rings	Numbers	Mean Weight	Numbers	Mean Weight	Numbers	Mean Weight	Numbers	Mean Weight	**Numbers**	**Mean Weight**
0	1.0	0.035	626.4	0.010	0.6	0.027	145.2	0.012	**773.2**	**0.010**
1	42.6	0.086	67.4	0.038	70.6	0.065	104.2	0.023	**284.8**	**0.046**
2	404.4	0.131	7.2	0.111	35.5	0.073	7.6	0.040	**454.6**	**0.124**
3	667.1	0.171	4.2	0.131	1.8	0.124	0.0	0.085	**673.2**	**0.171**
4	402.7	0.185	0.0	0.000	1.1	0.169	0.0	0.000	**403.9**	**0.185**
5	305.3	0.206	0.7	0.195	0.2	0.175	0.0	0.000	**306.2**	**0.206**
6	149.5	0.222	1.4	0.160	0.2	0.199	0.0	0.000	**151.1**	**0.222**
7	104.3	0.239	0.0	0.000	0.1	0.220	0.0	0.000	**104.5**	**0.239**
8	89.1	0.240	0.4	0.184	0.0	0.216	0.0	0.000	**89.5**	**0.239**
9+	108.5	0.247	0.0	0.000	0.0	0.000	0.0	0.000	**108.5**	**0.247**
TOTAL	2,274.5		707.9		110.1		257.0		3,349.5	
SOP catch	**414.4**		**10.6**		**7.7**		**4.4**		**437.2**	

Figures for A fleet include unsampled bycatch in the industrial fishery

Table 2.2.7: Catch at age (numbers in millions) of North Sea herring, 1997-2012. SG Rednose's revisions are included.

Year/rings	0	1	2	3	4	5	6	7	8	9+	Total
1997	364	174	565	428	285	109	31	12	19	6	1993
1998	208	254	1084	525	267	179	89	14	17	4	2642
1999	968	73	487	1034	289	134	70	28	10	2	3096
2000	873	194	516	453	636	212	82	36	15	3	3019
2001	1025	58	678	473	279	319	92	39	18	2	2982
2002	319	490	513	913	294	136	164	47	34	7	2917
2003	347	172	1022	507	809	244	106	121	37	8	3375
2004	627	136	274	1333	517	721	170	100	70	22	3970
2005	919	408	203	487	1326	480	577	116	108	39	4664
2006	844	72	354	309	475	1017	257	252	65	44	3689
2007	553	46	142	413	284	307	628	147	133	23	2677
2008	713	148	260	183	199	137	118	215	74	43	2090
2009	533	98	253	108	96	88	40	58	112	34	1421
2010	526	84	243	234	124	84	63	34	59	56	1508
2011	575	124	306	271	218	130	63	52	60	66	1865
2012	627	110	412	671	403	306	151	104	89	109	2982

Table 2.2.8: Catch at age (numbers in millions) of WBSS Herring taken in the North Sea, and transferred to the assessment of the spring spawning stock in IIIa, 1997-2012.

Year/rings	0	1	2	3	4	5	6	7	8	9+	Total
1997	0.0	0.0	2.2	1.3	1.5	0.4	0.2	0.1	0.2	0.0	5.9
1998	0.0	5.1	9.5	12.0	10.1	6.0	3.0	0.4	0.9	0.0	47.0
1999	0.0	0.0	3.3	14.3	5.6	3.6	1.4	0.6	0.4	0.0	29.3
2000	0.0	0.0	8.2	9.8	10.2	5.7	2.5	0.6	0.7	0.1	37.6
2001	0.0	0.0	11.3	10.2	6.1	7.2	2.7	1.6	0.4	0.0	39.9
2002	0.0	0.0	7.6	14.8	10.6	3.3	2.9	1.0	0.5	0.1	40.8
2003	0.0	0.0	0.0	3.1	6.0	3.5	1.2	1.3	0.5	0.1	15.7
2004	0.0	0.0	15.1	27.9	3.5	4.1	1.0	0.5	0.1	0.0	52.3
2005	0.0	0.0	6.6	17.4	12.7	2.6	3.8	1.1	0.4	0.3	44.8
2006	0.0	0.1	3.5	8.8	14.0	22.4	5.1	5.3	2.1	1.0	62.2
2007	0.0	0.0	0.1	2.6	1.3	0.6	0.8	0.4	0.5	0.2	6.3
2008	0.0	0.0	0.1	0.1	0.2	0.1	0.1	0.2	0.0	0.0	0.7
2009	0.0	0.0	1.0	2.1	3.4	1.4	1.7	4.5	1.8	1.4	17.2
2010	0.0	0.0	0.0	0.5	1.0	0.4	0.5	0.3	0.3	0.7	3.8
2011	0.0	0.0	0.1	0.4	0.4	0.2	0.1	0.1	0.1	0.2	1.6
2012	0.0	0.0	0.0	0.2	0.4	0.0	1.4	0.0	1.1	6.3	9.4

Table 2.2.9: Catch at age (numbers in millions) of NSAS taken in IIIa, and transfered to the assessment of NSAS, 1997 - 2012. SG Rednose's revisions and revision of 2002 splitting are included.

Year/rings	0	1	2	3	4	5	6	7	8+	Total
1997	68	305	125	20	1	1	0	0	0	521
1998	51	729	145	25	19	3	3	1	0	977
1999	598	231	133	39	10	5	1	1	0	1017
2000	232	978	115	20	21	7	3	1	0	1377
2001	808	557	140	15	1	0	0	0	0	1521
2002	411	345	48	5	1	0	0	0	0	811
2003	22	445	182	13	16	2	1	1	0	682
2004	88	71	180	21	6	10	2	2	1	380
2005	96	307	159	16	5	2	2	0	0	590
2006	35	150	50	10	3	3	1	0	0	253
2007	68	189	77	2	0	1	0	1	0	339
2008	86	87	72	2	0	0	0	0	0	247
2009	117	78	7	0	0	0	0	0	0	202
2010	49	197	43	0	0	0	0	0	0	290
2011	204	35	61	3	0	0	0	0	0	305
2012	146	175	44	2	1	0	0	0	0	368

Table 2.2.10: Catch at age (numbers in millions) of the total NSAS stock 1997 - 2012. SG Rednose's revisions and the revision of 2002 splitting are included.

Year/rings	0	1	2	3	4	5	6	7	8	9+	Total
1997	431	480	688	447	285	109	31	12	19	6	2507
1998	260	978	1220	538	276	176	89	15	17	4	3572
1999	1566	304	616	1059	294	136	69	28	10	2	4084
2000	1105	1172	623	463	647	213	82	36	15	2	4358
2001	1833	614	806	477	274	312	89	37	17	2	4463
2002	730	835	553	903	284	133	161	46	33	7	3687
2003	369	617	1204	517	820	243	106	120	37	8	4042
2004	716	207	439	1326	520	726	171	101	71	22	4298
2005	1016	716	355	486	1318	480	576	115	108	39	5209
2006	879	222	401	311	465	999	253	249	63	44	3885
2007	621	236	219	412	283	308	628	147	132	23	3009
2008	798	235	332	185	199	137	118	215	74	43	2336
2009	650	176	259	107	93	86	38	53	110	33	1606
2010	575	281	287	233	123	83	63	34	59	55	1794
2011	779	160	368	274	218	130	63	52	60	65	2168
2012	773	285	455	673	404	306	150	104	88	102	3341

Table 2.2.11: Comparison of mean weight (kg) at age (rings) in the catch of adult North Sea herring (by Div.) and NSAS caught in Div. IIIa in 2002 – 2012. SG Rednose's revisions are included.

		Age (Rings)							
Div.	Year	2	3	4	5	6	7	8	9+
IIIa	2002	0.104	0.126	0.144	0.164	0.180	0.180	0.218	-
	2003	0.067	0.123	0.150	0.163	0.191	0.214	0.187	-
	2004	0.070	0.121	0.141	0.152	0.170	0.187	0.178	-
	2005	0.071	0.106	0.155	0.173	0.185	0.200	0.209	-
	2006	0.079	0.117	0.140	0.186	0.191	0.216	0.207	-
	2007	0.071	0.108	0.125	0.152	0.184	0.175	0.154	-
	2008	0.087	0.109	0.139	0.168	0.176	0.204	0.198	-
	2009	0.101	0.082	0.206	0.000	0.000	0.000	0.269	-
	2010	0.077	0.122	0.149	0.191	0.221	0.216	0.205	-
	2011	0.084	0.114	0.134	0.191	0.193	0.234	0.248	-
	2012	0.067	0.124	0.169	0.175	0.200	0.221	0.216	-
IVa(E)	2002	0.130	0.154	0.167	0.189	0.198	0.212	0.229	0.238
	2003	0.122	0.154	0.162	0.177	0.189	0.203	0.213	0.218
	2004	0.119	0.133	0.171	0.185	0.212	0.192	0.218	0.252
	2005	0.117	0.146	0.153	0.202	0.209	0.233	0.262	0.265
	2006	0.125	0.149	0.164	0.175	0.214	0.224	0.229	0.254
	2007	0.156	0.148	0.156	0.186	0.184	0.204	0.226	0.239
	2008	0.138	0.173	0.172	0.174	0.216	0.210	0.253	0.266
	2009	0.139	0.167	0.208	0.219	0.232	0.245	0.253	0.288
	2010	0.131	0.154	0.201	0.201	0.210	0.223	0.248	0.235
	2011	0.142	0.162	0.180	0.204	0.215	0.209	0.216	0.222
	2012	0.146	0.185	0.195	0.203	0.216	0.225	0.225	0.232
IVa(W)	2002	0.144	0.161	0.191	0.211	0.230	0.242	0.261	0.263
	2003	0.130	0.167	0.184	0.202	0.224	0.237	0.259	0.276
	2004	0.131	0.155	0.193	0.220	0.242	0.251	0.246	0.299
	2005	0.122	0.158	0.174	0.213	0.229	0.245	0.275	0.267
	2006	0.145	0.156	0.180	0.193	0.230	0.251	0.247	0.286
	2007	0.150	0.156	0.166	0.196	0.191	0.227	0.241	0.264
	2008	0.142	0.187	0.187	0.188	0.230	0.219	0.262	0.281
	2009	0.152	0.180	0.211	0.223	0.266	0.251	0.252	0.278
	2010	0.137	0.166	0.195	0.223	0.220	0.216	0.236	0.252
	2011	0.141	0.161	0.185	0.195	0.216	0.223	0.220	0.243
	2012	0.132	0.184	0.186	0.206	0.226	0.240	0.242	0.254
IVb	2002	0.086	0.149	0.161	0.206	0.214	0.189	0.270	0.241
	2003	0.098	0.161	0.178	0.195	0.214	0.214	0.222	0.281
	2004	0.118	0.143	0.186	0.214	0.234	0.239	0.297	0.308
	2005	0.132	0.172	0.187	0.217	0.220	0.245	0.253	0.252
	2006	0.097	0.141	0.172	0.183	0.202	0.220	0.232	0.239
	2007	0.145	0.160	0.180	0.201	0.210	0.246	0.234	0.252
	2008	0.142	0.172	0.185	0.191	0.222	0.228	0.265	0.223
	2009	0.140	0.188	0.228	0.219	0.223	0.243	0.255	0.255
	2010	0.134	0.176	0.182	0.229	0.237	0.235	0.232	0.265
	2011	0.145	0.162	0.187	0.206	0.235	0.234	0.240	0.268
	2012	0.131	0.141	0.178	0.209	0.214	0.245	0.250	0.258

Table 2.2.11 continued: Comparison of mean weight (kg) at age (rings) in the catch of adult North Sea herring (by Div.) and NSAS caught in Div. IIIa in 2002 – 2012. SG Rednose's revisions are included.

		Age (Rings)							
Div.	**Year**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9+**
IVa & IVb	2002	0.119	0.157	0.177	0.203	0.219	0.228	0.253	0.253
	2003	0.113	0.163	0.178	0.190	0.210	0.225	0.239	0.255
	2004	0.122	0.147	0.187	0.210	0.227	0.233	0.247	0.266
	2005	0.121	0.157	0.172	0.212	0.225	0.242	0.269	0.265
	2006	0.123	0.150	0.174	0.187	0.222	0.239	0.238	0.269
	2007	0.149	0.155	0.165	0.196	0.192	0.227	0.238	0.257
	2008	0.142	0.182	0.185	0.188	0.226	0.220	0.262	0.275
	2009	0.142	0.183	0.217	0.221	0.248	0.248	0.253	0.277
	2010	0.136	0.167	0.192	0.224	0.222	0.220	0.236	0.250
	2011	0.142	0.161	0.184	0.198	0.220	0.224	0.224	0.243
	2012	0.132	0.171	0.185	0.207	0.222	0.239	0.243	0.248
IVc & VIId	2002	0.108	0.123	0.153	0.170	0.187	0.219	0.208	-
	2003	0.103	0.127	0.144	0.168	0.176	0.188	0.200	0.227
	2004	0.099	0.113	0.135	0.162	0.184	0.191	0.186	0.224
	2005	0.122	0.132	0.139	0.170	0.207	0.228	0.237	0.245
	2006	0.119	0.125	0.153	0.152	0.178	0.205	0.209	0.219
	2007	0.129	0.131	0.154	0.158	0.173	0.196	0.209	0.218
	2008	0.120	0.157	0.156	0.173	0.188	0.192	0.215	0.247
	2009	0.156	0.162	0.197	0.197	0.211	0.192	0.219	0.244
	2010	0.145	0.167	0.187	0.204	0.207	0.207	0.223	0.216
	2011	0.122	0.154	0.179	0.189	0.195	0.205	0.209	0.217
	2012	0.119	0.165	0.186	0.202	0.212	0.234	0.209	0.226
Total North Sea Catch	2002	0.118	0.153	0.170	0.199	0.214	0.228	0.250	0.252
	2003	0.104	0.158	0.174	0.184	0.205	0.222	0.232	0.256
	2004	0.100	0.138	0.183	0.201	0.216	0.228	0.246	0.272
	2005	0.099	0.153	0.166	0.208	0.223	0.240	0.257	0.278
	2006	0.122	0.145	0.172	0.181	0.220	0.237	0.235	0.262
	2007	0.149	0.152	0.164	0.194	0.190	0.224	0.235	0.252
	2008	0.141	0.180	0.181	0.183	0.216	0.216	0.256	0.273
	2009	0.145	0.181	0.216	0.216	0.239	0.243	0.248	0.273
	2010	0.138	0.167	0.192	0.222	0.219	0.217	0.234	0.245
	2011	0.141	0.160	0.183	0.197	0.217	0.221	0.223	0.240
	2012	0.130	0.171	0.185	0.206	0.222	0.239	0.239	0.247

Values for total NS catch updated in 2006 for the years 2001-2005 due to an incorrect allocation of fish in the plus group in the Danish catches and new information of misreporting from the UK.

Table 2.2.12: Sampling of commercial landings of North Sea herring (Div. IV and VIId) in 2012 by quarter. Sampled catch means the proportion of the reported catch to which sampling was applied. It is not possible to judge the quality of the sampling by this figure alone. Note that only one nation sampled their by-catches in the industrial fishery (Denmark, fleet B). Metiers are each *reported* combination of nation/fleet/area/quarter.

Country (fleet)	Quarter	No of metiers	Metiers sampled	Sampled Catch %	Official Catch	No. of samples	No. fish aged	No. fish measured	>1 sample per 1 kt catch
Denmark (A)	1	3	2	99%	23494	27	477	3929	n
	2	2	2	100%	3835	11	189	1576	y
	3	3	2	97%	59000	22	606	3046	n
	4	3	2	96%	8740	3	81	413	n
total		11	8	98%	95069	63	1353	8964	n
Denmark (B)	1	2	1	100%	118	1	7	7	y
	3	3	1	99%	2380	6	124	126	y
	4	3	2	100%	6021	15	258	260	y
total		9	4	100%	8928	22	389	393	y
England and Wales*	1	3	0	0%	444	0	0	0	n
	2	4	2	98%	1381	8	200	1249	y
	3	3	1	15%	19448	6	150	787	n
	4	3	0	0%	4072	0	0	0	n
total		13	3	17%	25346	14	350	2036	n
France	1	3	0	0%	1337	0	0	0	n
	2	4	0	0%	3346	0	0	0	n
	3	4	0	0%	11716	0	0	0	n
	4	3	0	0%	7418	0	0	0	n
total		14	0	0%	23817	0	0	0	n
Germany	3	2	1	91%	14120	5	471	835	y
	4	3	3	100%	10395	16	1035	3905	y
total		5	4	95%	24514	21	1506	4740	y
Netherlands	1	3	2	69%	2181	10	249	1564	y
	2	2	2	114%	3472	16	399	3425	y
	3	2	2	93%	48856	74	1850	7213	y
	4	4	2	99%	17834	11	275	1964	n
total		11	8	95%	72344	111	2773	14166	y
Norway	1	2	1	56%	2515	1	30	100	n
	2	3	2	100%	60684	34	1233	2621	n
	3	3	2	97%	12562	6	198	349	n
	4	3	2	72%	43492	8	337	656	n
total		11	7	89%	119253	49	1798	3726	n
Scotland	1	1	1	100%	1075	1	58	170	y
	2	2	1	91%	2823	7	340	1205	y
	3	2	1	97%	30367	24	1072	4266	y
	4	2	0	0%	149	0	0	0	n
total		7	3	97%	34414	32	1470	5641	y
Sweden	2	3	0	0%	7190	0	0	0	n
	3	2	0	0%	3555	0	0	0	n
	4	1	0	0%	3347	0	0	0	n
total		6	0	0%	14092	0	0	0	n
Northern Ireland	1	1	0	0%	335	0	0	0	n
	3	1	0	0%	4264	0	0	0	n
	4	1	0	0%	195	0	0	0	n
total		3	0	0%	4794	0	0	0	n
Belgium	4	2	0	0%	3	0	0	0	n
total		2	0	0%	3	0	0	0	n
grand total		88	37	80%	424284	368	9942	41092	n
Period total	1	16	6	87%	31381	39	814	5763	y
Period total	2	21	10	87%	83425	77	2456	10172	n
Period total	3	23	10	79%	206045	157	4690	17474	n
Period total	4	28	11	73%	103433	95	1982	7683	n
Total for stock 2012		88	37	80%	424284	368	9942	41092	n
Human Cons. only		83	33	79%	413646	290	9250	39273	n
Total for stock 2010		85	37	81%	174628.28	294	9917	46589	y
Total for stock 2011		84	36	84%	218399	241	7621	30992	y
Human Cons. only 2011		75	32	82%	209471	219	7232	30599	y

* majority of catches landed to IJmuiden, the Netherlands

Table 2.3.1.1. North Sea herring. Acoustic Surveys in the North Sea (HERAS) in June-July 2012. Vessels, areas and cruise dates.

Vessel	Period	Area	Rectangles
Celtic Explorer (IR)	09 July – 26 July	53°-58.6°N ,12°-7°W	35D8-D9, 36D8-D9, 37D9-E1, 38D9-E1, 39E0-E2, 40E0-E2,41E0-E3, 42E0-E3, 43E0-E3, 44E0-E3, 45E0-E4
Scotia & Charter vessel (SCO)	30 June – 23 July	58°30′-62°N, 4°W-2°E	46E2-F1, 47E3-F1, 48E4-F1, 49E5-F1, 50E7-F1, 51E8-F1
Johan Hjort (NOR)	25 June – 23 July	56°30-62°N, 2°-5°E	42F2-F5, 43F2-F5, 44F2-F5, 45F2-F5, 46F2-F4, 47F2-F4, 48F2-F4, 49F2-F4, 50F2-F4, 51F2-F4, 52F2-F4
Tridens (NED)	25 June – 20 July	54°09– 58°16′N, 3° W–6°E	37E9-F1, 38E8-F1, 39E8-F1, 40E8-F5, 41E7-F5, 42E7-F1, 43E7-F1, 44E6-F1, 45E6-F1
Solea (GER) DBFH	29 June – 19 July	52°-56°N, Eng to Den/Ger coasts	34F2-F4, 35F2-F4, 36F3-F7, 37F2-F8, 38F3-F7, 39F3-F7, 40F6-F7
Dana (DEN) OXBH	3 July – 16 July	Kattegat and North of 56°N, east of 6°E	41 F6-F7, 41G1-G2, 42F6-F7, 42G0-G2, 43F6-G1, 44F6-G1, 45F8-G1, 46F9-G0

Table 2.3.1.2. North Sea herring. Acoustic Surveys in the North Sea (HERAS) in June-July 2012. Total numbers (millions of fish) and biomass (thousands of tonnes) of North Sea autumn spawning herring in the area surveyed in the pelagic acoustic surveys, with mean weight and mean length by age ring.

Age (ring)	Numbers	Biomass	Maturity	Weight (g)	Length (cm)
0	2936	16	0.00	5.3	9.2
1	7437	357	0.00	48.1	18.3
2	4719	588	0.91	124.7	23.9
3	4067	782	0.99	192.4	27.3
4	1738	340	1.00	195.4	27.7
5	1209	256	1.00	211.6	28.4
6	593	137	1.00	231.5	29.2
7	247	60	1.00	241.9	29.6
8	218	52	1.00	239.0	29.6
9+	478	116	1.00	242.8	29.7
Immature	10973	435		39.6	15.9
Mature	12668	2269		179.1	26.8
Total	23641	2704	0.54	114.38	21.77

Table 2.3.2.1: North Sea herring – LAI, MLAI, and SCAI time-series of herring larval abundance <10 mm long (<11 mm for the SNS), by standard sampling area and time periods. The number of larvae are expressed as mean number per ICES rectangle * 10^9

	Orkney/ Shetland		Buchan		Central North Sea			Southern North Sea			MLAI	SCAI
Period	1–15 Sep.	16–30 Sep.	1–15 Sep.	16–30 Sep.	1–15 Sep.	16–30 Sep.	1–15 Oct.	16–31 Dec.	1–15 Jan.	16–31 Jan.		
1972	1133	4583	30		165	88	134	2	46			3334
1973	2029	822	3	4	492	830	1213			1	13.0	3286
1974	758	421	101	284	81		1184		10		7.7	2210
1975	371	50	312			90	77	1	2		2.8	1372
1976	545	81		1	64	108			3		2.5	1217
1977	1133	221	124	32	520	262	89	1			6.1	1624
1978	3047	50		162	1406	81	269	33	3		7.3	2130
1979	2882	2362	197	10	662	131	507		111	89	13.5	3236
1980	3534	720	21	1	317	188	9	247	129	40	9.2	3543
1981	3667	277	3	12	903	235	119	1456		70	13.5	4054
1982	2353	1116	340	257	86	64	1077	710	275	54	19.8	5089
1983	2579	812	3647	768	1459	281	63	71	243	58	25.3	7779
1984	1795	1912	2327	1853	688	2404	824	523	185	39	45.6	12195
1985	5632	3432	2521	1812	130	13039	1794	1851	407	38	69.9	15236
1986	3529	1842	3278	341	1611	6112	188	780	123	18	36.4	14518
1987	7409	1848	2551	670	799	4927	1992	934	297	146	64.7	18443
1988	7538	8832	6812	5248	5533	3808	1960	1679	162	112	128.5	26213
1989	11477	5725	5879	692	1442	5010	2364	1514	2120	512	127.2	22243
1990		10144	4590	2045	19955	1239	975	2552	1204		164.9	20829
1991	1021	2397		2032	4823	2110	1249	4400	873		87.8	14280
1992	189	4917		822	10	165	163	176	1616		40.4	7425
1993		66		174		685	85	1358	1103		28.4	5049
1994	26	1179				1464	44	537	595		20.0	4333
1995		8688					43	74	230	164	20.2	5400
1996		809		184		564		337	675	691	40.2	7022
1997		3611		23				9374	918	355	52.9	10145
1998		8528		1490	205	66		1522	953	170	65.9	13250
1999		4064		185		134	181	804	1260	344	55.6	14279
2000		3352	28	83		376		7346	338	106	37.2	16318
2001		11918		164		1604		971	5531	909	124.0	21780
2002		6669		1038			3291	2008	260	925	104.3	26083
2003		3199		2263		12018	3277	12048	3109	1116	249.9	34332
2004		7055		3884		5545		7055	2052	4175	308.9	37733
2005		3380		1364		5614		498	3999	4822	184.7	32190
2006	6311	2312		280		2259		10858	2700	2106	112.8	30004
2007		1753		1304		291		4443	2439	3854	159.9	31009
2008	4978	6875		533		11201		8426	2317	4008	179.9	38187
2009		7543		4629		4219		15295	14712	1689	464.3	49186
2010		2362		1493		2317		7493	13230	8073	379.5	51153
2011		3831		2839		17766		5461	6160	1215	313.0	53284
2012		19552		5856		517		22768	11103	3285	658.9	69188

Table 2.3.3.1 North Sea herring. Density and abundance estimates of 0-ringers caught in February during the IBTS. Values given for year classes by areas are density estimates in numbers per square metre. Total abundance is found by multiplying density by area and summing up.

Area	North west	North east	Central west	Central east	South west	South east	Div. IIIa	South' Bight	IBTS-0 index
Area m^2 x 10^9	83	34	86	102	37	93	31	31	
Year class									no. in 10^9
1976	0.054	0.014	0.122	0.005	0.008	0.002	0.002	0.016	17.1
1977	0.024	0.024	0.05	0.015	0.056	0.013	0.006	0.034	13.1
1978	0.176	0.031	0.061	0.02	0.01	0.005	0.074	0	52.1
1979	0.061	0.195	0.262	0.408	0.226	0.143	0.099	0.053	101.1
1980	0.052	0.001	0.145	0.115	0.089	0.339	0.248	0.187	76.7
1981	0.197	0	0.289	0.199	0.215	0.645	0.109	0.036	133.9
1982	0.025	0.011	0.068	0.248	0.29	0.309	0.47	0.14	91.8
1983	0.019	0.007	0.114	0.268	0.271	0.473	0.339	0.377	115
1984	0.083	0.019	0.303	0.259	0.996	0.718	0.277	0.298	181.3
1985	0.116	0.057	0.421	0.344	0.464	0.777	0.085	0.084	177.4
1986	0.317	0.029	0.73	0.557	0.83	0.933	0.048	0.244	270.9
1987	0.078	0.031	0.417	0.314	0.159	0.618	0.483	0.495	168.9
1988	0.036	0.02	0.095	0.096	0.151	0.411	0.181	0.016	71.4
1989	0.083	0.03	0.04	0.094	0.013	0.035	0.041	0	25.9
1990	0.075	0.053	0.202	0.158	0.121	0.198	0.086	0.196	69.9
1991	0.255	0.39	0.431	0.539	0.5	0.369	0.298	0.395	200.7
1992	0.168	0.039	0.672	0.444	0.734	0.268	0.345	0.285	190.1
1993	0.358	0.212	0.26	0.187	0.12	0.119	0.223	0.028	101.7
1994	0.148	0.024	0.417	0.381	0.332	0.148	0.252	0.169	126.9
1995	0.26	0.086	0.699	0.092	0.266	0.018	0.001	0.02	106.2
1996	0.003	0.004	0.935	0.135	0.436	0.379	0.039	0.032	148.1
1997	0.042	0.021	0.338	0.064	0.178	0.035	0.023	0.083	53.1
1998	0.1	0.056	1.15	0.592	0.998	0.265	0.28	0.127	244.0
1999	0.045	0.011	0.799	0.2	0.514	0.22	0.107	0.026	137.1
2000	0.284	0.011	1.052	0.197	1.156	0.376	0.063	0.006	214.8
2001	0.08	0.019	0.566	0.473	0.567	0.247	0.209	0.226	161.8
2002	0.141	0.04	0.287	0.028	0.121	0.045	0.003	0.157	54.4
2003	0.045	0.005	0.284	0.074	0.106	0.021	0.022	0.154	47.3
2004	0.017	0.010	0.189	0.089	0.268	0.187	0.027	0.198	61.3
2005	0.013	0.018	0.327	0.081	0.633	0.184	0.007	0.131	83.1
2006	0.004	0.001	0.240	0.025	0.098	0.018	0.040	0.228	37.2
2007	0.013	0.009	0.184	0.029	0.067	0.047	0.018	0.007	27.8
2008	0.145	0.139	0.277	0.241	0.101	0.093	0.160	0.433	95.8
2009	0.077	0.085	0.228	0.073	0.350	0.253	0.000	0.139	77.1
2010	0.024	0.004	0.586	0.063	0.187	0.090	0	0.080	77.0
2011	0.008	0.001	0.345	0.136	0.215	0.129	0.076	0.040	68.0
2012	0.018	0.005	0.198	0.094	0.108	0.181	0.006	0.038	50.4

Table 2.3.3.2. North Sea herring. Indices of 1-ringers from the IBTS 1st Quarter. Estimation of the small sized component (possibly Downs herring) in different areas. " North Sea" = total area of sampling minus IIIa.

Year class	Year of sampling	All1-ringers in total area (IBTS-1 index) (no/hour)	Small<13cm 1-ringers in total area (no/hour)	Proportion of small in total area vs. all sizes	Small<13cm 1-ringers in North Sea (no/hour)	Proportion of small in North Sea vs. all sizes	Proportion of small in IIIa vs small in total area
1977	1979	168	11	0.07	12	0.07	0
1978	1980	316	108	0.34	106	0.34	0.09
1979	1981	495	51	0.10	41	0.08	0.25
1980	1982	798	177	0.22	185	0.23	0.03
1981	1983	1270	192	0.15	185	0.15	0.10
1982	1984	1516	346	0.23	297	0.20	0.20
1983	1985	2097	315	0.15	298	0.14	0.12
1984	1986	2663	596	0.22	390	0.15	0.39
1985	1987	3693	628	0.17	529	0.14	0.22
1986	1988	4394	2371	0.54	720	0.16	0.72
1987	1989	2332	596	0.26	531	0.23	0.17
1988	1990	1062	70	0.07	62	0.06	0.18
1989	1991	1287	330	0.26	337	0.26	0.05
1990	1992	1268	125	0.10	130	0.10	0.03
1991	1993	2794	676	0.24	176	0.06	0.76
1992	1994	1752	283	0.16	240	0.14	0.21
1993	1995	1346	449	0.33	445	0.33	0.08
1994	1996	1891	604	0.32	467	0.25	0.28
1995	1997	4405	1356	0.31	1089	0.25	0.25
1996	1998	2276	1322	0.58	1399	0.61	0.02
1997	1999	753	152	0.20	149	0.20	0.09
1998	2000	3725	1117	0.30	991	0.27	0.17
1999	2001	2499	328	0.13	307	0.12	0.13
2000	2002	4065	1553	0.38	1471	0.36	0.12
2001	2003	2837	664	0.23	180	0.06	0.75
2002	2004	979	665	0.68	710	0.73	0.01
2003	2005	1010	340	0.34	357	0.35	0.03
2004	2006	893	115	0.13	121	0.14	0.02
2005	2007	1321	303	0.23	304	0.23	0.07
2006	2008	1792	417	0.23	444	0.25	0.011
2007	2009	2340	734	0.31	623	0.27	0.211
2008	2010	1323	279	0.21	286	0.22	0.046
2009	2011	2937	1331	0.45	1407	0.48	0.018
2010	2012	1353	279	0.21	288	0.21	0.041
2011	2013	**1651**	738	0.45	785	0.48	0.011

Table 2.4.1.1. North Sea herring. Mean stock weight-at-age (wr) in the third quarter, in Divisions IVa, IVb and IIIa. Mean catch weight-at-age for the same quarter and area is included for comparison. Weights-at-age in the catch for 1996 to 2001 were revised by SG Rednose, for details of the revision see the 2007 report (ICES CM 2007/ACFM:11). AS = acoustic survey, 3Q = catch.

W. rings	**1**		**2**		**3**		**4**		**5**		**6**		**7**		**8**		**9+**	
Year	AS	3Q	AS	3Q	AS	3Q	AS	3Q	AS	3Q	AS	3Q	AS	3Q	AS	3Q	AS	3Q
1996	45	75	119	135	196	186	253	224	262	229	299	253	306	292	325	300	335	302
1997	45	43	120	129	168	175	233	220	256	247	245	255	265	278	269	295	329	295
1998	52	54	109	131	198	172	238	209	275	237	307	263	289	269	308	313	363	298
1999	52	62	118	128	171	163	207	193	236	228	267	252	272	263	230	275	260	306
2000	46	54	118	123	180	172	218	201	232	228	261	241	295	266	300	286	280	271
2001	50	69	127	136	162	167	204	199	228	218	237	237	255	262	286	288	294	298
2002	45	50	138	140	172	177	194	200	224	224	247	244	261	252	280	281	249	298
2003	46	65	104	119	185	177	209	198	214	210	243	236	281	247	290	272	307	282
2004	35	45	116	125	139	159	206	203	231	234	253	250	262	264	279	262	270	299
2005	43	53	135	124	171	177	181	201	229	234	248	249	253	261	274	287	295	270
2006	45	61	127	139	158	163	188	192	188	205	225	242	243	257	244	260	265	285
2007	66	75	123	153	155	171	171	183	204	215	198	211	218	252	247	263	233	273
2008	62	67	141	151	180	192	183	207	194	211	230	240	217	243	268	276	282	312
2009	56	56	148	166	208	217	236	242	232	259	240	261	266	274	249	274	263	292
2010	38	74	138	150	183	190	229	222	245	245	233	239	237	248	252	265	251	271
2011	35	86	151	155	171	176	210	201	242	227	258	244	249	246	252	253	275	267
2012	48	61	125	142	192	198	194	205	212	223	232	223	242	251	239	256	243	268

Table 2.4.2.1. North Sea herring. Percentage maturity at 2, 3, 4 and 5+ ring for autumn spawning herring in the North Sea. The values are derived from the acoustic survey for 1988 to 2012.

Year \ Ring	2	3	4	5+
1988	65.6	87.7	100	100
1989	78.7	93.9	100	100
1990	72.6	97.0	100	100
1991	63.8	98.0	100	100
1992	51.3	100	100	100
1993	47.1	62.9	100	100
1994	72.1	85.8	100	100
1995	72.6	95.4	100	100
1996	60.5	97.5	100	100
1997	64.0	94.2	100	100
1998	64.0	89.0	100	100
1999	81.0	91.0	100	100
2000	66.0	96.0	100	100
2001	77.0	92.0	100	100
2002	86.0	97.0	100	100
2003	43.0	93.0	100	100
2004	69.8	64.9	100	100
2005	76.0	97.0	96.0	100
2006	66.0	88.0	98.0	100
2007	71.0	92.0	93.0	100
2008	86.0	98.0	99.0	100
2009	89.0	100	100	100
2010	45.0	90.0	100	100
2011	87.0	84.0	99.0	100
2012	91.0	99.0	100	100

Table 2.6.1.1 North Sea herring. Years of duration of survey and years used in the assessment.

Survey	Age range	Years survey has been running	Years used in assessment
SCAI (Larvae survey)	SSB	1972-2012	1973-2012
IBTS 1st Quarter (Trawl survey)	1-wr	1971-2013	1984-2013
Acoustic (+trawl)	1wr	1995-2012	1997-2012
	2-9+wr	1984-2012	1989-2012
IBTS0	0wr	1977-2013	1992-2013

TABLE 2.6.3.1 North Sea Herring. CATCH IN NUMBER

Units : thousands

year

age	1947	1948	1949	1950	1951	1952	1953	1954	1955
0	0	0	0	0	0	0	150000	219000	164000
1	0	3000	0	0	462000	722000	1023000	1451000	2072000
2	494000	247000	478000	535000	660000	1346000	1322000	1493000	1931000
3	415000	672000	644000	1039000	959000	576000	1003000	1111000	1032000
4	638000	328000	396000	617000	1255000	610000	474000	591000	479000
5	526000	601000	287000	290000	630000	652000	386000	361000	337000
6	756000	487000	652000	254000	262000	464000	473000	330000	232000
7	431000	400000	462000	331000	142000	236000	278000	379000	120000
8	1311000	917000	1037000	597000	445000	554000	392000	511000	215000

year

age	1956	1957	1958	1959	1960	1961	1962	1963	1964
0	96000	279000	97000	0	194600	1269200	141800	442800	496900
1	1697000	1483000	4279000	1609000	2392700	336000	2146900	1262200	2971700
2	1860000	1644000	1029000	4934000	1142300	1889400	269600	2961200	1547500
3	1221000	736000	999000	488000	1966700	479900	797400	177200	2243100
4	516000	644000	322000	497000	165900	1455900	335100	158300	148400
5	249000	344000	461000	233000	167700	124000	1081800	80600	149000
6	194000	207000	147000	249000	112900	157900	126900	229700	95000
7	104000	147000	73000	120000	125800	61400	145100	22400	256300
8	292000	253000	118000	301000	270600	143500	173100	93000	84000

year

age	1965	1966	1967	1968	1969	1970	1971	1972	1973
0	157100	374500	645400	839300	112000	898100	684000	750400	289400
1	3209300	1383100	1674300	2425000	2503300	1196200	4378500	3340600	2368000
2	2217600	2569700	1171500	1795200	1883000	2002800	1146800	1440500	1344200
3	1324600	741200	1364700	1494300	296300	883600	662500	343800	659200
4	2039400	450100	371500	621400	133100	125200	208300	130600	150200
5	145100	889800	297800	157100	190800	50300	26900	32900	59300
6	151900	45300	393100	145000	49900	61000	30500	5000	30600
7	117600	64800	67900	163400	42700	7900	26800	200	3700
8	491400	331800	254400	105500	52500	24200	12500	1500	2000

year

age	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
0	996100	263800	238200	256800	NA	NA	1262700	9519700	11956700	13296900
1	846100	2460500	126600	144300	NA	NA	245100	872000	1116400	2448600
2	772600	541700	901500	44700	NA	NA	134000	284300	299400	573800
3	362000	259600	117300	186400	NA	NA	91800	56900	230100	216400
4	126000	140500	52000	10800	NA	NA	32200	39500	33700	105100
5	56100	57200	34500	7000	NA	NA	21700	28500	14400	26200
6	22300	16100	6100	4100	NA	NA	2300	22700	6800	22800
7	5000	9100	4400	1500	NA	NA	1400	18700	7800	12800
8	3100	4800	1400	700	NA	NA	500	6600	4700	23100

year

age	1984	1985	1986	1987	1988	1989	1990	1991	1992
0	6973300	4211000	3724700	8229200	3164800	3057800	1302800	2386600	10331300
1	1818400	3253000	4801400	6836300	7867000	3145900	3020000	2138900	2303100
2	1146200	1326300	1266700	2137200	2232500	1593700	899300	1132800	1284900
3	441400	1182400	840800	667900	1090700	1363800	779100	556700	442700
4	201500	368500	465900	467100	383700	809300	861000	548900	361500
5	81100	124500	129800	245800	255800	211800	387500	501200	360500
6	22600	43600	62100	74700	128100	123700	80200	205300	375600
7	25200	20200	20500	23800	38000	61000	54400	39300	152400
8	29700	29200	28400	16200	23800	28200	40700	38600	62500

year

age	1993	1994	1995	1996	1997	1998	1999	2000	2001
0	10265400	4498900	7438469	2311226	431175	259526	1566349	1105085	1832691
1	3826800	1785200	1664874	1606393	479702	977680	303520	1171677	614469
2	1176300	1783200	1444061	642084	687920	1220105	616354	622853	842635
3	609000	489100	816703	525601	446909	537932	1058716	463170	485628
4	305500	347600	231794	172099	284920	276333	294066	646814	278884
5	215600	109000	118536	57586	109178	175817	135648	213466	321743
6	226000	91800	55128	22534	31389	88927	69299	82481	90918
7	188000	76400	41409	9264	11832	15232	27998	35706	38252
8	129000	116600	98200	21143	24467	20550	12228	17087	20602

year

age	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
0	730279	369074	715597	1015554	878637	621005	798284	650043	574895	778927
1	837557	617021	206648	715547	222111	235553	235022	175923	280728	159504
2	579592	1221992	447918	355453	401087	219115	331772	259434	293887	367820
3	970577	529386	1366155	485746	310602	417452	184771	106738	236804	275016

TABLE 2.6.3.1 (cont) North Sea Herring. CATCH IN NUMBER

4	292205	835552	543376	1318647	464620	285746	199069	93321	126241	218711
5	140701	244780	753231	479961	997782	309454	137529	86137	83893	130127
6	174570	107751	169324	576154	252150	629187	118349	37951	61542	62938
7	48908	123291	104945	115212	247042	147830	215542	53130	33305	52081
8	43322	46715	97142	146808	106412	156750	117258	143131	113675	125734

year

age	2012
0	773241
1	284906
2	455259
3	673465
4	404265
5	306234
6	152577
7	104461
8	205427

TABLE 2.6.3.2 North Sea Herring. WEIGHTS AT AGE IN THE CATCH

Units : kg

year

age	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956	1957
0	0.015	0.015	0.0150	0.015	0.0150	0.015	0.015	0.0150	0.0150	0.015	0.0150
1	0.050	0.050	0.0500	0.050	0.0500	0.050	0.050	0.0500	0.0500	0.050	0.0500
2	0.122	0.122	0.1280	0.128	0.1340	0.137	0.137	0.1390	0.1400	0.140	0.1410
3	0.140	0.140	0.1450	0.151	0.1570	0.165	0.167	0.1690	0.1700	0.172	0.1730
4	0.156	0.156	0.1610	0.166	0.1760	0.183	0.190	0.1930	0.1950	0.197	0.1980
5	0.171	0.171	0.1760	0.180	0.1890	0.199	0.205	0.2110	0.2140	0.216	0.2180
6	0.185	0.185	0.1890	0.193	0.2010	0.210	0.218	0.2230	0.2280	0.231	0.2330
7	0.197	0.197	0.2010	0.204	0.2110	0.219	0.226	0.2330	0.2380	0.242	0.2440
8	0.242	0.242	0.2435	0.245	0.2475	0.251	0.254	0.2565	0.2595	0.261	0.2625

year

age	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969
0	0.0150	0.0150	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015
1	0.0500	0.0500	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
2	0.1410	0.1430	0.126	0.126	0.126	0.126	0.126	0.126	0.126	0.126	0.126	0.126
3	0.1740	0.1760	0.176	0.176	0.176	0.176	0.176	0.176	0.176	0.176	0.176	0.176
4	0.1990	0.2010	0.211	0.211	0.211	0.211	0.211	0.211	0.211	0.211	0.211	0.211
5	0.2190	0.2210	0.243	0.243	0.243	0.243	0.243	0.243	0.243	0.243	0.243	0.243
6	0.2340	0.2360	0.251	0.251	0.251	0.251	0.251	0.251	0.251	0.251	0.251	0.251
7	0.2450	0.2470	0.267	0.267	0.267	0.267	0.267	0.267	0.267	0.267	0.267	0.267
8	0.2635	0.2645	0.271	0.271	0.271	0.271	0.271	0.271	0.271	0.271	0.271	0.271

year

age	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
0	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.007
1	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.049
2	0.126	0.126	0.126	0.126	0.126	0.126	0.126	0.126	0.126	0.126	0.126	0.118
3	0.176	0.176	0.176	0.176	0.176	0.176	0.176	0.176	0.176	0.176	0.176	0.142
4	0.211	0.211	0.211	0.211	0.211	0.211	0.211	0.211	0.211	0.211	0.211	0.189
5	0.243	0.243	0.243	0.243	0.243	0.243	0.243	0.243	0.243	0.243	0.243	0.211
6	0.251	0.251	0.251	0.251	0.251	0.251	0.251	0.251	0.251	0.251	0.251	0.222
7	0.267	0.267	0.267	0.267	0.267	0.267	0.267	0.267	0.267	0.267	0.267	0.267
8	0.271	0.271	0.271	0.271	0.271	0.271	0.271	0.271	0.271	0.271	0.271	0.271

year

age	1982	1983	1984	1985	1986	1987	1988
0	0.010000	0.0100000	0.0100000	0.0090000	0.0060000	0.0110000	0.0110000
1	0.059000	0.0590000	0.0590000	0.0360000	0.0670000	0.0350000	0.0550000
2	0.118000	0.1180000	0.1180000	0.1280000	0.1210000	0.0990000	0.1110000
3	0.149000	0.1490000	0.1490000	0.1640000	0.1530000	0.1500000	0.1450000
4	0.179000	0.1790000	0.1790000	0.1940000	0.1820000	0.1800000	0.1740000
5	0.217000	0.2170000	0.2170000	0.2110000	0.2080000	0.2110000	0.1970000
6	0.238000	0.2380000	0.2380000	0.2200000	0.2210000	0.2340000	0.2160000
7	0.265000	0.2650000	0.2650000	0.2580000	0.2380000	0.2580000	0.2370000
8	0.274234	0.2745238	0.2746263	0.2821301	0.2572113	0.2881358	0.2565714

year

age	1989	1990	1991	1992	1993	1994	1995
0	0.0170000	0.0190000	0.0170000	0.0100000	0.0100000	0.0060000	0.0090000
1	0.0430000	0.0550000	0.0580000	0.0530000	0.0330000	0.0560000	0.0420000
2	0.1150000	0.1140000	0.1300000	0.1020000	0.1150000	0.1300000	0.1300000
3	0.1530000	0.1490000	0.1660000	0.1750000	0.1450000	0.1590000	0.1690000
4	0.1730000	0.1770000	0.1840000	0.1890000	0.1890000	0.1810000	0.1980000

TABLE 2.6.3.2 (cont) North Sea Herring. WEIGHTS AT AGE IN THE CATCH

5	0.2080000	0.1930000	0.2030000	0.2070000	0.2040000	0.2140000	0.2070000
6	0.2310000	0.2290000	0.2170000	0.2230000	0.2280000	0.2400000	0.2430000
7	0.2470000	0.2360000	0.2350000	0.2370000	0.2440000	0.2550000	0.2470000
8	0.2631489	0.2608182	0.2630415	0.2631664	0.2734558	0.2761973	0.2809153

year

age	1996	1997	1998	1999	2000	2001	2002
0	0.0150000	0.0150000	0.0210000	0.009000	0.0150000	0.012000	0.0120000
1	0.0180000	0.0440000	0.0510000	0.045000	0.0330000	0.048000	0.0370000
2	0.1120000	0.1080000	0.1140000	0.115000	0.1130000	0.118000	0.1180000
3	0.1560000	0.1480000	0.1450000	0.151000	0.1570000	0.149000	0.1530000
4	0.1880000	0.1950000	0.1830000	0.171000	0.1790000	0.177000	0.1700000
5	0.2040000	0.2270000	0.2190000	0.207000	0.2010000	0.198000	0.1990000
6	0.2120000	0.2260000	0.2380000	0.233000	0.2160000	0.213000	0.2140000
7	0.2610000	0.2350000	0.2470000	0.245000	0.2460000	0.238000	0.2280000
8	0.2814938	0.2549437	0.2878952	0.267719	0.2731261	0.269744	0.2504017

year

age	2003	2004	2005	2006	2007	2008	2009
0	0.0140000	0.0140000	0.0110000	0.0100000	0.0124000	0.007900	0.0094000
1	0.0370000	0.0360000	0.0440000	0.0490000	0.0638000	0.053500	0.0514000
2	0.1040000	0.1000000	0.0990000	0.1170000	0.1214000	0.128800	0.1440000
3	0.1580000	0.1380000	0.1530000	0.1440000	0.1513000	0.179600	0.1811000
4	0.1740000	0.1830000	0.1660000	0.1720000	0.1634000	0.181200	0.2158000
5	0.1840000	0.2010000	0.2080000	0.1810000	0.1933000	0.183200	0.2162000
6	0.2050000	0.2160000	0.2230000	0.2200000	0.1900000	0.215700	0.2390000
7	0.2220000	0.2280000	0.2400000	0.2370000	0.2232000	0.216100	0.2428000
8	0.2366464	0.2545115	0.2653676	0.2460061	0.2374933	0.262076	0.2532723

year

age	2010	2011	2012
0	0.0075000	0.008000	0.0106000
1	0.0571000	0.041300	0.0463000
2	0.1292000	0.131700	0.1243000
3	0.1669000	0.159300	0.1706000
4	0.1912000	0.183100	0.1854000
5	0.2203000	0.197000	0.2058000
6	0.2193000	0.216700	0.2215000
7	0.2160000	0.221100	0.2387000
8	0.2383892	0.231918	0.2427213

TABLE 2.6.3.3 North Sea Herring. WEIGHTS AT AGE IN THE STOCK

Units : kg

year

age	1947	1948	1949	1950	1951	1952	1953	1954
0	0.0150	0.0150	0.0150000	0.0150000	0.0150000	0.0150000	0.0150000	0.0150000
1	0.0500	0.0500	0.0500000	0.0500000	0.0500000	0.0500000	0.0500000	0.0500000
2	0.1220	0.1220	0.1240000	0.1260000	0.1300000	0.1330000	0.1360000	0.1376667
3	0.1400	0.1400	0.1416667	0.1453333	0.1510000	0.1576667	0.1630000	0.1670000
4	0.1560	0.1560	0.1576667	0.1610000	0.1676667	0.1750000	0.1830000	0.1886667
5	0.1710	0.1710	0.1726667	0.1756667	0.1816667	0.1893333	0.1976667	0.2050000
6	0.1850	0.1850	0.1863333	0.1890000	0.1943333	0.2013333	0.2096667	0.2170000
7	0.1970	0.1970	0.1983333	0.2006667	0.2053333	0.2113333	0.2186667	0.2260000
8	0.2625	0.2625	0.2630000	0.2640000	0.2658333	0.2683333	0.2713333	0.2743333

year

age	1955	1956	1957	1958	1959	1960	1961
0	0.0150000	0.0150000	0.0150000	0.0150000	0.0150000	0.0150000	0.0150000
1	0.0500000	0.0500000	0.0500000	0.0500000	0.0500000	0.0500000	0.0500000
2	0.1386667	0.1396667	0.1403333	0.1406667	0.1416667	0.1463333	0.1510000
3	0.1686667	0.1703333	0.1716667	0.1730000	0.1743333	0.1790000	0.1833333
4	0.1926667	0.1950000	0.1966667	0.1980000	0.1993333	0.2076667	0.2156667
5	0.2100000	0.2136667	0.2160000	0.2176667	0.2193333	0.2263333	0.2330000
6	0.2230000	0.2273333	0.2306667	0.2326667	0.2343333	0.2486667	0.2626667
7	0.2323333	0.2376667	0.2413333	0.2436667	0.2453333	0.2636667	0.2816667
8	0.2771667	0.2795000	0.2815000	0.2828333	0.2840000	0.2936240	0.3034146

year

age	1962	1963	1964	1965	1966	1967	1968
0	0.0150000	0.0150000	0.0150000	0.0150000	0.0150000	0.0150000	0.0150000
1	0.0500000	0.0500000	0.0500000	0.0500000	0.0500000	0.0500000	0.0500000
2	0.1550000	0.1550000	0.1550000	0.1550000	0.1550000	0.1550000	0.1550000
3	0.1870000	0.1870000	0.1870000	0.1870000	0.1870000	0.1870000	0.1870000
4	0.2230000	0.2230000	0.2230000	0.2230000	0.2230000	0.2230000	0.2230000
5	0.2390000	0.2390000	0.2390000	0.2390000	0.2390000	0.2390000	0.2390000
6	0.2760000	0.2760000	0.2760000	0.2760000	0.2760000	0.2760000	0.2760000

TABLE 2.6.3.3 (cont) North Sea Herring. WEIGHTS AT AGE IN THE STOCK

7	0.2990000	0.2990000	0.2990000	0.2990000	0.2990000	0.2990000	0.2990000
8	0.3090087	0.3092903	0.3101214	0.3069573	0.3102731	0.3100755	0.3112209

age \ year	1969	1970	1971	1972	1973	1974	1975	1976	1977
0	0.0150000	0.0150000	0.015000	0.0150	0.0150	0.015000	0.01500	0.0150000	0.015
1	0.0500000	0.0500000	0.050000	0.0500	0.0500	0.050000	0.05000	0.0500000	0.050
2	0.1550000	0.1550000	0.155000	0.1550	0.1550	0.155000	0.15500	0.1550000	0.155
3	0.1870000	0.1870000	0.187000	0.1870	0.1870	0.187000	0.18700	0.1870000	0.187
4	0.2230000	0.2230000	0.223000	0.2230	0.2230	0.223000	0.22300	0.2230000	0.223
5	0.2390000	0.2390000	0.239000	0.2390	0.2390	0.239000	0.23900	0.2390000	0.239
6	0.2760000	0.2760000	0.276000	0.2760	0.2760	0.276000	0.27600	0.2760000	0.276
7	0.2990000	0.2990000	0.299000	0.2990	0.2990	0.299000	0.29900	0.2990000	0.299
8	0.3088686	0.3090248	0.311952	0.3076	0.3078	0.308129	0.30775	0.3077143	0.306

age \ year	1978	1979	1980	1981	1982	1983	1984	1985
0	0.0150	0.0150000	0.0150	0.015	0.0150000	0.0150000	0.01733333	0.01566667
1	0.0500	0.0500000	0.0500	0.050	0.0500000	0.0500000	0.05666667	0.05633333
2	0.1550	0.1550000	0.1550	0.155	0.1550000	0.1550000	0.15033333	0.13800000
3	0.1870	0.1870000	0.1870	0.187	0.1870000	0.1870000	0.19033333	0.18700000
4	0.2230	0.2230000	0.2230	0.223	0.2230000	0.2230000	0.22966667	0.23233333
5	0.2390	0.2390000	0.2390	0.239	0.2390000	0.2390000	0.24333333	0.24666667
6	0.2760	0.2760000	0.2760	0.276	0.2760000	0.2760000	0.28200000	0.27466667
7	0.2990	0.2990000	0.2990	0.299	0.2990000	0.2990000	0.31066667	0.32100000
8	0.3096	0.3068571	0.3072	0.307	0.3074043	0.3091429	0.34351178	0.35438242

age \ year	1986	1987	1988	1989	1990	1991
0	0.0140000	0.00900000	0.00800000	0.008666667	0.01233333	0.01133333
1	0.0610000	0.05033333	0.04833333	0.043666667	0.05200000	0.05900000
2	0.1300000	0.12166667	0.12300000	0.122333333	0.12566667	0.13900000
3	0.1833333	0.17000000	0.16633333	0.165333333	0.17433333	0.18366667
4	0.2316667	0.21233333	0.20833333	0.204666667	0.21166667	0.21200000
5	0.2520000	0.23000000	0.22900000	0.228333333	0.24366667	0.23866667
6	0.2730000	0.24200000	0.24833333	0.252333333	0.27066667	0.26533333
7	0.3146667	0.27466667	0.25866667	0.261333333	0.28366667	0.27966667
8	0.3627746	0.30562963	0.28535714	0.288595745	0.30788452	0.30953886

age \ year	1992	1993	1994	1995	1996	1997
0	0.01033333	0.005666667	0.007333333	0.00600000	0.0060000	0.00500000
1	0.06366667	0.061000000	0.060000000	0.05733333	0.0540000	0.04866667
2	0.13666667	0.134000000	0.126333333	0.12933333	0.1296667	0.12333333
3	0.19400000	0.184333333	0.191666667	0.18566667	0.1993333	0.18333333
4	0.21400000	0.213000000	0.214333333	0.21066667	0.2273333	0.23033333
5	0.23433333	0.234333333	0.239666667	0.22433333	0.2343333	0.23733333
6	0.25300000	0.261666667	0.274666667	0.26800000	0.2736667	0.25666667
7	0.27166667	0.272666667	0.291333333	0.29333333	0.3006667	0.28033333
8	0.29870453	0.307936434	0.320523728	0.32614016	0.3270679	0.31004007

age \ year	1998	1999	2000	2001	2002	2003
0	0.005666667	0.00600000	0.005666667	0.00600000	0.006333333	0.006666667
1	0.047333333	0.05066667	0.051333333	0.05066667	0.047333333	0.047000000
2	0.116000000	0.11600000	0.115666667	0.12166667	0.128000000	0.123000000
3	0.187333333	0.17933333	0.183666667	0.17166667	0.171666667	0.173000000
4	0.241333333	0.22633333	0.221333333	0.21000000	0.205333333	0.202333333
5	0.264333333	0.25600000	0.248333333	0.23266667	0.228333333	0.222000000
6	0.283666667	0.27333333	0.278666667	0.25533333	0.248333333	0.242333333
7	0.286666667	0.27600000	0.286000000	0.27466667	0.270333333	0.265666667
8	0.308339011	0.27811880	0.284171183	0.27449422	0.286521182	0.284946134

year

TABLE 2.6.3.3 (cont) North Sea Herring. WEIGHTS AT AGE IN THE STOCK

age	2004	2005	2006	2007	2008	2009
0	0.006666667	0.005733333	0.006766667	0.00610000	0.007933333	0.007233333
1	0.042000000	0.041433333	0.041000000	0.05133333	0.057700000	0.061433333
2	0.119333333	0.118100000	0.125666667	0.12800000	0.130366667	0.137366667
3	0.165333333	0.164433333	0.155400000	0.16073333	0.164200000	0.181000000
4	0.202666667	0.197900000	0.190900000	0.17956667	0.180766667	0.196866667
5	0.223000000	0.224500000	0.215800000	0.20680000	0.195433333	0.209966667
6	0.247666667	0.247833333	0.241900000	0.22356667	0.217700000	0.222500000
7	0.267666667	0.264866667	0.252133333	0.23780000	0.226066667	0.233633333
8	0.280490193	0.284945260	0.270223450	0.25648110	0.255556491	0.255759739

year

age	2010	2011	2012
0	0.007133333	0.006666667	0.00610000
1	0.052233333	0.043166667	0.04056667
2	0.142266667	0.145300000	0.13763333
3	0.190366667	0.187433333	0.18213333
4	0.216266667	0.225066667	0.21143333
5	0.223600000	0.239366667	0.23273333
6	0.234200000	0.243500000	0.24080000
7	0.240100000	0.250766667	0.24290000
8	0.260682861	0.257247512	0.25246564

TABLE 2.6.3.4 North Sea Herring. NATURAL MORTALITY

Units : NA

year

age	1947	1948	1949	1950	1951	1952	1953
0	1.3062962	1.3063903	1.3068821	1.3072083	1.3066220	1.3043784	1.3068605
1	0.8597480	0.8597415	0.8597118	0.8596935	0.8597301	0.8598630	0.8597093
2	0.3056970	0.3056669	0.3055191	0.3054245	0.3056036	0.3062708	0.3055162
3	0.2817484	0.2817165	0.2815592	0.2814580	0.2816484	0.2823597	0.2815574
4	0.2531908	0.2531580	0.2529935	0.2528867	0.2530850	0.2538308	0.2529940
5	0.2300403	0.2300068	0.2298389	0.2297298	0.2299323	0.2306936	0.2298396
6	0.2293962	0.2293629	0.2291975	0.2290907	0.2292906	0.2300393	0.2291965
7	0.2258074	0.2257749	0.2256149	0.2255120	0.2257058	0.2264292	0.2256128
8	0.2258074	0.2257749	0.2256149	0.2255120	0.2257058	0.2264292	0.2256128

year

age	1954	1955	1956	1957	1958	1959	1960
0	1.3093415	1.3088394	1.3036901	1.2931602	1.3192712	1.3217465	1.3063292
1	0.8595631	0.8596017	0.8599133	0.8605277	0.8589407	0.8588323	0.8597945
2	0.3047803	0.3049514	0.3064994	0.3096070	0.3017431	0.3011004	0.3058071
3	0.2807726	0.2809519	0.2826002	0.2859165	0.2775460	0.2768483	0.2818484
4	0.2521708	0.2523528	0.2540767	0.2575595	0.2488103	0.2480547	0.2532628
5	0.2289991	0.2291846	0.2309444	0.2345002	0.2255694	0.2247968	0.2301122
6	0.2283702	0.2285568	0.2302904	0.2337826	0.2249822	0.2242391	0.2294894
7	0.2248147	0.2249976	0.2266746	0.2300461	0.2215312	0.2208238	0.2259122
8	0.2248147	0.2249976	0.2266746	0.2300461	0.2215312	0.2208238	0.2259122

year

age	1961	1962	1963	1964	1965	1966	1967
0	1.2779437	1.2405107	1.4498257	1.3341230	1.2292427	1.1360167	1.0533453
1	0.8614710	0.8636000	0.8510058	0.8582902	0.8646056	0.8698533	0.8742452
2	0.3142394	0.3251448	0.2624238	0.2978870	0.3293404	0.3564009	0.3796720
3	0.2908419	0.3024979	0.2356937	0.2733594	0.3068488	0.3358097	0.3607781
4	0.2626962	0.2749736	0.2050645	0.2442764	0.2793030	0.3098633	0.3363605
5	0.2397436	0.2522790	0.1809156	0.2209336	0.2566889	0.2879006	0.3149562
6	0.2389587	0.2512436	0.1809803	0.2205236	0.2557409	0.2863048	0.3126683
7	0.2350598	0.2469035	0.1789569	0.2172865	0.2513544	0.2807976	0.3061220
8	0.2350598	0.2469035	0.1789569	0.2172865	0.2513544	0.2807976	0.3061220

year

age	1968	1969	1970	1971	1972	1973	1974
0	0.9805771	0.9186008	0.8673622	0.8247947	0.7939643	0.7755027	0.7636920
1	0.8778144	0.8804017	0.8820627	0.8831532	0.8837601	0.8837618	0.8832010
2	0.3993545	0.4145945	0.4255663	0.4340132	0.4379065	0.4368385	0.4349828
3	0.3819478	0.3985622	0.4107716	0.4201306	0.4248969	0.4246783	0.4230544
4	0.3589555	0.3770431	0.3907393	0.4012868	0.4073827	0.4086825	0.4078663
5	0.3380276	0.3565578	0.3706479	0.3814567	0.3878100	0.3893628	0.3885181
6	0.3350369	0.3527903	0.3660364	0.3760727	0.3815138	0.3819820	0.3802856
7	0.3275616	0.3444648	0.3569392	0.3663576	0.3711496	0.3709273	0.3688377
8	0.3275616	0.3444648	0.3569392	0.3663576	0.3711496	0.3709273	0.3688377

TABLE 2.6.3.4 (Cont) North Sea Herring. NATURAL MORTALITY

year

age	1975	1976	1977	1978	1979	1980	1981
0	0.7688703	0.7901108	0.8047986	0.8124459	0.8238513	0.8333298	0.8394171
1	0.8844545	0.8864425	0.8840221	0.8733575	0.8587716	0.8473594	0.8375958
2	0.4302030	0.4213890	0.4142544	0.4088044	0.4024214	0.3968846	0.3944146
3	0.4169843	0.4059054	0.3971144	0.3908862	0.3837073	0.3771918	0.3739079
4	0.4009955	0.3882011	0.3782681	0.3706733	0.3613179	0.3536230	0.3507997
5	0.3810519	0.3672796	0.3564138	0.3475373	0.3365057	0.3276900	0.3241351
6	0.3724155	0.3584487	0.3473240	0.3381604	0.3269489	0.3179354	0.3140861
7	0.3614341	0.3484669	0.3378787	0.3289188	0.3180598	0.3090793	0.3044325
8	0.3614341	0.3484669	0.3378787	0.3289188	0.3180598	0.3090793	0.3044325

year

age	1982	1983	1984	1985	1986	1987	1988
0	0.8450021	0.8509293	0.8618818	0.8758657	0.8837108	0.8833518	0.8801386
1	0.8262204	0.8177263	0.8133933	0.8098846	0.8047687	0.8030194	0.8053149
2	0.3936631	0.3910560	0.3846764	0.3767758	0.3700325	0.3620220	0.3521287
3	0.3724725	0.3685723	0.3595125	0.3482600	0.3389950	0.3289309	0.3167563
4	0.3504278	0.3474814	0.3402310	0.3317459	0.3241989	0.3145318	0.3025221
5	0.3230039	0.3198456	0.3133267	0.3060806	0.2996061	0.2913129	0.2812120
6	0.3127191	0.3096080	0.3032829	0.2962165	0.2900961	0.2824154	0.2730801
7	0.3018394	0.2979753	0.2910907	0.2832448	0.2768250	0.2693836	0.2604610
8	0.3018394	0.2979753	0.2910907	0.2832448	0.2768250	0.2693836	0.2604610

year

age	1989	1990	1991	1992	1993	1994	1995
0	0.8760232	0.8686097	0.8577137	0.8486048	0.8323958	0.8088519	0.7962212
1	0.8027804	0.7939753	0.7837381	0.7726129	0.7494854	0.7166964	0.6949720
2	0.3457447	0.3443718	0.3448689	0.3456637	0.3462418	0.3476941	0.3508561
3	0.3088644	0.3066102	0.3063299	0.3068890	0.3096982	0.3151729	0.3206849
4	0.2945958	0.2911509	0.2887064	0.2878693	0.2900670	0.2948533	0.3000248
5	0.2747040	0.2720989	0.2704650	0.2703406	0.2726507	0.2770603	0.2822178
6	0.2673958	0.2662294	0.2665871	0.2679837	0.2713861	0.2769124	0.2828047
7	0.2554274	0.2559625	0.2588839	0.2622695	0.2671514	0.2742681	0.2812562
8	0.2554274	0.2559625	0.2588839	0.2622695	0.2671514	0.2742681	0.2812562

year

age	1996	1997	1998	1999	2000	2001	2002
0	0.7964933	0.8003559	0.8091044	0.8315196	0.8635228	0.8871207	0.9021687
1	0.6869137	0.6817761	0.6802653	0.6913413	0.7113333	0.7220006	0.7236466
2	0.3570840	0.3656584	0.3743015	0.3869205	0.4027811	0.4126429	0.4164810
3	0.3273645	0.3362859	0.3447364	0.3550340	0.3672442	0.3752758	0.3791293
4	0.3072634	0.3173345	0.3266605	0.3373851	0.3500588	0.3587136	0.3632873
5	0.2899977	0.3006973	0.3105983	0.3222252	0.3360710	0.3453713	0.3500951
6	0.2906329	0.3009355	0.3104069	0.3214765	0.3345297	0.3431944	0.3474571
7	0.2892593	0.2992269	0.3085044	0.3196391	0.3326829	0.3412380	0.3453142
8	0.2892593	0.2992269	0.3085044	0.3196391	0.3326829	0.3412380	0.3453142

year

age	2003	2004	2005	2006	2007	2008	2009
0	0.9180715	0.9311605	0.9417495	0.9515479	0.9589797	0.9629198	0.9639524
1	0.7255318	0.7228521	0.7158512	0.7068146	0.6940013	0.6761454	0.6539054
2	0.4190357	0.4182149	0.4141342	0.4078147	0.3985226	0.3856549	0.3694447
3	0.3818664	0.3819880	0.3795281	0.3752508	0.3687520	0.3596482	0.3480426
4	0.3667856	0.3678416	0.3664798	0.3634001	0.3582492	0.3506907	0.3408148
5	0.3536407	0.3543872	0.3523644	0.3483950	0.3420464	0.3329287	0.3211651
6	0.3504963	0.3507288	0.3481721	0.3436320	0.3367076	0.3270346	0.3147281
7	0.3480817	0.3478837	0.3447272	0.3394611	0.3316919	0.3210542	0.3076583
8	0.3480817	0.3478837	0.3447272	0.3394611	0.3316919	0.3210542	0.3076583

year

age	2010	2011	2012
0	0.9630652	0.9600930	0.9622293
1	0.6284271	0.6718588	0.6631198
2	0.3504123	0.3823698	0.3760086
3	0.3342612	0.3571910	0.3526760
4	0.3289086	0.3484127	0.3446658
5	0.3070936	0.3303257	0.3258084
6	0.3001065	0.3244418	0.3196442
7	0.2918243	0.3183380	0.3130572
8	0.2918243	0.3183380	0.3130572

TABLE 2.6.3.5 North Sea Herring. PROPORTION MATURE

Units : NA

age \ year	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
4	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
5	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
6	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
7	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
8	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

age \ year	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
0	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
1	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
2	1	1	1	1	1	1	1	1	1	1	0.82	0.82	0.82	0.82	0.82
3	1	1	1	1	1	1	1	1	1	1	1.00	1.00	1.00	1.00	1.00
4	1	1	1	1	1	1	1	1	1	1	1.00	1.00	1.00	1.00	1.00
5	1	1	1	1	1	1	1	1	1	1	1.00	1.00	1.00	1.00	1.00
6	1	1	1	1	1	1	1	1	1	1	1.00	1.00	1.00	1.00	1.00
7	1	1	1	1	1	1	1	1	1	1	1.00	1.00	1.00	1.00	1.00
8	1	1	1	1	1	1	1	1	1	1	1.00	1.00	1.00	1.00	1.00

age \ year	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	0.0	0.00	0.00	0.00	0.00
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	0.0	0.00	0.00	0.00	0.00
2	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.7	0.75	0.8	0.85	0.82	0.91	0.86
3	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.0	1.00	1.0	0.93	0.94	0.97	0.99
4	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.0	1.00	1.0	1.00	1.00	1.00	1.00
5	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.0	1.00	1.0	1.00	1.00	1.00	1.00
6	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.0	1.00	1.0	1.00	1.00	1.00	1.00
7	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.0	1.00	1.0	1.00	1.00	1.00	1.00
8	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.0	1.00	1.0	1.00	1.00	1.00	1.00

age \ year	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.50	0.47	0.73	0.67	0.61	0.64	0.64	0.69	0.67	0.77	0.87	0.43	0.70	0.76	0.66
3	0.99	0.61	0.93	0.95	0.98	0.94	0.89	0.91	0.96	0.92	0.97	0.93	0.65	0.96	0.88
4	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.96	0.98
5	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
6	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
7	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
8	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

age \ year	2007	2008	2009	2010	2011	2012
0	0.00	0.00	0.00	0.00	0.00	0.00
1	0.00	0.00	0.00	0.00	0.00	0.00
2	0.71	0.86	0.89	0.45	0.87	0.91
3	0.92	0.98	1.00	0.90	0.84	0.99
4	0.93	0.99	1.00	1.00	1.00	1.00
5	1.00	1.00	1.00	1.00	1.00	1.00
6	1.00	1.00	1.00	1.00	1.00	1.00
7	1.00	1.00	1.00	1.00	1.00	1.00
8	1.00	1.00	1.00	1.00	1.00	1.00

TABLE 2.6.3.6 North Sea Herring. FRACTION OF HARVEST BEFORE SPAWNING

Units : NA

	year														
age	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961
0	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
1	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
2	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
3	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
4	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
5	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
6	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
7	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
8	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67

	year														
age	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
0	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
1	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
2	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
3	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
4	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
5	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
6	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
7	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
8	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67

	year														
age	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
0	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
1	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
2	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
3	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
4	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
5	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
6	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
7	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
8	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67

	year														
age	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
0	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
1	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
2	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
3	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
4	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
5	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
6	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
7	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
8	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67

	year					
age	2007	2008	2009	2010	2011	2012
0	0.67	0.67	0.67	0.67	0.67	0.67
1	0.67	0.67	0.67	0.67	0.67	0.67
2	0.67	0.67	0.67	0.67	0.67	0.67
3	0.67	0.67	0.67	0.67	0.67	0.67
4	0.67	0.67	0.67	0.67	0.67	0.67
5	0.67	0.67	0.67	0.67	0.67	0.67
6	0.67	0.67	0.67	0.67	0.67	0.67
7	0.67	0.67	0.67	0.67	0.67	0.67
8	0.67	0.67	0.67	0.67	0.67	0.67

TABLE 2.6.3.7 North Sea Herring. FRACTION OF NATURAL MORTALITY BEFORE SPAWNING

Units : NA

year

age	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961
0	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
1	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
2	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
3	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
4	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
5	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
6	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
7	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
8	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67

year

age	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
0	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
1	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
2	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
3	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
4	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
5	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
6	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
7	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
8	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67

year

age	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
0	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
1	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
2	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
3	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
4	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
5	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
6	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
7	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
8	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67

year

age	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
0	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
1	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
2	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
3	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
4	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
5	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
6	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
7	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
8	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67

year

age	2007	2008	2009	2010	2011	2012
0	0.67	0.67	0.67	0.67	0.67	0.67
1	0.67	0.67	0.67	0.67	0.67	0.67
2	0.67	0.67	0.67	0.67	0.67	0.67
3	0.67	0.67	0.67	0.67	0.67	0.67
4	0.67	0.67	0.67	0.67	0.67	0.67
5	0.67	0.67	0.67	0.67	0.67	0.67
6	0.67	0.67	0.67	0.67	0.67	0.67
7	0.67	0.67	0.67	0.67	0.67	0.67
8	0.67	0.67	0.67	0.67	0.67	0.67

TABLE 2.6.3.8 North Sea Herring. SURVEY INDICES

```
SCAI - Configuration

SCAI - Configuration

Spawning component abundance index
      min       max plusgroup   minyear   maxyear    startf      endf
       NA        NA        NA      1972      2012        NA        NA
Index type : biomass

SCAI - Index Values

Units  :  NA
     year
age       1972     1973     1974     1975     1976     1977     1978     1979
  all 3334.407 3286.069 2209.502 1372.471 1216.997 1623.603 2130.417 3235.861
     year
age       1980     1981     1982     1983     1984     1985     1986     1987
  all 3542.521 4054.349 5089.215 7779.292 12195.16 15236.04 14518.34 18443.44
     year
age       1988     1989     1990     1991     1992     1993    1994     1995
  all 26213.08 22243.02 20828.84 14279.93 7425.138 5048.563 4332.87 5400.227
     year
age       1996     1997     1998    1999     2000     2001     2002     2003
  all 7022.088 10144.91 13250.44 14279.4 16318.19 21779.55 26082.72 34332.07
     year
age       2004     2005     2006     2007     2008     2009    2010     2011
  all 37733.06 32190.21 30003.81 31008.57 38186.53 49186.42 51153.2 53284.39
     year
age       2012
  all 69188.05

HERAS - Configuration

Herring in Sub-area IV, Divisions VIId & IIIa (autumn-spawners) . Imported from
VPA file.
      min       max plusgroup   minyear   maxyear    startf      endf
     1.00      8.00      8.00   1989.00   2012.00      0.54      0.56
Index type : number

HERAS - Index Values

Units  :  NA
   year
age    1989    1990    1991    1992    1993    1994    1995    1996    1997
  1      -1      -1      -1      -1      -1      -1      -1      -1 9361000
  2 4090000 3306000 2634000 3734000 2984000 3185000 3849000 4497000 5960000
  3 3903000 3521000 1700000 1378000 1637000  839000 2041000 2824000 2935000
  4 1633000 3414000 1959000 1147000  902000  399000  672000 1087000 1441000
  5  492000 1366000 1849000 1134000  741000  381000  299000  311000  601000
  6  283000  392000  644000 1246000  777000  321000  203000   99000  215000
  7  120000  210000  228000  395000  551000  326000  138000   83000   46000
  8   66000  176000  145000  218000  296000  350000  212000  339000  237000
   year
age    1998    1999     2000     2001     2002     2003    2004    2005    2006
  1 4449000 5087000 24736000  6837000 23055000  9829400 5183700 3114100 6822800
  2 5747000 3078000  2923000 12290000  4875000 18949400 3415900 2055100 3772300
  3 2520000 4725000  2156000  3083000  8220000  3081000 9191800 3648500 1997200
  4 1625000 1116000  3140000  1462000  1390000  4188900 2167300 5789600 2097500
  5  982000  506000  1007000  1676000   794600   675100 2590700 1212900 4175100
  6  445000  314000   483000   450000  1031000   494800  317100 1174900  618200
  7  170000  139000   266000   170000   244400   568300  327600  139900  562100
  8  166000  141000   217000   157000   270500   323200  527650  233200  154700
   year
age    2007    2008    2009     2010     2011    2012
  1 6261000 3714000 4655000 14577000 10119000 7437000
  2 2750000 2853000 5632000  4237000  4166000 4719000
  3 1848000 1709000 2553000  4216000  2534000 4067000
  4  898000 1485000 1023000  2453000  2173000 1738000
  5  806000  809000 1077000  1246000  1016000 1209000
  6 1323000  712000  674000  1332000   651000  593000
  7  243000 1749000  638000   688000   688000  247000
  8  217000  455000 1720000  2729000  1737000  696000
```

TABLE 2.6.3.8 (Cont.) North Sea Herring. SURVEY INDICES

```
IBTS-Q1 - Configuration

Herring in Sub-area IV, Divisions VIId & IIIa (autumn-spawners) . Imported from
VPA file.
      min       max plusgroup   minyear   maxyear    startf      endf
     1.00      1.00        NA   1984.00   2013.00      0.08      0.17
Index type : number

IBTS-Q1 - Index Values

Units  :  NA
   year
age     1984    1985     1986     1987     1988     1989     1990     1991
  1 1515.627 2097.28 2662.812 3692.965 4394.168 2331.566 1061.572 1286.747
   year
age     1992     1993     1994     1995     1996     1997     1998    1999
  1 1268.145 2794.007 1752.053 1345.754 1890.872 4402.996 2275.845 752.862
   year
age     2000     2001     2002   2003    2004     2005    2006     2007    2008
  1 3303.932 2499.391 3881.426 2836.7 979.036 1009.807 899.755 1322.345 1791.55
   year
age     2009     2010     2011     2012     2013
  1 2338.813 1206.335 2938.813 1352.769 1651.281

IBTS0 - Configuration

Herring in Sub-area IV, Divisions VIId & IIIa (autumn-spawners) . Imported from
VPA file.
      min       max plusgroup   minyear   maxyear    startf      endf
     0.00      0.00        NA   1992.00   2013.00      0.08      0.17
Index type : number

IBTS0 - Index Values

Units  :  NA
   year
age  1992  1993  1994 1995  1996  1997 1998 1999  2000  2001  2002 2003 2004
  0 200.7 190.1 101.7  127 106.5 148.1 53.1  244 137.1 214.8 161.8 54.4 47.3
   year
age 2005 2006 2007 2008 2009 2010 2011 2012 2013
  0 61.3 83.1 37.2 27.8 95.8 77.1   77   68 50.4
```

TABLE 2.6.3.9 North Sea Herring. STOCK OBJECT CONFIGURATION

min	max	plusgroup	minyear	maxyear	minfbar	maxfbar
0	8	8	1947	2012	2	6

TABLE 2.6.3.10 North Sea Herring. FLSAM CONFIGURATION SETTINGS

```
name           : Final Assessment
desc           :
range          :       min       max plusgroup   minyear   maxyear   minfbar
maxfbar
range          :         0         8         8      1947      2013         2
6
fleets         :   catch    SCAI   HERAS IBTS-Q1   IBTS0
fleets         :       0       3       2       2       2
plus.group     : TRUE
states         :          age
states         : fleet      0  1  2  3  4  5  6  7  8
states         :   catch    1  2  3  4  5  6  7  8  8
states         :   SCAI    NA NA NA NA NA NA NA NA NA
states         :   HERAS   NA NA NA NA NA NA NA NA NA
states         :   IBTS-Q1 NA NA NA NA NA NA NA NA NA
states         :   IBTS0   NA NA NA NA NA NA NA NA NA
logN.vars      : 1 2 2 2 2 2 2 2 2
catchabilities :          age
catchabilities : fleet      0  1  2  3  4  5  6  7  8
catchabilities :   catch   NA NA NA NA NA NA NA NA NA
catchabilities :   SCAI    NA NA NA NA NA NA NA NA NA
catchabilities :   HERAS   NA  3  3  4  4  5  5  5  5
catchabilities :   IBTS-Q1 NA  1 NA NA NA NA NA NA NA
catchabilities :   IBTS0    2 NA NA NA NA NA NA NA NA
power.law.exps :          age
power.law.exps : fleet      0  1  2  3  4  5  6  7  8
power.law.exps :   catch   NA NA NA NA NA NA NA NA NA
power.law.exps :   SCAI    NA NA NA NA NA NA NA NA NA
power.law.exps :   HERAS   NA NA NA NA NA NA NA NA NA
power.law.exps :   IBTS-Q1 NA NA NA NA NA NA NA NA NA
power.law.exps :   IBTS0   NA NA NA NA NA NA NA NA NA
f.vars         :          age
f.vars         : fleet      0  1  2  3  4  5  6  7  8
f.vars         :   catch    1  1  2  2  3  3  4  4  4
f.vars         :   SCAI    NA NA NA NA NA NA NA NA NA
f.vars         :   HERAS   NA NA NA NA NA NA NA NA NA
f.vars         :   IBTS-Q1 NA NA NA NA NA NA NA NA NA
f.vars         :   IBTS0   NA NA NA NA NA NA NA NA NA
obs.vars       :          age
obs.vars       : fleet      0  1  2  3  4  5  6  7  8
obs.vars       :   catch    3  4  4  4  4  4  5  5  5
obs.vars       :   SCAI    NA NA NA NA NA NA NA NA NA
obs.vars       :   HERAS   NA  6  7  7  7  7  8  8  8
obs.vars       :   IBTS-Q1 NA  1 NA NA NA NA NA NA NA
obs.vars       :   IBTS0    2 NA NA NA NA NA NA NA NA
srr            : 0
cor.F          : FALSE
nohess         : FALSE
timeout        : 3600
```

TABLE 2.6.3.11 North Sea Herring. FLR, R SOFTWARE VERSIONS

```
FLSAM.version                         0.99-9
FLCore.version                           2.4
R.version      R version 2.13.2 (2011-09-30)
platform                     i386-pc-mingw32
run.date                 2013-03-17 15:53:50
```

TABLE 2.6.3.12 North Sea Herring. STOCK SUMMARY

Year	Recruitment Age 0	TSB	SSB	Fbar (Ages 2-6) f	Landings tonnes	Landings SOP
1947	75905523	7088611	3764027	0.1731	581760	1.4609
1948	67930793	6394827	3201084	0.1704	502100	1.3326
1949	58644245	6089034	3122049	0.1834	508500	1.4502
1950	80922301	6119555	3038881	0.1931	491700	1.3073
1951	73883494	6174880	2839107	0.2330	600400	1.3238
1952	74253836	6040516	2785673	0.2461	664400	1.2720
1953	80599258	5944637	2610363	0.2613	698500	1.1979
1954	74105477	5797863	2431454	0.2922	762900	1.2509
1955	66519121	5460222	2412080	0.2893	806400	1.0598
1956	48447922	4891453	2219961	0.2924	675200	1.2712
1957	135299311	5649062	2041101	0.3069	682900	1.1575
1958	49575137	5309456	1698065	0.3156	670500	1.1674
1959	56911045	5487591	2626073	0.3276	784500	1.5186
1960	22567018	4448155	2253511	0.2844	696200	1.1830
1961	111440347	5096171	2122277	0.3202	696700	1.1348
1962	53489718	4742144	1527282	0.3434	627800	1.1705
1963	78766631	5405892	2483054	0.2394	716000	0.8602
1964	83053871	5705836	2392860	0.3199	871200	1.0656
1965	38455028	5010268	1933805	0.5007	1168800	1.1496
1966	34449326	3886424	1580102	0.5103	895500	1.0707
1967	42926504	3169232	1024792	0.6542	695500	1.1757
1968	40832954	2744200	561856	0.9515	717800	1.2551
1969	19697455	2141463	512471	0.8653	546700	0.9674
1970	36506468	2065742	488454	0.9046	563100	0.9657
1971	26963644	1945442	350109	1.2110	520100	1.0747
1972	17592795	1681169	349759	0.6415	497500	0.9197
1973	8850637	1282087	301040	0.8293	484000	0.9575
1974	16502130	946949	201793	0.8532	275100	0.9680
1975	3933342	775296	117008	0.9855	312800	0.9343
1976	4945556	540365	163244	0.7363	174800	0.9530
1977	5542743	413743	126754	0.3380	46000	1.1979
1978	5763180	464167	156686	0.2471	11000	1.2152
1979	11228885	591845	191186	0.2044	25100	1.0056
1980	17021708	814231	212140	0.1812	70764	1.0936
1981	37355847	1401425	309898	0.1997	174879	1.0081
1982	59769138	2126526	431490	0.1835	275079	0.9786
1983	56514059	2856192	644996	0.2303	387202	1.0771
1984	53382845	3591211	1023767	0.3054	428631	1.0543
1985	68339603	4085685	1084902	0.3912	613780	1.0419
1986	81003263	4713777	1116825	0.3811	671488	1.1373
1987	81409294	4629688	1292385	0.3749	792058	1.0173
1988	42712407	4538014	1649528	0.3653	887686	1.1641
1989	35676401	3809468	1699764	0.3509	787899	1.0335
1990	30189357	3696881	1730637	0.3023	645229	1.0515
1991	31484314	3422904	1491063	0.3310	658008	1.0197
1992	58761651	3426329	1133703	0.3743	716799	0.9950
1993	51136035	3153426	800507	0.4312	671397	1.0231
1994	36215581	2819302	866312	0.4438	568234	1.0498
1995	46362430	2733245	913465	0.3847	579371	1.0084
1996	44366711	2913891	1050734	0.2308	275098	0.9987
1997	30614980	3109586	1202604	0.2037	264313	1.0006
1998	22297832	3305175	1457160	0.2249	391628	1.0018
1999	71128595	3419483	1534937	0.2123	363163	1.0000
2000	47917915	4295163	1521185	0.2132	388157	1.0004
2001	86616423	4842782	2074021	0.1879	374065	0.9901
2002	44013194	5632140	2390469	0.1772	394709	0.9974
2003	21423521	5932759	2446087	0.2012	482281	1.0153
2004	25191067	5045463	2416909	0.2429	587698	0.9985
2005	23300841	4231216	2296737	0.2582	663813	1.0033
2006	27425944	3502544	1792282	0.2299	514597	0.9950
2007	26615385	2996633	1444105	0.1974	406482	1.0056
2008	26642014	3011654	1495543	0.1310	257870	1.0040
2009	36251815	3422904	1826661	0.0795	168443	1.0023
2010	36873364	3929411	1857979	0.0842	187611	1.0034
2011	33131664	4106165	2226630	0.1089	226478	0.9938
2012	30431840	4077522	2347825	0.1684	434710	1.0109
2013	22544462					

TABLE 2.6.3.13 North Sea Herring. ESTIMATED FISHING MORTALITY

Units : f

year						
age	1947	1948	1949	1950	1951	1952
0	0.0035090849	0.0035104888	0.003512596	0.003508032	0.003509436	0.003509085
1	0.0002463887	0.0002463887	0.001207142	0.005914194	0.028885949	0.054448499
2	0.0695993535	0.0493854220	0.061004967	0.084728776	0.128220992	0.183012651
3	0.1401418717	0.1595975412	0.153723461	0.174191502	0.212396599	0.199428401
4	0.1456134167	0.1580253209	0.168604423	0.202725993	0.274034848	0.250699567
5	0.1885107961	0.1985726998	0.206449386	0.204763423	0.268850451	0.266468298
6	0.3214542652	0.2865334488	0.327129226	0.299153039	0.281506427	0.330714438
7	0.3315422588	0.3178740639	0.401631611	0.317365872	0.280438733	0.382766552
8	0.3315422588	0.3178740639	0.401631611	0.317365872	0.280438733	0.382766552

year						
age	1953	1954	1955	1956	1957	1958
0	0.003508032	0.004966202	0.004391432	0.003654485	0.003692321	0.003853783
1	0.078355431	0.102181974	0.164359365	0.152696956	0.194368391	0.163408840
2	0.217729895	0.251931010	0.290834762	0.366594114	0.340683972	0.367695547
3	0.251025689	0.312453382	0.312172300	0.315309684	0.326018875	0.354693941
4	0.245956645	0.257844136	0.262527353	0.273104711	0.279850429	0.268393793
5	0.263553209	0.284250326	0.256147968	0.244705459	0.303795652	0.332704690
6	0.328440363	0.354587549	0.324717404	0.262212509	0.284108236	0.254412071
7	0.374381481	0.437503751	0.246744967	0.274610925	0.282408691	0.180775382
8	0.374381481	0.437503751	0.246744967	0.274610925	0.282408691	0.180775382

year						
age	1959	1960	1961	1962	1963	1964
0	0.007451798	0.0145393	0.01698882	0.005828474	0.009965761	0.01043176
1	0.205358099	0.2265250	0.11228668	0.103281191	0.130354189	0.25732896
2	0.375495046	0.3853551	0.42507485	0.254539309	0.282323981	0.35412688
3	0.343283034	0.2824652	0.31793765	0.415962569	0.280326580	0.35373756
4	0.304708408	0.2495490	0.29903340	0.343386034	0.236430732	0.31908428
5	0.298346415	0.2222394	0.27025211	0.321293578	0.209485658	0.29951224
6	0.316351924	0.2823240	0.28877715	0.381948308	0.188378885	0.27321397
7	0.308294433	0.3323057	0.25668644	0.334673450	0.188661665	0.22155155
8	0.308294433	0.3323057	0.25668644	0.334673450	0.188661665	0.22155155

year						
age	1965	1966	1967	1968	1969	1970
0	0.008198533	0.01728874	0.02395927	0.02807994	0.01151045	0.03287312
1	0.233027222	0.20486583	0.26898491	0.27720444	0.28845967	0.26447726
2	0.538488036	0.49781836	0.49294385	0.90931292	0.70795836	0.75309040
3	0.525807554	0.55828260	0.69695809	1.28443637	0.81473693	0.94675115
4	0.509854443	0.49283542	0.66997157	0.77623498	0.75870670	0.91163918
5	0.483821133	0.61209364	0.69271266	0.86358755	0.81555208	0.81606604
6	0.445441212	0.39058487	0.71851406	0.92386160	1.22945379	1.09531063
7	0.473894763	0.56127741	0.94634602	1.13566684	0.98913743	0.92259493
8	0.473894763	0.56127741	0.94634602	1.13566684	0.98913743	0.92259493

year							
age	1971	1972	1973	1974	1975	1976	1977
0	0.03910128	0.05887728	0.05260732	0.08356755	0.09710135	0.0742216	0.07203523
1	0.52160744	0.53608101	0.60347540	0.43470832	0.50739271	0.1503634	0.10898991
2	0.70084397	0.69777401	0.80282381	0.86312134	0.94159315	0.6200966	0.16627703
3	0.87313945	0.69124566	0.93522139	0.81249136	1.04215012	0.8631472	0.47543743
4	0.87957187	0.65396595	0.73305833	0.77657659	0.90465647	0.7954638	0.29801841
5	0.70450489	0.53842342	0.72566268	0.92492928	1.16388087	0.8357966	0.44170634
6	2.89707034	0.62611576	0.94973052	0.88878493	0.87498372	0.5670771	0.30847947
7	1.27515788	0.32870322	0.56511841	0.77905004	1.42649445	0.8910453	0.36077528
8	1.27515788	0.32870322	0.56511841	0.77905004	1.42649445	0.8910453	0.36077528

year							
age	1978	1979	1980	1981	1982	1983	1984
0	0.0907724	0.10724922	0.13064128	0.3792157	0.3418785	0.3776868	0.2112950
1	0.1022433	0.09919179	0.08969861	0.1959492	0.1711183	0.2020581	0.1852961
2	0.1754502	0.19046249	0.20975817	0.1972270	0.1797479	0.1990897	0.2257110
3	0.3068795	0.26775042	0.24144828	0.1997877	0.2616886	0.2351339	0.2910384
4	0.2427556	0.18983500	0.17578388	0.1908820	0.1919923	0.2556362	0.3495181
5	0.3248148	0.27182413	0.21636251	0.2211310	0.1497332	0.2240693	0.3495530
6	0.1854259	0.10211047	0.06262442	0.1894368	0.1341361	0.2376396	0.3113306
7	0.3096230	0.22532759	0.13061516	0.3950354	0.2007490	0.3521845	0.5035461
8	0.3096230	0.22532759	0.13061516	0.3950354	0.2007490	0.3521845	0.5035461

TABLE 2.6.3.13 (Cont.) North Sea Herring. ESTIMATED FISHING MORTALITY

age \ year	1985	1986	1987	1988	1989	1990	1991
0	0.1028072	0.08009835	0.1443954	0.1216752	0.1264131	0.0765432	0.1249802
1	0.2933174	0.29590998	0.3472536	0.4758179	0.3612446	0.3869693	0.2869349
2	0.2775095	0.30095335	0.3014051	0.2778705	0.2838527	0.2816191	0.3781327
3	0.3959173	0.35508432	0.3261493	0.2976015	0.2856466	0.2599672	0.2989437
4	0.4392485	0.39376933	0.3891502	0.3795496	0.3811661	0.3151521	0.3141452
5	0.4142979	0.38639311	0.4124996	0.4244802	0.4019048	0.3513052	0.3280793
6	0.4292353	0.46928266	0.4454724	0.4472489	0.4018325	0.3033706	0.3360148
7	0.5405166	0.54881712	0.4217258	0.4542171	0.4192743	0.3432830	0.2740897
8	0.5405166	0.54881712	0.4217258	0.4542171	0.4192743	0.3432830	0.2740897

age \ year	1992	1993	1994	1995	1996	1997	1998
0	0.2707390	0.3248148	0.2151758	0.2219729	0.07652789	0.02373036	0.01898891
1	0.3248798	0.3320732	0.1897781	0.1919155	0.13942897	0.04194064	0.09822446
2	0.4056924	0.4408988	0.4244207	0.3100257	0.17576630	0.14768111	0.15870629
3	0.3385444	0.4385112	0.4468108	0.4087547	0.24937437	0.20842000	0.21625435
4	0.3566145	0.4531011	0.5796215	0.4030841	0.22745565	0.22584644	0.22976459
5	0.3611001	0.3882096	0.3786095	0.4361103	0.24514633	0.22400207	0.24647370
6	0.4095690	0.4352695	0.3894889	0.3653863	0.25635297	0.21273671	0.27318665
7	0.3888973	0.4726926	0.3804997	0.3293284	0.12777300	0.16408019	0.15291088
8	0.3888973	0.4726926	0.3804997	0.3293284	0.12777300	0.16408019	0.15291088

age \ year	1999	2000	2001	2002	2003	2004
0	0.03099281	0.03430377	0.03169171	0.02643940	0.02819812	0.04381846
1	0.04853355	0.05324241	0.04831564	0.03391832	0.05069135	0.03989916
2	0.15227000	0.14085842	0.08469489	0.08980631	0.08015444	0.08736155
3	0.22117523	0.20410923	0.18723327	0.14580284	0.14471341	0.14108397
4	0.22431589	0.23186499	0.21794773	0.21627598	0.20894170	0.23133232
5	0.23911755	0.25648118	0.22368868	0.21686071	0.31638356	0.32860462
6	0.22465262	0.23274776	0.22586902	0.21720797	0.25591754	0.42605365
7	0.13728448	0.14163528	0.15429329	0.20056839	0.23047797	0.34572902
8	0.13728448	0.14163528	0.15429329	0.20056839	0.23047797	0.34572902

age \ year	2005	2006	2007	2008	2009	2010
0	0.06380651	0.05054456	0.03866193	0.04375279	0.02937533	0.02606401
1	0.09045525	0.04091740	0.03368509	0.02974780	0.02359548	0.02645262
2	0.10872864	0.09957940	0.07961920	0.08144723	0.05819243	0.06372362
3	0.14552607	0.15673481	0.15875391	0.10064055	0.05673863	0.07124718
4	0.22119735	0.22953494	0.21515426	0.13779337	0.09117268	0.08518755
5	0.35765015	0.28616120	0.26350050	0.17415667	0.10495748	0.10915351
6	0.45795699	0.37755841	0.26984704	0.16075079	0.08629359	0.09167551
7	0.61421515	0.54708013	0.43462139	0.21214188	0.11632119	0.09132780
8	0.61421515	0.54708013	0.43462139	0.21214188	0.11632119	0.09132780

age \ year	2011	2012	2013
0	0.03594375	0.03959312	0.03966048
1	0.01656605	0.03072434	0.03066909
2	0.06505645	0.07448928	0.07448928
3	0.09807723	0.14973324	0.14973324
4	0.11130290	0.18561141	0.18561141
5	0.14054887	0.21341855	0.21341855
6	0.12932845	0.21895260	0.21895260
7	0.12140782	0.26535148	0.26535148
8	0.12140782	0.26535148	0.26535148

TABLE 2.6.3.14 North Sea Herring. ESTIMATED POPULATION ABUNDANCE

Units : NA

age \ year	1947	1948	1949	1950	1951	1952	1953
0	75905523	67930793	58644245	80922301	73883493.6	74253836.2	80599257.9
1	16159198	20624701	18384160	15371105	22364825.7	19815995.0	19975158.8
2	7810660	6837960	9559060	7787263	6287034.2	8966446.5	7795054.1
3	3745254	5065685	5267150	7370529	5357457.1	3937277.3	5225181.0
4	5427559	2508010	3020703	3790468	5168019.0	3181934.8	2473142.1
5	3460764	3693186	1687907	1897409	2676445.1	3090983.9	1901207.9
6	2969785	2296737	2429024	1095805	1242952.3	1684534.8	1897409.3
7	1691286	1701465	1401425	1384708	649527.2	762989.8	976763.7
8	5116596	3890312	3278839	2483054	2242271.6	1794074.8	1412681.2

age \ year	1954	1955	1956	1957	1958	1959	1960
0	74105477	66519121.1	48447921.7	135299310.9	49575137.2	56911045.4	22567017.6
1	22364826	19462498.1	18056205.9	12212859.4	41866644.8	12736723.6	16062533.4
2	7748424	8868356.1	6669130.2	6715977.9	3933342.0	17072849.3	4239687.0
3	4524420	4408301.4	5085988.7	3150274.0	3641841.4	1891725.6	9473414.9
4	2946121	2385692.5	2424170.6	2893565.4	1628223.3	1955194.0	950743.9
5	1539549	1704871.0	1379180.4	1424028.0	1713416.7	962221.5	1075181.5
6	1169398	912551.7	1029928.6	872397.1	810981.1	960299.0	549629.7
7	1099098	649527.2	516587.5	632224.6	520736.8	502826.3	539285.3
8	1353223	1249182.6	1218340.2	1056001.3	988555.4	1057057.9	925417.3

age \ year	1961	1962	1963	1964	1965	1966
0	111440346.9	53489717.7	78766630.9	83053870.7	38455027.5	34449326.3
1	5045463.1	32867668.1	15665948.0	18183042.7	22409600.1	11296460.4
2	5493081.8	1676133.1	13564952.5	6101224.2	5722978.8	7671325.7
3	2094865.7	2429023.8	933783.6	8537681.1	3355126.4	2195674.8
4	6028447.1	1153140.9	1024791.8	610479.5	4940613.1	1441219.2
5	580706.1	3715411.5	578387.9	657368.5	381551.1	2191287.9
6	716404.3	350109.1	2010713.1	421679.2	397917.5	185906.7
7	323191.4	444186.6	175957.9	1441219.2	274306.1	192914.0
8	805324.0	680783.8	614153.4	537132.5	1343783.9	815046.1

age \ year	1967	1968	1969	1970	1971	1972
0	42926503.9	40832953.6	19697455.05	36506467.70	26963644.05	17592794.979
1	10427947.3	14724156.5	14665377.48	7952524.63	14946683.59	11594019.931
2	3972872.7	3181934.8	4666873.88	4479401.49	2663096.23	3591210.894
3	3348422.8	1839492.0	766814.35	1583265.43	1345128.36	887354.639
4	870654.1	1234282.0	323191.40	232117.73	403527.53	358972.118
5	674009.8	306508.3	399512.37	103053.13	61944.87	108120.324
6	865445.8	254740.3	87640.63	124991.37	30760.91	20387.964
7	100107.5	298641.8	73497.01	17455.32	30454.83	1099.598
8	446413.1	159213.3	104192.98	46910.65	18010.32	8934.719

age \ year	1973	1974	1975	1976	1977	1978
0	8850637.073	16502129.646	3933341.984	4945556.230	5542742.653	5763180.209
1	7407473.641	3696880.818	7802853.047	1479182.310	2122276.731	2347825.175
2	2847636.756	1633115.340	980678.541	1949337.248	497325.490	810170.501
3	1176435.898	827363.982	443742.625	234685.125	634758.569	330380.401
4	317426.000	290686.312	252963.376	98420.067	61697.581	257300.515
5	129702.676	105134.946	88521.435	67643.057	26502.650	33792.697
6	45524.230	43174.270	28681.282	17738.630	19483.047	11544.911
7	8119.306	12056.992	12236.762	8130.681	6725.759	9860.577
8	5163.655	5523.682	5820.259	2942.162	3092.082	4822.270

age \ year	1979	1980	1981	1982	1983	1984
0	11228884.616	17021707.513	37355846.87	59769138.07	56514059.17	53382845.13
1	2249008.477	4492859.874	6642506.93	10627972.52	18811896.12	16062533.40
2	900765.287	830680.065	1867292.35	2305942.40	3855456.59	6885993.65
3	463239.742	499818.344	424216.83	1075181.45	1314543.48	2115919.44
4	194658.107	244996.695	264078.05	243044.54	555708.97	762227.24
5	134726.220	132058.462	149342.86	149193.59	150391.93	299539.03
6	18592.248	70685.801	90944.07	82950.56	104088.84	92410.88
7	6614.371	13033.784	51896.16	57699.28	54339.14	64601.96
8	7467.384	7613.665	14849.18	33826.51	63322.75	67846.29

TABLE 2.6.3.14 (Cont.) North Sea Herring. ESTIMATED POPULATION ABUNDANCE

age \ year	1985	1986	1987	1988	1989	1990
0	68339603.31	81003263.34	81409293.89	42712407.08	35676401.29	30189356.9
1	17858676.03	26403311.61	32573186.24	29034635.42	15448152.89	12736723.6
2	6218255.75	5745916.58	9313728.01	10886129.35	7587403.53	4680895.5
3	3832393.11	3282119.63	2830602.09	4920890.17	6064726.47	4130875.8
4	1111254.37	1735836.52	1657796.72	1425452.69	2711465.98	3711698.0
5	393564.40	489921.28	830680.07	823237.49	706444.56	1474751.4
6	146239.36	187962.92	243774.77	403124.21	401514.93	374370.0
7	52260.70	67440.43	86249.54	117125.35	192336.17	208772.4
8	65251.22	55547.84	53798.45	70615.15	91035.06	153430.0

age \ year	1991	1992	1993	1994	1995	1996
0	31484313.6	58761650.6	51136035.4	36215581.1	46362430.4	44366711.3
1	12200652.6	11582431.7	18643348.7	15096900.3	12736723.6	15966446.7
2	3996781.6	4501854.6	3867040.3	5838590.7	6028447.1	5235641.8
3	2465733.8	1856122.1	1976819.9	1569080.0	2628700.0	3035843.9
4	2390468.7	1397226.8	979698.4	821592.7	762227.2	1164730.2
5	2088590.5	1329083.3	747881.6	427624.2	333034.0	350459.3
6	806129.8	1194215.4	714973.0	361132.4	209609.2	137036.1
7	214271.7	457714.1	592437.1	333034.0	175782.0	100508.7
8	189662.2	237280.9	360050.7	422523.4	352921.2	270763.2

age \ year	1997	1998	1999	2000	2001	2002
0	30614980.32	22297831.7	71128595.4	47917915.0	86616423.2	44013193.5
1	18962994.88	12864729.8	9379152.8	30922666.0	17966150.2	37169533.8
2	6491472.82	9520900.6	5277695.0	5020298.7	14592233.6	7904952.3
3	2984670.76	3365206.9	6010388.8	2984670.8	3213913.8	9074692.0
4	1664441.18	1610411.0	1758549.7	3562595.8	1708284.1	1781560.1
5	662648.52	926343.1	783871.2	1043405.0	1947388.9	944111.9
6	210238.95	393171.0	464167.1	456799.6	547435.5	1110143.7
7	73644.15	128155.5	201591.8	261189.1	250947.7	301040.5
8	225708.59	172646.3	162105.1	205253.3	242316.5	294489.9

age \ year	2003	2004	2005	2006	2007	2008
0	21423521.2	25191066.9	23300840.7	27425944.4	26615385.3	26642014.0
1	16751527.4	8056582.4	10019061.6	8096966.1	9909455.9	10875248.7
2	20175912.5	6803855.5	3847753.4	4915971.7	3704282.0	4662209.3
3	4666873.9	12509513.6	4303761.6	2475616.5	2984670.8	2231088.2
4	5427558.7	2943176.5	7881273.0	2605147.9	1534937.2	1828488.1
5	973837.8	3156580.9	1691286.4	4751638.2	1411269.2	957422.4
6	574927.9	498321.1	1636384.8	856834.4	2657775.4	847460.9
7	634124.1	337729.3	233048.1	741180.9	430628.0	1664441.2
8	332368.6	518139.6	402318.8	246224.7	418737.7	466493.8

age \ year	2009	2010	2011	2012	2013
0	36251814.7	36873363.8	33131664.0	30431840.4	22544461.9
1	10553836.5	13783737.3	14533981.2	12237309.5	11455723.1
2	6070794.2	5526139.3	7188549.7	7326437.9	6113438.9
3	2813669.3	4139145.8	3576874.7	5070753.6	4666873.9
4	1380560.3	1986728.8	2633962.7	2412080.0	3066354.6
5	1160080.5	989544.5	1224447.2	1656139.7	1419762.3
6	631592.7	857691.7	644351.7	769887.7	965112.5
7	568070.0	466027.5	584200.8	400312.2	449099.6
8	1491063.2	1565944.9	1376424.8	1135972.9	861129.3

TABLE 2.6.3.15 North Sea Herring. PREDICTED CATCH NUMBERS AT AGE

Units : NA

age \ year	1947	1948	1949	1950	1951	1952	1953
0	453295.722	653828.3	282434.0	338947.3	493510.8	157566.0	204884.2
1	428266.096	325071.4	609625.4	608346.6	707363.5	1015813.2	1468129.9
2	651739.356	596718.0	418193.7	428180.5	1297565.0	1320868.5	1496889.7
3	533012.417	514319.5	977838.7	654024.4	622812.0	1017236.3	1066614.3
4	734246.440	417024.4	546396.4	898156.9	626309.5	479116.9	594930.6
5	429853.615	953695.8	1030855.9	1100527.3	648748.2	395655.8	342422.3
6	1300552.848	488356.0	617293.6	566368.4	426258.0	477681.8	314079.1
7	3406.873	656383.2	315085.7	274086.8	218753.3	274882.8	351723.3
8	284247.325	415608.9	254689.4	142914.2	514165.3	397599.3	433046.3

age \ year	1954	1955	1956	1957	1958	1959	1960
0	162575.9	98755.27	279959.4	105937.02	1609767.0	2218185.3	361964.0
1	2001084.8	1733408.05	1466222.6	4286152.35	4659878.8	1179852.5	1650353.4
2	1942720.8	1779067.66	1681673.5	1053786.05	483835.4	2044369.5	498969.4
3	1037682.1	1207545.08	768272.7	957326.71	457576.8	186409.3	1379732.2
4	489431.6	514834.10	626121.7	341294.15	223552.2	192201.6	122884.5
5	346105.9	268578.90	334469.2	437005.04	234544.4	121479.4	160700.9
6	227498.7	213330.95	193455.0	163947.25	120415.1	137365.4	65532.4
7	127707.8	111602.64	139664.7	77489.68	253039.3	235696.4	163243.8
8	245634.5	263076.46	233397.9	147207.73	182097.9	1061613.0	178189.0

age \ year	1961	1962	1963	1964	1965	1966	1967
0	2175349.72	1300552.8	2820712.30	3169232.49	1418343.22	1670611.02	2420537.06
1	323838.43	2954086.4	1586593.78	2059965.93	2567132.31	1306549.17	1613635.07
2	720643.61	204536.1	2242720.06	1197803.48	810170.50	1439490.80	1150031.63
3	295433.78	195888.3	148925.28	1742445.25	488551.42	367765.21	573033.81
4	908181.93	100307.9	153568.19	130378.89	883989.09	294254.41	154075.80
5	99022.26	316760.1	90889.52	127427.14	52749.00	387860.11	133853.34
6	112724.27	27766.9	258409.29	92410.88	73167.02	53997.88	178206.81
7	172698.05	96925.7	96307.36	452842.65	309155.60	240963.32	94939.96
8	412957.52	476536.7	180773.47	353344.93	629763.73	722519.73	147650.02

age \ year	1968	1969	1970	1971	1972	1973
0	2495750.39	1251558.334	4189533.71	3319417.919	2325859.021	892873.328
1	1985140.00	1981966.318	1116377.92	1497638.362	1309819.632	789614.397
2	361783.05	819705.165	659079.87	369423.884	601330.513	385887.054
3	146605.41	118349.809	200125.51	144668.471	138759.847	132230.250
4	191855.93	49227.121	26627.51	37971.836	56743.705	54154.698
5	54105.98	71955.273	26194.38	8043.423	23899.194	21729.803
6	40134.84	9084.728	19075.12	259.971	2979.438	5586.175
7	56891.43	24416.148	11280.83	2112.294	1894.841	2559.251
8	791116.09	706232.654	696832.26	316696.759	929962.926	255531.252

age \ year	1974	1975	1976	1977	1980	1981
0	2137398.514	138399.540	146708.0740	261607.351	811386.669	1151297.356
1	502273.464	750728.990	62724.0358	130666.036	277923.173	315400.961
2	243312.037	114737.249	201410.4209	89985.156	64505.128	208334.450
3	127733.329	45880.708	13360.9293	33439.730	38933.097	36029.740
4	52443.936	32895.791	8066.7826	22046.299	25448.193	17804.028
5	14339.740	6560.880	4407.9279	3681.480	13537.380	8974.926
6	8129.868	4152.600	1746.0825	1377.355	14746.337	9101.914
7	3866.906	1502.732	802.7152	804.628	4219.703	5336.258
8	245757.363	265879.905	1426450.8584	8185705.833	11956671.918	12288814.299

age \ year	1982	1983	1984	1985	1986	1987
0	2384023.11	1882102.39	3172086.08	4737404.64	6718664.78	7788041.70
1	579603.77	1162868.09	1267047.56	1259593.99	2052768.65	2243617.33
2	232094.52	452525.77	1070139.96	840035.98	677456.08	1093943.92
3	106702.51	192528.60	340339.86	487721.59	463286.07	392189.34
4	25988.26	76534.74	116215.33	137022.44	246101.66	250646.79
5	19047.10	21483.27	44636.18	61821.10	77141.76	128527.74
6	14070.14	22435.50	19235.64	25187.42	26273.08	38009.83
7	16396.78	23564.58	24035.81	20744.57	16389.07	22916.21
8	6914284.17	4479849.45	4165304.75	7346246.06	3281791.43	2847636.76

TABLE 2.6.3.15 (Cont.) North Sea Herring. PREDICTED CATCH NUMBERS AT AGE

age	1988	1989	1990	1991	1992	1993	1994
0	3298901.20	2892118.97	2148541.93	2284596.55	3784407.9	1883985.43	1621237.01
1	1597259.65	980286.35	1075934.34	1283626.71	1179970.5	1726488.27	1367643.85
2	1306026.66	820115.12	552716.23	463008.18	610418.5	490705.78	762608.44
3	751104.45	877033.09	564276.69	367324.16	313357.5	317521.24	220708.92
4	206364.64	385501.36	515606.93	355898.20	212458.1	118705.39	103600.77
5	117630.07	86560.60	203414.29	355364.75	223217.1	102652.01	56364.79
6	58665.08	53927.72	45515.13	130796.77	197817.5	92976.31	43316.98
7	27769.68	39616.46	40279.58	67819.16	120222.6	118018.89	87029.29
8	1494646.08	2504751.28	9577239.92	9843284.46	4878752.0	6457159.03	2265486.31

age	1995	1996	1997	1998	1999	2000	2001
0	1515263.64	565858.881	877647.23	321740.31	1150721.85	605372.95	883989.09
1	713116.44	750053.638	1171036.72	621194.80	545413.77	973448.30	557211.41
2	575100.45	479452.449	556710.15	1010544.65	464027.92	460468.63	1029207.86
3	205150.68	290018.502	283878.04	301763.84	626184.29	283055.99	292494.17
4	66516.15	115473.922	175062.79	143429.66	201854.01	332202.50	156310.55
5	27062.38	34989.385	81413.79	80378.34	81129.34	94277.70	184259.43
6	10497.79	9672.093	15694.73	22212.27	29457.39	30531.07	46546.17
7	28279.71	29655.414	21147.99	17858.06	23146.53	29483.91	45528.78
8	494993.54	287995.461	1476817.51	1084793.28	1794792.55	758122.30	390545.59

age	2002	2003	2004	2005	2006	2007	2008
0	590898.77	224852.52	622065.08	233421.24	237162.3	232094.52	180791.55
1	1272889.41	466353.87	325852.47	384077.64	234380.2	303488.80	287477.54
2	524919.40	1374499.19	487282.83	300859.90	368243.6	179889.85	131242.23
3	861732.35	512010.29	1317965.74	451125.12	251223.9	199366.48	102252.45
4	224582.86	751630.41	432959.73	1006711.87	279037.1	130744.46	99101.51
5	110370.70	147576.21	514525.30	230475.54	537777.4	107861.15	44886.84
6	110979.41	84204.19	92051.18	268793.85	130731.4	273593.85	53868.44
7	58180.18	129159.07	158974.64	89330.66	127185.3	76733.99	141364.93
8	704892.09	937338.73	875718.53	650827.56	734613.7	675224.16	610113.33

age	2009	2010	2011	2012
0	267426.49	173998.16	271007.02	428266.096
1	288370.10	377112.94	439371.25	651739.356
2	242340.73	281728.75	596658.38	533012.417
3	138593.44	235060.92	347632.09	734246.440
4	88318.07	137200.69	273101.83	429853.615
5	65075.28	67010.19	130300.68	1300552.848
6	35355.17	57411.51	80635.96	3406.873
7	118812.27	135198.59	228844.95	284247.325
8	754265.72	760856.46	453295.72	653828.262

TABLE 2.6.3.16 North Sea Herring. CATCH AT AGE RESIDUALS

Units : NA

age \ year	1947	1948	1949	1950	1951	1952
0	0.51406100	0.1640470	0.09600500	-0.0843250	-0.367612	-0.22075100
1	-0.18790700	0.0537309	0.23885200	-0.0670296	0.122468	0.04191960
2	-0.12738100	0.0428950	0.35400700	0.4542520	0.218892	0.00484074
3	-0.07936980	-0.1937460	0.20869700	0.0546261	-0.466705	-0.08406140
4	0.10363800	-0.1480990	-0.12590000	0.3918710	-0.157463	-0.06401560
5	0.00938532	-0.1394600	0.04689730	0.7850120	0.030018	-0.14753300
6	0.02839550	-0.1279640	-0.00300181	0.6363970	0.301481	-0.03488520
7	-0.75987100	-0.1139390	-0.49597300	-0.1601820	0.269682	0.04013510
8	-0.83946900	-0.2887940	-0.00951583	-0.0226804	0.264996	-0.05024210

age \ year	1953	1954	1955	1956	1957	1958	1959
0	0.2989600	0.0392670	-0.1268990	-0.0152234	-0.395113	-0.00303765	0.452230
1	-0.0701027	0.2079070	-0.1266320	0.0679263	-0.010040	0.34149400	-0.193068
2	-0.0154400	-0.0362156	0.2659280	-0.1353050	-0.142304	0.05122810	-0.231422
3	0.2437780	-0.0326047	0.0661936	-0.2563690	0.254467	0.49360400	-0.696248
4	-0.0397507	-0.1286560	0.0136312	0.1681210	-0.347542	0.24722600	-0.814685
5	0.3158430	-0.1593200	-0.4520730	0.1677940	0.319600	0.21231500	-0.260326
6	0.1755940	0.0696939	-0.3372260	0.2403600	-0.387436	-0.01225190	-0.312505
7	0.2654600	-0.2212910	-0.2504580	0.1819800	-0.212176	0.61638800	0.490612
8	0.5879510	-0.4730160	0.3705470	0.2864010	-0.785616	0.29762600	0.800983

age \ year	1960	1961	1962	1963	1964	1965
0	-0.4447610	-0.0786587	-0.1791040	0.31135600	0.0748269	-0.15009800
1	0.8082680	-1.0954000	0.0146338	-0.14888500	0.4407970	0.00582722
2	-0.2325270	0.6046640	-0.8573490	0.00116072	0.6010740	-0.53161300
3	0.3209200	0.7527800	-1.2728500	-0.02106320	0.9404430	-0.48990000
4	0.0537166	1.0454100	-1.3069700	-0.18071300	0.6391260	0.03926220
5	-0.0624738	0.8811410	-1.1416300	0.15709100	0.6238990	-0.54079300
6	-0.2314400	0.8966720	-0.7627700	-0.02912990	0.8562990	-0.43142400
7	-0.4580470	0.0083690	-0.1467750	-0.48556000	0.2903490	0.25122300
8	-1.0243900	0.3130960	0.1876320	-0.62967400	0.2606720	0.10990900

age \ year	1966	1967	1968	1969	1970	1971	1972
0	0.0130820	0.0111239	0.0179104	-0.2701890	0.2636560	0.037939	0.107316
1	-0.6519770	0.6370860	-0.3156570	0.0627221	0.1603680	-0.232379	0.154952
2	-0.3189620	1.5643500	-1.1932400	0.4486060	0.0307112	-0.429258	0.548939
3	0.0605032	0.4839420	-0.5774860	0.3364290	0.2393020	-0.611410	0.473175
4	0.0716588	0.1163700	-0.0331417	0.1285920	0.0610769	-0.856772	0.263488
5	0.0475756	0.2840360	-0.2874460	-0.5868230	0.5404420	-1.688710	0.877941
6	0.8138650	-0.3081930	0.2202290	-0.4963410	1.2077500	-0.931523	0.769362
7	0.1927250	0.3745440	-0.2853460	-0.0315157	0.3645080	-1.215900	0.191840
8	0.6719850	-1.2396100	0.5690150	-0.1435170	0.3323690	-0.404131	0.308273

age \ year	1973	1974	1975	1976	1977	1980	1981
0	-0.3216990	0.840885	-0.532221	-0.0988287	-0.3894810	0.430355000	-0.183735
1	-0.1298660	0.451451	1.093580	-2.0238800	0.1503540	0.135331000	-0.311226
2	-0.3816600	0.387290	0.131850	-0.4629970	0.1194100	-0.749338000	0.593443
3	-0.2885950	0.569224	0.747905	-1.2714000	-0.2254910	0.086475900	-0.399407
4	0.2109390	0.518602	0.284195	-0.8474980	-0.0944248	0.676445000	-1.267840
5	0.0920025	0.411264	-0.258702	-0.2572300	-1.6709100	1.836080000	-0.985733
6	-0.3937540	0.400424	0.205542	-0.5395910	0.0579380	0.843722000	-0.548293
7	0.6808780	0.767800	-0.251512	-0.4863450	-1.6899600	1.588830000	-0.450960
8	0.1426720	-0.140081	-0.156022	-0.5467320	0.6773910	-0.000135634	0.353791

age \ year	1982	1983	1984	1985	1986	1987
0	0.1595250	-0.2054690	0.1503170	0.08043770	0.10391000	0.060382200
1	-0.0600959	-0.0861224	0.2732830	0.03353410	0.24089100	-0.029943000
2	-0.4185290	-0.1485240	0.5959290	0.00531848	-0.08494770	-0.017491900
3	-0.0902917	0.2724100	0.4748170	-0.27328600	0.04871560	-0.130616000
4	0.0483538	0.3461450	0.4114290	-0.32349800	-0.00741624	0.121333000
5	0.6388190	0.1800030	-0.0833308	0.01589110	-0.11423300	-0.011943000
6	-0.3360720	0.4127160	0.1737440	-0.73152000	-0.35115300	-0.000921802
7	1.2174400	0.8219660	0.6912550	1.11572000	-0.04121930	0.134261000
8	0.0379487	-0.2777210	-0.5016370	0.50919400	-0.16271600	0.319262000

TABLE 2.6.3.16 (Cont.) North Sea Herring. CATCH AT AGE RESIDUALS

age \ year	1988	1989	1990	1991	1992	1993
0	-0.2838260	0.2584930	-0.0271454	0.04804930	0.0664798	-0.3218360
1	-0.0135252	-0.5149660	0.3078280	0.00573366	-0.0187915	0.1930190
2	0.2587160	-0.3066720	0.0429630	-0.26796300	-0.0140666	-0.0197517
3	0.4458540	-0.1104260	-0.1648130	-0.09556130	-0.1515350	0.5410510
4	0.1552540	0.0308689	-0.1691680	0.07663160	0.0876662	-0.5097880
5	0.1786790	-0.2710530	0.0327970	0.19676400	0.0441152	-0.3967040
6	0.1387290	0.0310868	-0.5216570	0.54286600	-0.1807360	-0.6975330
7	0.0544971	0.0957381	-0.1514020	-0.29021900	0.2502430	-0.0429005
8	-0.6161640	-0.2168590	0.3400390	0.18826700	-0.3635490	0.6345890

age \ year	1994	1995	1996	1997	1998	1999	2000
0	0.1585900	0.348993	-0.986730	0.6450850	-0.3481740	0.1081010	0.0892167
1	0.3248530	-0.627131	-0.516529	0.2450670	-0.0465223	0.7934220	-0.8622390
2	0.4094220	-0.537685	-0.420057	-0.2052110	0.2779600	-0.0109487	0.3178740
3	0.2930390	-1.049580	-0.106142	-0.1609330	-0.1546510	0.1936580	-0.0889651
4	0.8045810	-0.861319	-0.334760	0.0254379	-0.3334980	0.3340090	-0.1913860
5	-0.0788062	-0.650370	-0.385716	0.3136090	-0.5269260	0.0587563	-0.1290690
6	-0.1601070	-0.444119	0.715965	-0.1063010	0.8222690	0.6831660	0.8008200
7	0.4291110	-1.033020	-0.683117	-0.1018960	-1.3452500	-1.0781300	-1.2731200
8	0.0897149	-0.619348	-0.466911	0.2638080	0.0833268	0.0935795	-0.1678780

age \ year	2001	2002	2003	2004	2005	2006
0	-0.32261500	0.2585050	-0.5046620	0.83674400	-0.2965260	-0.0408328
1	0.23550600	-0.2436450	-0.2408670	0.51979000	0.2590290	-0.4022690
2	-0.35050400	0.0504999	-0.0362106	-0.01859000	0.1901640	0.7495980
3	-0.00592977	-0.1843880	0.3553260	0.00315744	0.1759010	0.7692420
4	-0.62850000	0.5147040	0.0125927	0.61584000	-0.0534003	0.6181690
5	-0.19187900	-0.0852915	0.4881660	0.40192500	0.3191080	0.5576420
6	0.17595100	0.3737600	0.7819680	0.79705600	-0.2998970	0.4364980
7	-0.17653800	-0.7794660	-1.0118700	-0.28278000	0.6215740	0.7423820
8	-0.25345500	0.0675529	0.3594200	0.01488280	-0.2104590	0.3728740

age \ year	2007	2008	2009	2010	2011	2012
0	0.07488230	-0.1632500	0.289795	-0.5194580	0.298822	-0.18790700
1	0.53264800	-0.6135380	0.113468	-0.1488640	0.212459	-0.12738100
2	0.16018600	-1.2350700	-0.137892	-0.1438340	0.723610	-0.07936980
3	-0.00901981	-0.5461720	-0.557596	-0.4309720	0.901904	0.10363800
4	0.30216700	-0.8375320	-0.307279	-0.3164980	0.684330	0.00938532
5	0.32977400	-0.5962210	-0.198316	-0.2227680	0.560675	0.02839550
6	-0.84715400	-0.0489407	-0.212267	-0.3459970	0.919410	-0.75987100
7	1.50629000	0.0442687	-0.157042	-0.2577820	-0.383389	-0.83946900
8	-0.17046200	-0.2669010	0.144241	0.0725268	0.514061	0.16404700

TABLE 2.6.3.17 North Sea Herring. PREDICTED INDEX AT AGE SCAI

```
Units  :  NA
     year
age       1972    1973    1974     1975     1976     1977     1978     1979
  all 4259.725 3666.16 2458.68 1425.232 1988.071 1544.059 1908.094 2328.105
     year
age       1980     1981     1982     1983     1984     1985     1986     1987
  all 2582.982 3773.733 5254.079 7852.208 12467.99 13208.69 13595.85 15737.95
     year
age       1988     1989     1990     1991     1992     1993    1994     1995
  all 20080.81 20709.96 21075.36 18160.42 13804.78 9745.588 10550.2 11123.66
     year
age       1996     1997     1998     1999     2000     2001     2002     2003
  all 12795.39 14639.52 17749.45 18684.32 18522.84 25252.99 29100.19 29801.08
     year
age       2004     2005     2006    2007     2008     2009     2010     2011
  all 29445.61 27961.95 21834.79 17594.3 18204.24 22243.39 22629.28 27116.56
     year
age       2012
  all 28586.79
```

TABLE 2.6.3.18 North Sea Herring. INDEX AT AGE RESIDUALS SCAI

```
Units  :  NA
     year
age        1972      1973      1974       1975     1976     1977     1978
  all -0.575051 -0.257005 -0.250897 -0.0885734 -1.15235 0.117956 0.258787
     year
age       1979     1980    1981       1982       1983       1984     1985
  all 0.773061 0.741738 0.16842 -0.0748494 -0.0219093 -0.0519467 0.335265
     year
age       1986     1987     1988     1989       1990      1991     1992
  all 0.154152 0.372474 0.625735 0.167671 -0.0276243 -0.564436 -1.45612
     year
age       1993     1994     1995     1996      1997      1998      1999
  all -1.54432 -2.08956 -1.69676 -1.40888 -0.861155 -0.686399 -0.631315
     year
age       2000      2001      2002     2003    2004     2005     2006    2007
  all -0.29756 -0.347561 -0.257067 0.332389 0.58228 0.330709 0.746244 1.33061
     year
age      2008    2009    2010    2011    2012
  all 1.73948 1.86328 1.91495 1.58616 2.07549
```

TABLE 2.6.3.19 North Sea Herring. PREDICTED INDEX AT AGE IBTS-Q1

```
Units  :  NA
   year
age     1984     1985     1986    1987     1988    1989     1990     1991
  1 1980.907 2173.904 3215.635 3941.08 3456.667 1867.34 1535.529 1491.161
   year
age    1992     1993     1994     1995     1996     1997     1998     1999
  1 1411.15 2276.581 1883.788 1593.662 2012.675 2419.993 1630.497 1195.189
   year
age     2000     2001     2002     2003     2004     2005     2006    2007
  1 3926.603 2280.409 4725.081 2125.559 1023.404 1265.687 1031.026 1264.51
   year
age     2008     2009     2010     2011     2012     2013
  1 1391.629 1354.476 1774.191 1863.068 1567.395 1467.771
```

TABLE 2.6.3.20 North Sea Herring. INDEX AT AGE RESIDUALS IBTS-Q1

```
Units  :  NA
   year
age      1984      1985      1986      1987   1988     1989     1990      1991
  1 -0.902348 -0.120951 -0.635809 -0.219178 0.8088 0.748308 -1.24412 -0.496934
   year
age      1992    1993      1994      1995      1996    1997    1998     1999
  1 -0.360137 0.69027 -0.244345 -0.569873 -0.210411 2.01728 1.12394 -1.55774
   year
age      2000     2001      2002     2003      2004      2005      2006
  1 -0.581949 0.309028 -0.662916 0.972733 -0.149374 -0.761238 -0.459009
   year
```

TABLE 2.6.3.20 (Cont.) North Sea Herring. INDEX AT AGE RESIDUALS IBTS-Q1

age	2007	2008	2009	2010	2011	2012	2013
1	0.150731	0.851412	1.84103	-1.30017	1.53618	-0.496348	0.397057

TABLE 2.6.3.21 North Sea Herring. PREDICTED INDEX AT AGE HERAS

Units : NA

age \ year	1989	1990	1991	1992	1993	1994	1995
1	4876313.20	3256618.7	1847418.8	1117606.6	576943.7	276426.4	300288.81
2	4706240.73	2861338.3	1788164.1	979110.7	469066.6	350880.2	3549083.65
3	2011718.72	1245316.2	688520.2	380636.5	285101.3	3809848.6	2378070.49
4	579545.82	325559.3	190156.0	197363.0	3471162.1	1893618.3	933783.60
5	330644.81	178724.4	168282.6	2279803.9	1110587.8	557322.9	310612.05
6	157944.66	131294.7	2706319.1	1409858.6	546669.7	266918.9	120704.42
7	74772.09	2441199.3	1400584.2	700815.5	354654.7	174625.7	95053.96
8	3017079.90	1901207.9	1054945.9	618715.0	297777.0	149462.4	256068.43

age \ year	1996	1997	1998	1999	2000	2001	2002
1	11574326.84	7618575.7	5676809.9	18455998.5	10693001.3	22275545.0	9941216.9
2	4450824.87	6454576.7	3566516.8	3383766.5	10087423.4	5441144.6	13934801.9
3	2379497.76	2658838.7	4711891.6	2345478.5	2539556.5	7314725.0	3758761.2
4	1328551.75	1276458.5	1389285.3	2783445.2	1339222.8	1394156.3	4253701.1
5	590721.53	811467.8	684949.2	896003.9	1694502.9	822661.4	801708.2
6	188659.67	339558.0	409175.7	397798.2	476298.5	968399.5	490313.4
7	67920.96	118290.6	186539.8	239426.1	227339.6	265375.2	548915.6
8	208251.13	159388.5	149971.4	188132.2	219542.3	259600.7	287765.2

age \ year	2003	2004	2005	2006	2007	2008	2009
1	4814294.2	5844432.2	4881191.9	6037496.5	6706582.1	6606734.1	8737197.1
2	4681363.6	2623972.6	3381736.9	2588010.5	3278839.1	4362692.6	4000780.4
3	10097515.9	3469773.9	1987921.1	2403171.8	1863188.8	2422958.8	3562239.6
4	2277297.5	6137327.8	2023420.6	1204530.0	1504392.9	1171973.9	1702826.4
5	2579742.1	1361503.3	3988397.2	1203927.9	861646.2	1091539.9	936214.6
6	386659.6	1249932.4	685703.1	2265712.9	771506.2	602594.6	822990.6
7	274415.9	163636.0	541392.6	336179.3	1476669.8	535469.9	449189.4
8	420878.7	282603.5	179907.8	327060.4	414115.4	1405213.8	1509365.6

age \ year	2010	2011	2012
1	9044794.9	7591957.3	4876313.20
2	5109949.1	5198600.4	4706240.73
3	2995434.9	4138318.1	2011718.72
4	2201831.3	1940002.8	579545.82
5	1124220.0	1464317.8	330644.81
6	597554.0	681056.1	157944.66
7	546014.1	346452.2	74772.09
8	1285810.7	983133.3	3017079.90

TABLE 2.6.3.22 North Sea Herring. INDEX AT AGE RESIDUALS HERAS

Units : NA

year

age	1989	1990	1991	1992	1993	1994	1995
1	-0.890161	0.395368	0.2970310	0.0735302	1.100360	0.60964500	-1.28664000
2	-0.947557	0.893917	0.1695740	0.8906900	0.594837	-0.00915785	1.19830000
3	-1.055670	0.468087	-0.2469810	0.1370350	0.138725	0.05157950	0.86988000
4	-0.828955	0.686252	0.6708630	0.3677060	-0.435366	0.37960300	0.76919800
5	-0.575211	0.596062	-0.5502440	1.3628300	-1.419860	0.94744900	0.00651978
6	-1.015560	1.082850	1.6297800	0.7560140	-1.594150	0.57458100	-0.73263500
7	-0.461186	0.384821	-0.0821646	1.2775800	0.362760	0.55629000	-0.50120800
8	0.462815	-0.566224	0.4234580	0.9130680	0.277647	-0.29507300	1.03697000

year

age	1996	1997	1998	1999	2000	2001	2002
1	-0.5772290	-1.463180	-0.2985250	0.796556	-1.2164200	0.0935114	-0.0308516
2	1.4779800	-0.587706	-0.7458320	-0.740985	0.9996850	-0.5560630	1.5561400
3	1.0622000	-0.271535	0.0141454	-0.426683	0.9818150	0.5904570	-1.0064900
4	0.4113680	1.222030	-1.1088000	0.610108	0.4439990	-0.0151878	-0.0775496
5	0.0875668	0.965835	-1.5328900	0.591225	-0.0557941	-0.1756140	-0.8701270
6	0.4831090	0.999555	-0.9785530	0.717379	-0.2097570	0.2316600	0.0337047
7	-1.4403500	1.340200	-1.0872100	0.388834	-1.0743300	-0.3044300	0.1280960
8	0.4778580	0.150027	-0.2280420	0.527600	-1.2392400	0.1520430	0.4290760

year

age	2003	2004	2005	2006	2007	2008	2009
1	0.2012130	-1.712470	0.9109950	0.0988471	-1.6073700	-0.9523340	1.392240
2	-1.5954300	-1.237200	0.5531950	0.3072210	-0.7045190	1.2926400	0.290528
3	-0.4759350	0.254048	0.0235131	-1.3296600	-0.4374840	0.2647950	0.852804
4	-0.2506510	-0.295303	0.1818090	-1.4865300	-0.0657987	-0.6881560	1.848120
5	0.0212622	-0.584993	0.2318420	-2.0315900	-0.3192570	-0.0679344	1.447080
6	-0.7331090	-0.228741	-0.3830120	-1.9881400	-0.2965670	0.4138500	1.779590
7	0.6548580	-0.579312	0.1387240	-1.1996400	0.6256870	0.6475550	1.575850
8	0.8355260	-0.710099	-0.5580550	-1.5161500	0.3479040	0.7472090	2.188670

year

age	2010	2011	2012
1	0.305153	-0.0561662	-0.890161
2	-1.034130	-0.4899160	-0.947557
3	-0.847000	-0.0879262	-1.055670
4	-0.066699	-0.5563970	-0.828955
5	-0.512278	-0.9699310	-0.575211
6	0.316531	-0.5115700	-1.015560
7	0.854390	-1.2504400	-0.461186
8	1.111590	-1.2766500	0.462815

TABLE 2.6.3.23 North Sea Herring. PREDICTED INDEX AT AGE IBTS0

Units : NA

year

age	1992	1993	1994	1995	1996	1997	1998	1999
0	146.4963	126.8582	91.36569	117.0241	114.0561	79.18208	57.64192	183.008

year

age	2000	2001	2002	2003	2004	2005	2006	2007
0	122.7476	221.2471	112.3411	54.54522	63.89685	58.88109	69.37385	67.31479

year

age	2008	2009	2010	2011	2012	2013
0	67.31546	91.79887	93.37373	83.87688	76.93262	56.99708

TABLE 2.6.3.24 North Sea Herring. INDEX AT AGE RESIDUALS IBTS0

Units : NA

year

age	1992	1993	1994	1995	1996	1997	1998	1999
0	0.88337	1.13499	0.300689	0.229567	-0.192329	1.75698	-0.230303	0.807128

year

age	2000	2001	2002	2003	2004	2005	2006	2007
0	0.310308	-0.0829742	1.02369	-0.00749229	-0.843943	0.11298	0.506586	-1.66419

year

age	2008	2009	2010	2011	2012	2013
0	-2.48154	0.119722	-0.537374	-0.240041	-0.346318	-0.345164

TABLE 2.6.3.25 North Sea Herring. FIT PARAMETERS

	name	value	std.dev
1	logFpar	-8.875700	0.071766
2	logFpar	-12.763000	0.097963
3	logFpar	-0.095347	0.064202
4	logFpar	0.073372	0.062212
5	logFpar	0.173860	0.084331
6	logSdLogFsta	-0.524980	0.097871
7	logSdLogFsta	-1.114200	0.129500
8	logSdLogFsta	-1.152600	0.130500
9	logSdLogFsta	-0.662660	0.113180
10	logSdLogN	-0.586140	0.114820
11	logSdLogN	-1.989000	0.158240
12	logSdLogObs	-1.215000	0.157110
13	logSdLogObs	-1.031800	0.190450
14	logSdLogObs	-1.500800	0.563580
15	logSdLogObs	-1.787600	0.263190
16	logSdLogObs	-1.267500	0.174710
17	logSdLogObs	-1.000600	0.202050
18	logSdLogObs	-1.621900	0.107610
19	logSdLogObs	-1.307200	0.124310
20	logScaleSSB	-4.408100	0.080191
21	logSdSSB	-0.853380	0.116090

TABLE 2.6.3.26 North Sea Herring. NEGATIVE LOG-LIKELIHOOD

621.568

TABLE 2.7.1 NORTH SEA HERRING. WEIGHTS AT AGE IN THE CATCH

Units : kg

, , unit = A

age	2010	2011	2012	2013	2014	2015
0	0.0075000	0.008000	0.0106000	0.03499964	0.03499964	0.03499964
1	0.0571000	0.041300	0.0463000	0.08895434	0.08895434	0.08895434
2	0.1292000	0.131700	0.1243000	0.13613888	0.13613888	0.13613888
3	0.1669000	0.159300	0.1706000	0.16754697	0.16754697	0.16754697
4	0.1912000	0.183100	0.1854000	0.18586328	0.18586328	0.18586328
5	0.2203000	0.197000	0.2058000	0.20623603	0.20623603	0.20623603
6	0.2193000	0.216700	0.2215000	0.22086051	0.22086051	0.22086051
7	0.2160000	0.221100	0.2387000	0.22998847	0.22998847	0.22998847
8	0.2383892	0.231918	0.2427213	0.23913406	0.23913406	0.23913406

, , unit = B

age	2010	2011	2012	2013	2014	2015
0	0.0075000	0.008000	0.0106000	0.00837153	0.00837153	0.00837153
1	0.0571000	0.041300	0.0463000	0.03934736	0.03934736	0.03934736
2	0.1292000	0.131700	0.1243000	0.09884222	0.09884222	0.09884222
3	0.1669000	0.159300	0.1706000	0.15612871	0.15612871	0.15612871
4	0.1912000	0.183100	0.1854000	0.14250000	0.14250000	0.14250000
5	0.2203000	0.197000	0.2058000	0.20355800	0.20355800	0.20355800
6	0.2193000	0.216700	0.2215000	0.18454458	0.18454458	0.18454458
7	0.2160000	0.221100	0.2387000	0.00000000	0.00000000	0.00000000
8	0.2383892	0.231918	0.2427213	0.18400000	0.18400000	0.18400000

, , unit = C

age	2010	2011	2012	2013	2014	2015
0	0.0075000	0.008000	0.0106000	0.02275957	0.02275957	0.02275957
1	0.0571000	0.041300	0.0463000	0.06807189	0.06807189	0.06807189
2	0.1292000	0.131700	0.1243000	0.08025797	0.08025797	0.08025797
3	0.1669000	0.159300	0.1706000	0.11899671	0.11899671	0.11899671
4	0.1912000	0.183100	0.1854000	0.16139705	0.16139705	0.16139705
5	0.2203000	0.197000	0.2058000	0.18447644	0.18447644	0.18447644
6	0.2193000	0.216700	0.2215000	0.19706129	0.19706129	0.19706129
7	0.2160000	0.221100	0.2387000	0.22311705	0.22311705	0.22311705
8	0.2383892	0.231918	0.2427213	0.22861725	0.22861725	0.22861725

, , unit = D

age	2010	2011	2012	2013	2014	2015
0	0.0075000	0.008000	0.0106000	0.009140937	0.009140937	0.009140937
1	0.0571000	0.041300	0.0463000	0.019469740	0.019469740	0.019469740
2	0.1292000	0.131700	0.1243000	0.040452932	0.040452932	0.040452932
3	0.1669000	0.159300	0.1706000	0.073380157	0.073380157	0.073380157
4	0.1912000	0.183100	0.1854000	0.000000000	0.000000000	0.000000000
5	0.2203000	0.197000	0.2058000	0.000000000	0.000000000	0.000000000
6	0.2193000	0.216700	0.2215000	0.000000000	0.000000000	0.000000000
7	0.2160000	0.221100	0.2387000	0.000000000	0.000000000	0.000000000
8	0.2383892	0.231918	0.2427213	0.000000000	0.000000000	0.000000000

TABLE 2.7.2 NORTH SEA HERRING. WEIGHTS AT AGE IN THE STOCK

Units : kg

, , unit = A

age \ year	2010	2011	2012	2013	2014	2015
0	0.007133333	0.006666667	0.00610000	0.00610000	0.00610000	0.00610000
1	0.052233333	0.043166667	0.04056667	0.04056667	0.04056667	0.04056667
2	0.142266667	0.145300000	0.13763333	0.13763333	0.13763333	0.13763333
3	0.190366667	0.187433333	0.18213333	0.18213333	0.18213333	0.18213333
4	0.216266667	0.225066667	0.21143333	0.21143333	0.21143333	0.21143333
5	0.223600000	0.239366667	0.23273333	0.23273333	0.23273333	0.23273333
6	0.234200000	0.243500000	0.24080000	0.24080000	0.24080000	0.24080000
7	0.240100000	0.250766667	0.24290000	0.24290000	0.24290000	0.24290000
8	0.260682861	0.257247512	0.25246564	0.25246564	0.25246564	0.25246564

, , unit = B

age \ year	2010	2011	2012	2013	2014	2015
0	0.007133333	0.006666667	0.00610000	0.00610000	0.00610000	0.00610000
1	0.052233333	0.043166667	0.04056667	0.04056667	0.04056667	0.04056667
2	0.142266667	0.145300000	0.13763333	0.13763333	0.13763333	0.13763333
3	0.190366667	0.187433333	0.18213333	0.18213333	0.18213333	0.18213333
4	0.216266667	0.225066667	0.21143333	0.21143333	0.21143333	0.21143333
5	0.223600000	0.239366667	0.23273333	0.23273333	0.23273333	0.23273333
6	0.234200000	0.243500000	0.24080000	0.24080000	0.24080000	0.24080000
7	0.240100000	0.250766667	0.24290000	0.24290000	0.24290000	0.24290000
8	0.260682861	0.257247512	0.25246564	0.25246564	0.25246564	0.25246564

, , unit = C

age \ year	2010	2011	2012	2013	2014	2015
0	0.007133333	0.006666667	0.00610000	0.00610000	0.00610000	0.00610000
1	0.052233333	0.043166667	0.04056667	0.04056667	0.04056667	0.04056667
2	0.142266667	0.145300000	0.13763333	0.13763333	0.13763333	0.13763333
3	0.190366667	0.187433333	0.18213333	0.18213333	0.18213333	0.18213333
4	0.216266667	0.225066667	0.21143333	0.21143333	0.21143333	0.21143333
5	0.223600000	0.239366667	0.23273333	0.23273333	0.23273333	0.23273333
6	0.234200000	0.243500000	0.24080000	0.24080000	0.24080000	0.24080000
7	0.240100000	0.250766667	0.24290000	0.24290000	0.24290000	0.24290000
8	0.260682861	0.257247512	0.25246564	0.25246564	0.25246564	0.25246564

, , unit = D

age \ year	2010	2011	2012	2013	2014	2015
0	0.007133333	0.006666667	0.00610000	0.00610000	0.00610000	0.00610000
1	0.052233333	0.043166667	0.04056667	0.04056667	0.04056667	0.04056667
2	0.142266667	0.145300000	0.13763333	0.13763333	0.13763333	0.13763333
3	0.190366667	0.187433333	0.18213333	0.18213333	0.18213333	0.18213333
4	0.216266667	0.225066667	0.21143333	0.21143333	0.21143333	0.21143333
5	0.223600000	0.239366667	0.23273333	0.23273333	0.23273333	0.23273333
6	0.234200000	0.243500000	0.24080000	0.24080000	0.24080000	0.24080000
7	0.240100000	0.250766667	0.24290000	0.24290000	0.24290000	0.24290000
8	0.260682861	0.257247512	0.25246564	0.25246564	0.25246564	0.25246564

TABLE 2.7.3 NORTH SEA HERRING. STOCK IN NUMBER

Units : NA

, , unit = A

age \ year	2010	2011	2012	2013
0	36873363.795782	33131664.0200214	30431840.4050515	22544461.8609403
1	13783737.3181974	14533981.2488453	12237309.5147492	11455723.1326463
2	5526139.34280045	7188549.70976515	7326437.94436663	6113438.87407001
3	4139145.81651342	3576874.74194456	5070753.58187241	4666873.87634683
4	1986728.75022817	2633962.69943847	2412079.99089431	3066354.63893165
5	989544.484937427	1224447.15738433	1656139.74923268	1419762.26990211
6	857691.708672606	644351.716733336	769887.746934104	965112.544552443
7	466027.535305253	584200.777608237	400312.191329883	449099.614189211
8	1565944.94740321	1376424.84024507	1135972.87461682	861129.346198833

, , unit = B

age \ year	2010	2011	2012	2013
0	36873363.795782	33131664.0200214	30431840.4050515	22544461.8609403
1	13783737.3181974	14533981.2488453	12237309.5147492	11455723.1326463
2	5526139.34280045	7188549.70976515	7326437.94436663	6113438.87407001
3	4139145.81651342	3576874.74194456	5070753.58187241	4666873.87634683
4	1986728.75022817	2633962.69943847	2412079.99089431	3066354.63893165
5	989544.484937427	1224447.15738433	1656139.74923268	1419762.26990211
6	857691.708672606	644351.716733336	769887.746934104	965112.544552443
7	466027.535305253	584200.777608237	400312.191329883	449099.614189211
8	1565944.94740321	1376424.84024507	1135972.87461682	861129.346198833

, , unit = C

age \ year	2010	2011	2012	2013
0	36873363.795782	33131664.0200214	30431840.4050515	22544461.8609403
1	13783737.3181974	14533981.2488453	12237309.5147492	11455723.1326463
2	5526139.34280045	7188549.70976515	7326437.94436663	6113438.87407001
3	4139145.81651342	3576874.74194456	5070753.58187241	4666873.87634683
4	1986728.75022817	2633962.69943847	2412079.99089431	3066354.63893165
5	989544.484937427	1224447.15738433	1656139.74923268	1419762.26990211
6	857691.708672606	644351.716733336	769887.746934104	965112.544552443
7	466027.535305253	584200.777608237	400312.191329883	449099.614189211
8	1565944.94740321	1376424.84024507	1135972.87461682	861129.346198833

, , unit = D

age \ year	2010	2011	2012	2013
0	36873363.795782	33131664.0200214	30431840.4050515	22544461.8609403
1	13783737.3181974	14533981.2488453	12237309.5147492	11455723.1326463
2	5526139.34280045	7188549.70976515	7326437.94436663	6113438.87407001
3	4139145.81651342	3576874.74194456	5070753.58187241	4666873.87634683
4	1986728.75022817	2633962.69943847	2412079.99089431	3066354.63893165
5	989544.484937427	1224447.15738433	1656139.74923268	1419762.26990211
6	857691.708672606	644351.716733336	769887.746934104	965112.544552443
7	466027.535305253	584200.777608237	400312.191329883	449099.614189211
8	1565944.94740321	1376424.84024507	1135972.87461682	861129.346198833

TABLE 2.7.4 NORTH SEA HERRING. FISHING MORTALITY AT AGE IN THE STOCK

```
Units  :  f
, , unit = A

   year
age                2010               2011               2012
  0 0.0260640059197201 0.0359437522465639 0.0395931165629026
  1 0.0264526218718673 0.0165660476572378 0.0307243432149803
  2 0.0637236190126432 0.0650564450845016 0.0744892842136805
  3 0.0712471828188244 0.0980772348493581  0.14973235225983
  4 0.0851875485164576  0.111302896141661  0.185611407072263
  5  0.109153514248464  0.140548873022558  0.213418553826955
  6 0.0916755101750633  0.129328448250415  0.218952602397085
  7 0.0913278042959743  0.121407818455061  0.265351477926195
  8 0.0913278042959743  0.121407818455061  0.265351477926195
   year
age                2013
  0 6.92119101038945e-05
  1  0.00643664334469448
  2   0.0928283549901861
  3    0.207875404680911
  4    0.259299826533286
  5    0.298091214602138
  6    0.303405111765905
  7     0.37135114374894
  8    0.370906372313717

, , unit = B

   year
age                2010               2011               2012
  0 0.0260640059197201 0.0359437522465639 0.0395931165629026
  1 0.0264526218718673 0.0165660476572378 0.0307243432149803
  2 0.0637236190126432 0.0650564450845016 0.0744892842136805
  3 0.0712471828188244 0.0980772348493581  0.14973235225983
  4 0.0851875485164576  0.111302896141661  0.185611407072263
  5  0.109153514248464  0.140548873022558  0.213418553826955
  6 0.0916755101750633  0.129328448250415  0.218952602397085
  7 0.0913278042959743  0.121407818455061  0.265351477926195
  8 0.0913278042959743  0.121407818455061  0.265351477926195
   year
age                2013
  0   0.0355345286801768
  1  0.00806123293572382
  2  0.00130182478145806
  3  0.00104179250849887
  4                    0
  5 0.000565204536364659
  6  0.00232581391257492
  7                    0
  8 0.000620979345393883

, , unit = C
```

```
   year
age              2010               2011               2012
  0 0.0260640059197201 0.0359437522465639 0.0395931165629026
  1 0.0264526218718673 0.0165660476572378 0.0307243432149803
  2 0.0637236190126432 0.0650564450845016 0.0744892842136805
  3 0.0712471828188244 0.0980772348493581  0.149733235225983
  4 0.0851875485164576  0.111302896141661  0.185611407072263
  5  0.109153514248464  0.140548873022558  0.213418553826955
  6 0.0916755101750633  0.129328448250415  0.218952602397085
  7 0.0913278042959743  0.121407818455061  0.265351477926195
  8 0.0913278042959743  0.121407818455061  0.265351477926195
   year
age                2013
  0 5.30149026451595e-05
  1    0.012757599692211
  2  0.00973392994112187
  3 0.000679403113815759
  4 0.000878266841535201
  5 0.000221073707108251
  6 0.000475326935669362
  7 0.000473182246424064
  8 6.58825827020319e-05

, , unit = D

   year
age              2010               2011               2012
  0 0.0260640059197201 0.0359437522465639 0.0395931165629026
  1 0.0264526218718673 0.0165660476572378 0.0307243432149803
  2 0.0637236190126432 0.0650564450845016 0.0744892842136805
  3 0.0712471828188244 0.0980772348493581  0.149733235225983
  4 0.0851875485164576  0.111302896141661  0.185611407072263
  5  0.109153514248464  0.140548873022558  0.213418553826955
  6 0.0916755101750633  0.129328448250415  0.218952602397085
  7 0.0913278042959743  0.121407818455061  0.265351477926195
  8 0.0913278042959743  0.121407818455061  0.265351477926195
   year
age                2013
  0  0.00624679331802958
  1  0.00944252458249594
  2  0.00104553583082978
  3 5.59773350195079e-06
  4                    0
  5                    0
  6                    0
  7                    0
  8                    0
```

TABLE 2.7.5 NORTH SEA HERRING. NATURAL MORTALITY

Units : NA

, , unit = A

year

age	2010	2011	2012	2013	2014	2015
0	0.9630652	0.9600930	0.9622293	0.9624519	0.9624519	0.9624519
1	0.6284271	0.6718588	0.6631198	0.6586913	0.6586913	0.6586913
2	0.3504123	0.3823698	0.3760086	0.3727781	0.3727781	0.3727781
3	0.3342612	0.3571910	0.3526760	0.3503638	0.3503638	0.3503638
4	0.3289086	0.3484127	0.3446658	0.3426985	0.3426985	0.3426985
5	0.3070936	0.3303257	0.3258084	0.3234643	0.3234643	0.3234643
6	0.3001065	0.3244418	0.3196442	0.3171910	0.3171910	0.3171910
7	0.2918243	0.3183380	0.3130572	0.3103864	0.3103864	0.3103864
8	0.2918243	0.3183380	0.3130572	0.3103864	0.3103864	0.3103864

, , unit = B

year

age	2010	2011	2012	2013	2014	2015
0	0.9630652	0.9600930	0.9622293	0.9624519	0.9624519	0.9624519
1	0.6284271	0.6718588	0.6631198	0.6586913	0.6586913	0.6586913
2	0.3504123	0.3823698	0.3760086	0.3727781	0.3727781	0.3727781
3	0.3342612	0.3571910	0.3526760	0.3503638	0.3503638	0.3503638
4	0.3289086	0.3484127	0.3446658	0.3426985	0.3426985	0.3426985
5	0.3070936	0.3303257	0.3258084	0.3234643	0.3234643	0.3234643
6	0.3001065	0.3244418	0.3196442	0.3171910	0.3171910	0.3171910
7	0.2918243	0.3183380	0.3130572	0.3103864	0.3103864	0.3103864
8	0.2918243	0.3183380	0.3130572	0.3103864	0.3103864	0.3103864

, , unit = C

year

age	2010	2011	2012	2013	2014	2015
0	0.9630652	0.9600930	0.9622293	0.9624519	0.9624519	0.9624519
1	0.6284271	0.6718588	0.6631198	0.6586913	0.6586913	0.6586913
2	0.3504123	0.3823698	0.3760086	0.3727781	0.3727781	0.3727781
3	0.3342612	0.3571910	0.3526760	0.3503638	0.3503638	0.3503638
4	0.3289086	0.3484127	0.3446658	0.3426985	0.3426985	0.3426985
5	0.3070936	0.3303257	0.3258084	0.3234643	0.3234643	0.3234643
6	0.3001065	0.3244418	0.3196442	0.3171910	0.3171910	0.3171910
7	0.2918243	0.3183380	0.3130572	0.3103864	0.3103864	0.3103864
8	0.2918243	0.3183380	0.3130572	0.3103864	0.3103864	0.3103864

, , unit = D

year

age	2010	2011	2012	2013	2014	2015
0	0.9630652	0.9600930	0.9622293	0.9624519	0.9624519	0.9624519
1	0.6284271	0.6718588	0.6631198	0.6586913	0.6586913	0.6586913
2	0.3504123	0.3823698	0.3760086	0.3727781	0.3727781	0.3727781
3	0.3342612	0.3571910	0.3526760	0.3503638	0.3503638	0.3503638
4	0.3289086	0.3484127	0.3446658	0.3426985	0.3426985	0.3426985
5	0.3070936	0.3303257	0.3258084	0.3234643	0.3234643	0.3234643
6	0.3001065	0.3244418	0.3196442	0.3171910	0.3171910	0.3171910
7	0.2918243	0.3183380	0.3130572	0.3103864	0.3103864	0.3103864
8	0.2918243	0.3183380	0.3130572	0.3103864	0.3103864	0.3103864

TABLE 2.7.6 NORTH SEA HERRING. PROPORTION MATURE

Units : NA

, , unit = A

age \ year	2010	2011	2012	2013	2014	2015
0	0.00	0.00	0.00	0.0000000	0.0000000	0.0000000
1	0.00	0.00	0.00	0.0000000	0.0000000	0.0000000
2	0.45	0.87	0.91	0.7433333	0.7433333	0.7433333
3	0.90	0.84	0.99	0.9100000	0.9100000	0.9100000
4	1.00	1.00	1.00	1.0000000	1.0000000	1.0000000
5	1.00	1.00	1.00	1.0000000	1.0000000	1.0000000
6	1.00	1.00	1.00	1.0000000	1.0000000	1.0000000
7	1.00	1.00	1.00	1.0000000	1.0000000	1.0000000
8	1.00	1.00	1.00	1.0000000	1.0000000	1.0000000

, , unit = B

age \ year	2010	2011	2012	2013	2014	2015
0	0.00	0.00	0.00	0.0000000	0.0000000	0.0000000
1	0.00	0.00	0.00	0.0000000	0.0000000	0.0000000
2	0.45	0.87	0.91	0.7433333	0.7433333	0.7433333
3	0.90	0.84	0.99	0.9100000	0.9100000	0.9100000
4	1.00	1.00	1.00	1.0000000	1.0000000	1.0000000
5	1.00	1.00	1.00	1.0000000	1.0000000	1.0000000
6	1.00	1.00	1.00	1.0000000	1.0000000	1.0000000
7	1.00	1.00	1.00	1.0000000	1.0000000	1.0000000
8	1.00	1.00	1.00	1.0000000	1.0000000	1.0000000

, , unit = C

age \ year	2010	2011	2012	2013	2014	2015
0	0.00	0.00	0.00	0.0000000	0.0000000	0.0000000
1	0.00	0.00	0.00	0.0000000	0.0000000	0.0000000
2	0.45	0.87	0.91	0.7433333	0.7433333	0.7433333
3	0.90	0.84	0.99	0.9100000	0.9100000	0.9100000
4	1.00	1.00	1.00	1.0000000	1.0000000	1.0000000
5	1.00	1.00	1.00	1.0000000	1.0000000	1.0000000
6	1.00	1.00	1.00	1.0000000	1.0000000	1.0000000
7	1.00	1.00	1.00	1.0000000	1.0000000	1.0000000
8	1.00	1.00	1.00	1.0000000	1.0000000	1.0000000

, , unit = D

age \ year	2010	2011	2012	2013	2014	2015
0	0.00	0.00	0.00	0.0000000	0.0000000	0.0000000
1	0.00	0.00	0.00	0.0000000	0.0000000	0.0000000
2	0.45	0.87	0.91	0.7433333	0.7433333	0.7433333
3	0.90	0.84	0.99	0.9100000	0.9100000	0.9100000
4	1.00	1.00	1.00	1.0000000	1.0000000	1.0000000
5	1.00	1.00	1.00	1.0000000	1.0000000	1.0000000
6	1.00	1.00	1.00	1.0000000	1.0000000	1.0000000
7	1.00	1.00	1.00	1.0000000	1.0000000	1.0000000
8	1.00	1.00	1.00	1.0000000	1.0000000	1.0000000

TABLE 2.7.7 NORTH SEA HERRING. FRACTION OF HARVEST BEFORE SPAWNING

Units : NA
, , unit = A

age	2010	2011	2012	2013	2014	2015
0	0.67	0.67	0.67	0.67	0.67	0.67
1	0.67	0.67	0.67	0.67	0.67	0.67
2	0.67	0.67	0.67	0.67	0.67	0.67
3	0.67	0.67	0.67	0.67	0.67	0.67
4	0.67	0.67	0.67	0.67	0.67	0.67
5	0.67	0.67	0.67	0.67	0.67	0.67
6	0.67	0.67	0.67	0.67	0.67	0.67
7	0.67	0.67	0.67	0.67	0.67	0.67
8	0.67	0.67	0.67	0.67	0.67	0.67

, , unit = B

age	2010	2011	2012	2013	2014	2015
0	0.67	0.67	0.67	0.67	0.67	0.67
1	0.67	0.67	0.67	0.67	0.67	0.67
2	0.67	0.67	0.67	0.67	0.67	0.67
3	0.67	0.67	0.67	0.67	0.67	0.67
4	0.67	0.67	0.67	0.67	0.67	0.67
5	0.67	0.67	0.67	0.67	0.67	0.67
6	0.67	0.67	0.67	0.67	0.67	0.67
7	0.67	0.67	0.67	0.67	0.67	0.67
8	0.67	0.67	0.67	0.67	0.67	0.67

, , unit = C

age	2010	2011	2012	2013	2014	2015
0	0.67	0.67	0.67	0.67	0.67	0.67
1	0.67	0.67	0.67	0.67	0.67	0.67
2	0.67	0.67	0.67	0.67	0.67	0.67
3	0.67	0.67	0.67	0.67	0.67	0.67
4	0.67	0.67	0.67	0.67	0.67	0.67
5	0.67	0.67	0.67	0.67	0.67	0.67
6	0.67	0.67	0.67	0.67	0.67	0.67
7	0.67	0.67	0.67	0.67	0.67	0.67
8	0.67	0.67	0.67	0.67	0.67	0.67

, , unit = D

age	2010	2011	2012	2013	2014	2015
0	0.67	0.67	0.67	0.67	0.67	0.67
1	0.67	0.67	0.67	0.67	0.67	0.67
2	0.67	0.67	0.67	0.67	0.67	0.67
3	0.67	0.67	0.67	0.67	0.67	0.67
4	0.67	0.67	0.67	0.67	0.67	0.67
5	0.67	0.67	0.67	0.67	0.67	0.67
6	0.67	0.67	0.67	0.67	0.67	0.67
7	0.67	0.67	0.67	0.67	0.67	0.67
8	0.67	0.67	0.67	0.67	0.67	0.67

TABLE 2.7.8 NORTH SEA HERRING. FRACTION OF NATURAL MORTALITY BEFORE SPAWNING

Units : NA

, , unit = A

age \ year	2010	2011	2012	2013	2014	2015
0	0.67	0.67	0.67	0.67	0.67	0.67
1	0.67	0.67	0.67	0.67	0.67	0.67
2	0.67	0.67	0.67	0.67	0.67	0.67
3	0.67	0.67	0.67	0.67	0.67	0.67
4	0.67	0.67	0.67	0.67	0.67	0.67
5	0.67	0.67	0.67	0.67	0.67	0.67
6	0.67	0.67	0.67	0.67	0.67	0.67
7	0.67	0.67	0.67	0.67	0.67	0.67
8	0.67	0.67	0.67	0.67	0.67	0.67

, , unit = B

age \ year	2010	2011	2012	2013	2014	2015
0	0.67	0.67	0.67	0.67	0.67	0.67
1	0.67	0.67	0.67	0.67	0.67	0.67
2	0.67	0.67	0.67	0.67	0.67	0.67
3	0.67	0.67	0.67	0.67	0.67	0.67
4	0.67	0.67	0.67	0.67	0.67	0.67
5	0.67	0.67	0.67	0.67	0.67	0.67
6	0.67	0.67	0.67	0.67	0.67	0.67
7	0.67	0.67	0.67	0.67	0.67	0.67
8	0.67	0.67	0.67	0.67	0.67	0.67

, , unit = C

age \ year	2010	2011	2012	2013	2014	2015
0	0.67	0.67	0.67	0.67	0.67	0.67
1	0.67	0.67	0.67	0.67	0.67	0.67
2	0.67	0.67	0.67	0.67	0.67	0.67
3	0.67	0.67	0.67	0.67	0.67	0.67
4	0.67	0.67	0.67	0.67	0.67	0.67
5	0.67	0.67	0.67	0.67	0.67	0.67
6	0.67	0.67	0.67	0.67	0.67	0.67
7	0.67	0.67	0.67	0.67	0.67	0.67
8	0.67	0.67	0.67	0.67	0.67	0.67

, , unit = D

age \ year	2010	2011	2012	2013	2014	2015
0	0.67	0.67	0.67	0.67	0.67	0.67
1	0.67	0.67	0.67	0.67	0.67	0.67
2	0.67	0.67	0.67	0.67	0.67	0.67
3	0.67	0.67	0.67	0.67	0.67	0.67
4	0.67	0.67	0.67	0.67	0.67	0.67
5	0.67	0.67	0.67	0.67	0.67	0.67
6	0.67	0.67	0.67	0.67	0.67	0.67
7	0.67	0.67	0.67	0.67	0.67	0.67
8	0.67	0.67	0.67	0.67	0.67	0.67

TABLE 2.7.9 NORTH SEA HERRING. Recruitment in 2014

29245304

TABLE 2.7.10 NORTH SEA HERRING. Recruitment in 2015

29245304

TABLE 2.7.11 NORTH SEA HERRING. FLR, R SOFTWARE VERSIONS

```
R version 2.13.2 (2011-09-30)

Package  : FLSAM
Version  : 0.99-99
Packaged :
Built    : R 2.13.2; ; 2013-03-17 22:10:20 UTC; windows

Package  : FLAssess
Version  : 2.4
Packaged :
Built    : R 2.13.2; i386-pc-mingw32; 2011-10-05 12:21:47 UTC; windows

Package  : FLCore
Version  : 2.4
Packaged :
Built    : R 2.13.2; i386-pc-mingw32; 2011-10-05 12:21:01 UTC; windows
```

Table 2.7.12. North Sea herring. Management options for North Sea herring.

Outlook assuming a TAC constraint for fleet A in 2013, proportion of 2012 by-catch ceiling taken applied to 2013 for fleet B

Basis: Intermediate year (2013) with catch constraint

F fleet A	F fleet B	F fleet C	F fleet D	F_{0-1}	F_{2-6}	Catch fleet A	Catch fleet B	Catch Fleet C	Catch fleet D	SSB 2013
0.232	0.022	0.006	0.008	0.039	0.236	497.9[1]	8.6	11.8	2.5	1996

[1]Includes a transfer of 2095 tonnes of the Norwegian quota and 40% of IIIa TAC from the C-fleet to the A-fleet

Scenarios for prediction year (2014)

	F-values by fleet and total						Catches by fleet				Biomass			
	FLEET A	FLEET B	FLEET C	FLEET D	F_{0-1}	F_{2-6}	FLEET A	FLEET B	FLEET C	FLEET D	**SSB 2014[1)]**	**SSB 2015**	**%SSB CHANGE [2)]**	**%TAC CHANGE FLEET A [3)]**
A	0	0	0	0	0	0	0	0	0	0	2101	2183	+5%	-100%
B	0.245	0.031	0.008	0.008	0.05	0.25	470037	12440	11242	2427	1780	1508	-11%	-2%
C	0.250	0.031	0.008	0.008	0.05	0.25	478000	12440	11242	2427	1774	1498	-11%	0%
D	0.294	0.031	0.008	0.008	0.05	0.30	549700	12440	11242	2427	1724	1411	-14%	+15%
E	0.208	0.031	0.008	0.008	0.05	0.21	406300	12440	11242	2427	1824	1590	-9%	-15%
F	0.265	0.031	0.008	0.008	0.05	0.27	503399	12440	11242	2427	1757	1467	-12%	+5%

Weights in '000 t.

All numbers apply to North Sea autumn-spawning herring only.

1) For autumn spawning stocks, the SSB is determined at spawning time and is influenced by fisheries between 1st January and spawning.

2) SSB (2014) relative to SSB (2013).

3) Calculated landings (2014) relative to TAC 2013 for the A fleet.

Table 2.7.2.1. North Sea herring. Exploratory short term forecast management options for North Sea herring.

Outlook assuming a TAC constraint for fleet A in 2013, proportion of 2012 by-catch ceiling taken applied to 2013 for fleet B

Basis: Intermediate year (2013) with catch constraint (95% CI between '[ ]')

F fleet A	F fleet B	F fleet C	F fleet D	F_{0-1}	F_{2-6}	Catch fleet A[1]	Catch fleet B	Catch Fleet C	Catch fleet D	SSB 2013
0.226 [0.183, 0.282]	0.021 [0.015, 0.032]	0.006 [0.004, 0.008]	0.008 [0.006, 0.011]	0.04 [0.03, 0.05]	0.23 [0.18, 0.29]	497.9	8.6	11.8	2.5	2007 [1621, 2760]

[1]Includes a transfer of 2095 tonnes of the Norwegian quota and 40% of IIIa TAC from the C-fleet to the A-fleet

Scenarios for prediction year (2014) (95% CI between '[ ]')

	F-values by fleet and total						Catches by fleet				Biomass			
	fleet A	fleet B	fleet C	fleet D	F0-1	F2-6	fleet A	fleet B	fleet C	fleet D	SSB 2014)	SSB 2015	%SSB change 2)	%TAC change fleet A 3)
A	0	0	0	0	0	0	0	0	0	0	2131 [1712, 2658]	2212 [1758, 2760]	+6% [+6%, +11%]	-100%
B	0.245 [0.235, 0.247]	0.031 [0.024, 0.036]	0.008 [0.005, 0.011]	0.008 [0.006, 0.011]	0.05 [0.05, 005]	0.25 [0.24, 0.25]	473616 [380856, 610384]	13045 [8723, 18396]	11242	2427	1796 [1456, 2552]	1533 [1186, 1958]	-11% [-10%, -6%]	-1% [-20%, +28%]
C	0.243 [0.190, 0.313]	0.031 [0.023, 0.039]	0.007 [0.005, 0.011]	0.008 [0.006, 0.011]	0.05 [0.04, 0.06]	0.25 [0.19, 0.32]	478000	13045 [8723, 18396]	11242	2427	1806 [1373, 2333]	1523 [1111, 2045]	-10% [-15%, -2%]	0%
D	0.285 [0.223, 0.368]	0.031 [0.023, 0.039]	0.007 [0.005, 0.011]	0.008 [0.006, 0.011]	0.05 [0.04, 0.06]	0.29 [0.23, 0.37]	549700	13045 [8723, 18396]	11242	2427	1757 [1320, 2284]	1434 [1028, 1953]	-12% [-19%, -5%]	+15%
E	0.202 [0.159, 0.260]	0.031 [0.023, 0.039]	0.007 [0.005, 0.011]	0.008 [0.006, 0.011]	0.05 [0.04, 0.06]	0.21 [0.16, 0.26]	406300	13045 [8723, 18396]	11242	2427	1856 [1424, 2381]	1615 [1198, 2141]	-8% [-12%, -0%]	-15%
F	0.265 [0.264, 0.267]	0.031 [0.023, 0.039]	0.007 [0.005, 0.011]	0.008 [0.006, 0.011]	0.05 [0.04, 0.06]	0.27	515277 [413858, 641089	13045 [8723, 18396]	11242	2427	1751 [1428, 2242]	1475 [1152, 1938]	-13% [-12%, -6%]	+8% [-13%, +34%]

Weights in '000 t.

All numbers apply to North Sea autumn-spawning herring only.

1) For autumn spawning stocks, the SSB is determined at spawning time and is influenced by fisheries between 1st January and spawning.

2) SSB (2014) relative to SSB (2013). 3) Calculated landings (2014) relative to TAC 2013 for the A fleet.

Table 2.1.1: Herring caught in the North Sea. Catch in tonnes by country, 2003 – 2012. These figures do not in all cases correspond to the official statistics and cannot be used for legal purposes.

Country	2003	2004	2005	2006	2007
Belgium	5	8	6	3	1
Denmark [6]	78606	99037	128380	102322	84697
Faroe Islands	627	402	738	1785	2891
France	31544	34521	38829	49475	24909
Germany	43953	41858	46555	40414	14893
Netherlands	81108	96162	81531	76315	66393
Norway [1]	112481	137638	156802	135361	100050
Poland	-	-	458	-	-
Sweden	4781	5692	13464	10529	15448
USSR/Russia	-	-	99	-	-
UK (England)	18639	20855	25311	22198	15993
UK (Scotland)	40292	45331	73227	48428	35115
UK (N.Ireland)	2010	2656	2912	3531	638
Unallocated landings	31875 [5]	48898 [5]	57788	18764	26641
Total landings	445921	533058	626101	509125	387669
Discards	4125	17059	12824	1492	93
Total catch	**450046**	**550117**	**638925**	**510617**	**387762**
Estimates of the parts of the catches which have been allocated to spring spawning stocks					
WBSS	2821	7079	7039	10954	1070
Thames estuary [2]	84	62	74	65	2
Others [3]	308	0	0	0	0
Norw. Spring Spawners [4]	979	452	417	626	685

Country	2008	2009	2010	2011	2012
Belgium	-	-	-	4	3
Denmark [6]	62864	46238	45869	58726	105707
Faroe Islands	2014	1803	3014	-	-
France	30347	18114	17745	16693	23819
Germany	8095	5368	7670	9427	24515
Netherlands	23122	24552	23872	34708	72344
Norway [1]	59321	50445	46816	60705	119253
Lithuania	-	-	90	-	-
Sweden	13840	5299	4395	8086	14092
Russia	-	-	-	-	-
UK (England)	11717	652	10770	11468	25346
UK (Scotland)	16021	14006	14373	18564	34414
UK (N.Ireland)	331	-	-	17	4794
Unallocated landings	17151	-726	0	0	321
Total landings	244823	165751	174614	218398	424608
Discards	224	91	13	0	0
Total catch	**245047**	**165842**	**174627**	**218398**	**424608**
Estimates of the parts of the catches which have been allocated to spring spawning stocks					
WBSS	124	3941	774	308	2095
Thames estuary [2]	7	48	85	2	63
Others [3]	0	0	0	0	0
Norw. Spring Spawners [4]	2721	44560	56900	12178	9619

1 **Catches of Norwegian spring spawners removed (taken under a separate TAC).**

2 **Landings from the Thames estuary area are included in the North Sea catch figure for UK (England).**

3 **Caught in the whole North Sea, partly included in the catch figure for The Netherlands**

4 **These catches (including some local fjord-type Spring Spawners) are taken by Norway under a separate quota south of 62°N and are not included in the Norwegian North Sea catch figure for this area.**

5 **may include misreported catch from VIaN and discards**

6 **Including any by-catches in the industrial fishery**

Table 2.1.2: Herring caught in the North Sea. Catch in tonnes in Division IVa West. These figures do not in all cases correspond to the official statistics and cannot be used for legal purposes.

Country	**2003**	**2004**	**2005**	**2006**	**2007**
Denmark [1]	48358	48128	80990	60462	45948
Faroe Islands	95	-		580	1118
France	11237	10941	13474	18453	8570
Germany	25796	17559	22278	18605	4985
Netherlands	25045	43876	36619	39209	42622
Norway	34443	36119	66232	38363	40279
Poland	-	-	458	-	-
Sweden	2647	2178	8261	4957	7658
Russia	-	-	99	-	-
UK (England)	12030	13480	15523	12031	11833
UK (Scotland)	39970	43490	71941	47368	35115
UK (N. Ireland)	2010	2656	2912	3531	638
Unallocated landings	14115 [2]	28631 [2]	39324 [2]	10981 [2]	22215
Misreporting from VIa North					
Total Landings	215746	247058	358111	253048	220981
Discards	4125	15794	10861	1492	93
Total catch	**219871**	**262852**	**368972**	**254540**	**221074**

Country	**2008**	**2009**	**2010**	**2011**	**2012**
Denmark [1]	28426	16550	25092	26523	42867
Faroe Islands	2	288	1110	-	-
France	13068	7067	6412	7885	11131
Germany	498	-	505	2642	13060
Netherlands	11634	11017	13593	15202	46654
Norway	40304	25926	38897	45200	72581
Lithuania	-	-	90	-	-
Sweden	7025	1435	2310	5121	6065
Russia	-	-	-	-	-
UK (England)	8355	578	7384	4555	18289
UK (Scotland)	14727	10249	13567	17909	33352
UK (N. Ireland)	331	-	-	17	4794
Unallocated landings	14952	-977	0	0	-3416
Misreporting from VIa North					
Total Landings	139322	72133	108960	125054	245377
Discards	194	91	13	0	0
Total catch	**139516**	**72224**	**108973**	**125054**	**245377**

1 **Including any by-catches in the industrial fishery**

2 **May include misreported catch from VIaN and discards**

Table 2.1.3: Herring caught in the North Sea. Catch in tonnes in Division IVa East. These figures do not in all cases correspond to the official statistics and cannot be used for legal purposes.

Country	2003	2004	2005	2006	2007
Denmark 1	7401	16278	5761	8614	2646
Faroe Islands	359	-	738	975	577
France	-	-	-	-	-
Germany	54	888	-	34	-
Netherlands	-	-	-	-	263
Norway 2	62306	100443	89925	90065	54424
UK (Scotland)	-	-	-	83	-
Sweden	1529	1720	3510	2857	640
Unallocated landings	9988	0	0	0	-96 3
Total landings	81637	119329	99934	102628	58454
Discards	-	-	-	-	-
Total catch	**83640**	**119329**	**99934**	**102628**	**58454**
Norw. Spring Spawners 4	979	452	417	626	685

Country	2008	2009	2010	2011	2012
Denmark 1	1587	499	-	1590	1822
Faroe Islands	400	700	719	-	-
France	-	-	-	-	-
Germany	-	-	-	-	-
Netherlands	-	-	-	-	-
Norway 2	17474	6981	7362	12922	32714
UK (Scotland)	-	-	-	167	
Sweden	-	1735	1505	150	815
Unallocated landings	0	0	0	0	0
Total landings	19461	9915	9586	14829	35351
Discards	-	-	-	-	-
Total catch	**19461**	**9915**	**9586**	**14829**	**35351**
Norw. Spring Spawners 4	2721	44560	56900	12178	9619

[1] Including any by-catches in the industrial fishery
[2] Catches of Norwegian spring spawning herring removed (taken under a separate TAC)
[3] Negative unallocated catches due to misreporting into other areas
[4] These catches (including some fjord-type spring spawners) are taken by Norway under a separate quota south of 62°N and are not included in the Norwegian North Sea catch figure for this area

Table 2.1.4: Herring caught in the North Sea. Catch in tonnes in Division IVb. These figures do not in all cases correspond to the official statistics and cannot be used for legal purposes.

Country	2003	2004	2005	2006	2007
Denmark [1]	22574	33857	41423	32277	35990
Faroe Islands	173	402	-	200	1196
France	7918	10592	10205	17385	8421
Germany	12116	13823	14381	14222	2205
Netherlands	19115	23649	10038	13363	8550
Norway	15732	1076	645	6933	5347
Sweden	605	1794	1694	2715	7150
UK (England)	2632	2864	3869	4924	577
UK (Scotland)	322	1841	1286	977	-
Unallocated landings [3]	-2401	8300	10233	2364	-203
Total landings	78786	98198	93774	95360	69233
Discards [2]		1265	1963		
Total catch	**78786**	**99463**	**95737**	**95360**	**69233**

Country	2008	2009	2010	2011	2012
Denmark [1]	32230	29164	19671	30498	60503
Faroe Islands	1612	815	1185	-	-
France	9687	4316	2349	1687	3898
Germany	2415	1061	1994	1778	4187
Netherlands	904	3164	830	7314	9202
Norway	1543	17538	557	2537	13958
Sweden	6815	2129	580	2815	7212
UK (England)	833	2	1577	4748	3045
UK (Scotland)	1293	3757	805	488	1062
Unallocated landings [3]	-904	-166	0	0	411
Total landings	56428	61780	29548	51865	103478
Discards [2]	30				
Total catch	**56458**	**61780**	**29548**	**51865**	**103478**

[1] **Including any by-catches in the industrial fishery**

[2] **Discards partly included in unallocated landings**

[3] **Negative unallocated catches due to misreporting into other areas**

Table 2.1.5: Herring caught in the North Sea. Catch in tonnes in Division IVc and VIId. These figures do not in all cases correspond to the official statistics and cannot be used for legal purposes.

Country	2003	2004	2005	2006	2007
Belgium	5	8	6	3	1
Denmark	273	774	206	969	113
Faroe Islands				30	-
France	12389	12988	15150	13637	7918
Germany	5987	9588	9896	7553	7703
Netherlands	36948	28637	34874	23743	14958
UK (England)	3977	4511	5919	5243	3583
UK (Scotland)	-	-	-	-	-
Unallocated landings	8170	9963	8231	5419	4725
Total landings	67749	68473	74282	56597	39001
Discards 2	-	-	-	-	-
Total catch	**67749**	**68473**	**74282**	**56597**	**39001**
Coastal spring spawners included above 1	84	62	74	65	2

Country	2008	2009	2010	2011	2012
Belgium	-	-	-	4	3
Denmark [3]	621	25	1106	115	515
France	7592	6731	8984	7121	8790
Germany	5182	4307	5171	5007	7268
Netherlands	10584	10371	9449	12192	16488
Norway	-	-	-	46	-
UK (England)	2529	72	1809	2165	4012
UK (Scotland)	1	-	1	-	-
Unallocated landings	3103	417	0	0	3326
Total landings	29612	21923	26520	26650	40402
Discards 2	-				
Total catch	**29612**	**21923**	**26520**	**26650**	**40402**
Coastal spring spawners included above 1	7	48	85	2	63

[1] Landings from the Thames estuary area are included in the North Sea catch figure for UK (England)

[2] Discards partly included in unallocated landings

Table 2.1.6 ("The Wonderful Table"): Herring caught in the North Sea. Catch in thousand tonnes in Subarea IV, Division VIId and Division IIIa.

Table 2.1.6 ("The Wonderful Table"): HERRING in Sub-area IV, Division VIId and Division IIIa. Figures in thousand tonnes.

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Sub-Area IV and Division VIId: TAC (IV and VIId)														
Recommended Divisions IVa, b	265	- [15]	- [15]	- [15]	- [15]	- [15]	- [15]	- [15]	- [15]	- [15]	-	-	-	
Recommended Divisions IVc, VIId	- [11]	- [11]	- [11]	- [11]	- [11]	- [11]	- [11]	- [11]	- [11]	- [11]	-	-	-	
Expected catch of spring spawners														
Agreed Divisions IVa,b [1]	240	240	223	340.5	393.9	460.7	404.7	303.5	174.6	147.4	149.0	173.5	360.4	427.7
Agreed Div. IVc, VIId	25	25	42.7	59.5	66.1	74.3	50.0	37.5	26.7	23.6	15.3	26.5	44.6	50.3
Bycatch ceiling in the small mesh fishery	36	36	36	52.0	38.0	50.0	42.5	31.9	18.8	16.0	13.6	16.5	17.9	14.4
CATCH (IV and VIId)														
National landings Divisions IVa,b [2]	261	272	261	354.5	427.7	502.3	439.2	326.8	201.2	145.0	148.1	191.7	387.2	
Unallocated landings Divisions IVa,b	35	2	24	23.7	36.9	49.6	13.3	21.9	14.0	-1.1	0.0	0.0	-3.0	
Discard/slipping Divisions IVa,b [3]	-	-	17	4.1	17.1	12.8	1.5	0.1	0.2	0.1	0.0	0.0	0	
Total catch Divisions IVa,b [4]	296	273	303	382.3	481.6	564.6	454.0	348.8	215.4	143.9	148.1	191.7	384.2	
National landings Divisions IVc, VIId [3]	23	24	43	59.5	56.5	66.1	51.2	34.3	26.5	21.5	26.5	26.7	37.1	
Unallocated landings Divisions IVc,VIId	27	26	7	8.2	12.0	8.2	5.4	4.7	3.1	0.4	0	0	3.3	
Discard/slipping Divisions IVc, VIId [3]	-	-	0	-	-	-	-	-	-	-	-	-	-	
Total catch Divisions IVc, VIId	50	50	50	67.7	68.5	74.3	56.6	39.0	29.6	21.9	26.5	26.7	40.4	
Total catch IV and VIId as used by ICES [4]	**346**	**323**	**353**	**450.0**	**550.1**	**638.9**	**510.62**	**387.8**	**245.0**	**165.8**	**174.6**	**218.4**	**424.6**	
CATCH BY FLEET/STOCK (IV and VIId) [7]														
North Sea autumn spawners directed fisheries (Fleet A)	322	296	323	434.9	529.5	610.0	487.1	379.6	236.3	152.1	164.8	209.2	411.8	
North Sea autumn spawners industrial (Fleet B)	18	20	22	12.3	13.6	21.8	11.9	7.1	8.6	9.8	9.1	8.9	10.6	
North Sea autumn spawners in IV and VIId total	**339**	**317**	**346**	**447.2**	**543.0**	**631.9**	**499.0**	**386.7**	**244.9**	**161.9**	**173.9**	**218.1**	**422.5**	
Baltic-IIIa-type spring spawners in IV	7	6	7	2.8	7.1	7.0	11.0	1.1	0.1	3.9	0.8	0.3	2.1	
Coastal-type spring spawners	0.1	1.2	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.1	0.0	0.1	
Norw. Spring Spawners caught under a separate quota in IV [14]	26	7	4	1.0	0.5	0.4	0.6	0.7	2.7	44.6	56.9	12.2	9.6	
Division IIIa: TAC (IIIa)														
Predicted catch of autumn spawners	53	- [15]	- [15]	- [15]	- [15]	- [15]	- [15]	- [15]	- [15]	- [15]	- [15]	- [15]	-	
Recommended spring spawners	- [12]	- [12]	- [12]	- [12]	- [15]	- [15]	- [15]	- [15]	- [15]	- [15]	- [15]	- [15]	-	
Recommended mixed clupeoids	-	-	-	-	-	-	-	-	-	-	-			
Agreed herring TAC	80	80	80	80.0	70.0	96.0	81.6	69.4	51.7	37.7	33.9	30.0	45.0	55.0
Agreed mixed clupeoid TAC														
Bycatch ceiling in the small mesh fishery	21	21	21	21.0	21.0	24.2	20.5	15.4	11.5	8.4	7.5	6.7	6.7	6.7
CATCH (IIIa)														
National landings	108	90	79	76.0	61.1	90.8	88.9	47.3	38.2	38.8	37.3	20.0	27.7	
Catch as used by ICES	99	82	73	68.1	52.7	69.6	51.2	47.4	38.2	38.8	37.3	20.0	27.7	
CATCH BY FLEET/STOCK (IIIa) [7]														
Autumn spawners human consumption (Fleet C)	36	34	17	24.1	13.4	22.9	11.6	16.4	9.2	5.1	12.0	6.6	7.8	
Autumn spawners mixed clupeoid (Fleet D) [13]	13	12	9	8.4	10.8	9.0	3.4	3.4	3.7	1.5	1.8	1.8	4.4	
Autumn spawners other industrial landings (Fleet E)														
Autumn spawners in IIIa total	**49**	**46**	**26**	**32.5**	**24.2**	**31.9**	**15.0**	**19.8**	**12.9**	**6.5**	**13.8**	**8.4**	**12.2**	
Spring spawners human consumption (Fleet C)	45	33	38	31.6	16.8	32.5	30.2	25.3	23.0	29.4	23.0	10.8	14.5	
Spring spawners mixed clupeoid (Fleet D) [13]	5	3	9	4.0	11.2	5.1	5.9	2.3	2.2	2.9	0.5	0.8	1.0	
Spring spawners other industrial landings (Fleet E)														
Spring spawners in IIIa total	**50**	**36**	**47**	**35.6**	**28.0**	**37.6**	**36.1**	**27.6**	**25.2**	**32.3**	**23.5**	**11.6**	**15.5**	
North Sea autumn spawners Total as used by ICES	**388**	**363**	**372**	**479.7**	**567.2**	**663.8**	**514.6**	**406.5**	**257.9**	**168.4**	**187.6**	**226.5**	**434.6**	

1 IVa,b and EC zone of IIa. 2 Provided by Working Group members. 3 Incomplete, only some countries providing discard information. 4 Includes spring spawners not included in assessment. 5 Based on F=0.3 in directed fishery only; TAC advised for IVc, VIId subtracted. 6 130-180 for spring spawners in all areas. 7 Based on sum-of-products (number x mean weight at age). 8 Status quo F catch for fleet A. 9 The catch should not exceed recent catch levels. 10 During the middle of 1996 revised to 50% of its original agreed TAC. 11 Included in IVa,b. 12 Managed in accordance with autumn spawners. 13 Fleet D and E are merged from 1999 onwards. 14 These catches (including local fjord-type Spring Spawners) are taken by Norway under a separate quota south of 62°N and are not included in the Norwegian North Sea catch figure for this area. 15 See catch option tables for different fleets.

Table 2.2.1: North Sea autumn spawning herring (NSAS), and western Baltic spring spawners (WBSS) caught in the North Sea and Div IIIa in 2012. Catch in numbers (millions) at age (CANUM), by quarter and division.

WR	IIIa NSAS	IVa(E) all	IVa(E) WBBS	IVa(E) NSAS only	IVa(W)	IVb	IVc	VIId	IVa & IVb NSAS	IVc & VIId	Total NSAS	Herring caught in the North Sea
Quarters: 1-4												
0	**145.8**	**0.0**	**0.0**	**0.0**	**0.0**	**619.4**	**8.1**	**0.0**	**619.4**	**8.1**	**773.2**	**627.4**
1	**174.9**	**2.3**	**0.0**	**2.3**	**6.8**	**95.2**	**4.5**	**1.2**	**104.3**	**5.7**	**284.9**	**110.0**
2	**43.7**	**7.6**	**0.0**	**7.6**	**232.3**	**128.1**	**14.0**	**29.4**	**368.1**	**43.5**	**455.2**	**411.5**
3	**1.9**	**52.4**	**0.2**	**52.2**	**402.9**	**194.8**	**1.5**	**19.8**	**649.8**	**21.3**	**673.0**	**671.4**
4	**1.2**	**23.1**	**0.4**	**22.7**	**253.4**	**57.9**	**4.6**	**63.7**	**334.0**	**68.3**	**403.5**	**402.7**
5	**0.2**	**20.2**	**0.0**	**20.2**	**179.0**	**57.3**	**3.0**	**46.4**	**256.6**	**49.5**	**306.2**	**306.0**
6	**0.2**	**19.5**	**1.4**	**18.1**	**91.7**	**32.2**	**0.5**	**7.0**	**142.0**	**7.5**	**149.7**	**150.9**
7	**0.1**	**14.0**	**0.0**	**14.0**	**56.5**	**22.9**	**0.3**	**10.7**	**93.4**	**11.0**	**104.5**	**104.3**
8	**0.0**	**8.0**	**1.1**	**6.9**	**39.1**	**31.5**	**1.1**	**9.7**	**77.5**	**10.8**	**88.4**	**89.5**
9+	**0.0**	**28.5**	**6.3**	**22.2**	**48.7**	**22.4**	**0.6**	**8.5**	**93.2**	**9.0**	**102.2**	**108.5**
Sum	**368.0**	**175.7**	**9.4**	**166.2**	**1310.3**	**1261.7**	**38.2**	**196.5**	**2738.2**	**234.7**	**3341.0**	**2982.4**
Quarter: 1												
0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	**0.0**
1	60.7	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.5	0.0	**61.2**	**0.5**
2	28.9	0.2	0.0	0.2	4.6	19.3	0.1	0.0	24.1	0.1	**53.1**	**24.2**
3	1.0	2.3	0.0	2.2	22.0	113.0	0.6	1.9	137.2	2.5	**140.7**	**139.7**
4	0.0	1.2	0.0	1.2	5.5	15.1	1.0	4.9	21.8	5.9	**27.8**	**27.8**
5	0.0	1.3	0.0	1.3	5.3	7.3	1.1	3.8	13.9	4.9	**18.9**	**18.9**
6	0.0	0.6	0.0	0.6	4.1	9.8	0.4	1.2	14.4	1.6	**16.0**	**16.0**
7	0.0	0.3	0.0	0.3	1.9	1.6	0.3	0.6	3.8	0.9	**4.7**	**4.7**
8	0.0	0.3	0.0	0.3	1.2	1.8	0.6	1.4	3.3	2.0	**5.3**	**5.3**
9+	0.0	0.5	0.0	0.5	1.7	0.0	0.5	2.7	2.2	3.3	**5.5**	**5.5**
Sum	**90.7**	**6.6**	**0.1**	**6.5**	**46.8**	**167.9**	**4.6**	**16.6**	**221.3**	**21.2**	**333.1**	**242.5**
Quarter: 2												
0	0.0	0.0	0.0	0.0	0.0	167.9	0.0	0.0	167.9	0.0	**167.9**	**167.9**
1	29.5	0.0	0.0	0.0	1.2	7.5	0.1	0.0	8.6	0.1	**38.1**	**8.7**
2	1.7	0.2	0.0	0.2	102.9	13.9	0.2	0.0	117.0	0.2	**118.9**	**117.2**
3	0.1	20.4	0.1	20.3	98.7	10.2	0.0	0.0	129.2	0.1	**129.3**	**129.4**
4	0.0	12.4	0.0	12.4	107.4	4.0	0.0	0.1	123.8	0.1	**123.9**	**123.9**
5	0.0	14.0	0.0	14.0	60.8	3.0	0.0	0.1	77.8	0.1	**77.8**	**77.8**
6	0.0	5.9	0.0	5.9	19.3	1.4	0.0	0.0	26.6	0.0	**26.6**	**26.6**
7	0.0	3.6	0.0	3.6	10.0	1.2	0.0	0.0	14.7	0.0	**14.8**	**14.8**
8	0.0	3.3	0.0	3.3	5.5	1.4	0.0	0.0	10.1	0.0	**10.2**	**10.2**
9+	0.0	5.8	0.0	5.8	7.9	1.1	0.0	0.0	14.8	0.0	**14.9**	**14.9**
Sum	**31.2**	**65.7**	**0.1**	**65.6**	**413.6**	**211.5**	**0.3**	**0.2**	**690.7**	**0.5**	**722.4**	**691.3**
Quarter: 3												
0	104.3	0.0	0.0	0.0	0.0	238.0	0.0	0.0	238.0	0.0	**342.3**	**238.0**
1	55.0	0.1	0.0	0.1	1.5	15.5	0.0	0.0	17.1	0.0	**72.1**	**17.1**
2	11.0	0.8	0.0	0.8	86.2	57.8	0.0	0.0	144.8	0.0	**155.8**	**144.8**
3	0.5	3.3	0.0	3.3	252.5	46.6	0.0	0.0	302.4	0.0	**302.9**	**302.4**
4	0.8	2.3	0.0	2.3	129.6	25.4	0.0	0.0	157.3	0.0	**158.1**	**157.3**
5	0.2	1.2	0.0	1.2	102.8	38.3	0.0	0.0	142.3	0.0	**142.5**	**142.3**
6	0.2	0.9	0.0	0.9	56.1	13.3	0.0	0.0	70.4	0.0	**70.5**	**70.4**
7	0.1	0.6	0.0	0.6	36.1	14.0	0.0	0.0	50.8	0.0	**50.8**	**50.8**
8	0.0	0.6	0.0	0.6	29.4	23.3	0.0	0.0	53.3	0.0	**53.3**	**53.3**
9+	0.0	0.3	0.0	0.3	32.1	9.3	0.0	0.0	41.7	0.0	**41.7**	**41.7**
Sum	**172.0**	**10.1**	**0.1**	**10.0**	**726.4**	**481.6**	**0.0**	**0.0**	**1218.0**	**0.0**	**1390.1**	**1218.2**
Quarter: 4												
0	41.5	0.0	0.0	0.0	0.0	213.5	8.1	0.0	213.5	8.1	**263.1**	**221.6**
1	29.7	2.3	0.0	2.3	3.6	72.2	4.4	1.2	78.1	5.7	**113.4**	**83.7**
2	2.2	6.4	0.0	6.4	38.6	37.1	13.7	29.4	82.1	43.1	**127.4**	**125.3**
3	0.3	26.4	0.0	26.4	29.7	24.9	0.9	17.9	81.1	18.8	**100.1**	**99.9**
4	0.3	7.2	0.3	6.8	10.9	13.4	3.6	58.7	31.1	62.3	**93.7**	**93.7**
5	0.0	3.8	0.0	3.8	10.1	8.7	1.9	42.5	22.6	44.4	**67.0**	**67.0**
6	0.0	12.1	1.4	10.7	12.2	7.7	0.2	5.8	30.6	6.0	**36.6**	**38.0**
7	0.1	9.4	0.0	9.4	8.4	6.2	0.0	10.1	24.0	10.1	**34.2**	**34.1**
8	0.0	3.8	1.1	2.7	3.0	5.1	0.5	8.3	10.8	8.8	**19.6**	**20.7**
9+	0.0	21.9	6.3	15.6	6.9	11.9	0.0	5.7	34.4	5.7	**40.1**	**46.4**
Sum	**74.1**	**93.2**	**9.1**	**84.1**	**123.5**	**400.7**	**33.3**	**179.7**	**608.3**	**213.0**	**895.3**	**830.4**

Table 2.2.2: North Sea autumn spawning herring (NSAS), and western Baltic spring spawners (WBSS) caught in the North Sea and Div IIIa in 2012. Mean weight-at-age (kg) in the catch (WE-CA), by quarter and division.

WR	IIIa NSAS	IVa(E) all	IVa(E) WBSS	IVa(W)	IVb	IVc	VIId	IVa & IVb all	IVc & VIId	Total NSAS	Herring caught in the North Sea
Quarters: 1-4											
0	0.013	0.000	0.000	0.000	0.010	0.019	0.000	0.010	0.019	0.011	0.010
1	0.040	0.101	0.000	0.089	0.053	0.058	0.094	0.056	0.065	0.046	0.057
2	0.067	0.146	0.150	0.132	0.131	0.106	0.125	0.132	0.119	0.124	0.130
3	0.124	0.185	0.167	0.184	0.141	0.155	0.165	0.171	0.165	0.171	0.171
4	0.169	0.195	0.183	0.186	0.178	0.184	0.186	0.185	0.186	0.185	0.185
5	0.175	0.203	0.208	0.206	0.209	0.191	0.203	0.207	0.202	0.206	0.206
6	0.200	0.216	0.213	0.226	0.214	0.204	0.213	0.222	0.212	0.222	0.222
7	0.221	0.225	0.211	0.240	0.245	0.197	0.235	0.239	0.234	0.239	0.239
8	0.216	0.225	0.201	0.242	0.250	0.188	0.212	0.243	0.209	0.239	0.239
9+	0.000	0.232	0.230	0.254	0.258	0.218	0.227	0.248	0.226	0.246	0.247
Quarter: 1											
0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1	0.017	0.089	0.089	0.089	0.000	0.000	0.000	0.089	0.000	0.018	0.089
2	0.053	0.119	0.119	0.113	0.088	0.096	0.000	0.093	0.096	0.071	0.093
3	0.105	0.173	0.173	0.133	0.111	0.128	0.127	0.116	0.127	0.116	0.116
4	0.121	0.184	0.184	0.153	0.130	0.153	0.143	0.139	0.145	0.140	0.140
5	0.135	0.196	0.196	0.184	0.155	0.173	0.161	0.169	0.164	0.168	0.168
6	0.208	0.213	0.213	0.184	0.157	0.190	0.184	0.167	0.185	0.169	0.169
7	0.000	0.213	0.213	0.213	0.170	0.198	0.188	0.196	0.191	0.195	0.195
8	0.000	0.217	0.217	0.217	0.180	0.184	0.167	0.197	0.172	0.188	0.188
9+	0.000	0.251	0.251	0.236	0.214	0.218	0.221	0.239	0.220	0.228	0.228
Quarter: 2											
0	0.000	0.000	0.000	0.000	0.004	0.000	0.000	0.004	0.000	0.004	0.004
1	0.022	0.000	0.000	0.076	0.037	0.043	0.000	0.043	0.043	0.027	0.043
2	0.060	0.159	0.159	0.125	0.097	0.075	0.000	0.121	0.075	0.120	0.121
3	0.113	0.187	0.187	0.155	0.151	0.123	0.127	0.160	0.125	0.160	0.160
4	0.127	0.190	0.190	0.161	0.168	0.144	0.143	0.164	0.143	0.164	0.164
5	0.118	0.198	0.198	0.177	0.190	0.158	0.161	0.181	0.160	0.181	0.181
6	0.000	0.219	0.219	0.194	0.218	0.200	0.184	0.201	0.185	0.201	0.201
7	0.156	0.214	0.214	0.198	0.227	0.162	0.188	0.204	0.181	0.204	0.204
8	0.000	0.218	0.218	0.202	0.230	0.183	0.167	0.211	0.168	0.211	0.211
9+	0.000	0.251	0.251	0.200	0.250	0.221	0.221	0.224	0.221	0.224	0.224
Quarter: 3											
0	0.010	0.000	0.000	0.000	0.008	0.035	0.000	0.008	0.035	0.009	0.008
1	0.061	0.090	0.090	0.083	0.057	0.069	0.085	0.059	0.070	0.061	0.059
2	0.097	0.145	0.145	0.144	0.147	0.106	0.140	0.145	0.110	0.142	0.145
3	0.149	0.191	0.191	0.200	0.185	0.182	0.173	0.198	0.177	0.198	0.198
4	0.168	0.196	0.196	0.208	0.197	0.193	0.193	0.206	0.193	0.206	0.206
5	0.178	0.218	0.219	0.226	0.216	0.204	0.207	0.223	0.206	0.223	0.223
6	0.201	0.231	0.231	0.247	0.234	0.219	0.215	0.244	0.217	0.244	0.244
7	0.212	0.244	0.244	0.252	0.248	0.200	0.246	0.251	0.235	0.251	0.251
8	0.224	0.249	0.249	0.252	0.261	0.203	0.216	0.256	0.210	0.256	0.256
9+	0.000	0.239	0.236	0.274	0.250	0.224	0.217	0.268	0.221	0.268	0.268
Quarter: 4											
0	0.019	0.000	0.000	0.000	0.017	0.019	0.000	0.017	0.019	0.017	0.017
1	0.064	0.101	0.101	0.095	0.054	0.058	0.094	0.057	0.066	0.059	0.058
2	0.106	0.146	0.146	0.125	0.142	0.106	0.125	0.135	0.119	0.129	0.129
3	0.149	0.183	0.183	0.178	0.189	0.174	0.169	0.183	0.170	0.180	0.181
4	0.181	0.206	0.206	0.191	0.197	0.193	0.190	0.197	0.190	0.193	0.193
5	0.000	0.221	0.221	0.199	0.231	0.201	0.207	0.215	0.206	0.209	0.209
6	0.193	0.213	0.213	0.196	0.251	0.232	0.219	0.216	0.219	0.216	0.216
7	0.233	0.229	0.229	0.245	0.261	0.000	0.238	0.243	0.238	0.241	0.241
8	0.209	0.228	0.228	0.229	0.229	0.192	0.220	0.228	0.218	0.224	0.224
9+	0.000	0.226	0.226	0.227	0.266	0.000	0.229	0.238	0.229	0.236	0.237

Table 2.2.3: North Sea autumn spawning herring (NSAS), and western Baltic spring spawners (WBSS) caught in the North Sea in 2012. Mean length-at-age (cm) in the catch, by quarter and division.

WR	IIIa NSAS	IVa(E) all	IVa(E) WBSS	IVa(W)	IVb	IVc	VIId	IVa & IVb all	IVc & VIId
Quarters: 1-4									
0	**n.d.**	**0.0**	**n.d.**	**0.0**	**11.7**	**14.6**	**0.0**	**11.7**	**14.6**
1	**n.d.**	**23.6**	**n.d.**	**22.4**	**19.3**	**20.2**	**22.9**	**19.6**	**20.8**
2	**n.d.**	**25.9**	**n.d.**	**24.6**	**24.7**	**23.5**	**24.3**	**24.6**	**24.0**
3	**n.d.**	**27.7**	**n.d.**	**27.3**	**26.5**	**26.3**	**26.3**	**27.1**	**26.3**
4	**n.d.**	**28.2**	**n.d.**	**27.5**	**27.7**	**27.2**	**27.4**	**27.6**	**27.4**
5	**n.d.**	**28.6**	**n.d.**	**28.5**	**28.9**	**28.2**	**28.4**	**28.6**	**28.4**
6	**n.d.**	**29.7**	**n.d.**	**29.5**	**29.4**	**28.7**	**28.7**	**29.5**	**28.7**
7	**n.d.**	**30.3**	**n.d.**	**30.1**	**30.3**	**28.6**	**29.5**	**30.1**	**29.5**
8	**n.d.**	**30.2**	**n.d.**	**30.0**	**30.9**	**28.5**	**29.0**	**30.4**	**29.0**
9+	**n.d.**	**30.7**	**n.d.**	**30.4**	**29.9**	**29.2**	**29.5**	**30.4**	**29.5**
Quarter: 1									
0	n.d.	0.0	n.d.	0.0	0.0	0.0	0.0	0.0	0.0
1	n.d.	24.0	n.d.	23.9	0.0	0.0	0.0	23.9	0.0
2	n.d.	25.9	n.d.	25.7	23.6	23.3	0.0	24.0	23.3
3	n.d.	27.2	n.d.	26.8	25.9	25.1	25.1	26.1	25.1
4	n.d.	27.6	n.d.	28.3	27.4	26.7	26.8	27.6	26.8
5	n.d.	28.1	n.d.	29.5	29.0	27.8	27.9	29.1	27.9
6	n.d.	28.9	n.d.	29.6	29.1	28.2	28.5	29.2	28.4
7	n.d.	29.1	n.d.	30.4	30.0	28.6	28.5	30.1	28.5
8	n.d.	29.5	n.d.	31.7	30.5	28.5	28.7	30.8	28.6
9+	n.d.	29.8	n.d.	31.2	28.9	29.2	29.5	30.9	29.5
Quarter: 2									
0	n.d.	0.0	n.d.	0.0	9.3	0.0	0.0	9.3	0.0
1	n.d.	0.0	n.d.	20.6	16.7	17.7	0.0	17.2	17.7
2	n.d.	25.2	n.d.	23.8	22.4	20.8	0.0	23.6	20.8
3	n.d.	27.2	n.d.	25.6	26.6	24.8	25.1	25.9	24.9
4	n.d.	27.5	n.d.	26.3	27.1	26.4	26.8	26.5	26.7
5	n.d.	28.0	n.d.	27.2	28.6	27.6	27.9	27.4	27.8
6	n.d.	28.8	n.d.	28.1	29.6	28.7	28.5	28.3	28.5
7	n.d.	29.0	n.d.	28.2	30.0	28.2	28.5	28.5	28.4
8	n.d.	29.2	n.d.	28.7	30.5	28.5	28.7	29.1	28.7
9+	n.d.	29.8	n.d.	28.5	29.6	29.3	29.5	29.1	29.5
Quarter: 3									
0	n.d.	0.0	n.d.	0.0	11.1	17.1	0.0	11.1	17.1
1	n.d.	22.9	n.d.	21.9	19.6	21.5	22.8	19.8	21.5
2	n.d.	25.7	n.d.	25.1	25.7	23.5	25.0	25.3	23.7
3	n.d.	28.0	n.d.	28.0	27.6	27.1	26.6	27.9	26.8
4	n.d.	28.2	n.d.	28.4	27.9	27.4	27.6	28.3	27.5
5	n.d.	29.3	n.d.	29.0	28.8	28.3	28.6	29.0	28.5
6	n.d.	29.8	n.d.	30.0	29.7	29.2	28.7	29.9	29.0
7	n.d.	30.4	n.d.	30.3	30.5	28.3	30.1	30.3	29.7
8	n.d.	30.4	n.d.	30.2	31.3	28.8	29.2	30.7	29.0
9+	n.d.	30.4	n.d.	30.6	29.6	28.8	29.6	30.4	29.1
Quarter: 4									
0	n.d.	0.0	n.d.	0.0	14.3	14.6	0.0	14.3	14.6
1	n.d.	23.6	n.d.	23.0	19.5	20.2	22.9	19.8	20.8
2	n.d.	25.9	n.d.	25.4	24.7	23.5	24.3	25.1	24.0
3	n.d.	28.0	n.d.	28.1	27.3	27.2	26.5	27.8	26.5
4	n.d.	29.5	n.d.	28.4	27.9	27.4	27.5	28.5	27.5
5	n.d.	30.5	n.d.	29.8	29.2	28.4	28.4	29.6	28.4
6	n.d.	30.2	n.d.	29.8	29.5	29.8	28.7	29.9	28.8
7	n.d.	30.8	n.d.	31.3	29.8	0.0	29.6	30.7	29.6
8	n.d.	31.0	n.d.	30.2	29.4	28.6	29.1	30.1	29.1
9+	n.d.	31.0	n.d.	31.1	30.1	0.0	29.5	30.8	29.5

Table 2.2.4: North Sea autumn spawning herring (NSAS), and western Baltic spring spawners (WBSS) caught in the North Sea and Div IIIa in 2012. Catches (tonnes) at-age (SOP figures), by quarter and division.

WR	IIIa NSAS	IVa(E) all	IVa(E) WBSS	IVa(E) NSAS only	IVa(W)	IVb	IVc	VIId	IVa & IVb NSAS	IVc & VIId	Total NSAS
Quarters: 1-4											
0	1.8	0.0	0.0	0.0	0.0	6.2	0.2	0.0	6.2	0.2	8.2
1	6.9	0.2	0.0	0.2	0.6	5.1	0.3	0.1	5.9	0.4	13.2
2	2.9	1.1	0.0	1.1	30.6	16.8	1.5	3.7	48.5	5.2	56.6
3	0.2	9.7	0.0	9.6	74.1	27.4	0.2	3.3	111.1	3.5	114.8
4	0.2	4.5	0.1	4.4	47.2	10.3	0.9	11.9	61.9	12.7	74.8
5	0.0	4.1	0.0	4.1	36.9	12.0	0.6	9.4	53.0	10.0	63.0
6	0.0	4.2	0.3	3.9	20.8	6.9	0.1	1.5	31.5	1.6	33.2
7	0.0	3.2	0.0	3.2	13.6	5.6	0.1	2.5	22.3	2.6	24.9
8	0.0	1.8	0.2	1.6	9.5	7.9	0.2	2.1	18.9	2.3	21.2
9+	0.0	6.6	1.4	5.1	12.3	5.8	0.1	1.9	23.3	2.0	25.3
Sum	12.2	35.4	2.1	33.3	245.5	103.8	4.1	36.3	382.6	40.4	435.2
Quarter: 1											
0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1
2	1.5	0.0	0.0	0.0	0.5	1.7	0.0	0.0	2.2	0.0	3.8
3	0.1	0.4	0.0	0.4	2.9	12.5	0.1	0.2	15.9	0.3	16.3
4	0.0	0.2	0.0	0.2	0.8	2.0	0.2	0.7	3.0	0.9	3.9
5	0.0	0.3	0.0	0.3	1.0	1.1	0.2	0.6	2.4	0.8	3.2
6	0.0	0.1	0.0	0.1	0.8	1.5	0.1	0.2	2.4	0.3	2.7
7	0.0	0.1	0.0	0.1	0.4	0.3	0.1	0.1	0.7	0.2	0.9
8	0.0	0.1	0.0	0.1	0.3	0.3	0.1	0.2	0.6	0.3	1.0
9+	0.0	0.1	0.0	0.1	0.4	0.0	0.1	0.6	0.5	0.7	1.3
Sum	2.7	1.3	0.0	1.2	7.1	19.5	0.8	2.7	27.9	3.5	34.0
Quarter: 2											
0	0.0	0.0	0.0	0.0	0.0	0.7	0.0	0.0	0.7	0.0	0.7
1	0.6	0.0	0.0	0.0	0.1	0.3	0.0	0.0	0.4	0.0	1.0
2	0.1	0.0	0.0	0.0	12.8	1.4	0.0	0.0	14.2	0.0	14.3
3	0.0	3.8	0.0	3.8	15.3	1.5	0.0	0.0	20.6	0.0	20.6
4	0.0	2.4	0.0	2.4	17.3	0.7	0.0	0.0	20.4	0.0	20.4
5	0.0	2.8	0.0	2.8	10.7	0.6	0.0	0.0	14.1	0.0	14.1
6	0.0	1.3	0.0	1.3	3.7	0.3	0.0	0.0	5.3	0.0	5.3
7	0.0	0.8	0.0	0.8	2.0	0.3	0.0	0.0	3.0	0.0	3.0
8	0.0	0.7	0.0	0.7	1.1	0.3	0.0	0.0	2.1	0.0	2.1
9+	0.0	1.5	0.0	1.5	1.6	0.3	0.0	0.0	3.3	0.0	3.3
Sum	0.8	13.2	0.0	13.2	64.7	6.2	0.0	0.0	84.1	0.1	84.9
Quarter: 3											
0	1.0	0.0	0.0	0.0	0.0	1.9	0.0	0.0	1.9	0.0	2.9
1	3.4	0.0	0.0	0.0	0.1	0.9	0.0	0.0	1.0	0.0	4.4
2	1.1	0.1	0.0	0.1	12.4	8.5	0.0	0.0	21.0	0.0	22.1
3	0.1	0.6	0.0	0.6	50.6	8.6	0.0	0.0	59.8	0.0	59.9
4	0.1	0.4	0.0	0.4	26.9	5.0	0.0	0.0	32.4	0.0	32.5
5	0.0	0.3	0.0	0.3	23.2	8.3	0.0	0.0	31.7	0.0	31.7
6	0.0	0.2	0.0	0.2	13.9	3.1	0.0	0.0	17.2	0.0	17.2
7	0.0	0.2	0.0	0.2	9.1	3.5	0.0	0.0	12.7	0.0	12.8
8	0.0	0.2	0.0	0.2	7.4	6.1	0.0	0.0	13.6	0.0	13.6
9+	0.0	0.1	0.0	0.1	8.8	2.3	0.0	0.0	11.2	0.0	11.2
Sum	5.8	2.1	0.0	2.0	152.4	48.1	0.0	0.0	202.6	0.0	208.3
Quarter: 4											
0	0.8	0.0	0.0	0.0	0.0	3.6	0.2	0.0	3.6	0.2	4.6
1	1.9	0.2	0.0	0.2	0.3	3.9	0.3	0.1	4.5	0.4	6.7
2	0.2	0.9	0.0	0.9	4.8	5.3	1.5	3.7	11.0	5.1	16.4
3	0.0	4.8	0.0	4.8	5.3	4.7	0.2	3.0	14.8	3.2	18.1
4	0.1	1.5	0.1	1.4	2.1	2.6	0.7	11.2	6.1	11.9	18.0
5	0.0	0.8	0.0	0.8	2.0	2.0	0.4	8.8	4.9	9.2	14.0
6	0.0	2.6	0.3	2.3	2.4	1.9	0.0	1.3	6.6	1.3	7.9
7	0.0	2.2	0.0	2.2	2.1	1.6	0.0	2.4	5.8	2.4	8.3
8	0.0	0.9	0.2	0.6	0.7	1.2	0.1	1.8	2.5	1.9	4.4
9+	0.0	4.9	1.4	3.5	1.6	3.2	0.0	1.3	8.3	1.3	9.6
Sum	3.0	18.8	2.0	16.8	21.3	30.0	3.2	33.6	68.1	36.8	108.0

Table 2.2.5: North Sea autumn spawning herring (NSAS), and western Baltic spring spawners (WBSS) caught in the North Sea in 2012. Percentage age composition (based on numbers, 3+ group summarised), by quarter and division.

WR	IIIa NSAS	IVa(E) all	IVa(E) WBSS	IVa(E) NSAS only	IVa(W)	IVb	IVc	VIId	IVa & IVb NSAS	IVc & VIId	Total NSAS
Quarters: 1-4											
0	**39.6%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**49.1%**	**21.1%**	**0.0%**	**22.6%**	**3.4%**	**23.1%**
1	**47.5%**	**1.3%**	**0.0%**	**1.4%**	**0.5%**	**7.5%**	**11.7%**	**0.6%**	**3.8%**	**2.4%**	**8.5%**
2	**11.9%**	**4.4%**	**0.2%**	**4.6%**	**17.7%**	**10.2%**	**36.6%**	**15.0%**	**13.4%**	**18.5%**	**13.6%**
3	**0.5%**	**29.8%**	**2.3%**	**31.4%**	**30.7%**	**15.4%**	**4.0%**	**10.1%**	**23.7%**	**9.1%**	**20.1%**
4	**0.3%**	**13.1%**	**3.8%**	**13.7%**	**19.3%**	**4.6%**	**12.1%**	**32.4%**	**12.2%**	**29.1%**	**12.1%**
5	**0.1%**	**11.5%**	**0.0%**	**12.2%**	**13.7%**	**4.5%**	**7.9%**	**23.6%**	**9.4%**	**21.1%**	**9.2%**
6	**0.1%**	**11.1%**	**15.2%**	**10.9%**	**7.0%**	**2.6%**	**1.4%**	**3.6%**	**5.2%**	**3.2%**	**4.5%**
7	**0.0%**	**8.0%**	**0.0%**	**8.4%**	**4.3%**	**1.8%**	**0.8%**	**5.4%**	**3.4%**	**4.7%**	**3.1%**
8	**0.0%**	**4.5%**	**11.7%**	**4.1%**	**3.0%**	**2.5%**	**2.9%**	**4.9%**	**2.8%**	**4.6%**	**2.6%**
9+	**0.0%**	**16.2%**	**66.8%**	**13.3%**	**3.7%**	**1.8%**	**1.4%**	**4.3%**	**3.4%**	**3.8%**	**3.1%**
Sum 3+	**1.0%**	**94.3%**	**99.8%**	**94.0%**	**81.8%**	**33.2%**	**30.6%**	**84.4%**	**60.1%**	**75.6%**	**54.7%**
Quarter: 1											
0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	**0.0%**
1	67.0%	0.3%	0.0%	0.3%	1.0%	0.0%	0.0%	0.0%	0.2%	0.0%	**18.4%**
2	31.8%	2.7%	4.0%	2.7%	9.8%	11.5%	3.0%	0.0%	10.9%	0.7%	**15.9%**
3	1.1%	34.1%	50.9%	33.8%	46.9%	67.3%	12.8%	11.4%	62.0%	11.7%	**42.2%**
4	0.0%	18.3%	7.4%	18.4%	11.7%	9.0%	21.6%	29.6%	9.9%	27.9%	**8.3%**
5	0.0%	19.2%	0.0%	19.5%	11.4%	4.4%	24.0%	23.2%	6.3%	23.4%	**5.7%**
6	0.0%	8.5%	8.4%	8.5%	8.7%	5.8%	7.6%	7.3%	6.5%	7.4%	**4.8%**
7	0.0%	4.9%	0.0%	5.0%	4.1%	0.9%	6.6%	3.3%	1.7%	4.1%	**1.4%**
8	0.0%	4.7%	11.4%	4.6%	2.6%	1.0%	12.3%	8.6%	1.5%	9.4%	**1.6%**
9+	0.0%	7.3%	17.8%	7.2%	3.6%	0.0%	11.9%	16.6%	1.0%	15.6%	**1.6%**
Sum 3+	**1.2%**	**97.0%**	**96.0%**	**97.0%**	**89.1%**	**88.5%**	**97.0%**	**100.0%**	**88.9%**	**99.3%**	**65.7%**
Quarter: 2											
0	0.0%	0.0%	0.0%	0.0%	0.0%	79.4%	0.0%	0.0%	24.3%	0.0%	**23.2%**
1	94.3%	0.0%	0.0%	0.0%	0.3%	3.5%	17.6%	0.0%	1.2%	10.1%	**5.3%**
2	5.4%	0.4%	1.2%	0.4%	24.9%	6.6%	54.0%	0.0%	16.9%	31.0%	**16.5%**
3	0.2%	31.1%	98.8%	30.9%	23.9%	4.8%	8.5%	11.4%	18.7%	9.7%	**17.9%**
4	0.0%	18.9%	0.0%	19.0%	26.0%	1.9%	10.6%	29.6%	17.9%	18.7%	**17.2%**
5	0.0%	21.3%	0.0%	21.4%	14.7%	1.4%	6.0%	23.2%	11.3%	13.3%	**10.8%**
6	0.0%	9.0%	0.0%	9.0%	4.7%	0.6%	0.6%	7.3%	3.8%	3.4%	**3.7%**
7	0.0%	5.5%	0.0%	5.5%	2.4%	0.6%	0.9%	3.4%	2.1%	1.9%	**2.0%**
8	0.0%	5.0%	0.0%	5.0%	1.3%	0.6%	0.5%	8.6%	1.5%	3.9%	**1.4%**
9+	0.0%	8.8%	0.0%	8.8%	1.9%	0.5%	1.5%	16.6%	2.1%	7.9%	**2.1%**
Sum 3+	**0.2%**	**99.6%**	**98.8%**	**99.6%**	**74.8%**	**10.5%**	**28.4%**	**100.0%**	**57.5%**	**59.0%**	**55.0%**
Quarter: 3											
0	60.6%	0.0%	0.0%	0.0%	0.0%	49.4%	3.3%	0.0%	19.5%	2.1%	**24.6%**
1	32.0%	0.6%	0.0%	0.6%	0.2%	3.2%	9.2%	0.6%	1.4%	6.2%	**5.2%**
2	6.4%	8.0%	11.9%	8.0%	11.9%	12.0%	46.6%	10.4%	11.9%	33.9%	**11.2%**
3	0.3%	32.6%	47.7%	32.5%	34.8%	9.7%	4.4%	12.3%	24.8%	7.2%	**21.8%**
4	0.5%	22.5%	8.9%	22.6%	17.8%	5.3%	16.3%	34.6%	12.9%	22.7%	**11.4%**
5	0.1%	11.7%	0.0%	11.8%	14.2%	8.0%	13.1%	27.6%	11.7%	18.2%	**10.3%**
6	0.1%	9.2%	9.1%	9.2%	7.7%	2.8%	1.9%	3.1%	5.8%	2.4%	**5.1%**
7	0.0%	6.2%	0.0%	6.2%	5.0%	2.9%	0.7%	4.1%	4.2%	1.9%	**3.7%**
8	0.0%	6.1%	14.6%	6.0%	4.0%	4.8%	2.5%	5.0%	4.4%	3.4%	**3.8%**
9+	0.0%	3.0%	7.9%	3.0%	4.4%	1.9%	2.0%	2.2%	3.4%	2.1%	**3.0%**
Sum 3+	**1.0%**	**91.4%**	**88.1%**	**91.4%**	**87.9%**	**35.4%**	**41.0%**	**89.0%**	**67.2%**	**57.8%**	**59.0%**
Quarter: 4											
0	56.1%	0.0%	0.0%	0.0%	0.0%	53.3%	24.2%	0.0%	35.1%	3.8%	**29.4%**
1	40.1%	2.4%	0.0%	2.7%	2.9%	18.0%	13.3%	0.7%	12.8%	2.7%	**12.7%**
2	2.9%	6.9%	0.0%	7.6%	31.2%	9.3%	41.1%	16.4%	13.5%	20.3%	**14.2%**
3	0.4%	28.3%	0.0%	31.4%	24.1%	6.2%	2.7%	10.0%	13.3%	8.8%	**11.2%**
4	0.4%	7.7%	3.8%	8.1%	8.8%	3.3%	10.8%	32.7%	5.1%	29.3%	**10.5%**
5	0.0%	4.0%	0.0%	4.5%	8.1%	2.2%	5.7%	23.7%	3.7%	20.9%	**7.5%**
6	0.1%	13.0%	15.5%	12.7%	9.9%	1.9%	0.5%	3.2%	5.0%	2.8%	**4.1%**
7	0.1%	10.1%	0.0%	11.2%	6.8%	1.5%	0.0%	5.6%	3.9%	4.8%	**3.8%**
8	0.0%	4.0%	11.9%	3.2%	2.4%	1.3%	1.6%	4.6%	1.8%	4.1%	**2.2%**
9+	0.0%	23.5%	68.8%	18.6%	5.6%	3.0%	0.0%	3.2%	5.7%	2.7%	**4.5%**
Sum 3+	**0.9%**	**90.7%**	**100.0%**	**89.7%**	**65.9%**	**19.4%**	**21.4%**	**82.9%**	**38.6%**	**73.3%**	**43.7%**

Table 2.2.6: Total catch of herring caught in the North Sea and Div. IIIa: North Sea autumn spawners (NSAS). Catch in numbers (millions) at mean weight-at-age (kg) by fleet, and SOP catches ('000 t). SOP catch might deviate from reported catch as used for the assessment.

2010	Fleet A		Fleet B		Fleet C		Fleet D		TOTAL	
Total		Mean		Mean		Mean		Mean		**Mean**
Winter rings	Numbers	Weight	Numbers	Weight	Numbers	Weight	Numbers	Weight	**Numbers**	**Weight**
0	0.0	0.000	594.7	0.007	0.1	0.028	48.6	0.007	**643.3**	**0.007**
1	49.1	0.086	34.5	0.051	120.5	0.072	76.6	0.016	**280.6**	**0.057**
2	237.4	0.139	6.6	0.086	39.4	0.080	4.0	0.040	**287.3**	**0.128**
3	229.6	0.167	3.8	0.184	0.3	0.122	0.0	0.114	**233.7**	**0.167**
4	123.1	0.192	1.1	0.143	0.1	0.149	0.0	0.000	**124.4**	**0.192**
5	79.8	0.222	3.6	0.205	0.1	0.191	0.0	0.000	**83.5**	**0.222**
6	57.5	0.222	5.6	0.191	0.0	0.221	0.0	0.000	**63.1**	**0.219**
7	34.2	0.217	0.0	0.000	0.1	0.216	0.0	0.000	**34.3**	**0.217**
8	59.4	0.234	0.0	0.000	0.0	0.205	0.0	0.000	**59.4**	**0.234**
9+	56.0	0.245	0.0	0.000	0.0	0.000	0.0	0.000	**56.0**	**0.245**
TOTAL	926.0		649.9		160.5		129.1		1,865.5	
SOP catch	**164.6**		**9.1**		**12.0**		**1.8**		**187.5**	

Figures for A fleet include 4 451 t unsampled bycatch in the industrial fishery

2011	Fleet A		Fleet B		Fleet C		Fleet D		TOTAL	
Total		Mean		Mean		Mean		Mean		**Mean**
Winter rings	Numbers	Weight	Numbers	Weight	Numbers	Weight	Numbers	Weight	**Numbers**	**Weight**
0	0.0	0.000	575.1	0.008	2.3	0.021	201.5	0.007	**778.9**	**0.008**
1	11.0	0.112	113.1	0.036	19.4	0.053	16.0	0.013	**159.5**	**0.041**
2	306.2	0.141	0.0	0.000	59.7	0.085	1.7	0.045	**367.7**	**0.132**
3	270.9	0.160	0.0	0.000	3.1	0.115	0.2	0.071	**274.1**	**0.159**
4	217.6	0.183	0.0	0.000	0.3	0.134	0.0	0.000	**217.9**	**0.183**
5	129.5	0.197	0.0	0.000	0.2	0.191	0.0	0.000	**129.7**	**0.197**
6	62.7	0.217	0.0	0.000	0.1	0.193	0.0	0.000	**62.8**	**0.217**
7	51.8	0.221	0.0	0.000	0.1	0.234	0.0	0.000	**51.9**	**0.221**
8	59.8	0.223	0.0	0.000	0.0	0.248	0.0	0.000	**59.8**	**0.223**
9+	65.3	0.240	0.0	0.000	0.0	0.000	0.0	0.000	**65.3**	**0.240**
TOTAL	1,174.8		688.3		85.1		219.5		2,167.6	
SOP catch	**207.2**		**8.8**		**6.6**		**1.8**		**224.4**	

Figures for A fleet include unsampled bycatch in the industrial fishery

2012	Fleet A		Fleet B		Fleet C		Fleet D		TOTAL	
Total		Mean		Mean		Mean		Mean		**Mean**
Winter rings	Numbers	Weight	Numbers	Weight	Numbers	Weight	Numbers	Weight	**Numbers**	**Weight**
0	1.0	0.035	626.4	0.010	0.6	0.027	145.2	0.012	**773.2**	**0.010**
1	42.6	0.086	67.4	0.038	70.6	0.065	104.2	0.023	**284.8**	**0.046**
2	404.4	0.131	7.2	0.111	35.5	0.073	7.6	0.040	**454.6**	**0.124**
3	667.1	0.171	4.2	0.131	1.8	0.124	0.0	0.085	**673.2**	**0.171**
4	402.7	0.185	0.0	0.000	1.1	0.169	0.0	0.000	**403.9**	**0.185**
5	305.3	0.206	0.7	0.195	0.2	0.175	0.0	0.000	**306.2**	**0.206**
6	149.5	0.222	1.4	0.160	0.2	0.199	0.0	0.000	**151.1**	**0.222**
7	104.3	0.239	0.0	0.000	0.1	0.220	0.0	0.000	**104.5**	**0.239**
8	89.1	0.240	0.4	0.184	0.0	0.216	0.0	0.000	**89.5**	**0.239**
9+	108.5	0.247	0.0	0.000	0.0	0.000	0.0	0.000	**108.5**	**0.247**
TOTAL	2,274.5		707.9		110.1		257.0		3,349.5	
SOP catch	**414.4**		**10.6**		**7.7**		**4.4**		**437.2**	

Figures for A fleet include unsampled bycatch in the industrial fishery

Table 2.2.7: Catch at age (numbers in millions) of North Sea herring, 1997-2012. SG Rednose's revisions are included.

Year/rings	0	1	2	3	4	5	6	7	8	9+	Total
1997	364	174	565	428	285	109	31	12	19	6	1993
1998	208	254	1084	525	267	179	89	14	17	4	2642
1999	968	73	487	1034	289	134	70	28	10	2	3096
2000	873	194	516	453	636	212	82	36	15	3	3019
2001	1025	58	678	473	279	319	92	39	18	2	2982
2002	319	490	513	913	294	136	164	47	34	7	2917
2003	347	172	1022	507	809	244	106	121	37	8	3375
2004	627	136	274	1333	517	721	170	100	70	22	3970
2005	919	408	203	487	1326	480	577	116	108	39	4664
2006	844	72	354	309	475	1017	257	252	65	44	3689
2007	553	46	142	413	284	307	628	147	133	23	2677
2008	713	148	260	183	199	137	118	215	74	43	2090
2009	533	98	253	108	96	88	40	58	112	34	1421
2010	526	84	243	234	124	84	63	34	59	56	1508
2011	575	124	306	271	218	130	63	52	60	66	1865
2012	627	110	412	671	403	306	151	104	89	109	2982

Table 2.2.8: Catch at age (numbers in millions) of WBSS Herring taken in the North Sea, and transferred to the assessment of the spring spawning stock in IIIa, 1997-2012.

Year/rings	0	1	2	3	4	5	6	7	8	9+	Total
1997	0.0	0.0	2.2	1.3	1.5	0.4	0.2	0.1	0.2	0.0	5.9
1998	0.0	5.1	9.5	12.0	10.1	6.0	3.0	0.4	0.9	0.0	47.0
1999	0.0	0.0	3.3	14.3	5.6	3.6	1.4	0.6	0.4	0.0	29.3
2000	0.0	0.0	8.2	9.8	10.2	5.7	2.5	0.6	0.7	0.1	37.6
2001	0.0	0.0	11.3	10.2	6.1	7.2	2.7	1.6	0.4	0.0	39.9
2002	0.0	0.0	7.6	14.8	10.6	3.3	2.9	1.0	0.5	0.1	40.8
2003	0.0	0.0	0.0	3.1	6.0	3.5	1.2	1.3	0.5	0.1	15.7
2004	0.0	0.0	15.1	27.9	3.5	4.1	1.0	0.5	0.1	0.0	52.3
2005	0.0	0.0	6.6	17.4	12.7	2.6	3.8	1.1	0.4	0.3	44.8
2006	0.0	0.1	3.5	8.8	14.0	22.4	5.1	5.3	2.1	1.0	62.2
2007	0.0	0.0	0.1	2.6	1.3	0.6	0.8	0.4	0.5	0.2	6.3
2008	0.0	0.0	0.1	0.1	0.2	0.1	0.1	0.2	0.0	0.0	0.7
2009	0.0	0.0	1.0	2.1	3.4	1.4	1.7	4.5	1.8	1.4	17.2
2010	0.0	0.0	0.0	0.5	1.0	0.4	0.5	0.3	0.3	0.7	3.8
2011	0.0	0.0	0.1	0.4	0.4	0.2	0.1	0.1	0.1	0.2	1.6
2012	0.0	0.0	0.0	0.2	0.4	0.0	1.4	0.0	1.1	6.3	9.4

Table 2.2.9: Catch at age (numbers in millions) of NSAS taken in IIIa, and transfered to the assessment of NSAS, 1997 - 2012. SG Rednose's revisions and revision of 2002 splitting are included.

Year/rings	0	1	2	3	4	5	6	7	8+	Total
1997	68	305	125	20	1	1	0	0	0	521
1998	51	729	145	25	19	3	3	1	0	977
1999	598	231	133	39	10	5	1	1	0	1017
2000	232	978	115	20	21	7	3	1	0	1377
2001	808	557	140	15	1	0	0	0	0	1521
2002	411	345	48	5	1	0	0	0	0	811
2003	22	445	182	13	16	2	1	1	0	682
2004	88	71	180	21	6	10	2	2	1	380
2005	96	307	159	16	5	2	2	0	0	590
2006	35	150	50	10	3	3	1	0	0	253
2007	68	189	77	2	0	1	0	1	0	339
2008	86	87	72	2	0	0	0	0	0	247
2009	117	78	7	0	0	0	0	0	0	202
2010	49	197	43	0	0	0	0	0	0	290
2011	204	35	61	3	0	0	0	0	0	305
2012	146	175	44	2	1	0	0	0	0	368

Table 2.2.10: Catch at age (numbers in millions) of the total NSAS stock 1997 - 2012. SG Rednose's revisions and the revision of 2002 splitting are included.

Year/rings	0	1	2	3	4	5	6	7	8	9+	Total
1997	431	480	688	447	285	109	31	12	19	6	2507
1998	260	978	1220	538	276	176	89	15	17	4	3572
1999	1566	304	616	1059	294	136	69	28	10	2	4084
2000	1105	1172	623	463	647	213	82	36	15	2	4358
2001	1833	614	806	477	274	312	89	37	17	2	4463
2002	730	835	553	903	284	133	161	46	33	7	3687
2003	369	617	1204	517	820	243	106	120	37	8	4042
2004	716	207	439	1326	520	726	171	101	71	22	4298
2005	1016	716	355	486	1318	480	576	115	108	39	5209
2006	879	222	401	311	465	999	253	249	63	44	3885
2007	621	236	219	412	283	308	628	147	132	23	3009
2008	798	235	332	185	199	137	118	215	74	43	2336
2009	650	176	259	107	93	86	38	53	110	33	1606
2010	575	281	287	233	123	83	63	34	59	55	1794
2011	779	160	368	274	218	130	63	52	60	65	2168
2012	773	285	455	673	404	306	150	104	88	102	3341

Table 2.2.11: Comparison of mean weight (kg) at age (rings) in the catch of adult North Sea herring (by Div.) and NSAS caught in Div. IIIa in 2002 – 2012. SG Rednose's revisions are included.

		Age (Rings)							
Div.	Year	2	3	4	5	6	7	8	9+
IIIa	2002	0.104	0.126	0.144	0.164	0.180	0.180	0.218	-
	2003	0.067	0.123	0.150	0.163	0.191	0.214	0.187	-
	2004	0.070	0.121	0.141	0.152	0.170	0.187	0.178	-
	2005	0.071	0.106	0.155	0.173	0.185	0.200	0.209	-
	2006	0.079	0.117	0.140	0.186	0.191	0.216	0.207	-
	2007	0.071	0.108	0.125	0.152	0.184	0.175	0.154	-
	2008	0.087	0.109	0.139	0.168	0.176	0.204	0.198	-
	2009	0.101	0.082	0.206	0.000	0.000	0.000	0.269	-
	2010	0.077	0.122	0.149	0.191	0.221	0.216	0.205	-
	2011	0.084	0.114	0.134	0.191	0.193	0.234	0.248	-
	2012	0.067	0.124	0.169	0.175	0.200	0.221	0.216	-
IVa(E)	2002	0.130	0.154	0.167	0.189	0.198	0.212	0.229	0.238
	2003	0.122	0.154	0.162	0.177	0.189	0.203	0.213	0.218
	2004	0.119	0.133	0.171	0.185	0.212	0.192	0.218	0.252
	2005	0.117	0.146	0.153	0.202	0.209	0.233	0.262	0.265
	2006	0.125	0.149	0.164	0.175	0.214	0.224	0.229	0.254
	2007	0.156	0.148	0.156	0.186	0.184	0.204	0.226	0.239
	2008	0.138	0.173	0.172	0.174	0.216	0.210	0.253	0.266
	2009	0.139	0.167	0.208	0.219	0.232	0.245	0.253	0.288
	2010	0.131	0.154	0.201	0.201	0.210	0.223	0.248	0.235
	2011	0.142	0.162	0.180	0.204	0.215	0.209	0.216	0.222
	2012	0.146	0.185	0.195	0.203	0.216	0.225	0.225	0.232
IVa(W)	2002	0.144	0.161	0.191	0.211	0.230	0.242	0.261	0.263
	2003	0.130	0.167	0.184	0.202	0.224	0.237	0.259	0.276
	2004	0.131	0.155	0.193	0.220	0.242	0.251	0.246	0.299
	2005	0.122	0.158	0.174	0.213	0.229	0.245	0.275	0.267
	2006	0.145	0.156	0.180	0.193	0.230	0.251	0.247	0.286
	2007	0.150	0.156	0.166	0.196	0.191	0.227	0.241	0.264
	2008	0.142	0.187	0.187	0.188	0.230	0.219	0.262	0.281
	2009	0.152	0.180	0.211	0.223	0.266	0.251	0.252	0.278
	2010	0.137	0.166	0.195	0.223	0.220	0.216	0.236	0.252
	2011	0.141	0.161	0.185	0.195	0.216	0.223	0.220	0.243
	2012	0.132	0.184	0.186	0.206	0.226	0.240	0.242	0.254
IVb	2002	0.086	0.149	0.161	0.206	0.214	0.189	0.270	0.241
	2003	0.098	0.161	0.178	0.195	0.214	0.214	0.222	0.281
	2004	0.118	0.143	0.186	0.214	0.234	0.239	0.297	0.308
	2005	0.132	0.172	0.187	0.217	0.220	0.245	0.253	0.252
	2006	0.097	0.141	0.172	0.183	0.202	0.220	0.232	0.239
	2007	0.145	0.160	0.180	0.201	0.210	0.246	0.234	0.252
	2008	0.142	0.172	0.185	0.191	0.222	0.228	0.265	0.223
	2009	0.140	0.188	0.228	0.219	0.223	0.243	0.255	0.255
	2010	0.134	0.176	0.182	0.229	0.237	0.235	0.232	0.265
	2011	0.145	0.162	0.187	0.206	0.235	0.234	0.240	0.268
	2012	0.131	0.141	0.178	0.209	0.214	0.245	0.250	0.258

Table 2.2.11 continued: Comparison of mean weight (kg) at age (rings) in the catch of adult North Sea herring (by Div.) and NSAS caught in Div. IIIa in 2002 – 2012. SG Rednose's revisions are included.

		Age (Rings)							
Div.	**Year**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9+**
IVa & IVb	2002	0.119	0.157	0.177	0.203	0.219	0.228	0.253	0.253
	2003	0.113	0.163	0.178	0.190	0.210	0.225	0.239	0.255
	2004	0.122	0.147	0.187	0.210	0.227	0.233	0.247	0.266
	2005	0.121	0.157	0.172	0.212	0.225	0.242	0.269	0.265
	2006	0.123	0.150	0.174	0.187	0.222	0.239	0.238	0.269
	2007	0.149	0.155	0.165	0.196	0.192	0.227	0.238	0.257
	2008	0.142	0.182	0.185	0.188	0.226	0.220	0.262	0.275
	2009	0.142	0.183	0.217	0.221	0.248	0.248	0.253	0.277
	2010	0.136	0.167	0.192	0.224	0.222	0.220	0.236	0.250
	2011	0.142	0.161	0.184	0.198	0.220	0.224	0.224	0.243
	2012	0.132	0.171	0.185	0.207	0.222	0.239	0.243	0.248
IVc & VIId	2002	0.108	0.123	0.153	0.170	0.187	0.219	0.208	-
	2003	0.103	0.127	0.144	0.168	0.176	0.188	0.200	0.227
	2004	0.099	0.113	0.135	0.162	0.184	0.191	0.186	0.224
	2005	0.122	0.132	0.139	0.170	0.207	0.228	0.237	0.245
	2006	0.119	0.125	0.153	0.152	0.178	0.205	0.209	0.219
	2007	0.129	0.131	0.154	0.158	0.173	0.196	0.209	0.218
	2008	0.120	0.157	0.156	0.173	0.188	0.192	0.215	0.247
	2009	0.156	0.162	0.197	0.197	0.211	0.192	0.219	0.244
	2010	0.145	0.167	0.187	0.204	0.207	0.207	0.223	0.216
	2011	0.122	0.154	0.179	0.189	0.195	0.205	0.209	0.217
	2012	0.119	0.165	0.186	0.202	0.212	0.234	0.209	0.226
Total North Sea Catch	2002	0.118	0.153	0.170	0.199	0.214	0.228	0.250	0.252
	2003	0.104	0.158	0.174	0.184	0.205	0.222	0.232	0.256
	2004	0.100	0.138	0.183	0.201	0.216	0.228	0.246	0.272
	2005	0.099	0.153	0.166	0.208	0.223	0.240	0.257	0.278
	2006	0.122	0.145	0.172	0.181	0.220	0.237	0.235	0.262
	2007	0.149	0.152	0.164	0.194	0.190	0.224	0.235	0.252
	2008	0.141	0.180	0.181	0.183	0.216	0.216	0.256	0.273
	2009	0.145	0.181	0.216	0.216	0.239	0.243	0.248	0.273
	2010	0.138	0.167	0.192	0.222	0.219	0.217	0.234	0.245
	2011	0.141	0.160	0.183	0.197	0.217	0.221	0.223	0.240
	2012	0.130	0.171	0.185	0.206	0.222	0.239	0.239	0.247

Values for total NS catch updated in 2006 for the years 2001-2005 due to an incorrect allocation of fish in the plus group in the Danish catches and new information of misreporting from the UK.

Table 2.2.12: Sampling of commercial landings of North Sea herring (Div. IV and VIId) in 2012 by quarter. Sampled catch means the proportion of the reported catch to which sampling was applied. It is not possible to judge the quality of the sampling by this figure alone. Note that only one nation sampled their by-catches in the industrial fishery (Denmark, fleet B). Metiers are each *reported* combination of nation/fleet/area/quarter.

Country (fleet)	Quarter	No of metiers	Metiers sampled	Sampled Catch %	Official Catch	No. of samples	No. fish aged	No. fish measured	>1 sample per 1 kt catch
Denmark (A)	1	3	2	99%	23494	27	477	3929	n
	2	2	2	100%	3835	11	189	1576	y
	3	3	2	97%	59000	22	606	3046	n
	4	3	2	96%	8740	3	81	413	n
total		11	8	98%	95069	63	1353	8964	n
Denmark (B)	1	2	1	100%	118	1	7	7	y
	3	3	1	99%	2380	6	124	126	y
	4	3	2	100%	6021	15	258	260	y
total		9	4	100%	8928	22	389	393	y
England and Wales*	1	3	0	0%	444	0	0	0	n
	2	4	2	98%	1381	8	200	1249	y
	3	3	1	15%	19448	6	150	787	n
	4	3	0	0%	4072	0	0	0	n
total		13	3	17%	25346	14	350	2036	n
France	1	3	0	0%	1337	0	0	0	n
	2	4	0	0%	3346	0	0	0	n
	3	4	0	0%	11716	0	0	0	n
	4	3	0	0%	7418	0	0	0	n
total		14	0	0%	23817	0	0	0	n
Germany	3	2	1	91%	14120	5	471	835	y
	4	3	3	100%	10395	16	1035	3905	y
total		5	4	95%	24514	21	1506	4740	y
Netherlands	1	3	2	69%	2181	10	249	1564	y
	2	2	2	114%	3472	16	399	3425	y
	3	2	2	93%	48856	74	1850	7213	y
	4	4	2	99%	17834	11	275	1964	n
total		11	8	95%	72344	111	2773	14166	y
Norway	1	2	1	56%	2515	1	30	100	n
	2	3	2	100%	60684	34	1233	2621	n
	3	3	2	97%	12562	6	198	349	n
	4	3	2	72%	43492	8	337	656	n
total		11	7	89%	119253	49	1798	3726	n
Scotland	1	1	1	100%	1075	1	58	170	y
	2	2	1	91%	2823	7	340	1205	y
	3	2	1	97%	30367	24	1072	4266	y
	4	2	0	0%	149	0	0	0	n
total		7	3	97%	34414	32	1470	5641	y
Sweden	2	3	0	0%	7190	0	0	0	n
	3	2	0	0%	3555	0	0	0	n
	4	1	0	0%	3347	0	0	0	n
total		6	0	0%	14092	0	0	0	n
Northern Ireland	1	1	0	0%	335	0	0	0	n
	3	1	0	0%	4264	0	0	0	n
	4	1	0	0%	195	0	0	0	n
total		3	0	0%	4794	0	0	0	n
Belgium	4	2	0	0%	3	0	0	0	n
total		2	0	0%	3	0	0	0	n
grand total		88	37	80%	424284	368	9942	41092	n
Period total	1	16	6	87%	31381	39	814	5763	y
Period total	2	21	10	87%	83425	77	2456	10172	n
Period total	3	23	10	79%	206045	157	4690	17474	n
Period total	4	28	11	73%	103433	95	1982	7683	n
Total for stock 2012		88	37	80%	424284	368	9942	41092	n
Human Cons. only		83	33	79%	413646	290	9250	39273	n
Total for stock 2010		85	37	81%	174628.28	294	9917	46589	y
Total for stock 2011		84	36	84%	218399	241	7621	30992	y
Human Cons. only 2011		75	32	82%	209471	219	7232	30599	y

* majority of catches landed to IJmuiden, the Netherlands

Table 2.3.1.1. North Sea herring. Acoustic Surveys in the North Sea (HERAS) in June-July 2012. Vessels, areas and cruise dates.

Vessel	Period	Area	Rectangles
Celtic Explorer (IR)	09 July – 26 July	53°-58.6°N ,12°-7°W	35D8-D9, 36D8-D9, 37D9-E1, 38D9-E1, 39E0-E2, 40E0-E2,41E0-E3, 42E0-E3, 43E0-E3, 44E0-E3, 45E0-E4
Scotia & Charter vessel (SCO)	30 June – 23 July	58°30′-62°N, 4°W-2°E	46E2-F1, 47E3-F1, 48E4-F1, 49E5-F1, 50E7-F1, 51E8-F1
Johan Hjort (NOR)	25 June – 23 July	56°30-62°N, 2°-5°E	42F2-F5, 43F2-F5, 44F2-F5, 45F2-F5, 46F2-F4, 47F2-F4, 48F2-F4, 49F2-F4, 50F2-F4, 51F2-F4, 52F2-F4
Tridens (NED)	25 June – 20 July	54°09– 58°16′N, 3° W–6°E	37E9-F1, 38E8-F1, 39E8-F1, 40E8-F5, 41E7-F5, 42E7-F1, 43E7-F1, 44E6-F1, 45E6-F1
Solea (GER) DBFH	29 June – 19 July	52°-56°N, Eng to Den/Ger coasts	34F2-F4, 35F2-F4, 36F3-F7, 37F2-F8, 38F3-F7, 39F3-F7, 40F6-F7
Dana (DEN) OXBH	3 July – 16 July	Kattegat and North of 56°N, east of 6°E	41 F6-F7, 41G1-G2, 42F6-F7, 42G0-G2, 43F6-G1, 44F6-G1, 45F8-G1, 46F9-G0

Table 2.3.1.2. North Sea herring. Acoustic Surveys in the North Sea (HERAS) in June-July 2012. Total numbers (millions of fish) and biomass (thousands of tonnes) of North Sea autumn spawning herring in the area surveyed in the pelagic acoustic surveys, with mean weight and mean length by age ring.

Age (ring)	Numbers	Biomass	Maturity	Weight (g)	Length (cm)
0	2936	16	0.00	5.3	9.2
1	7437	357	0.00	48.1	18.3
2	4719	588	0.91	124.7	23.9
3	4067	782	0.99	192.4	27.3
4	1738	340	1.00	195.4	27.7
5	1209	256	1.00	211.6	28.4
6	593	137	1.00	231.5	29.2
7	247	60	1.00	241.9	29.6
8	218	52	1.00	239.0	29.6
9+	478	116	1.00	242.8	29.7
Immature	10973	435		39.6	15.9
Mature	12668	2269		179.1	26.8
Total	23641	2704	0.54	114.38	21.77

Table 2.3.2.1: North Sea herring – LAI, MLAI, and SCAI time-series of herring larval abundance <10 mm long (<11 mm for the SNS), by standard sampling area and time periods. The number of larvae are expressed as mean number per ICES rectangle * 10^9

	Orkney/ Shetland		Buchan		Central North Sea			Southern North Sea			MLAI	SCAI
Period	1–15 Sep.	16–30 Sep.	1–15 Sep.	16–30 Sep.	1–15 Sep.	16–30 Sep.	1–15 Oct.	16–31 Dec.	1–15 Jan.	16–31 Jan.		
1972	1133	4583	30		165	88	134	2	46			3334
1973	2029	822	3	4	492	830	1213			1	13.0	3286
1974	758	421	101	284	81		1184		10		7.7	2210
1975	371	50	312			90	77	1	2		2.8	1372
1976	545	81		1	64	108			3		2.5	1217
1977	1133	221	124	32	520	262	89	1			6.1	1624
1978	3047	50		162	1406	81	269	33	3		7.3	2130
1979	2882	2362	197	10	662	131	507		111	89	13.5	3236
1980	3534	720	21	1	317	188	9	247	129	40	9.2	3543
1981	3667	277	3	12	903	235	119	1456		70	13.5	4054
1982	2353	1116	340	257	86	64	1077	710	275	54	19.8	5089
1983	2579	812	3647	768	1459	281	63	71	243	58	25.3	7779
1984	1795	1912	2327	1853	688	2404	824	523	185	39	45.6	12195
1985	5632	3432	2521	1812	130	13039	1794	1851	407	38	69.9	15236
1986	3529	1842	3278	341	1611	6112	188	780	123	18	36.4	14518
1987	7409	1848	2551	670	799	4927	1992	934	297	146	64.7	18443
1988	7538	8832	6812	5248	5533	3808	1960	1679	162	112	128.5	26213
1989	11477	5725	5879	692	1442	5010	2364	1514	2120	512	127.2	22243
1990		10144	4590	2045	19955	1239	975	2552	1204		164.9	20829
1991	1021	2397		2032	4823	2110	1249	4400	873		87.8	14280
1992	189	4917		822	10	165	163	176	1616		40.4	7425
1993		66		174		685	85	1358	1103		28.4	5049
1994	26	1179				1464	44	537	595		20.0	4333
1995		8688					43	74	230	164	20.2	5400
1996		809		184		564		337	675	691	40.2	7022
1997		3611		23				9374	918	355	52.9	10145
1998		8528		1490	205	66		1522	953	170	65.9	13250
1999		4064		185		134	181	804	1260	344	55.6	14279
2000		3352	28	83		376		7346	338	106	37.2	16318
2001		11918		164		1604		971	5531	909	124.0	21780
2002		6669		1038			3291	2008	260	925	104.3	26083
2003		3199		2263		12018	3277	12048	3109	1116	249.9	34332
2004		7055		3884		5545		7055	2052	4175	308.9	37733
2005		3380		1364		5614		498	3999	4822	184.7	32190
2006	6311	2312		280		2259		10858	2700	2106	112.8	30004
2007		1753		1304		291		4443	2439	3854	159.9	31009
2008	4978	6875		533		11201		8426	2317	4008	179.9	38187
2009		7543		4629		4219		15295	14712	1689	464.3	49186
2010		2362		1493		2317		7493	13230	8073	379.5	51153
2011		3831		2839		17766		5461	6160	1215	313.0	53284
2012		19552		5856		517		22768	11103	3285	658.9	69188

Table 2.3.3.1 North Sea herring. Density and abundance estimates of 0-ringers caught in February during the IBTS. Values given for year classes by areas are density estimates in numbers per square metre. Total abundance is found by multiplying density by area and summing up.

Area	North west	North east	Central west	Central east	South west	South east	Div. IIIa	South' Bight	IBTS-0 index
Area m² x 10^9	83	34	86	102	37	93	31	31	
Year class									no. in 10^9
1976	0.054	0.014	0.122	0.005	0.008	0.002	0.002	0.016	17.1
1977	0.024	0.024	0.05	0.015	0.056	0.013	0.006	0.034	13.1
1978	0.176	0.031	0.061	0.02	0.01	0.005	0.074	0	52.1
1979	0.061	0.195	0.262	0.408	0.226	0.143	0.099	0.053	101.1
1980	0.052	0.001	0.145	0.115	0.089	0.339	0.248	0.187	76.7
1981	0.197	0	0.289	0.199	0.215	0.645	0.109	0.036	133.9
1982	0.025	0.011	0.068	0.248	0.29	0.309	0.47	0.14	91.8
1983	0.019	0.007	0.114	0.268	0.271	0.473	0.339	0.377	115
1984	0.083	0.019	0.303	0.259	0.996	0.718	0.277	0.298	181.3
1985	0.116	0.057	0.421	0.344	0.464	0.777	0.085	0.084	177.4
1986	0.317	0.029	0.73	0.557	0.83	0.933	0.048	0.244	270.9
1987	0.078	0.031	0.417	0.314	0.159	0.618	0.483	0.495	168.9
1988	0.036	0.02	0.095	0.096	0.151	0.411	0.181	0.016	71.4
1989	0.083	0.03	0.04	0.094	0.013	0.035	0.041	0	25.9
1990	0.075	0.053	0.202	0.158	0.121	0.198	0.086	0.196	69.9
1991	0.255	0.39	0.431	0.539	0.5	0.369	0.298	0.395	200.7
1992	0.168	0.039	0.672	0.444	0.734	0.268	0.345	0.285	190.1
1993	0.358	0.212	0.26	0.187	0.12	0.119	0.223	0.028	101.7
1994	0.148	0.024	0.417	0.381	0.332	0.148	0.252	0.169	126.9
1995	0.26	0.086	0.699	0.092	0.266	0.018	0.001	0.02	106.2
1996	0.003	0.004	0.935	0.135	0.436	0.379	0.039	0.032	148.1
1997	0.042	0.021	0.338	0.064	0.178	0.035	0.023	0.083	53.1
1998	0.1	0.056	1.15	0.592	0.998	0.265	0.28	0.127	244.0
1999	0.045	0.011	0.799	0.2	0.514	0.22	0.107	0.026	137.1
2000	0.284	0.011	1.052	0.197	1.156	0.376	0.063	0.006	214.8
2001	0.08	0.019	0.566	0.473	0.567	0.247	0.209	0.226	161.8
2002	0.141	0.04	0.287	0.028	0.121	0.045	0.003	0.157	54.4
2003	0.045	0.005	0.284	0.074	0.106	0.021	0.022	0.154	47.3
2004	0.017	0.010	0.189	0.089	0.268	0.187	0.027	0.198	61.3
2005	0.013	0.018	0.327	0.081	0.633	0.184	0.007	0.131	83.1
2006	0.004	0.001	0.240	0.025	0.098	0.018	0.040	0.228	37.2
2007	0.013	0.009	0.184	0.029	0.067	0.047	0.018	0.007	27.8
2008	0.145	0.139	0.277	0.241	0.101	0.093	0.160	0.433	95.8
2009	0.077	0.085	0.228	0.073	0.350	0.253	0.000	0.139	77.1
2010	0.024	0.004	0.586	0.063	0.187	0.090	0	0.080	77.0
2011	0.008	0.001	0.345	0.136	0.215	0.129	0.076	0.040	68.0
2012	0.018	0.005	0.198	0.094	0.108	0.181	0.006	0.038	50.4

Table 2.3.3.2. North Sea herring. Indices of 1-ringers from the IBTS 1st Quarter. Estimation of the small sized component (possibly Downs herring) in different areas. " North Sea" = total area of sampling minus IIIa.

Year class	Year of sampling	All1-ringers in total area (IBTS-1 index) (no/hour)	Small<13cm 1-ringers in total area (no/hour)	Proportion of small in total area vs. all sizes	Small<13cm 1-ringers in North Sea (no/hour)	Proportion of small in North Sea vs. all sizes	Proportion of small in IIIa vs small in total area
1977	1979	168	11	0.07	12	0.07	0
1978	1980	316	108	0.34	106	0.34	0.09
1979	1981	495	51	0.10	41	0.08	0.25
1980	1982	798	177	0.22	185	0.23	0.03
1981	1983	1270	192	0.15	185	0.15	0.10
1982	1984	1516	346	0.23	297	0.20	0.20
1983	1985	2097	315	0.15	298	0.14	0.12
1984	1986	2663	596	0.22	390	0.15	0.39
1985	1987	3693	628	0.17	529	0.14	0.22
1986	1988	4394	2371	0.54	720	0.16	0.72
1987	1989	2332	596	0.26	531	0.23	0.17
1988	1990	1062	70	0.07	62	0.06	0.18
1989	1991	1287	330	0.26	337	0.26	0.05
1990	1992	1268	125	0.10	130	0.10	0.03
1991	1993	2794	676	0.24	176	0.06	0.76
1992	1994	1752	283	0.16	240	0.14	0.21
1993	1995	1346	449	0.33	445	0.33	0.08
1994	1996	1891	604	0.32	467	0.25	0.28
1995	1997	4405	1356	0.31	1089	0.25	0.25
1996	1998	2276	1322	0.58	1399	0.61	0.02
1997	1999	753	152	0.20	149	0.20	0.09
1998	2000	3725	1117	0.30	991	0.27	0.17
1999	2001	2499	328	0.13	307	0.12	0.13
2000	2002	4065	1553	0.38	1471	0.36	0.12
2001	2003	2837	664	0.23	180	0.06	0.75
2002	2004	979	665	0.68	710	0.73	0.01
2003	2005	1010	340	0.34	357	0.35	0.03
2004	2006	893	115	0.13	121	0.14	0.02
2005	2007	1321	303	0.23	304	0.23	0.07
2006	2008	1792	417	0.23	444	0.25	0.011
2007	2009	2340	734	0.31	623	0.27	0.211
2008	2010	1323	279	0.21	286	0.22	0.046
2009	2011	2937	1331	0.45	1407	0.48	0.018
2010	2012	1353	279	0.21	288	0.21	0.041
2011	2013	**1651**	738	0.45	785	0.48	0.011

Table 2.4.1.1. North Sea herring. Mean stock weight-at-age (wr) in the third quarter, in Divisions IVa, IVb and IIIa. Mean catch weight-at-age for the same quarter and area is included for comparison. Weights-at-age in the catch for 1996 to 2001 were revised by SG Rednose, for details of the revision see the 2007 report (ICES CM 2007/ACFM:11). AS = acoustic survey, 3Q = catch.

W. rings	1		2		3		4		5		6		7		8		9+	
Year	AS	3Q	AS	3Q	AS	3Q	AS	3Q	AS	3Q	AS	3Q	AS	3Q	AS	3Q	AS	3Q
1996	45	75	119	135	196	186	253	224	262	229	299	253	306	292	325	300	335	302
1997	45	43	120	129	168	175	233	220	256	247	245	255	265	278	269	295	329	295
1998	52	54	109	131	198	172	238	209	275	237	307	263	289	269	308	313	363	298
1999	52	62	118	128	171	163	207	193	236	228	267	252	272	263	230	275	260	306
2000	46	54	118	123	180	172	218	201	232	228	261	241	295	266	300	286	280	271
2001	50	69	127	136	162	167	204	199	228	218	237	237	255	262	286	288	294	298
2002	45	50	138	140	172	177	194	200	224	224	247	244	261	252	280	281	249	298
2003	46	65	104	119	185	177	209	198	214	210	243	236	281	247	290	272	307	282
2004	35	45	116	125	139	159	206	203	231	234	253	250	262	264	279	262	270	299
2005	43	53	135	124	171	177	181	201	229	234	248	249	253	261	274	287	295	270
2006	45	61	127	139	158	163	188	192	188	205	225	242	243	257	244	260	265	285
2007	66	75	123	153	155	171	171	183	204	215	198	211	218	252	247	263	233	273
2008	62	67	141	151	180	192	183	207	194	211	230	240	217	243	268	276	282	312
2009	56	56	148	166	208	217	236	242	232	259	240	261	266	274	249	274	263	292
2010	38	74	138	150	183	190	229	222	245	245	233	239	237	248	252	265	251	271
2011	35	86	151	155	171	176	210	201	242	227	258	244	249	246	252	253	275	267
2012	48	61	125	142	192	198	194	205	212	223	232	223	242	251	239	256	243	268

Table 2.4.2.1. North Sea herring. Percentage maturity at 2, 3, 4 and 5+ ring for autumn spawning herring in the North Sea. The values are derived from the acoustic survey for 1988 to 2012.

Year \ Ring	2	3	4	5+
1988	65.6	87.7	100	100
1989	78.7	93.9	100	100
1990	72.6	97.0	100	100
1991	63.8	98.0	100	100
1992	51.3	100	100	100
1993	47.1	62.9	100	100
1994	72.1	85.8	100	100
1995	72.6	95.4	100	100
1996	60.5	97.5	100	100
1997	64.0	94.2	100	100
1998	64.0	89.0	100	100
1999	81.0	91.0	100	100
2000	66.0	96.0	100	100
2001	77.0	92.0	100	100
2002	86.0	97.0	100	100
2003	43.0	93.0	100	100
2004	69.8	64.9	100	100
2005	76.0	97.0	96.0	100
2006	66.0	88.0	98.0	100
2007	71.0	92.0	93.0	100
2008	86.0	98.0	99.0	100
2009	89.0	100	100	100
2010	45.0	90.0	100	100
2011	87.0	84.0	99.0	100
2012	91.0	99.0	100	100

Table 2.6.1.1 North Sea herring. Years of duration of survey and years used in the assessment.

Survey	Age range	Years survey has been running	Years used in assessment
SCAI (Larvae survey)	SSB	1972-2012	1973-2012
IBTS 1st Quarter (Trawl survey)	1-wr	1971-2013	1984-2013
Acoustic (+trawl)	1wr	1995-2012	1997-2012
	2-9+wr	1984-2012	1989-2012
IBTS0	0wr	1977-2013	1992-2013

TABLE 2.6.3.1 North Sea Herring. CATCH IN NUMBER

Units : thousands

age	1947	1948	1949	1950	1951	1952	1953	1954	1955
0	0	0	0	0	0	0	150000	219000	164000
1	0	3000	0	0	462000	722000	1023000	1451000	2072000
2	494000	247000	478000	535000	660000	1346000	1322000	1493000	1931000
3	415000	672000	644000	1039000	959000	576000	1003000	1111000	1032000
4	638000	328000	396000	617000	1255000	610000	474000	591000	479000
5	526000	601000	287000	290000	630000	652000	386000	361000	337000
6	756000	487000	652000	254000	262000	464000	473000	330000	232000
7	431000	400000	462000	331000	142000	236000	278000	379000	120000
8	1311000	917000	1037000	597000	445000	554000	392000	511000	215000

age	1956	1957	1958	1959	1960	1961	1962	1963	1964
0	96000	279000	97000	0	194600	1269200	141800	442800	496900
1	1697000	1483000	4279000	1609000	2392700	336000	2146900	1262200	2971700
2	1860000	1644000	1029000	4934000	1142300	1889400	269600	2961200	1547500
3	1221000	736000	999000	488000	1966700	479900	797400	177200	2243100
4	516000	644000	322000	497000	165900	1455900	335100	158300	148400
5	249000	344000	461000	233000	167700	124000	1081800	80600	149000
6	194000	207000	147000	249000	112900	157900	126900	229700	95000
7	104000	147000	73000	120000	125800	61400	145100	22400	256300
8	292000	253000	118000	301000	270600	143500	173100	93000	84000

age	1965	1966	1967	1968	1969	1970	1971	1972	1973
0	157100	374500	645400	839300	112000	898100	684000	750400	289400
1	3209300	1383100	1674300	2425000	2503300	1196200	4378500	3340600	2368000
2	2217600	2569700	1171500	1795200	1883000	2002800	1146800	1440500	1344200
3	1324600	741200	1364700	1494300	296300	883600	662500	343800	659200
4	2039400	450100	371500	621400	133100	125200	208300	130600	150200
5	145100	889800	297800	157100	190800	50300	26900	32900	59300
6	151900	45300	393100	145000	49900	61000	30500	5000	30600
7	117600	64800	67900	163400	42700	7900	26800	200	3700
8	491400	331800	254400	105500	52500	24200	12500	1500	2000

age	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
0	996100	263800	238200	256800	NA	NA	1262700	9519700	11956700	13296900
1	846100	2460500	126600	144300	NA	NA	245100	872000	1116400	2448600
2	772600	541700	901500	44700	NA	NA	134000	284300	299400	573800
3	362000	259600	117300	186400	NA	NA	91800	56900	230100	216400
4	126000	140500	52000	10800	NA	NA	32200	39500	33700	105100
5	56100	57200	34500	7000	NA	NA	21700	28500	14400	26200
6	22300	16100	6100	4100	NA	NA	2300	22700	6800	22800
7	5000	9100	4400	1500	NA	NA	1400	18700	7800	12800
8	3100	4800	1400	700	NA	NA	500	6600	4700	23100

age	1984	1985	1986	1987	1988	1989	1990	1991	1992
0	6973300	4211000	3724700	8229200	3164800	3057800	1302800	2386600	10331300
1	1818400	3253000	4801400	6836300	7867000	3145900	3020000	2138900	2303100
2	1146200	1326300	1266700	2137200	2232500	1593700	899300	1132800	1284900
3	441400	1182400	840800	667900	1090700	1363800	779100	556700	442700
4	201500	368500	465900	467100	383700	809300	861000	548900	361500
5	81100	124500	129800	245800	255800	211800	387500	501200	360500
6	22600	43600	62100	74700	128100	123700	80200	205300	375600
7	25200	20200	20500	23800	38000	61000	54400	39300	152400
8	29700	29200	28400	16200	23800	28200	40700	38600	62500

age	1993	1994	1995	1996	1997	1998	1999	2000	2001
0	10265400	4498900	7438469	2311226	431175	259526	1566349	1105085	1832691
1	3826800	1785200	1664874	1606393	479702	977680	303520	1171677	614469
2	1176300	1783200	1444061	642084	687920	1220105	616354	622853	842635
3	609000	489100	816703	525601	446909	537932	1058716	463170	485628
4	305500	347600	231794	172099	284920	276333	294066	646814	278884
5	215600	109000	118536	57586	109178	175817	135648	213466	321743
6	226000	91800	55128	22534	31389	88927	69299	82481	90918
7	188000	76400	41409	9264	11832	15232	27998	35706	38252
8	129000	116600	98200	21143	24467	20550	12228	17087	20602

age	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
0	730279	369074	715597	1015554	878637	621005	798284	650043	574895	778927
1	837557	617021	206648	715547	222111	235553	235022	175923	280728	159504
2	579592	1221992	447918	355453	401087	219115	331772	259434	293887	367820
3	970577	529386	1366155	485746	310602	417452	184771	106738	236804	275016

TABLE 2.6.3.1 (cont) North Sea Herring. CATCH IN NUMBER

4	292205	835552	543376	1318647	464620	285746	199069	93321	126241	218711
5	140701	244780	753231	479961	997782	309454	137529	86137	83893	130127
6	174570	107751	169324	576154	252150	629187	118349	37951	61542	62938
7	48908	123291	104945	115212	247042	147830	215542	53130	33305	52081
8	43322	46715	97142	146808	106412	156750	117258	143131	113675	125734

age \ year	2012
0	773241
1	284906
2	455259
3	673465
4	404265
5	306234
6	152577
7	104461
8	205427

TABLE 2.6.3.2 North Sea Herring. WEIGHTS AT AGE IN THE CATCH

Units : kg

age \ year	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956	1957
0	0.015	0.015	0.0150	0.015	0.0150	0.015	0.015	0.0150	0.0150	0.015	0.0150
1	0.050	0.050	0.0500	0.050	0.0500	0.050	0.050	0.0500	0.0500	0.050	0.0500
2	0.122	0.122	0.1280	0.128	0.1340	0.137	0.137	0.1390	0.1400	0.140	0.1410
3	0.140	0.140	0.1450	0.151	0.1570	0.165	0.167	0.1690	0.1700	0.172	0.1730
4	0.156	0.156	0.1610	0.166	0.1760	0.183	0.190	0.1930	0.1950	0.197	0.1980
5	0.171	0.171	0.1760	0.180	0.1890	0.199	0.205	0.2110	0.2140	0.216	0.2180
6	0.185	0.185	0.1890	0.193	0.2010	0.210	0.218	0.2230	0.2280	0.231	0.2330
7	0.197	0.197	0.2010	0.204	0.2110	0.219	0.226	0.2330	0.2380	0.242	0.2440
8	0.242	0.242	0.2435	0.245	0.2475	0.251	0.254	0.2565	0.2595	0.261	0.2625

age \ year	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969
0	0.0150	0.0150	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015
1	0.0500	0.0500	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
2	0.1410	0.1430	0.126	0.126	0.126	0.126	0.126	0.126	0.126	0.126	0.126	0.126
3	0.1740	0.1760	0.176	0.176	0.176	0.176	0.176	0.176	0.176	0.176	0.176	0.176
4	0.1990	0.2010	0.211	0.211	0.211	0.211	0.211	0.211	0.211	0.211	0.211	0.211
5	0.2190	0.2210	0.243	0.243	0.243	0.243	0.243	0.243	0.243	0.243	0.243	0.243
6	0.2340	0.2360	0.251	0.251	0.251	0.251	0.251	0.251	0.251	0.251	0.251	0.251
7	0.2450	0.2470	0.267	0.267	0.267	0.267	0.267	0.267	0.267	0.267	0.267	0.267
8	0.2635	0.2645	0.271	0.271	0.271	0.271	0.271	0.271	0.271	0.271	0.271	0.271

age \ year	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
0	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.007
1	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.049
2	0.126	0.126	0.126	0.126	0.126	0.126	0.126	0.126	0.126	0.126	0.126	0.118
3	0.176	0.176	0.176	0.176	0.176	0.176	0.176	0.176	0.176	0.176	0.176	0.142
4	0.211	0.211	0.211	0.211	0.211	0.211	0.211	0.211	0.211	0.211	0.211	0.189
5	0.243	0.243	0.243	0.243	0.243	0.243	0.243	0.243	0.243	0.243	0.243	0.211
6	0.251	0.251	0.251	0.251	0.251	0.251	0.251	0.251	0.251	0.251	0.251	0.222
7	0.267	0.267	0.267	0.267	0.267	0.267	0.267	0.267	0.267	0.267	0.267	0.267
8	0.271	0.271	0.271	0.271	0.271	0.271	0.271	0.271	0.271	0.271	0.271	0.271

age \ year	1982	1983	1984	1985	1986	1987	1988
0	0.010000	0.0100000	0.0100000	0.0090000	0.0060000	0.0110000	0.0110000
1	0.059000	0.0590000	0.0590000	0.0360000	0.0670000	0.0350000	0.0550000
2	0.118000	0.1180000	0.1180000	0.1280000	0.1210000	0.0990000	0.1110000
3	0.149000	0.1490000	0.1490000	0.1640000	0.1530000	0.1500000	0.1450000
4	0.179000	0.1790000	0.1790000	0.1940000	0.1820000	0.1800000	0.1740000
5	0.217000	0.2170000	0.2170000	0.2110000	0.2080000	0.2110000	0.1970000
6	0.238000	0.2380000	0.2380000	0.2200000	0.2210000	0.2340000	0.2160000
7	0.265000	0.2650000	0.2650000	0.2580000	0.2380000	0.2580000	0.2370000
8	0.274234	0.2745238	0.2746263	0.2821301	0.2572113	0.2881358	0.2565714

age \ year	1989	1990	1991	1992	1993	1994	1995
0	0.0170000	0.0190000	0.0170000	0.0100000	0.0100000	0.0060000	0.0090000
1	0.0430000	0.0550000	0.0580000	0.0530000	0.0330000	0.0560000	0.0420000
2	0.1150000	0.1140000	0.1300000	0.1020000	0.1150000	0.1300000	0.1300000
3	0.1530000	0.1490000	0.1660000	0.1750000	0.1450000	0.1590000	0.1690000
4	0.1730000	0.1770000	0.1840000	0.1890000	0.1890000	0.1810000	0.1980000

TABLE 2.6.3.2 (cont) North Sea Herring. WEIGHTS AT AGE IN THE CATCH

5	0.2080000	0.1930000	0.2030000	0.2070000	0.2040000	0.2140000	0.2070000
6	0.2310000	0.2290000	0.2170000	0.2230000	0.2280000	0.2400000	0.2430000
7	0.2470000	0.2360000	0.2350000	0.2370000	0.2440000	0.2550000	0.2470000
8	0.2631489	0.2608182	0.2630415	0.2631664	0.2734558	0.2761973	0.2809153

year							
age	1996	1997	1998	1999	2000	2001	2002
0	0.0150000	0.0150000	0.0210000	0.009000	0.0150000	0.012000	0.0120000
1	0.0180000	0.0440000	0.0510000	0.045000	0.0330000	0.048000	0.0370000
2	0.1120000	0.1080000	0.1140000	0.115000	0.1130000	0.118000	0.1180000
3	0.1560000	0.1480000	0.1450000	0.151000	0.1570000	0.149000	0.1530000
4	0.1880000	0.1950000	0.1830000	0.171000	0.1790000	0.177000	0.1700000
5	0.2040000	0.2270000	0.2190000	0.207000	0.2010000	0.198000	0.1990000
6	0.2120000	0.2260000	0.2380000	0.233000	0.2160000	0.213000	0.2140000
7	0.2610000	0.2350000	0.2470000	0.245000	0.2460000	0.238000	0.2280000
8	0.2814938	0.2549437	0.2878952	0.267719	0.2731261	0.269744	0.2504017

year							
age	2003	2004	2005	2006	2007	2008	2009
0	0.0140000	0.0140000	0.0110000	0.0100000	0.0124000	0.007900	0.0094000
1	0.0370000	0.0360000	0.0440000	0.0490000	0.0638000	0.053500	0.0514000
2	0.1040000	0.1000000	0.0990000	0.1170000	0.1214000	0.128800	0.1440000
3	0.1580000	0.1380000	0.1530000	0.1440000	0.1513000	0.179600	0.1811000
4	0.1740000	0.1830000	0.1660000	0.1720000	0.1634000	0.181200	0.2158000
5	0.1840000	0.2010000	0.2080000	0.1810000	0.1933000	0.183200	0.2162000
6	0.2050000	0.2160000	0.2230000	0.2200000	0.1900000	0.215700	0.2390000
7	0.2220000	0.2280000	0.2400000	0.2370000	0.2232000	0.216100	0.2428000
8	0.2366464	0.2545115	0.2653676	0.2460061	0.2374933	0.262076	0.2532723

year			
age	2010	2011	2012
0	0.0075000	0.008000	0.0106000
1	0.0571000	0.041300	0.0463000
2	0.1292000	0.131700	0.1243000
3	0.1669000	0.159300	0.1706000
4	0.1912000	0.183100	0.1854000
5	0.2203000	0.197000	0.2058000
6	0.2193000	0.216700	0.2215000
7	0.2160000	0.221100	0.2387000
8	0.2383892	0.231918	0.2427213

TABLE 2.6.3.3 North Sea Herring. WEIGHTS AT AGE IN THE STOCK

Units : kg

year								
age	1947	1948	1949	1950	1951	1952	1953	1954
0	0.0150	0.0150	0.0150000	0.0150000	0.0150000	0.0150000	0.0150000	0.0150000
1	0.0500	0.0500	0.0500000	0.0500000	0.0500000	0.0500000	0.0500000	0.0500000
2	0.1220	0.1220	0.1240000	0.1260000	0.1300000	0.1330000	0.1360000	0.1376667
3	0.1400	0.1400	0.1416667	0.1453333	0.1510000	0.1576667	0.1630000	0.1670000
4	0.1560	0.1560	0.1576667	0.1610000	0.1676667	0.1750000	0.1830000	0.1886667
5	0.1710	0.1710	0.1726667	0.1756667	0.1816667	0.1893333	0.1976667	0.2050000
6	0.1850	0.1850	0.1863333	0.1890000	0.1943333	0.2013333	0.2096667	0.2170000
7	0.1970	0.1970	0.1983333	0.2006667	0.2053333	0.2113333	0.2186667	0.2260000
8	0.2625	0.2625	0.2630000	0.2640000	0.2658333	0.2683333	0.2713333	0.2743333

year							
age	1955	1956	1957	1958	1959	1960	1961
0	0.0150000	0.0150000	0.0150000	0.0150000	0.0150000	0.0150000	0.0150000
1	0.0500000	0.0500000	0.0500000	0.0500000	0.0500000	0.0500000	0.0500000
2	0.1386667	0.1396667	0.1403333	0.1406667	0.1416667	0.1463333	0.1510000
3	0.1686667	0.1703333	0.1716667	0.1730000	0.1743333	0.1790000	0.1833333
4	0.1926667	0.1950000	0.1966667	0.1980000	0.1993333	0.2076667	0.2156667
5	0.2100000	0.2136667	0.2160000	0.2176667	0.2193333	0.2263333	0.2330000
6	0.2230000	0.2273333	0.2306667	0.2326667	0.2343333	0.2486667	0.2626667
7	0.2323333	0.2376667	0.2413333	0.2436667	0.2453333	0.2636667	0.2816667
8	0.2771667	0.2795000	0.2815000	0.2828333	0.2840000	0.2936240	0.3034146

year							
age	1962	1963	1964	1965	1966	1967	1968
0	0.0150000	0.0150000	0.0150000	0.0150000	0.0150000	0.0150000	0.0150000
1	0.0500000	0.0500000	0.0500000	0.0500000	0.0500000	0.0500000	0.0500000
2	0.1550000	0.1550000	0.1550000	0.1550000	0.1550000	0.1550000	0.1550000
3	0.1870000	0.1870000	0.1870000	0.1870000	0.1870000	0.1870000	0.1870000
4	0.2230000	0.2230000	0.2230000	0.2230000	0.2230000	0.2230000	0.2230000
5	0.2390000	0.2390000	0.2390000	0.2390000	0.2390000	0.2390000	0.2390000
6	0.2760000	0.2760000	0.2760000	0.2760000	0.2760000	0.2760000	0.2760000

TABLE 2.6.3.3 (cont) North Sea Herring. WEIGHTS AT AGE IN THE STOCK

```
  7 0.2990000 0.2990000 0.2990000 0.2990000 0.2990000 0.2990000 0.2990000
  8 0.3090087 0.3092903 0.3101214 0.3069573 0.3102731 0.3100755 0.3112209
   year
age      1969      1970     1971   1972   1973     1974    1975      1976  1977
  0 0.0150000 0.0150000 0.015000 0.0150 0.0150 0.015000 0.01500 0.0150000 0.015
  1 0.0500000 0.0500000 0.050000 0.0500 0.0500 0.050000 0.05000 0.0500000 0.050
  2 0.1550000 0.1550000 0.155000 0.1550 0.1550 0.155000 0.15500 0.1550000 0.155
  3 0.1870000 0.1870000 0.187000 0.1870 0.1870 0.187000 0.18700 0.1870000 0.187
  4 0.2230000 0.2230000 0.223000 0.2230 0.2230 0.223000 0.22300 0.2230000 0.223
  5 0.2390000 0.2390000 0.239000 0.2390 0.2390 0.239000 0.23900 0.2390000 0.239
  6 0.2760000 0.2760000 0.276000 0.2760 0.2760 0.276000 0.27600 0.2760000 0.276
  7 0.2990000 0.2990000 0.299000 0.2990 0.2990 0.299000 0.29900 0.2990000 0.299
  8 0.3088686 0.3090248 0.311952 0.3076 0.3078 0.308129 0.30775 0.3077143 0.306
   year
age   1978      1979   1980  1981      1982      1983       1984       1985
  0 0.0150 0.0150000 0.0150 0.015 0.0150000 0.0150000 0.01733333 0.01566667
  1 0.0500 0.0500000 0.0500 0.050 0.0500000 0.0500000 0.05666667 0.05633333
  2 0.1550 0.1550000 0.1550 0.155 0.1550000 0.1550000 0.15033333 0.13800000
  3 0.1870 0.1870000 0.1870 0.187 0.1870000 0.1870000 0.19033333 0.18700000
  4 0.2230 0.2230000 0.2230 0.223 0.2230000 0.2230000 0.22966667 0.23233333
  5 0.2390 0.2390000 0.2390 0.239 0.2390000 0.2390000 0.24333333 0.24666667
  6 0.2760 0.2760000 0.2760 0.276 0.2760000 0.2760000 0.28200000 0.27466667
  7 0.2990 0.2990000 0.2990 0.299 0.2990000 0.2990000 0.31066667 0.32100000
  8 0.3096 0.3068571 0.3072 0.307 0.3074043 0.3091429 0.34351178 0.35438242
   year
age      1986       1987       1988        1989       1990       1991
  0 0.0140000 0.00900000 0.00800000 0.008666667 0.01233333 0.01133333
  1 0.0610000 0.05033333 0.04833333 0.043666667 0.05200000 0.05900000
  2 0.1300000 0.12166667 0.12300000 0.122333333 0.12566667 0.13900000
  3 0.1833333 0.17000000 0.16633333 0.165333333 0.17433333 0.18366667
  4 0.2316667 0.21233333 0.20833333 0.204666667 0.21166667 0.21200000
  5 0.2520000 0.23000000 0.22900000 0.228333333 0.24366667 0.23866667
  6 0.2730000 0.24200000 0.24833333 0.252333333 0.27066667 0.26533333
  7 0.3146667 0.27466667 0.25866667 0.261333333 0.28366667 0.27966667
  8 0.3627746 0.30562963 0.28535714 0.288595745 0.30788452 0.30953886
   year
age       1992        1993        1994       1995      1996       1997
  0 0.01033333 0.005666667 0.007333333 0.00600000 0.0060000 0.00500000
  1 0.06366667 0.061000000 0.060000000 0.05733333 0.0540000 0.04866667
  2 0.13666667 0.134000000 0.126333333 0.12933333 0.1296667 0.12333333
  3 0.19400000 0.184333333 0.191666667 0.18566667 0.1993333 0.18333333
  4 0.21400000 0.213000000 0.214333333 0.21066667 0.2273333 0.23033333
  5 0.23433333 0.234333333 0.239666667 0.22433333 0.2343333 0.23733333
  6 0.25300000 0.261666667 0.274666667 0.26800000 0.2736667 0.25666667
  7 0.27166667 0.272666667 0.291333333 0.29333333 0.3006667 0.28033333
  8 0.29870453 0.307936434 0.320523728 0.32614016 0.3270679 0.31004007
   year
age        1998       1999        2000       2001        2002        2003
  0 0.005666667 0.00600000 0.005666667 0.00600000 0.006333333 0.006666667
  1 0.047333333 0.05066667 0.051333333 0.05066667 0.047333333 0.047000000
  2 0.116000000 0.11600000 0.115666667 0.12166667 0.128000000 0.123000000
  3 0.187333333 0.17933333 0.183666667 0.17166667 0.171666667 0.173000000
  4 0.241333333 0.22633333 0.221333333 0.21000000 0.205333333 0.202333333
  5 0.264333333 0.25600000 0.248333333 0.23266667 0.228333333 0.222000000
  6 0.283666667 0.27333333 0.278666667 0.25533333 0.248333333 0.242333333
  7 0.286666667 0.27600000 0.286000000 0.27466667 0.270333333 0.265666667
  8 0.308339011 0.27811880 0.284171183 0.27449422 0.286521182 0.284946134
   year
```

TABLE 2.6.3.3 (cont) North Sea Herring. WEIGHTS AT AGE IN THE STOCK

age	2004	2005	2006	2007	2008	2009
0	0.006666667	0.005733333	0.006766667	0.00610000	0.007933333	0.007233333
1	0.042000000	0.041433333	0.041000000	0.05133333	0.057700000	0.061433333
2	0.119333333	0.118100000	0.125666667	0.12800000	0.130366667	0.137366667
3	0.165333333	0.164433333	0.155400000	0.16073333	0.164200000	0.181000000
4	0.202666667	0.197900000	0.190900000	0.17956667	0.180766667	0.196866667
5	0.223000000	0.224500000	0.215800000	0.20680000	0.195433333	0.209966667
6	0.247666667	0.247833333	0.241900000	0.22356667	0.217700000	0.222500000
7	0.267666667	0.264866667	0.252133333	0.23780000	0.226066667	0.233633333
8	0.280490193	0.284945260	0.270223450	0.25648110	0.255556491	0.255759739

year

age	2010	2011	2012
0	0.007133333	0.006666667	0.00610000
1	0.052233333	0.043166667	0.04056667
2	0.142266667	0.145300000	0.13763333
3	0.190366667	0.187433333	0.18213333
4	0.216266667	0.225066667	0.21143333
5	0.223600000	0.239366667	0.23273333
6	0.234200000	0.243500000	0.24080000
7	0.240100000	0.250766667	0.24290000
8	0.260682861	0.257247512	0.25246564

TABLE 2.6.3.4 North Sea Herring. NATURAL MORTALITY

Units : NA

year

age	1947	1948	1949	1950	1951	1952	1953
0	1.3062962	1.3063903	1.3068821	1.3072083	1.3066220	1.3043784	1.3068605
1	0.8597480	0.8597415	0.8597118	0.8596935	0.8597301	0.8598630	0.8597093
2	0.3056970	0.3056669	0.3055191	0.3054245	0.3056036	0.3062708	0.3055162
3	0.2817484	0.2817165	0.2815592	0.2814580	0.2816484	0.2823597	0.2815574
4	0.2531908	0.2531580	0.2529935	0.2528867	0.2530850	0.2538308	0.2529940
5	0.2300403	0.2300068	0.2298389	0.2297298	0.2299323	0.2306936	0.2298396
6	0.2293962	0.2293629	0.2291975	0.2290907	0.2292906	0.2300393	0.2291965
7	0.2258074	0.2257749	0.2256149	0.2255120	0.2257058	0.2264292	0.2256128
8	0.2258074	0.2257749	0.2256149	0.2255120	0.2257058	0.2264292	0.2256128

year

age	1954	1955	1956	1957	1958	1959	1960
0	1.3093415	1.3088394	1.3036901	1.2931602	1.3192712	1.3217465	1.3063292
1	0.8595631	0.8596017	0.8599133	0.8605277	0.8589407	0.8588323	0.8597945
2	0.3047803	0.3049514	0.3064994	0.3096070	0.3017431	0.3011004	0.3058071
3	0.2807726	0.2809519	0.2826002	0.2859165	0.2775460	0.2768483	0.2818484
4	0.2521708	0.2523528	0.2540767	0.2575595	0.2488103	0.2480547	0.2532628
5	0.2289991	0.2291846	0.2309444	0.2345002	0.2255694	0.2247968	0.2301122
6	0.2283702	0.2285568	0.2302904	0.2337826	0.2249822	0.2242391	0.2294894
7	0.2248147	0.2249976	0.2266746	0.2300461	0.2215312	0.2208238	0.2259122
8	0.2248147	0.2249976	0.2266746	0.2300461	0.2215312	0.2208238	0.2259122

year

age	1961	1962	1963	1964	1965	1966	1967
0	1.2779437	1.2405107	1.4498257	1.3341230	1.2292427	1.1360167	1.0533453
1	0.8614710	0.8636000	0.8510058	0.8582902	0.8646056	0.8698533	0.8742452
2	0.3142394	0.3251448	0.2624238	0.2978870	0.3293404	0.3564009	0.3796720
3	0.2908419	0.3024979	0.2356937	0.2733594	0.3068488	0.3358097	0.3607781
4	0.2626962	0.2749736	0.2050645	0.2442764	0.2793030	0.3098633	0.3363605
5	0.2397436	0.2522790	0.1809156	0.2209336	0.2566889	0.2879006	0.3149562
6	0.2389587	0.2512436	0.1809803	0.2205236	0.2557409	0.2863048	0.3126683
7	0.2350598	0.2469035	0.1789569	0.2172865	0.2513544	0.2807976	0.3061220
8	0.2350598	0.2469035	0.1789569	0.2172865	0.2513544	0.2807976	0.3061220

year

age	1968	1969	1970	1971	1972	1973	1974
0	0.9805771	0.9186008	0.8673622	0.8247947	0.7939643	0.7755027	0.7636920
1	0.8778144	0.8804017	0.8820627	0.8831532	0.8837601	0.8837618	0.8832010
2	0.3993545	0.4145945	0.4255663	0.4340132	0.4379065	0.4368385	0.4349828
3	0.3819478	0.3985622	0.4107716	0.4201306	0.4248969	0.4246783	0.4230544
4	0.3589555	0.3770431	0.3907393	0.4012868	0.4073827	0.4086825	0.4078663
5	0.3380276	0.3565578	0.3706479	0.3814567	0.3878100	0.3893628	0.3885181
6	0.3350369	0.3527903	0.3660364	0.3760727	0.3815138	0.3819820	0.3802856
7	0.3275616	0.3444648	0.3569392	0.3663576	0.3711496	0.3709273	0.3688377
8	0.3275616	0.3444648	0.3569392	0.3663576	0.3711496	0.3709273	0.3688377

TABLE 2.6.3.4 (Cont) North Sea Herring. NATURAL MORTALITY

age	1975	1976	1977	1978	1979	1980	1981
0	0.7688703	0.7901108	0.8047986	0.8124459	0.8238513	0.8333298	0.8394171
1	0.8844545	0.8864425	0.8840221	0.8733575	0.8587716	0.8473594	0.8375958
2	0.4302030	0.4213890	0.4142544	0.4088044	0.4024214	0.3968846	0.3944146
3	0.4169843	0.4059054	0.3971144	0.3908862	0.3837073	0.3771918	0.3739079
4	0.4009955	0.3882011	0.3782681	0.3706733	0.3613179	0.3536230	0.3507997
5	0.3810519	0.3672796	0.3564138	0.3475373	0.3365057	0.3276900	0.3241351
6	0.3724155	0.3584487	0.3473240	0.3381604	0.3269489	0.3179354	0.3140861
7	0.3614341	0.3484669	0.3378787	0.3289188	0.3180598	0.3090793	0.3044325
8	0.3614341	0.3484669	0.3378787	0.3289188	0.3180598	0.3090793	0.3044325

age	1982	1983	1984	1985	1986	1987	1988
0	0.8450021	0.8509293	0.8618818	0.8758657	0.8837108	0.8833518	0.8801386
1	0.8262204	0.8177263	0.8133933	0.8098846	0.8047687	0.8030194	0.8053149
2	0.3936631	0.3910560	0.3846764	0.3767758	0.3700325	0.3620220	0.3521287
3	0.3724725	0.3685723	0.3595125	0.3482600	0.3389950	0.3289309	0.3167563
4	0.3504278	0.3474814	0.3402310	0.3317459	0.3241989	0.3145318	0.3025221
5	0.3230039	0.3198456	0.3133267	0.3060806	0.2996061	0.2913129	0.2812120
6	0.3127191	0.3096080	0.3032829	0.2962165	0.2900961	0.2824154	0.2730801
7	0.3018394	0.2979753	0.2910907	0.2832448	0.2768250	0.2693836	0.2604610
8	0.3018394	0.2979753	0.2910907	0.2832448	0.2768250	0.2693836	0.2604610

age	1989	1990	1991	1992	1993	1994	1995
0	0.8760232	0.8686097	0.8577137	0.8486048	0.8323958	0.8088519	0.7962212
1	0.8027804	0.7939753	0.7837381	0.7726129	0.7494854	0.7166964	0.6949720
2	0.3457447	0.3443718	0.3448689	0.3456637	0.3462418	0.3476941	0.3508561
3	0.3088644	0.3066102	0.3063299	0.3068890	0.3096982	0.3151729	0.3206849
4	0.2945958	0.2911509	0.2887064	0.2878693	0.2900670	0.2948533	0.3000248
5	0.2747040	0.2720989	0.2704650	0.2703406	0.2726507	0.2770603	0.2822178
6	0.2673958	0.2662294	0.2665871	0.2679837	0.2713861	0.2769124	0.2828047
7	0.2554274	0.2559625	0.2588839	0.2622695	0.2671514	0.2742681	0.2812562
8	0.2554274	0.2559625	0.2588839	0.2622695	0.2671514	0.2742681	0.2812562

age	1996	1997	1998	1999	2000	2001	2002
0	0.7964933	0.8003559	0.8091044	0.8315196	0.8635228	0.8871207	0.9021687
1	0.6869137	0.6817761	0.6802653	0.6913413	0.7113333	0.7220006	0.7236466
2	0.3570840	0.3656584	0.3743015	0.3869205	0.4027811	0.4126429	0.4164810
3	0.3273645	0.3362859	0.3447364	0.3550340	0.3672442	0.3752758	0.3791293
4	0.3072634	0.3173345	0.3266605	0.3373851	0.3500588	0.3587136	0.3632873
5	0.2899977	0.3006973	0.3105983	0.3222252	0.3360710	0.3453713	0.3500951
6	0.2906329	0.3009355	0.3104069	0.3214765	0.3345297	0.3431944	0.3474571
7	0.2892593	0.2992269	0.3085044	0.3196391	0.3326829	0.3412380	0.3453142
8	0.2892593	0.2992269	0.3085044	0.3196391	0.3326829	0.3412380	0.3453142

age	2003	2004	2005	2006	2007	2008	2009
0	0.9180715	0.9311605	0.9417495	0.9515479	0.9589797	0.9629198	0.9639524
1	0.7255318	0.7228521	0.7158512	0.7068146	0.6940013	0.6761454	0.6539054
2	0.4190357	0.4182149	0.4141342	0.4078147	0.3985226	0.3856549	0.3694447
3	0.3818664	0.3819880	0.3795281	0.3752508	0.3687520	0.3596482	0.3480426
4	0.3667856	0.3678416	0.3664798	0.3634001	0.3582492	0.3506907	0.3408148
5	0.3536407	0.3543872	0.3523644	0.3483950	0.3420464	0.3329287	0.3211651
6	0.3504963	0.3507288	0.3481721	0.3436320	0.3367076	0.3270346	0.3147281
7	0.3480817	0.3478837	0.3447272	0.3394611	0.3316919	0.3210542	0.3076583
8	0.3480817	0.3478837	0.3447272	0.3394611	0.3316919	0.3210542	0.3076583

age	2010	2011	2012
0	0.9630652	0.9600930	0.9622293
1	0.6284271	0.6718588	0.6631198
2	0.3504123	0.3823698	0.3760086
3	0.3342612	0.3571910	0.3526760
4	0.3289086	0.3484127	0.3446658
5	0.3070936	0.3303257	0.3258084
6	0.3001065	0.3244418	0.3196442
7	0.2918243	0.3183380	0.3130572
8	0.2918243	0.3183380	0.3130572

TABLE 2.6.3.5 North Sea Herring. PROPORTION MATURE

Units : NA

year

age	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
4	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
5	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
6	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
7	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
8	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

year

age	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
0	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
1	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
2	1	1	1	1	1	1	1	1	1	1	0.82	0.82	0.82	0.82	0.82
3	1	1	1	1	1	1	1	1	1	1	1.00	1.00	1.00	1.00	1.00
4	1	1	1	1	1	1	1	1	1	1	1.00	1.00	1.00	1.00	1.00
5	1	1	1	1	1	1	1	1	1	1	1.00	1.00	1.00	1.00	1.00
6	1	1	1	1	1	1	1	1	1	1	1.00	1.00	1.00	1.00	1.00
7	1	1	1	1	1	1	1	1	1	1	1.00	1.00	1.00	1.00	1.00
8	1	1	1	1	1	1	1	1	1	1	1.00	1.00	1.00	1.00	1.00

year

age	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	0.0	0.00	0.00	0.00	0.00
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	0.0	0.00	0.00	0.00	0.00
2	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.7	0.75	0.8	0.85	0.82	0.91	0.86
3	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.0	1.00	1.0	0.93	0.94	0.97	0.99
4	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.0	1.00	1.0	1.00	1.00	1.00	1.00
5	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.0	1.00	1.0	1.00	1.00	1.00	1.00
6	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.0	1.00	1.0	1.00	1.00	1.00	1.00
7	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.0	1.00	1.0	1.00	1.00	1.00	1.00
8	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.0	1.00	1.0	1.00	1.00	1.00	1.00

year

age	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.50	0.47	0.73	0.67	0.61	0.64	0.64	0.69	0.67	0.77	0.87	0.43	0.70	0.76	0.66
3	0.99	0.61	0.93	0.95	0.98	0.94	0.89	0.91	0.96	0.92	0.97	0.93	0.65	0.96	0.88
4	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.96	0.98
5	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
6	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
7	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
8	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

year

age	2007	2008	2009	2010	2011	2012
0	0.00	0.00	0.00	0.00	0.00	0.00
1	0.00	0.00	0.00	0.00	0.00	0.00
2	0.71	0.86	0.89	0.45	0.87	0.91
3	0.92	0.98	1.00	0.90	0.84	0.99
4	0.93	0.99	1.00	1.00	1.00	1.00
5	1.00	1.00	1.00	1.00	1.00	1.00
6	1.00	1.00	1.00	1.00	1.00	1.00
7	1.00	1.00	1.00	1.00	1.00	1.00
8	1.00	1.00	1.00	1.00	1.00	1.00

TABLE 2.6.3.6 North Sea Herring. FRACTION OF HARVEST BEFORE SPAWNING

Units : NA

year

age	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961
0	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
1	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
2	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
3	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
4	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
5	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
6	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
7	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
8	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67

year

age	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
0	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
1	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
2	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
3	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
4	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
5	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
6	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
7	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
8	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67

year

age	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
0	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
1	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
2	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
3	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
4	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
5	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
6	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
7	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
8	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67

year

age	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
0	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
1	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
2	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
3	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
4	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
5	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
6	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
7	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
8	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67

year

age	2007	2008	2009	2010	2011	2012
0	0.67	0.67	0.67	0.67	0.67	0.67
1	0.67	0.67	0.67	0.67	0.67	0.67
2	0.67	0.67	0.67	0.67	0.67	0.67
3	0.67	0.67	0.67	0.67	0.67	0.67
4	0.67	0.67	0.67	0.67	0.67	0.67
5	0.67	0.67	0.67	0.67	0.67	0.67
6	0.67	0.67	0.67	0.67	0.67	0.67
7	0.67	0.67	0.67	0.67	0.67	0.67
8	0.67	0.67	0.67	0.67	0.67	0.67

TABLE 2.6.3.7 North Sea Herring. FRACTION OF NATURAL MORTALITY BEFORE SPAWNING

Units : NA

age \ year	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961
0	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
1	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
2	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
3	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
4	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
5	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
6	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
7	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
8	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67

age \ year	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
0	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
1	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
2	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
3	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
4	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
5	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
6	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
7	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
8	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67

age \ year	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
0	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
1	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
2	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
3	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
4	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
5	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
6	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
7	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
8	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67

age \ year	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
0	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
1	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
2	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
3	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
4	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
5	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
6	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
7	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
8	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67

age \ year	2007	2008	2009	2010	2011	2012
0	0.67	0.67	0.67	0.67	0.67	0.67
1	0.67	0.67	0.67	0.67	0.67	0.67
2	0.67	0.67	0.67	0.67	0.67	0.67
3	0.67	0.67	0.67	0.67	0.67	0.67
4	0.67	0.67	0.67	0.67	0.67	0.67
5	0.67	0.67	0.67	0.67	0.67	0.67
6	0.67	0.67	0.67	0.67	0.67	0.67
7	0.67	0.67	0.67	0.67	0.67	0.67
8	0.67	0.67	0.67	0.67	0.67	0.67

TABLE 2.6.3.8 North Sea Herring. SURVEY INDICES

```
SCAI - Configuration

SCAI - Configuration

Spawning component abundance index
      min       max plusgroup   minyear   maxyear    startf      endf
       NA        NA        NA      1972      2012        NA        NA
Index type : biomass

SCAI - Index Values

Units  :  NA
     year
age       1972     1973     1974     1975     1976     1977     1978     1979
  all 3334.407 3286.069 2209.502 1372.471 1216.997 1623.603 2130.417 3235.861
     year
age       1980     1981     1982     1983     1984     1985     1986     1987
  all 3542.521 4054.349 5089.215 7779.292 12195.16 15236.04 14518.34 18443.44
     year
age       1988     1989     1990     1991     1992     1993    1994     1995
  all 26213.08 22243.02 20828.84 14279.93 7425.138 5048.563 4332.87 5400.227
     year
age       1996     1997     1998    1999     2000     2001     2002     2003
  all 7022.088 10144.91 13250.44 14279.4 16318.19 21779.55 26082.72 34332.07
     year
age       2004     2005     2006     2007     2008     2009    2010     2011
  all 37733.06 32190.21 30003.81 31008.57 38186.53 49186.42 51153.2 53284.39
     year
age       2012
  all 69188.05

HERAS - Configuration

Herring in Sub-area IV, Divisions VIId & IIIa (autumn-spawners) . Imported from
VPA file.
      min       max plusgroup   minyear   maxyear    startf      endf
     1.00      8.00      8.00   1989.00   2012.00      0.54      0.56
Index type : number

HERAS - Index Values

Units  :  NA
   year
age    1989    1990    1991    1992    1993    1994    1995    1996    1997
  1      -1      -1      -1      -1      -1      -1      -1      -1 9361000
  2 4090000 3306000 2634000 3734000 2984000 3185000 3849000 4497000 5960000
  3 3903000 3521000 1700000 1378000 1637000  839000 2041000 2824000 2935000
  4 1633000 3414000 1959000 1147000  902000  399000  672000 1087000 1441000
  5  492000 1366000 1849000 1134000  741000  381000  299000  311000  601000
  6  283000  392000  644000 1246000  777000  321000  203000   99000  215000
  7  120000  210000  228000  395000  551000  326000  138000   83000   46000
  8   66000  176000  145000  218000  296000  350000  212000  339000  237000
   year
age    1998    1999     2000     2001     2002     2003    2004    2005    2006
  1 4449000 5087000 24736000  6837000 23055000  9829400 5183700 3114100 6822800
  2 5747000 3078000  2923000 12290000  4875000 18949400 3415900 2055100 3772300
  3 2520000 4725000  2156000  3083000  8220000  3081000 9191800 3648500 1997200
  4 1625000 1116000  3140000  1462000  1390000  4188900 2167300 5789600 2097500
  5  982000  506000  1007000  1676000   794600   675100 2590700 1212900 4175100
  6  445000  314000   483000   450000  1031000   494800  317100 1174900  618200
  7  170000  139000   266000   170000   244400   568300  327600  139900  562100
  8  166000  141000   217000   157000   270500   323200  527650  233200  154700
   year
age    2007    2008    2009     2010     2011    2012
  1 6261000 3714000 4655000 14577000 10119000 7437000
  2 2750000 2853000 5632000  4237000  4166000 4719000
  3 1848000 1709000 2553000  4216000  2534000 4067000
  4  898000 1485000 1023000  2453000  2173000 1738000
  5  806000  809000 1077000  1246000  1016000 1209000
  6 1323000  712000  674000  1332000   651000  593000
  7  243000 1749000  638000   688000   688000  247000
  8  217000  455000 1720000  2729000  1737000  696000
```

TABLE 2.6.3.8 (Cont.) North Sea Herring. SURVEY INDICES

```
IBTS-Q1 - Configuration

Herring in Sub-area IV, Divisions VIId & IIIa (autumn-spawners) . Imported from
VPA file.
      min       max plusgroup   minyear   maxyear    startf      endf
     1.00      1.00        NA   1984.00   2013.00      0.08      0.17
Index type : number

IBTS-Q1 - Index Values

Units  :  NA
   year
age     1984    1985     1986     1987     1988     1989     1990     1991
  1 1515.627 2097.28 2662.812 3692.965 4394.168 2331.566 1061.572 1286.747
   year
age     1992     1993     1994     1995     1996     1997     1998    1999
  1 1268.145 2794.007 1752.053 1345.754 1890.872 4402.996 2275.845 752.862
   year
age     2000     2001     2002   2003    2004     2005    2006     2007    2008
  1 3303.932 2499.391 3881.426 2836.7 979.036 1009.807 899.755 1322.345 1791.55
   year
age     2009     2010     2011     2012     2013
  1 2338.813 1206.335 2938.813 1352.769 1651.281

IBTS0 - Configuration

Herring in Sub-area IV, Divisions VIId & IIIa (autumn-spawners) . Imported from
VPA file.
      min       max plusgroup   minyear   maxyear    startf      endf
     0.00      0.00        NA   1992.00   2013.00      0.08      0.17
Index type : number

IBTS0 - Index Values

Units  :  NA
   year
age  1992  1993  1994 1995  1996  1997 1998 1999  2000  2001  2002 2003 2004
  0 200.7 190.1 101.7  127 106.5 148.1 53.1  244 137.1 214.8 161.8 54.4 47.3
   year
age 2005 2006 2007 2008 2009 2010 2011 2012 2013
  0 61.3 83.1 37.2 27.8 95.8 77.1   77   68 50.4
```

TABLE 2.6.3.9 North Sea Herring. STOCK OBJECT CONFIGURATION

```
      min       max plusgroup   minyear   maxyear   minfbar   maxfbar
        0         8         8      1947      2012         2         6
```

TABLE 2.6.3.10 North Sea Herring. FLSAM CONFIGURATION SETTINGS

```
name           : Final Assessment
desc           :
range          :       min       max plusgroup   minyear   maxyear   minfbar
maxfbar
range          :         0         8         8      1947      2013         2
6
fleets         :   catch    SCAI   HERAS IBTS-Q1   IBTS0
fleets         :       0       3       2       2       2
plus.group     : TRUE
states         :          age
states         : fleet      0  1  2  3  4  5  6  7  8
states         :   catch    1  2  3  4  5  6  7  8  8
states         :   SCAI    NA NA NA NA NA NA NA NA NA
states         :   HERAS   NA NA NA NA NA NA NA NA NA
states         :   IBTS-Q1 NA NA NA NA NA NA NA NA NA
states         :   IBTS0   NA NA NA NA NA NA NA NA NA
logN.vars      : 1 2 2 2 2 2 2 2 2
catchabilities :          age
catchabilities : fleet      0  1  2  3  4  5  6  7  8
catchabilities :   catch   NA NA NA NA NA NA NA NA NA
catchabilities :   SCAI    NA NA NA NA NA NA NA NA NA
catchabilities :   HERAS   NA  3  3  4  4  5  5  5  5
catchabilities :   IBTS-Q1 NA  1 NA NA NA NA NA NA NA
catchabilities :   IBTS0    2 NA NA NA NA NA NA NA NA
power.law.exps :          age
power.law.exps : fleet      0  1  2  3  4  5  6  7  8
power.law.exps :   catch   NA NA NA NA NA NA NA NA NA
power.law.exps :   SCAI    NA NA NA NA NA NA NA NA NA
power.law.exps :   HERAS   NA NA NA NA NA NA NA NA NA
power.law.exps :   IBTS-Q1 NA NA NA NA NA NA NA NA NA
power.law.exps :   IBTS0   NA NA NA NA NA NA NA NA NA
f.vars         :          age
f.vars         : fleet      0  1  2  3  4  5  6  7  8
f.vars         :   catch    1  1  2  2  3  3  4  4  4
f.vars         :   SCAI    NA NA NA NA NA NA NA NA NA
f.vars         :   HERAS   NA NA NA NA NA NA NA NA NA
f.vars         :   IBTS-Q1 NA NA NA NA NA NA NA NA NA
f.vars         :   IBTS0   NA NA NA NA NA NA NA NA NA
obs.vars       :          age
obs.vars       : fleet      0  1  2  3  4  5  6  7  8
obs.vars       :   catch    3  4  4  4  4  4  5  5  5
obs.vars       :   SCAI    NA NA NA NA NA NA NA NA NA
obs.vars       :   HERAS   NA  6  7  7  7  7  8  8  8
obs.vars       :   IBTS-Q1 NA  1 NA NA NA NA NA NA NA
obs.vars       :   IBTS0    2 NA NA NA NA NA NA NA NA
srr            : 0
cor.F          : FALSE
nohess         : FALSE
timeout        : 3600
```

TABLE 2.6.3.11 North Sea Herring. FLR, R SOFTWARE VERSIONS

```
FLSAM.version                         0.99-9
FLCore.version                           2.4
R.version      R version 2.13.2 (2011-09-30)
platform                     i386-pc-mingw32
run.date                 2013-03-17 15:53:50
```

TABLE 2.6.3.12 North Sea Herring. STOCK SUMMARY

Year	Recruitment Age 0	TSB	SSB	Fbar (Ages 2-6) f	Landings tonnes	Landings SOP
1947	75905523	7088611	3764027	0.1731	581760	1.4609
1948	67930793	6394827	3201084	0.1704	502100	1.3326
1949	58644245	6089034	3122049	0.1834	508500	1.4502
1950	80922301	6119555	3038881	0.1931	491700	1.3073
1951	73883494	6174880	2839107	0.2330	600400	1.3238
1952	74253836	6040516	2785673	0.2461	664400	1.2720
1953	80599258	5944637	2610363	0.2613	698500	1.1979
1954	74105477	5797863	2431454	0.2922	762900	1.2509
1955	66519121	5460222	2412080	0.2893	806400	1.0598
1956	48447922	4891453	2219961	0.2924	675200	1.2712
1957	135299311	5649062	2041101	0.3069	682900	1.1575
1958	49575137	5309456	1698065	0.3156	670500	1.1674
1959	56911045	5487591	2626073	0.3276	784500	1.5186
1960	22567018	4448155	2253511	0.2844	696200	1.1830
1961	111440347	5096171	2122277	0.3202	696700	1.1348
1962	53489718	4742144	1527282	0.3434	627800	1.1705
1963	78766631	5405892	2483054	0.2394	716000	0.8602
1964	83053871	5705836	2392860	0.3199	871200	1.0656
1965	38455028	5010268	1933805	0.5007	1168800	1.1496
1966	34449326	3886424	1580102	0.5103	895500	1.0707
1967	42926504	3169232	1024792	0.6542	695500	1.1757
1968	40832954	2744200	561856	0.9515	717800	1.2551
1969	19697455	2141463	512471	0.8653	546700	0.9674
1970	36506468	2065742	488454	0.9046	563100	0.9657
1971	26963644	1945442	350109	1.2110	520100	1.0747
1972	17592795	1681169	349759	0.6415	497500	0.9197
1973	8850637	1282087	301040	0.8293	484000	0.9575
1974	16502130	946949	201793	0.8532	275100	0.9680
1975	3933342	775296	117008	0.9855	312800	0.9343
1976	4945556	540365	163244	0.7363	174800	0.9530
1977	5542743	413743	126754	0.3380	46000	1.1979
1978	5763180	464167	156686	0.2471	11000	1.2152
1979	11228885	591845	191186	0.2044	25100	1.0056
1980	17021708	814231	212140	0.1812	70764	1.0936
1981	37355847	1401425	309898	0.1997	174879	1.0081
1982	59769138	2126526	431490	0.1835	275079	0.9786
1983	56514059	2856192	644996	0.2303	387202	1.0771
1984	53382845	3591211	1023767	0.3054	428631	1.0543
1985	68339603	4085685	1084902	0.3912	613780	1.0419
1986	81003263	4713777	1116825	0.3811	671488	1.1373
1987	81409294	4629688	1292385	0.3749	792058	1.0173
1988	42712407	4538014	1649528	0.3653	887686	1.1641
1989	35676401	3809468	1699764	0.3509	787899	1.0335
1990	30189357	3696881	1730637	0.3023	645229	1.0515
1991	31484314	3422904	1491063	0.3310	658008	1.0197
1992	58761651	3426329	1133703	0.3743	716799	0.9950
1993	51136035	3153426	800507	0.4312	671397	1.0231
1994	36215581	2819302	866312	0.4438	568234	1.0498
1995	46362430	2733245	913465	0.3847	579371	1.0084
1996	44366711	2913891	1050734	0.2308	275098	0.9987
1997	30614980	3109586	1202604	0.2037	264313	1.0006
1998	22297832	3305175	1457160	0.2249	391628	1.0018
1999	71128595	3419483	1534937	0.2123	363163	1.0000
2000	47917915	4295163	1521185	0.2132	388157	1.0004
2001	86616423	4842782	2074021	0.1879	374065	0.9901
2002	44013194	5632140	2390469	0.1772	394709	0.9974
2003	21423521	5932759	2446087	0.2012	482281	1.0153
2004	25191067	5045463	2416909	0.2429	587698	0.9985
2005	23300841	4231216	2296737	0.2582	663813	1.0033
2006	27425944	3502544	1792282	0.2299	514597	0.9950
2007	26615385	2996633	1444105	0.1974	406482	1.0056
2008	26642014	3011654	1495543	0.1310	257870	1.0040
2009	36251815	3422904	1826661	0.0795	168443	1.0023
2010	36873364	3929411	1857979	0.0842	187611	1.0034
2011	33131664	4106165	2226630	0.1089	226478	0.9938
2012	30431840	4077522	2347825	0.1684	434710	1.0109
2013	22544462					

TABLE 2.6.3.13 North Sea Herring. ESTIMATED FISHING MORTALITY

Units : f

age	1947	1948	1949	1950	1951	1952
0	0.0035090849	0.0035104888	0.003512596	0.003508032	0.003509436	0.003509085
1	0.0002463887	0.0002463887	0.001207142	0.005914194	0.028885949	0.054448499
2	0.0695993535	0.0493854220	0.061004967	0.084728776	0.128220992	0.183012651
3	0.1401418717	0.1595975412	0.153723461	0.174191502	0.212396599	0.199428401
4	0.1456134167	0.1580253209	0.168604423	0.202725993	0.274034848	0.250699567
5	0.1885107961	0.1985726998	0.206449386	0.204763423	0.268850451	0.266468298
6	0.3214542652	0.2865334488	0.327129226	0.299153039	0.281506427	0.330714438
7	0.3315422588	0.3178740639	0.401631611	0.317365872	0.280438733	0.382766552
8	0.3315422588	0.3178740639	0.401631611	0.317365872	0.280438733	0.382766552

age	1953	1954	1955	1956	1957	1958
0	0.003508032	0.004966202	0.004391432	0.003654485	0.003692321	0.003853783
1	0.078355431	0.102181974	0.164359365	0.152696956	0.194368391	0.163408840
2	0.217729895	0.251931010	0.290834762	0.366594114	0.340683972	0.367695547
3	0.251025689	0.312453382	0.312172300	0.315309684	0.326018875	0.354693941
4	0.245956645	0.257844136	0.262527353	0.273104711	0.279850429	0.268393793
5	0.263553209	0.284250326	0.256147968	0.244705459	0.303795652	0.332704690
6	0.328440363	0.354587549	0.324717404	0.262212509	0.284108236	0.254412071
7	0.374381481	0.437503751	0.246744967	0.274610925	0.282408691	0.180775382
8	0.374381481	0.437503751	0.246744967	0.274610925	0.282408691	0.180775382

age	1959	1960	1961	1962	1963	1964
0	0.007451798	0.0145393	0.01698882	0.005828474	0.009965761	0.01043176
1	0.205358099	0.2265250	0.11228668	0.103281191	0.130354189	0.25732896
2	0.375495046	0.3853551	0.42507485	0.254539309	0.282323981	0.35412688
3	0.343283034	0.2824652	0.31793765	0.415962569	0.280326580	0.35373756
4	0.304708408	0.2495490	0.29903340	0.343386034	0.236430732	0.31908428
5	0.298346415	0.2222394	0.27025211	0.321293578	0.209485658	0.29951224
6	0.316351924	0.2823240	0.28877715	0.381948308	0.188378885	0.27321397
7	0.308294433	0.3323057	0.25668644	0.334673450	0.188661665	0.22155155
8	0.308294433	0.3323057	0.25668644	0.334673450	0.188661665	0.22155155

age	1965	1966	1967	1968	1969	1970
0	0.008198533	0.01728874	0.02395927	0.02807994	0.01151045	0.03287312
1	0.233027222	0.20486583	0.26898491	0.27720444	0.28845967	0.26447726
2	0.538488036	0.49781836	0.49294385	0.90931292	0.70795836	0.75309040
3	0.525807554	0.55828260	0.69695809	1.28443637	0.81473693	0.94675115
4	0.509854443	0.49283542	0.66997157	0.77623498	0.75870670	0.91163918
5	0.483821133	0.61209364	0.69271266	0.86358755	0.81555208	0.81606604
6	0.445441212	0.39058487	0.71851406	0.92386160	1.22945379	1.09531063
7	0.473894763	0.56127741	0.94634602	1.13566684	0.98913743	0.92259493
8	0.473894763	0.56127741	0.94634602	1.13566684	0.98913743	0.92259493

age	1971	1972	1973	1974	1975	1976	1977
0	0.03910128	0.05887728	0.05260732	0.08356755	0.09710135	0.0742216	0.07203523
1	0.52160744	0.53608101	0.60347540	0.43470832	0.50739271	0.1503634	0.10898991
2	0.70084397	0.69777401	0.80282381	0.86312134	0.94159315	0.6200966	0.16627703
3	0.87313945	0.69124566	0.93522139	0.81249136	1.04215012	0.8631472	0.47543743
4	0.87957187	0.65396595	0.73305833	0.77657659	0.90465647	0.7954638	0.29801841
5	0.70450489	0.53842342	0.72566268	0.92492928	1.16388087	0.8357966	0.44170634
6	2.89707034	0.62611576	0.94973052	0.88878493	0.87498372	0.5670771	0.30847947
7	1.27515788	0.32870322	0.56511841	0.77905004	1.42649445	0.8910453	0.36077528
8	1.27515788	0.32870322	0.56511841	0.77905004	1.42649445	0.8910453	0.36077528

age	1978	1979	1980	1981	1982	1983	1984
0	0.0907724	0.10724922	0.13064128	0.3792157	0.3418785	0.3776868	0.2112950
1	0.1022433	0.09919179	0.08969861	0.1959492	0.1711183	0.2020581	0.1852961
2	0.1754502	0.19046249	0.20975817	0.1972270	0.1797479	0.1990897	0.2257110
3	0.3068795	0.26775042	0.24144828	0.1997877	0.2616886	0.2351339	0.2910384
4	0.2427556	0.18983500	0.17578388	0.1908820	0.1919923	0.2556362	0.3495181
5	0.3248148	0.27182413	0.21636251	0.2211310	0.1497332	0.2240693	0.3495530
6	0.1854259	0.10211047	0.06262442	0.1894368	0.1341361	0.2376396	0.3113306
7	0.3096230	0.22532759	0.13061516	0.3950354	0.2007490	0.3521845	0.5035461
8	0.3096230	0.22532759	0.13061516	0.3950354	0.2007490	0.3521845	0.5035461

TABLE 2.6.3.13 (Cont.) North Sea Herring. ESTIMATED FISHING MORTALITY

age \ year	1985	1986	1987	1988	1989	1990	1991
0	0.1028072	0.08009835	0.1443954	0.1216752	0.1264131	0.0765432	0.1249802
1	0.2933174	0.29590998	0.3472536	0.4758179	0.3612446	0.3869693	0.2869349
2	0.2775095	0.30095335	0.3014051	0.2778705	0.2838527	0.2816191	0.3781327
3	0.3959173	0.35508432	0.3261493	0.2976015	0.2856466	0.2599672	0.2989437
4	0.4392485	0.39376933	0.3891502	0.3795496	0.3811661	0.3151521	0.3141452
5	0.4142979	0.38639311	0.4124996	0.4244802	0.4019048	0.3513052	0.3280793
6	0.4292353	0.46928266	0.4454724	0.4472489	0.4018325	0.3033706	0.3360148
7	0.5405166	0.54881712	0.4217258	0.4542171	0.4192743	0.3432830	0.2740897
8	0.5405166	0.54881712	0.4217258	0.4542171	0.4192743	0.3432830	0.2740897

age \ year	1992	1993	1994	1995	1996	1997	1998
0	0.2707390	0.3248148	0.2151758	0.2219729	0.07652789	0.02373036	0.01898891
1	0.3248798	0.3320732	0.1897781	0.1919155	0.13942897	0.04194064	0.09822446
2	0.4056924	0.4408988	0.4244207	0.3100257	0.17576630	0.14768111	0.15870629
3	0.3385444	0.4385112	0.4468108	0.4087547	0.24937437	0.20842000	0.21625435
4	0.3566145	0.4531011	0.5796215	0.4030841	0.22745565	0.22584644	0.22976459
5	0.3611001	0.3882096	0.3786095	0.4361103	0.24514633	0.22400207	0.24647370
6	0.4095690	0.4352695	0.3894889	0.3653863	0.25635297	0.21273671	0.27318665
7	0.3888973	0.4726926	0.3804997	0.3293284	0.12777300	0.16408019	0.15291088
8	0.3888973	0.4726926	0.3804997	0.3293284	0.12777300	0.16408019	0.15291088

age \ year	1999	2000	2001	2002	2003	2004
0	0.03099281	0.03430377	0.03169171	0.02643940	0.02819812	0.04381846
1	0.04853355	0.05324241	0.04831564	0.03391832	0.05069135	0.03989916
2	0.15227000	0.14085842	0.08469489	0.08980631	0.08015444	0.08736155
3	0.22117523	0.20410923	0.18723327	0.14580284	0.14471341	0.14108397
4	0.22431589	0.23186499	0.21794773	0.21627598	0.20894170	0.23133232
5	0.23911755	0.25648118	0.22368868	0.21686071	0.31638356	0.32860462
6	0.22465262	0.23274776	0.22586902	0.21720797	0.25591754	0.42605365
7	0.13728448	0.14163528	0.15429329	0.20056839	0.23047797	0.34572902
8	0.13728448	0.14163528	0.15429329	0.20056839	0.23047797	0.34572902

age \ year	2005	2006	2007	2008	2009	2010
0	0.06380651	0.05054456	0.03866193	0.04375279	0.02937533	0.02606401
1	0.09045525	0.04091740	0.03368509	0.02974780	0.02359548	0.02645262
2	0.10872864	0.09957940	0.07961920	0.08144723	0.05819243	0.06372362
3	0.14552607	0.15673481	0.15875391	0.10064055	0.05673863	0.07124718
4	0.22119735	0.22953494	0.21515426	0.13779337	0.09117268	0.08518755
5	0.35765015	0.28616120	0.26350050	0.17415667	0.10495748	0.10915351
6	0.45795699	0.37755841	0.26984704	0.16075079	0.08629359	0.09167551
7	0.61421515	0.54708013	0.43462139	0.21214188	0.11632119	0.09132780
8	0.61421515	0.54708013	0.43462139	0.21214188	0.11632119	0.09132780

age \ year	2011	2012	2013
0	0.03594375	0.03959312	0.03966048
1	0.01656605	0.03072434	0.03066909
2	0.06505645	0.07448928	0.07448928
3	0.09807723	0.14973324	0.14973324
4	0.11130290	0.18561141	0.18561141
5	0.14054887	0.21341855	0.21341855
6	0.12932845	0.21895260	0.21895260
7	0.12140782	0.26535148	0.26535148
8	0.12140782	0.26535148	0.26535148

TABLE 2.6.3.14 North Sea Herring. ESTIMATED POPULATION ABUNDANCE

Units : NA

age \ year	1947	1948	1949	1950	1951	1952	1953
0	75905523	67930793	58644245	80922301	73883493.6	74253836.2	80599257.9
1	16159198	20624701	18384160	15371105	22364825.7	19815995.0	19975158.8
2	7810660	6837960	9559060	7787263	6287034.2	8966446.5	7795054.1
3	3745254	5065685	5267150	7370529	5357457.1	3937277.3	5225181.0
4	5427559	2508010	3020703	3790468	5168019.0	3181934.8	2473142.1
5	3460764	3693186	1687907	1897409	2676445.1	3090983.9	1901207.9
6	2969785	2296737	2429024	1095805	1242952.3	1684534.8	1897409.3
7	1691286	1701465	1401425	1384708	649527.2	762989.8	976763.7
8	5116596	3890312	3278839	2483054	2242271.6	1794074.8	1412681.2

age \ year	1954	1955	1956	1957	1958	1959	1960
0	74105477	66519121.1	48447921.7	135299310.9	49575137.2	56911045.4	22567017.6
1	22364826	19462498.1	18056205.9	12212859.4	41866644.8	12736723.6	16062533.4
2	7748424	8868356.1	6669130.2	6715977.9	3933342.0	17072849.3	4239687.0
3	4524420	4408301.4	5085988.7	3150274.0	3641841.4	1891725.6	9473414.9
4	2946121	2385692.5	2424170.6	2893565.4	1628223.3	1955194.0	950743.9
5	1539549	1704871.0	1379180.4	1424028.0	1713416.7	962221.5	1075181.5
6	1169398	912551.7	1029928.6	872397.1	810981.1	960299.0	549629.7
7	1099098	649527.2	516587.5	632224.6	520736.8	502826.3	539285.3
8	1353223	1249182.6	1218340.2	1056001.3	988555.4	1057057.9	925417.3

age \ year	1961	1962	1963	1964	1965	1966
0	111440346.9	53489717.7	78766630.9	83053870.7	38455027.5	34449326.3
1	5045463.1	32867668.1	15665948.0	18183042.7	22409600.1	11296460.4
2	5493081.8	1676133.1	13564952.5	6101224.2	5722978.8	7671325.7
3	2094865.7	2429023.8	933783.6	8537681.1	3355126.4	2195674.8
4	6028447.1	1153140.9	1024791.8	610479.5	4940613.1	1441219.2
5	580706.1	3715411.5	578387.9	657368.5	381551.1	2191287.9
6	716404.3	350109.1	2010713.1	421679.2	397917.5	185906.7
7	323191.4	444186.6	175957.9	1441219.2	274306.1	192914.0
8	805324.0	680783.8	614153.4	537132.5	1343783.9	815046.1

age \ year	1967	1968	1969	1970	1971	1972
0	42926503.9	40832953.6	19697455.05	36506467.70	26963644.05	17592794.979
1	10427947.3	14724156.5	14665377.48	7952524.63	14946683.59	11594019.931
2	3972872.7	3181934.8	4666873.88	4479401.49	2663096.23	3591210.894
3	3348422.8	1839492.0	766814.35	1583265.43	1345128.36	887354.639
4	870654.1	1234282.0	323191.40	232117.73	403527.53	358972.118
5	674009.8	306508.3	399512.37	103053.13	61944.87	108120.324
6	865445.8	254740.3	87640.63	124991.37	30760.91	20387.964
7	100107.5	298641.8	73497.01	17455.32	30454.83	1099.598
8	446413.1	159213.3	104192.98	46910.65	18010.32	8934.719

age \ year	1973	1974	1975	1976	1977	1978
0	8850637.073	16502129.646	3933341.984	4945556.230	5542742.653	5763180.209
1	7407473.641	3696880.818	7802853.047	1479182.310	2122276.731	2347825.175
2	2847636.756	1633115.340	980678.541	1949337.248	497325.490	810170.501
3	1176435.898	827363.982	443742.625	234685.125	634758.569	330380.401
4	317426.000	290686.312	252963.376	98420.067	61697.581	257300.515
5	129702.676	105134.946	88521.435	67643.057	26502.650	33792.697
6	45524.230	43174.270	28681.282	17738.630	19483.047	11544.911
7	8119.306	12056.992	12236.762	8130.681	6725.759	9860.577
8	5163.655	5523.682	5820.259	2942.162	3092.082	4822.270

age \ year	1979	1980	1981	1982	1983	1984
0	11228884.616	17021707.513	37355846.87	59769138.07	56514059.17	53382845.13
1	2249008.477	4492859.874	6642506.93	10627972.52	18811896.12	16062533.40
2	900765.287	830680.065	1867292.35	2305942.40	3855456.59	6885993.65
3	463239.742	499818.344	424216.83	1075181.45	1314543.48	2115919.44
4	194658.107	244996.695	264078.05	243044.54	555708.97	762227.24
5	134726.220	132058.462	149342.86	149193.59	150391.93	299539.03
6	18592.248	70685.801	90944.07	82950.56	104088.84	92410.88
7	6614.371	13033.784	51896.16	57699.28	54339.14	64601.96
8	7467.384	7613.665	14849.18	33826.51	63322.75	67846.29

TABLE 2.6.3.14 (Cont.) North Sea Herring. ESTIMATED POPULATION ABUNDANCE

age	1985	1986	1987	1988	1989	1990
0	68339603.31	81003263.34	81409293.89	42712407.08	35676401.29	30189356.9
1	17858676.03	26403311.61	32573186.24	29034635.42	15448152.89	12736723.6
2	6218255.75	5745916.58	9313728.01	10886129.35	7587403.53	4680895.5
3	3832393.11	3282119.63	2830602.09	4920890.17	6064726.47	4130875.8
4	1111254.37	1735836.52	1657796.72	1425452.69	2711465.98	3711698.0
5	393564.40	489921.28	830680.07	823237.49	706444.56	1474751.4
6	146239.36	187962.92	243774.77	403124.21	401514.93	374370.0
7	52260.70	67440.43	86249.54	117125.35	192336.17	208772.4
8	65251.22	55547.84	53798.45	70615.15	91035.06	153430.0

age	1991	1992	1993	1994	1995	1996
0	31484313.6	58761650.6	51136035.4	36215581.1	46362430.4	44366711.3
1	12200652.6	11582431.7	18643348.7	15096900.3	12736723.6	15966446.7
2	3996781.6	4501854.6	3867040.3	5838590.7	6028447.1	5235641.8
3	2465733.8	1856122.1	1976819.9	1569080.0	2628700.0	3035843.9
4	2390468.7	1397226.8	979698.4	821592.7	762227.2	1164730.2
5	2088590.5	1329083.3	747881.6	427624.2	333034.0	350459.3
6	806129.8	1194215.4	714973.0	361132.4	209609.2	137036.1
7	214271.7	457714.1	592437.1	333034.0	175782.0	100508.7
8	189662.2	237280.9	360050.7	422523.4	352921.2	270763.2

age	1997	1998	1999	2000	2001	2002
0	30614980.32	22297831.7	71128595.4	47917915.0	86616423.2	44013193.5
1	18962994.88	12864729.8	9379152.8	30922666.0	17966150.2	37169533.8
2	6491472.82	9520900.6	5277695.0	5020298.7	14592233.6	7904952.3
3	2984670.76	3365206.9	6010388.8	2984670.8	3213913.8	9074692.0
4	1664441.18	1610411.0	1758549.7	3562595.8	1708284.1	1781560.1
5	662648.52	926343.1	783871.2	1043405.0	1947388.9	944111.9
6	210238.95	393171.0	464167.1	456799.6	547435.5	1110143.7
7	73644.15	128155.5	201591.8	261189.1	250947.7	301040.5
8	225708.59	172646.3	162105.1	205253.3	242316.5	294489.9

age	2003	2004	2005	2006	2007	2008
0	21423521.2	25191066.9	23300840.7	27425944.4	26615385.3	26642014.0
1	16751527.4	8056582.4	10019061.6	8096966.1	9909455.9	10875248.7
2	20175912.5	6803855.5	3847753.4	4915971.7	3704282.0	4662209.3
3	4666873.9	12509513.6	4303761.6	2475616.5	2984670.8	2231088.2
4	5427558.7	2943176.5	7881273.0	2605147.9	1534937.2	1828488.1
5	973837.8	3156580.9	1691286.4	4751638.2	1411269.2	957422.4
6	574927.9	498321.1	1636384.8	856834.4	2657775.4	847460.9
7	634124.1	337729.3	233048.1	741180.9	430628.0	1664441.2
8	332368.6	518139.6	402318.8	246224.7	418737.7	466493.8

age	2009	2010	2011	2012	2013
0	36251814.7	36873363.8	33131664.0	30431840.4	22544461.9
1	10553836.5	13783737.3	14533981.2	12237309.5	11455723.1
2	6070794.2	5526139.3	7188549.7	7326437.9	6113438.9
3	2813669.3	4139145.8	3576874.7	5070753.6	4666873.9
4	1380560.3	1986728.8	2633962.7	2412080.0	3066354.6
5	1160080.5	989544.5	1224447.2	1656139.7	1419762.3
6	631592.7	857691.7	644351.7	769887.7	965112.5
7	568070.0	466027.5	584200.8	400312.2	449099.6
8	1491063.2	1565944.9	1376424.8	1135972.9	861129.3

TABLE 2.6.3.15 North Sea Herring. PREDICTED CATCH NUMBERS AT AGE

Units : NA

age \ year	1947	1948	1949	1950	1951	1952	1953
0	453295.722	653828.3	282434.0	338947.3	493510.8	157566.0	204884.2
1	428266.096	325071.4	609625.4	608346.6	707363.5	1015813.2	1468129.9
2	651739.356	596718.0	418193.7	428180.5	1297565.0	1320868.5	1496889.7
3	533012.417	514319.5	977838.7	654024.4	622812.0	1017236.3	1066614.3
4	734246.440	417024.4	546396.4	898156.9	626309.5	479116.9	594930.6
5	429853.615	953695.8	1030855.9	1100527.3	648748.2	395655.8	342422.3
6	1300552.848	488356.0	617293.6	566368.4	426258.0	477681.8	314079.1
7	3406.873	656383.2	315085.7	274086.8	218753.3	274882.8	351723.3
8	284247.325	415608.9	254689.4	142914.2	514165.3	397599.3	433046.3

age \ year	1954	1955	1956	1957	1958	1959	1960
0	162575.9	98755.27	279959.4	105937.02	1609767.0	2218185.3	361964.0
1	2001084.8	1733408.05	1466222.6	4286152.35	4659878.8	1179852.5	1650353.4
2	1942720.8	1779067.66	1681673.5	1053786.05	483835.4	2044369.5	498969.4
3	1037682.1	1207545.08	768272.7	957326.71	457576.8	186409.3	1379732.2
4	489431.6	514834.10	626121.7	341294.15	223552.2	192201.6	122884.5
5	346105.9	268578.90	334469.2	437005.04	234544.4	121479.4	160700.9
6	227498.7	213330.95	193455.0	163947.25	120415.1	137365.4	65532.4
7	127707.8	111602.64	139664.7	77489.68	253039.3	235696.4	163243.8
8	245634.5	263076.46	233397.9	147207.73	182097.9	1061613.0	178189.0

age \ year	1961	1962	1963	1964	1965	1966	1967
0	2175349.72	1300552.8	2820712.30	3169232.49	1418343.22	1670611.02	2420537.06
1	323838.43	2954086.4	1586593.78	2059965.93	2567132.31	1306549.17	1613635.07
2	720643.61	204536.1	2242720.06	1197803.48	810170.50	1439490.80	1150031.63
3	295433.78	195888.3	148925.28	1742445.25	488551.42	367765.21	573033.81
4	908181.93	100307.9	153568.19	130378.89	883989.09	294254.41	154075.80
5	99022.26	316760.1	90889.52	127427.14	52749.00	387860.11	133853.34
6	112724.27	27766.9	258409.29	92410.88	73167.02	53997.88	178206.81
7	172698.05	96925.7	96307.36	452842.65	309155.60	240963.32	94939.96
8	412957.52	476536.7	180773.47	353344.93	629763.73	722519.73	147650.02

age \ year	1968	1969	1970	1971	1972	1973
0	2495750.39	1251558.334	4189533.71	3319417.919	2325859.021	892873.328
1	1985140.00	1981966.318	1116377.92	1497638.362	1309819.632	789614.397
2	361783.05	819705.165	659079.87	369423.884	601330.513	385887.054
3	146605.41	118349.809	200125.51	144668.471	138759.847	132230.250
4	191855.93	49227.121	26627.51	37971.836	56743.705	54154.698
5	54105.98	71955.273	26194.38	8043.423	23899.194	21729.803
6	40134.84	9084.728	19075.12	259.971	2979.438	5586.175
7	56891.43	24416.148	11280.83	2112.294	1894.841	2559.251
8	791116.09	706232.654	696832.26	316696.759	929962.926	255531.252

age \ year	1974	1975	1976	1977	1980	1981
0	2137398.514	138399.540	146708.0740	261607.351	811386.669	1151297.356
1	502273.464	750728.990	62724.0358	130666.036	277923.173	315400.961
2	243312.037	114737.249	201410.4209	89985.156	64505.128	208334.450
3	127733.329	45880.708	13360.9293	33439.730	38933.097	36029.740
4	52443.936	32895.791	8066.7826	22046.299	25448.193	17804.028
5	14339.740	6560.880	4407.9279	3681.480	13537.380	8974.926
6	8129.868	4152.600	1746.0825	1377.355	14746.337	9101.914
7	3866.906	1502.732	802.7152	804.628	4219.703	5336.258
8	245757.363	265879.905	1426450.8584	8185705.833	11956671.918	12288814.299

age \ year	1982	1983	1984	1985	1986	1987
0	2384023.11	1882102.39	3172086.08	4737404.64	6718664.78	7788041.70
1	579603.77	1162868.09	1267047.56	1259593.99	2052768.65	2243617.33
2	232094.52	452525.77	1070139.96	840035.98	677456.08	1093943.92
3	106702.51	192528.60	340339.86	487721.59	463286.07	392189.34
4	25988.26	76534.74	116215.33	137022.44	246101.66	250646.79
5	19047.10	21483.27	44636.18	61821.10	77141.76	128527.74
6	14070.14	22435.50	19235.64	25187.42	26273.08	38009.83
7	16396.78	23564.58	24035.81	20744.57	16389.07	22916.21
8	6914284.17	4479849.45	4165304.75	7346246.06	3281791.43	2847636.76

TABLE 2.6.3.15 (Cont.) North Sea Herring. PREDICTED CATCH NUMBERS AT AGE

age	1988	1989	1990	1991	1992	1993	1994
0	3298901.20	2892118.97	2148541.93	2284596.55	3784407.9	1883985.43	1621237.01
1	1597259.65	980286.35	1075934.34	1283626.71	1179970.5	1726488.27	1367643.85
2	1306026.66	820115.12	552716.23	463008.18	610418.5	490705.78	762608.44
3	751104.45	877033.09	564276.69	367324.16	313357.5	317521.24	220708.92
4	206364.64	385501.36	515606.93	355898.20	212458.1	118705.39	103600.77
5	117630.07	86560.60	203414.29	355364.75	223217.1	102652.01	56364.79
6	58665.08	53927.72	45515.13	130796.77	197817.5	92976.31	43316.98
7	27769.68	39616.46	40279.58	67819.16	120222.6	118018.89	87029.29
8	1494646.08	2504751.28	9577239.92	9843284.46	4878752.0	6457159.03	2265486.31

age	1995	1996	1997	1998	1999	2000	2001
0	1515263.64	565858.881	877647.23	321740.31	1150721.85	605372.95	883989.09
1	713116.44	750053.638	1171036.72	621194.80	545413.77	973448.30	557211.41
2	575100.45	479452.449	556710.15	1010544.65	464027.92	460468.63	1029207.86
3	205150.68	290018.502	283878.04	301763.84	626184.29	283055.99	292494.17
4	66516.15	115473.922	175062.79	143429.66	201854.01	332202.50	156310.55
5	27062.38	34989.385	81413.79	80378.34	81129.34	94277.70	184259.43
6	10497.79	9672.093	15694.73	22212.27	29457.39	30531.07	46546.17
7	28279.71	29655.414	21147.99	17858.06	23146.53	29483.91	45528.78
8	494993.54	287995.461	1476817.51	1084793.28	1794792.55	758122.30	390545.59

age	2002	2003	2004	2005	2006	2007	2008
0	590898.77	224852.52	622065.08	233421.24	237162.3	232094.52	180791.55
1	1272889.41	466353.87	325852.47	384077.64	234380.2	303488.80	287477.54
2	524919.40	1374499.19	487282.83	300859.90	368243.6	179889.85	131242.23
3	861732.35	512010.29	1317965.74	451125.12	251223.9	199366.48	102252.45
4	224582.86	751630.41	432959.73	1006711.87	279037.1	130744.46	99101.51
5	110370.70	147576.21	514525.30	230475.54	537777.4	107861.15	44886.84
6	110979.41	84204.19	92051.18	268793.85	130731.4	273593.85	53868.44
7	58180.18	129159.07	158974.64	89330.66	127185.3	76733.99	141364.93
8	704892.09	937338.73	875718.53	650827.56	734613.7	675224.16	610113.33

age	2009	2010	2011	2012
0	267426.49	173998.16	271007.02	428266.096
1	288370.10	377112.94	439371.25	651739.356
2	242340.73	281728.75	596658.38	533012.417
3	138593.44	235060.92	347632.09	734246.440
4	88318.07	137200.69	273101.83	429853.615
5	65075.28	67010.19	130300.68	1300552.848
6	35355.17	57411.51	80635.96	3406.873
7	118812.27	135198.59	228844.95	284247.325
8	754265.72	760856.46	453295.72	653828.262

TABLE 2.6.3.16 North Sea Herring. CATCH AT AGE RESIDUALS

Units : NA

age \ year	1947	1948	1949	1950	1951	1952
0	0.51406100	0.1640470	0.09600500	-0.0843250	-0.367612	-0.22075100
1	-0.18790700	0.0537309	0.23885200	-0.0670296	0.122468	0.04191960
2	-0.12738100	0.0428950	0.35400700	0.4542520	0.218892	0.00484074
3	-0.07936980	-0.1937460	0.20869700	0.0546261	-0.466705	-0.08406140
4	0.10363800	-0.1480990	-0.12590000	0.3918710	-0.157463	-0.06401560
5	0.00938532	-0.1394600	0.04689730	0.7850120	0.030018	-0.14753300
6	0.02839550	-0.1279640	-0.00300181	0.6363970	0.301481	-0.03488520
7	-0.75987100	-0.1139390	-0.49597300	-0.1601820	0.269682	0.04013510
8	-0.83946900	-0.2887940	-0.00951583	-0.0226804	0.264996	-0.05024210

age \ year	1953	1954	1955	1956	1957	1958	1959
0	0.2989600	0.0392670	-0.1268990	-0.0152234	-0.395113	-0.00303765	0.452230
1	-0.0701027	0.2079070	-0.1266320	0.0679263	-0.010040	0.34149400	-0.193068
2	-0.0154400	-0.0362156	0.2659280	-0.1353050	-0.142304	0.05122810	-0.231422
3	0.2437780	-0.0326047	0.0661936	-0.2563690	0.254467	0.49360400	-0.696248
4	-0.0397507	-0.1286560	0.0136312	0.1681210	-0.347542	0.24722600	-0.814685
5	0.3158430	-0.1593200	-0.4520730	0.1677940	0.319600	0.21231500	-0.260326
6	0.1755940	0.0696939	-0.3372260	0.2403600	-0.387436	-0.01225190	-0.312505
7	0.2654600	-0.2212910	-0.2504580	0.1819800	-0.212176	0.61638800	0.490612
8	0.5879510	-0.4730160	0.3705470	0.2864010	-0.785616	0.29762600	0.800983

age \ year	1960	1961	1962	1963	1964	1965
0	-0.4447610	-0.0786587	-0.1791040	0.31135600	0.0748269	-0.15009800
1	0.8082680	-1.0954000	0.0146338	-0.14888500	0.4407970	0.00582722
2	-0.2325270	0.6046640	-0.8573490	0.00116072	0.6010740	-0.53161300
3	0.3209200	0.7527800	-1.2728500	-0.02106320	0.9404430	-0.48990000
4	0.0537166	1.0454100	-1.3069700	-0.18071300	0.6391260	0.03926220
5	-0.0624738	0.8811410	-1.1416300	0.15709100	0.6238990	-0.54079300
6	-0.2314400	0.8966720	-0.7627700	-0.02912990	0.8562990	-0.43142400
7	-0.4580470	0.0083690	-0.1467750	-0.48556000	0.2903490	0.25122300
8	-1.0243900	0.3130960	0.1876320	-0.62967400	0.2606720	0.10990900

age \ year	1966	1967	1968	1969	1970	1971	1972
0	0.0130820	0.0111239	0.0179104	-0.2701890	0.2636560	0.037939	0.107316
1	-0.6519770	0.6370860	-0.3156570	0.0627221	0.1603680	-0.232379	0.154952
2	-0.3189620	1.5643500	-1.1932400	0.4486060	0.0307112	-0.429258	0.548939
3	0.0605032	0.4839420	-0.5774860	0.3364290	0.2393020	-0.611410	0.473175
4	0.0716588	0.1163700	-0.0331417	0.1285920	0.0610769	-0.856772	0.263488
5	0.0475756	0.2840360	-0.2874460	-0.5868230	0.5404420	-1.688710	0.877941
6	0.8138650	-0.3081930	0.2202290	-0.4963410	1.2077500	-0.931523	0.769362
7	0.1927250	0.3745440	-0.2853460	-0.0315157	0.3645080	-1.215900	0.191840
8	0.6719850	-1.2396100	0.5690150	-0.1435170	0.3323690	-0.404131	0.308273

age \ year	1973	1974	1975	1976	1977	1980	1981
0	-0.3216990	0.840885	-0.532221	-0.0988287	-0.3894810	0.430355000	-0.183735
1	-0.1298660	0.451451	1.093580	-2.0238800	0.1503540	0.135331000	-0.311226
2	-0.3816600	0.387290	0.131850	-0.4629970	0.1194100	-0.749338000	0.593443
3	-0.2885950	0.569224	0.747905	-1.2714000	-0.2254910	0.086475900	-0.399407
4	0.2109390	0.518602	0.284195	-0.8474980	-0.0944248	0.676445000	-1.267840
5	0.0920025	0.411264	-0.258702	-0.2572300	-1.6709100	1.836080000	-0.985733
6	-0.3937540	0.400424	0.205542	-0.5395910	0.0579380	0.843722000	-0.548293
7	0.6808780	0.767800	-0.251512	-0.4863450	-1.6899600	1.588830000	-0.450960
8	0.1426720	-0.140081	-0.156022	-0.5467320	0.6773910	-0.000135634	0.353791

age \ year	1982	1983	1984	1985	1986	1987
0	0.1595250	-0.2054690	0.1503170	0.08043770	0.10391000	0.060382200
1	-0.0600959	-0.0861224	0.2732830	0.03353410	0.24089100	-0.029943000
2	-0.4185290	-0.1485240	0.5959290	0.00531848	-0.08494770	-0.017491900
3	-0.0902917	0.2724100	0.4748170	-0.27328600	0.04871560	-0.130616000
4	0.0483538	0.3461450	0.4114290	-0.32349800	-0.00741624	0.121333000
5	0.6388190	0.1800030	-0.0833308	0.01589110	-0.11423300	-0.011943000
6	-0.3360720	0.4127160	0.1737440	-0.73152000	-0.35115300	-0.000921802
7	1.2174400	0.8219660	0.6912550	1.11572000	-0.04121930	0.134261000
8	0.0379487	-0.2777210	-0.5016370	0.50919400	-0.16271600	0.319262000

TABLE 2.6.3.16 (Cont.) North Sea Herring. CATCH AT AGE RESIDUALS

age \ year	1988	1989	1990	1991	1992	1993
0	-0.2838260	0.2584930	-0.0271454	0.04804930	0.0664798	-0.3218360
1	-0.0135252	-0.5149660	0.3078280	0.00573366	-0.0187915	0.1930190
2	0.2587160	-0.3066720	0.0429630	-0.26796300	-0.0140666	-0.0197517
3	0.4458540	-0.1104260	-0.1648130	-0.09556130	-0.1515350	0.5410510
4	0.1552540	0.0308689	-0.1691680	0.07663160	0.0876662	-0.5097880
5	0.1786790	-0.2710530	0.0327970	0.19676400	0.0441152	-0.3967040
6	0.1387290	0.0310868	-0.5216570	0.54286600	-0.1807360	-0.6975330
7	0.0544971	0.0957381	-0.1514020	-0.29021900	0.2502430	-0.0429005
8	-0.6161640	-0.2168590	0.3400390	0.18826700	-0.3635490	0.6345890

age \ year	1994	1995	1996	1997	1998	1999	2000
0	0.1585900	0.348993	-0.986730	0.6450850	-0.3481740	0.1081010	0.0892167
1	0.3248530	-0.627131	-0.516529	0.2450670	-0.0465223	0.7934220	-0.8622390
2	0.4094220	-0.537685	-0.420057	-0.2052110	0.2779600	-0.0109487	0.3178740
3	0.2930390	-1.049580	-0.106142	-0.1609330	-0.1546510	0.1936580	-0.0889651
4	0.8045810	-0.861319	-0.334760	0.0254379	-0.3334980	0.3340090	-0.1913860
5	-0.0788062	-0.650370	-0.385716	0.3136090	-0.5269260	0.0587563	-0.1290690
6	-0.1601070	-0.444119	0.715965	-0.1063010	0.8222690	0.6831660	0.8008200
7	0.4291110	-1.033020	-0.683117	-0.1018960	-1.3452500	-1.0781300	-1.2731200
8	0.0897149	-0.619348	-0.466911	0.2638080	0.0833268	0.0935795	-0.1678780

age \ year	2001	2002	2003	2004	2005	2006
0	-0.32261500	0.2585050	-0.5046620	0.83674400	-0.2965260	-0.0408328
1	0.23550600	-0.2436450	-0.2408670	0.51979000	0.2590290	-0.4022690
2	-0.35050400	0.0504999	-0.0362106	-0.01859000	0.1901640	0.7495980
3	-0.00592977	-0.1843880	0.3553260	0.00315744	0.1759010	0.7692420
4	-0.62850000	0.5147040	0.0125927	0.61584000	-0.0534003	0.6181690
5	-0.19187900	-0.0852915	0.4881660	0.40192500	0.3191080	0.5576420
6	0.17595100	0.3737600	0.7819680	0.79705600	-0.2998970	0.4364980
7	-0.17653800	-0.7794660	-1.0118700	-0.28278000	0.6215740	0.7423820
8	-0.25345500	0.0675529	0.3594200	0.01488280	-0.2104590	0.3728740

age \ year	2007	2008	2009	2010	2011	2012
0	0.07488230	-0.1632500	0.289795	-0.5194580	0.298822	-0.18790700
1	0.53264800	-0.6135380	0.113468	-0.1488640	0.212459	-0.12738100
2	0.16018600	-1.2350700	-0.137892	-0.1438340	0.723610	-0.07936980
3	-0.00901981	-0.5461720	-0.557596	-0.4309720	0.901904	0.10363800
4	0.30216700	-0.8375320	-0.307279	-0.3164980	0.684330	0.00938532
5	0.32977400	-0.5962210	-0.198316	-0.2227680	0.560675	0.02839550
6	-0.84715400	-0.0489407	-0.212267	-0.3459970	0.919410	-0.75987100
7	1.50629000	0.0442687	-0.157042	-0.2577820	-0.383389	-0.83946900
8	-0.17046200	-0.2669010	0.144241	0.0725268	0.514061	0.16404700

TABLE 2.6.3.17 North Sea Herring. PREDICTED INDEX AT AGE SCAI

Units : NA

age \ year	1972	1973	1974	1975	1976	1977	1978	1979
all	4259.725	3666.16	2458.68	1425.232	1988.071	1544.059	1908.094	2328.105

age \ year	1980	1981	1982	1983	1984	1985	1986	1987
all	2582.982	3773.733	5254.079	7852.208	12467.99	13208.69	13595.85	15737.95

age \ year	1988	1989	1990	1991	1992	1993	1994	1995
all	20080.81	20709.96	21075.36	18160.42	13804.78	9745.588	10550.2	11123.66

age \ year	1996	1997	1998	1999	2000	2001	2002	2003
all	12795.39	14639.52	17749.45	18684.32	18522.84	25252.99	29100.19	29801.08

age \ year	2004	2005	2006	2007	2008	2009	2010	2011
all	29445.61	27961.95	21834.79	17594.3	18204.24	22243.39	22629.28	27116.56

age \ year	2012
all	28586.79

TABLE 2.6.3.18 North Sea Herring. INDEX AT AGE RESIDUALS SCAI

Units : NA

age \ year	1972	1973	1974	1975	1976	1977	1978
all	-0.575051	-0.257005	-0.250897	-0.0885734	-1.15235	0.117956	0.258787

age \ year	1979	1980	1981	1982	1983	1984	1985
all	0.773061	0.741738	0.16842	-0.0748494	-0.0219093	-0.0519467	0.335265

age \ year	1986	1987	1988	1989	1990	1991	1992
all	0.154152	0.372474	0.625735	0.167671	-0.0276243	-0.564436	-1.45612

age \ year	1993	1994	1995	1996	1997	1998	1999
all	-1.54432	-2.08956	-1.69676	-1.40888	-0.861155	-0.686399	-0.631315

age \ year	2000	2001	2002	2003	2004	2005	2006	2007
all	-0.29756	-0.347561	-0.257067	0.332389	0.58228	0.330709	0.746244	1.33061

age \ year	2008	2009	2010	2011	2012
all	1.73948	1.86328	1.91495	1.58616	2.07549

TABLE 2.6.3.19 North Sea Herring. PREDICTED INDEX AT AGE IBTS-Q1

Units : NA

age \ year	1984	1985	1986	1987	1988	1989	1990	1991
1	1980.907	2173.904	3215.635	3941.08	3456.667	1867.34	1535.529	1491.161

age \ year	1992	1993	1994	1995	1996	1997	1998	1999
1	1411.15	2276.581	1883.788	1593.662	2012.675	2419.993	1630.497	1195.189

age \ year	2000	2001	2002	2003	2004	2005	2006	2007
1	3926.603	2280.409	4725.081	2125.559	1023.404	1265.687	1031.026	1264.51

age \ year	2008	2009	2010	2011	2012	2013
1	1391.629	1354.476	1774.191	1863.068	1567.395	1467.771

TABLE 2.6.3.20 North Sea Herring. INDEX AT AGE RESIDUALS IBTS-Q1

Units : NA

age \ year	1984	1985	1986	1987	1988	1989	1990	1991
1	-0.902348	-0.120951	-0.635809	-0.219178	0.8088	0.748308	-1.24412	-0.496934

age \ year	1992	1993	1994	1995	1996	1997	1998	1999
1	-0.360137	0.69027	-0.244345	-0.569873	-0.210411	2.01728	1.12394	-1.55774

age \ year	2000	2001	2002	2003	2004	2005	2006
1	-0.581949	0.309028	-0.662916	0.972733	-0.149374	-0.761238	-0.459009

year

TABLE 2.6.3.20 (Cont.) North Sea Herring. INDEX AT AGE RESIDUALS IBTS-Q1

age	2007	2008	2009	2010	2011	2012	2013
1	0.150731	0.851412	1.84103	-1.30017	1.53618	-0.496348	0.397057

TABLE 2.6.3.21 North Sea Herring. PREDICTED INDEX AT AGE HERAS

Units : NA

year							
age	1989	1990	1991	1992	1993	1994	1995
1	4876313.20	3256618.7	1847418.8	1117606.6	576943.7	276426.4	300288.81
2	4706240.73	2861338.3	1788164.1	979110.7	469066.6	350880.2	3549083.65
3	2011718.72	1245316.2	688520.2	380636.5	285101.3	3809848.6	2378070.49
4	579545.82	325559.3	190156.0	197363.0	3471162.1	1893618.3	933783.60
5	330644.81	178724.4	168282.6	2279803.9	1110587.8	557322.9	310612.05
6	157944.66	131294.7	2706319.1	1409858.6	546669.7	266918.9	120704.42
7	74772.09	2441199.3	1400584.2	700815.5	354654.7	174625.7	95053.96
8	3017079.90	1901207.9	1054945.9	618715.0	297777.0	149462.4	256068.43

year							
age	1996	1997	1998	1999	2000	2001	2002
1	11574326.84	7618575.7	5676809.9	18455998.5	10693001.3	22275545.0	9941216.9
2	4450824.87	6454576.7	3566516.8	3383766.5	10087423.4	5441144.6	13934801.9
3	2379497.76	2658838.7	4711891.6	2345478.5	2539556.5	7314725.0	3758761.2
4	1328551.75	1276458.5	1389285.3	2783445.2	1339222.8	1394156.3	4253701.1
5	590721.53	811467.8	684949.2	896003.9	1694502.9	822661.4	801708.2
6	188659.67	339558.0	409175.7	397798.2	476298.5	968399.5	490313.4
7	67920.96	118290.6	186539.8	239426.1	227339.6	265375.2	548915.6
8	208251.13	159388.5	149971.4	188132.2	219542.3	259600.7	287765.2

year							
age	2003	2004	2005	2006	2007	2008	2009
1	4814294.2	5844432.2	4881191.9	6037496.5	6706582.1	6606734.1	8737197.1
2	4681363.6	2623972.6	3381736.9	2588010.5	3278839.1	4362692.6	4000780.4
3	10097515.9	3469773.9	1987921.1	2403171.8	1863188.8	2422958.8	3562239.6
4	2277297.5	6137327.8	2023420.6	1204530.0	1504392.9	1171973.9	1702826.4
5	2579742.1	1361503.3	3988397.2	1203927.9	861646.2	1091539.9	936214.6
6	386659.6	1249932.4	685703.1	2265712.9	771506.2	602594.6	822990.6
7	274415.9	163636.0	541392.6	336179.3	1476669.8	535469.9	449189.4
8	420878.7	282603.5	179907.8	327060.4	414115.4	1405213.8	1509365.6

year			
age	2010	2011	2012
1	9044794.9	7591957.3	4876313.20
2	5109949.1	5198600.4	4706240.73
3	2995434.9	4138318.1	2011718.72
4	2201831.3	1940002.8	579545.82
5	1124220.0	1464317.8	330644.81
6	597554.0	681056.1	157944.66
7	546014.1	346452.2	74772.09
8	1285810.7	983133.3	3017079.90

TABLE 2.6.3.22 North Sea Herring. INDEX AT AGE RESIDUALS HERAS

Units : NA

age \ year	1989	1990	1991	1992	1993	1994	1995
1	-0.890161	0.395368	0.2970310	0.0735302	1.100360	0.60964500	-1.28664000
2	-0.947557	0.893917	0.1695740	0.8906900	0.594837	-0.00915785	1.19830000
3	-1.055670	0.468087	-0.2469810	0.1370350	0.138725	0.05157950	0.86988000
4	-0.828955	0.686252	0.6708630	0.3677060	-0.435366	0.37960300	0.76919800
5	-0.575211	0.596062	-0.5502440	1.3628300	-1.419860	0.94744900	0.00651978
6	-1.015560	1.082850	1.6297800	0.7560140	-1.594150	0.57458100	-0.73263500
7	-0.461186	0.384821	-0.0821646	1.2775800	0.362760	0.55629000	-0.50120800
8	0.462815	-0.566224	0.4234580	0.9130680	0.277647	-0.29507300	1.03697000

age \ year	1996	1997	1998	1999	2000	2001	2002
1	-0.5772290	-1.463180	-0.2985250	0.796556	-1.2164200	0.0935114	-0.0308516
2	1.4779800	-0.587706	-0.7458320	-0.740985	0.9996850	-0.5560630	1.5561400
3	1.0622000	-0.271535	0.0141454	-0.426683	0.9818150	0.5904570	-1.0064900
4	0.4113680	1.222030	-1.1088000	0.610108	0.4439990	-0.0151878	-0.0775496
5	0.0875668	0.965835	-1.5328900	0.591225	-0.0557941	-0.1756140	-0.8701270
6	0.4831090	0.999555	-0.9785530	0.717379	-0.2097570	0.2316600	0.0337047
7	-1.4403500	1.340200	-1.0872100	0.388834	-1.0743300	-0.3044300	0.1280960
8	0.4778580	0.150027	-0.2280420	0.527600	-1.2392400	0.1520430	0.4290760

age \ year	2003	2004	2005	2006	2007	2008	2009
1	0.2012130	-1.712470	0.9109950	0.0988471	-1.6073700	-0.9523340	1.392240
2	-1.5954300	-1.237200	0.5531950	0.3072210	-0.7045190	1.2926400	0.290528
3	-0.4759350	0.254048	0.0235131	-1.3296600	-0.4374840	0.2647950	0.852804
4	-0.2506510	-0.295303	0.1818090	-1.4865300	-0.0657987	-0.6881560	1.848120
5	0.0212622	-0.584993	0.2318420	-2.0315900	-0.3192570	-0.0679344	1.447080
6	-0.7331090	-0.228741	-0.3830120	-1.9881400	-0.2965670	0.4138500	1.779590
7	0.6548580	-0.579312	0.1387240	-1.1996400	0.6256870	0.6475550	1.575850
8	0.8355260	-0.710099	-0.5580550	-1.5161500	0.3479040	0.7472090	2.188670

age \ year	2010	2011	2012
1	0.305153	-0.0561662	-0.890161
2	-1.034130	-0.4899160	-0.947557
3	-0.847000	-0.0879262	-1.055670
4	-0.066699	-0.5563970	-0.828955
5	-0.512278	-0.9699310	-0.575211
6	0.316531	-0.5115700	-1.015560
7	0.854390	-1.2504400	-0.461186
8	1.111590	-1.2766500	0.462815

TABLE 2.6.3.23 North Sea Herring. PREDICTED INDEX AT AGE IBTS0

Units : NA

age \ year	1992	1993	1994	1995	1996	1997	1998	1999
0	146.4963	126.8582	91.36569	117.0241	114.0561	79.18208	57.64192	183.008

age \ year	2000	2001	2002	2003	2004	2005	2006	2007
0	122.7476	221.2471	112.3411	54.54522	63.89685	58.88109	69.37385	67.31479

age \ year	2008	2009	2010	2011	2012	2013
0	67.31546	91.79887	93.37373	83.87688	76.93262	56.99708

TABLE 2.6.3.24 North Sea Herring. INDEX AT AGE RESIDUALS IBTS0

Units : NA

age \ year	1992	1993	1994	1995	1996	1997	1998	1999
0	0.88337	1.13499	0.300689	0.229567	-0.192329	1.75698	-0.230303	0.807128

age \ year	2000	2001	2002	2003	2004	2005	2006	2007
0	0.310308	-0.0829742	1.02369	-0.00749229	-0.843943	0.11298	0.506586	-1.66419

age \ year	2008	2009	2010	2011	2012	2013
0	-2.48154	0.119722	-0.537374	-0.240041	-0.346318	-0.345164

TABLE 2.6.3.25 North Sea Herring. FIT PARAMETERS

	name	value	std.dev
1	logFpar	-8.875700	0.071766
2	logFpar	-12.763000	0.097963
3	logFpar	-0.095347	0.064202
4	logFpar	0.073372	0.062212
5	logFpar	0.173860	0.084331
6	logSdLogFsta	-0.524980	0.097871
7	logSdLogFsta	-1.114200	0.129500
8	logSdLogFsta	-1.152600	0.130500
9	logSdLogFsta	-0.662660	0.113180
10	logSdLogN	-0.586140	0.114820
11	logSdLogN	-1.989000	0.158240
12	logSdLogObs	-1.215000	0.157110
13	logSdLogObs	-1.031800	0.190450
14	logSdLogObs	-1.500800	0.563580
15	logSdLogObs	-1.787600	0.263190
16	logSdLogObs	-1.267500	0.174710
17	logSdLogObs	-1.000600	0.202050
18	logSdLogObs	-1.621900	0.107610
19	logSdLogObs	-1.307200	0.124310
20	logScaleSSB	-4.408100	0.080191
21	logSdSSB	-0.853380	0.116090

TABLE 2.6.3.26 North Sea Herring. NEGATIVE LOG-LIKELIHOOD

621.568

TABLE 2.7.1 NORTH SEA HERRING. WEIGHTS AT AGE IN THE CATCH

```
Units  :  kg
, , unit = A

   year
age      2010     2011      2012       2013       2014       2015
  0 0.0075000 0.008000 0.0106000 0.03499964 0.03499964 0.03499964
  1 0.0571000 0.041300 0.0463000 0.08895434 0.08895434 0.08895434
  2 0.1292000 0.131700 0.1243000 0.13613888 0.13613888 0.13613888
  3 0.1669000 0.159300 0.1706000 0.16754697 0.16754697 0.16754697
  4 0.1912000 0.183100 0.1854000 0.18586328 0.18586328 0.18586328
  5 0.2203000 0.197000 0.2058000 0.20623603 0.20623603 0.20623603
  6 0.2193000 0.216700 0.2215000 0.22086051 0.22086051 0.22086051
  7 0.2160000 0.221100 0.2387000 0.22998847 0.22998847 0.22998847
  8 0.2383892 0.231918 0.2427213 0.23913406 0.23913406 0.23913406

, , unit = B

   year
age      2010     2011      2012       2013       2014       2015
  0 0.0075000 0.008000 0.0106000 0.00837153 0.00837153 0.00837153
  1 0.0571000 0.041300 0.0463000 0.03934736 0.03934736 0.03934736
  2 0.1292000 0.131700 0.1243000 0.09884222 0.09884222 0.09884222
  3 0.1669000 0.159300 0.1706000 0.15612871 0.15612871 0.15612871
  4 0.1912000 0.183100 0.1854000 0.14250000 0.14250000 0.14250000
  5 0.2203000 0.197000 0.2058000 0.20355800 0.20355800 0.20355800
  6 0.2193000 0.216700 0.2215000 0.18454458 0.18454458 0.18454458
  7 0.2160000 0.221100 0.2387000 0.00000000 0.00000000 0.00000000
  8 0.2383892 0.231918 0.2427213 0.18400000 0.18400000 0.18400000

, , unit = C

   year
age      2010     2011      2012       2013       2014       2015
  0 0.0075000 0.008000 0.0106000 0.02275957 0.02275957 0.02275957
  1 0.0571000 0.041300 0.0463000 0.06807189 0.06807189 0.06807189
  2 0.1292000 0.131700 0.1243000 0.08025797 0.08025797 0.08025797
  3 0.1669000 0.159300 0.1706000 0.11899671 0.11899671 0.11899671
  4 0.1912000 0.183100 0.1854000 0.16139705 0.16139705 0.16139705
  5 0.2203000 0.197000 0.2058000 0.18447644 0.18447644 0.18447644
  6 0.2193000 0.216700 0.2215000 0.19706129 0.19706129 0.19706129
  7 0.2160000 0.221100 0.2387000 0.22311705 0.22311705 0.22311705
  8 0.2383892 0.231918 0.2427213 0.22861725 0.22861725 0.22861725

, , unit = D

   year
age      2010     2011      2012        2013        2014        2015
  0 0.0075000 0.008000 0.0106000 0.009140937 0.009140937 0.009140937
  1 0.0571000 0.041300 0.0463000 0.019469740 0.019469740 0.019469740
  2 0.1292000 0.131700 0.1243000 0.040452932 0.040452932 0.040452932
  3 0.1669000 0.159300 0.1706000 0.073380157 0.073380157 0.073380157
  4 0.1912000 0.183100 0.1854000 0.000000000 0.000000000 0.000000000
  5 0.2203000 0.197000 0.2058000 0.000000000 0.000000000 0.000000000
  6 0.2193000 0.216700 0.2215000 0.000000000 0.000000000 0.000000000
  7 0.2160000 0.221100 0.2387000 0.000000000 0.000000000 0.000000000
  8 0.2383892 0.231918 0.2427213 0.000000000 0.000000000 0.000000000
```

TABLE 2.7.2 NORTH SEA HERRING. WEIGHTS AT AGE IN THE STOCK

Units : kg

, , unit = A

age	2010	2011	2012	2013	2014	2015
0	0.007133333	0.006666667	0.00610000	0.00610000	0.00610000	0.00610000
1	0.052233333	0.043166667	0.04056667	0.04056667	0.04056667	0.04056667
2	0.142266667	0.145300000	0.13763333	0.13763333	0.13763333	0.13763333
3	0.190366667	0.187433333	0.18213333	0.18213333	0.18213333	0.18213333
4	0.216266667	0.225066667	0.21143333	0.21143333	0.21143333	0.21143333
5	0.223600000	0.239366667	0.23273333	0.23273333	0.23273333	0.23273333
6	0.234200000	0.243500000	0.24080000	0.24080000	0.24080000	0.24080000
7	0.240100000	0.250766667	0.24290000	0.24290000	0.24290000	0.24290000
8	0.260682861	0.257247512	0.25246564	0.25246564	0.25246564	0.25246564

, , unit = B

age	2010	2011	2012	2013	2014	2015
0	0.007133333	0.006666667	0.00610000	0.00610000	0.00610000	0.00610000
1	0.052233333	0.043166667	0.04056667	0.04056667	0.04056667	0.04056667
2	0.142266667	0.145300000	0.13763333	0.13763333	0.13763333	0.13763333
3	0.190366667	0.187433333	0.18213333	0.18213333	0.18213333	0.18213333
4	0.216266667	0.225066667	0.21143333	0.21143333	0.21143333	0.21143333
5	0.223600000	0.239366667	0.23273333	0.23273333	0.23273333	0.23273333
6	0.234200000	0.243500000	0.24080000	0.24080000	0.24080000	0.24080000
7	0.240100000	0.250766667	0.24290000	0.24290000	0.24290000	0.24290000
8	0.260682861	0.257247512	0.25246564	0.25246564	0.25246564	0.25246564

, , unit = C

age	2010	2011	2012	2013	2014	2015
0	0.007133333	0.006666667	0.00610000	0.00610000	0.00610000	0.00610000
1	0.052233333	0.043166667	0.04056667	0.04056667	0.04056667	0.04056667
2	0.142266667	0.145300000	0.13763333	0.13763333	0.13763333	0.13763333
3	0.190366667	0.187433333	0.18213333	0.18213333	0.18213333	0.18213333
4	0.216266667	0.225066667	0.21143333	0.21143333	0.21143333	0.21143333
5	0.223600000	0.239366667	0.23273333	0.23273333	0.23273333	0.23273333
6	0.234200000	0.243500000	0.24080000	0.24080000	0.24080000	0.24080000
7	0.240100000	0.250766667	0.24290000	0.24290000	0.24290000	0.24290000
8	0.260682861	0.257247512	0.25246564	0.25246564	0.25246564	0.25246564

, , unit = D

age	2010	2011	2012	2013	2014	2015
0	0.007133333	0.006666667	0.00610000	0.00610000	0.00610000	0.00610000
1	0.052233333	0.043166667	0.04056667	0.04056667	0.04056667	0.04056667
2	0.142266667	0.145300000	0.13763333	0.13763333	0.13763333	0.13763333
3	0.190366667	0.187433333	0.18213333	0.18213333	0.18213333	0.18213333
4	0.216266667	0.225066667	0.21143333	0.21143333	0.21143333	0.21143333
5	0.223600000	0.239366667	0.23273333	0.23273333	0.23273333	0.23273333
6	0.234200000	0.243500000	0.24080000	0.24080000	0.24080000	0.24080000
7	0.240100000	0.250766667	0.24290000	0.24290000	0.24290000	0.24290000
8	0.260682861	0.257247512	0.25246564	0.25246564	0.25246564	0.25246564

TABLE 2.7.3 NORTH SEA HERRING. STOCK IN NUMBER

Units : NA

, , unit = A

year

age	2010	2011	2012	2013
0	36873363.795782	33131664.0200214	30431840.4050515	22544461.8609403
1	13783737.3181974	14533981.2488453	12237309.5147492	11455723.1326463
2	5526139.34280045	7188549.70976515	7326437.94436663	6113438.87407001
3	4139145.81651342	3576874.74194456	5070753.58187241	4666873.87634683
4	1986728.75022817	2633962.69943847	2412079.99089431	3066354.63893165
5	989544.484937427	1224447.15738433	1656139.74923268	1419762.26990211
6	857691.708672606	644351.716733336	769887.746934104	965112.544552443
7	466027.535305253	584200.777608237	400312.191329883	449099.614189211
8	1565944.94740321	1376424.84024507	1135972.87461682	861129.346198833

, , unit = B

year

age	2010	2011	2012	2013
0	36873363.795782	33131664.0200214	30431840.4050515	22544461.8609403
1	13783737.3181974	14533981.2488453	12237309.5147492	11455723.1326463
2	5526139.34280045	7188549.70976515	7326437.94436663	6113438.87407001
3	4139145.81651342	3576874.74194456	5070753.58187241	4666873.87634683
4	1986728.75022817	2633962.69943847	2412079.99089431	3066354.63893165
5	989544.484937427	1224447.15738433	1656139.74923268	1419762.26990211
6	857691.708672606	644351.716733336	769887.746934104	965112.544552443
7	466027.535305253	584200.777608237	400312.191329883	449099.614189211
8	1565944.94740321	1376424.84024507	1135972.87461682	861129.346198833

, , unit = C

year

age	2010	2011	2012	2013
0	36873363.795782	33131664.0200214	30431840.4050515	22544461.8609403
1	13783737.3181974	14533981.2488453	12237309.5147492	11455723.1326463
2	5526139.34280045	7188549.70976515	7326437.94436663	6113438.87407001
3	4139145.81651342	3576874.74194456	5070753.58187241	4666873.87634683
4	1986728.75022817	2633962.69943847	2412079.99089431	3066354.63893165
5	989544.484937427	1224447.15738433	1656139.74923268	1419762.26990211
6	857691.708672606	644351.716733336	769887.746934104	965112.544552443
7	466027.535305253	584200.777608237	400312.191329883	449099.614189211
8	1565944.94740321	1376424.84024507	1135972.87461682	861129.346198833

, , unit = D

year

age	2010	2011	2012	2013
0	36873363.795782	33131664.0200214	30431840.4050515	22544461.8609403
1	13783737.3181974	14533981.2488453	12237309.5147492	11455723.1326463
2	5526139.34280045	7188549.70976515	7326437.94436663	6113438.87407001
3	4139145.81651342	3576874.74194456	5070753.58187241	4666873.87634683
4	1986728.75022817	2633962.69943847	2412079.99089431	3066354.63893165
5	989544.484937427	1224447.15738433	1656139.74923268	1419762.26990211
6	857691.708672606	644351.716733336	769887.746934104	965112.544552443
7	466027.535305253	584200.777608237	400312.191329883	449099.614189211
8	1565944.94740321	1376424.84024507	1135972.87461682	861129.346198833

TABLE 2.7.4 NORTH SEA HERRING. FISHING MORTALITY AT AGE IN THE STOCK

```
Units  :  f
, , unit = A

   year
age                2010               2011               2012
  0 0.0260640059197201 0.0359437522465639 0.0395931165629026
  1 0.0264526218718673 0.0165660476572378 0.0307243432149803
  2 0.0637236190126432 0.0650564450845016 0.0744892842136805
  3 0.0712471828188244 0.0980772348493581  0.14973235225983
  4 0.0851875485164576  0.111302896141661  0.185611407072263
  5  0.109153514248464  0.140548873022558  0.213418553826955
  6 0.0916755101750633  0.129328448250415  0.218952602397085
  7 0.0913278042959743  0.121407818455061  0.265351477926195
  8 0.0913278042959743  0.121407818455061  0.265351477926195
   year
age                2013
  0 6.92119101038945e-05
  1  0.00643664334469448
  2   0.0928283549901861
  3    0.207875404680911
  4    0.259299826533286
  5    0.298091214602138
  6    0.303405111765905
  7     0.37135114374894
  8    0.370906372313717

, , unit = B

   year
age                2010               2011               2012
  0 0.0260640059197201 0.0359437522465639 0.0395931165629026
  1 0.0264526218718673 0.0165660476572378 0.0307243432149803
  2 0.0637236190126432 0.0650564450845016 0.0744892842136805
  3 0.0712471828188244 0.0980772348493581  0.14973235225983
  4 0.0851875485164576  0.111302896141661  0.185611407072263
  5  0.109153514248464  0.140548873022558  0.213418553826955
  6 0.0916755101750633  0.129328448250415  0.218952602397085
  7 0.0913278042959743  0.121407818455061  0.265351477926195
  8 0.0913278042959743  0.121407818455061  0.265351477926195
   year
age                2013
  0   0.0355345286801768
  1  0.00806123293572382
  2  0.00130182478145806
  3  0.00104179250849887
  4                    0
  5 0.000565204536364659
  6  0.00232581391257492
  7                    0
  8 0.000620979345393883

, , unit = C
```

age \ year	2010	2011	2012
0	0.0260640059197201	0.0359437522465639	0.0395931165629026
1	0.0264526218718673	0.0165660476572378	0.0307243432149803
2	0.0637236190126432	0.0650564450845016	0.0744892842136805
3	0.0712471828188244	0.0980772348493581	0.149733235225983
4	0.0851875485164576	0.111302896141661	0.185611407072263
5	0.109153514248464	0.140548873022558	0.213418553826955
6	0.0916755101750633	0.129328448250415	0.218952602397085
7	0.0913278042959743	0.121407818455061	0.265351477926195
8	0.0913278042959743	0.121407818455061	0.265351477926195

age \ year	2013
0	5.30149026451595e-05
1	0.012757599692211
2	0.00973392994112187
3	0.000679403113815759
4	0.000878266841535201
5	0.000221073707108251
6	0.000475326935669362
7	0.000473182246424064
8	6.58825827020319e-05

, , unit = D

age \ year	2010	2011	2012
0	0.0260640059197201	0.0359437522465639	0.0395931165629026
1	0.0264526218718673	0.0165660476572378	0.0307243432149803
2	0.0637236190126432	0.0650564450845016	0.0744892842136805
3	0.0712471828188244	0.0980772348493581	0.149733235225983
4	0.0851875485164576	0.111302896141661	0.185611407072263
5	0.109153514248464	0.140548873022558	0.213418553826955
6	0.0916755101750633	0.129328448250415	0.218952602397085
7	0.0913278042959743	0.121407818455061	0.265351477926195
8	0.0913278042959743	0.121407818455061	0.265351477926195

age \ year	2013
0	0.00624679331802958
1	0.00944252458249594
2	0.00104553583082978
3	5.59773350195079e-06
4	0
5	0
6	0
7	0
8	0

TABLE 2.7.5 NORTH SEA HERRING. NATURAL MORTALITY

Units : NA
, , unit = A

age \ year	2010	2011	2012	2013	2014	2015
0	0.9630652	0.9600930	0.9622293	0.9624519	0.9624519	0.9624519
1	0.6284271	0.6718588	0.6631198	0.6586913	0.6586913	0.6586913
2	0.3504123	0.3823698	0.3760086	0.3727781	0.3727781	0.3727781
3	0.3342612	0.3571910	0.3526760	0.3503638	0.3503638	0.3503638
4	0.3289086	0.3484127	0.3446658	0.3426985	0.3426985	0.3426985
5	0.3070936	0.3303257	0.3258084	0.3234643	0.3234643	0.3234643
6	0.3001065	0.3244418	0.3196442	0.3171910	0.3171910	0.3171910
7	0.2918243	0.3183380	0.3130572	0.3103864	0.3103864	0.3103864
8	0.2918243	0.3183380	0.3130572	0.3103864	0.3103864	0.3103864

, , unit = B

```
   year
age      2010      2011      2012      2013      2014      2015
  0 0.9630652 0.9600930 0.9622293 0.9624519 0.9624519 0.9624519
  1 0.6284271 0.6718588 0.6631198 0.6586913 0.6586913 0.6586913
  2 0.3504123 0.3823698 0.3760086 0.3727781 0.3727781 0.3727781
  3 0.3342612 0.3571910 0.3526760 0.3503638 0.3503638 0.3503638
  4 0.3289086 0.3484127 0.3446658 0.3426985 0.3426985 0.3426985
  5 0.3070936 0.3303257 0.3258084 0.3234643 0.3234643 0.3234643
  6 0.3001065 0.3244418 0.3196442 0.3171910 0.3171910 0.3171910
  7 0.2918243 0.3183380 0.3130572 0.3103864 0.3103864 0.3103864
  8 0.2918243 0.3183380 0.3130572 0.3103864 0.3103864 0.3103864

, , unit = C

   year
age      2010      2011      2012      2013      2014      2015
  0 0.9630652 0.9600930 0.9622293 0.9624519 0.9624519 0.9624519
  1 0.6284271 0.6718588 0.6631198 0.6586913 0.6586913 0.6586913
  2 0.3504123 0.3823698 0.3760086 0.3727781 0.3727781 0.3727781
  3 0.3342612 0.3571910 0.3526760 0.3503638 0.3503638 0.3503638
  4 0.3289086 0.3484127 0.3446658 0.3426985 0.3426985 0.3426985
  5 0.3070936 0.3303257 0.3258084 0.3234643 0.3234643 0.3234643
  6 0.3001065 0.3244418 0.3196442 0.3171910 0.3171910 0.3171910
  7 0.2918243 0.3183380 0.3130572 0.3103864 0.3103864 0.3103864
  8 0.2918243 0.3183380 0.3130572 0.3103864 0.3103864 0.3103864

, , unit = D

   year
age      2010      2011      2012      2013      2014      2015
  0 0.9630652 0.9600930 0.9622293 0.9624519 0.9624519 0.9624519
  1 0.6284271 0.6718588 0.6631198 0.6586913 0.6586913 0.6586913
  2 0.3504123 0.3823698 0.3760086 0.3727781 0.3727781 0.3727781
  3 0.3342612 0.3571910 0.3526760 0.3503638 0.3503638 0.3503638
  4 0.3289086 0.3484127 0.3446658 0.3426985 0.3426985 0.3426985
  5 0.3070936 0.3303257 0.3258084 0.3234643 0.3234643 0.3234643
  6 0.3001065 0.3244418 0.3196442 0.3171910 0.3171910 0.3171910
  7 0.2918243 0.3183380 0.3130572 0.3103864 0.3103864 0.3103864
  8 0.2918243 0.3183380 0.3130572 0.3103864 0.3103864 0.3103864
```

TABLE 2.7.6 NORTH SEA HERRING. PROPORTION MATURE

```
Units  :  NA
, , unit = A

   year
age 2010 2011 2012      2013      2014      2015
  0 0.00 0.00 0.00 0.0000000 0.0000000 0.0000000
  1 0.00 0.00 0.00 0.0000000 0.0000000 0.0000000
  2 0.45 0.87 0.91 0.7433333 0.7433333 0.7433333
  3 0.90 0.84 0.99 0.9100000 0.9100000 0.9100000
  4 1.00 1.00 1.00 1.0000000 1.0000000 1.0000000
  5 1.00 1.00 1.00 1.0000000 1.0000000 1.0000000
  6 1.00 1.00 1.00 1.0000000 1.0000000 1.0000000
  7 1.00 1.00 1.00 1.0000000 1.0000000 1.0000000
  8 1.00 1.00 1.00 1.0000000 1.0000000 1.0000000

, , unit = B

   year
age 2010 2011 2012      2013      2014      2015
  0 0.00 0.00 0.00 0.0000000 0.0000000 0.0000000
  1 0.00 0.00 0.00 0.0000000 0.0000000 0.0000000
  2 0.45 0.87 0.91 0.7433333 0.7433333 0.7433333
  3 0.90 0.84 0.99 0.9100000 0.9100000 0.9100000
  4 1.00 1.00 1.00 1.0000000 1.0000000 1.0000000
  5 1.00 1.00 1.00 1.0000000 1.0000000 1.0000000
  6 1.00 1.00 1.00 1.0000000 1.0000000 1.0000000
  7 1.00 1.00 1.00 1.0000000 1.0000000 1.0000000
  8 1.00 1.00 1.00 1.0000000 1.0000000 1.0000000
```

, , unit = C

year

age	2010	2011	2012	2013	2014	2015
0	0.00	0.00	0.00	0.0000000	0.0000000	0.0000000
1	0.00	0.00	0.00	0.0000000	0.0000000	0.0000000
2	0.45	0.87	0.91	0.7433333	0.7433333	0.7433333
3	0.90	0.84	0.99	0.9100000	0.9100000	0.9100000
4	1.00	1.00	1.00	1.0000000	1.0000000	1.0000000
5	1.00	1.00	1.00	1.0000000	1.0000000	1.0000000
6	1.00	1.00	1.00	1.0000000	1.0000000	1.0000000
7	1.00	1.00	1.00	1.0000000	1.0000000	1.0000000
8	1.00	1.00	1.00	1.0000000	1.0000000	1.0000000

, , unit = D

year

age	2010	2011	2012	2013	2014	2015
0	0.00	0.00	0.00	0.0000000	0.0000000	0.0000000
1	0.00	0.00	0.00	0.0000000	0.0000000	0.0000000
2	0.45	0.87	0.91	0.7433333	0.7433333	0.7433333
3	0.90	0.84	0.99	0.9100000	0.9100000	0.9100000
4	1.00	1.00	1.00	1.0000000	1.0000000	1.0000000
5	1.00	1.00	1.00	1.0000000	1.0000000	1.0000000
6	1.00	1.00	1.00	1.0000000	1.0000000	1.0000000
7	1.00	1.00	1.00	1.0000000	1.0000000	1.0000000
8	1.00	1.00	1.00	1.0000000	1.0000000	1.0000000

TABLE 2.7.7 NORTH SEA HERRING. FRACTION OF HARVEST BEFORE SPAWNING

Units : NA

, , unit = A

year

age	2010	2011	2012	2013	2014	2015
0	0.67	0.67	0.67	0.67	0.67	0.67
1	0.67	0.67	0.67	0.67	0.67	0.67
2	0.67	0.67	0.67	0.67	0.67	0.67
3	0.67	0.67	0.67	0.67	0.67	0.67
4	0.67	0.67	0.67	0.67	0.67	0.67
5	0.67	0.67	0.67	0.67	0.67	0.67
6	0.67	0.67	0.67	0.67	0.67	0.67
7	0.67	0.67	0.67	0.67	0.67	0.67
8	0.67	0.67	0.67	0.67	0.67	0.67

, , unit = B

year

age	2010	2011	2012	2013	2014	2015
0	0.67	0.67	0.67	0.67	0.67	0.67
1	0.67	0.67	0.67	0.67	0.67	0.67
2	0.67	0.67	0.67	0.67	0.67	0.67
3	0.67	0.67	0.67	0.67	0.67	0.67
4	0.67	0.67	0.67	0.67	0.67	0.67
5	0.67	0.67	0.67	0.67	0.67	0.67
6	0.67	0.67	0.67	0.67	0.67	0.67
7	0.67	0.67	0.67	0.67	0.67	0.67
8	0.67	0.67	0.67	0.67	0.67	0.67

, , unit = C

year

age	2010	2011	2012	2013	2014	2015
0	0.67	0.67	0.67	0.67	0.67	0.67
1	0.67	0.67	0.67	0.67	0.67	0.67
2	0.67	0.67	0.67	0.67	0.67	0.67
3	0.67	0.67	0.67	0.67	0.67	0.67
4	0.67	0.67	0.67	0.67	0.67	0.67
5	0.67	0.67	0.67	0.67	0.67	0.67
6	0.67	0.67	0.67	0.67	0.67	0.67
7	0.67	0.67	0.67	0.67	0.67	0.67
8	0.67	0.67	0.67	0.67	0.67	0.67

, , unit = D

year						
age	2010	2011	2012	2013	2014	2015
0	0.67	0.67	0.67	0.67	0.67	0.67
1	0.67	0.67	0.67	0.67	0.67	0.67
2	0.67	0.67	0.67	0.67	0.67	0.67
3	0.67	0.67	0.67	0.67	0.67	0.67
4	0.67	0.67	0.67	0.67	0.67	0.67
5	0.67	0.67	0.67	0.67	0.67	0.67
6	0.67	0.67	0.67	0.67	0.67	0.67
7	0.67	0.67	0.67	0.67	0.67	0.67
8	0.67	0.67	0.67	0.67	0.67	0.67

TABLE 2.7.8 NORTH SEA HERRING. FRACTION OF NATURAL MORTALITY BEFORE SPAWNING

Units : NA

, , unit = A

year						
age	2010	2011	2012	2013	2014	2015
0	0.67	0.67	0.67	0.67	0.67	0.67
1	0.67	0.67	0.67	0.67	0.67	0.67
2	0.67	0.67	0.67	0.67	0.67	0.67
3	0.67	0.67	0.67	0.67	0.67	0.67
4	0.67	0.67	0.67	0.67	0.67	0.67
5	0.67	0.67	0.67	0.67	0.67	0.67
6	0.67	0.67	0.67	0.67	0.67	0.67
7	0.67	0.67	0.67	0.67	0.67	0.67
8	0.67	0.67	0.67	0.67	0.67	0.67

, , unit = B

year						
age	2010	2011	2012	2013	2014	2015
0	0.67	0.67	0.67	0.67	0.67	0.67
1	0.67	0.67	0.67	0.67	0.67	0.67
2	0.67	0.67	0.67	0.67	0.67	0.67
3	0.67	0.67	0.67	0.67	0.67	0.67
4	0.67	0.67	0.67	0.67	0.67	0.67
5	0.67	0.67	0.67	0.67	0.67	0.67
6	0.67	0.67	0.67	0.67	0.67	0.67
7	0.67	0.67	0.67	0.67	0.67	0.67
8	0.67	0.67	0.67	0.67	0.67	0.67

, , unit = C

year						
age	2010	2011	2012	2013	2014	2015
0	0.67	0.67	0.67	0.67	0.67	0.67
1	0.67	0.67	0.67	0.67	0.67	0.67
2	0.67	0.67	0.67	0.67	0.67	0.67
3	0.67	0.67	0.67	0.67	0.67	0.67
4	0.67	0.67	0.67	0.67	0.67	0.67
5	0.67	0.67	0.67	0.67	0.67	0.67
6	0.67	0.67	0.67	0.67	0.67	0.67
7	0.67	0.67	0.67	0.67	0.67	0.67
8	0.67	0.67	0.67	0.67	0.67	0.67

, , unit = D

year						
age	2010	2011	2012	2013	2014	2015
0	0.67	0.67	0.67	0.67	0.67	0.67
1	0.67	0.67	0.67	0.67	0.67	0.67
2	0.67	0.67	0.67	0.67	0.67	0.67
3	0.67	0.67	0.67	0.67	0.67	0.67
4	0.67	0.67	0.67	0.67	0.67	0.67
5	0.67	0.67	0.67	0.67	0.67	0.67
6	0.67	0.67	0.67	0.67	0.67	0.67
7	0.67	0.67	0.67	0.67	0.67	0.67
8	0.67	0.67	0.67	0.67	0.67	0.67

TABLE 2.7.9 NORTH SEA HERRING. Recruitment in 2014

29245304

TABLE 2.7.10 NORTH SEA HERRING. Recruitment in 2015

29245304

TABLE 2.7.11 NORTH SEA HERRING. FLR, R SOFTWARE VERSIONS

```
R version 2.13.2 (2011-09-30)

Package  : FLSAM
Version  : 0.99-99
Packaged :
Built    : R 2.13.2; ; 2013-03-17 22:10:20 UTC; windows

Package  : FLAssess
Version  : 2.4
Packaged :
Built    : R 2.13.2; i386-pc-mingw32; 2011-10-05 12:21:47 UTC; windows

Package  : FLCore
Version  : 2.4
Packaged :
Built    : R 2.13.2; i386-pc-mingw32; 2011-10-05 12:21:01 UTC; windows
```

Table 2.7.12. North Sea herring. Management options for North Sea herring.

Outlook assuming a TAC constraint for fleet A in 2013, proportion of 2012 by-catch ceiling taken applied to 2013 for fleet B

Basis: Intermediate year (2013) with catch constraint

F fleet A	F fleet B	F fleet C	F fleet D	F_{0-1}	F_{2-6}	Catch fleet A	Catch fleet B	Catch Fleet C	Catch fleet D	SSB 2013
0.232	0.022	0.006	0.008	0.039	0.236	497.9[1]	8.6	11.8	2.5	1996

[1]Includes a transfer of 2095 tonnes of the Norwegian quota and 40% of IIIa TAC from the C-fleet to the A-fleet

Scenarios for prediction year (2014)

	F-values by fleet and total						Catches by fleet				Biomass			
	FLEET A	FLEET B	FLEET C	FLEET D	F_{0-1}	F_{2-6}	FLEET A	FLEET B	FLEET C	FLEET D	**SSB 2014[1)]**	**SSB 2015**	**%SSB CHANGE [2)]**	**%TAC CHANGE FLEET A [3)]**
A	0	0	0	0	0	0	0	0	0	0	2101	2183	+5%	-100%
B	0.245	0.031	0.008	0.008	0.05	0.25	470037	12440	11242	2427	1780	1508	-11%	-2%
C	0.250	0.031	0.008	0.008	0.05	0.25	478000	12440	11242	2427	1774	1498	-11%	0%
D	0.294	0.031	0.008	0.008	0.05	0.30	549700	12440	11242	2427	1724	1411	-14%	+15%
E	0.208	0.031	0.008	0.008	0.05	0.21	406300	12440	11242	2427	1824	1590	-9%	-15%
F	0.265	0.031	0.008	0.008	0.05	0.27	503399	12440	11242	2427	1757	1467	-12%	+5%

Weights in '000 t.

All numbers apply to North Sea autumn-spawning herring only.

[1)] For autumn spawning stocks, the SSB is determined at spawning time and is influenced by fisheries between 1st January and spawning.

[2)] SSB (2014) relative to SSB (2013).

[3)] Calculated landings (2014) relative to TAC 2013 for the A fleet.

Table 2.7.2.1. North Sea herring. Exploratory short term forecast management options for North Sea herring.

Outlook assuming a TAC constraint for fleet A in 2013, proportion of 2012 by-catch ceiling taken applied to 2013 for fleet B

Basis: Intermediate year (2013) with catch constraint (95% CI between '[ ]')

F fleet A	F fleet B	F fleet C	F fleet D	F_{0-1}	F_{2-6}	Catch fleet A[1]	Catch fleet B	Catch Fleet C	Catch fleet D	SSB 2013
0.226 [0.183, 0.282]	0.021 [0.015, 0.032]	0.006 [0.004, 0.008]	0.008 [0.006, 0.011]	0.04 [0.03, 0.05]	0.23 [0.18, 0.29]	497.9	8.6	11.8	2.5	2007 [1621, 2760]

[1]Includes a transfer of 2095 tonnes of the Norwegian quota and 40% of IIIa TAC from the C-fleet to the A-fleet

Scenarios for prediction year (2014) (95% CI between '[ ]')

	F-values by fleet and total						Catches by fleet				Biomass			
	fleet A	fleet B	fleet C	fleet D	F0-1	F2-6	fleet A	fleet B	fleet C	fleet D	SSB 2014)	SSB 2015	%SSB change 2)	%TAC change fleet A 3)
A	0	0	0	0	0	0	0	0	0	0	2131 [1712, 2658]	2212 [1758, 2760]	+6% [+6%, +11%]	-100%
B	0.245 [0.235, 0.247]	0.031 [0.024, 0.036]	0.008 [0.005, 0.011]	0.008 [0.006, 0.011]	0.05 [0.05, 005]	0.25 [0.24, 0.25]	473616 [380856, 610384]	13045 [8723, 18396]	11242	2427	1796 [1456, 2552]	1533 [1186, 1958]	-11% [-10%, -6%]	-1% [-20%, +28%]
C	0.243 [0.190, 0.313]	0.031 [0.023, 0.039]	0.007 [0.005, 0.011]	0.008 [0.006, 0.011]	0.05 [0.04, 0.06]	0.25 [0.19, 0.32]	478000	13045 [8723, 18396]	11242	2427	1806 [1373, 2333]	1523 [1111, 2045]	-10% [-15%, -2%]	0%
D	0.285 [0.223, 0.368]	0.031 [0.023, 0.039]	0.007 [0.005, 0.011]	0.008 [0.006, 0.011]	0.05 [0.04, 0.06]	0.29 [0.23, 0.37]	549700	13045 [8723, 18396]	11242	2427	1757 [1320, 2284]	1434 [1028, 1953]	-12% [-19%, -5%]	+15%
E	0.202 [0.159, 0.260]	0.031 [0.023, 0.039]	0.007 [0.005, 0.011]	0.008 [0.006, 0.011]	0.05 [0.04, 0.06]	0.21 [0.16, 0.26]	406300	13045 [8723, 18396]	11242	2427	1856 [1424, 2381]	1615 [1198, 2141]	-8% [-12%, -0%]	-15%
F	0.265 [0.264, 0.267]	0.031 [0.023, 0.039]	0.007 [0.005, 0.011]	0.008 [0.006, 0.011]	0.05 [0.04, 0.06]	0.27	515277 [413858, 641089	13045 [8723, 18396]	11242	2427	1751 [1428, 2242]	1475 [1152, 1938]	-13% [-12%, -6%]	+8% [-13%, +34%]

Weights in '000 t.

All numbers apply to North Sea autumn-spawning herring only.

1) For autumn spawning stocks, the SSB is determined at spawning time and is influenced by fisheries between 1st January and spawning.

2) SSB (2014) relative to SSB (2013). 3) Calculated landings (2014) relative to TAC 2013 for the A fleet.

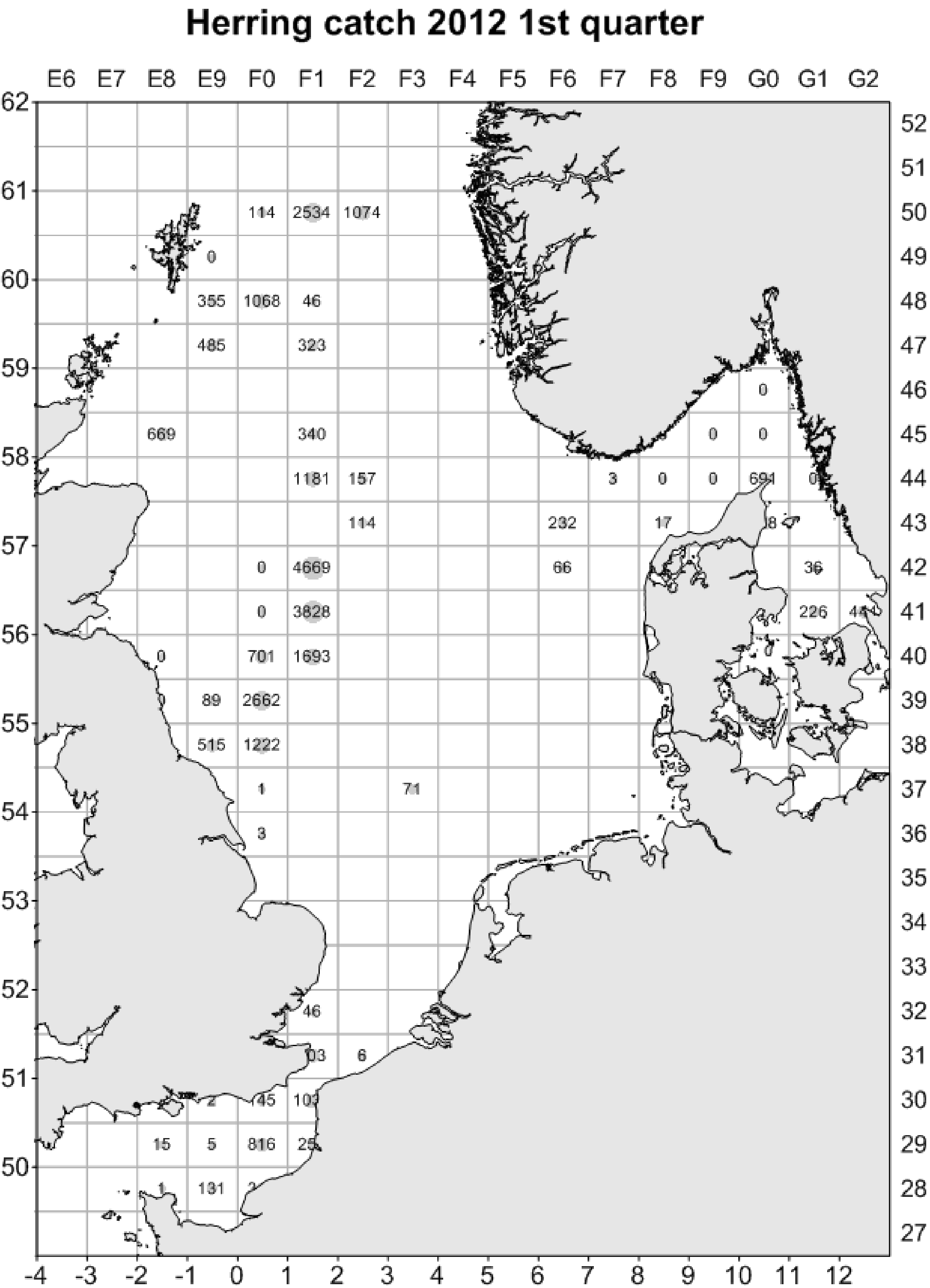


Figure 2.1.1a: Herring catches in the North Sea in the 1st quarter of 2012 (in tonnes) by statistical rectangle.

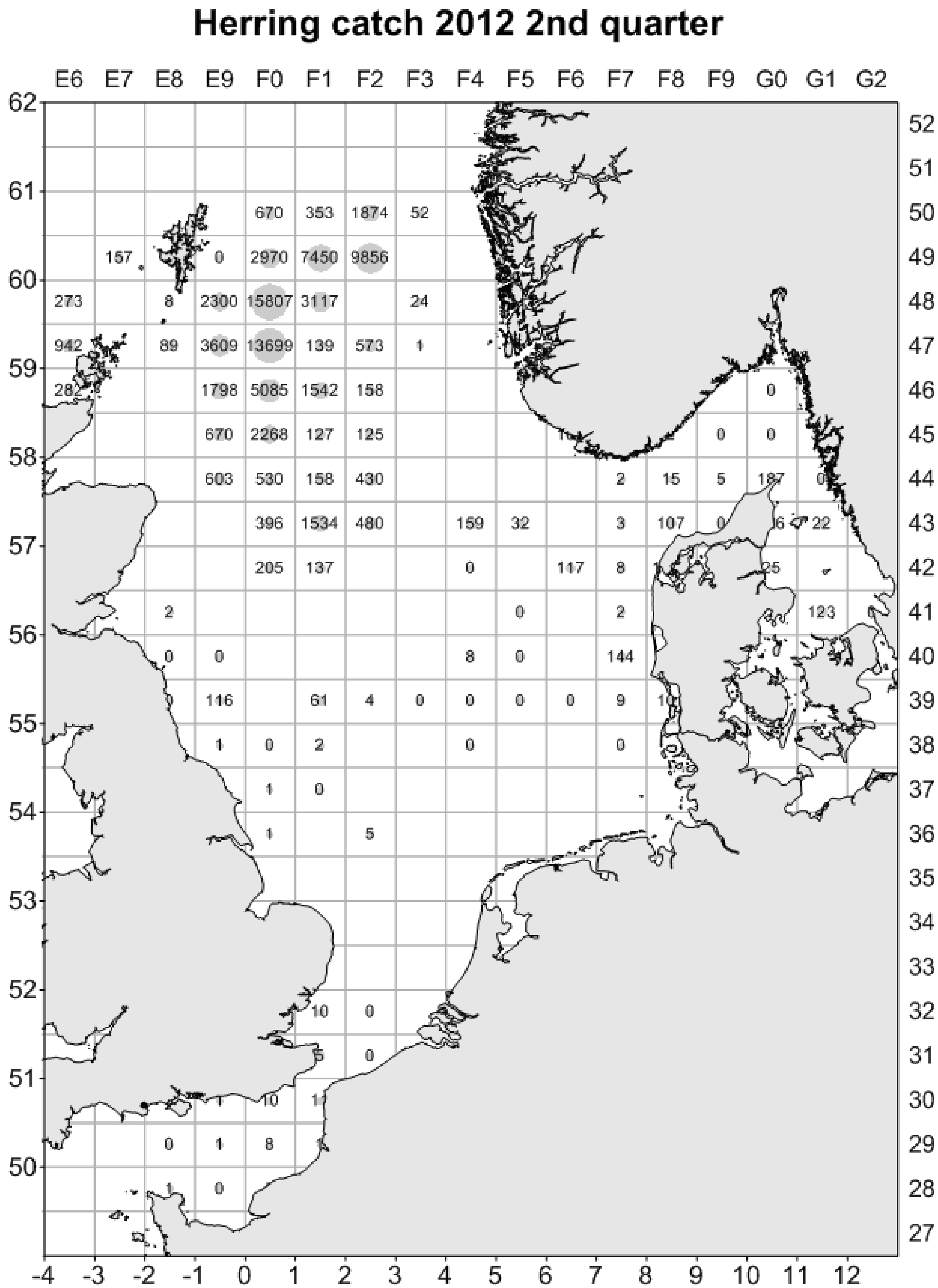


Figure 2.1.1b: Herring catches in the North Sea in the 2nd quarter of 2012 (in tonnes) by statistical rectangle.

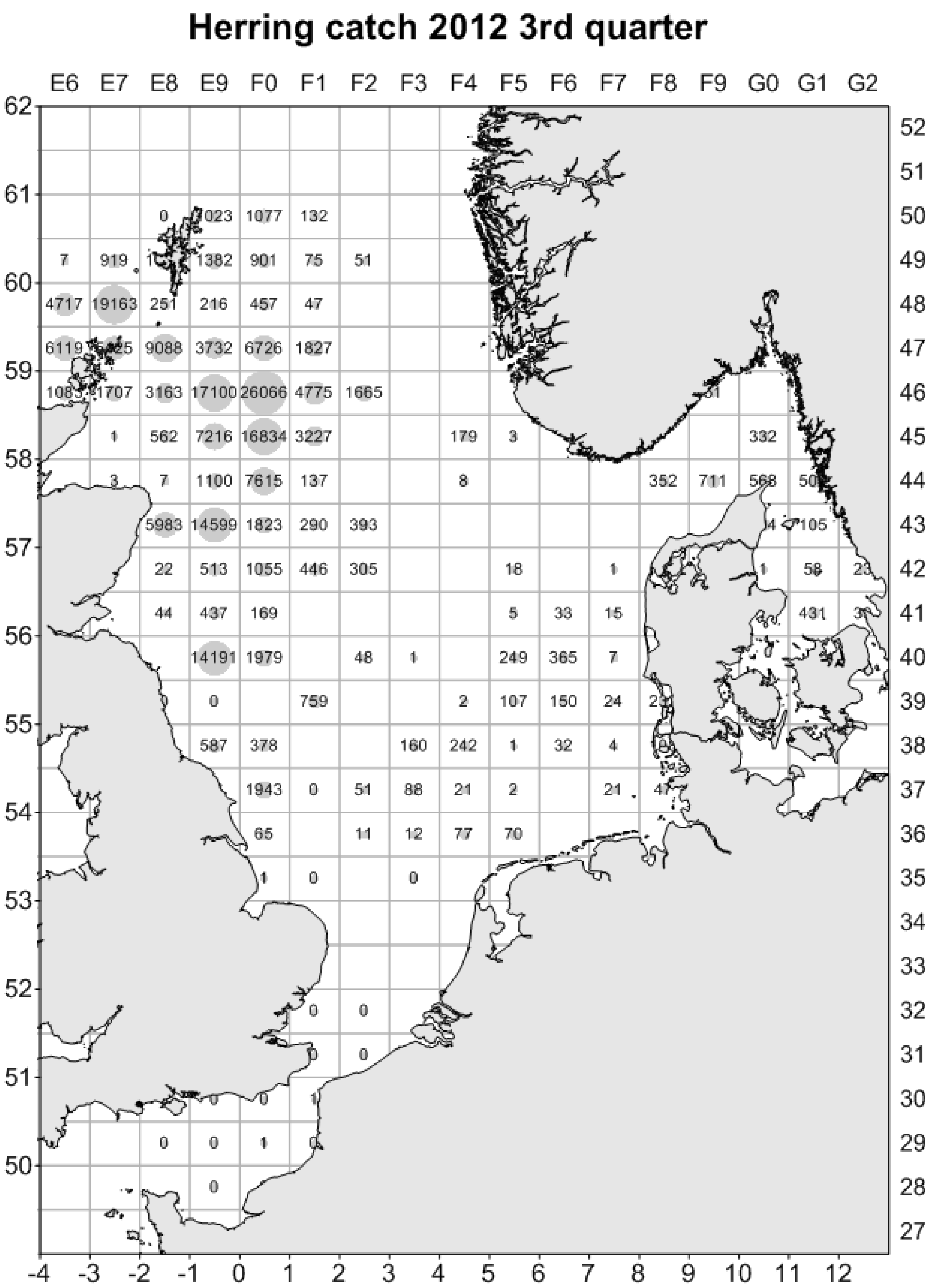


Figure 2.1.1c: Herring catches in theNorth Sea in the 3rd quarter of 2012 (in tonnes) by statistical rectangle.

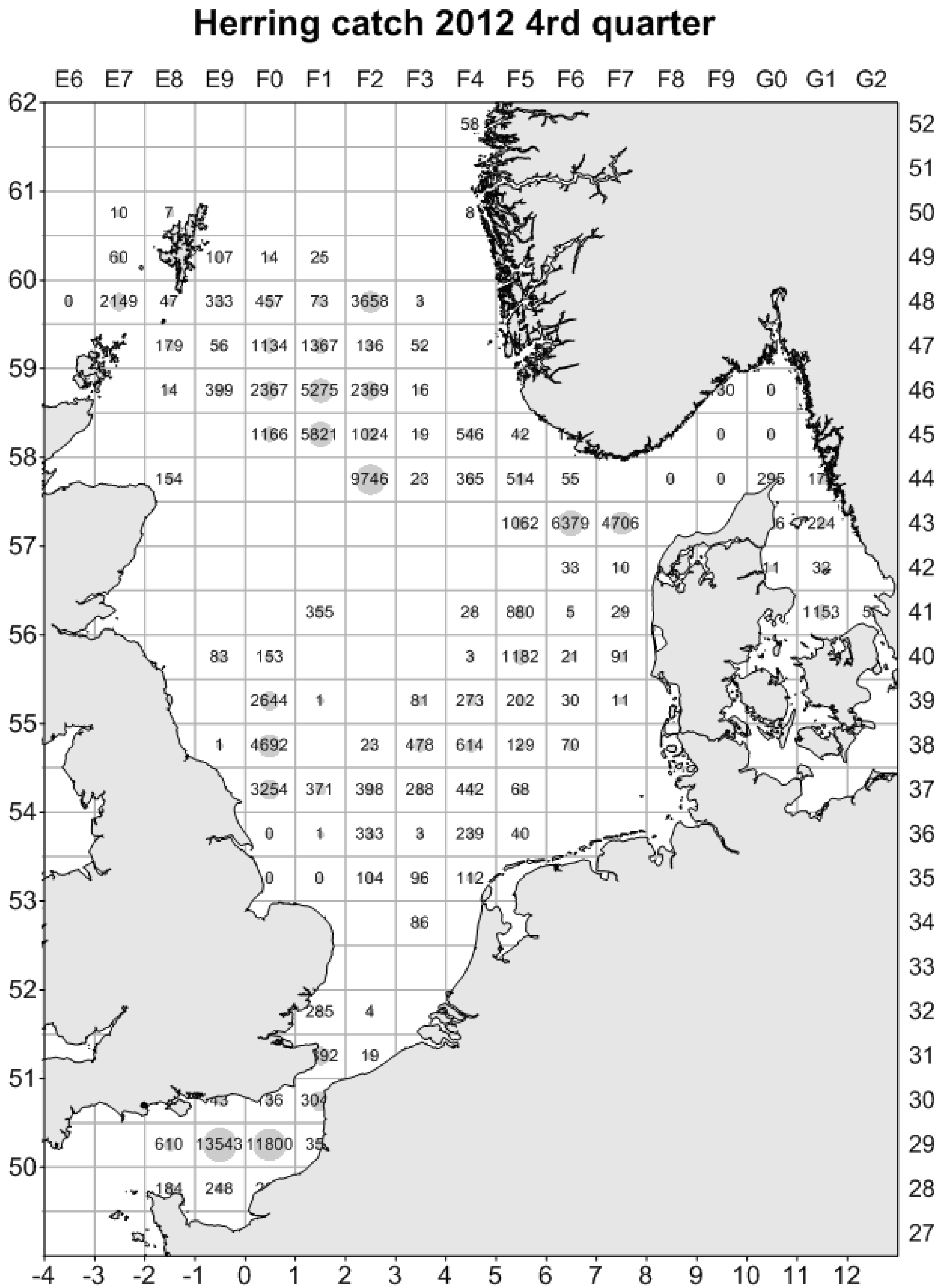


Figure 2.1.1d: Herring catches in the North Sea in the 4th quarter of 2012 (in tonnes) by statistical rectangle.

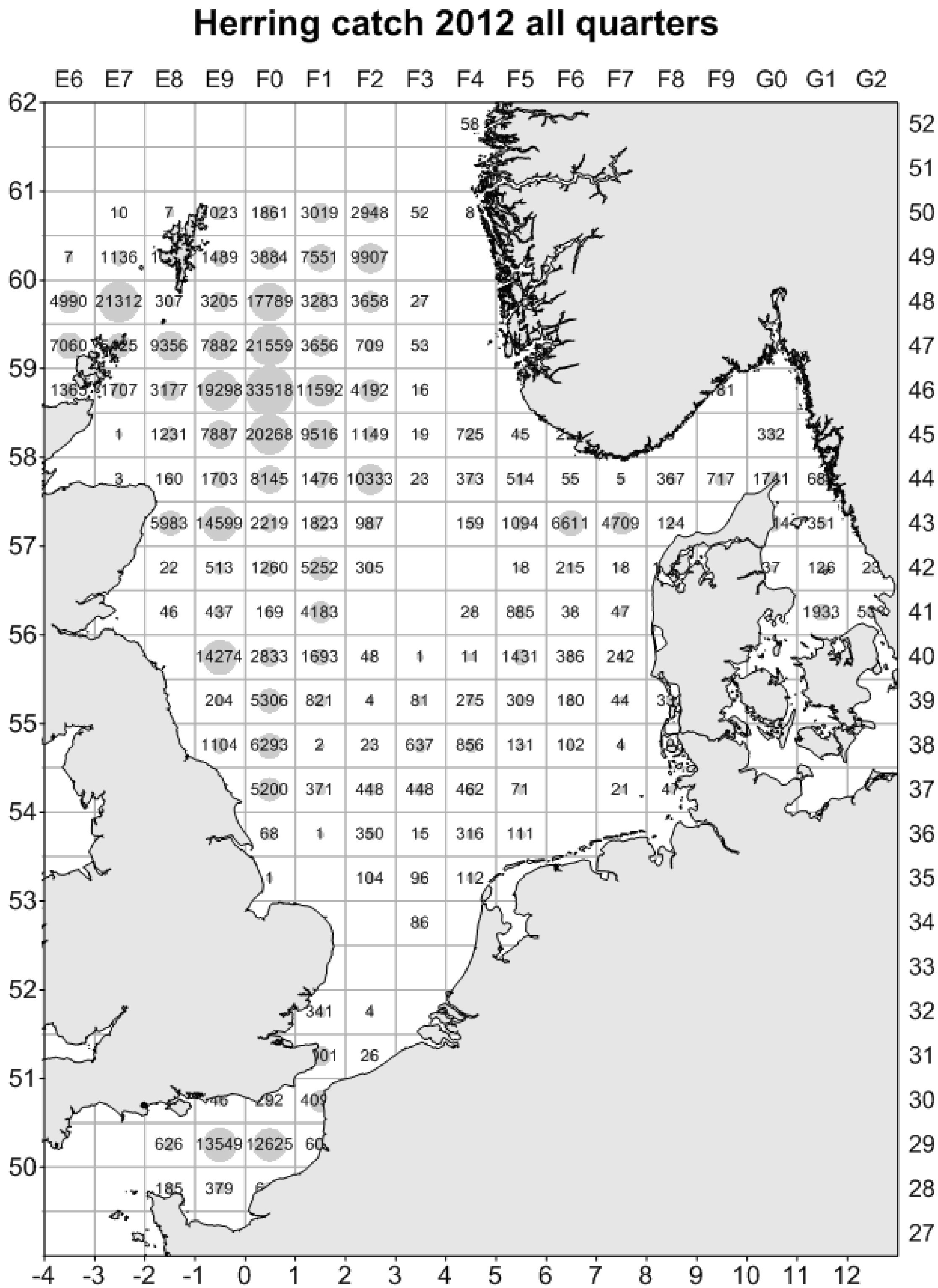


Figure 2.1.1e: Herring catches in the North Sea in all quarters of 2012 (in tonnes) by statistical rectangle.

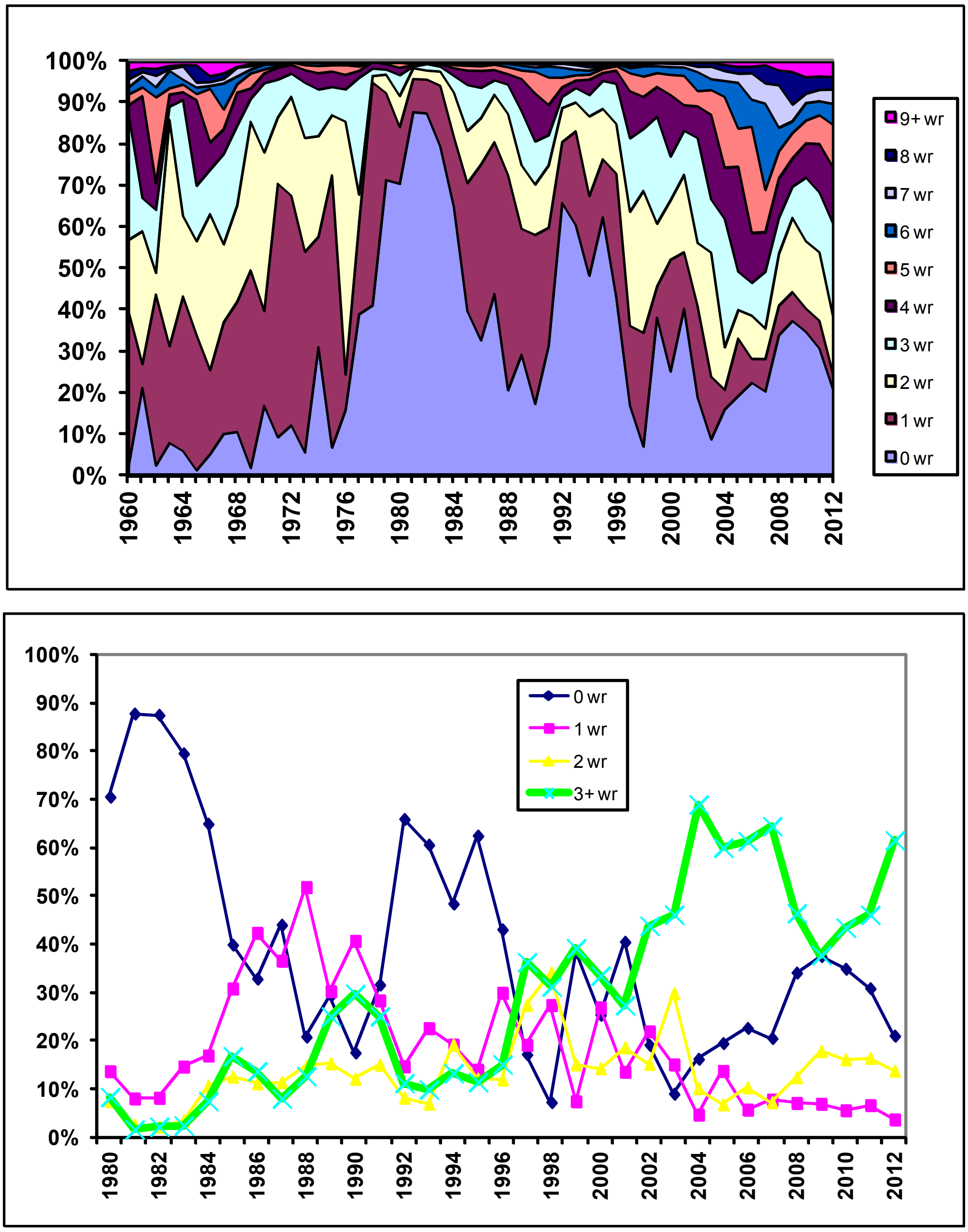


Figure 2.2.1: Proportions of age groups (numbers) in the total catch of herring caught in the North Sea (upper, 1960-2012, and lower panel, 1980-2012).

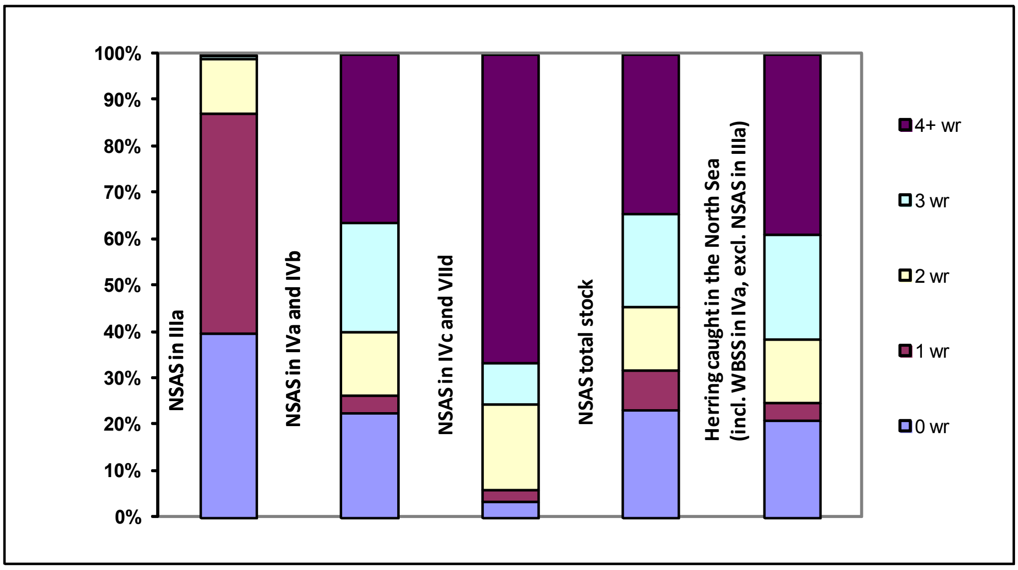


Figure 2.2.2: Proportion of age groups (numbers) in the total catch of NSAS and herring caught in the North Sea in 2012.

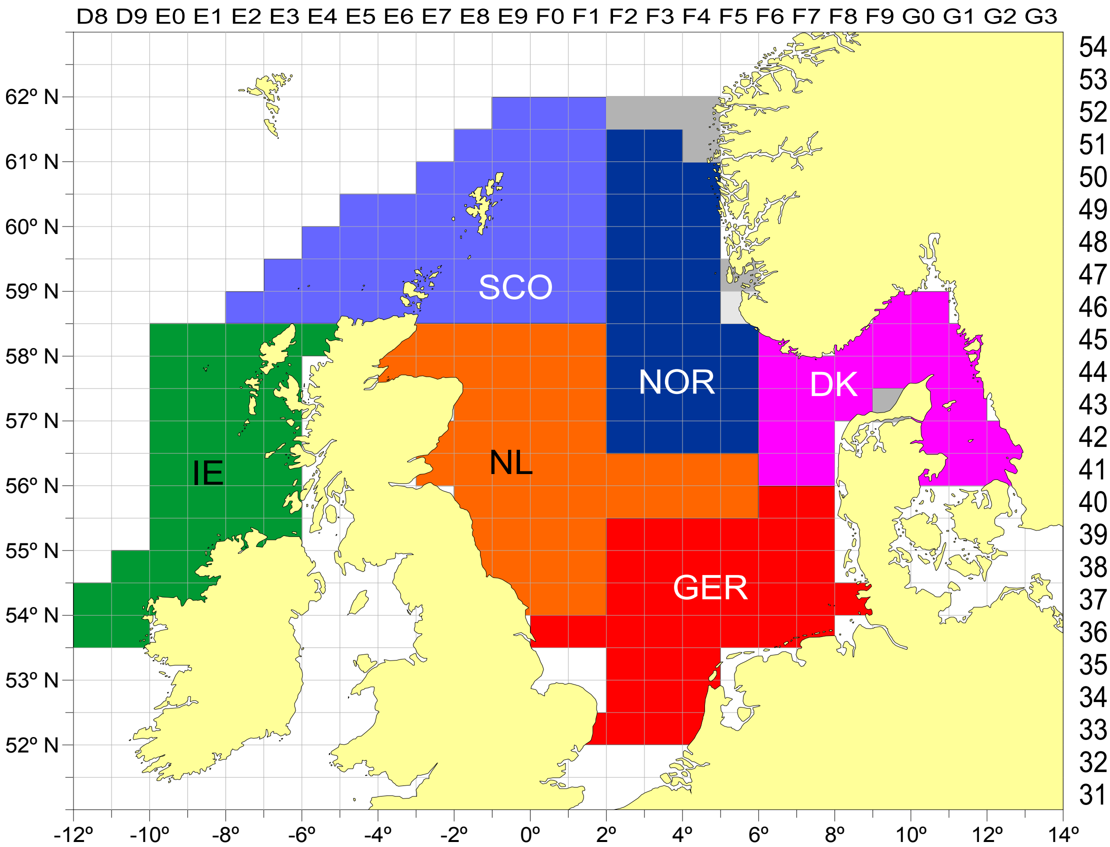


Figure 2.3.1.1. Survey area coverage in the combined acoustic surveys in 2012, by rectangle and nation (IE = Celtic Explorer; SCO = Scotia/Charter Vessel; NOR = Johan Hjort; DK = Dana; NL = Tridens; GER = Solea). Rectangles in dark grey were not covered and those in light grey were interpolated from surrounding ones.

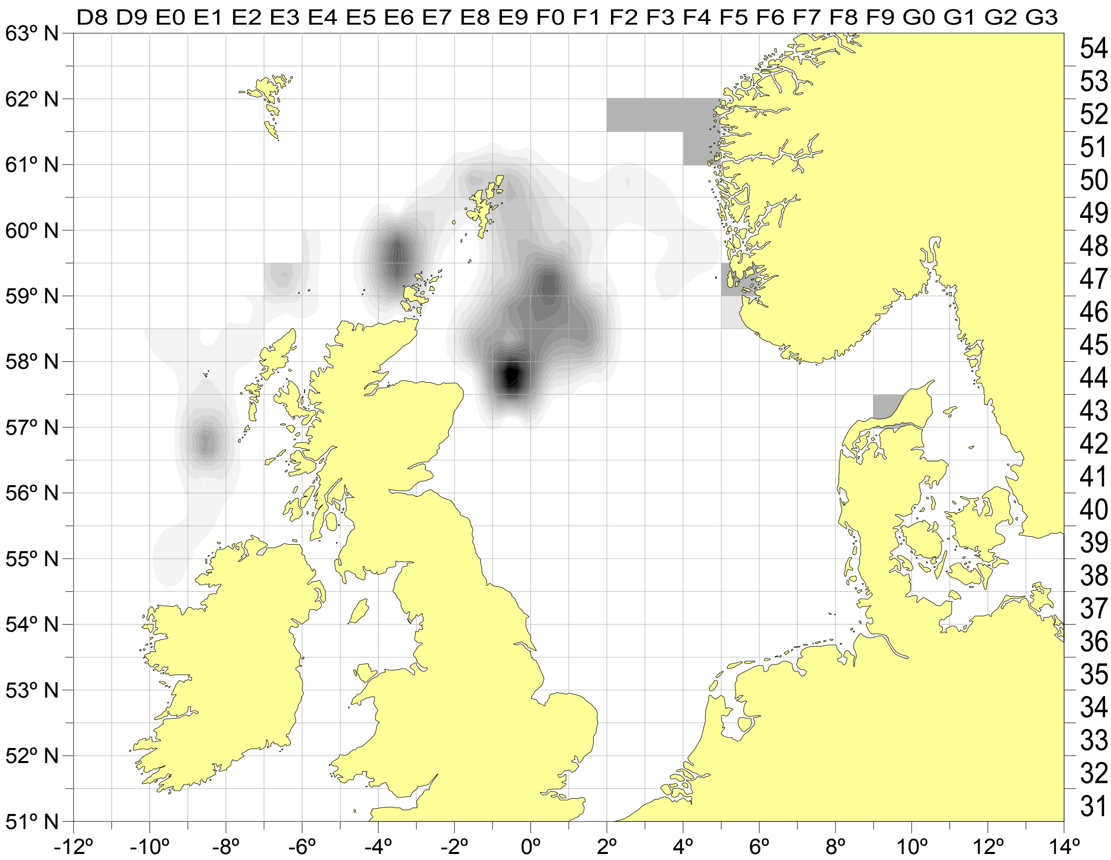


Figure 2.3.1.2. Biomass of mature autumn spawning herring from the combined acoustic surveys in the North Sea, West of Scotland VIa(N) and the Malin Shelf area in June – July 2012 (maximum value = 220 000). Rectangles in light grey were interpolated from surrounding ones. Rectangles in dark grey were not covered.

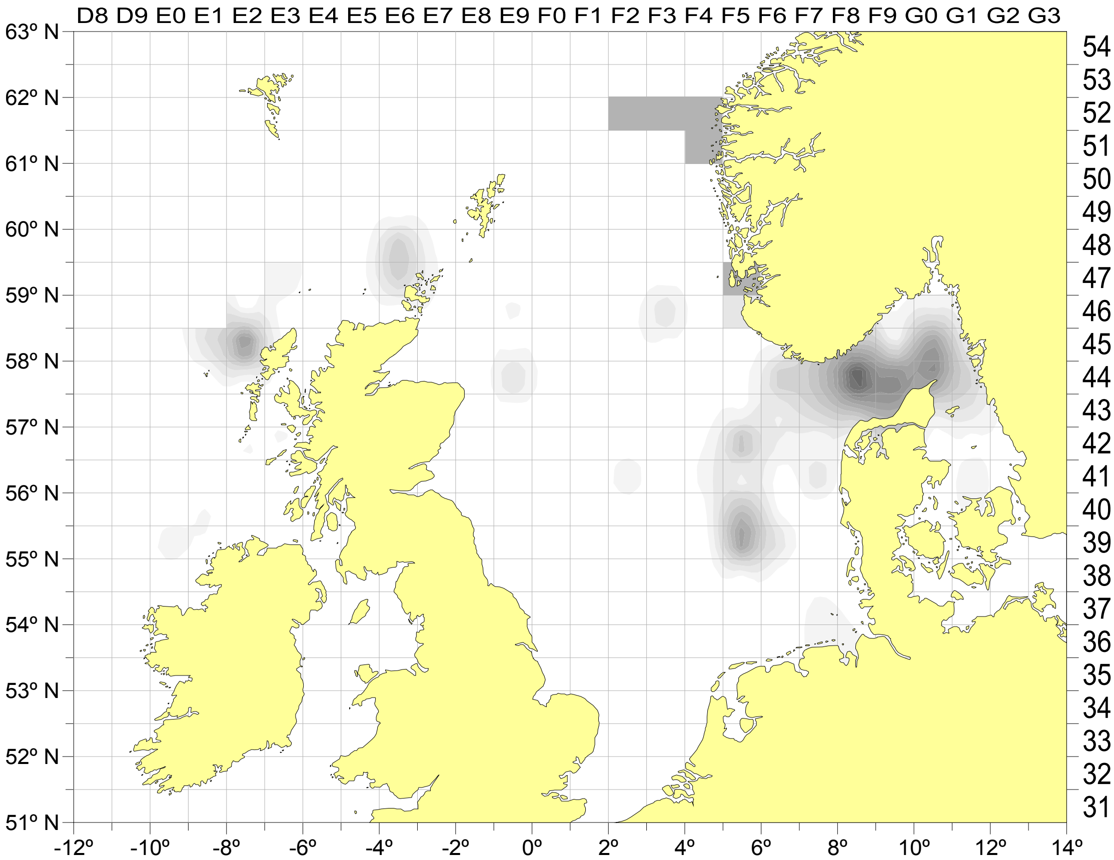


Figure 2.3.1.3. North Sea herring. Biomass of immature autumn spawning herring from the combined acoustic surveys in the North Sea, West of Scotland VIa(N) and the Malin Shelf area in June – July 2012 (maximum value = 57 500). Rectangles in light grey were interpolated from surrounding ones. Rectangles in dark grey were not covered.

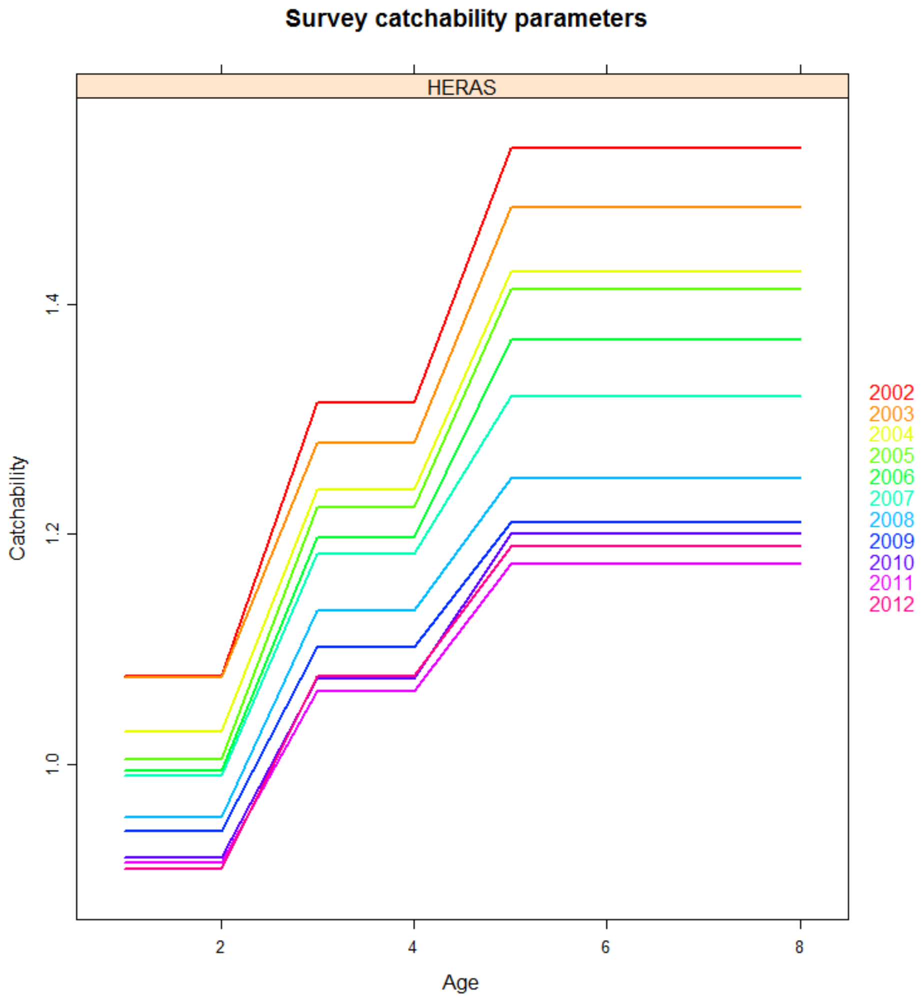


Figure 2.3.1.4. North Sea herring. North Sea Herring. Time series of survey catchability by ages 1-8+ in the HERAS.

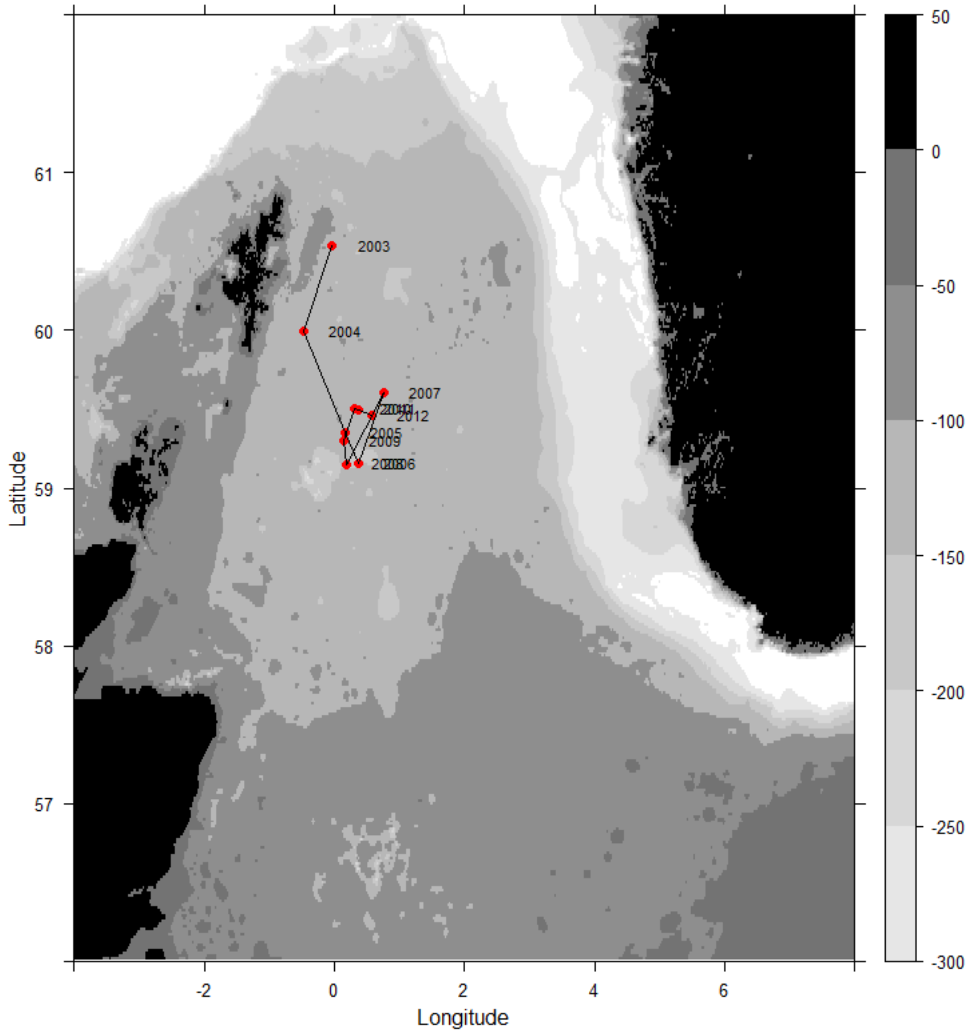


Figure 2.3.1.5. North Sea herring. Centre of gravity of autumn spawning herring at ages 4-9+ abundance from the acoustic survey in the North Sea in June – July for years 2003 - 2012. Colour scale indicates water depth (no shading represents depths > 300m).

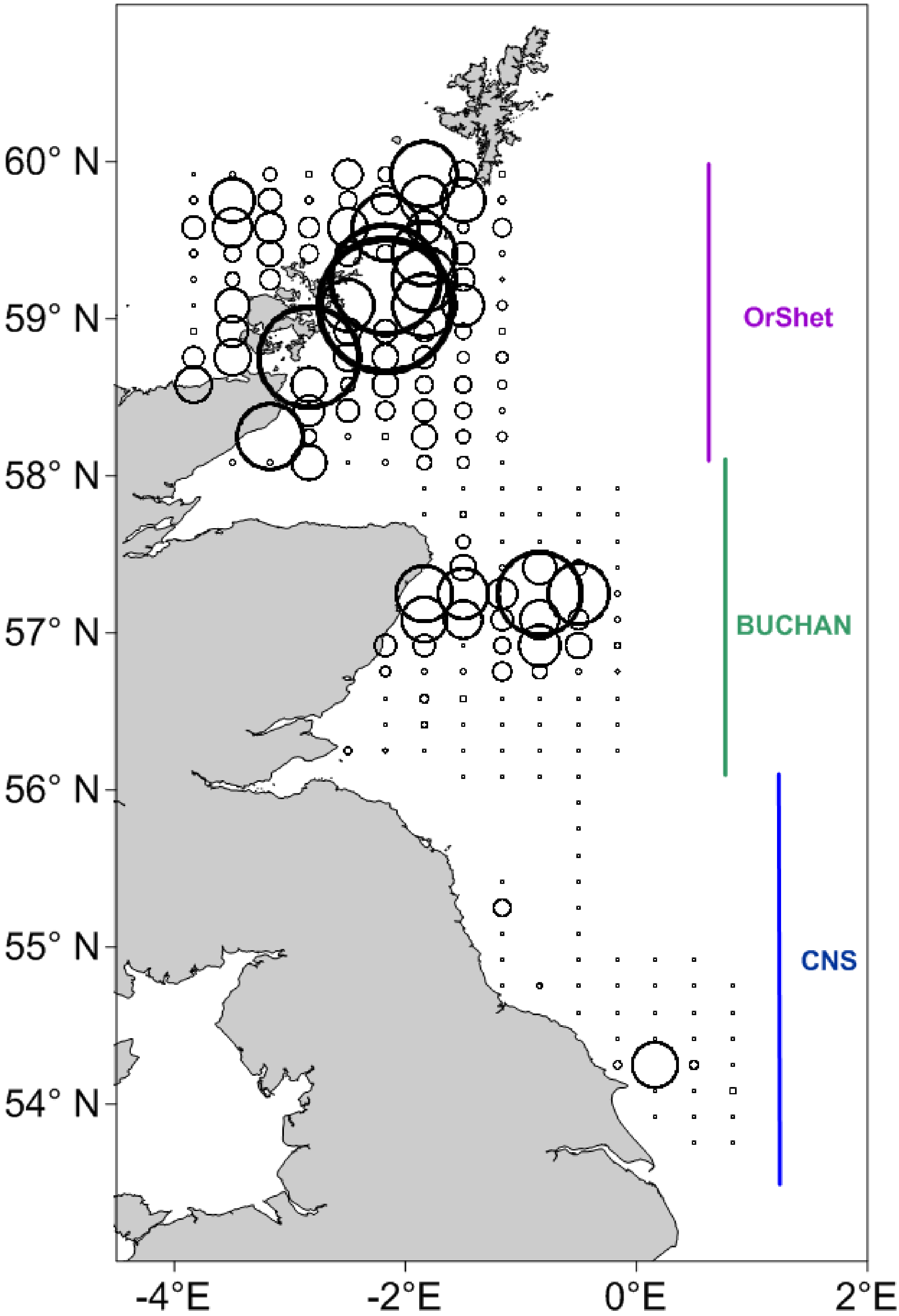


Figure 2.3.2.1: North Sea herring - Abundance of larvae < 10 mm (n/m²) in the Orkney/Shetland, Buchan and Central North Sea area (16-30 September 2012, scale 0.64 cm =4 000 n/m²).

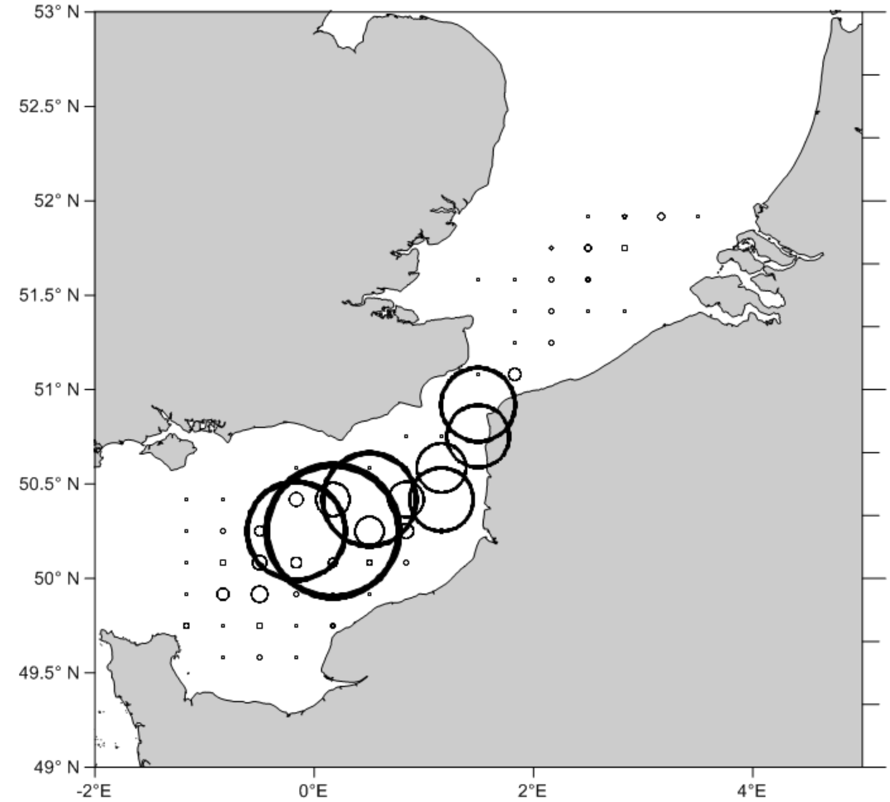


Figure 2.3.2.2. North Sea herring - Abundance of larvae < 11 mm (n/m²) in the Southern North Sea (16-31 December 2012, scale 0.64 cm = 4 000 n/m²).

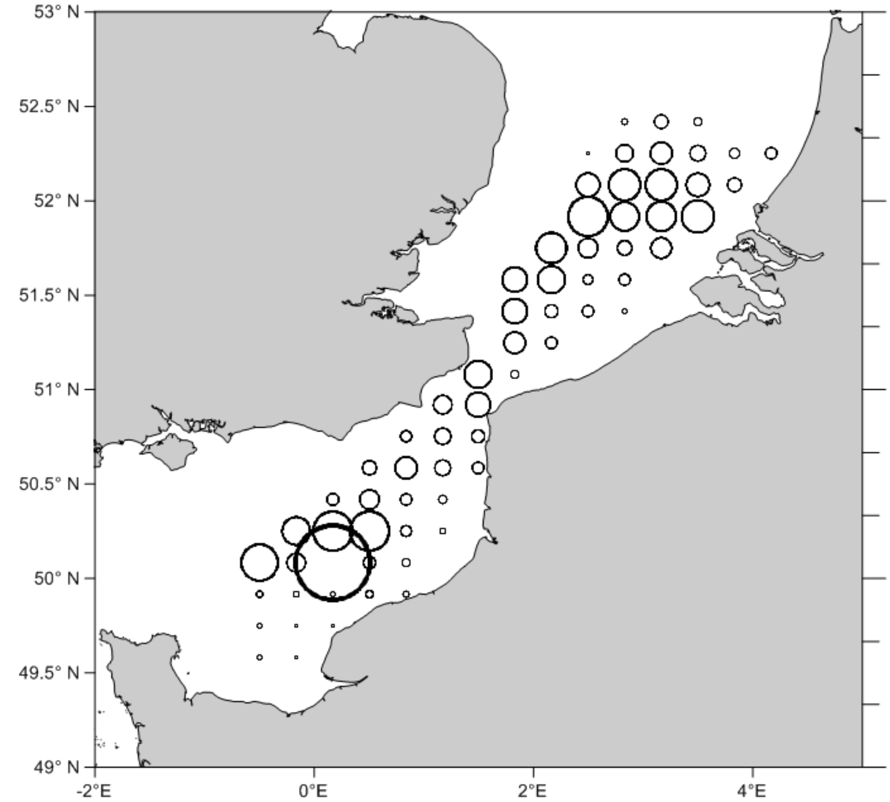


Figure 2.3.2.3. North Sea herring – Abundance of larvae < 11 mm (n/m²) in the Southern North Sea (01-15 January 2013, scale 0.64 cm = 4 000 n/m²).

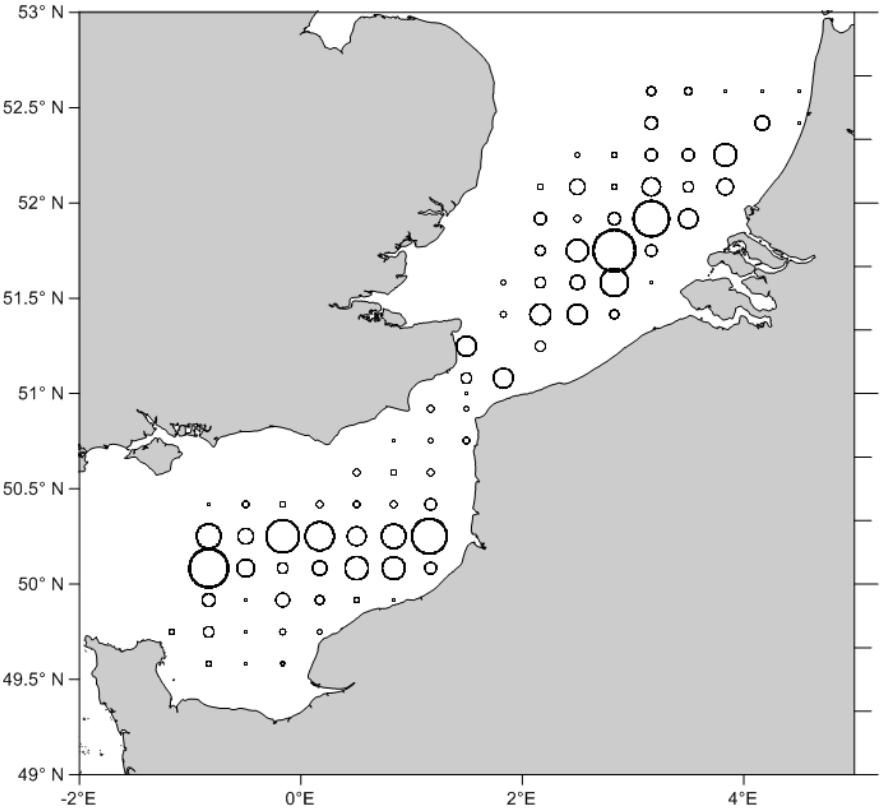


Figure2.3.2.4. North Sea herring – Abundance of larvae < 11 mm (n/m²) in the Southern North Sea (16-31 January 2013, scale 0.64 cm = 4 000 n/m²).

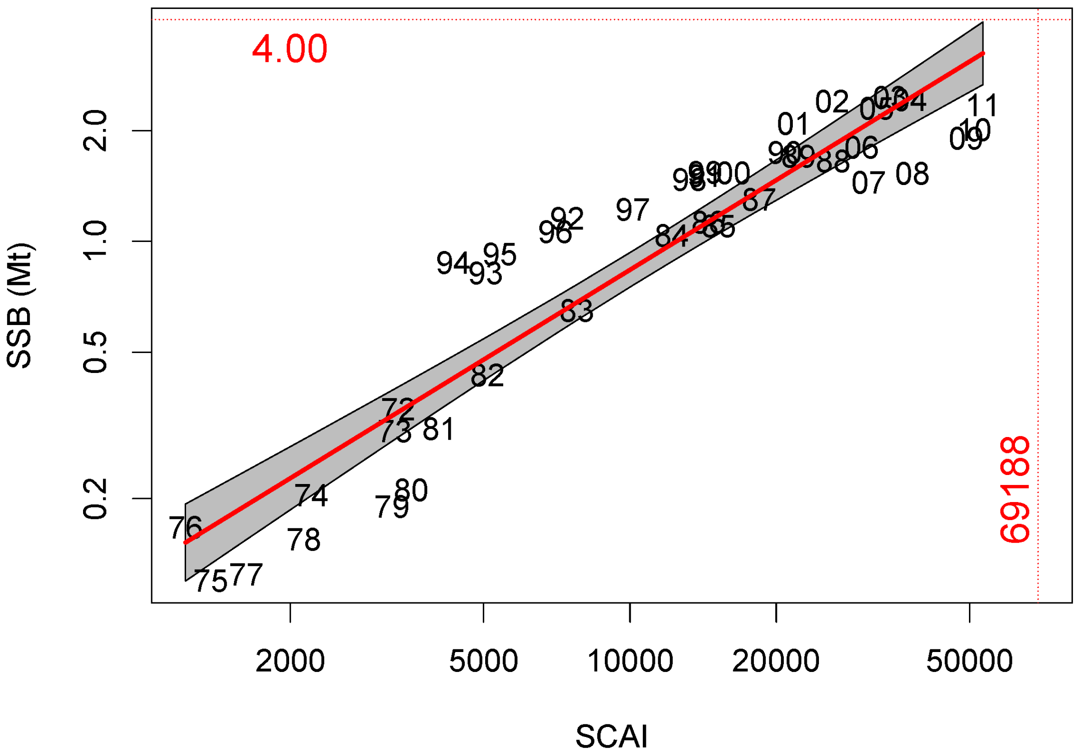


Figure 2.3.2.5 : North Sea herring. SSB estimated from the SCAI index (Payne 2010) and the spawning stock biomass (SSB) from previous assessments. Note the logarithmic scales on both axes. A linear regression line between the log values is plotted and used to estimate the SSB (4.00 Mt) based on the most recent value of the SCAI (69 188). Note that because the SSB is derived from the stock-assessment model which incorporates the SCAI as a tuning index, the two axes cannot be considered independent – the relationship shown here and the estimated SSB are only indicative.

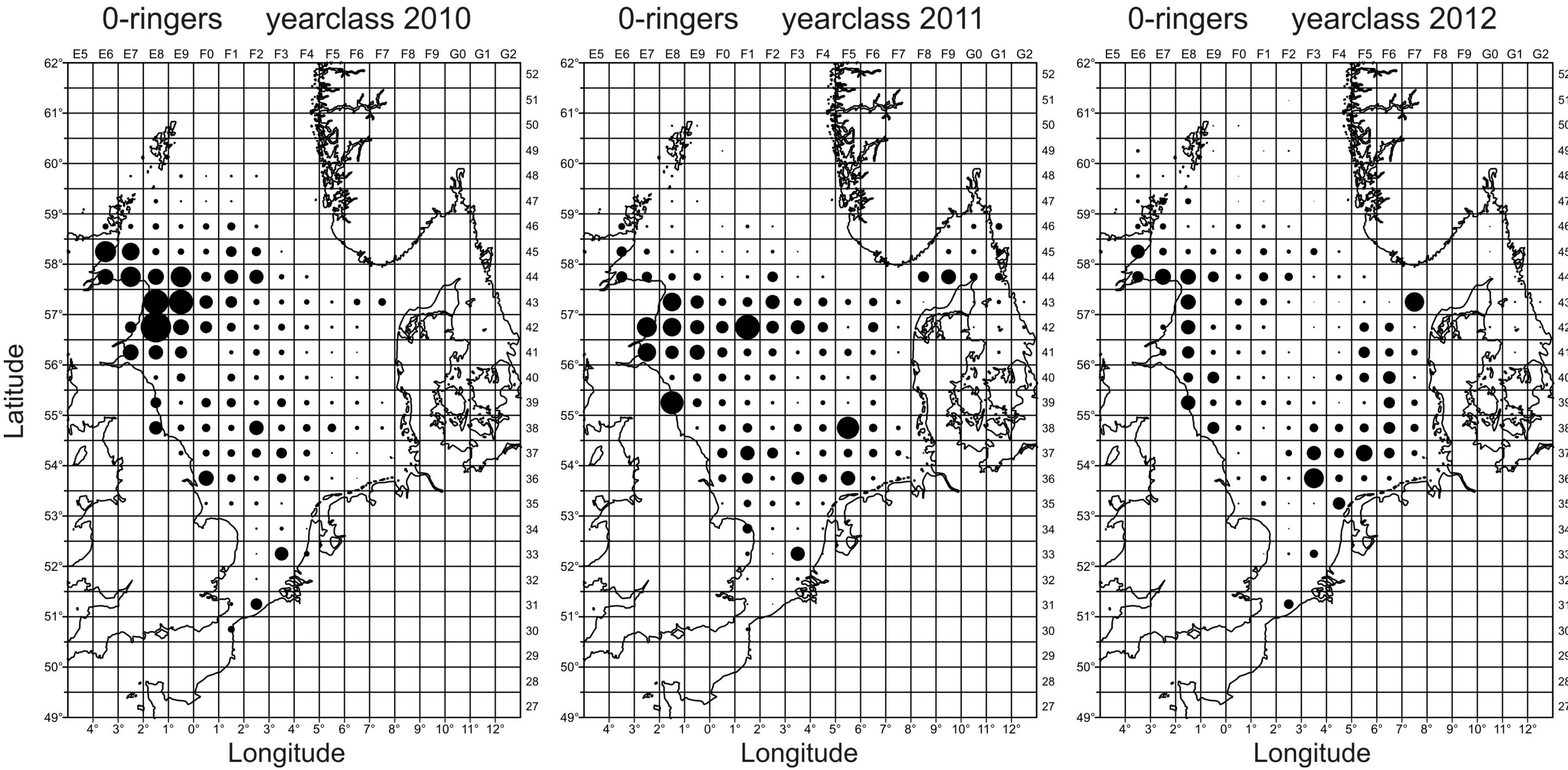


Figure 2.3.3.1. North Sea herring. Distribution of 0-ringer herring, year classes 2010-2012. Density estimates of 0-ringers within each statistical rectangle are based on MIK catches during IBTS in February 2011-2013. Areas of filled circles illustrate densities in no m^{-2}, the area of the largest circle represents a density of 1.63 m^{-2}.

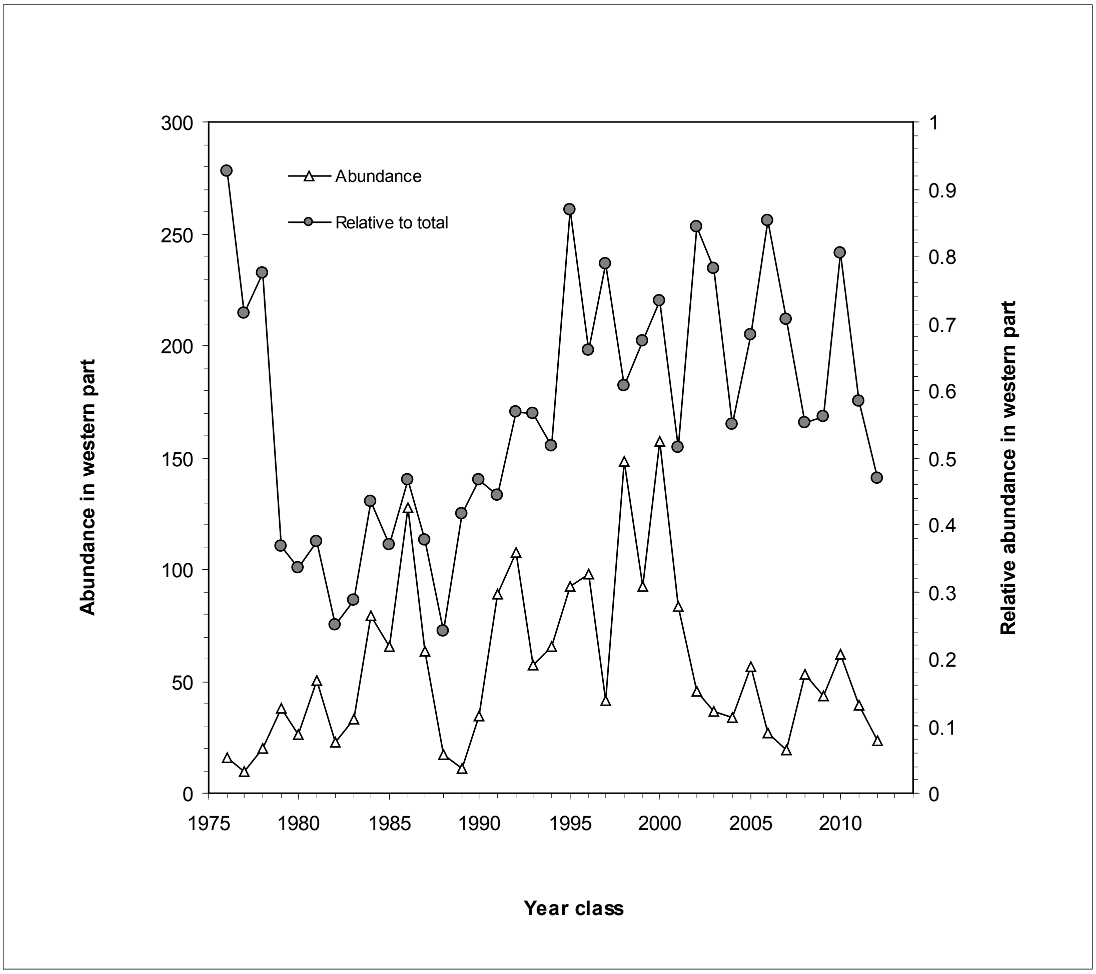


Figure 2.3.3.2. North Sea herring. Absolute (no * 10^9) and relative abundance of 0-ringers in the area west of 2°E in the North Sea. Abundances are based on MIK sampling during IBTS, the relative abundance in the western part is estimated as the number of 0-ringers west of 2°E relative to total number of 0-ringers.

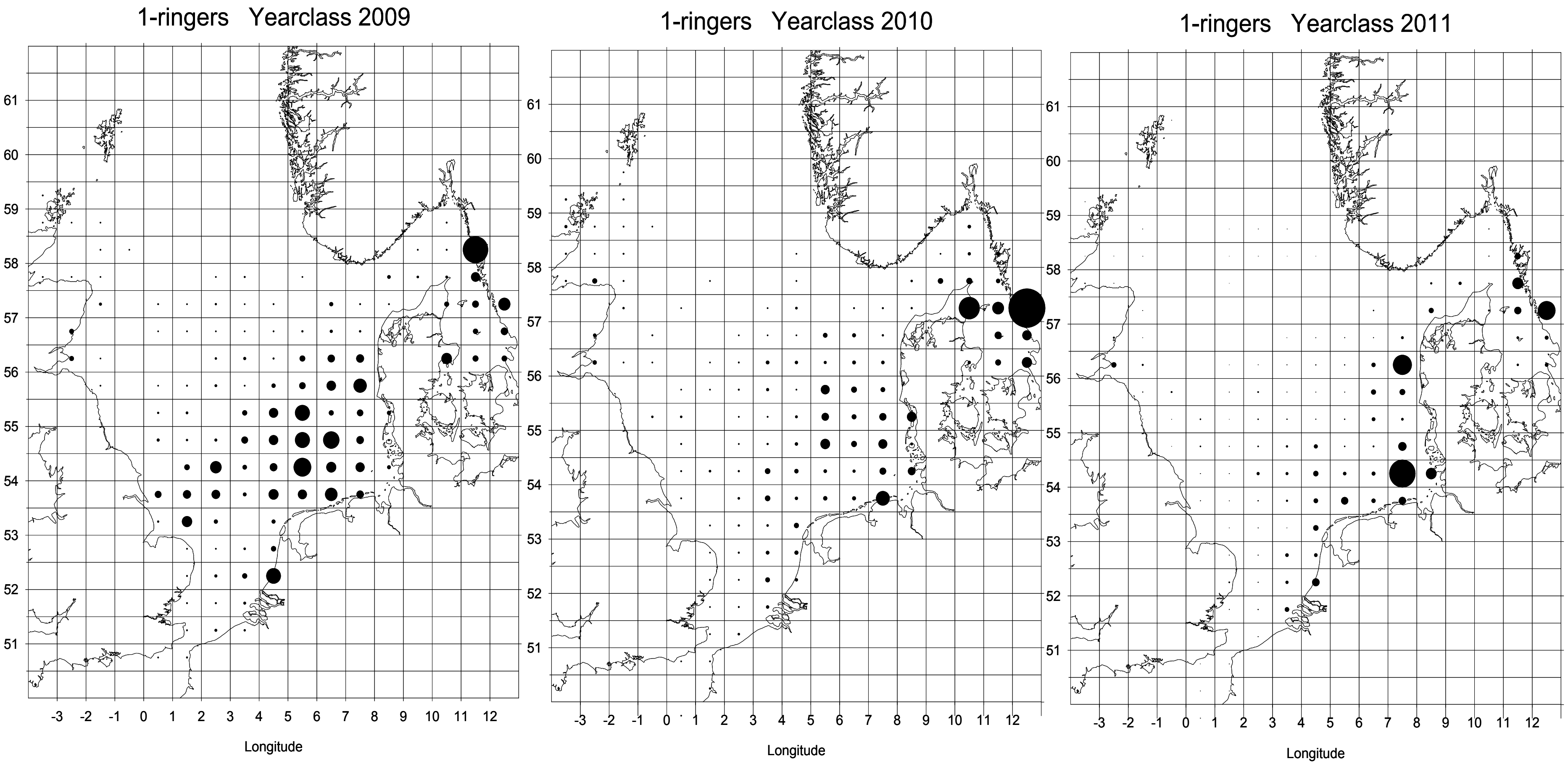
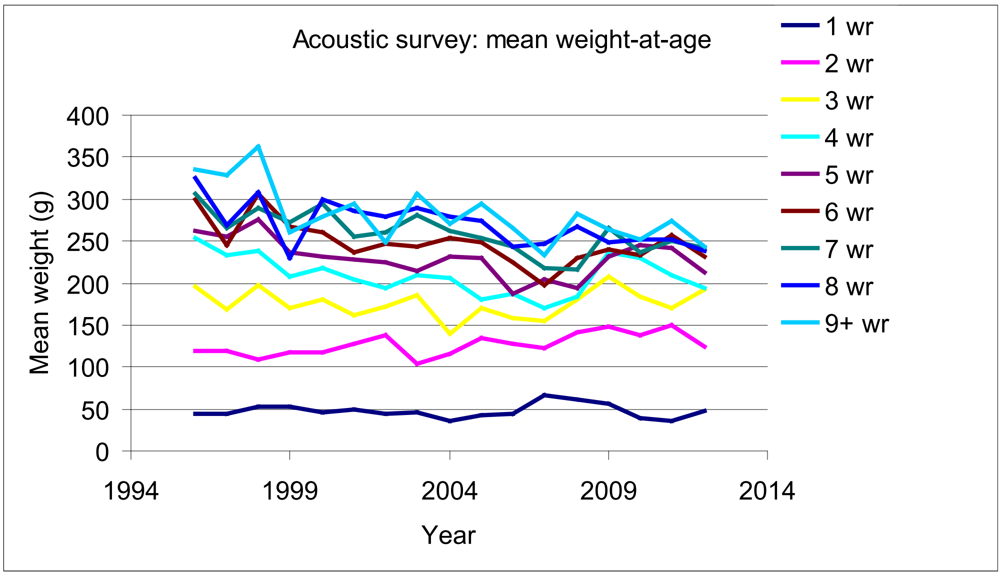


Figure 2.3.3.3. North Sea herring. Distribution of 1-ringer herring, year classes 2009-2011. Density estimates of 1-ringers within each statistical rectangle are based on GOV catches during IBTS in February 2011-2013. Areas of filled circles illustrate numbers per hour, the area of a circle extending to the border of a rectangle represents 45000 h^{-1}.



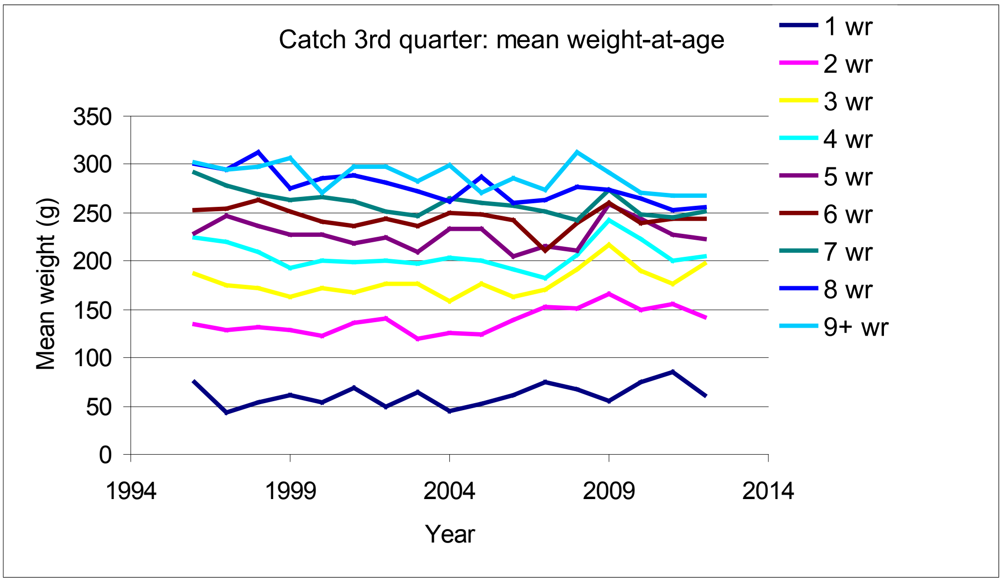


Figure 2.4.1.1. North Sea Herring. Mean weights-at-age for the 3rd quarter in Divisions IV and IIIa from the acoustic survey and mean weights-in-the-catch for comparison.

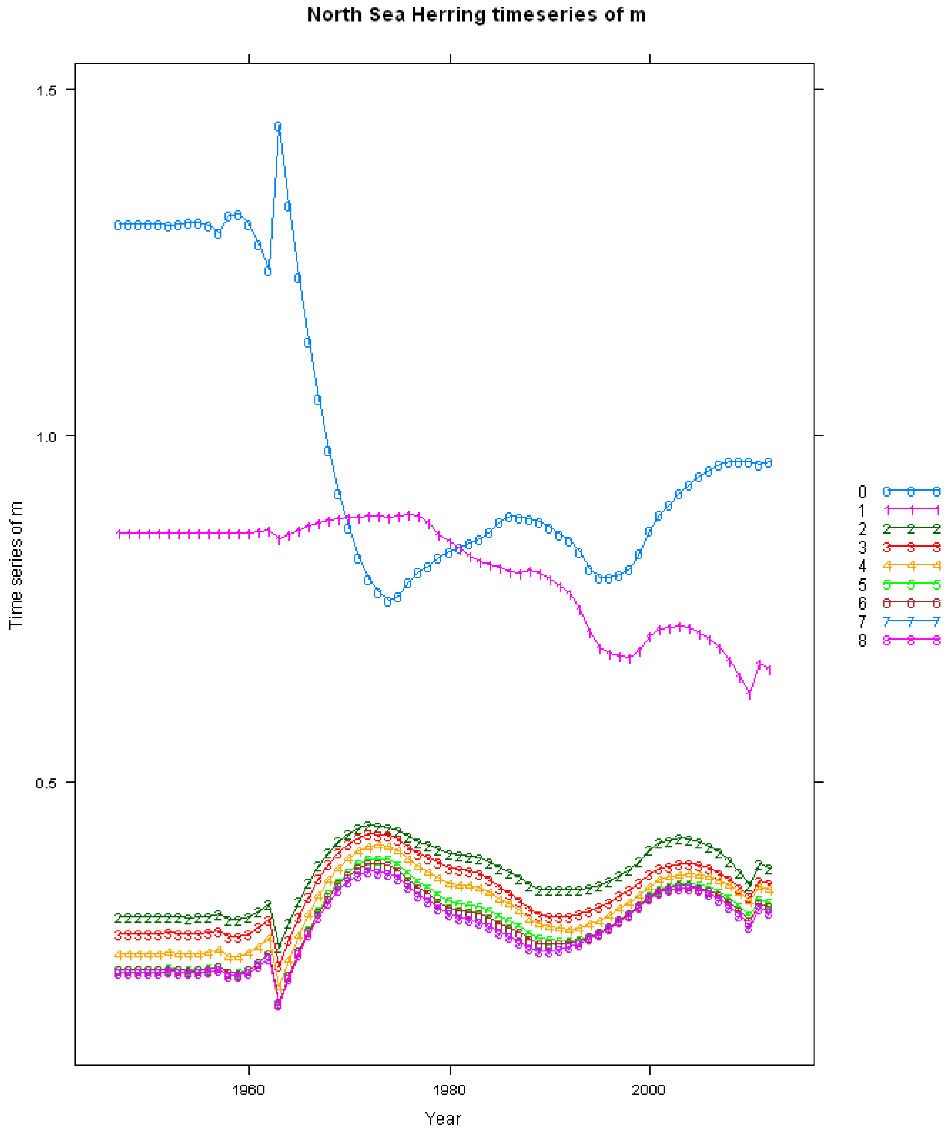


Figure 2.4.3.1 North Sea herring. Smoothed time varying natural mortality estimates at age for North Sea herring derived from the SMS model for the time period 1963-2010. The years 2011 and 2012 are based on a running average of the 5 years prior.

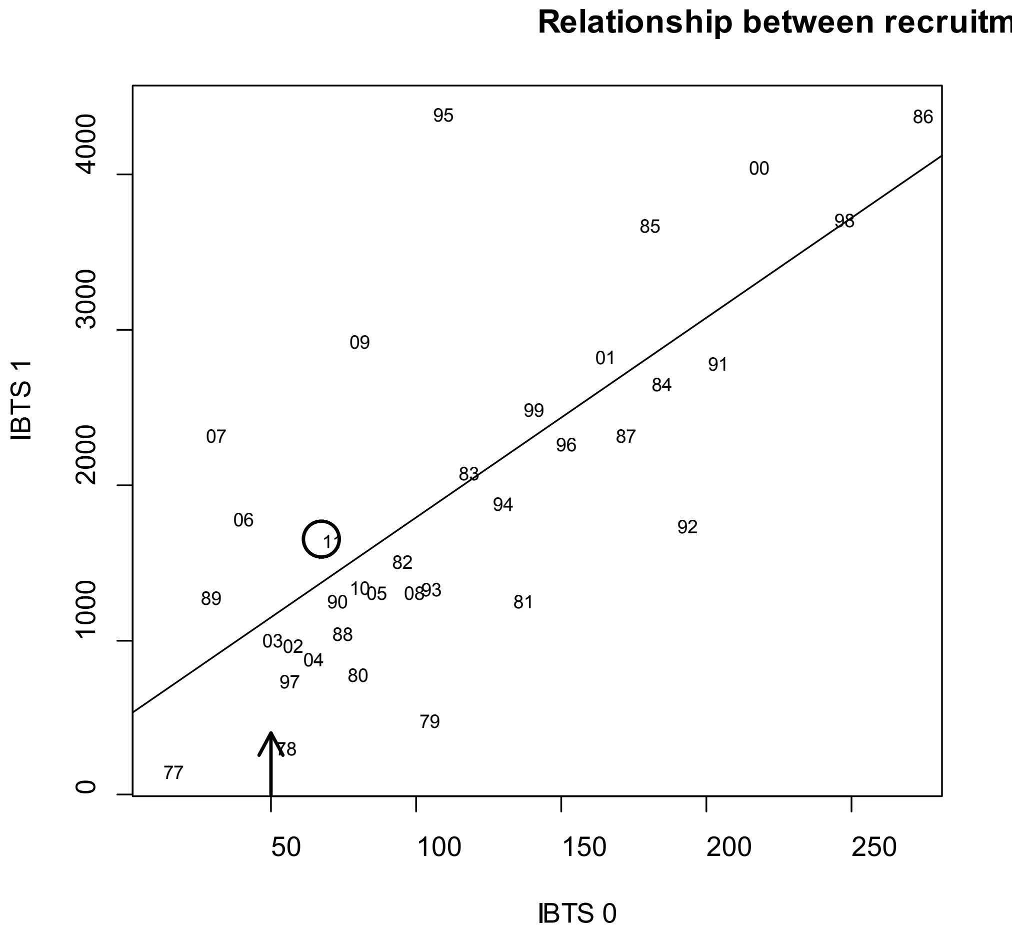


Figure 2.5.1. North Sea herring. Relationship between indices of 0-ringers and 1-ringers for year classes 1977 to 2011. The 2011 year class relation is circled; the present 0-ringer index for year class 2012 is indicated by an arrow.

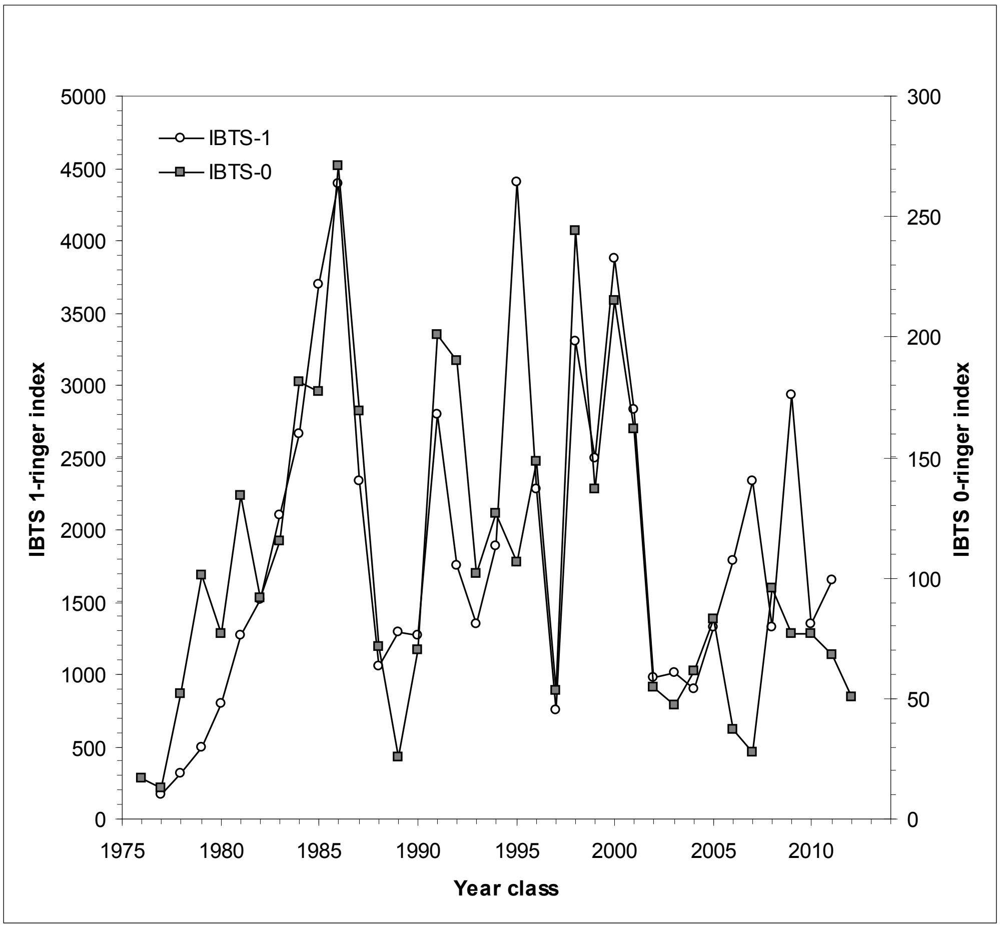


Figure 2.5.2 North Sea herring. Time series of 0-ringer and 1-ringer indices. Year classes 1976 to 2012 for 0-ringers, year classes 1977-2011 for 1-ringers.

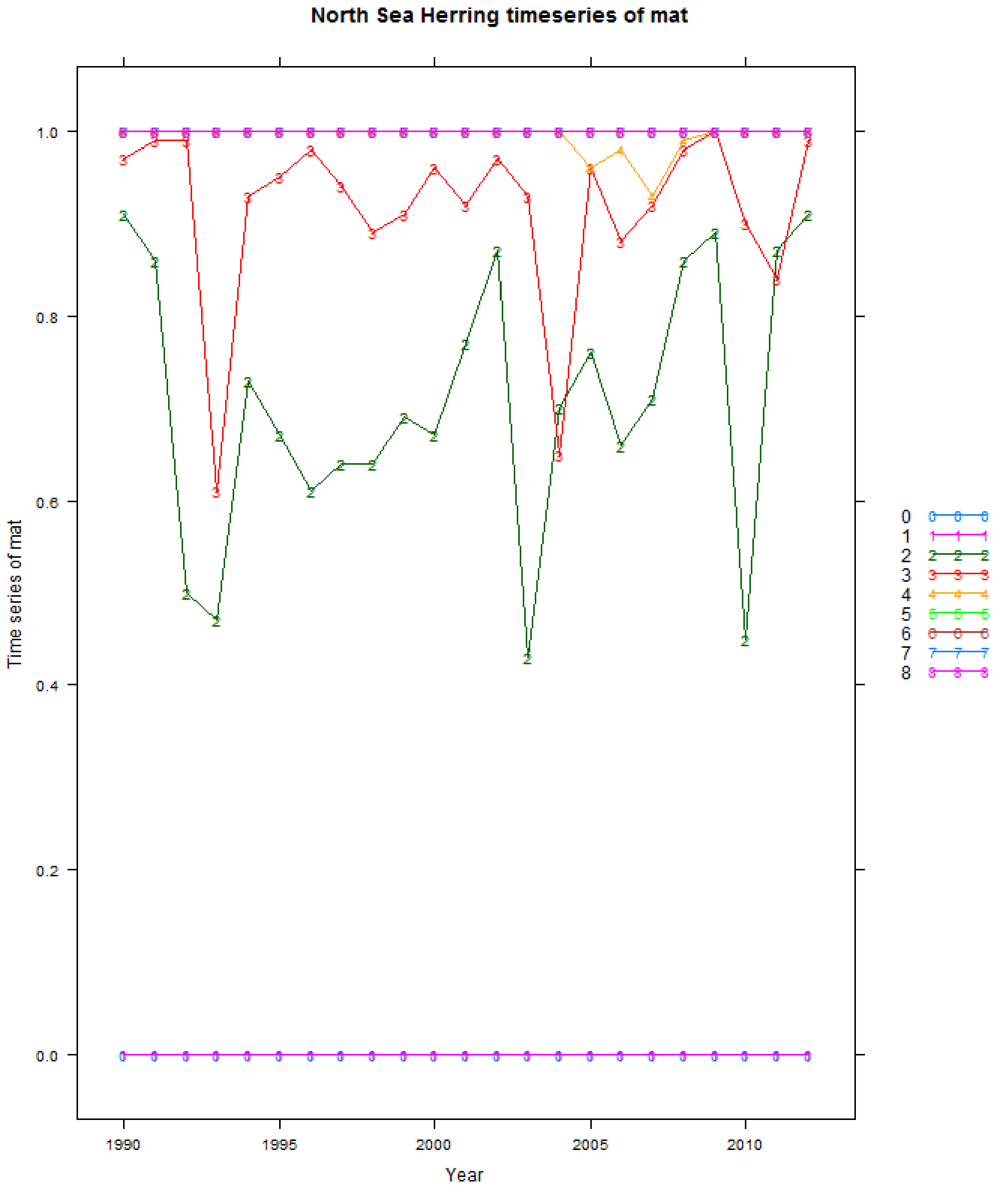


Figure 2.6.1.1 North Sea Herring. Time series of proportion mature at ages 0 to 8+ as used in the North Sea herring assessment.

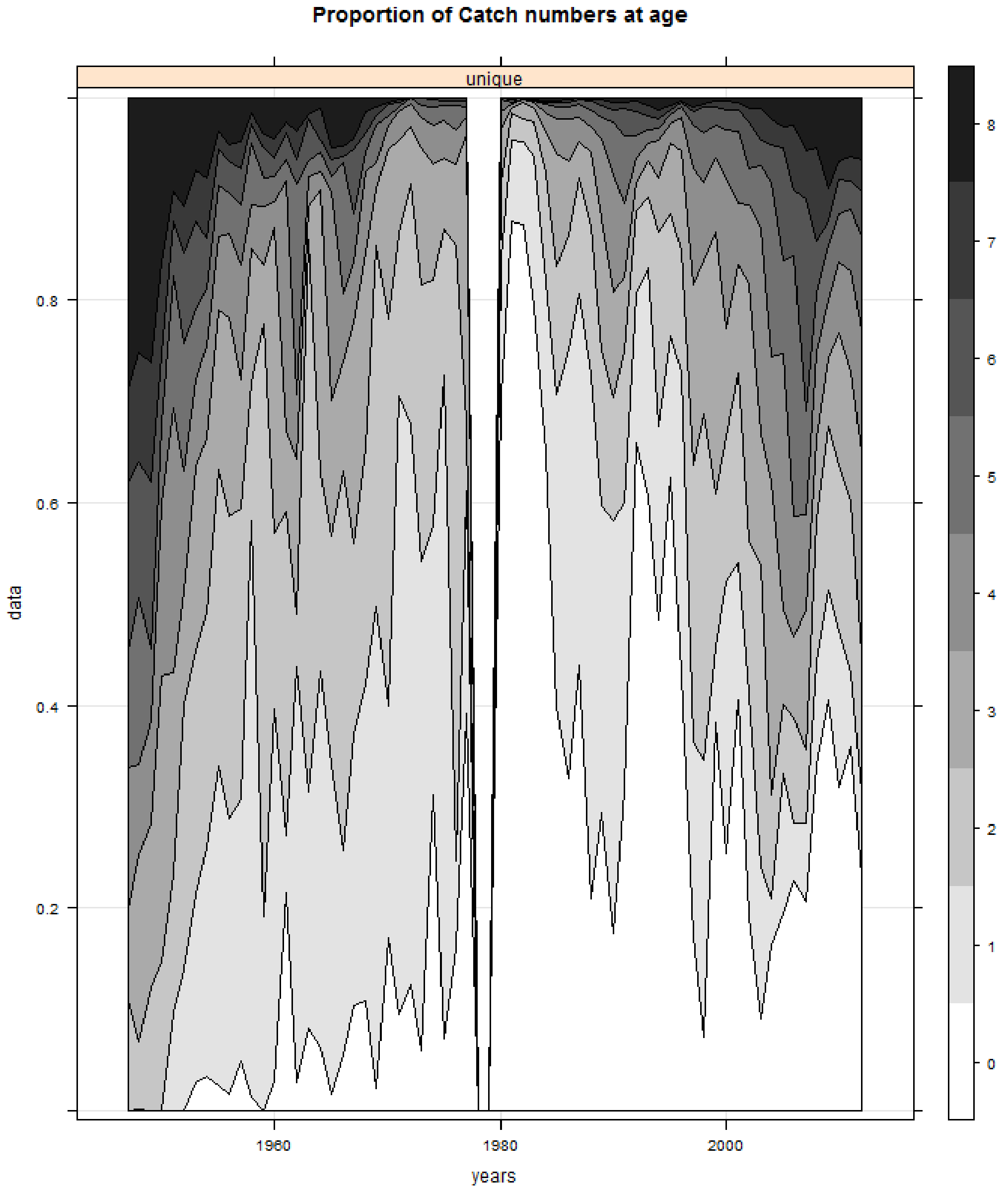


Figure 2.6.1.2. North Sea Herring. Time series of catch-at-age proportion at ages 0-8+ as used in the North Sea herring assessment.

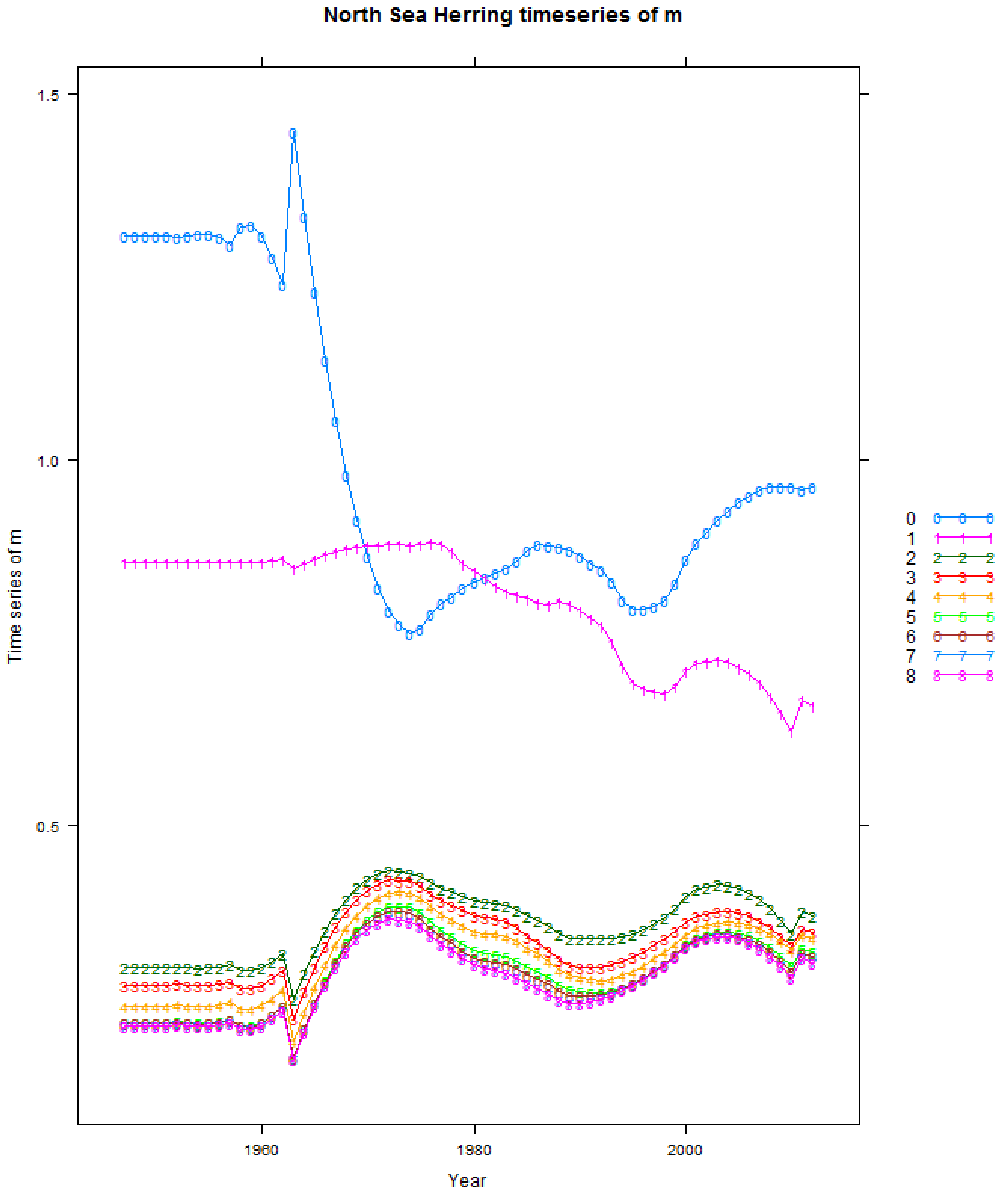


Figure 2.6.1.3. North Sea Herring. Time series of absolute natural mortality values at age 0-8+ as used in the North Sea herring assessment.

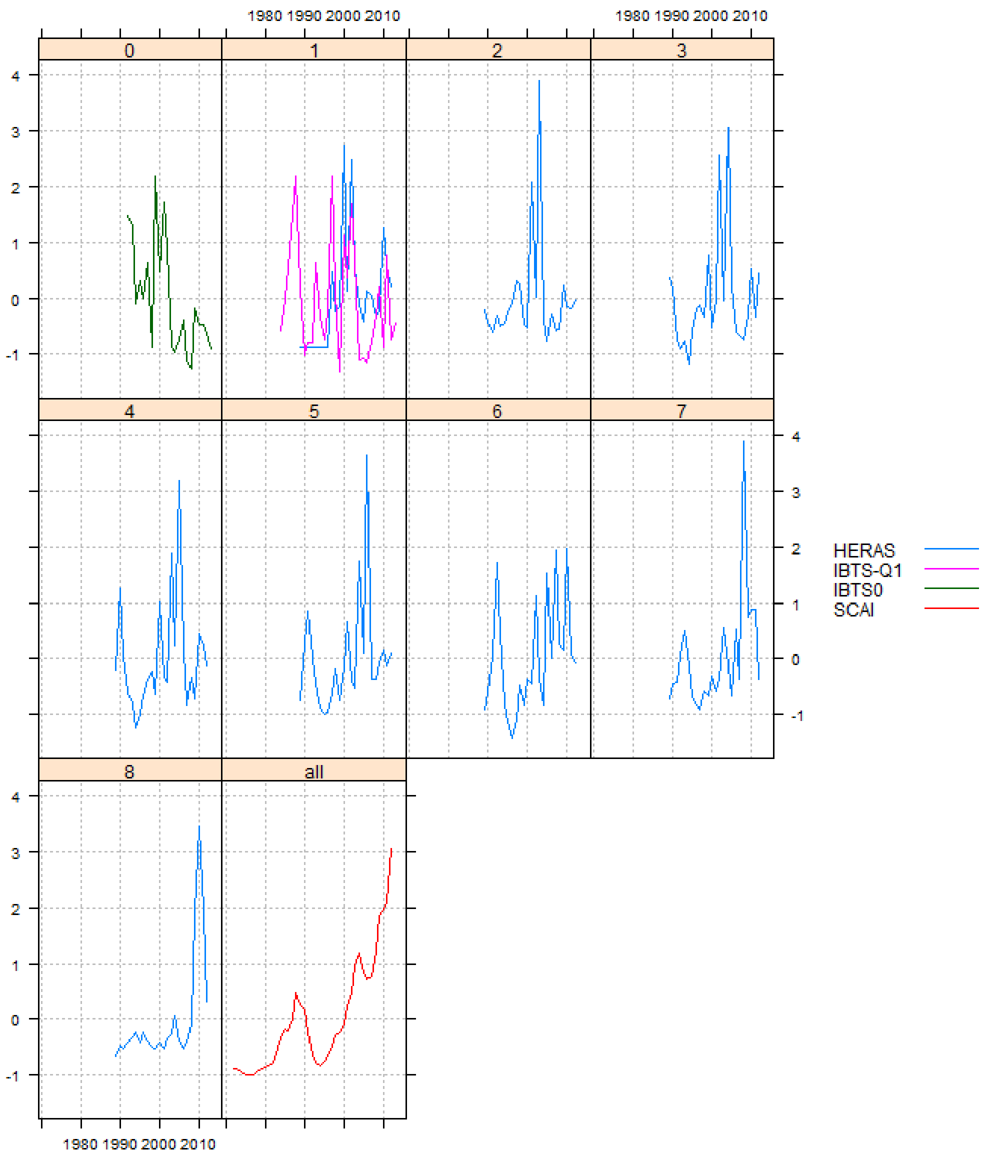


Figure 2.6.1.4. North Sea Herring. Time series of the standardized tuning series by ages 0-8+ (Acoustic survey: HERAS, IBTS quarter 1 survey: IBTS-Q1 and IBTS MIK net survey in quarter 1: IBTS0) and SSB tuning series (IHLS survey: SCAI).

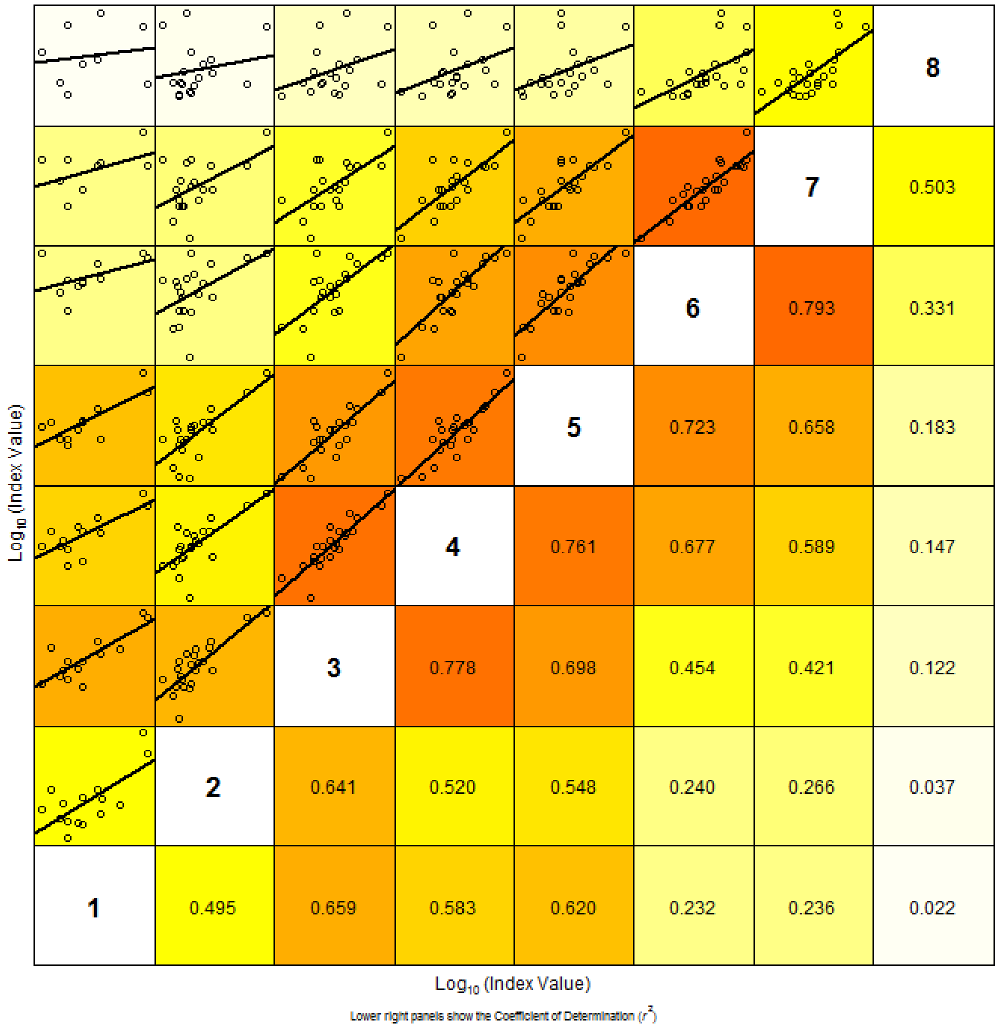


Figure 2.6.1.5. North Sea herring. Internal consistency plot of the acoustic survey (HERAS). Above the diagonal the linear regression is shown including the observations (in points) while under the diagonal the R2 value that is associated with the linear regression is given.

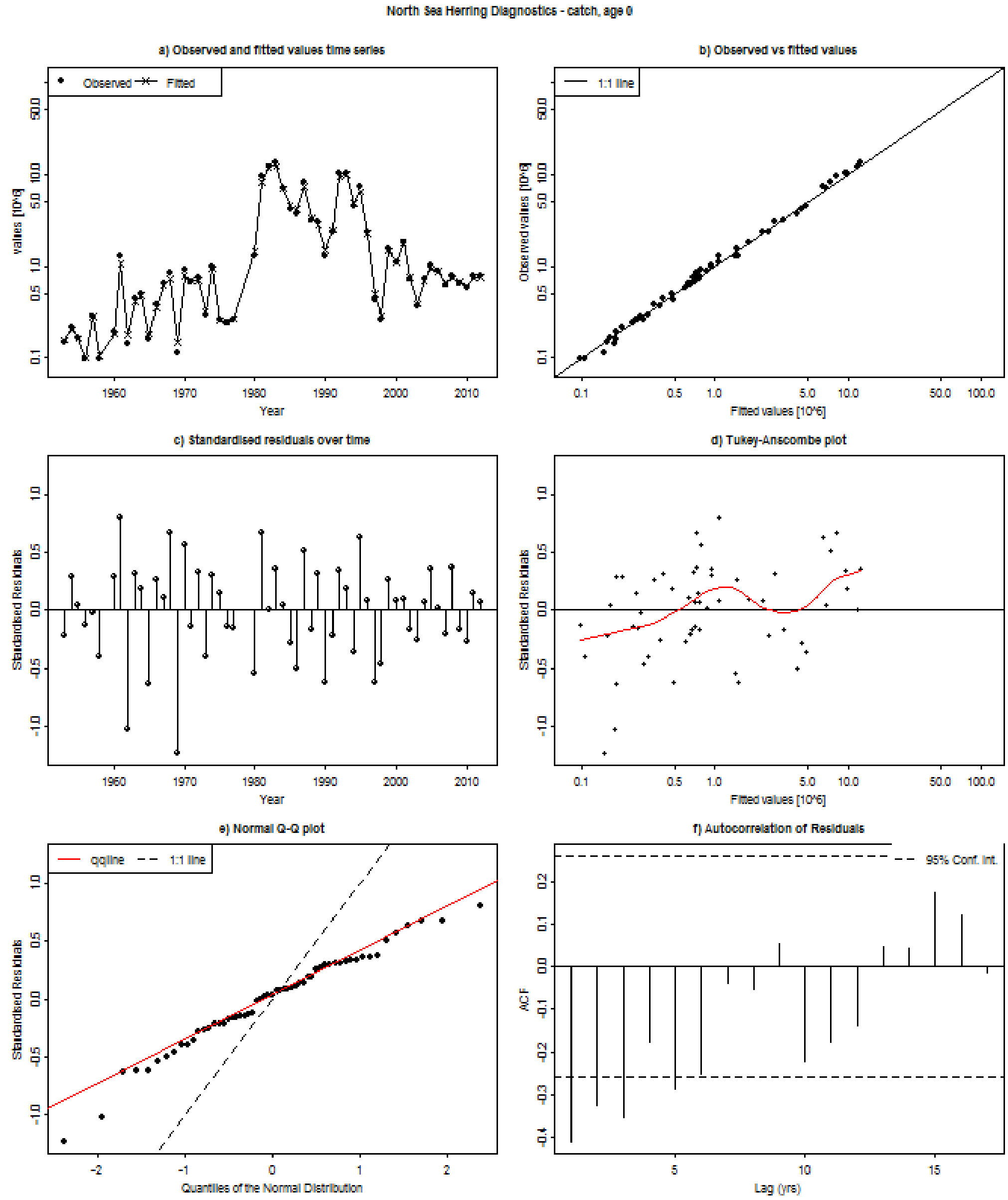


Figure 2.6.1.6 North Sea herring. Diagnostics of the assessment model fit to the catch at age 0 time series. Top left: Estimates of numbers at 0 wr (line) and numbers predicted from catch abundance at 0 wr. Top right: scatterplot of catch observations versus assessment model estimates of numbers at 0 wr with the best-fit catchability model (linear function). Middle right: catch observation versus standardized residuals at 0 wr. Middle left: Time series of standardized residuals of the catch at 0 wr. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation plot.

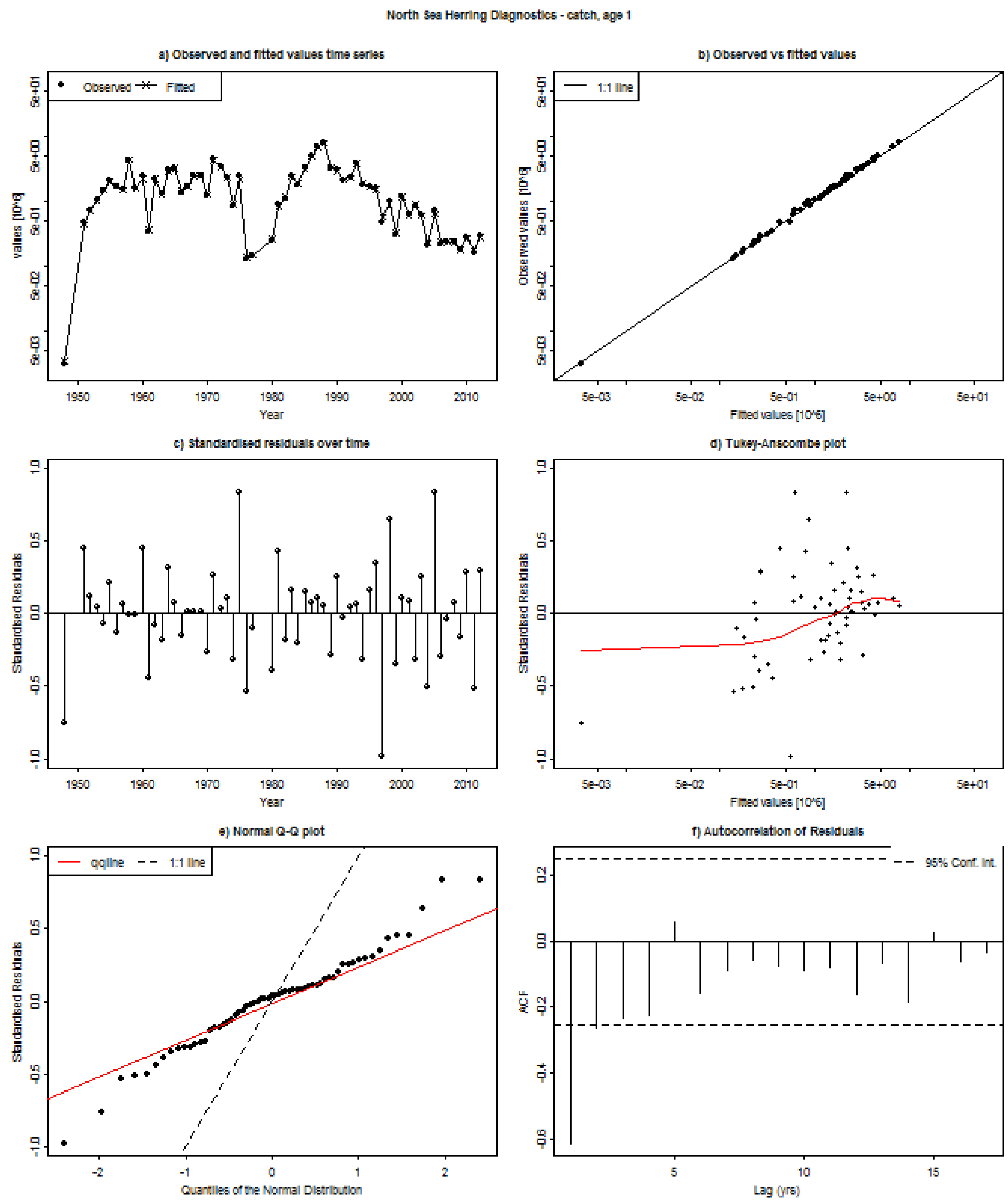


Figure 2.6.1.7 North Sea herring. Diagnostics of the assessment model fit to the catch at age 1 time series. Top left: Estimates of numbers at 1 wr (line) and numbers predicted from catch abundance at 1 wr. Top right: scatterplot of catch observations versus assessment model estimates of numbers at 1 wr with the best-fit catchability model (linear function). Middle right: catch observation versus standardized residuals at 1 wr. Middle left: Time series of standardized residuals of the catch at 1 wr. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation plot.

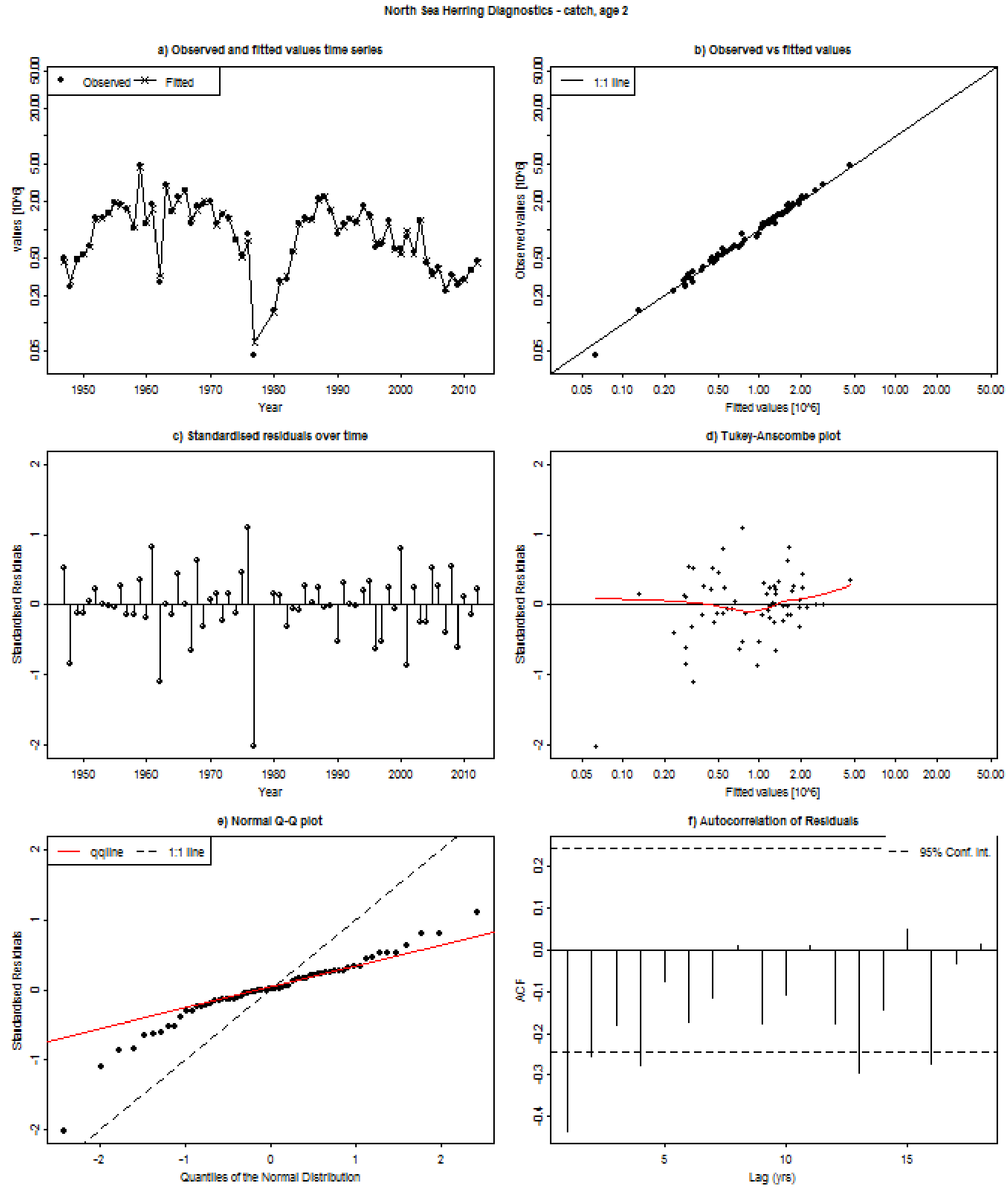


Figure 2.6.1.8 North Sea herring. Diagnostics of the assessment model fit to the catch at age 2 time series. Top left: Estimates of numbers at 2 wr (line) and numbers predicted from catch abundance at 2 wr. Top right: scatterplot of catch observations versus assessment model estimates of numbers at 2 wr with the best-fit catchability model (linear function). Middle right: catch observation versus standardized residuals at 2 wr. Middle left: Time series of standardized residuals of the catch at 2 wr. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation plot.

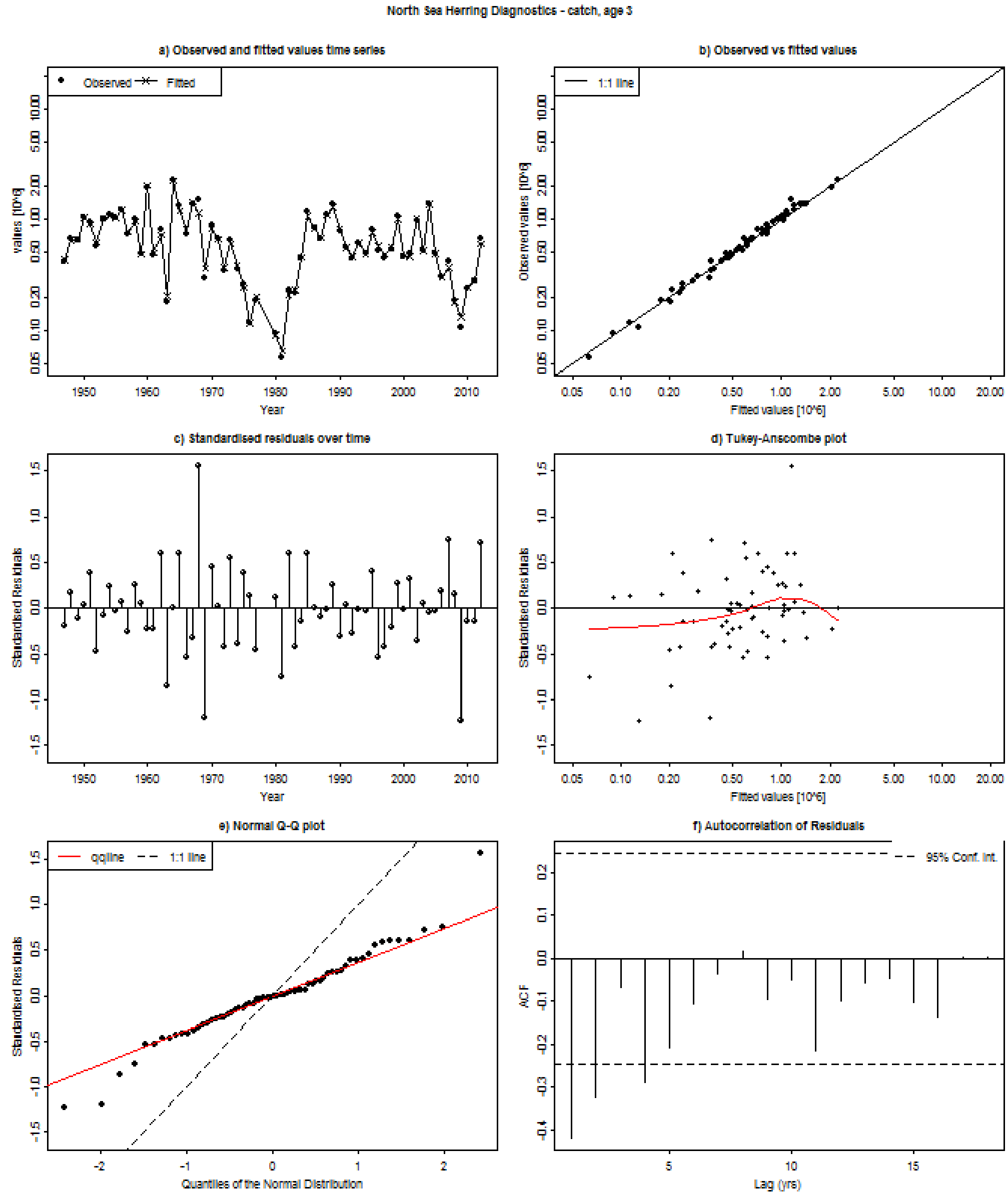


Figure 2.6.1.9 North Sea herring. Diagnostics of the assessment model fit to the catch at age 3 time series. Top left: Estimates of numbers at 3 wr (line) and numbers predicted from catch abundance at 3 wr. Top right: scatterplot of catch observations versus assessment model estimates of numbers at 3 wr with the best-fit catchability model (linear function). Middle right: catch observation versus standardized residuals at 3 wr. Middle left: Time series of standardized residuals of the catch at 3 wr. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation plot.

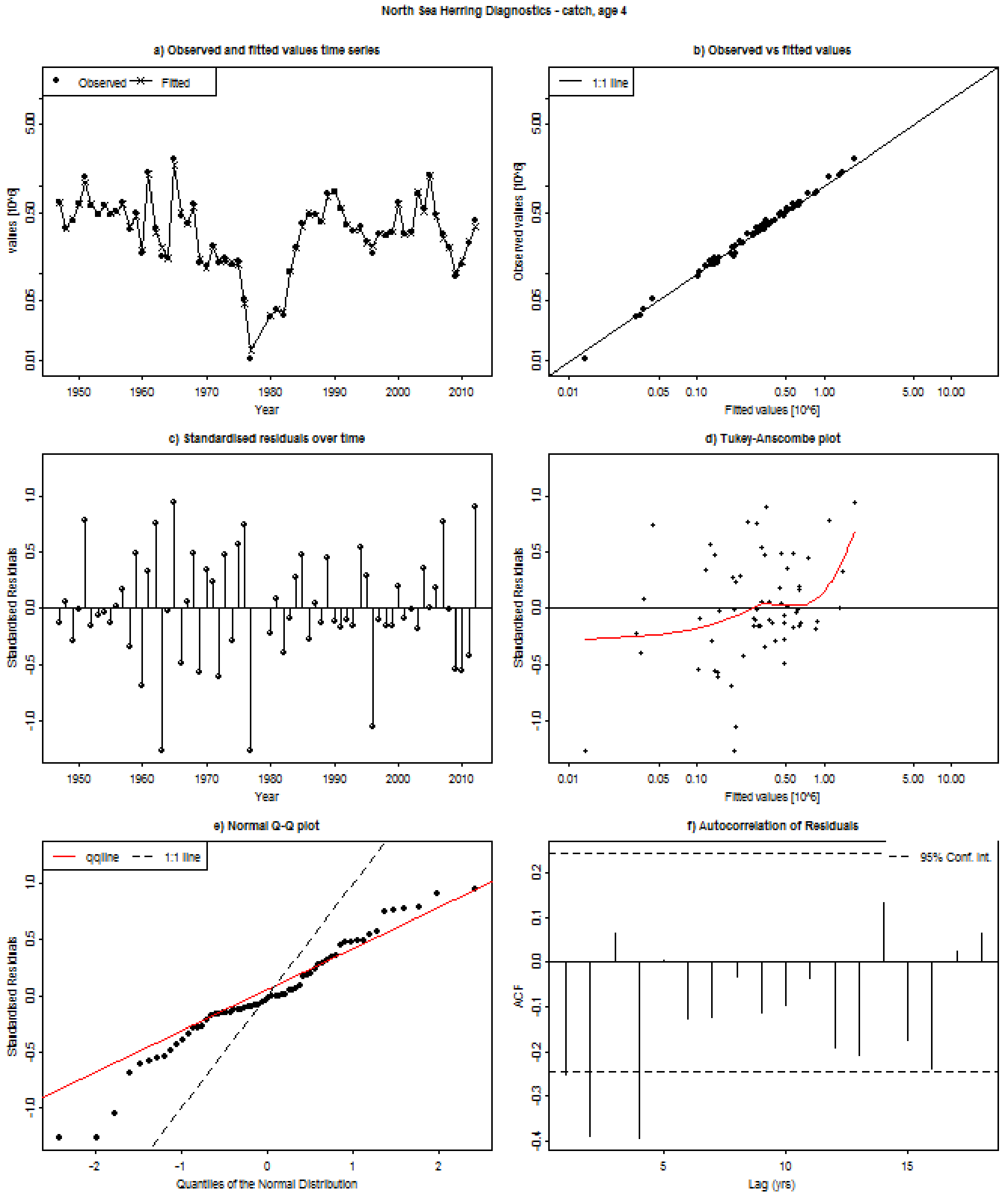


Figure 2.6.1.10 North Sea herring. Diagnostics of the assessment model fit to the catch at age 4 time series. Top left: Estimates of numbers at 4 wr (line) and numbers predicted from catch abundance at 4 wr. Top right: scatterplot of catch observations versus assessment model estimates of numbers at 4 wr with the best-fit catchability model (linear function). Middle right: catch observation versus standardized residuals at 4 wr. Middle left: Time series of standardized residuals of the catch at 4 wr. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation plot.

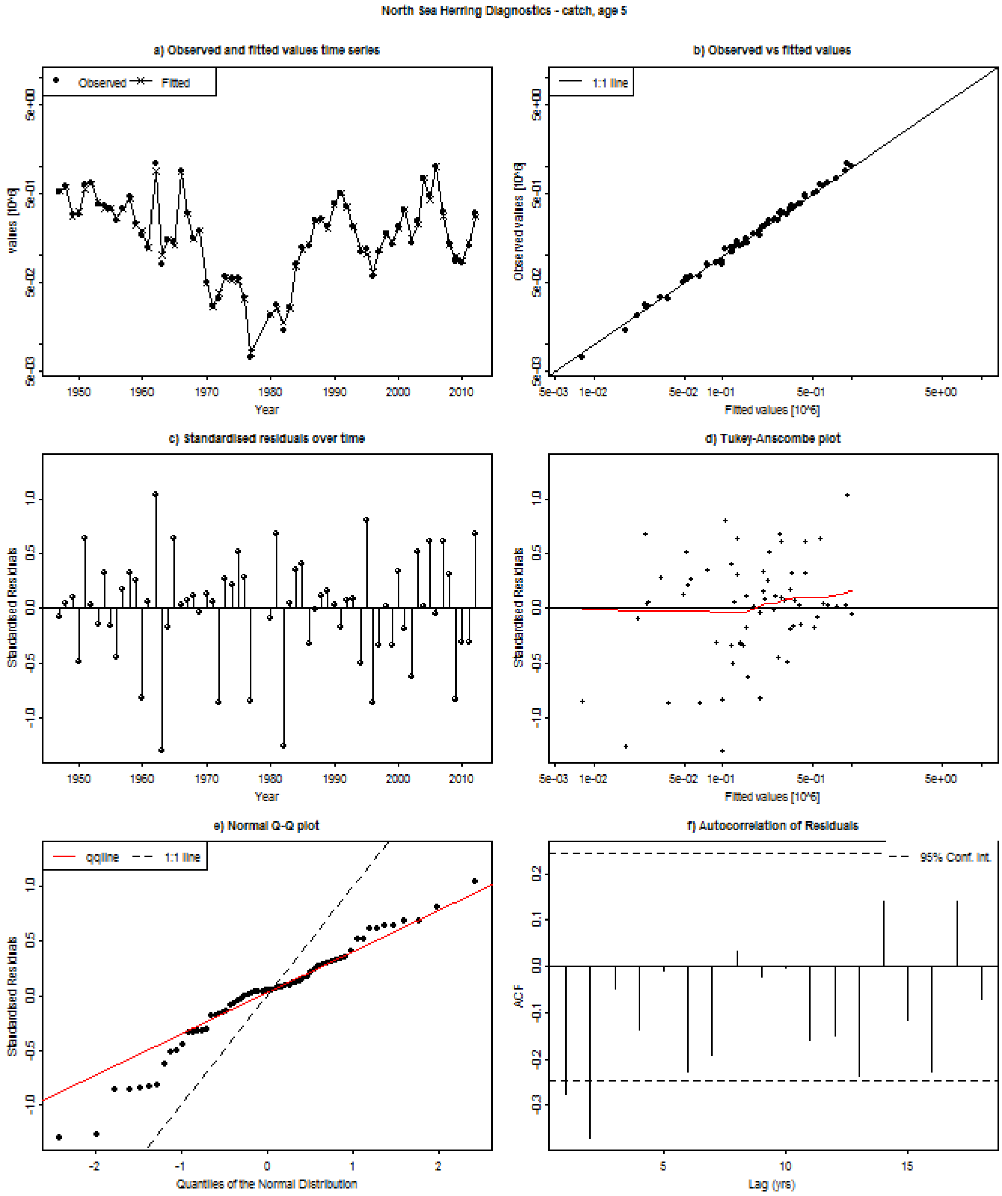


Figure 2.6.1.11 North Sea herring. Diagnostics of the assessment model fit to the catch at age 5 time series. Top left: Estimates of numbers at 5 wr (line) and numbers predicted from catch abundance at 5 wr. Top right: scatterplot of catch observations versus assessment model estimates of numbers at 5 wr with the best-fit catchability model (linear function). Middle right: catch observation versus standardized residuals at 5 wr. Middle left: Time series of standardized residuals of the catch at 5 wr. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation plot.

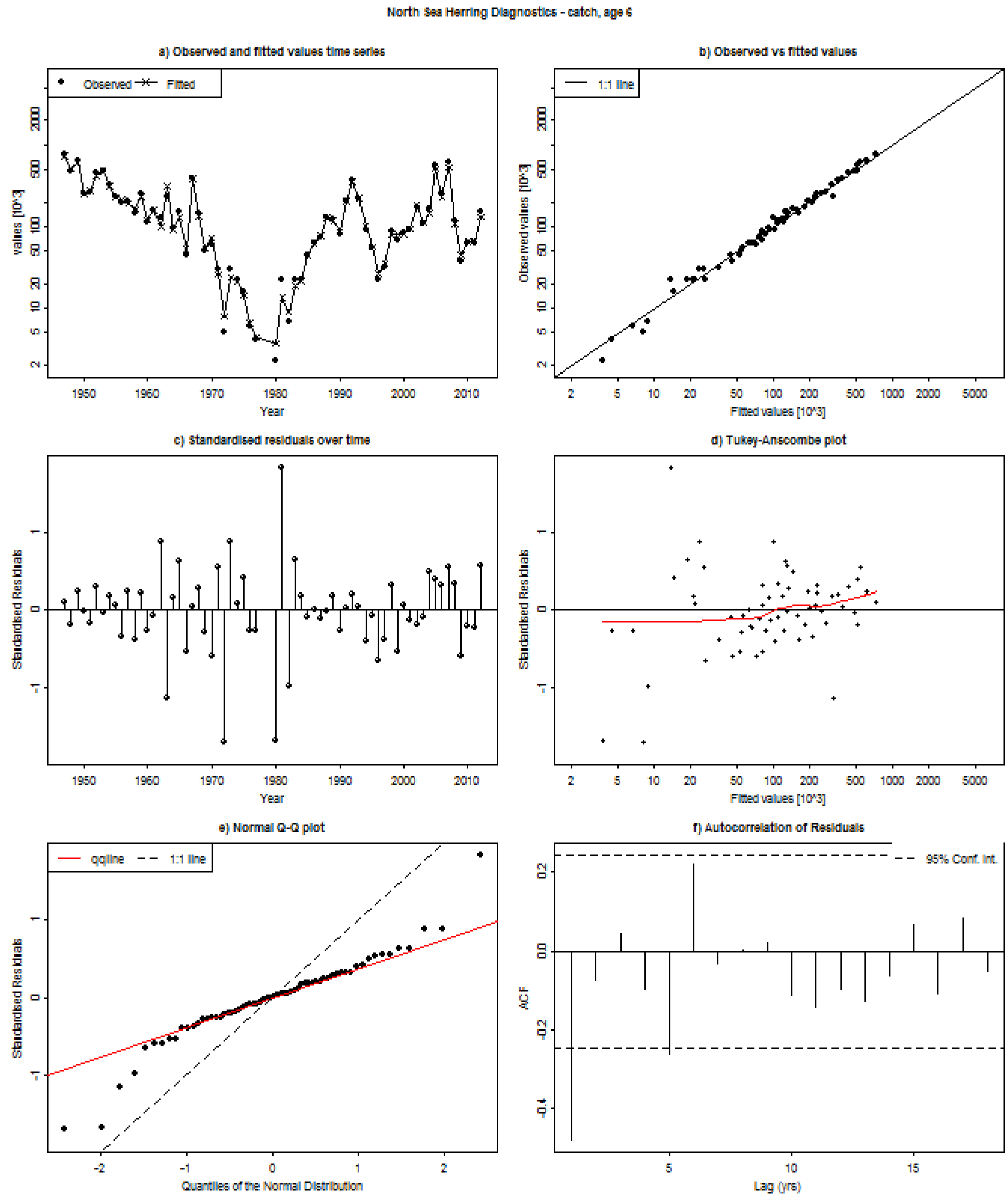


Figure 2.6.1.12 North Sea herring. Diagnostics of the assessment model fit to the catch at age 6 time series. Top left: Estimates of numbers at 6 wr (line) and numbers predicted from catch abundance at 6 wr. Top right: scatterplot of catch observations versus assessment model estimates of numbers at 6 wr with the best-fit catchability model (linear function). Middle right: catch observation versus standardized residuals at 6 wr. Middle left: Time series of standardized residuals of the catch at 6 wr. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation plot.

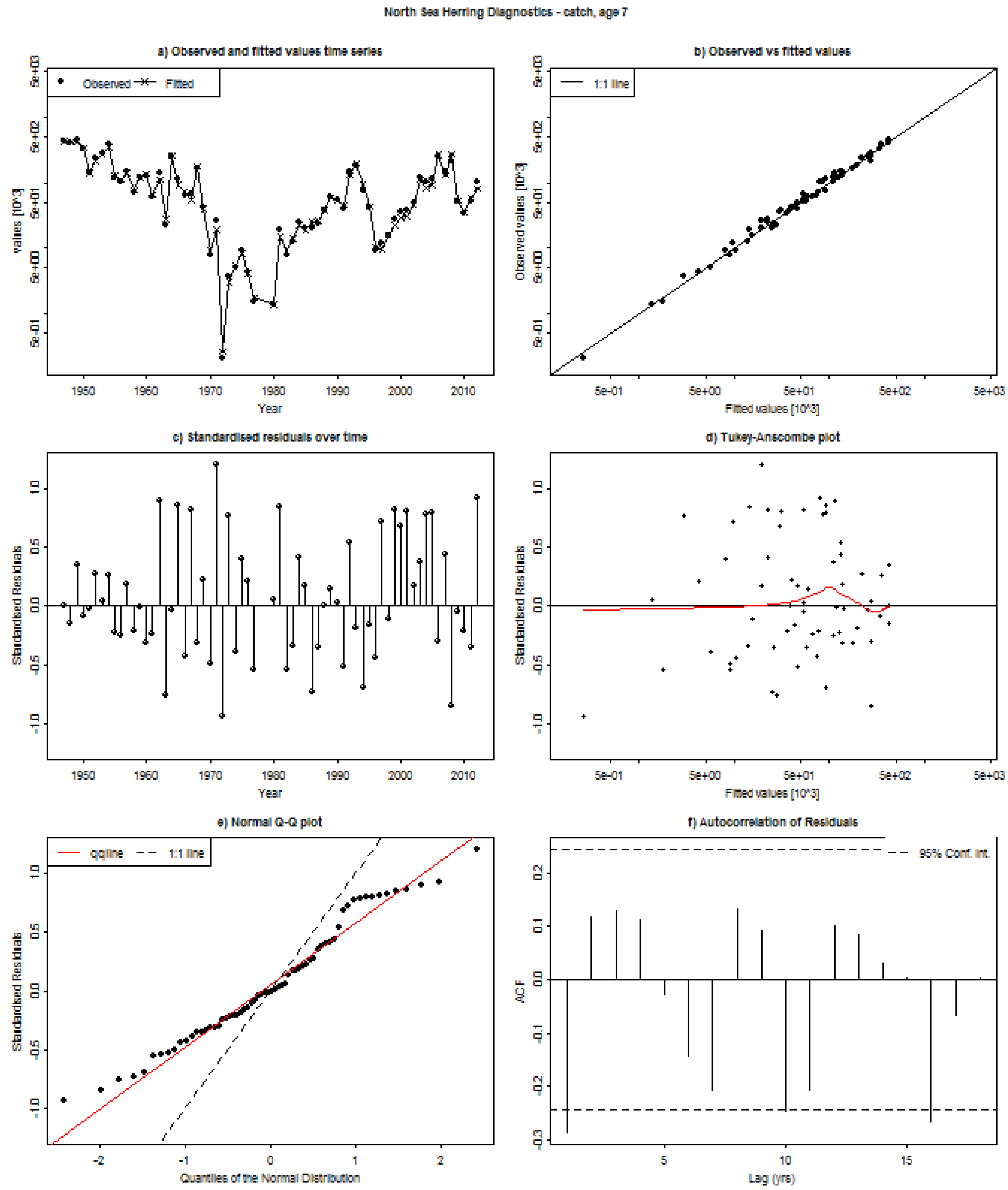


Figure 2.6.1.13 North Sea herring. Diagnostics of the assessment model fit to the catch at age 7 time series. Top left: Estimates of numbers at 7 wr (line) and numbers predicted from catch abundance at 7 wr. Top right: scatterplot of catch observations versus assessment model estimates of numbers at 7 wr with the best-fit catchability model (linear function). Middle right: catch observation versus standardized residuals at 7 wr. Middle left: Time series of standardized residuals of the catch at 7 wr. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation plot.

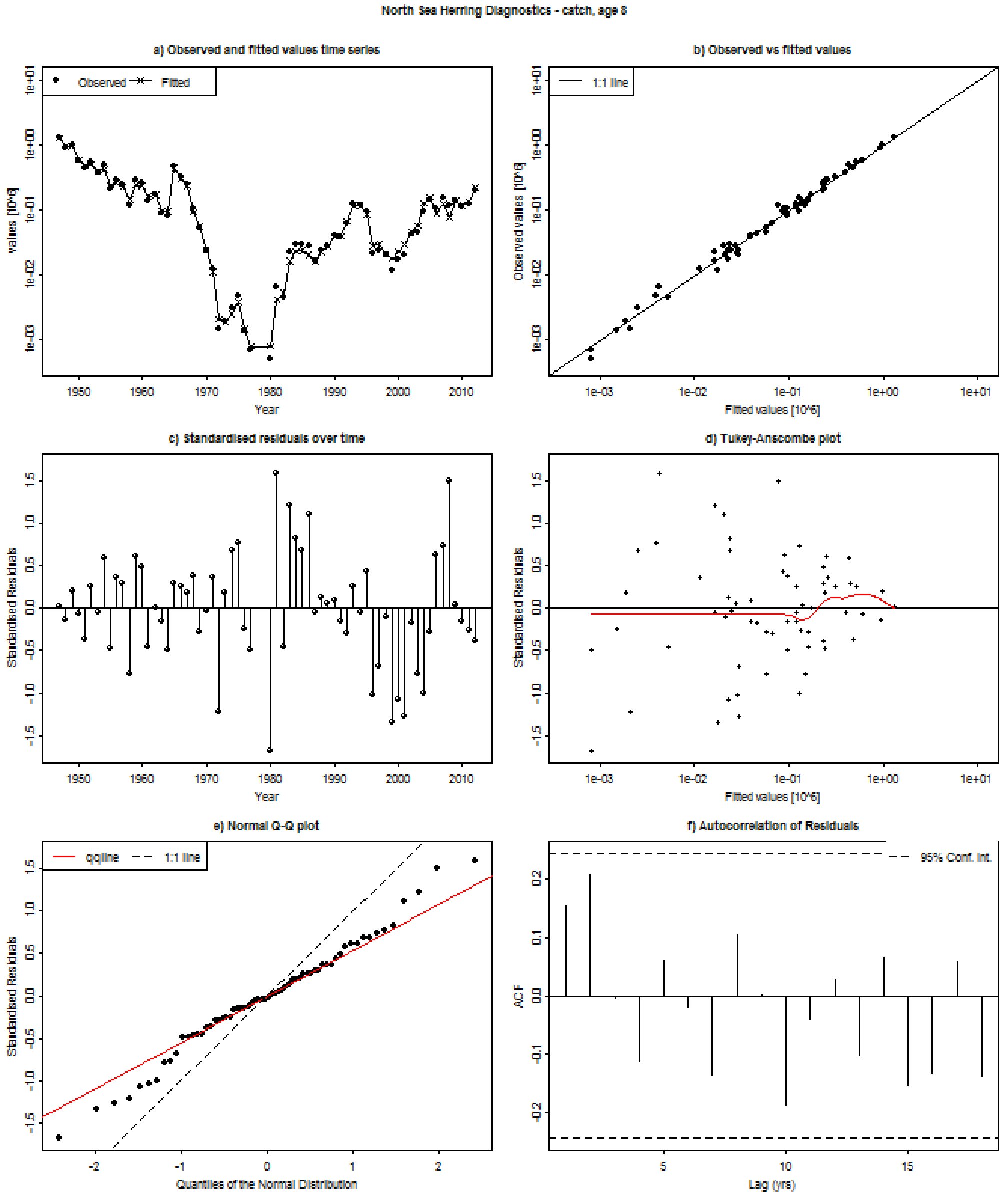


Figure 2.6.1.14. North Sea herring. Diagnostics of the assessment model fit to the catch at age 8+ time series. Top left: Estimates of numbers at 8+ wr (line) and numbers predicted from catch abundance at 8+ wr. Top right: scatterplot of catch observations versus assessment model estimates of numbers at 8+ wr with the best-fit catchability model (linear function). Middle right: catch observation versus standardized residuals at 8+ wr. Middle left: Time series of standardized residuals of the catch at 8+ wr. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation plot.

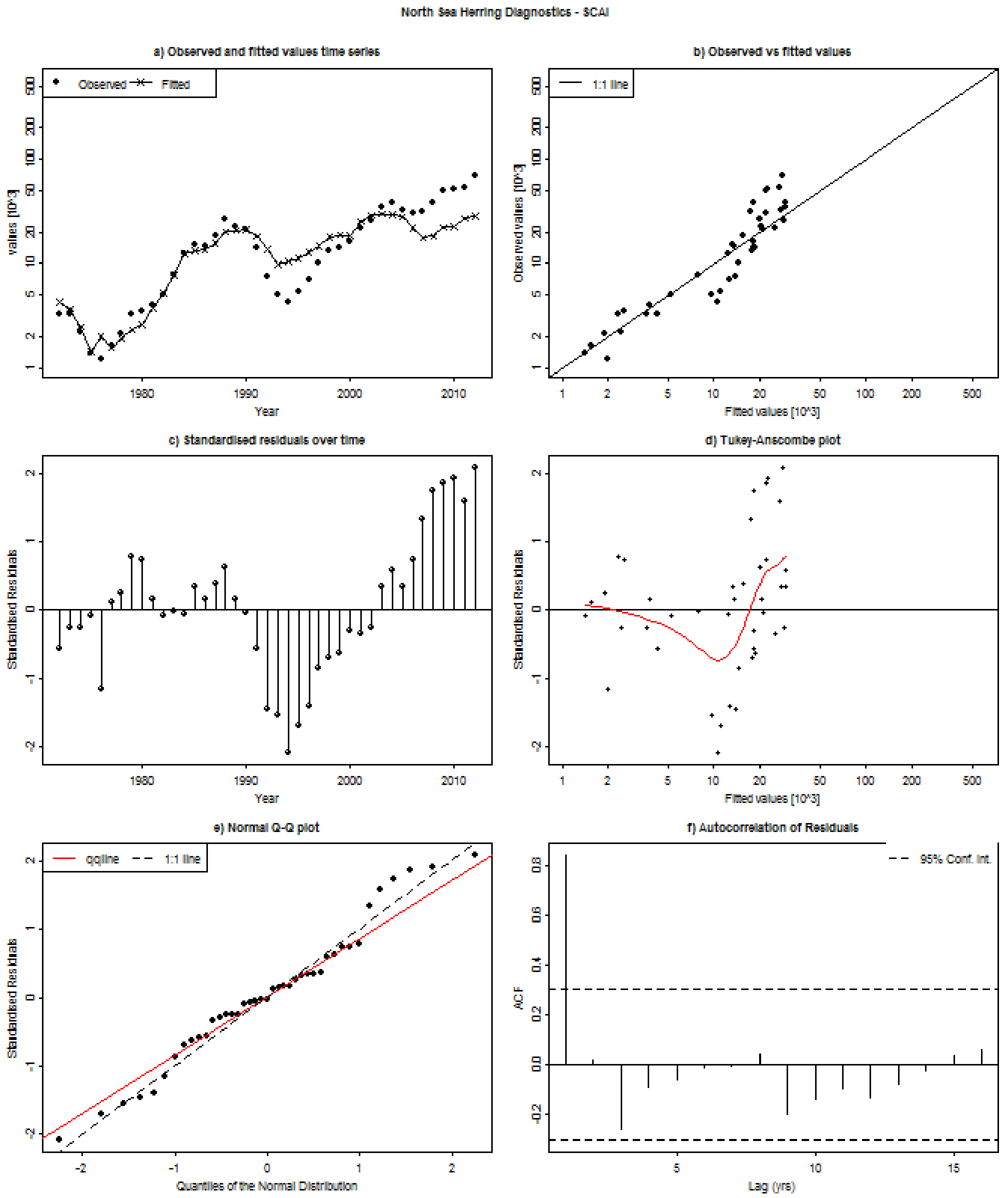


Figure 2.6.1.15. North Sea herring. Diagnostics of the assessment model fit to the SCAI SSB index time series. Top left: Estimates of SSB (line) and SSB predicted from assessment model. Top right: scatterplot of SSB observations versus assessment model estimates with the best-fit catchability model (linear function). Middle right: SSB observation versus standardized residuals. Middle left: Time series of standardized residuals of the SSB. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation plot.

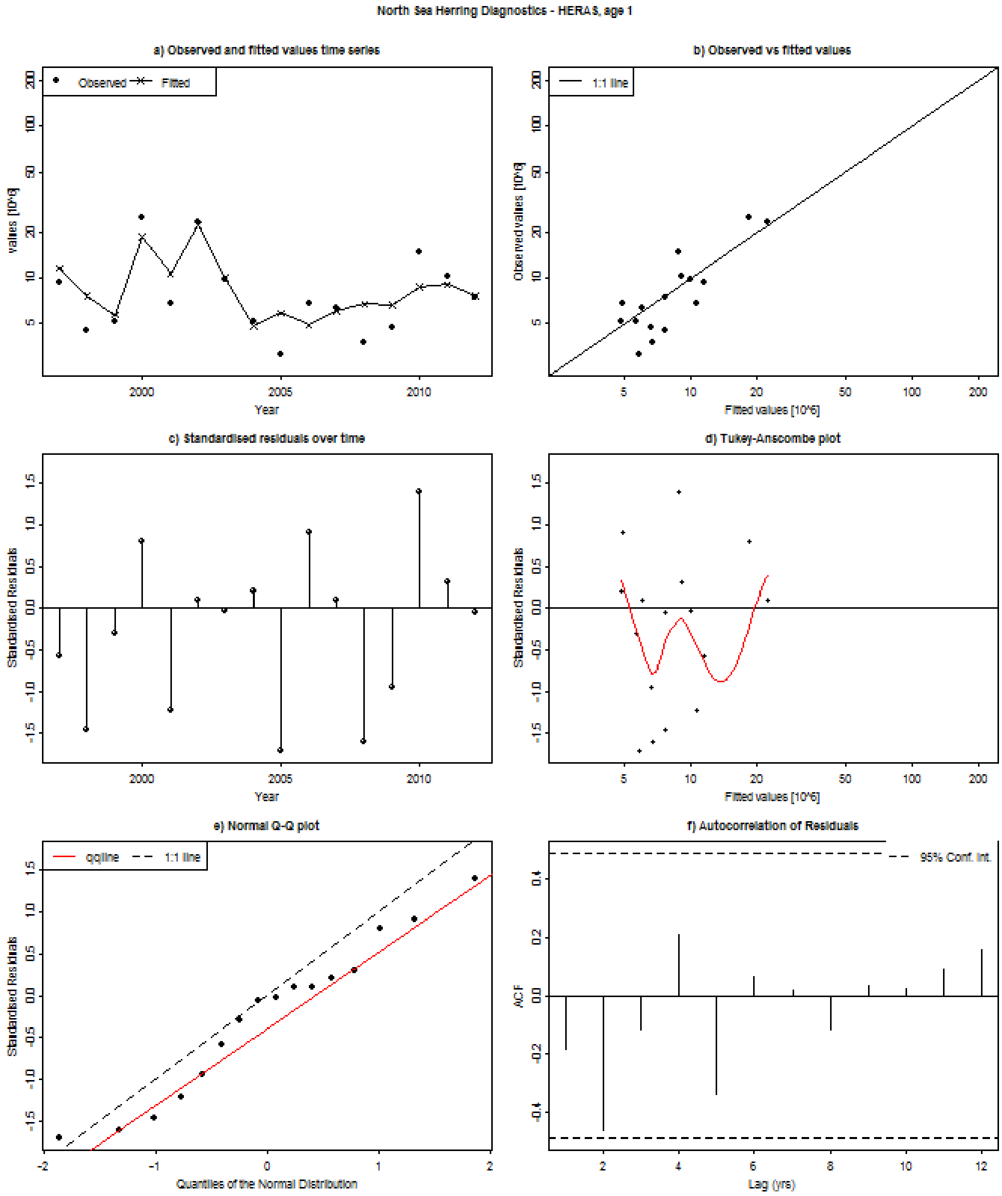


Figure 2.6.1.16. North Sea herring. Diagnostics of the assessment model fit to the HERAS index at age 1 wr time series. Top left: Estimates of numbers at 1 wr (line) and numbers predicted from index abundance at 1 wr. Top right: scatterplot of index observations versus assessment model estimates of numbers at 1 wr with the best-fit catchability model (linear function). Middle right: index observation versus standardized residuals at 1 wr. Middle left: Time series of standardized residuals of the index at 1 wr. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation plot.

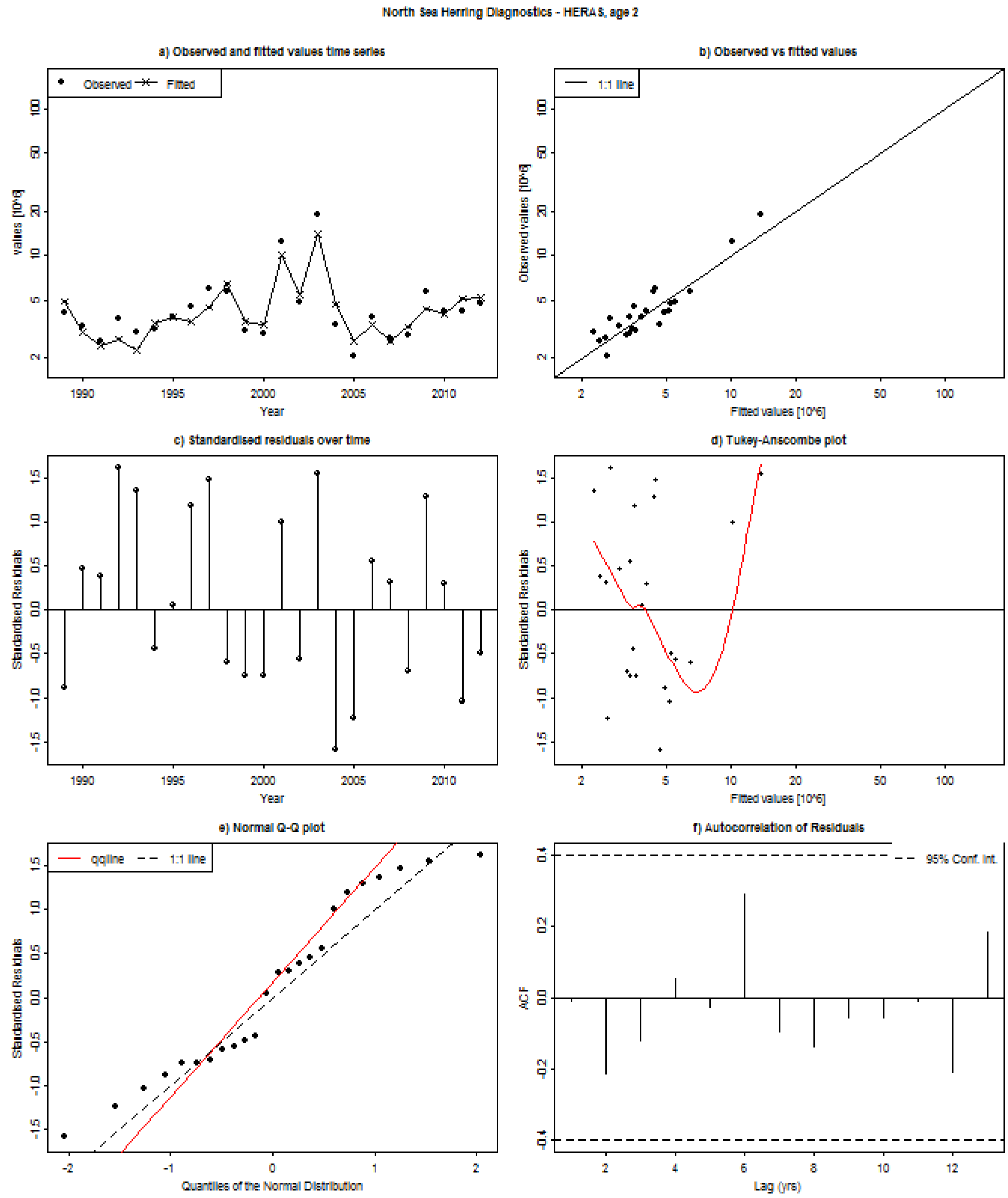


Figure 2.6.1.17. North Sea herring. Diagnostics of the assessment model fit to the HERAS index at age 2 wr time series. Top left: Estimates of numbers at 2 wr (line) and numbers predicted from index abundance at 2 wr. Top right: scatterplot of index observations versus assessment model estimates of numbers at 2 wr with the best-fit catchability model (linear function). Middle right: index observation versus standardized residuals at 2 wr. Middle left: Time series of standardized residuals of the index at 2 wr. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation plot.

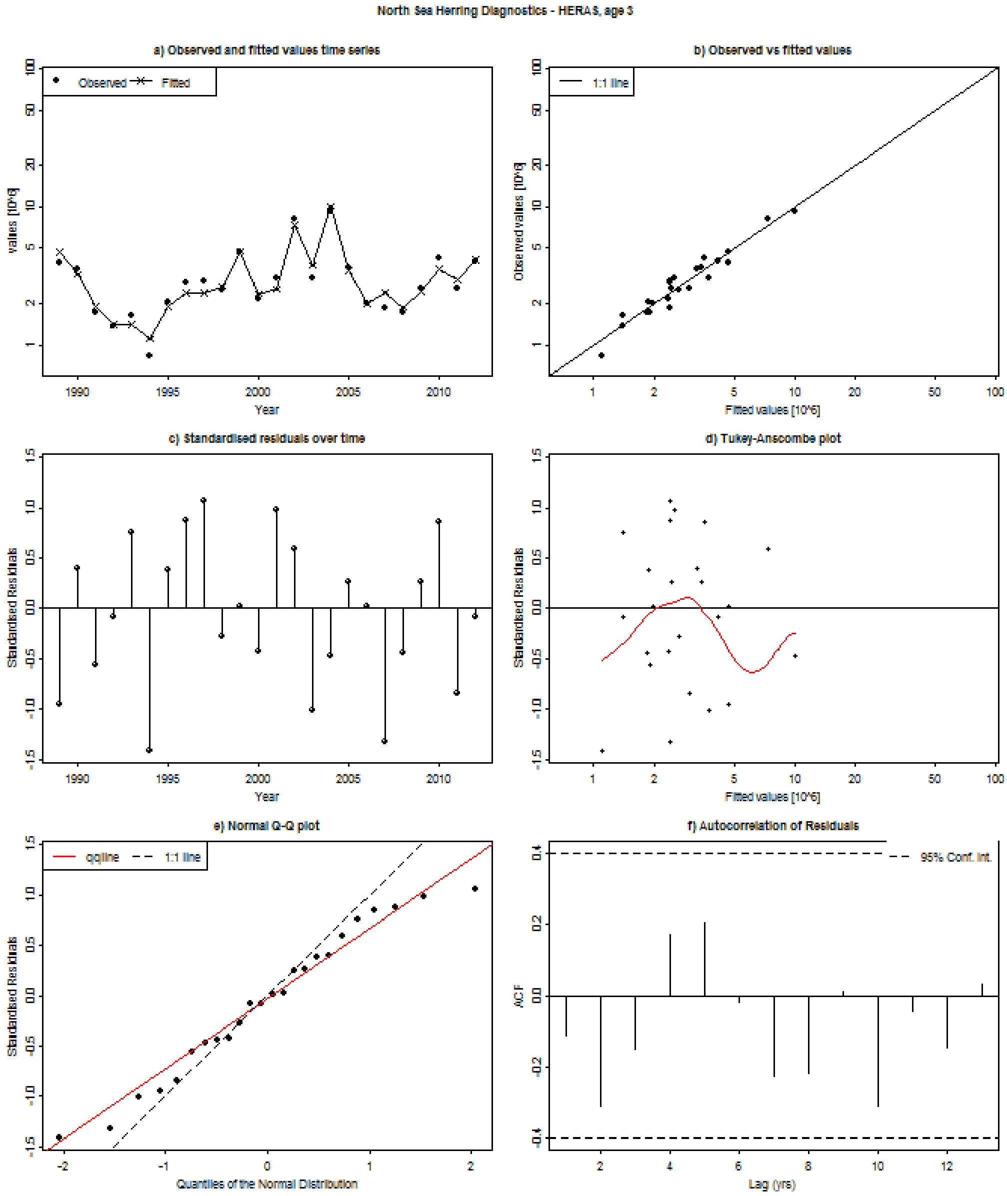


Figure 2.6.1.18. North Sea herring. Diagnostics of the assessment model fit to the HERAS index at age 3 wr time series. Top left: Estimates of numbers at 3 wr (line) and numbers predicted from index abundance at 3 wr. Top right: scatterplot of index observations versus assessment model estimates of numbers at 3 wr with the best-fit catchability model (linear function). Middle right: index observation versus standardized residuals at 3 wr. Middle left: Time series of standardized residuals of the index at 3 wr. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation plot.

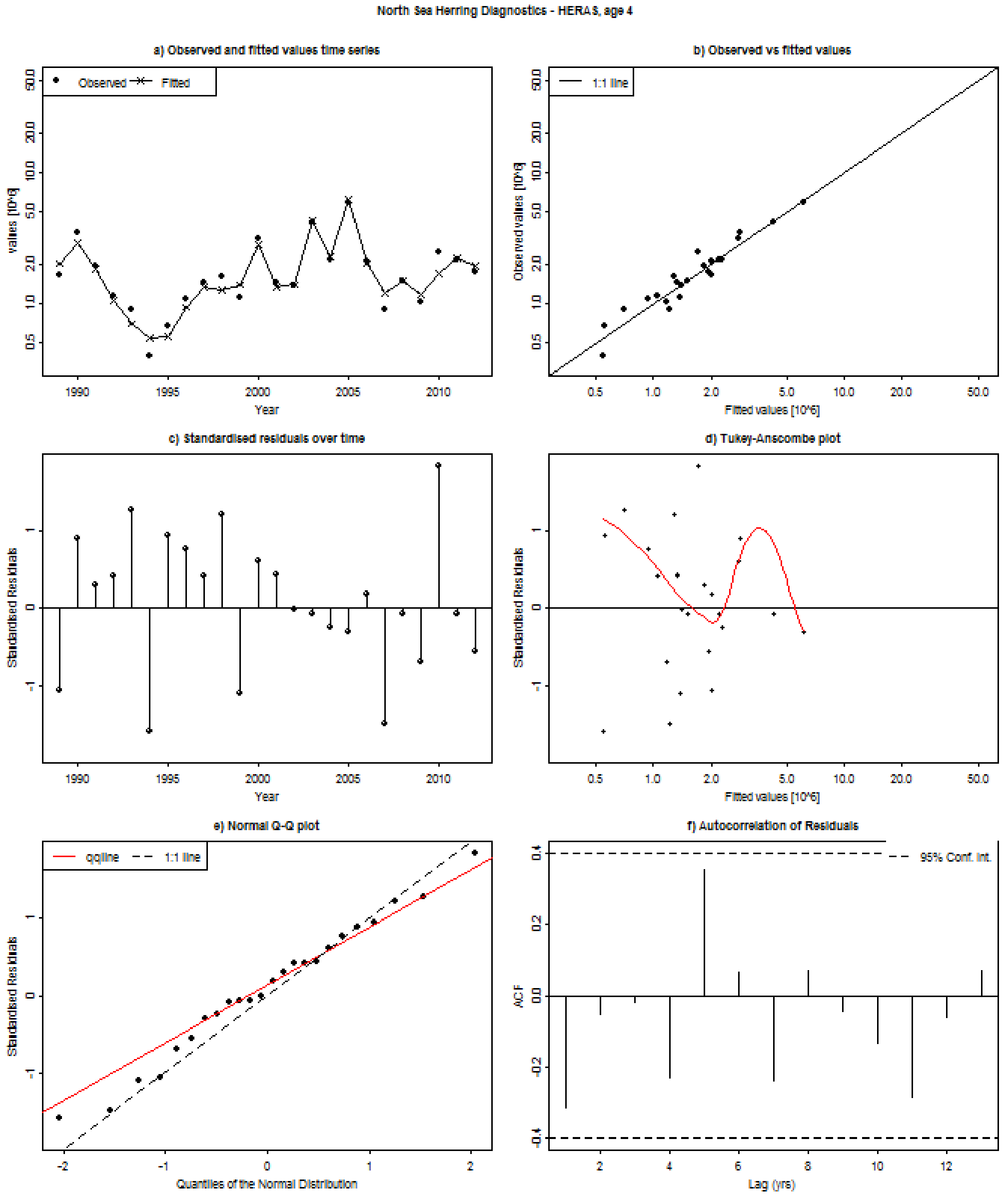


Figure 2.6.1.19. North Sea herring. Diagnostics of the assessment model fit to the HERAS index at age 4 wr time series. Top left: Estimates of numbers at 4 wr (line) and numbers predicted from index abundance at 4 wr. Top right: scatterplot of index observations versus assessment model estimates of numbers at 4 wr with the best-fit catchability model (linear function). Middle right: index observation versus standardized residuals at 4 wr. Middle left: Time series of standardized residuals of the index at 4 wr. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation plot.

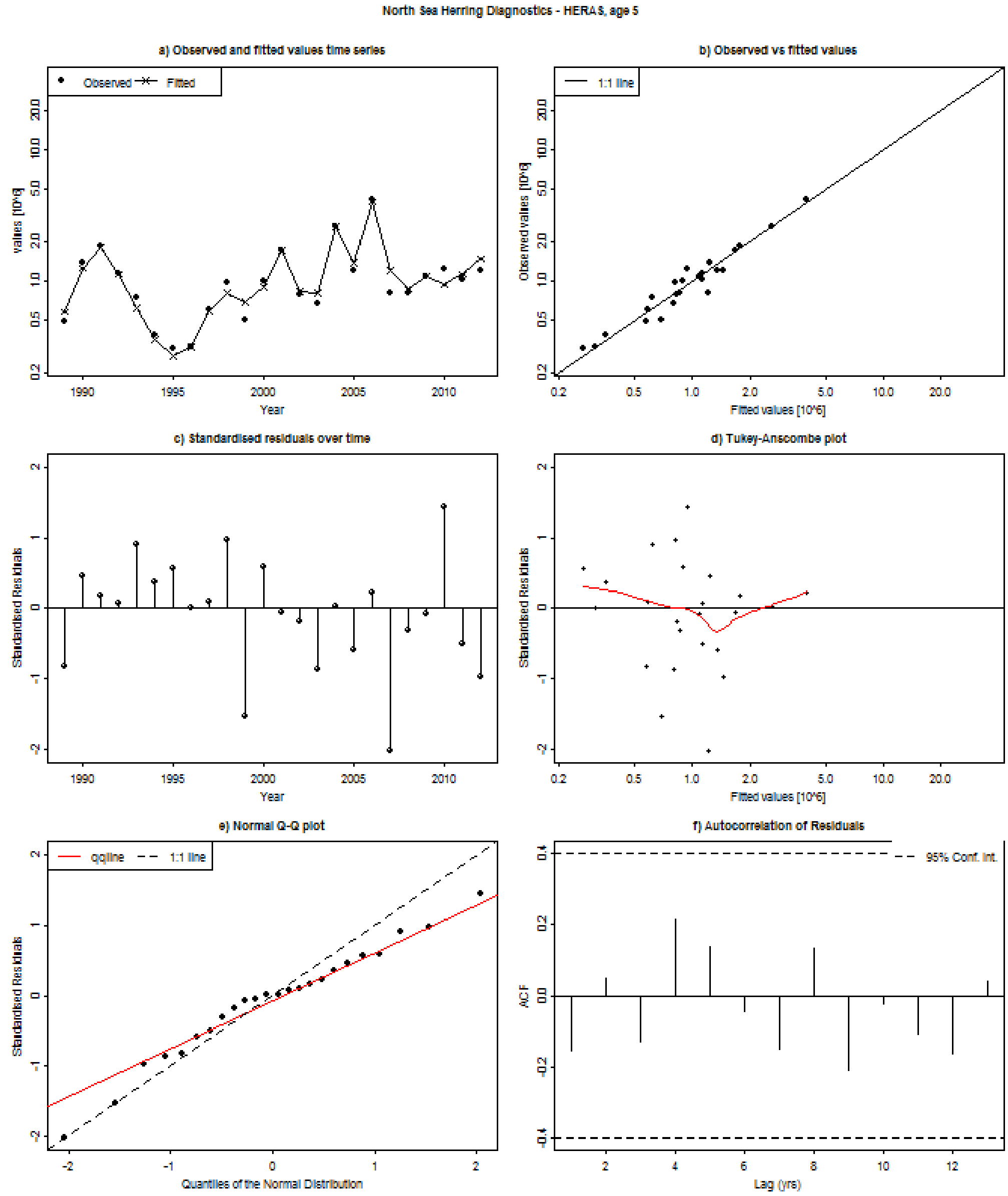


Figure 2.6.1.20. North Sea herring. Diagnostics of the assessment model fit to the HERAS index at age 5 wr time series. Top left: Estimates of numbers at 5 wr (line) and numbers predicted from index abundance at 5 wr. Top right: scatterplot of index observations versus assessment model estimates of numbers at 5 wr with the best-fit catchability model (linear function). Middle right: index observation versus standardized residuals at 5 wr. Middle left: Time series of standardized residuals of the index at 5 wr. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation plot.

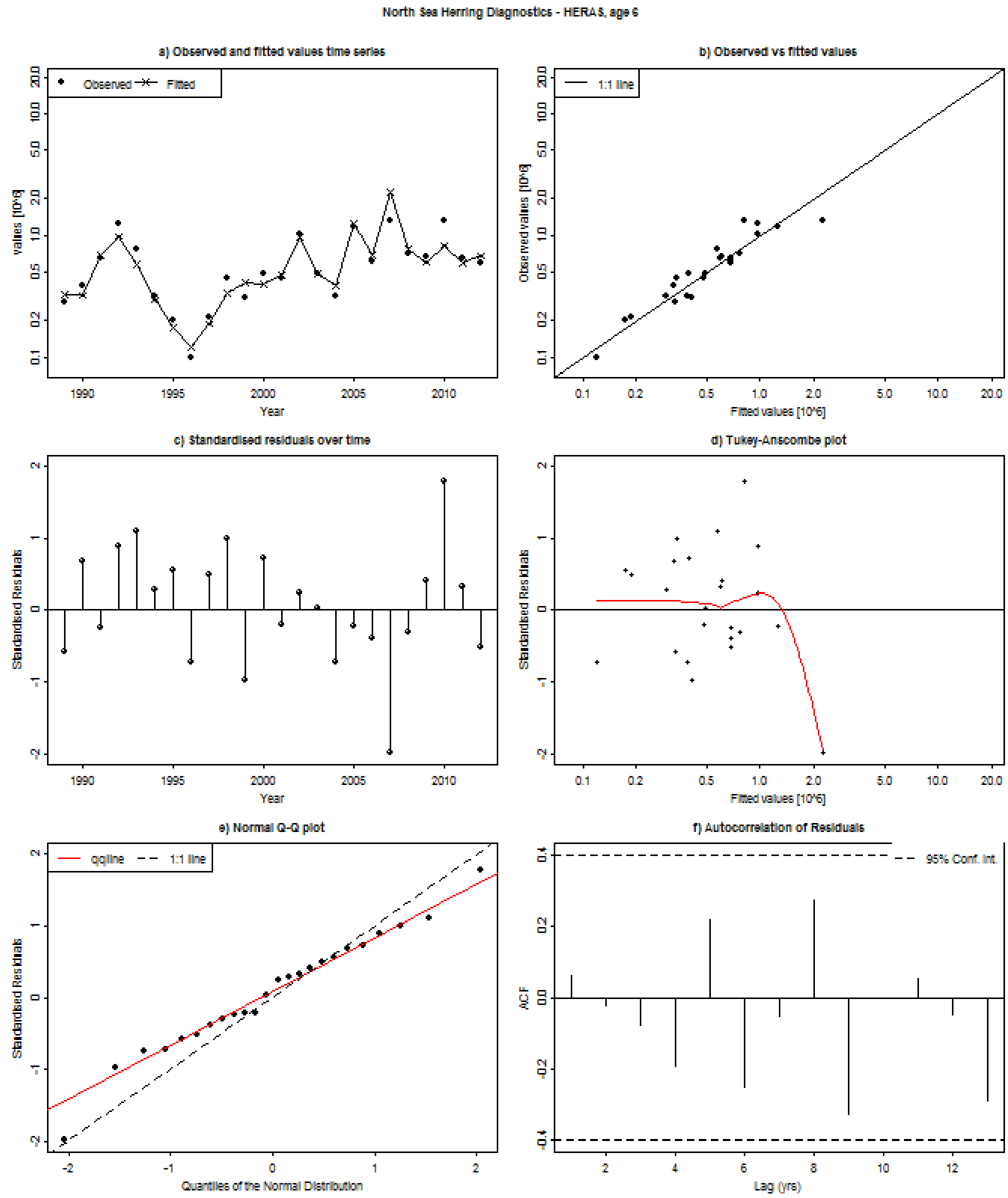


Figure 2.6.1.21. North Sea herring. Diagnostics of the assessment model fit to the HERAS index at age 6 wr time series. Top left: Estimates of numbers at 6 wr (line) and numbers predicted from index abundance at 6 wr. Top right: scatterplot of index observations versus assessment model estimates of numbers at 6 wr with the best-fit catchability model (linear function). Middle right: index observation versus standardized residuals at 6 wr. Middle left: Time series of standardized residuals of the index at 6 wr. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation plot.

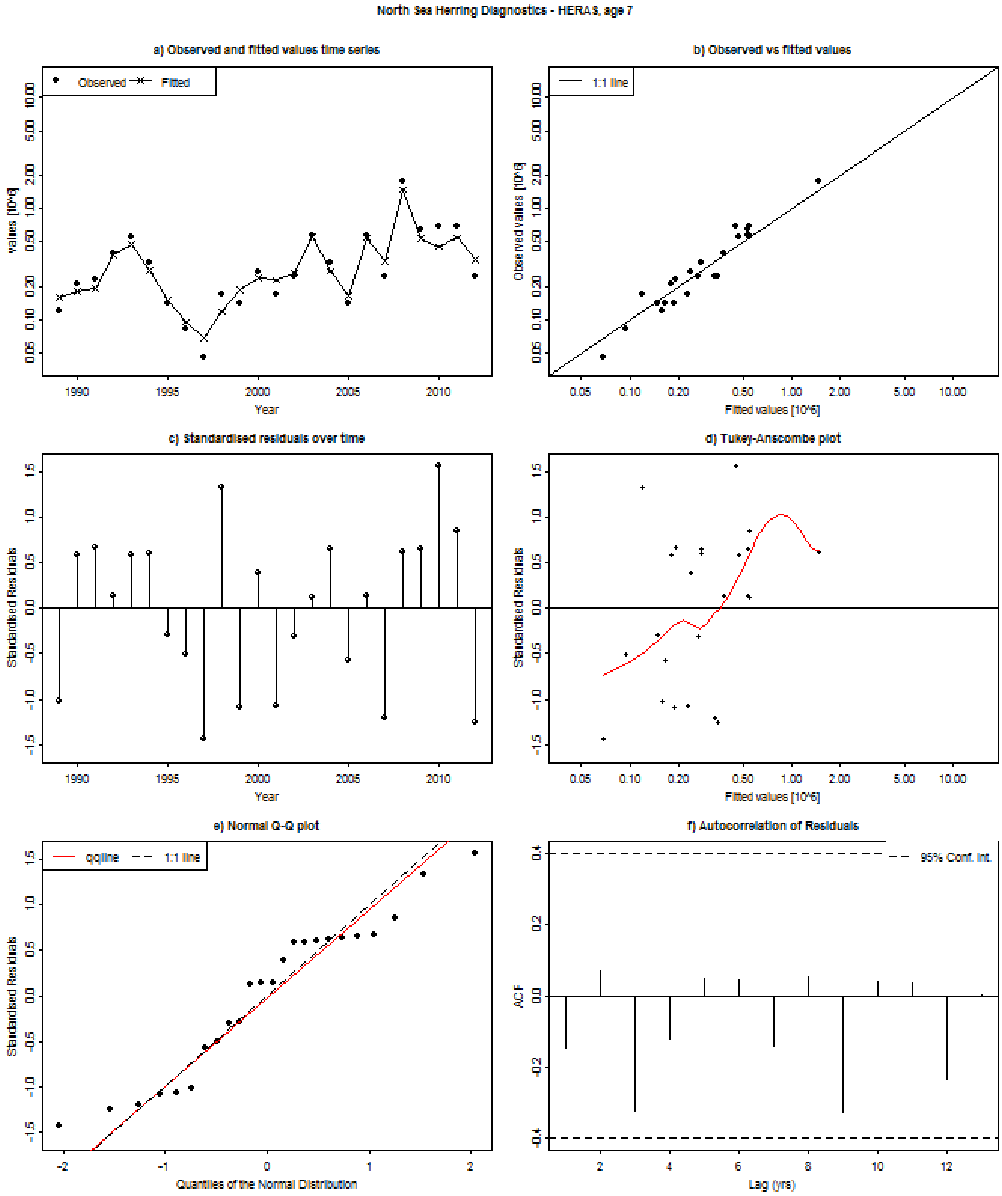


Figure 2.6.1.22. North Sea herring. Diagnostics of the assessment model fit to the HERAS index at age 7 wr time series. Top left: Estimates of numbers at 7 wr (line) and numbers predicted from index abundance at 7 wr. Top right: scatterplot of index observations versus assessment model estimates of numbers at 7 wr with the best-fit catchability model (linear function). Middle right: index observation versus standardized residuals at 7 wr. Middle left: Time series of standardized residuals of the index at 7 wr. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation plot.

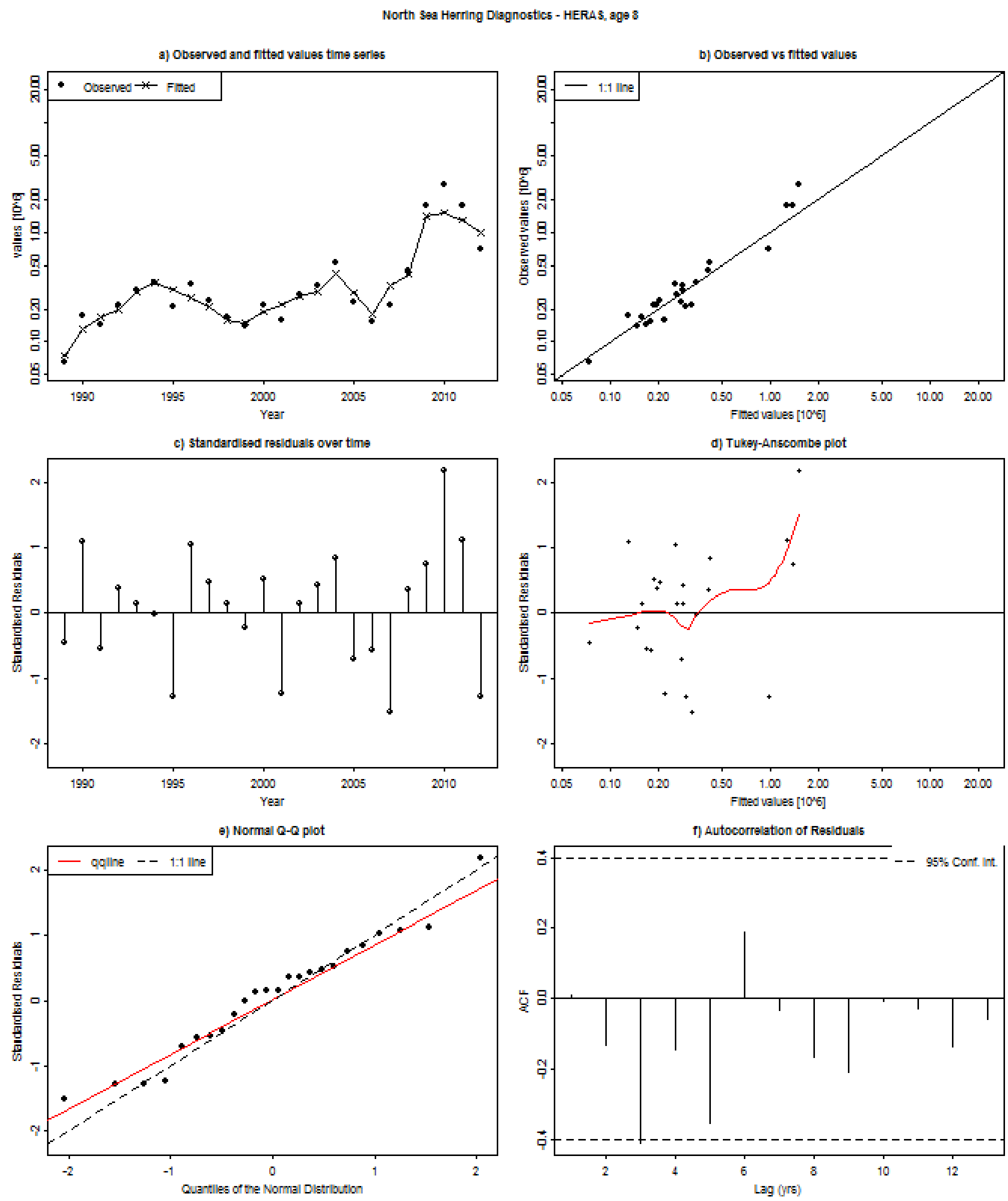


Figure 2.6.1.23. North Sea herring. Diagnostics of the assessment model fit to the HERAS index at age 8+ wr time series. Top left: Estimates of numbers at 8+ wr (line) and numbers predicted from index abundance at 8+ wr. Top right: scatterplot of index observations versus assessment model estimates of numbers at 8+ wr with the best-fit catchability model (linear function). Middle right: index observation versus standardized residuals at 8+ wr. Middle left: Time series of standardized residuals of the index at 8+ wr. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation plot.

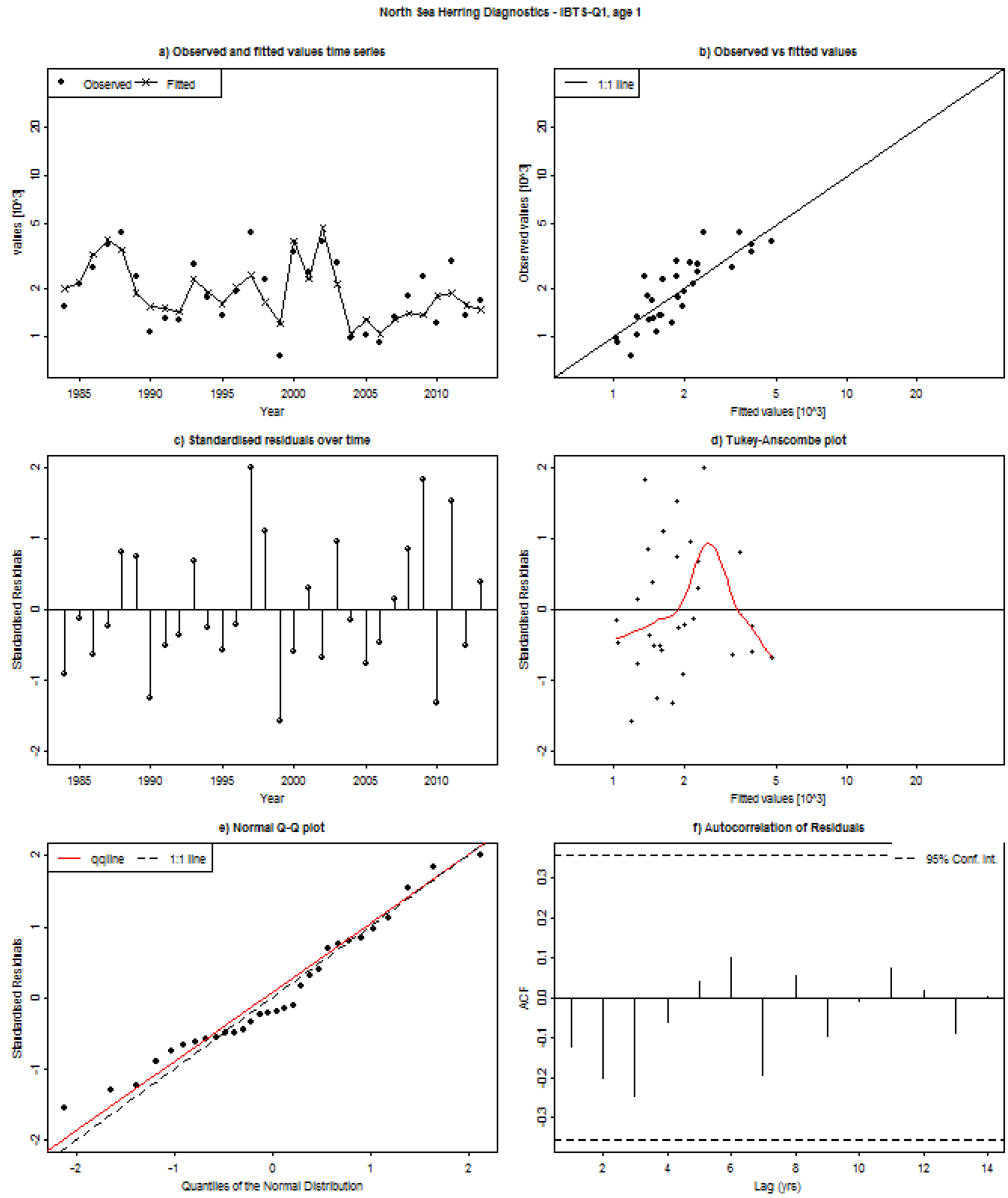


Figure 2.6.1.24. North Sea herring. Diagnostics of the assessment model fit to the IBTS-Q1 index at age 1 wr time series. Top left: Estimates of numbers at 1 wr (line) and numbers predicted from index abundance at 1 wr. Top right: scatterplot of index observations versus assessment model estimates of numbers at 1 wr with the best-fit catchability model (linear function). Middle right: index observation versus standardized residuals at 1 wr. Middle left: Time series of standardized residuals of the index at 1 wr. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation plot.

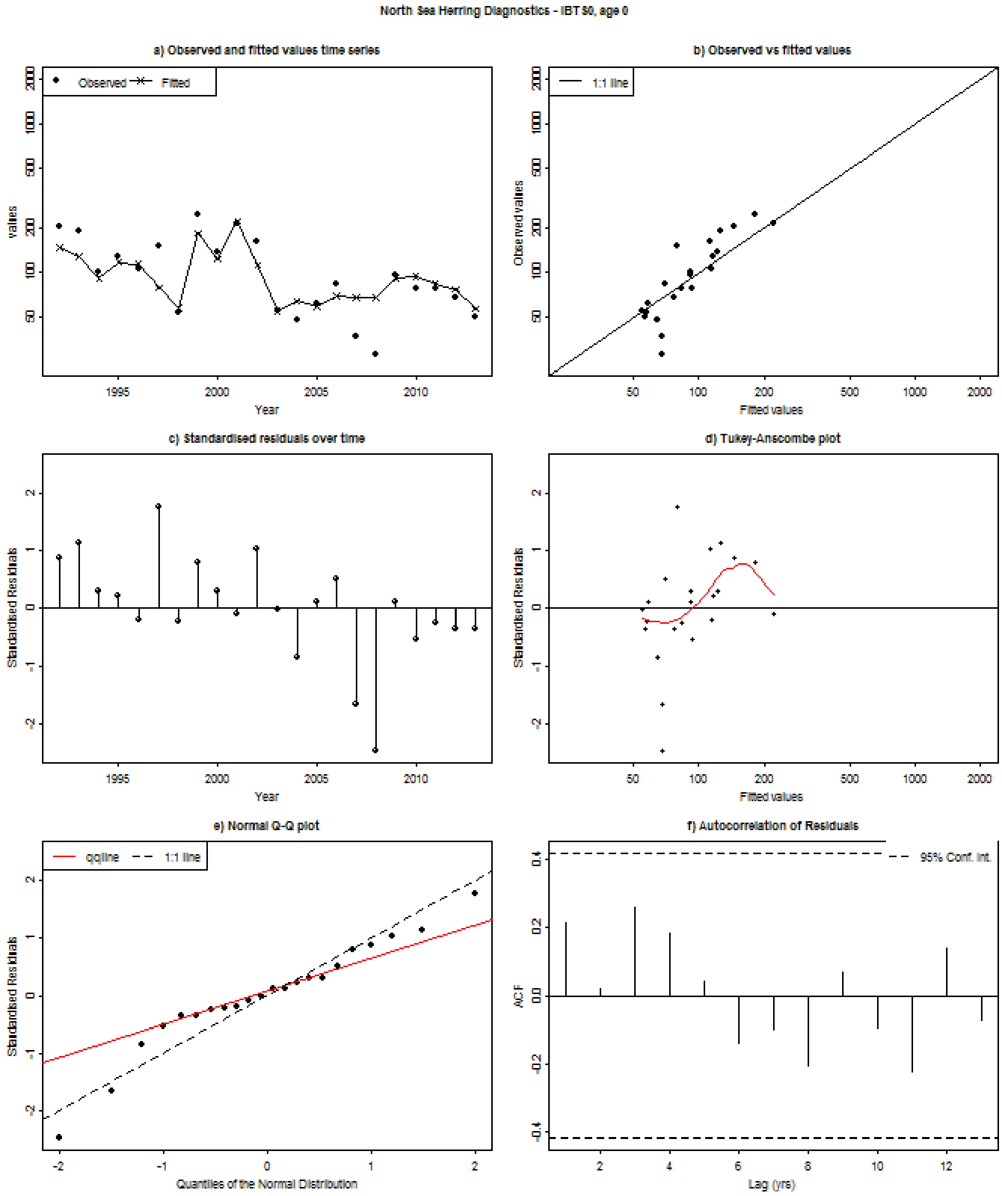


Figure 2.6.1.25. North Sea herring. Diagnostics of the assessment model fit to the IBTS0 index at age 0 wr time series. Top left: Estimates of numbers at 0 wr (line) and numbers predicted from index abundance at 0 wr. Top right: scatterplot of index observations versus assessment model estimates of numbers at 0 wr with the best-fit catchability model (linear function). Middle right: index observation versus standardized residuals at 0 wr. Middle left: Time series of standardized residuals of the index at 0 wr. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation plot.

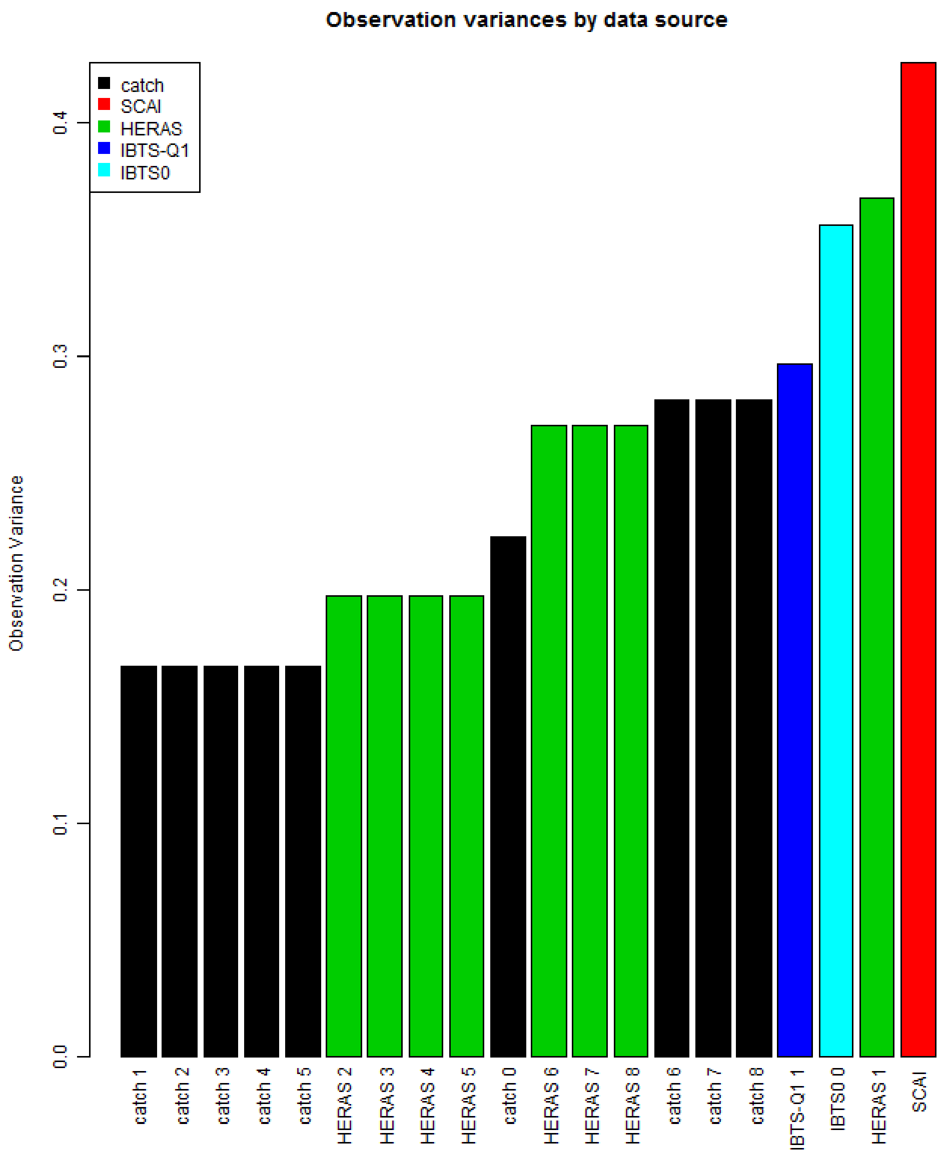


Figure 2.6.1.26. North Sea herring. Observation variance by data source as estimated by the assessment model. Observation variance is ordered from least (left) to most (right). Colours indicate the different data sources. Observation variance is not individually estimated for each data source individually thereby reducing the parameters needed to be estimated in the assessment model. In these cases of parameter bindings, observation variances have equal values.

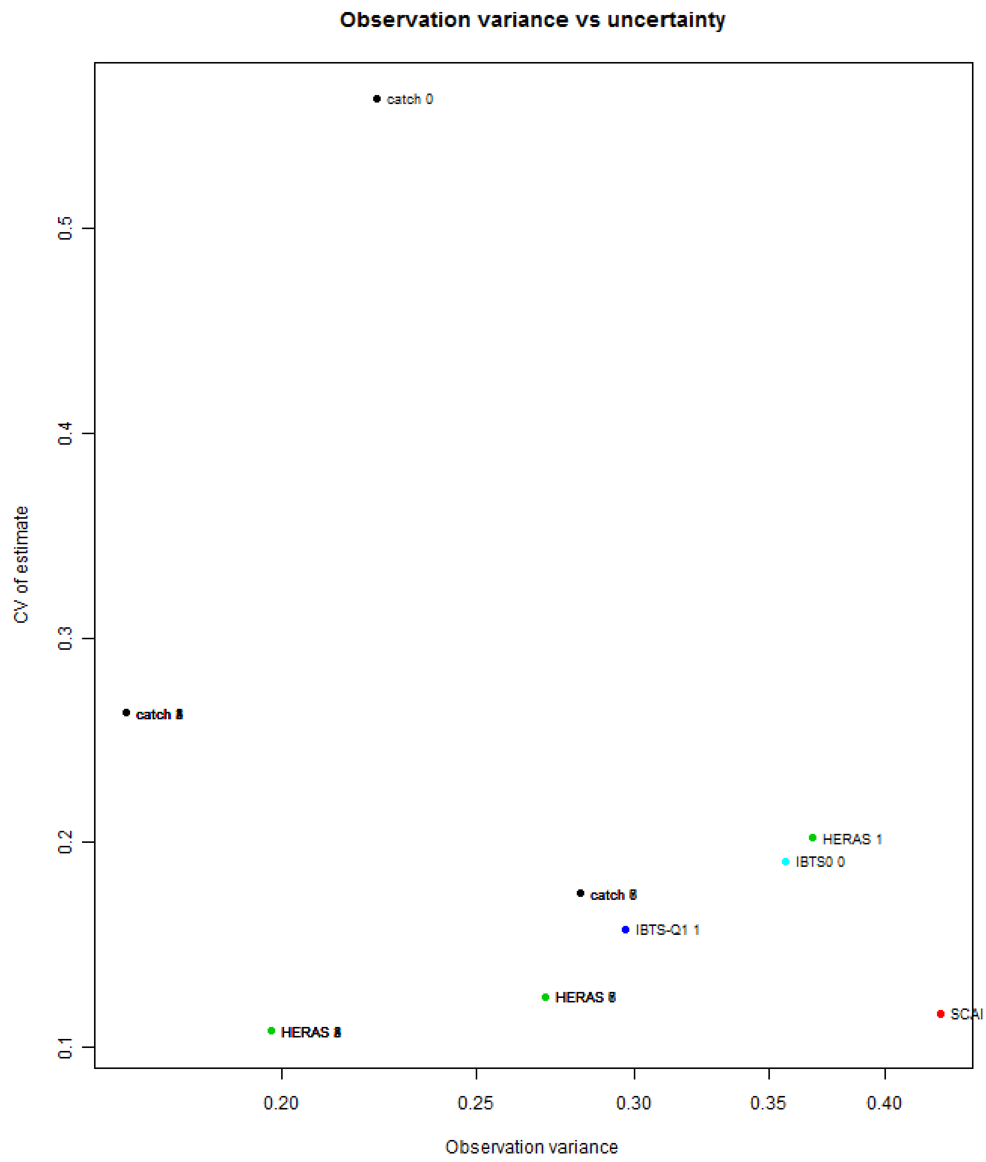


Figure 2.6.1.27. North Sea herring. Observation variance by data source as estimated by the assessment model plotted against the CV estimate of the observation variance parameter.

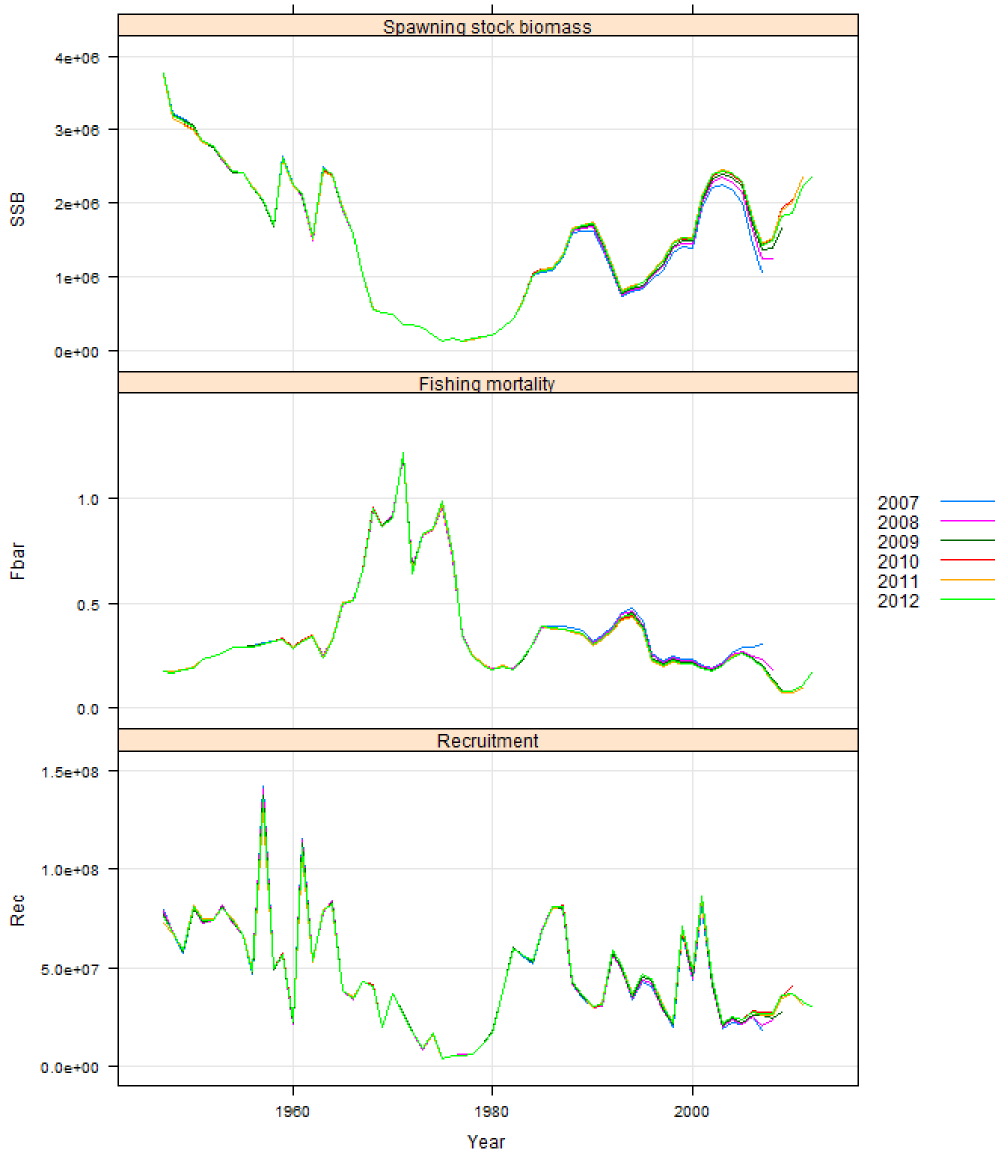


Figure 2.6.1.28. North Sea herring. Retrospective pattern of SSB (top panel) F (middle panel) and recruitment (bottom panel) for the assessments with respectively terminal years in 2012 to 2002.

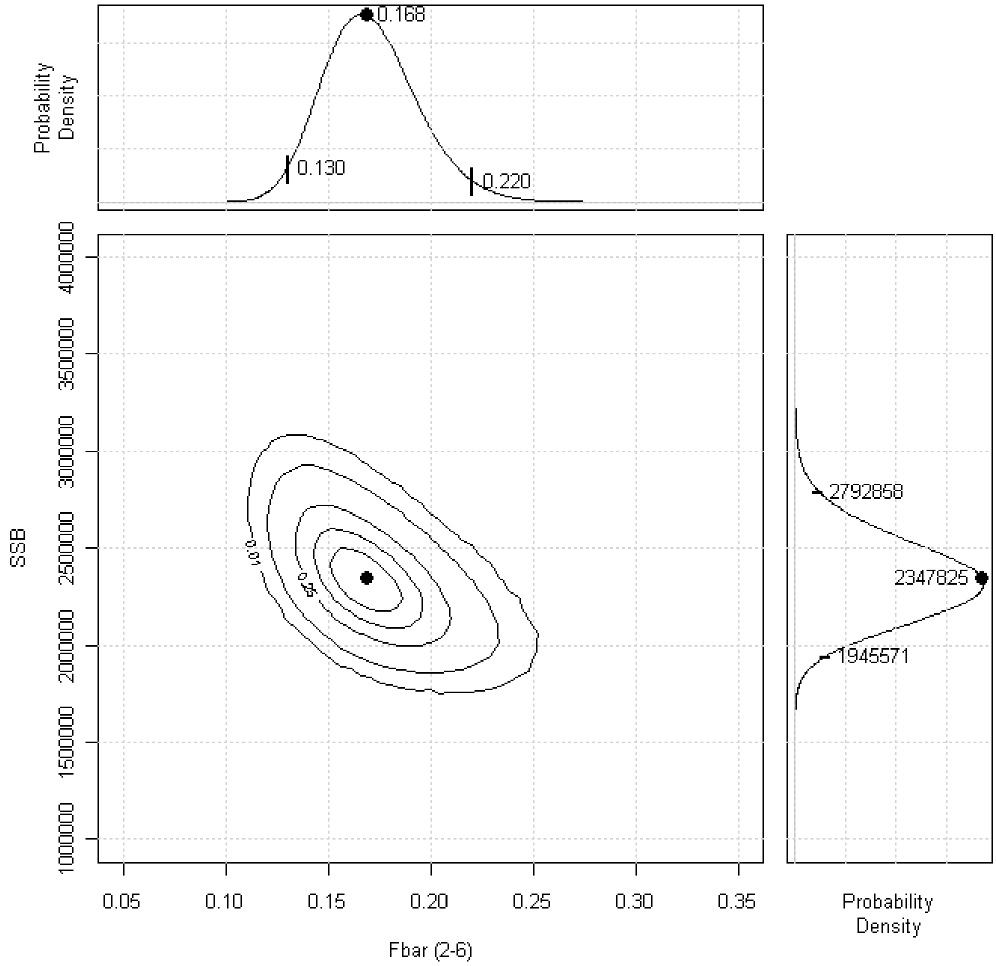


Figure 2.6.1.29. North Sea herring. Model uncertainty; distribution and quantiles of estimated SSB and F2-6 in the terminal year of the assessment. Estimates of precision are based on a parametric bootstrap from the FLSAM estimated variance / covariance estimates from the model.

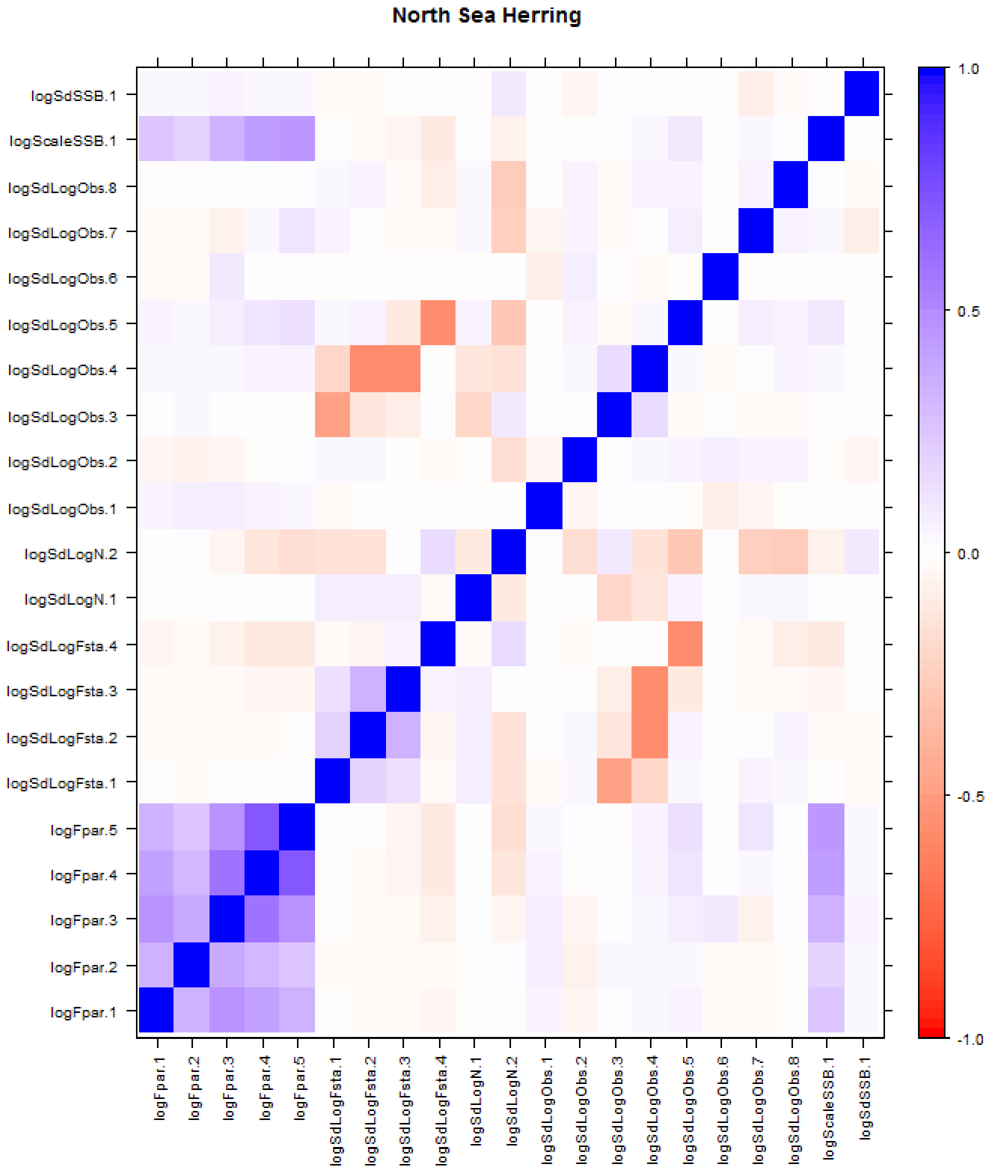


Figure 2.6.1.30. North Sea herring. Correlation plot of the FLSAM assessment model with the final set of parameters estimated in the model. The diagonal represents the correlation with the data source itself.

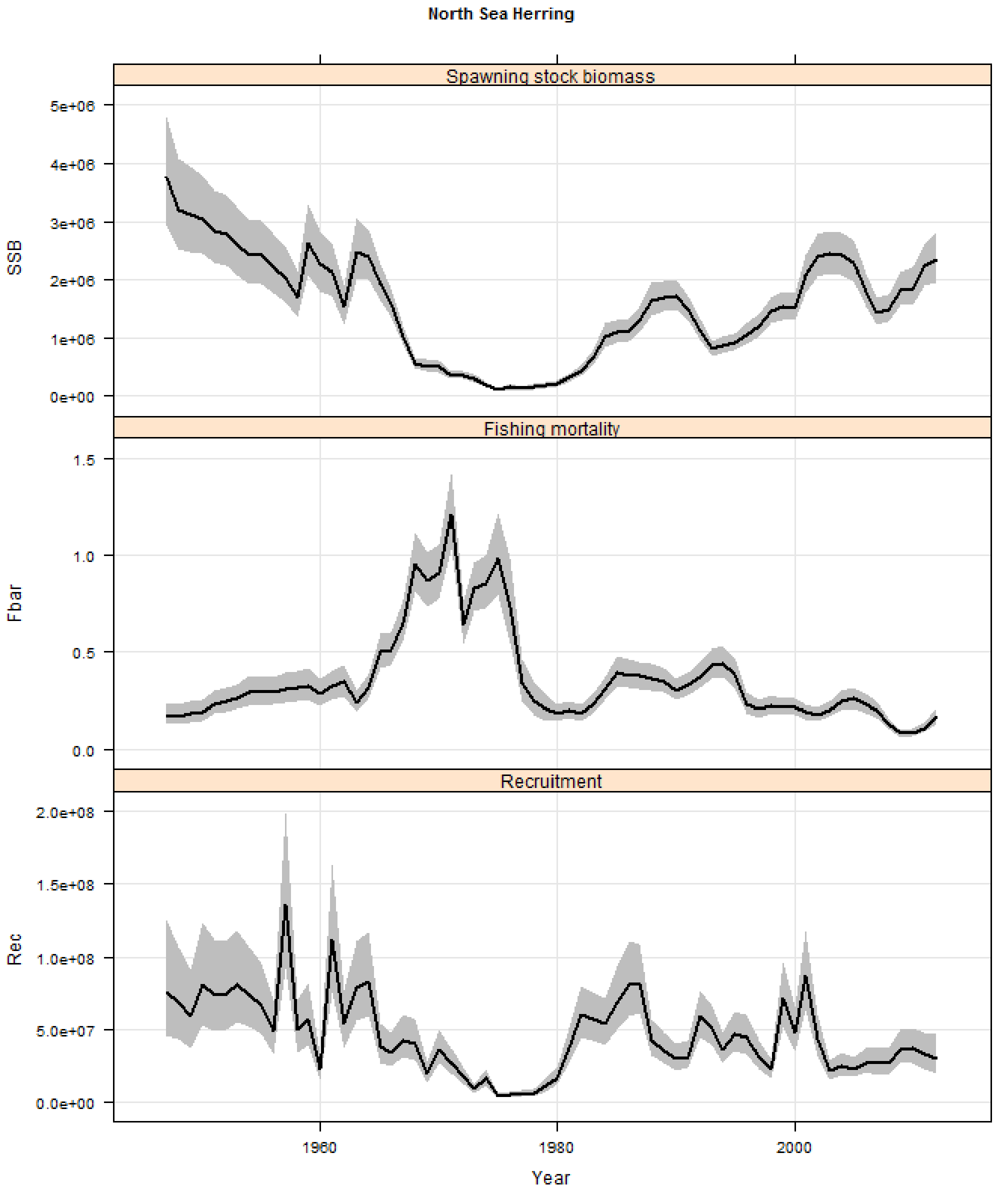


Figure 2.6.3.1 North Sea herring. Stock summary plot of North Sea herring with associated uncertainty for SSB (top panel), F ages 2-6 (middle panel) and recruitment (bottom panel).

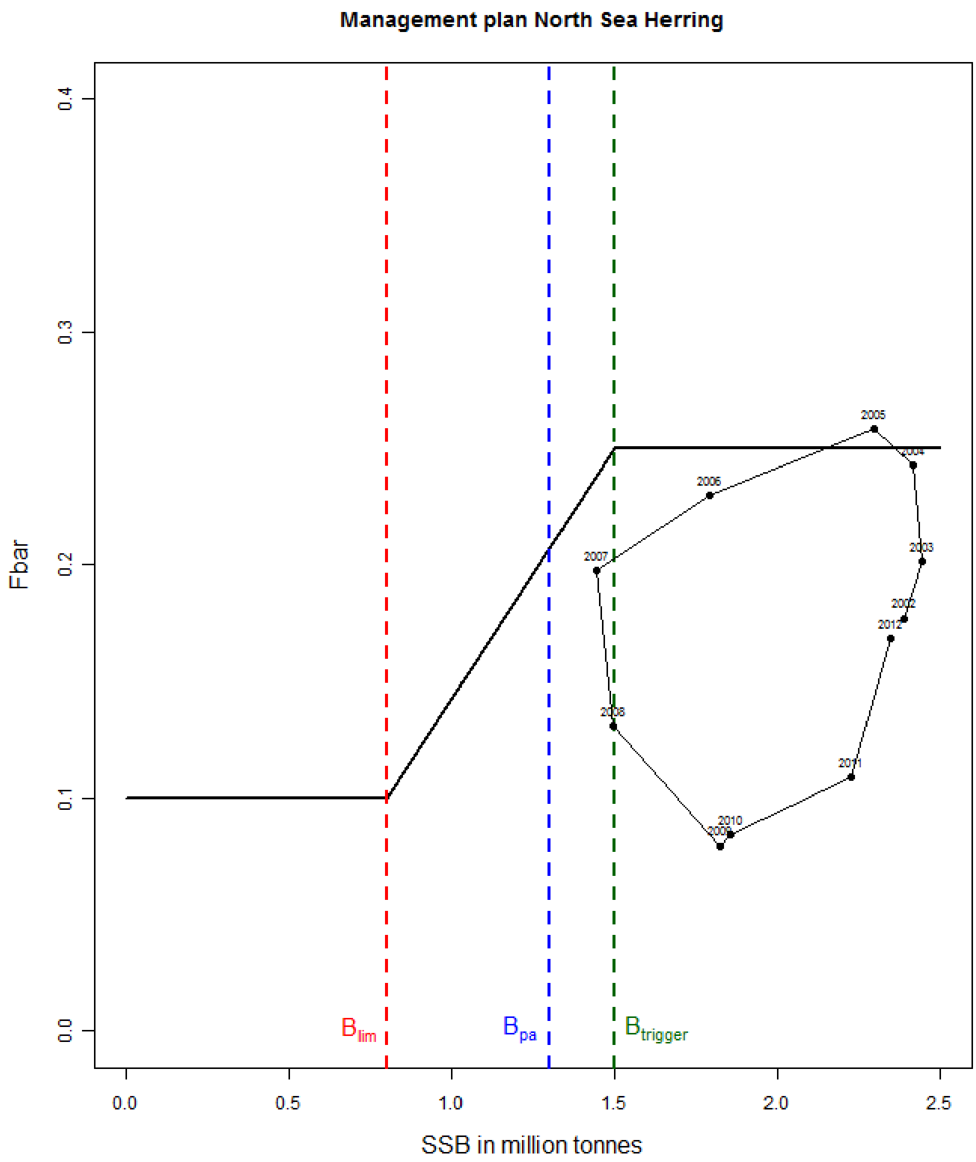


Figure 2.6.3.2. North Sea herring. Agreed management plan for North Sea herring including the most recent 10 years of SSB and F as estimated within the assessment in relation with the management plan.

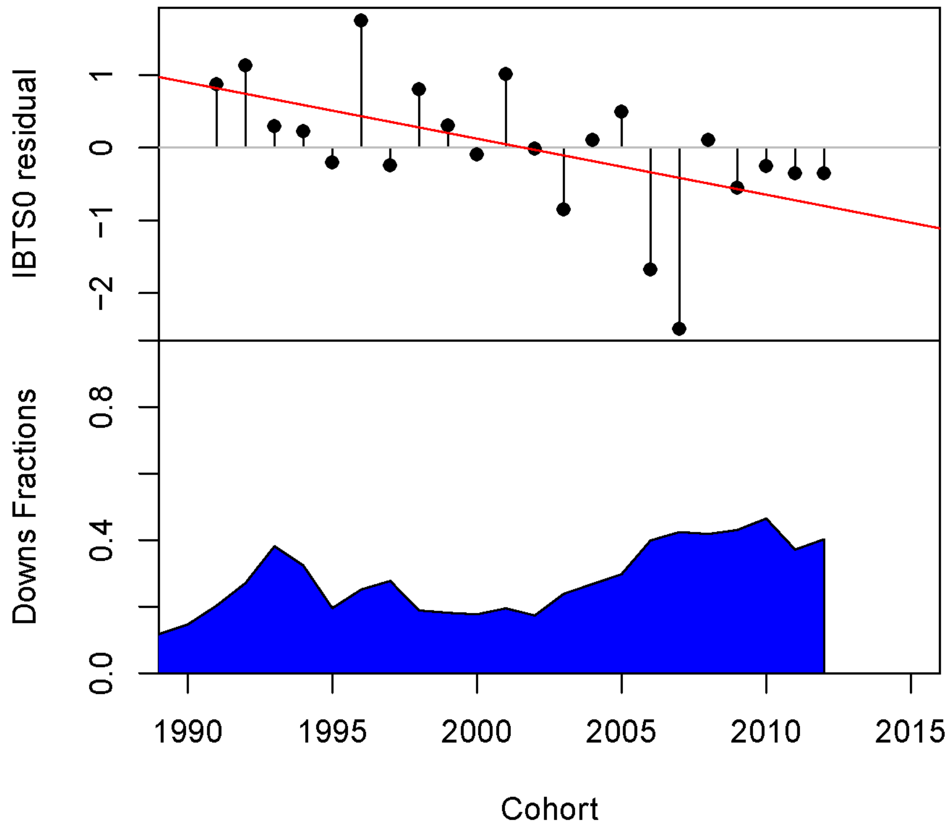


Figure 2.10.1 North Sea Autumn Spawning Herring. Upper panel: IBTS0 residuals from the SAM model as a function of time. Red line plots a trend line fitted to the residuals. Lower panel: Proportion of the stock contained in the Downs component. In both cases, time is represented by the corresponding cohort, on the common lower axis.

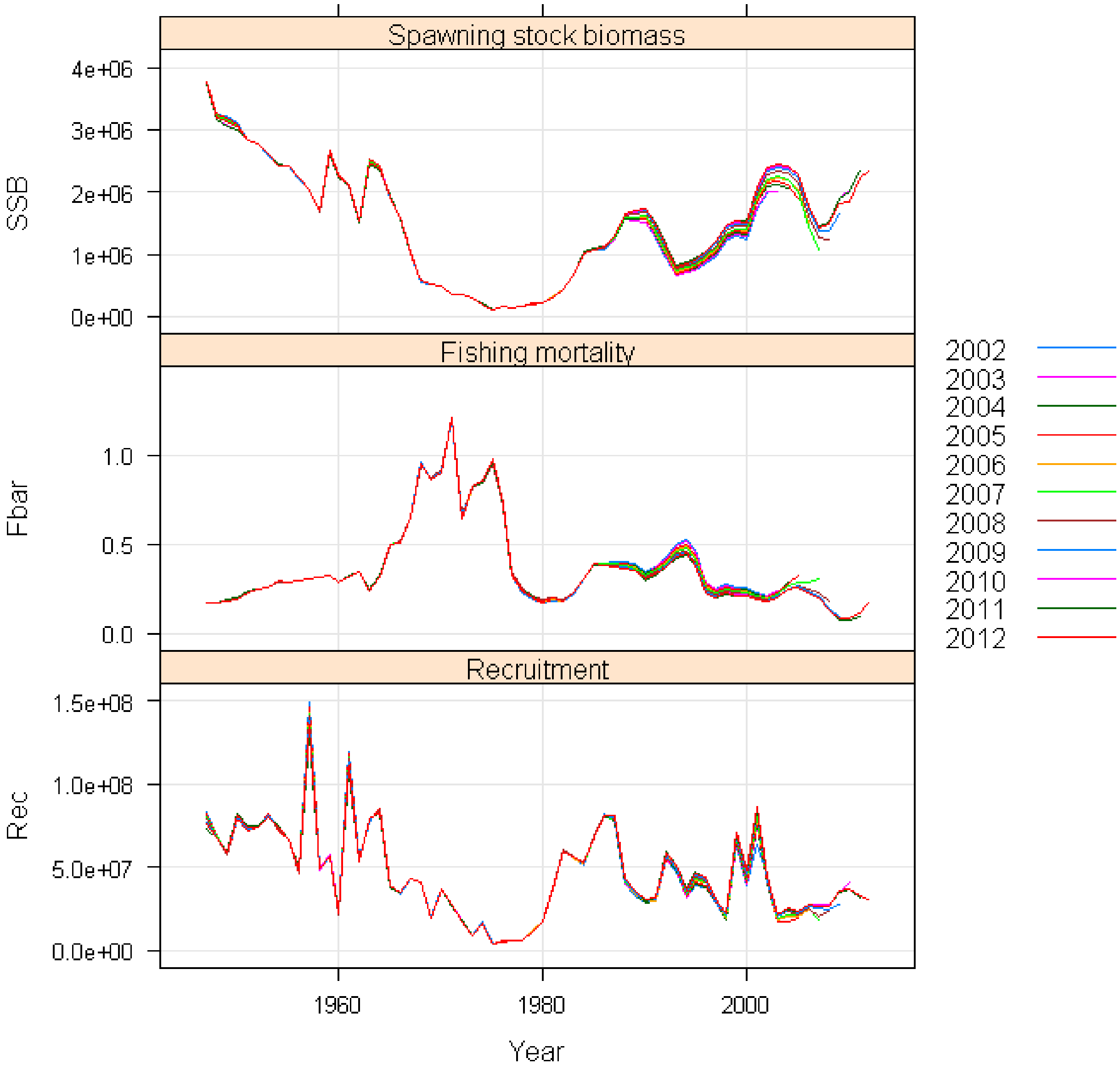


Figure 2.10.2 North Sea Autumn Spawning Herring. Analytical retrospective of the estimated spawning stock biomass, fishing mortality and recruitment as estimated over the year 2001 – 2012.

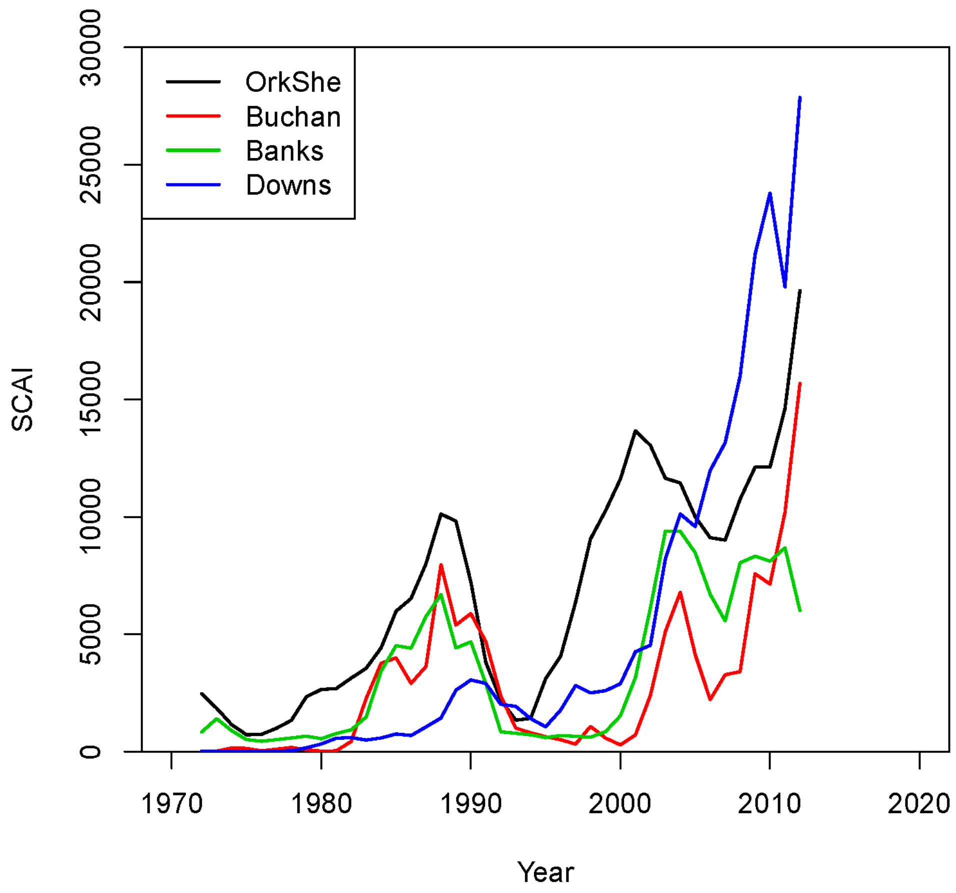


Figure 2.11.1 : North Sea herring. SCAI indices for the individual North Sea spawning components.

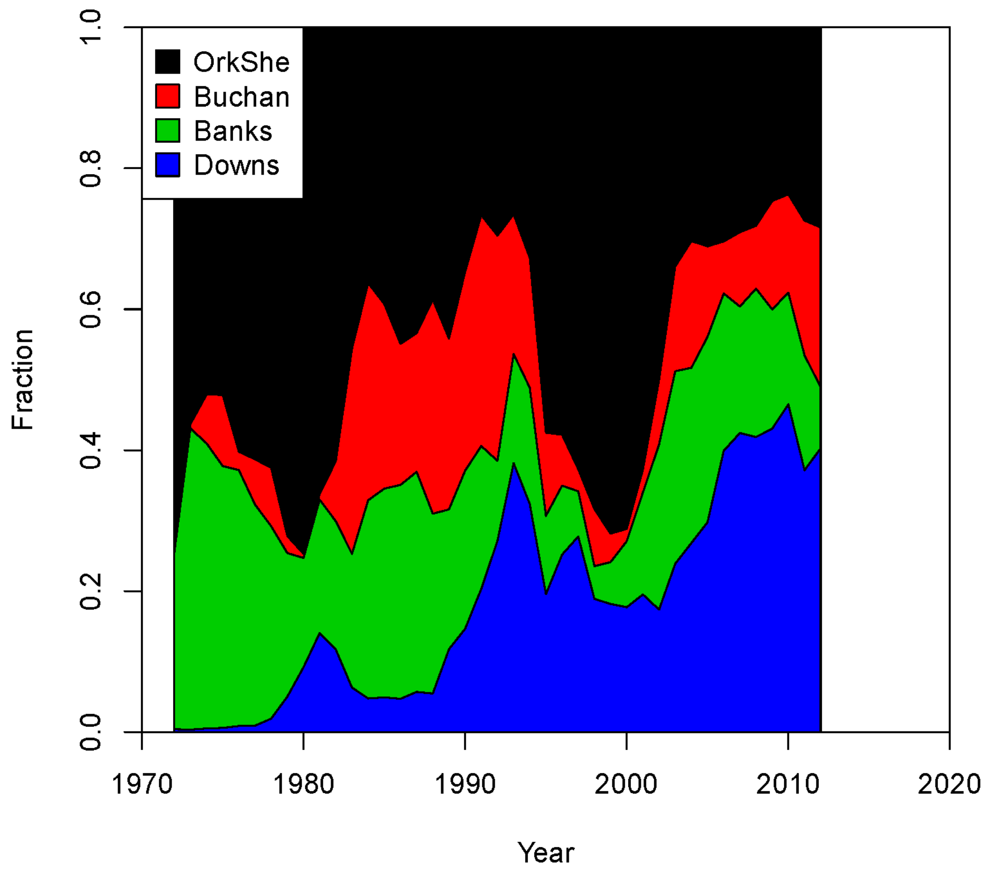


Figure 2.11.2 : North Sea herring. Time-series of the contribution of each spawning component to the total stock, as estimated from the SCAI index (Payne, 2010). Areas are arranged from top to bottom according to the north-to-south arrangement of the components. Black: Orkney–Shetland component. Red: Buchan component. Green: Banks component. Blue: Downs component.

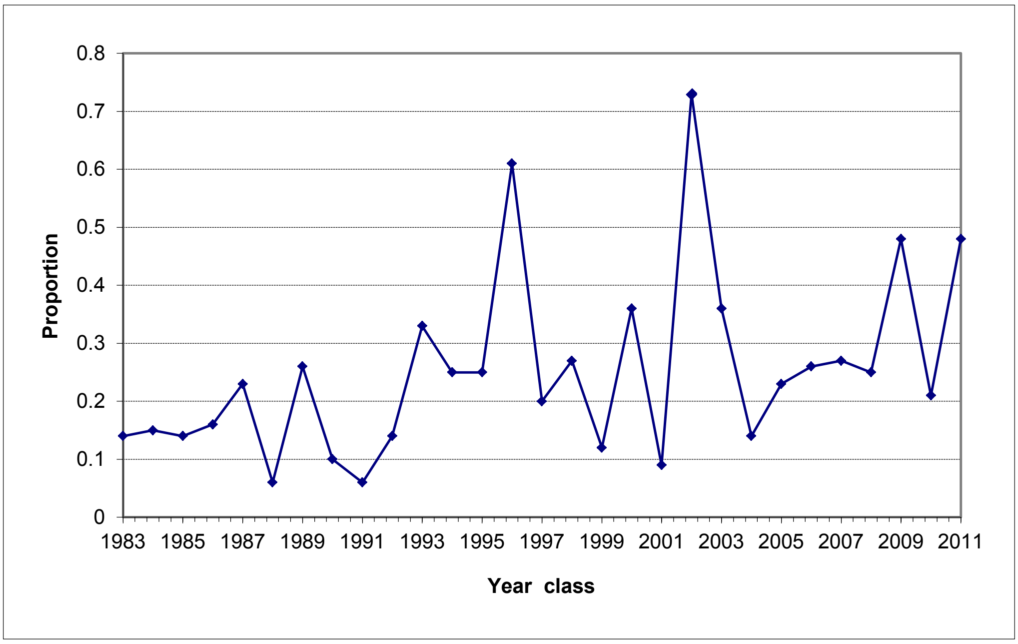


Figure 2.11.3. North Sea herring. Proportion of small 1-ringers versus all sizes in the North sea (from Table 2.3.3.2).

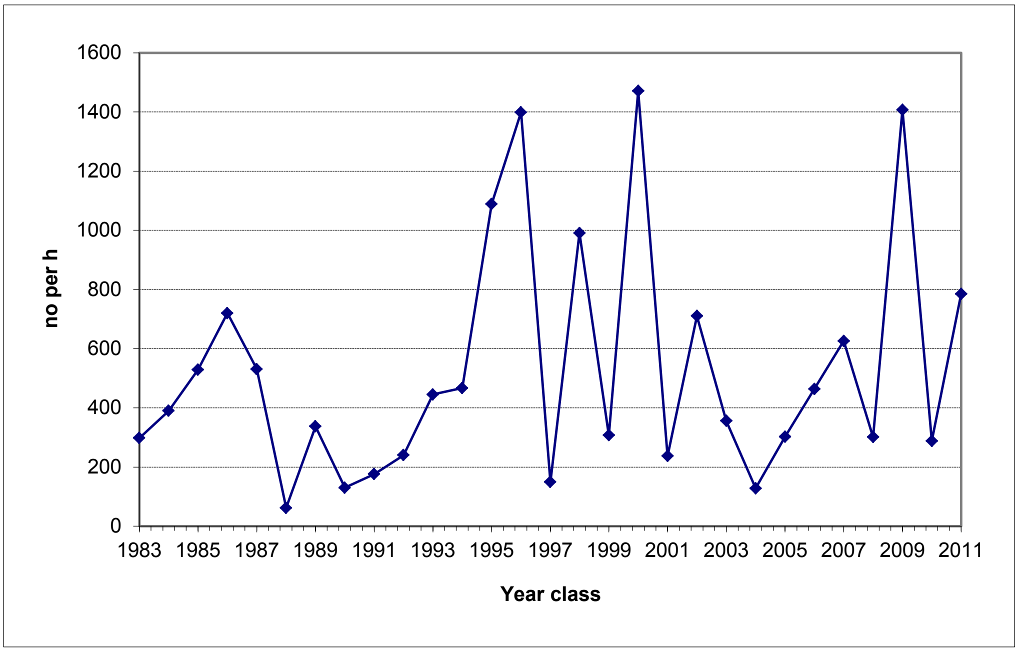


Figure 2.11.4. North Sea herring. Index (Numbers per hr) of small (<13cm) 1-ringers in the North from Table 2.3.3.2).

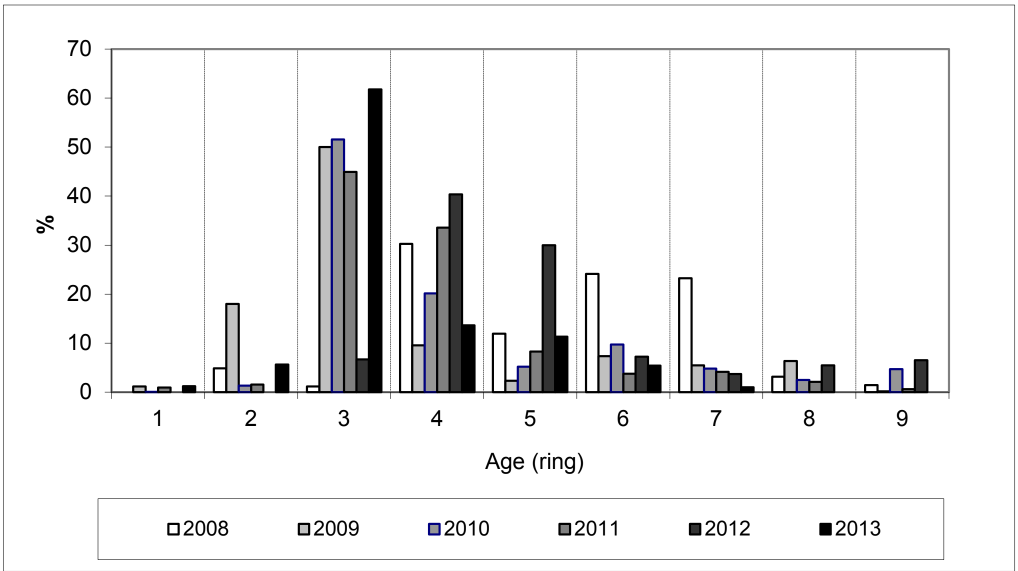


Figure 2.11.5. North Sea herring. Catch composition (percentage by age) from hauls (pelagics and bottom trawls) in the Eastern English Channel during IBTS 2008 to 2013.

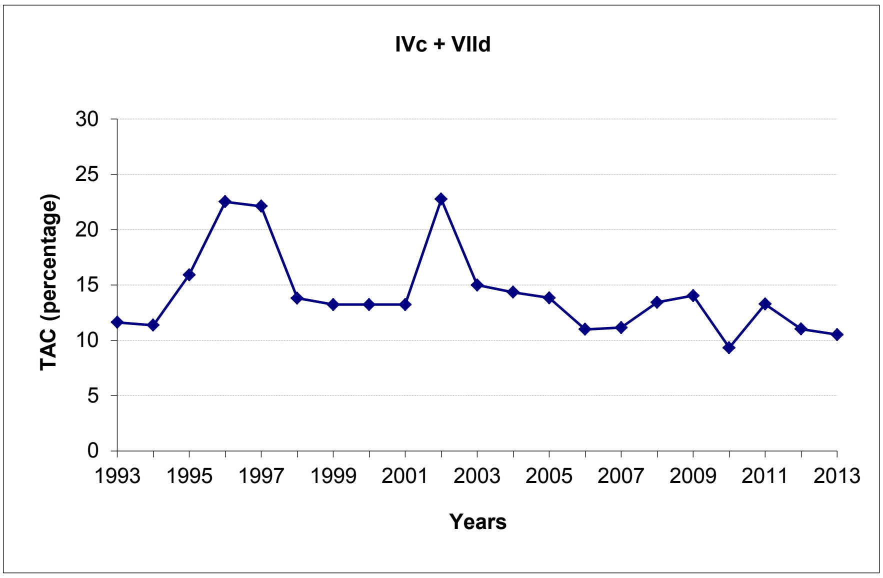


Figure 2.11.6. North Sea herring. TACs (percentage) for divisions IVc and VIId

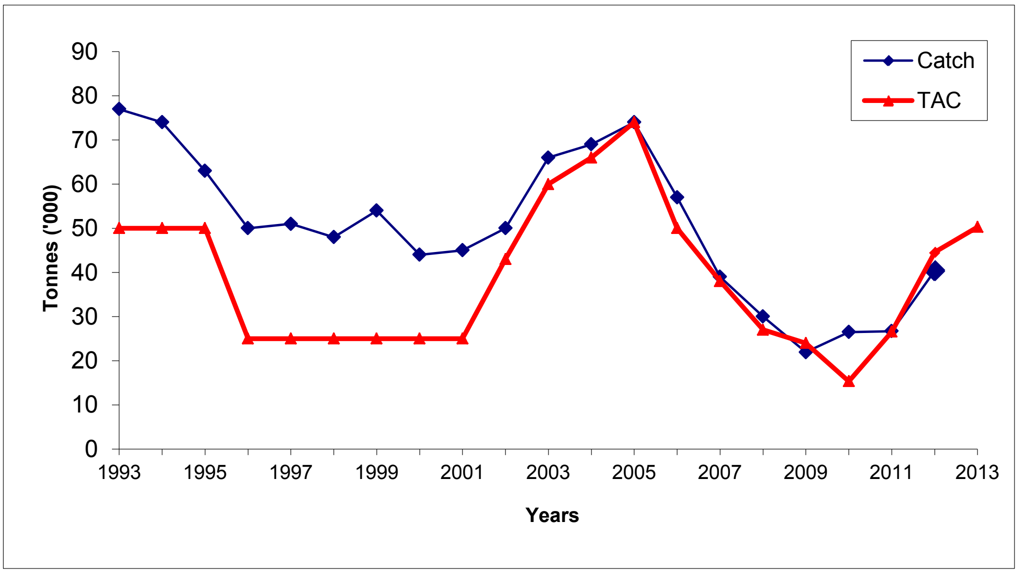


Figure 2.11.7. North Sea herring. Downs herring in IVc and VIId. Comparison of historical catches and TACs.

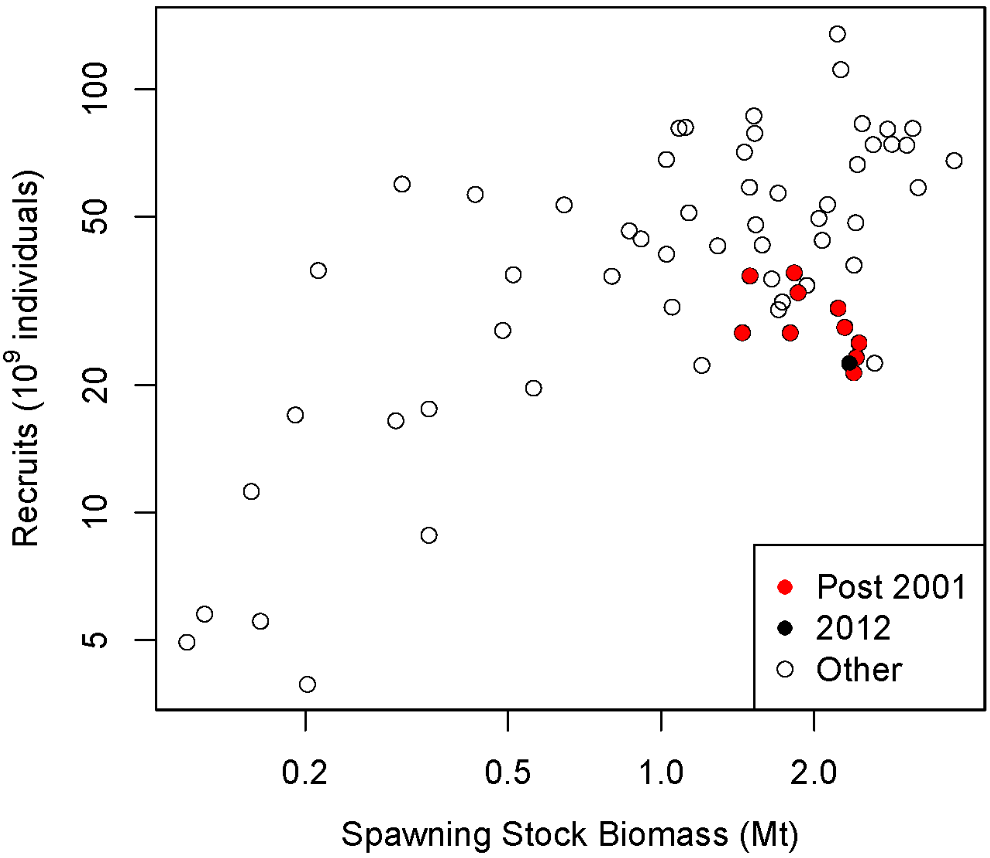


Figure 2.14.1. North Sea Autumn Spawning Herring. Stock recruitment curve, plotting estimated spawning stock biomass against the resulting recruitment. Year classes spawned after 2001 are plotted with fill red circles, to highlight the years of recent poor recruitment. The most recent year class is plotted in black. Note the logarithmic scaling on both axes.

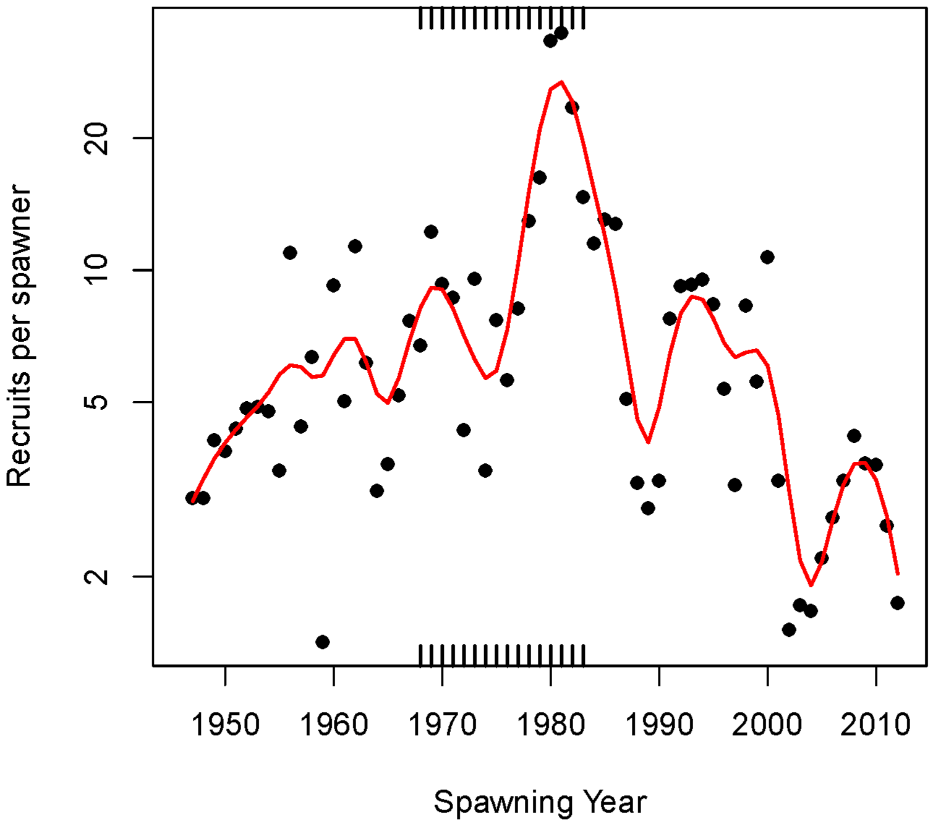


Figure 2.14.2. North Sea Autumn Spawning Herring. Time series of recruits per spawner (RPS). RPS is calculated as the estimated number of recruits from the assessment divided by the estimated number of mature fish at the time of spawning and is plotted against the year in which spawning occurred.. Black points: RPS in a given year. Red line: Spline smoother to aid visual interpretation. Internal tick marks on the horizontal axes indicate years when the spawning stock biomass is estimated as being below B_{lim} (800 000 tonnes). Note the logarithmic scale on the vertical axis.

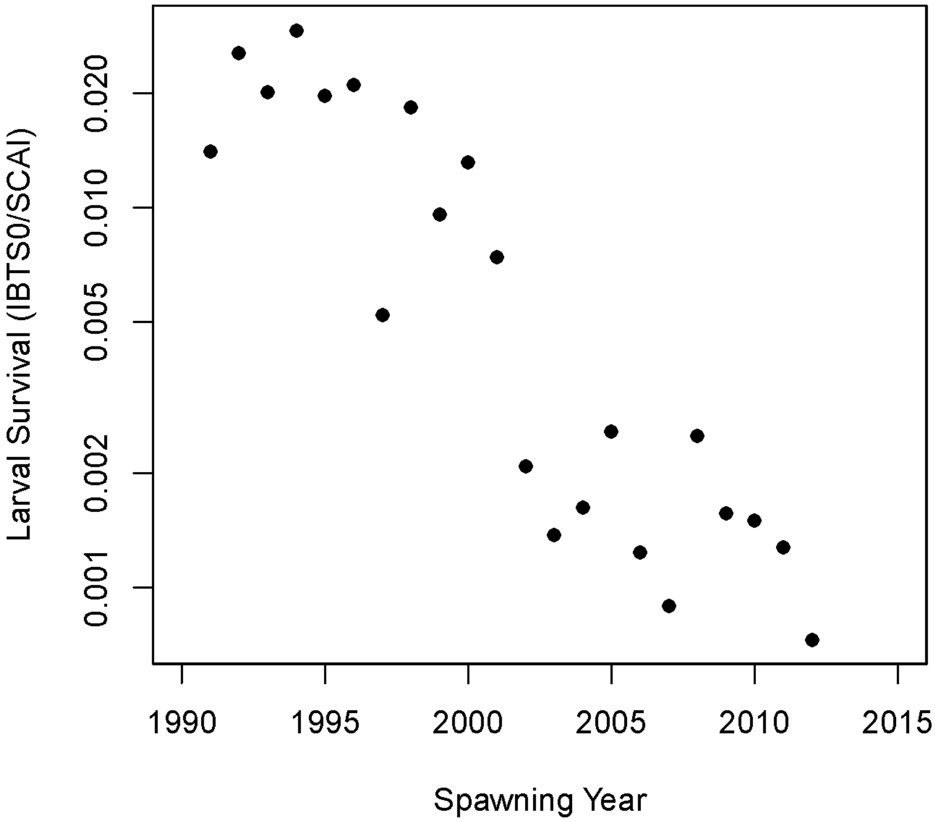


Figure 2.14.3. North Sea Autumn Spawning Herring. Time series of larval survival ratio (Dickey-Collas & Nash 2005; Payne et al 2009), defined as the ratio of the SCAI index (representing larvae less than 10-11mm) and the IBTS0 index (representing the late larvae, of approximately 20-30mm). Survival ratio is plotted against the year in which the larvae are spawned. Note the logarithmic scale on the vertical axis.

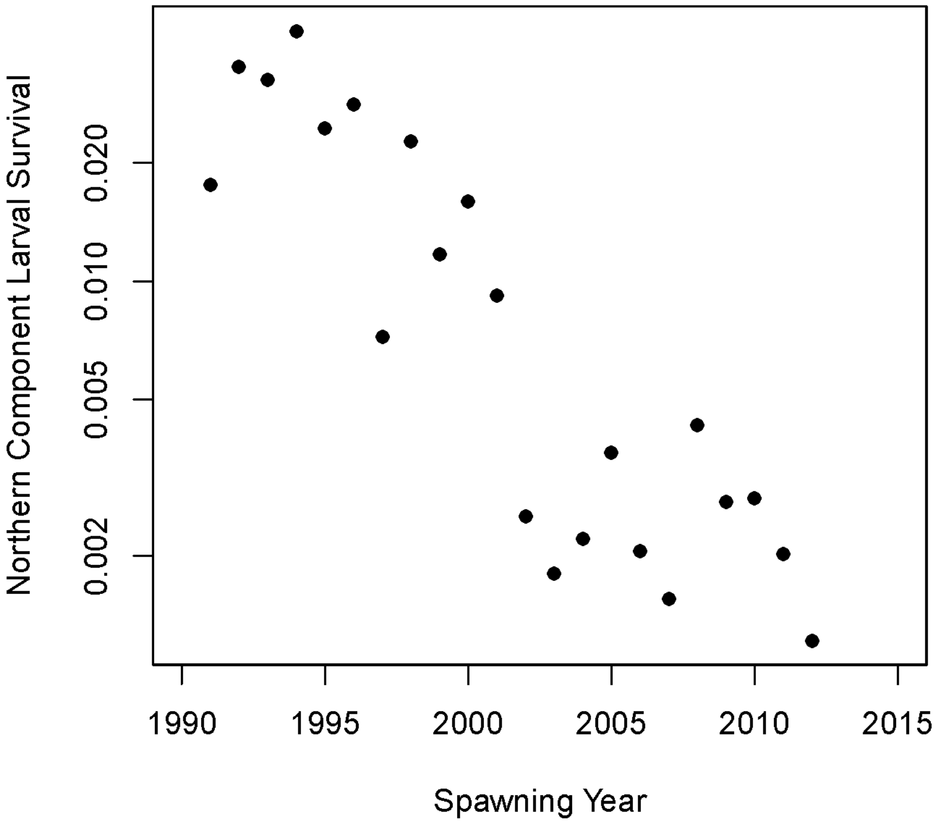


Figure 2.14.4. North Sea Autumn Spawning Herring. Time series of larval survival ratio (Dickey-Collas & Nash 2005; Payne et al 2009) for the northern-most spawning components (Banks, Buchan, Orkney-Shetland), defined as the ratio of the sum of the SCAI indices for these components (representing larvae less than 10-11mm) and the IBTS0 index (representing the late larvae, of approximately 20-30mm). Survival ratio is plotted against the year in which the larvae are spawned. Note the logarithmic scale on the vertical axis.

3 Herring in Division IIIa and Subdivisions 22–24 [update assessment]

3.1 The Fishery

3.1.1 Advice and management applicable to 2012 and 2013

In the absence of a management plan and agreed target and precautionary reference points ICES advised that fishing mortality should be less than the F related to high long-term yield (F = 0.25). This would correspond to landings of less than 51 900 t in 2013 as estimated by the last year assessment (ICES CM 2012/ACOM:06).

The EU and Norway agreement on a herring TAC for 2012 was 45 000 t in Division IIIa for the human consumption fleet and a by-catch ceiling of 6 659 t to be taken in the small mesh fishery. For 2013, the EU and Norway agreement on herring TACs in Division IIIa was 55 000 t for the human consumption fleet and a by-catch ceiling of 6 659 t to be taken in the small mesh fishery.

Prior to 2006 no separate TAC for Subdivisions 22-24 was set. In 2012, a TAC of 20 900 t was set on the Western Baltic stock component. The TAC for 2013 was set at 25 800 t.

3.1.2 Catches in 2012

Herring caught in Division IIIa are a mixture of North Sea Autumn Spawners (NSAS) and Western Baltic Spring Spawners (WBSS). This section gives the landings of both NSAS and WBSS but the stock assessment applies only to the spring spawners.

Landings from 1989 to 2012 are given in Table 3.1.1 and Figure 3.1.1. In 2012 the total landings in Division IIIa and Subdivisions 22–24 have increased to 48 800 t, which is the second lowest value of the time series (1986-2012). The increase in landings in 2012 is particularly evident in the Skagerrak (+55 %) and in SD 22-24 (+33 %). As in previous years the 2012 landing data are calculated by fleet according to the fleet definitions used when setting TACs.

Fleets are defined regardless their nationality as follows since 1998:

Fleet C: directed fishery for herring in which trawlers (with 32 mm minimum mesh size) and purse seiners participate.

Fleet D: All fisheries in which trawlers (with mesh sizes less than 32 mm) and small purse seiners, fishing for sprat along the Swedish coast and in the Swedish fjords, participate. For most of the landings taken by this fleet, herring is landed as by-catch. Danish and Swedish by-catches of herring from the sprat fishery and the Norway pout and blue whiting fisheries are listed under Fleet D.

Fleet F: Landings from Subdivisions 22–24. Most of the catches are taken in a directed fishery for herring and some as by-catch in a directed sprat fishery.

In Table 3.1.2 the landings are given for 2003 to 2012 in thousands of tonnes by fleet (as defined by HAWG) and quarter.

The age distribution in the catches of the Danish fleet D and the Swedish fleet in Subdivision 20 are unalike and the Swedish fleet D targets a larger part of the population as the landings of fish older than 3 years are higher than what is observed in the Danish catches of the same fleet. Thus the selection by fleet is not identical between the two countries. The Danish fleet definition follows the definition set by HAWG, where Fleet D (or the so called industrial fleet) is defined as all fisheries in which trawlers (with mesh sizes less than 32 mm) and small purse seiners, fish for sprat. For most of the landings taken by this fleet, herring is landed as by-catch from the sprat fishery and the Norway pout fishery. The Swedish fleet definition is based on mesh size of the gear, as for the Danish fleet. However, an earlier change in the Swedish industrial fishery implies that there is no difference in age structure of the landings between vessels using different mesh sizes since both are basically targeting herring for human consumption.

The text table below gives the TACs and Quotas (t) for the fishery by the C- and D-fleets in Division IIIa and for the F-fleet in Subdivisions 22-24.

	TAC	DK	GER	FI	PL	SWE	EC	NOR
	2012							
Div. IIIa fleet-C	45 000	18 912	303			19 783	38 998	6 002
Div. IIIa fleet-D	6 659	5 692	51			916	6 659	
SD 22-24 fleet-F	20 900	2 930	11 532	1	2 719	3 718	20 900	
% of IIIa fleet-C can be taken in IV EU waters							-50%	
% of IIIa fleet-C can be taken in IV Norwigian waters								-50 %
	2013							
Div. IIIa fleet-C	55 000	23 115	370			24 180	47 665	7 335
Div. IIIa fleet-D	6 659	5 692	51			916	6 659	
SD 22-24 fleet-F	25 800	3 617	14 234	2	3 357	4 590	25 800	
% of IIIa fleet-C can be taken in IV EU waters							-50%	
% of IIIa fleet-C can be taken in IV Norwigian waters								-50 %

3.1.3 Regulations and their effects

Before 2009, HAWG has calculated a substantial part of the catch reported as taken in Division IIIa in fleet C actually has been taken in Area IV. These catches have been allocated to the North Sea stock and accounted for under the A-fleet. Misreported catches have been moved to the appropriate stock for the assessment. However, from 2009 and on onwards, information from both the industry and VMS estimates suggest that this pattern of misreporting of catches into Division IIIa does not occur. Thus no catches were moved out of Division IIIa to the North Sea for catches taken in 2012.

Regulations allowing quota transfers from Division IIIa to the North Sea were introduced as an incentive to decrease misreporting of the fishery, and the percentage has gradually been reduced until 2010. Since 2011 the EU – Norway agreement allowed 50% of the Division IIIa quotas for human consumption (Fleet C) to be taken in the North Sea. The optional transfer of quotas from one management area to another introduces uncertainty for catch predictions and thus influence the quality of the stock projections. To decrease the uncertainty industry agreed in the 2013 benchmark to inform HAWG prior to the meeting of the assumed transfer in the intermediate year. In 2013 the industry (Pelagic RAC) informed HAWG that about 60% of the catches in the C-fleet will be taken in Division IIIa.

The quota for the C fleet and the by-catch TAC for the D fleet (see above) are set for the NSAS and the WBSS stocks together. The implication for the catch of NSAS must also be taken into account when setting quotas for the fleets that exploit these stocks.

3.1.4 Changes in fishing technology and fishing patterns

There have been no significant changes in the last few years.

3.2 Biological composition of the catch

Table 3.2.1 and Table 3.2.2 show the total catch in numbers and mean weight-at-age in the catch for herring by quarter and fleet landed from Skagerrak and Kattegat, respectively. The total catch in numbers and mean weights-at-age for herring landed from Subdivisions 22 - 24 are shown in Table 3.2.3.

The level of sampling of the commercial landings was generally within the directions set by the DCF, however, as the landings were minor, the regulation of 1 sample pr. 1 000 t landed resulted in few samples being taken. This resulted in unsampled Subdivisions (21, quarter 3?), despite a total catch of 500 t (Table 3.2.4). Where sampling was missing in areas and quarters on national landings, sampling from either other nations or adjacent areas and quarters were used to estimate catch in numbers and mean weight-at-age (Table 3.2.5).

Based on the proportions of spring- and autumn-spawners in the landings, catches were split between NSAS and WBSS (Table 3.2.6 and the stock annex for more details).

The total numbers and mean weight-at-age of the WBSS and NSAS landed from Kattegat, Skagerrak, and Division IIIa respectively were then estimated by quarter and fleet (Table 3.2.7 - 3.2.12).

The total catch, expressed as SOP, of the WBSS taken in the North Sea + Division IIIa in 2012 was estimated to be 12 553 t, which is the second lowest value of the time series (Table 3.2.13).

Total catches of WBSS from the North Sea, Division IIIa, and Subdivisions 22-24 respectively, by quarter, were estimated for 2012 (Table 3.2.14). Additionally, the total catches of WBSS in numbers and tonnes, divided between the North Sea and Division IIIa and Subdivisions 22–24 respectively for 1993–2012, are presented in Tables 3.2.15 and 3.2.16.

The total catch of NSAS in Division IIIa amounted to 12 128 t in 2012, which is the second lowest value of the time series (Table 3.2.17).

The transfer of WBSS from Subarea IVaE into Division IIIa and the transfer of NSAS from Division IIIa into Area IV in 2012 are shown in the text table below:

Stock	WBSS transfer route	Tonnes
WBSS	IVaE to IIIa	2 095
NSAS	IIIa to IV	12 128

3.2.1 Quality of Catch Data and Biological Sampling Data

No quantitative estimates of discards were available to the Working Group. However, the amount of discards for 2012 is assumed to be insignificant, as in previous years.

Table 3.2.4 shows the number of fish aged by country, area, fishery and quarter. The overall sampling in 2012 more than meets the recommended level of one sample per 1 000 t landed per quarter and the coverage of areas, times of the year and gear (mesh size) was acceptable. Fortunately occasional lack of national sampling of catches by quarter and area has been covered by similar fisheries in other countries.

Splitting of catches into WBSS and NSAS in Division IIIa were based on Danish and Swedish analyses of otolith micro-structure of hatch type and extended with discriminant analysis of otolith shape calibrated with hatch type and applied on production samples with classification parameters: herring length weight and age as well as otolith metrics (see Stock annex). The total sample size for hatch type was 1985 with 60% of the samples in Division IIIa North and 40% in IIIa South.

Sampling for split of catches in the transfer area in Division IVa East in 2012 was based on 147 Norwegian vertebral count (VC) observations from commercial catches in 2008, 2011 and 2012. The applied method was based on the average VC by age group and quarter as described in the stock annex.

3.3 Fishery Independent Information

3.3.1 German Autumn Acoustic Survey (GERAS) in Subdivisions 21–24

As a part of Baltic International Acoustic Survey (BIAS); the German autumn acoustic survey (GERAS) was carried out with R/V "SOLEA" between 2 and 21 October 2012 in the Western Baltic, covering Subdivisions 21, 22, 23 and 24. A survey report is given in the 'Report of the Working Group for International Pelagic Surveys (WGIPS, ICES CM 2012/SSGESST:22). The time series has been revised in 2008 (ICES 2008/ACOM:02) to include the southern part of SD 21. The years 1991-1993 were excluded from the assessment due to different recording method and 2001 was also excluded from the assessment since SD 23 was not covered during that year (ICES 2008/ACOM:02). All the age classes (0-8+) are included in the assessment.

Recent analyses suggested that a considerable fraction of central Baltic herring (CBH) is present in SD 24 and mix with WBSS. A stock separation function (SF, see Stock Annex 04) based on growth parameters in 2005 to 2010 has been proposed in the recent benchmark (ICES 2013/ACOM:46) to quantify the proportion of CBH and WBSS in the area. The estimates of the growth parameters based on baseline samples of WBSS and CBH in 2011 and 2012 support the applicability of SF (WD 2.to HAWG 2013). Thus, SF was applied to correct the GERAS index for WBSS from 2005–2012.

Individual mean weight, total numbers and biomass by age as estimated from the GERAS are presented in Table 3.3.1. The Western Baltic spring spawning herring stock in 2012 was estimated to be 5.6 x 10^9 fish or about 166 x 10^3 tonnes in Subdivisions 21–24. Estimates of total biomass are comparable to levels of abundance and biomass observed in 2003.

3.3.2 Herring Summer Acoustic Survey (HERAS) in Division IIIa

The Herring acoustic survey (HERAS) was conducted from 3 to 16 July 2012 and covered the Skagerrak and the Kattegat. Details of the survey are given in the WGIPS report (ICES CM 2012/SSGESST:22). The 1999 survey was excluded from the assessment due to different survey area coverage. The estimates of WBSS were 205 x 10^3 tonnes and 2.1 x 10^9 herring. The stock was dominated by 1 ring and 2 ring fish in 2012. This year's estimated abundance of 2 ringers is considerably larger than in the previous years. The results from this survey are summarised in Table 3.3.2. Ages 1-8+ are used in the assessment.

3.3.3 Larvae Surveys (N20)

Herring larvae surveys (Greifswalder Bodden and adjacent waters; SD 24) were conducted in the western Baltic at weekly intervals during the 2012 spawning season (March to June). The larval index was defined as the total number of larvae that reach the length of 20 mm (N20; Table 3.3.3; Oeberst *et al*, 2009). The recruitment index N20 derived from the survey is 1.1 x 10^9 number of larvae, which represents the second lowest estimate in the whole time series since 1992 (Table 3.3.3).

3.3.4 IBTS Q1 and Q3

The International Bottom Trawl Surveys (IBTS) in Division IIIa are part of the IBTS surveys in the North Sea. The survey is conducted during January (Q1) and August (Q3) 2012, and covers the Kattegat and Skagerrak. Details of the surveys are provided in the IBTSWG report (ICES 2013). Catch per unit effort (CPUE; n/h) were retrieved from DATRAS database (http://datras.ices.dk). The IBTS Q1 index for 2012 is dominated by very a high value for age 2 fish which represents the maximum observed in the time series. The indices for age 1, 3 and 4 show lower values than in 2011, but within the range of values and variability observed in the last 10 years. In contrast, the IBTS Q3 index shows overall very low abundances for all the ages. Since the recent benchmark (ICES 2013/ACOM:46), ages 1-4 are used in the assessment of WBSS.

3.4 Mean weights-at-age and maturity-at-age

Mean weights at age in the catch in the 1st quarter were used as estimates of mean weight at age in the stock (Table 3.6.3).

The maturity ogive of WBSS applied in HAWG has been assumed constant between years and has been the same since 1991 (ICES 1992/Assess:13), although large year-to-year variations in the percentage mature have been observed (Gröhsler and Müller, 2004). Maturity ogive has been investigated in the recent benchmark assessment of WBSS (ICES 2013). WKPELA decided to carry on with the application of the constant maturity ogive vector for WBSS.

The same maturity ogive was used as in the last year assessment (ICES CM 2012/ACOM:06):

W-rings	0	1	2	3	4	5	6	7	8+
Maturity	0.00	0.00	0.20	0.75	0.90	1.00	1.00	1.00	1.00

3.5 Recruitment

Indices of recruitment of 0-ringer WBSS in Subdivisions 22-24 for 2012 were available from both the GERAS and the larval surveys (see Section 3.3.1 and 3.3.3, respectively).

3.6 Assessment of Western Baltic spring spawners in Division IIIa and Subdivisions 22–24

3.6.1 Input data

3.6.1.1 Catch data

Catch in numbers at age from 1991 to 2012 were available for Subdivision IVa (East), Division IIIa and Subdivisions 22-24 (Table 3.6.1). Years before 1991 are excluded due to lack of reliable data for splitting spawning type and also due to a large change in fishing pattern caused by changes in the German fishing fleets (ICES 2008/ACOM:02).

Mean weights at age in the catch vary annually and are available for the same period as the catch in numbers (Table 3.6.2; Figure 3.6.1.1). Proportions at age thus reflect the combined variation in numbers at age and weight at age (Figure 3.6.1.3).

3.6.1.2 Biological data

Estimates of the mean weight of individuals in the stock (Tables 3.6.3 (Q1) and Figure 3.6.1.4) are available for all years considered.

Natural mortality was assumed constant over time and equal to 0.3, 0.5, and 0.2 for 0-ringers, 1-ringers, and 2+ -ringers respectively (Table 3.6.4). The estimates of natural mortality were derived as a mean for the years 1977–1995 from the Baltic MSVPA (ICES 1997/J:2) as no new values were available as confirmed in the recent benchmark.

The percentage of individuals that are mature is assumed constant over time (Table 3.6.5): ages 0-1 are assumed to be all immature, ages 2-4 are 20%, 75% and 90% mature respectively, and all older ages are 100% mature.

The proportions of fishing mortality and natural mortality before spawning are 0.1 and 0.25 respectively and are assumed to be constant over time (Table 3.6.6-7). The difference between these two values is due to differences in the seasonal patterns of fishing and natural mortality.

3.6.1.3 Surveys

Survey time series trends, internal and external consistencies have been investigated in the recent benchmark assessment of WBSS (ICES 2013/ACOM:46). The new assessment methodology proposed at the benchmark gave also the opportunity to include a larger number of age classes and surveys (i.e., IBTS) into the 2013 assessment of WBSS.

Survey	0	1	2	3	4	5	6	7	8+
HERAS									
GERAS									
N20									
IBTS Q1									
IBTS Q3									

3.6.2 Assessment method

The recent benchmark assessment (ICES 2013) has identified the state-space assessment model SAM as appropriate for the assessment of WBSS. The assessment run and the software internal code are available at https://www.stockassessment.org. An R based version of the same assessment has also been run for convenience. Details of the software version employed are given in Table 3.6.11.

3.6.3 Assessment configuration

The model configuration was set as specified in Tables 3.6.9-10.

3.6.4 Final run

The results of the assessment are given in Tables 3.6.12-23. The estimated SSB for 2012 is 87 904 [72 248, 106 627 (95% CI)] t. The mean fishing mortality (ages 3-6) is estimated as 0.331 [0.256, 0.427 (95% CI)] yr^{-1} (Figure 3.6.4.1).

After a marked decline from over 300 000 t in the early 1990s to a low of 120 000 t in the late 1990s, the SSB of this stock recovered somewhat, reaching a secondary peak of around 160 000 tonnes in the early 2000s (Figure 3.6.4.2). After a small peak in 2006 coinciding with the maturing of the 2003 year-class, the SSB has declined up to 2011 with the lowest SSB observed in the time series. This year assessment has slightly revised downward the 2011 estimate, and shown a minor increase in the 2012 estimate.

Fishing mortality on this stock was high in the mid 1990s, reaching a maximum of over 0.6 yr^{-1}. In 1999-2007 $F_{3\text{-}6}$ stabilised around 0.5. In 2010 and 2011 $F_{3\text{-}6}$ decreased significantly up to the value of approx. 0.32 yr^{-1}. In 2012 a value of 0.331 yr^{-1} has been estimated (Table 3.6.12, Figure 3.6.4.1).

Recruitment has significantly decreased since the late 1990s to values below 2×10^6, and remained at very low levels during the last 8 years. No signal of recovery is found in the estimated 2012 recruitment (Figure 3.6.4.2).

This year assessment shows a less pronounced reduction of fishing mortality during the second half of the 1990s and higher F up to the mid-2000s (Figure 3.6.4.2). Compared to the last year assessment, recruitment shows lower inter-annual variability.

Previous experience with separable models, and the recent benchmark (ICES 2013) demonstrated that the correlation in the fishing mortality at age is a key feature of the WBSS stock and assessment. This means that high correlation levels in F should be expected for WBSS. However, the high levels of correlation and the lack of sufficient contrast in the data on the oldest age classes may also represent a potentially harmful aspect due to poor estimation of this parameter that could compromise the assessment of this stock. After careful exploration of the model diagnostics and behaviour, the working group found the need to constrain the estimation of the fishing mortality for the oldest age groups (age 5+) to provide a sound estimation of the correlation parameter in the random walk on F. This resulted in a sensible improvement in the model stability and general behaviour in many respects and suggested the use of additional coupling in some of the catch-related variance parameters (Table 3.6.10). Estimation of all the parameters and their associated uncertainty has also been largely improved – i.e. stable uncertainty estimate in the primary run as well as in the retrospective analysis, no cross-correlation among the parameter estimates (Figure 3.6.4.47 - 3.6.4.48). In addition, comparison of the main model outcomes with an equivalent run based on the benchmark settings shown highly consistent results (Figure 3.6.4.3). Thus, the working group is now confident of having in hand a more robust model for the assessment of WBSS, and the revised settings have been used throughout this updated assessment.

The observation variance estimated to each data component is in agreement with the benchmark estimate (ICES 2013), and their rank well reflect our perception of the quality of the data in relation to the WBSS stock. The catches have the smallest observation variance estimated with the exception of age 0. These are followed by the different survey indices, with the ages 3-6 of the HERAS, and the ages 0-3 of the GERAS as the most relevant surveys for this assessment (Figure 3.6.4.4).

Inspection of the residuals for the catch shows a good fitting of the catch-at-age matrix. The catch residuals are very small and generally free from patterns over both time or ages (Figure 3.6.4.6, 3.6.4.14).

The individual survey diagnostics show remarkable differences in how the model fit the different survey data, and the level of fitting is widely in agreement with the estimated observation variance for each data component (Figures 3.6.4.15 – 3.6.4.40). In this respect, a generally good fit is found for the age 2-6 of the HERAS index, the first age classes of the GERAS index, with the exception of a major outlier in 2009, and for the ages 3-4 of the IBTS Q3. Poorer fit is observed for the other survey components, including the N20 larval index, all ages in the IBTS Q1, and ages 1-2 in IBTS Q3. The model shows also poor fitting of the age 1 HERAS index and the ages 7-8+ GERAS indices. Inspection of the residuals shows the occurrence of some year effects (i.e., 2009 in the GERAS; Figure 3.6.4.42) but they are still considered appropriate in relationship to the complexity of the model and the amount of information used in the model. Year effects are generally more problematic than age effects with the assessment model used, as temporally-invariant parameters have been adopted. Overall, the agreement between the data and the fitted model appears good throughout the data sources which are most influential in the model.

Estimation of the selectivity pattern shows an increase in the selectivity with age; the model was constrained to have same selectivity for age 5+. The selection pattern is relatively stable throughout the time period of the assessment (Figure 3.6.4.5).

The estimated surveys catchability shows rather different patterns for the surveys, with comparably higher catchability in the young age classes than in the oldest ages in several of the surveys (Figure 3.6.4.41). In the GERAS survey, age 0 has the highest catchability, which rapidly drops for age 1 and 2. Then it progressively increases up to age 5 to level a bit lower in ages 7–8+. In the HERAS survey, age 1 has the lowest catchability, while ages 2–3 have the highest catchability which declines for the oldest age groups. Even more pronounced reduction in catchability is estimated from age 1 to age 4 in both the IBTS surveys. Interpretation of the different catchability patterns is difficult, and likely a number of reasons including ontogenetic differences in the spatial distribution and behaviour of the different age classes at the time of the surveys may affect their relative availability to the different samplings.

A value of 0.79 was estimated for the correlation parameter in the F random walk, that is reflected in highly parallel fishing mortality at age estimates (Figure 3.6.4.43).

Retrospective analysis suggests that the assessment method gives a consistent perception of the stock and its dynamics (Figure 3.6.4.44). The changes from year-to-year are mostly less than the uncertainty of the estimated values (ICES 2008/ACOM:02) and are therefore consistent with the level of confidence in our estimates. A stable uncertainty associated to the model parameters was estimated for all the retrospective runs.

Retrospective analysis of the selectivity pattern for this fishery suggests a stable selection pattern (Figure 3.6.4.45).

The stock-recruitment plot for this stock (Figure 3.6.4.46) does not show any clear relationship between stock-size and recruitment.

3.7 State of the stock

The stock has decreased consistently during the second half of the 2000s. SSB has slightly increased from the last year which recorded minimum over the time period of this assessment. Fishing mortality (F3-6) was drastically reduced in 2010 (0.37 yr^{-1}) and 2011 (0.32 yr^{-1}), and showed a minor increase in 2012. The estimate of F3-6 for 2012 is 0.33 yr^{-1} and it is now above the revised estimate of F_{msy} (0.28 $yr^{-1, see}$ see section 3.7).

Recruitment has declined consistently from 2000, causing the following continuous reduction of SSB. According to the benchmark (ICES 2013/ACOM:46), this assessment further revised downward the 2010 year class. The last 8 years have been characterised by the lowest recruitment observed during the time period of the assessment, and no signal of recovery from such low levels have been found. This is in agreement with the low SSB.

3.8 Comparison with previous years perception of the stock

During the recent benchmark (ICES 2013/ACOM:46) the assessment model ICA used for the assessment of WBSS has been replaced by SAM. The use of a different assessment model, as well as the revision of the data sources and the addition of new observation, resulted in a new perception of the WBSS stock. In particular, SSB has been revised downward of approximately 20% in 2010-2011, with a consequent significant increase of the F estimate of about 40%. Also the perception of recent recruitment has been changed, and the 2010 year class appears in line with the low recruitment level estimated for the last 8-years period.

The text table below summarises the differences between the current and the previous year assessments.

Parameter	**Assessment in 2012 (ICA)**	**Assessment in 2013 (SAM)**	**Diff. 13-12 (+/-) %**
SSB (t) 2010	108 427	88 218	-19%
F(3-6) 2010	0.27	0.37	+37%
Recr. ('000) 2010	3 072 854	1 968 928	-36%
SSB (t) 2011	107 342	85 681	-20%
F(3-6) 2011	0.22	0.32	+45%
Recr. ('000) 2011	2 563 268	1 928 012	-25%

3.9 Short term predictions

Short term predictions were made in R using the function 'fwd', which implements a generic method for forward projections within FLR.

3.9.1 Input data

In the short term predictions recruitment (0-winter ring, wr) is assumed to be constant, and it is calculated as the geometric mean of the last five years prior the last year model estimate (i.e. for the 2013 assessment, recruitment for the forecasts was calculated on the period 2007–2011). 1-wr in the current year is calculated according to the geometric mean recruitment in the previous year. The mean weight-at-age in the catch and in the stock, as well as the maturities-at-age were calculated as the arithmetic averages over the last three years of the assessment (2010–2012). Based on earlier considerations in the herring working group, the different periods were chosen to reflect recent levels in recruitment and weights. The input data are shown in Table 3.9.1.

3.9.2 Intermediate year 2013

A catch constraint was assumed for the intermediate year (2013) by the following procedure:

a) The EU – Norway agreement allows an optional transfer of 50% of the TAC for herring in Division IIIa into the Area IV in the North Sea. Based on industry consultations the 2012 advice assumed a 50% transfer of the C-fleet quota from Division IIIa to the North Sea. With an actual transfer of 49%, forecasts are considered relatively precise. Based on information from the industry ICES assumes a 40% TAC transfer in 2013. This assumption influences the perception of the stock development in 2013 and 2014.

b) Misreporting of catches from the North Sea into Division IIIa is no longer assumed to occur after 2008. Therefore no account was taken in the compilations.

c) The catch by the F-fleet fishing for human consumption in Subdivisions 22-24 in 2012 was close to the TAC and utilisation of 100% is assumed for the intermediate year. The TAC utilisation for the C-fleet in Division IIIa is assumed to be 60% (provided by the industry). The proportion of the TAC taken in the small meshed fishery (D-fleet) has varied between 31% and 81% during the last three years and an average TAC utilisation of 50.3% is assumed for the intermediate year.

d) The catch of herring in Division IIIa consists of both WBSS and NSAS components. The expected catch of WBSS in Division IIIa was calculated assuming the same WBSS proportions in the catch of each fleet in 2013 and 2014 as the average of 2010-2012 in Division IIIa (64% and24% of WBSS in the C- and the D-fleet respectively).

e) The fractions of the total catch of WBSS in Division IIIa and Subdivisions 22-24 taken by each of the three fleets C, D, and F, according to 1c) are assumed to be equal to the utilised TAC in the respective areas times the proportion of WBSS in the catches for the intermediate year 2013.

f) A constant amount of 2095 t of WBSS taken in Division IVaE by the A-fleet in 2012 is assumed in 2013.

g) The mix of the two stocks in the Division IIIa catches is used to derive the outtake of NSAS and total catches in Division IIIa, whereas the Subdivision 22-24 TAC is assumed to be only WBSS herring.

Summary: predicted catches for 2013 of WBSS and NSAS by fleet in IIIa are based on 1) the TAC utilisation of 60% (provided by the industry) by the C-fleet in 2013 and the 2010-2012 average fraction in the D-fleet plus a constant catch of WBSS in IVaE (2012 catch) and 2) the 2010-2012 average proportion of the two stocks in the catches of the different fleets. These assumptions give the expected catch by fleet summing up to a total of 49 732 t WBSS in 2013.

3.9.3 Catch options for 2014

The output of the short-term prediction, based on a catch constraint in the intermediate year 2013 of 49 732 t is given in Table 3.9.2.

The following catch options for 2014 were explored:

Zero catch.

F_{2014} = 0.298, which is 0.8*F_{MSY}+ 0.2*F_{2010} according to the F_{MSY} approach.

A 15% reduction of all fleet-wise TACs for 2014, converted into a total herring catch by assuming that the TAC is completely taken in Division IIIa and Subdivision 22-24. The catches of WBSS herring are then calculated by assuming that the proportion of WBSS in each fleet catch is equal to the recent 3 years average pattern.

As for option 3, but with no change in the TAC.

As for option 3, but with a 15% increase in the TAC.

3.9.4 Exploring a range of total WBSS catches for 2014 (advice year)

Fleet wise catch options for the prediction year have the following assumptions:

A 50:50 allocation of TACs between Division IIIa and Subdivisions 22-24 is assumed with selection pattern assumed to be invariant among the C- and D-fleets.

A constant catch of 2095 t of WBSS caught in the A-fleet in Division IVa East.

This constant amount is subtracted from each of the TAC options presented and thereafter the observed allocation between Division IIIa and Subdivisions 22-24 of the remaining TAC is assumed.

The C-fleet and the D-fleet follow the recent three years 2010-2012 average share of the WBSS and NSAS in Division IIIa.

There will not be any transfer of quotas from the C-fleet to the A-fleet.

The total advised TAC is taken

The average 2010-2012 average proportions of WBSS by fleet is the same for 2014. (The proportions of WBSS in catches were 64% in the C-fleet, 24% in the D-fleet and 100% in the F-fleet).

The table below gives the 2014 fleet wise catch options for the Western Baltic spring spawners and North Sea North Sea autumn spawners in Division IIIa, in Subdivisions 22–24, and in Subarea IVaE for the catch options described in section 3.7.3:

1) F=0 not shown, 2) $F_{MSY\text{-}approach}$=0.298 3) $F_{-15\%TAC}$=0.44, 4) F_{TAC}=0.53, and 5) $F_{+15\%TAC}$=0.63												
Catch option for the WBSS and NSAS herring stock in 2014												
Catch option for the WBSS herring stock		WBSS herring				NSAS herring		Total catches of both stocks in Division IIIa and Subdivisions 22-24				
Option	Total catches of WBSS herring*	IVaE	Division IIIa		SD22-24	Division IIIa		Division IIIa		SD 22-24		TAC develop-ment
		Fleet A*	Fleet C	Fleet D	Fleet F	Fleet C	Fleet D	Fleet C**	Fleet D	Fleet F	Fleets A+ C+D+F	Total area
2	41 602	2 095	18 848	905	19 754	10 255	3 120	29 104	4 026	19 754	54 978	-40%
3	57 632	2 095	26 496	1 273	27 769	14 417	4 386	40 912	5 659	27 769	76 435	-15%
4	67 433	2 095	31 172	1 497	32 669	16 961	5 160	48 132	6 658	32 669	89 554	0%
5	77 233	2 095	35 847	1 722	37 569	19 505	5 934	55 352	7 656	37 569	102 673	15%

* total catches of WBSS herring include a constant catch of 2095 t WBSS taken by the A-fleet in Div. IVa East

1) Zero catch not shown in the table. After an increase of SSB to 117 082 t in 2014 the SSB further increases to 167 409 t in 2015.

2) The F_{MSY} option will give a yield of 41 602 t in 2014 with an increase in SSB from 113 825 t in 2014 to 127 016 t in 2015.

3) 15% reduced TAC option gives a yield in 2014 of 57 632 t. This option is very similar to option 2) based on F_{MSY} with an almost constant SSB of 112 357 t in 2014 and 113 552 t in 2015.

4) A TAC roll over option gives a catch in 2014 of 67 433 t and a SSB of 111 386 t. With this assumption the SSB decreases in 2015 to 105 400 t

5) A 15% increased TAC gives a catch in 2014 of 77 233 t. With this assumption the SSB is 110 348 t in 2014 and decreasing to 97 317t in 2015 below the breakpoint of 110 000 t.

3.10 Reference points

Based on a Blim value of 90 000 t (equal Bloss, ICES 2013/ACOM:46), the Bpa value of 110 000 t was calculated according to the concept developed by the study group on the Precautionary Approach to Fisheries Management (ICES 2003/ACFM:15) and later REF (ICES 2007/ACFM:11). In practice, Bpa should be set at a sufficient high level so that the risk of being below Blim due to assessment uncertainty is small (<5%). For this purpose, the following formulation was applied:

Bpa = exp(log(Blim) + cv*ucl)

where cv (~0.093) is the average coefficient of variation of the terminal year log(SSB) estimate over a 10-years' time series retrospective analysis, and ucl is the upper confidence limit of the standardized Normal distribution corresponding to the value of 1.64.

This year the working group had a preliminary trial of the software plotMSY (ICES 2013/ACOM:37) for the estimation of the Fmsy reference point for WBSS. The approach derives Fmsy using reformulation of the stock–recruit relationship in terms of F via a yield-per-recruit equation, and under the equilibrium assumption. A stochastic approach is applied using Markov Chain Monte Carlo (MCMC) simulation for the estimation of stock and recruitment and yield-per-recruit parameters and uncertainty.

The following input data, together with their associated cv, were used to run the procedure: mean weight at age (2010-2012), vectors of maturity and natural mortality, geometric mean recruitment (2007-2011), number of fish at age and fishing mortality in 2012, SSB and recruitment pairs as estimated from the assessment. The software plotMSY uses a statistical weighting procedure based on log-likelihood estimate of different stock-recruitment (SR) models (Beverton-Holt, Ricker, hockey-stick) fitting (ICES 2013/ACOM:37). After initial evaluation the hockey-stick SR model was excluded due to unrealistic Fmsy estimate of 0.51 yr^{-1} which approached the Fcrash value of 0.53 yr^{-1}. Thus, the Beverton-Holt and Ricker SR models were applied (Figure 3.10.1-3). Their relative contribution to the SR relationship of WBSS was 0.35 and 0.65, respectively, and this was used to calculate a simple weighted mean of Fmsy (Table 3.10.1). The estimated Fmsy value of 0.28 yr^{-1} is in line with recent years interpretation (ICES CM 2010/ACOM:06) that the long term maximum exploitation target (F_{MSY}) for WBSS could be approximately 0.25 yr^{-1}.

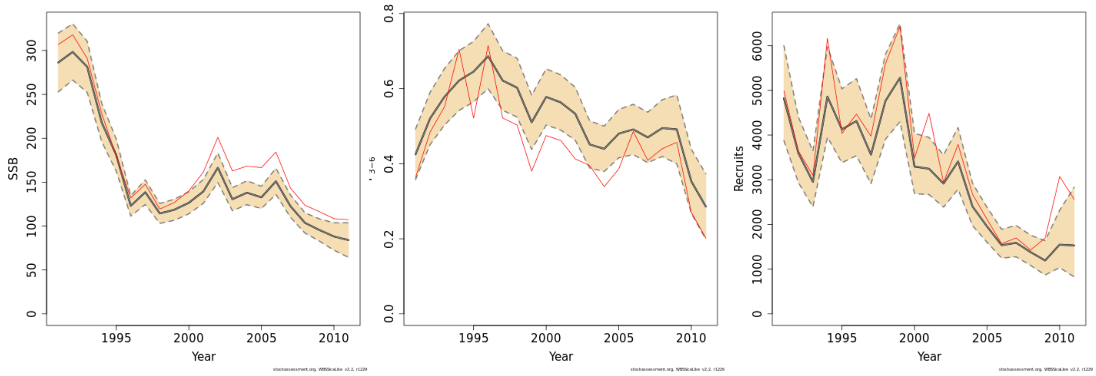
A more in depth evaluation of the Fmsy reference point is certainly needed for WBSS, together with an evaluation for a long term management plan for the stock.

3.11 Quality of the Assessment

The assessment has been benchmarked in 2013 (ICES 2013/ACOM:46) and a full statistical assessment model (SAM) was introduced and further slightly modified by the present HAWG. The perception of the stock has changed through this process. The assessment is considered to be an improvement to previous assessments. The fishing mortality is reliably estimated by the stock assessment and has been revised upwards in relation to HAWG 2012. The estimation of SSB compared to the estimate in HAWG 2012, is precise. Recruitment of WBSS herring is estimated with relatively high uncertainty but is indicated to have been at its lowest between 2004 and 2011.

The limited level of sampling for the splitting of NSAS and WBSS is mostly unchanged from the last year.

The assessment this year is the first update assessment after the benchmark in 2013; it follows the procedures and settings specified in the updated Stock Annex 4. Applying the new SAM model the perception of the stock pays more attention to the confidence limits around the estimated SSB, F and Recruitment.



In relation to the HAWG 2012 stock assessment applying the ICA model, the HAWG 2013 SAM model indicates no difference in recent fishing mortalities or recruitment (2007-2011), whereas the perception of SSB is downward revised from 1997 and on.

Variability in the retrospective perception of the stock is low and within confidence limits. Model residuals were examined for all the components (catch and survey indices) and no major undesirable pattern was observed.

The benchmark analysed the bimodal distribution of length-at-age in the German acoustic survey (GERAS) to separate components of WBSS and Central Baltic Herring (CBH) in Subdivision 22-24 (Section 3.3.1 and ICES 2013/ACOM:46). A von Bertalanffy growth based separation function was applied to correct the GERAS survey index. Catches from Subdivisions 24-25 may contain an unresolved mix of the same stocks. Based on the potential magnitude of the mix more attention should be paid to this problem. Genetic methods are available that may facilitate the solution to this analysis.

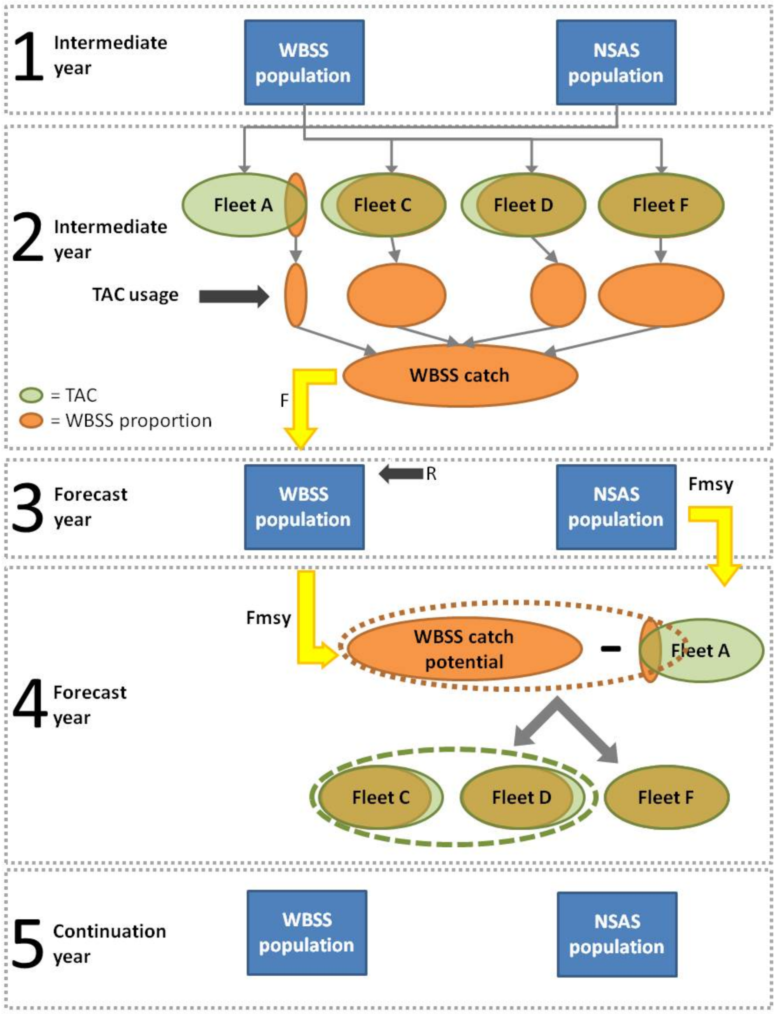
3.12 Management Considerations

Quotas in Division IIIa

The quota for the C-fleet and the by-catch quota for the D-fleet are set for both stocks of North Sea autumn spawners (NSAS) and Western Baltic spring spawners (WBSS) together (see Section 2.7). 50% of the EU and Norwegian quotas can be transferred from Division IIIa and taken in Area IV as NSAS in 2012. ICES assumes that a transfer of 40% will be effected in 2013.

ICES catch predictions versus management TAC

ICES gives advice on catch options for the entire distribution of the two herring stocks separately whereas herring is managed by areas (see the following text diagram). The procedure of setting TACs in ICES area IIIa and 22-24 takes into account the occurrence of different fleets catches of both WBSS and NSAS herring utilization of TACs and the proportion of NSAS and WBSS that mix in the areas. In the flowchart below a schematic is presented:



Box 1: Each year estimations of the WBSS and NSAS stock size is made using a stock assessment model. Stock size estimation together with the estimated pattern of harvesting is used as the starting point for the short term forecast.

Box 2: To derive at a TAC proposal in the forecast year first the intermediate year (the year where the TAC has already been agreed on) catches need to be resolved. Four different fleets catch WBSS the A fleet (within the IVaEast area where they take it as a mixture of mainly NSAS and partly WBSS) the C and D fleet (within the IIIa area where they take it as a mixture of mainly WBSS and partly NSAS) and the F fleet (within area 22-24 where they only take WBSS). Each of these fleets target herring taking into account a fleet share of the total TAC. Only part of this TAC is WBSS catches and not all fleets utilize their full TAC fleet share. This results in an estimate of the intermediate year WBSS catches. Given WBSS stock size and these intermediate year catches the fishing mortality the WBSS stock was exploited at can be estimated.

Box 3: Based on the estimated fishing mortality we can now calculate the survivors from the intermediate year to the forecast year assuming an incoming recruitment. The calculation of the stock size in the forecast year is needed to project catches in the forecast year.

Box 4: The EC targets to g*et a*ll stocks exploited at Fmsy by the year 2015. From now until 2015 there is an Fmsy transition period. For 2012 F was estimated above Fmsy and predicted F for 2013 was considerably above Fmsy, consequently catch options for the advice year were calculated following the Fmsy approach

F=(0.8*Fmsy+0.2*F_{2010}). The potential WBSS catches are used to define the total TAC in ICES area IIIa and 22-24. Therefore first the WBSS catches taken by the A fleet in the North Sea need to be taken into account. It is up to expert knowledge where these catches are subtracted from (either the C and D fleet share or the C D and F fleet shares), and also to split the remainder between the F and the C & D fleet according to the recent observed pattern e.g. a 50% - 50% ratio. To derive the C and D fleet TAC however a proportion of NSAS needs to be added here because of the mixed fishery on both WBSS and NSAS by these fleets. Therefore the TAC of the C and D fleet is larger than the proposed catches of WBSS by these fleets.

Box 5: The TAC advice from box 4 is taken into the political arena. The result of this will be taken into account to calculate the WBSS population again the year after. Hence box 5 is similar to box 1.

Development of a management plan for WBSS herring

ICES has in 2013 continued development of tools for analysis of reference points. A benchmark (WKPELA 2013) was carried out before this year HAWG. Here Blim was defined as Bloss and a Fmsy SSB-breakpoint of 110 000 t as the upper 95% confidence limits of Blim based on the cv of the terminal year in the assessment. Based on a Yield per Recruit relationship a value for F_{MSY}=0.28 was calculated applying the MSY-plot software during HAWG 2013. Initial management plan investigations within the EU FP7-project "JAKFISH" involving stakeholders have suggested a harvest control rule that includes a sloping change in F at SSB below a breakpoint. However a full evaluation of different management options for the WBSS stock is warranted, exploring the consequences of catch allocations among fleets and areas under the variation in distribution and development of the interacting stocks.

Data used for catch options for 2014 (prediction year)

There is no firm basis for predicting the yearly fraction of NSAS in the catches of the C- and D-fleets. The proportions of the two stocks are influenced by the year class strength and their relative geographical distributions as well as fleet behaviour.

The procedure of deriving separate catches by stock and fleet is described in the stock annex for North Sea herring. The catch options for 2014 are based on an assumed 50:50 allocation of the WBSS catches between Division IIIa and SD22-24 and the average share by fleet within area TACs plus the stock composition in catches for the most recent years 2010-2012.

National regulation and control initiatives have efficiently stopped misreporting which before 2009 amounted to more than 30%. This resulted in a continued increase in fishing mortality in 2009 and a decrease in SSB however enforcement of TAC regulations in 2010 decreased landings and fishing mortality considerably whereas SSB continued to decrease due to the poor year classes in the fishery.

Predicted stock development

Since 2011 managers have decided an optional transfer of 50% of the quotas for human consumption in Division IIIa to the North Sea, of which 49% was effected in 2012. Along with a lower TAC in recent years the quota transfer out of Division IIIa has led to decreasing Fs and halted the decline of the SSB going from 87 936 t in 2012 to 106 053 in 2013. Dependent on a 40% effected TAC transfer from IIIa to IV in 2013 SSB will further increase to about 114 000 t in 2014 and a fishing mortality (F= 0.30) according to the Fmsy-transition will increase SSB to 127 000 t in 2015. Any of the catch option within +/- 15% of a TAC roll over will over exploit the stock.

The catches of WBSS in the C- and D-fleets comprise 40% of the total out-take of the WBSS stock in 2012 whereas the catches of NSAS by the same fleets only comprise 1.4% of the total out-take of the NSAS stock. The NSAS has experienced a decline in fishing mortality and subsequent increase in SSB and there is an indication of an on-going similar development for WBSS. With the present recruitment level there is now a possibility for a consolidated fishing mortality at Fmsy on the WBSS. Therefore the consequences of the optional TAC transfer between IIIa and IV for the uncertainty of the realised outtake should be considered in the management plan for this stock.

The resulting catch option with the above assumptions was also used as constraint for short term predictions for the NSAS herring (see Section 2.7).

3.13 Ecosystem considerations

Herring in Division IIIa and Subdivisions 22–24 is a migratory stock. There are feeding migrations from the Western Baltic into more saline waters of Division IIIa and the eastern parts of Division IVa. There are indications from parasite infections that yet unknown proportions of stock components spawning at the southern coast in the Baltic Sea may perform similar migrations (Podolska *et al*. 2006). Herring in Division IIIa and Subdivisions 22–24 migrate back to Rügen area (SD 24) at the beginning of the winter for spawning. Moreover, there are recent indications that Central Baltic herring perform migrations into Subdivision 24 (Gröhsler *et al*. 2013).

Similarly to the NSAS, the WBSS has produced several poor year classes in the last decade. The SAM model indicates that the recent year-classes in 2010 and 2011, although point estimates appear higher, are at the same level as the recent 8 years' of low recruitment.

A recent analysis on different Baltic herring stocks showed that the Baltic Sea Index (BSI) reflecting Sea Surface Temperature (SST) was the main predictor for the recruitment of WBSS (Cardinale *et al*. 2009). There are no indications of systematic changes in growth or age at maturity, and a candidate key stage for reduced recruitment is probably the larval stage. The low recruitment phase appears to have been initiated before the observed occurrence of *Mnemiopsis leidyi* (Ctenophore) in the Western Baltic (Kube *et al*., 2007). The specific reasons for this low recruitment are unknown. Further investigation of the causes of the poor recruitment will require targeted research projects.

3.14 Changes in the Environment

There are no evident changes in the environment in the last decade that are thought to strongly affect productivity, migration patterns or growth of WBSS. There are indications that higher SST observed in the last decades might affect recruitment negatively, although the analyses were inconclusive and the observed SST effect rather weak (Cardinale *et al*. 2009).

Table 3.1.1 WESTERN BALTIC HERRING.

Total landings (both WBSS and NSAS) in 1989-2012 (1000 tonnes).
(Data provided by Working Group members 2013).

Year	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998 [2]	1999 [2]
Skagerrak											
Denmark	47.4	62.3	58.7	64.7	87.8	44.9	43.7	28.7	14.3	10.3	10.1
Faroe Islands											
Germany											
Lithuania											
Norway	1.6	5.6	8.1	13.9	24.2	17.7	16.7	9.4	8.8	8.0	7.4
Sweden	47.9	56.5	54.7	88.0	56.4	66.4	48.5	32.7	32.9	46.9	36.4
Total	96.9	124.4	121.5	166.6	168.4	129.0	108.9	70.8	56.0	65.2	53.9
Kattegat											
Denmark	57.1	32.2	29.7	33.5	28.7	23.6	16.9	17.2	8.8	23.7	17.9
Sweden	37.9	45.2	36.7	26.4	16.7	15.4	30.8	27.0	18.0	29.9	14.6
Total	95.0	77.4	66.4	59.9	45.4	39.0	47.7	44.2	26.8	53.6	32.5
Sub. Div. 22+24											
Denmark	21.7	13.6	25.2	26.9	38.0	39.5	36.8	34.4	30.5	30.1	32.5
Germany	56.4	45.5	15.8	15.6	11.1	11.4	13.4	7.3	12.8	9.0	9.8
Poland	8.5	9.7	5.6	15.5	11.8	6.3	7.3	6.0	6.9	6.5	5.3
Sweden	6.3	8.1	19.3	22.3	16.2	7.4	15.8	9.0	14.5	4.3	2.6
Total	92.9	76.9	65.9	80.3	77.1	64.6	73.3	56.7	64.7	49.9	50.2
Sub. Div. 23											
Denmark	1.5	1.1	1.7	2.9	3.3	1.5	0.9	0.7	2.2	0.4	0.5
Sweden	0.1	0.1	2.3	1.7	0.7	0.3	0.2	0.3	0.1	0.3	0.1
Total	1.6	1.2	4.0	4.6	4.0	1.8	1.1	1.0	2.3	0.7	0.6
Grand Total	**286.4**	**279.9**	**257.8**	**311.4**	**294.9**	**234.4**	**231.0**	**172.7**	**149.8**	**169.4**	**137.2**

Year	2000	2001 [5]	2002 [4]	2003	2004	2005	2006 [1,3]	2007	2008	2009	2010	2011	2012 [1]
Skagerrak													
Denmark	16.0	16.2	26.0	15.5	11.8	14.8	5.2	3.6	3.9	12.7	5.3	3.6	3.2
Faroe Islands						0.4			0.0	0.6	0.4		
Germany				0.7	0.5	0.8	0.6	0.5	1.6	0.3	0.1	0.1	0.6
Lithuania											0.4		
Norway	9.7							3.5	4.0	3.3	3.3	0.1	0.4
Sweden	45.8	30.8	26.4	25.8	21.8	32.5	26.0	19.4	16.5	12.9	17.4	9.5	16.2
Total	71.5	47.0	52.3	42.0	34.1	48.5	31.8	26.9	26.0	29.7	27.0	13.2	20.5
Kattegat													
Denmark	18.9	18.8	18.6	16.0	7.6	11.1	8.6	9.2	7.0	4.9	7.6	5.2	6.3
Sweden	17.3	16.2	7.2	10.2	9.6	10.0	10.8	11.2	5.2	3.6	2.7	1.7	0.8
Germany										0.6	0.0		
Total	36.2	35.0	25.9	26.2	17.2	21.1	19.4	20.3	12.2	9.1	10.3	6.8	7.1
Sub. Div. 22+24													
Denmark	32.6	28.3	13.1	6.1	7.3	5.3	1.4	2.8	3.1	2.1	0.8	3.1	4.1
Germany	9.3	11.4	22.4	18.8	18.5	21.0	22.9	24.6	**22.8**	16.0	12.2	8.2	11.2
Poland	6.6	9.3		4.4	5.5	6.3	5.5	2.9	5.5	5.2	1.8	1.8	2.4
Sweden	4.8	13.9	10.7	9.4	9.9	9.2	9.6	7.2	7.0	4.1	2.0	2.2	2.7
Total	53.3	62.9	46.2	38.7	41.2	41.8	39.4	37.6	38.5	27.4	16.8	15.3	20.4
Sub. Div. 23													
Denmark	0.9	0.6	4.6	2.3	0.1	1.8	1.8	2.9	5.3	2.8	0.1 [6]	0.03	0.04
Sweden	0.1	0.2		0.2	0.3	0.4	0.7		0.3	0.8	0.9	0.5	0.7
Total	1.0	0.8	4.6	2.6	0.4	2.2	2.5	2.9	5.7	3.6	1.0	0.6	0.7
Grand Total	**162.0**	**145.7**	**128.9**	**109.5**	**92.8**	**113.6**	**93.0**	**87.7**	**82.3**	**69.9**	**55.2**	**35.9**	**48.8**

[1] Preliminary data.

[2] Revised data for 1998 and 1999

Bold = German revised data for 2008 (in HAWG 2010)

[3] 2000 tonnes of Danish landings are missing, see text section 3.1.2 (HAWG 2007)

[4] The Danish national management regime for herring and sprat fishery in Subdivision 22 was changed in 2002

[5] The total landings in Skagerrak have been updated for 1995-2001 due to Norwegian misreportings into Skagerrak.

[6] Official reported catches: 3,103 tonnes, see text section 3.2.1 (HAWG 2011)

Table 3.1.2 **WESTERN BALTIC HERRING.**
Landings (SOP) in 2003-2012 by fleet and quarter (1000 t).
(both WBSS and NSAS)

Year	Quarter	Div. IIIa		SD 22-24	Div. IIIa + SD 22-24
		Fleet C	Fleet D	Fleet F	Total
2003	1	10.9	7	20.3	38.2
	2	7.9	1.3	12.9	22.1
	3	21.9	0.9	1.5	24.3
	4	15	3.3	5.6	23.9
	Total	55.7	12.5	40.3	108.5
2004	1	13.5	2.8	20.4	36.7
	2	2.8	3.3	10.4	16.5
	3	8.2	10.8	2.4	21.4
	4	5.9	5.0	8.6	19.4
	Total	30.3	22.0	41.7	93.9
2005	1	16.6	6.1	20.4	43.1
	2	3.4	1.9	15.6	20.9
	3	23.4	3.4	1.9	28.7
	4	12.0	2.6	5.8	20.5
	Total	55.4	14.1	43.7	113.3
2006	1	15.3	5.9	15.1	36.2
	2	2.6	0.1	17.2	19.9
	3	15.7	0.8	3.0	19.5
	4	8.3	2.4	6.5	17.3
	Total	41.9	9.3	41.9	93.0
2007	1	7.7	3.0	18.8	29.5
	2	3.8	0.1	10.5	14.4
	3	22.4	0.8	1.7	24.9
	4	7.7	1.8	9.5	18.9
	Total	41.6	5.7	40.5	87.7
2008	1	8.2	3.9	18.4	30.5
	2	2.7	0.3	11.3	14.3
	3	14.9	0.6	6.0	21.5
	4	6.5	1.0	8.4	16.0
	Total	32.3	5.9	44.1	82.3
2009	1	11.1	2.7	19.5	33.2
	2	3.1	0.1	6.8	10.1
	3	14.3	0.9	1.4	16.6
	4	6.0	0.7	3.3	10.0
	Total	34.5	4.3	31.0	69.9
2010	1	8.4	1.1	10.2	19.8
	2	3.9	0.7	5.4	10.1
	3	13.4	0.4	0.4	14.3
	4	9.2	0.1	1.8	11.1
	Total	35.0	2.3	17.9	55.2
2011	1	7.0	0.5	7.8	15.3
	2	0.5	0.2	4.1	4.8
	3	6.5	1.0	0.8	8.3
	4	3.4	0.9	3.2	7.4
	Total	17.4	2.6	15.8	35.9
2012	1	4.5	1.8	14.0	20.3
	2	0.3	0.7	2.5	3.5
	3	12.3	1.7	1.1	15.0
	4	5.2	1.1	3.5	9.9
	Total	22.3	5.4	21.1	48.8

Table 3.2.1 WESTERN BALTIC HERRING
Landings in numbers (mill.), mean weight (g.) and SOP (t) by age, quarter and fleet (both WBSS and NSAS).
Division: Skagerrak Year: 2012 Country: All

Quarter	W-rings	Fleet C Numbers	Fleet C Mean W.	Fleet D Numbers	Fleet D Mean W.	Total Numbers	Total Mean W.
1	1	2.92	26	24.34	16	27.26	17
	2	42.98	57	7.29	39	50.27	54
	3	6.34	108	0.06	85	6.41	108
	4	1.34	132			1.34	132
	5	0.64	181			0.64	181
	6	0.30	200			0.30	200
	7	0.17	277			0.17	277
	8+						
	Total	54.69		31.69		86.39	
	SOP		3,613		689		4,303
Quarter	W-rings	Fleet C Numbers	Fleet C Mean W.	Fleet D Numbers	Fleet D Mean W.	Total Numbers	Total Mean W.
2	1	0.17	35	9.53	21	9.70	22
	2	2.40	66	0.29	48	2.69	64
	3	0.30	116			0.30	116
	4	0.07	130			0.07	130
	5	0.03	106			0.03	106
	6						
	7	0.03	156			0.03	156
	8+	0.03	192			0.03	192
	Total	3.03		9.82		12.86	
	SOP		222		219		440
Quarter	W-rings	Fleet C Numbers	Fleet C Mean W.	Fleet D Numbers	Fleet D Mean W.	Total Numbers	Total Mean W.
3	0			42.60	9	42.60	9
	1	47.75	68	1.50	42	49.25	67
	2	45.65	97			45.65	97
	3	9.87	149			9.87	149
	4	5.07	167			5.07	167
	5	3.79	177			3.79	177
	6	1.74	199			1.74	199
	7	1.28	213			1.28	213
	8+	0.75	224			0.75	224
	Total	115.90		44.10		160.00	
	SOP		11,416		460		11,876
Quarter	W-rings	Fleet C Numbers	Fleet C Mean W.	Fleet D Numbers	Fleet D Mean W.	Total Numbers	Total Mean W.
4	0	0.60	27			0.60	27
	1	32.16	66	2.42	65	34.58	66
	2	9.82	101	0.12	68	9.94	100
	3	1.64	136			1.64	136
	4	0.97	179			0.97	179
	5	0.72	188			0.72	188
	6	0.16	193			0.16	193
	7	0.20	233			0.20	233
	8+	0.07	209			0.07	209
	Total	46.34		2.54		48.88	
	SOP		3,745		166		3,911
Quarter	W-rings	Fleet C Numbers	Fleet C Mean W.	Fleet D Numbers	Fleet D Mean W.	Total Numbers	Total Mean W.
Total	0	0.60	27	42.60	9	43.20	10
	1	83.00	65	37.79	22	120.80	52
	2	100.84	79	7.70	40	108.55	77
	3	18.15	133	0.06	85	18.21	133
	4	7.45	162			7.45	162
	5	5.18	178			5.18	178
	6	2.20	198			2.20	198
	7	1.68	220			1.68	220
	8+	0.85	222			0.85	222
	Total	219.96		88.15		308.12	
	SOP		18,996		1,534		20,530

Table 3.2.2 WESTERN BALTIC HERRING
Landings in numbers (mill.), mean weight (g.) and SOP (t) by age, quarter and fleet (both WBSS and NSAS)
Division: Kattegat Year: 2012 Country: ALL

		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
1	1	0.81	24	40.06	16	40.87	17
	2	10.66	59	12.00	39	22.66	48
	3	1.67	103	0.10	85	1.77	101
	4	0.52	121			0.52	121
	5	0.12	135			0.12	135
	6	0.05	208			0.05	208
	7						
	8+						
	Total	13.83		52.16		65.99	
	SOP		908		1,135		2,043
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
2	1	0.05	24	22.25	21	22.30	21
	2	0.60	59	0.69	48	1.28	53
	3	0.09	103			0.09	103
	4	0.03	121			0.03	121
	5	0.01	135			0.01	135
	6	0.00	208			0.00	208
	7						
	8+						
	Total	0.77		22.94		23.71	
	SOP		51		511		562
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
3	0			63.23	10	63.23	10
	1	1.43	72	15.22	40	16.65	43
	2	2.83	97			2.83	97
	3	0.90	153			0.90	153
	4	0.56	180			0.56	180
	5	0.58	188			0.58	188
	6	0.34	212			0.34	212
	7	0.21	212			0.21	212
	8+	0.18	224			0.18	224
	Total	7.04		78.45		85.49	
	SOP		884		1,232		2,115
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
4	0	0.01	27	40.91	19	40.92	19
	1	0.76	66	4.05	52	4.81	54
	2	2.68	125			2.68	125
	3	1.41	165			1.41	165
	4	1.78	183			1.78	183
	5	1.39	197			1.39	197
	6	0.38	193			0.38	193
	7	0.46	233			0.46	233
	8+	0.16	209			0.16	209
	Total	9.04		44.96		53.99	
	SOP		1,430		976		2,406
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
Total	0	0.01	27	104.14	13	104.16	13
	1	3.05	57	81.58	24	84.62	25
	2	16.77	76	12.68	40	29.45	60
	3	4.07	135	0.10	85	4.17	134
	4	2.89	170			2.89	170
	5	2.10	191			2.10	191
	6	0.78	202			0.78	202
	7	0.67	226			0.67	226
	8+	0.34	217			0.34	217
	Total	30.68		198.51		229.19	
	SOP		3,272		3,854		7,126

Table 3.2.3 WESTERN BALTIC HERRING
Landings in numbers (mill.), mean weight (g.) and SOP (t) by age and quarter (WBSS).
Subdivision: 22-24 Year: 2012 Country: ALL

		Sub-division 22		Sub-division 23		Sub-division 24		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
1	1	24.75	10	0.03	19	3.93	16	28.70	11
	2	1.73	29	0.37	44	18.68	45	20.78	44
	3	1.09	86	0.65	83	25.91	88	27.66	88
	4	1.77	106	0.38	98	23.47	114	25.62	113
	5	0.74	125	0.26	136	19.52	159	20.52	158
	6	0.30	137	0.08	161	9.52	178	9.89	177
	7	0.16	194	0.06	166	6.18	188	6.40	188
	8+	0.12	203	0.03	170	6.08	201	6.23	200
	Total	30.66		1.87		113.27		145.80	
	SOP		764		173		13,042		13,978
		Sub-division 22		Sub-division 23		Sub-division 24		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
2	1	8.95	10	0.00	18	1.67	19	10.62	11
	2	0.95	36	0.00	55	5.33	43	6.28	42
	3	1.02	75	0.00	100	4.27	75	5.29	75
	4	1.19	91	0.00	128	4.13	105	5.33	101
	5	0.43	125	0.00	153	2.90	124	3.34	124
	6	0.28	123	0.00	165	1.94	150	2.22	147
	7	0.25	139	0.00	188	1.22	165	1.47	160
	8+	0.09	177	0.00	204	1.11	184	1.20	184
	Total	13.16		0.00		22.58		35.74	
	SOP		446		0		2,066		2,512
		Sub-division 22		Sub-division 23		Sub-division 24		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
3	0	0.00	13			0.04	13	0.04	13
	1	0.01	46	0.10	47	0.36	42	0.47	43
	2	0.02	97	0.23	94	1.29	93	1.53	93
	3	0.01	135	0.51	139	2.07	106	2.59	113
	4	0.01	148	0.29	165	2.11	103	2.40	111
	5	0.00	155	0.15	176	1.74	92	1.90	99
	6	0.00	173	0.06	178	0.73	91	0.79	97
	7	0.00	170	0.02	189	0.22	100	0.24	108
	8+	0.00	189	0.02	211	0.39	108	0.41	112
	Total	0.04		1.37		8.96		10.37	
	SOP		5		188		866		1,059
		Sub-division 22		Sub-division 23		Sub-division 24		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
4	0	0.02	13			0.42	19	0.44	19
	1	0.16	43	0.19	47	6.17	44	6.53	44
	2	0.47	100	0.44	93	7.00	86	7.91	87
	3	0.33	139	0.99	138	6.90	127	8.22	129
	4	0.18	152	0.53	164	3.75	145	4.46	147
	5	0.07	167	0.30	175	2.24	161	2.60	162
	6	0.03	210	0.11	177	0.91	179	1.06	180
	7	0.03	206	0.04	189	0.84	142	0.90	146
	8+	0.01	219	0.03	208	0.56	160	0.60	163
	Total	1.30		2.63		28.79		32.71	
	SOP		154		358		3,034		3,545
		Sub-division 22		Sub-division 23		Sub-division 24		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
Total	0	0.02	13			0.46	18	0.48	18
	1	33.86	10	0.32	44	12.13	32	46.31	16
	2	3.17	42	1.04	76	32.28	56	36.50	55
	3	2.45	89	2.15	122	39.16	94	43.76	95
	4	3.15	103	1.20	143	33.47	115	37.81	115
	5	1.25	127	0.71	161	26.39	151	28.35	150
	6	0.61	135	0.25	172	13.10	169	13.96	168
	7	0.44	163	0.12	177	8.46	178	9.01	177
	8+	0.22	194	0.08	192	8.14	191	8.44	191
	Total	45.16		5.87		173.60		224.62	
	SOP		1,368		719		19,008		21,095

Table 3.2.4 HERRING IN DIVISION IIIa AND SUBDIVISIONS 22-24. Samples of commercial landings by quarter and area for 2012 available to the Working Group.

	Country	Quarter	Landings ('000 tons)	Numbers of samples	Numbers of fish meas.	Numbers of fish aged
Skagerrak	Denmark	1	0.707	No data available		
		2	0.304	No data available		
		3	1.939	7	689	562
		4	0.295	2	190	150
	Total		3.244	9	879	712
	Germany	1	0.000			
		2	0.000			
		3	0.444	No data available		
		4	0.186	No data available		
	Total		0.629			
	Norway	1	0.091	No data available		
		2	0.019	No data available		
		3	0.081	No data available		
		4	0.256	No data available		
	Total		0.446	0	0	0
	Sweden	1	3.505	14	700	696
		2	0.118	1	141	141
		3	9.413	16	800	798
		4	3.174	13	650	650
	Total		16.210	44	2,291	2,285
Kattegat	Denmark	1	1.525	18	1,772	428
		2	0.519	3	237	138
		3	1.951	4	129	79
		4	2.331	3	149	48
	Total		6.326	28	2,287	693
	Sweden	1	0.518	7	675	674
		2	0.043	No data available		
		3	0.164	No data available		
		4	0.075	No data available		
	Total		0.800	7	675	674

Table 3.2.4 (cont.) HERRING IN DIVISION IIIa AND SUBDIVISIONS 22-24. Samples of commercial landings by quarter and area for 2012

	Country	Quarter	Landings ('000 tons)	Numbers of samples	Numbers of fish meas.	Numbers of fish aged
Subdivision 22	**Denmark**	**1**	0.292	3	111	69
		2	0.105	No data available		
		3	0.004	No data available		
		4	0.125	No data available		
	Total		0.526	3	111	69
	Germany	**1**	0.472	3	1,259	216
		2	0.341	2	760	121
		3	0.001	No data available		
		4	0.029	1	516	85
	Total		0.843	6	2,535	422
Subdivision 23	**Denmark**	**1**	0.003	6	934	270
		2	0.000	No data available		
		3	0.017	No data available		
		4	0.018	1	107	54
	Total		0.038	7	1041	324
	Sweden	**1**	0.170	No data available		
		2	0.000			
		3	0.171	No data available		
		4	0.340	No data available		
	Total		0.681	0	0	0
Subdivision 24	**Denmark**	**1**	2.440	5	1,043	368
		2	0.132	No data available		
		3	0.282	No data available		
		4	0.726	2	173	119
	Total		3.580	7	1,216	487
	Germany	**1**	8.528	18	6,775	1,627
		2	1.140	8	3,372	658
		3	0.0001	No data available		
		4	0.659	6	2,507	589
	Total		10.328	32	12,654	2,874
	Poland	**1**	0.476	8	1,335	385
		2	0.769	12	1,688	477
		3	0.541	4	1,029	47
		4	0.607	5	964	312
	Total		2.394	29	5,016	1221
	Sweden	**1**	1.597	8	731	729
		2	0.024	1	172	168
		3	0.043	No data available		
		4	1.042	4	409	402
	Total		2.706	13	1,312	1,299
Total	**Skagerrak**	**1-4**	**20.530**	**53**	**3,170.00**	**2,997.00**
	Kattegat	**1-4**	**7.126**	**35**	**2,962.00**	**1,367.00**
	Subdivision 22	**1-4**	**1.368**	**9**	**2,646.00**	**491.00**
	Subdivision 23	**1-4**	**0.719**	**7**	**1,041.00**	**324.00**
	Subdivision 24	**1-4**	**19.008**	**81**	**20,198.00**	**5,881.00**
	Total	**1-4**	**48.750**	**185**	**30,017**	**11,060**

Table 3.2.5 WESTERN BALTIC HERRING.
Samples of landings by quarter and area used to
to estimate catch in numbers and mean weight at age for 2012

	Country	Quarter	Fleet	Sampling
Skagerrak	**Denmark**	1	C	Swedish sampling in Q1
		2	C	Swedish sampling in Q2
		3	C	Danish sampling in Q3
		4	C	Danish sampling in Q3
	Germany	1	C	No landings
		2	C	No landings
		3	C	Danish sampling in Q3
		4	C	Danish sampling in Q4
	Sweden	1	C	Swedish sampling in Q1
		2	C	Swedish sampling in Q2
		3	C	Swedish sampling in Q3
		4	C	Swedish sampling in Q4
	Denmark	1	D	Danish sampling in Q1 fleet D IIIaS
		2	D	Danish sampling in Q2 fleet D IIIaS
		3	D	Danish sampling in Q3
		4	D	Danish sampling in Q4
	Sweden	1	D	Swedish sampling in Q1
		2	D	Swedish sampling in Q2
		3	D	Swedish sampling in Q3
		4	D	Swedish sampling in Q4
	Norway	1	C	Swedish sampling in Q1
		2	C	Swedish sampling in Q2
		3	C	Danish sampling in Q3
		4	C	Danish sampling in Q4
Kattegat	**Denmark**	1	C	Swedish sampling in Q1
		2	C	Swedish sampling in Q2
		3	C	Danish sampling in Q3 fleet C IIIaN
		4	C	Danish sampling in Q4 fleet C IIIaN
	Sweden	1	C	Swedish sampling in Q1
		2	C	Swedish sampling in Q1
		3	C	Swedish sampling in Q3 fleet C IIIaN
		4	C	Swedish sampling in Q4 fleet C IIIaN
	Germany	1	C	No landings
		2	C	No landings
		3	C	No landings
		4	C	No landings
	Denmark	1	D	Danish sampling in Q1
		2	D	Danish sampling in Q2
		3	D	Danish sampling in Q3
		4	D	Danish sampling in Q4
Subdivision 22	**Denmark**	1	F	Danish sampling in Q1
		2	F	Danish sampling in Q2
		3	F	Danish sampling in Q4
		4	F	Danish sampling in Q4
	Germany	1	F	German sampling in SD 24 Q1
		2	F	German sampling in Q2
		3	F	German sampling in Q2
		4	F	German sampling in Q3

Fleet C= Human consumption, Fleet D= Industrial landings, Fleet F= All landings from Subdiv.22-24.

**Table 3.2.5 continued. WESTERN BALTIC HERRING.
Samples of landings by quarter and area used to
to estimate catch in numbers and mean weight by age for 2012**

	Country	Quarter	Fleet	Sampling
Subdivision 23	**Denmark**	**1**	**F**	Danish sampling SD 22 Q1
		2	**F**	Danish sampling SD 22 Q1
		3	**F**	Danish sampling SD 22 Q4
		4	**F**	Danish sampling SD 22 Q4
	Sweden	**1**	**F**	Swedish sampling SD 24 Q1
		2	**F**	No landings
		3	**F**	Swedish sampling SD 24 Q4
		4	**F**	Swedish sampling SD 24 Q4
Subdivision 24	**Denmark**	**1**	**F**	Danish sampling SD 24 Q1
		2	**F**	Danish sampling SD 24 Q1
		3	**F**	Danish sampling SD 24 Q4
		4	**F**	Danish sampling SD 24 Q4
	Germany	**1**	**F**	German sampling in Q1
		2	**F**	German sampling in Q2
		3	**F**	German sampling in Q3
		4	**F**	German sampling in Q4
	Poland	**1**	**F**	Polish sampling in Q1
		2	**F**	Polish sampling in Q2
		3	**F**	Polish sampling in Q3
		4	**F**	Polish sampling in Q4
	Sweden	**1**	**F**	Swedish sampling in Q1
		2	**F**	Swedish sampling in Q2
		3	**F**	Swedish sampling in Q4
		4	**F**	Swedish sampling in Q4

Fleet C= Human consumption, Fleet D= Industrial landings, Fleet F= All landings from Subdiv.22-24.

Table 3.2.6 WESTERN BALTIC HERRING.
Proportion of North Sea autumn spawners (NSAS) and Western Baltic spring spawners (WBSS) given in % in Skagerrak and Kattegat by age and quarter.
Year: 2012

		Skagerrak			Kattegat		
Quarter	W-rings	NSAS	WBSS	n	NSAS	WBSS	n
1	1	97.22%	2.78%	36	83.77%	16.23%	302
	2	42.00%	58.00%	50	34.25%	65.75%	146
	3	10.00%	90.00%	50	22.64%	77.36%	53
	4	0.00%	100.00%	17	7.69%	92.31%	26
	5	0.00%	100.00%	8	10.00%	90.00%	6
	6	0.00%	100.00%	3	10.00%	90.00%	2
	7	0.00%	100.00%	1	10.00%	90.00%	0
	8	0.00%	100.00%	0	10.00%	90.00%	0
		Skagerrak			Kattegat		
Quarter	W-rings	NSAS	WBSS	n	NSAS	WBSS	n
2	1	100.00%	0.00%	8	88.64%	11.36%	132
	2	44.00%	56.00%	50	40.00%	60.00%	5
	3	14.29%	85.71%	14	14.29%	85.71%	0
	4	14.47%	85.53%	3	14.47%	85.53%	0
	5	4.05%	95.95%	1	14.47%	85.53%	0
	6	7.50%	92.50%	0	14.47%	85.53%	0
	7	4.00%	96.00%	1	14.47%	85.53%	0
	8	0.00%	100.00%	1	14.47%	85.53%	0
		Skagerrak			Kattegat		
Quarter	W-rings	NSAS	WBSS	n	NSAS	WBSS	n
3	0	96.43%	3.57%	112	100.00%	0.00%	53
	1	85.92%	14.08%	71	76.00%	24.00%	25
	2	22.66%	77.34%	128	22.66%	77.34%	0
	3	4.88%	95.12%	123	4.88%	95.12%	0
	4	14.47%	85.53%	76	14.47%	85.53%	0
	5	4.05%	95.95%	74	4.05%	95.95%	0
	6	7.50%	92.50%	40	7.50%	92.50%	0
	7	4.00%	96.00%	25	7.50%	92.50%	0
	8	0.00%	100.00%	18	7.50%	92.50%	0
		Skagerrak			Kattegat		
Quarter	W-rings	NSAS	WBSS	n	NSAS	WBSS	n
4	0	100.00%	0.00%	9	100.00%	0.00%	44
	1	75.53%	24.47%	94	74.49%	25.51%	4
	2	17.07%	82.93%	82	17.07%	82.93%	0
	3	8.82%	91.18%	34	8.82%	91.18%	0
	4	11.54%	88.46%	26	11.54%	88.46%	0
	5	0.00%	100.00%	19	0.00%	100.00%	0
	6	7.69%	92.31%	5	7.69%	92.31%	0
	7	7.69%	92.31%	6	7.69%	92.31%	0
	8	7.69%	92.31%	2	7.69%	92.31%	0

when n for an age <12 data were borrowed according to the below table
borrowing either a mean of age groups or ages borrowed individually

Q	ages	Skagerrak	ages	Kattegat
1	5-8+	mean(Sk) Q1	5-8+	mean(Sk+Ka) Q1
2	5-8+	5-8+(Sk) Q3	4-8+	ind(Sk) Q3
3			3-8+	ind(Sk) Q3
4	6-8+	mean(Sk) Q4	1-8+	ind(Sk) Q4

Table 3.2.7 WESTERN BALTIC HERRING
Landings in numbers (mill.), mean weight (g.) and SOP (t) by age, quarter and fleet. ***North Sea Autumn spawners***
Division: Kattegat Year: 2012 Country: All

Quarter	W-rings	Fleet C Numbers	Fleet C Mean W.	Fleet D Numbers	Fleet D Mean W.	Total Numbers	Total Mean W.
1	1	0.68	24	33.56	16	34.24	17
	2	3.65	59	4.11	39	7.76	48
	3	0.38	103	0.02	85	0.40	101
	4	0.04	121			0.04	121
	5	0.01	135			0.01	135
	6	0.01	208			0.01	208
	7						
	8+						
	Total	4.76		37.69		42.46	
	SOP		278		713		990
2	1	0.04	24	19.72	21	19.76	21
	2	0.24	59	0.28	48	0.51	53
	3	0.01	103			0.01	103
	4	0.00	121			0.00	121
	5	0.00	135			0.00	135
	6	0.00	208			0.00	208
	7						
	8+						
	Total	0.30		20.00		20.30	
	SOP		17		437		454
3	0			63.23	10	63.23	10
	1	1.09	72	11.57	40	12.66	43
	2	0.64	97			0.64	97
	3	0.04	153			0.04	153
	4	0.08	180			0.08	180
	5	0.02	188			0.02	188
	6	0.03	212			0.03	212
	7	0.02	212			0.02	212
	8+	0.01	224			0.01	224
	Total	1.93		74.80		76.73	
	SOP		179		1,087		1,265
4	0	0.01	27	40.91	19	40.92	19
	1	0.57	66	3.01	52	3.58	54
	2	0.46	125			0.46	125
	3	0.12	165			0.12	165
	4	0.20	183			0.20	183
	5						
	6	0.03	193			0.03	193
	7	0.04	233			0.04	233
	8+	0.01	209			0.01	209
	Total	1.44		43.92		45.37	
	SOP		169		923		1,092
Total	0	0.01	27	104.14	13	104.16	13
	1	2.37	56	67.86	23	70.24	25
	2	4.99	70	4.38	40	9.37	56
	3	0.56	120	0.02	85	0.58	119
	4	0.33	174			0.33	174
	5	0.04	169			0.04	169
	6	0.06	202			0.06	202
	7	0.05	226			0.05	226
	8+	0.03	217			0.03	217
	Total	8.44		176.41		184.85	
	SOP		642		3,159		3,801

Table 3.2.8 WESTERN BALTIC HERRING
Landings in numbers (mill.), mean weight (g.) and SOP (t) by age, quarter and fleet. ***North Sea Autumn spawners***
Division: Skagerrak Year: 2012 Country: All

		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
1	1	2.84	26	23.66	16	26.51	17
	2	18.05	57	3.06	39	21.11	54
	3	0.63	108	0.01	85	0.64	108
	4						
	5						
	6						
	7						
	8+						
	Total	21.53		26.73		48.26	
	SOP		1,172		508		1,680
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
2	1	0.17	35	9.53	21	9.70	22
	2	1.05	66	0.13	48	1.18	64
	3	0.04	116			0.04	116
	4	0.01	130			0.01	130
	5	0.00	106			0.00	106
	6						
	7	0.00	156			0.00	156
	8+						
	Total	1.28		9.66		10.94	
	SOP		82		211		293
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
3	0			41.07	9	41.07	9
	1	41.02	68	1.29	42	42.31	67
	2	10.34	97			10.34	97
	3	0.48	149			0.48	149
	4	0.73	167			0.73	167
	5	0.15	177			0.15	177
	6	0.13	199			0.13	199
	7	0.05	213			0.05	213
	8+						
	Total	52.92		42.36		95.28	
	SOP		4,036		437		4,473
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
4	0	0.60	27			0.60	27
	1	24.29	66	1.83	65	26.12	66
	2	1.68	101	0.02	68	1.70	100
	3	0.14	136			0.14	136
	4	0.11	179			0.11	179
	5						
	6	0.01	193			0.01	193
	7	0.02	233			0.02	233
	8+	0.01	209			0.01	209
	Total	26.86		1.85		28.71	
	SOP		1,830		120		1,951
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
Total	0	0.60	27	41.07	9	41.68	10
	1	68.33	65	36.31	21	104.64	50
	2	31.12	73	3.21	40	34.34	70
	3	1.30	126	0.01	85	1.31	126
	4	0.86	168			0.86	168
	5	0.15	176			0.15	176
	6	0.14	198			0.14	198
	7	0.07	216			0.07	216
	8+	0.01	209			0.01	209
	Total	102.59		80.60		183.19	
	SOP		7,120		1,276		8,396

Table 3.2.9 WESTERN BALTIC HERRING
Landings in numbers (mill.), mean weight (g.) and SOP (t) by age, quarter and fleet. ***Baltic Spring spawners***
Division: Kattegat Year: 2012 Country: All

Quarter	W-rings	Fleet C Numbers	Fleet C Mean W.	Fleet D Numbers	Fleet D Mean W.	Total Numbers	Total Mean W.
1	1	0.13	24	6.50	16	6.63	17
	2	7.01	59	7.89	39	14.90	48
	3	1.29	103	0.08	85	1.37	101
	4	0.48	121			0.48	121
	5	0.11	135			0.11	135
	6	0.05	208			0.05	208
	7						
	8+						
	Total	9.07		14.47		23.54	
	SOP		630		422		1,052
2	1	0.01	24	2.53	21	2.53	21
	2	0.36	59	0.41	48	0.77	53
	3	0.08	103			0.08	103
	4	0.02	121			0.02	121
	5	0.01	135			0.01	135
	6	0.00	208			0.00	208
	7						
	8+						
	Total	0.48		2.94		3.42	
	SOP		34		74		108
3	0						
	1	0.34	72	3.65	40	4.00	43
	2	2.19	97			2.19	97
	3	0.85	153			0.85	153
	4	0.48	180			0.48	180
	5	0.56	188			0.56	188
	6	0.31	212			0.31	212
	7	0.19	212			0.19	212
	8+	0.17	224			0.17	224
	Total	5.10		3.65		8.76	
	SOP		705		145		850
4	0						
	1	0.19	66	1.03	52	1.23	54
	2	2.22	125			2.22	125
	3	1.29	165			1.29	165
	4	1.57	183			1.57	183
	5	1.39	197			1.39	197
	6	0.36	193			0.36	193
	7	0.43	233			0.43	233
	8+	0.15	209			0.15	209
	Total	7.59		1.03		8.62	
	SOP		1,261		54		1,314
Total	0						
	1	0.67	61	13.71	26	14.39	28
	2	11.78	78	8.30	40	20.08	62
	3	3.51	138	0.08	85	3.59	136
	4	2.55	170			2.55	170
	5	2.07	191			2.07	191
	6	0.72	202			0.72	202
	7	0.62	226			0.62	226
	8+	0.32	217			0.32	217
	Total	22.24		22.09		44.33	
	SOP		2,630		695		3,325

Table 3.2.10 WESTERN BALTIC HERRING
Landings in numbers (mill.), mean weight (g.) and SOP (t) by age, quarter and fleet. ***Baltic Spring spawners***
Division: Skagerrak Year: 2012 Country: All

Quarter	W-rings	Fleet C Numbers	Fleet C Mean W.	Fleet D Numbers	Fleet D Mean W.	Total Numbers	Total Mean W.
1	1	0.08	26	0.68	16	0.76	17
	2	24.93	57	4.23	39	29.15	54
	3	5.71	108	0.06	85	5.77	108
	4	1.34	132			1.34	132
	5	0.64	181			0.64	181
	6	0.30	200			0.30	200
	7	0.17	277			0.17	277
	8+						
	Total	33.17		4.96		38.13	
	SOP		2,441		181		2,623
Quarter	W-rings	Fleet C Numbers	Fleet C Mean W.	Fleet D Numbers	Fleet D Mean W.	Total Numbers	Total Mean W.
2	1						
	2	1.34	66	0.16	48	1.51	64
	3	0.25	116			0.25	116
	4	0.06	130			0.06	130
	5	0.03	106			0.03	106
	6						
	7	0.03	156			0.03	156
	8+	0.03	192			0.03	192
	Total	1.75		0.16		1.92	
	SOP		140		8		148
Quarter	W-rings	Fleet C Numbers	Fleet C Mean W.	Fleet D Numbers	Fleet D Mean W.	Total Numbers	Total Mean W.
3	0			1.52	9	1.52	9
	1	6.73	68	0.21	42	6.94	67
	2	35.31	97			35.31	97
	3	9.39	149			9.39	149
	4	4.34	167			4.34	167
	5	3.63	177			3.63	177
	6	1.61	199			1.61	199
	7	1.23	213			1.23	213
	8+	0.75	224			0.75	224
	Total	62.98		1.73		64.71	
	SOP		7,380		23		7,403
Quarter	W-rings	Fleet C Numbers	Fleet C Mean W.	Fleet D Numbers	Fleet D Mean W.	Total Numbers	Total Mean W.
4	0						
	1	7.87	66	0.59	65	8.46	66
	2	8.14	101	0.10	68	8.24	100
	3	1.49	136			1.49	136
	4	0.86	179			0.86	179
	5	0.72	188			0.72	188
	6	0.15	193			0.15	193
	7	0.18	233			0.18	233
	8+	0.06	209			0.06	209
	Total	19.48		0.69		20.17	
	SOP		1,915		45		1,960
Quarter	W-rings	Fleet C Numbers	Fleet C Mean W.	Fleet D Numbers	Fleet D Mean W.	Total Numbers	Total Mean W.
Total	0			1.52	9	1.52	9
	1	14.68	66	1.48	40	16.16	64
	2	69.72	82	4.49	40	74.21	80
	3	16.85	133	0.06	85	16.90	133
	4	6.60	161			6.60	161
	5	5.03	178			5.03	178
	6	2.06	198			2.06	198
	7	1.61	220			1.61	220
	8+	0.85	222			0.85	222
	Total	117.38		7.55		124.93	
	SOP		11,876		258		12,134

Table 3.2.11 WESTERN BALTIC HERRING
Landings in numbers (mill.), mean weight (g.) and SOP (t) by age, quarter and fleet. ***North Sea Autumn spawners***
Division: IIIa **Year: 2012** **Country: All**

		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
1	1	3.45	25	57.22	16	60.67	17
	2	21.25	57	7.17	39	28.42	53
	3	1.00	106	0.03	85	1.03	105
	4	0.04	121	0.00	0	0.04	121
	5	0.01	135	0.00	0	0.01	135
	6	0.01	208	0.00	0	0.01	208
	7	0.00	0	0.00	0	0.00	0
	8+	0.00	0	0.00	0	0.00	0
	Total	25.75	0	64.42	0	90.17	0
	SOP	0.0	1,420	0	1,221	0	2,640
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
2	1	0.20	33	29.25	21	29.45	22
	2	1.20	64	0.40	48	1.61	60
	3	0.05	112	0.00	0	0.05	112
	4	0.01	127	0.00	0	0.01	127
	5	0.00	119	0.00	0	0.00	119
	6	0.00	208	0.00	0	0.00	208
	7	0.00	156	0.00	0	0.00	156
	8+	0.00	0	0.00	0	0.00	0
	Total	1.47	0	29.66	0	31.13	0
	SOP	0.0	92	0	648	0	740
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
3	0	0.00	0	104.31	10	104.31	10
	1	42.05	68	12.85	40	54.91	61
	2	10.93	97	0.00	0	10.93	97
	3	0.52	149	0.00	0	0.52	149
	4	0.81	168	0.00	0	0.81	168
	5	0.17	178	0.00	0	0.17	178
	6	0.15	201	0.00	0	0.15	201
	7	0.07	212	0.00	0	0.07	212
	8+	0.01	224	0.00	0	0.01	224
	Total	54.72	0	117.16	0	171.88	0
	SOP	0.0	4,201	0	1,524	0	5,725
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
4	0	0.62	27	40.91	19	41.53	19
	1	24.87	66	4.84	57	29.71	64
	2	2.07	105	0.02	68	2.09	105
	3	0.25	148	0.00	0	0.25	148
	4	0.28	181	0.00	0	0.28	181
	5	0.00	0	0.00	0	0.00	0
	6	0.04	193	0.00	0	0.04	193
	7	0.04	233	0.00	0	0.04	233
	8+	0.02	209	0.00	0	0.02	209
	Total	28.18	0	45.78	0	73.96	0
	SOP	0.0	1,980	0	1,043	0	3,023
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
Total	0	0.62	27	145.22	12	145.83	12
	1	70.57	65	104.17	23	174.74	40
	2	35.45	73	7.59	40	43.05	67
	3	1.82	124	0.03	85	1.85	124
	4	1.14	169	0.00	0	1.14	169
	5	0.19	175	0.00	0	0.19	175
	6	0.20	199	0.00	0	0.20	199
	7	0.11	220	0.00	0	0.11	220
	8+	0.03	216	0.00	0	0.03	216
	Total	110.12	0	257.02	0	367.14	0
	SOP	0.0	7,693	0	4,435	0	12,128

Table 3.2.12 WESTERN BALTIC HERRING
Landings in numbers (mill.), mean weight (g.) and SOP (t) by age, quarter and fleet. ***Baltic Spring spawners***
Division: IIIa Year: 2012 Country: All

Quarter	W-rings	Fleet C Numbers	Fleet C Mean W.	Fleet D Numbers	Fleet D Mean W.	Total Numbers	Total Mean W.
1	1	0.21	25	7.18	16	7.39	17
	2	31.94	57	12.12	39	44.05	52
	3	7.00	107	0.14	85	7.14	107
	4	1.82	129			1.82	129
	5	0.75	174			0.75	174
	6	0.35	201			0.35	201
	7	0.17	277			0.17	277
	8+						
	Total	42.24		19.43		61.67	
	SOP		3,072		604		3,675
Quarter	W-rings	Fleet C Numbers	Fleet C Mean W.	Fleet D Numbers	Fleet D Mean W.	Total Numbers	Total Mean W.
2	1	0.01	24	2.53	21	2.53	21
	2	1.70	64	0.58	48	2.28	60
	3	0.33	113			0.33	113
	4	0.08	127			0.08	127
	5	0.04	110			0.04	110
	6	0.00	208			0.00	208
	7	0.03	156			0.03	156
	8+	0.03	192			0.03	192
	Total	2.23		3.11		5.33	
	SOP		174		82		256
Quarter	W-rings	Fleet C Numbers	Fleet C Mean W.	Fleet D Numbers	Fleet D Mean W.	Total Numbers	Total Mean W.
3	0			1.52	9	1.52	9
	1	7.07	68	3.86	40	10.93	58
	2	37.50	97			37.50	97
	3	10.24	149			10.24	149
	4	4.82	168			4.82	168
	5	4.19	178			4.19	178
	6	1.92	201			1.92	201
	7	1.42	212			1.42	212
	8+	0.92	224			0.92	224
	Total	68.08		5.39		73.47	
	SOP		8,085		168		8,253
Quarter	W-rings	Fleet C Numbers	Fleet C Mean W.	Fleet D Numbers	Fleet D Mean W.	Total Numbers	Total Mean W.
4	0						
	1	8.06	66	1.63	57	9.69	64
	2	10.36	106	0.10	68	10.46	106
	3	2.78	149			2.78	149
	4	2.43	181			2.43	181
	5	2.11	194			2.11	194
	6	0.50	193			0.50	193
	7	0.61	233			0.61	233
	8+	0.21	209			0.21	209
	Total	27.07		1.72		28.79	
	SOP		3,175		99		3,274
Quarter	W-rings	Fleet C Numbers	Fleet C Mean W.	Fleet D Numbers	Fleet D Mean W.	Total Numbers	Total Mean W.
Total	0			1.52	9	1.52	9
	1	15.35	66	15.19	28	30.54	47
	2	81.50	82	12.79	40	94.29	76
	3	20.36	134	0.14	85	20.49	134
	4	9.15	163			9.15	163
	5	7.09	182			7.09	182
	6	2.77	199			2.77	199
	7	2.23	222			2.23	222
	8+	1.17	221			1.17	221
	Total	139.62		29.64		169.26	
	SOP		14,506		953		15,458

Table 3.2.13 **WESTERN BALTIC HERRING.**
Total catch in numbers (mill) and mean weight (g), SOP (tonnes) of *Western Baltic Spring* spawners in Division IIIa and the North Sea in the years 1993-2012.

Year	W-rings	0	1	2	3	4	5	6	7	8+	Total
1993	Numbers	161.25	371.50	315.82	219.05	94.08	59.43	40.97	21.71	8.22	1,292.03
	Mean W.	15.1	25.9	81.4	127.5	150.1	171.1	195.9	209.1	239.0	
	SOP	2,435	9,612	25,696	27,936	14,120	10,167	8,027	4,541	1,966	104,498
1994	Numbers	60.62	153.11	261.14	221.64	130.97	77.30	44.40	14.39	8.62	972.19
	Mean W.	20.2	42.6	94.8	122.7	150.3	168.7	194.7	209.9	220.2	
	SOP	1,225	6,524	24,767	27,206	19,686	13,043	8,642	3,022	1,898	106,013
1995	Numbers	50.31	302.51	204.19	97.93	90.86	30.55	21.28	12.01	7.24	816.86
	Mean W.	17.9	41.5	97.8	138.0	163.1	198.5	207.0	228.8	234.3	
	SOP	902	12,551	19,970	13,517	14,823	6,065	4,404	2,747	1,696	76,674
1996	Numbers	166.23	228.05	317.74	75.60	40.41	30.63	12.58	6.73	5.63	883.60
	Mean W.	10.5	27.6	90.1	134.9	164.9	186.6	204.1	208.5	220.2	
	SOP	1,748	6,296	28,618	10,197	6,665	5,714	2,568	1,402	1,241	64,449
1997	Numbers	25.97	73.43	158.71	180.06	30.15	14.15	4.77	1.75	2.31	491.31
	Mean W.	19.2	49.7	76.7	127.2	154.4	175.8	184.4	192.0	208.0	
	SOP	498	3,648	12,176	22,913	4,656	2,489	879	337	480	48,075
1998	Numbers	36.26	175.14	315.15	94.53	54.72	11.19	8.72	2.19	2.09	699.98
	Mean W.	27.8	51.3	71.5	108.8	142.6	171.7	194.4	184.2	230.0	
	SOP	1,009	8,980	22,542	10,287	7,804	1,922	1,695	403	481	55,121
1999	Numbers	41.34	190.29	155.67	122.26	43.16	22.21	4.42	3.02	2.40	584.77
	Mean W.	11.5	51.0	83.6	114.9	121.2	145.2	169.6	123.8	152.3	
	SOP	477	9,698	13,012	14,048	5,232	3,225	749	373	366	47,179
2000	Numbers	114.83	318.22	302.10	99.88	50.85	18.76	8.21	1.35	1.40	915.60
	Mean W.	22.6	31.9	67.4	107.7	140.2	170.0	157.0	185.0	210.1	
	SOP	2,601	10,145	20,357	10,756	7,131	3,189	1,288	249	294	56,010
2001	Numbers	121.68	36.63	208.10	111.08	32.06	19.67	9.84	4.17	2.42	545.65
	Mean W.	9.0	51.2	76.2	108.9	145.3	171.4	188.2	187.2	203.3	
	SOP	1,096	1,875	15,863	12,093	4,657	3,371	1,852	780	492	42,079
2002	Numbers	69.63	577.69	168.26	134.60	53.09	12.05	7.48	2.43	2.02	1,027.26
	Mean W.	10.2	20.4	78.2	117.7	143.8	169.8	191.9	198.2	215.5	
	SOP	709	11,795	13,162	15,848	7,632	2,046	1,435	481	435	53,544
2003	Numbers	52.11	63.02	182.53	65.45	64.37	21.47	6.26	4.35	1.81	461.38
	Mean W.	13.0	37.4	76.5	113.3	132.7	142.2	153.5	169.9	162.2	
	SOP	678	2,355	13,957	7,416	8,540	3,053	961	740	294	37,994
2004	Numbers	25.67	209.34	96.02	93.98	18.24	16.84	4.51	1.51	0.59	466.71
	Mean W.	27.1	43.2	81.9	117.1	145.4	157.4	170.7	184.4	187.1	
	SOP	695	9,047	7,869	11,005	2,652	2,651	769	279	111	35,078
2005	Numbers	95.3	96.9	203.3	75.4	46.9	9.3	11.5	3.5	1.4	543.51
	Mean W.	14.1	54.9	85.6	121.6	148.3	162.7	176.3	178.3	200.6	
	SOP	1,341	5,319	17,415	9,163	6,961	1,519	2,028	618	282	44,645
2006 c	Numbers	7.3	104.1	115.6	114.2	48.9	55.7	11.1	10.3	5.2	472.49
	Mean W.	16.6	36.9	82.9	113.0	142.5	175.2	198.2	209.5	220.0	
	SOP	121	3,847	9,584	12,907	6,972	9,765	2,199	2,159	1,134	48,688
2007	Numbers	1.6	103.9	90.9	36.9	30.8	12.8	9.4	6.2	2.7	295.22
	Mean W.	25.2	65.6	85.0	115.7	138.4	159.2	190.8	178.6	211.9	
	SOP	41	6,816	7,723	4,269	4,265	2,035	1,802	1,114	567	28,632
2008	Numbers	4.9	101.8	71.1	38.9	13.5	15.1	7.7	4.5	1.3	258.80
	Mean W.	19.2	71.5	91.1	114.5	142.2	171.2	181.4	200.0	196.4	98.02
	SOP	94	7,281	6,472	4,456	1,917	2,590	1,402	900	256	25,368
2009	Numbers	14.8	149.6	132.3	45.9	24.4	10.9	7.8	7.7	5.3	398.63
	Mean W.	13.4	52.0	90.3	118.6	167.5	181.4	213.9	228.9	259.5	90.89
	SOP	199	7,783	11,946	5,436	4,094	1,974	1,669	1,757	1,371	36,230
2010	Numbers	9.1	48.6	106.1	45.2	20.8	8.6	5.9	7.2	5.9	257.38
	Mean W.	8.2	59.3	84.7	129.8	165.9	196.2	221.8	234.3	257.2	106.71
	SOP	75	2,878	8,991	5,870	3,445	1,686	1,311	1,696	1,513	27,465
2011	Numbers	6.2	83.1	29.9	21.0	13.4	6.0	3.0	1.0	1.1	164.56
	Mean W.	8.4	33.7	89.0	120.4	140.2	170.2	185.9	216.3	211.8	72.57
	SOP	52	2,797	2,660	2,522	1,878	1,020	554	222	237	11,941
2012	Numbers	1.5	30.5	94.3	20.7	9.5	7.1	4.2	2.2	8.6	178.68
	Mean W.	9.3	47.0	76.1	134.2	165.1	182.0	204.1	222.0	225.6	98.24
	SOP	14	1,434	7,180	2,780	1,570	1,290	858	495	1,931	17,553

Data for 1995 to 2001 was revised in 2003.

[c] values have been corrected in 2007

Table 3.2.14 **WESTERN BALTIC HERRING.**
Landings in numbers (mill.), mean weight (g.) and SOP (t)
by age and quarter from. **Western Baltic Spring Spawners**
(values from the North Sea, see Table 2.2.1-2.2.5)
Division: **IV + IIIa + 22-24** **Year:** **2012**

		Division IV		Division IIIa		Subdivision 22-24		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
1	1	0.000	89.00	7.39	16.62	28.70	10.66	36.087	11.88
	2	0.004	119.10	44.05	52.43	20.78	43.97	64.836	49.73
	3	0.049	173.20	7.14	106.65	27.66	87.81	34.843	91.79
	4	0.007	184.30	1.82	128.75	25.62	112.73	27.448	113.81
	5	0.000	195.80	0.75	173.90	20.52	157.86	21.271	158.42
	6	0.008	213.40	0.35	200.76	9.89	176.69	10.248	177.54
	7	0.000	212.60	0.17	277.00	6.40	188.36	6.567	190.62
	8+	0.028	237.86	0.00	0.00	6.23	200.48	6.262	200.65
	Total	0.097		61.67		145.80		207.562	
	SOP		19		3,675		13,978		17,672
		Division IV		Division IIIa		Subdivision 22-24		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
2	1	0.000	0.00	2.53	21.49	10.62	11.33	13.15	13.29
	2	0.001	159.00	2.28	60.07	6.28	41.60	8.56	46.54
	3	0.120	187.00	0.33	112.62	5.29	74.87	5.75	79.42
	4	0.000	190.00	0.08	127.23	5.33	101.45	5.41	101.83
	5	0.000	198.00	0.04	110.49	3.34	123.75	3.37	123.60
	6	0.000	219.00	0.00	207.90	2.22	146.51	2.22	146.58
	7	0.000	214.00	0.03	156.00	1.47	160.34	1.50	160.24
	8+	0.000	234.50	0.03	192.00	1.20	183.65	1.23	183.88
	Total	0.122		5.33		35.74		41.20	
	SOP		23		256		2,512		2,791
		Division IV		Division IIIa		Subdivision 22-24		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
3	0	0.00	0.00	1.52	9.31	0.04	13.00	1.56	9.41
	1	0.00	87.70	10.93	58.01	0.47	43.24	11.40	57.41
	2	0.01	144.60	37.50	96.71	1.53	93.49	39.04	96.59
	3	0.04	190.90	10.24	149.06	2.59	112.78	12.88	141.91
	4	0.01	195.90	4.82	168.15	2.40	110.66	7.24	149.08
	5	0.00	216.40	4.19	178.23	1.90	99.16	6.09	153.59
	6	0.01	231.20	1.92	200.93	0.79	97.40	2.72	170.92
	7	0.00	244.00	1.42	212.46	0.24	107.53	1.66	197.31
	8+	0.02	246.97	0.92	224.29	0.41	112.40	1.35	190.70
	Total	0.09		73.47		10.37		83.93	
	SOP		18		8,253		1,059		9,330
		Division IV		Division IIIa		Subdivision 22-24		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
4	0	0.000	0.00	0.00	0.00	0.44	18.63	0.44	18.63
	1	0.000	101.00	9.69	64.28	6.53	44.21	16.21	56.20
	2	0.000	146.00	10.46	105.58	7.91	87.24	18.38	97.68
	3	0.000	183.00	2.78	149.18	8.22	128.91	11.00	134.04
	4	0.344	206.00	2.43	181.50	4.46	147.28	7.23	161.57
	5	0.000	221.00	2.11	193.56	2.60	162.48	4.71	176.39
	6	1.415	213.00	0.50	192.70	1.06	179.60	2.98	197.68
	7	0.000	229.00	0.61	232.60	0.90	146.13	1.51	181.07
	8+	7.347	226.29	0.21	209.20	0.60	163.33	8.16	221.24
	Total	9.107		28.79		32.71		70.61	
	SOP		2,035		3,274		3,545		8,855
		Division IV		Division IIIa		Subdivision 22-24		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
Total	0	0.00	0.00	1.52	9.31	0.48	18.12	2.000	11.42
	1	0.00	0.00	30.54	46.96	46.31	15.87	76.854	28.23
	2	0.02	139.60	94.29	76.12	36.50	55.02	130.803	70.24
	3	0.21	184.63	20.49	133.71	43.76	95.44	64.468	107.91
	4	0.36	205.33	9.15	163.50	37.81	115.08	47.322	125.13
	5	0.00	0.00	7.09	181.96	28.35	150.34	35.444	156.66
	6	1.43	213.11	2.77	199.42	13.96	167.62	18.169	176.06
	7	0.00	0.00	2.23	222.01	9.01	177.42	11.238	186.27
	8+	7.39	226.39	1.17	220.63	8.44	191.18	17.001	208.52
	Total	9.42		169.26		224.62		403.300	
	SOP		2,095		15,458		21,095		38,648

Table 3.2.15 **WESTERN BALTIC HERRING.**
Total catch in numbers (mill) of *Western Baltic Spring Spawners* in Division IIIa + North Sea + Subdivisions 22-24 in the years 1993-2012

	W-rings	0	1	2	3	4	5	6	7	8+	Total
Year	Area										
1993	Div. IV+Div. IIIa	161.3	371.5	315.8	219.0	94.1	59.4	41.0	21.7	8.2	1130.8
	Subdiv. 22-24	44.9	159.2	180.1	196.1	166.9	151.1	61.8	42.2	16.3	973.7
1994	Div. IV+Div. IIIa	60.6	153.1	261.1	221.6	131.0	77.3	44.4	14.4	8.6	911.6
	Subdiv. 22-24	202.6	96.3	103.8	161.0	136.1	90.8	74.0	35.1	24.5	721.6
1995	Div. IV+Div. IIIa	50.3	302.5	204.2	97.9	90.9	30.6	21.3	12.0	7.2	816.9
	Subdiv. 22-24	491.0	1,358.2	233.9	128.9	104.0	53.6	38.8	20.9	13.2	1951.5
1996	Div. IV+Div. IIIa	166.2	228.1	317.7	75.6	40.4	30.6	12.6	6.7	5.6	883.6
	Subdiv. 22-24	4.9	410.8	82.8	124.1	103.7	99.5	52.7	24.0	19.5	917.1
1997	Div. IV+Div. IIIa	26.0	73.4	158.7	180.1	30.2	14.2	4.8	1.8	2.3	491.3
	Subdiv. 22-24	350.8	595.2	130.6	96.9	45.1	29.0	35.1	19.5	21.8	973.2
1998	Div. IV+Div. IIIa	36.3	175.1	315.1	94.5	54.7	11.2	8.7	2.2	2.1	700.0
	Subdiv. 22-24	513.5	447.9	115.8	88.3	92.0	34.1	15.0	13.2	12.0	818.4
1999	Div. IV+Div. IIIa	41.3	190.3	155.7	122.3	43.2	22.2	4.4	3.0	2.4	584.8
	Subdiv. 22-24	528.3	425.8	178.7	123.9	47.1	33.7	11.1	6.5	3.7	830.5
2000	Div. IV+Div. IIIa	114.83	318.22	302.10	99.88	50.85	18.76	8.21	1.35	1.40	915.6
	Subdiv. 22-24	37.7	616.3	194.3	86.7	77.8	53.0	30.1	12.4	9.3	1079.9
2001	Div. IV+Div. IIIa	121.7	36.6	208.1	111.1	32.1	19.7	9.8	4.2	2.4	545.6
	Subdiv. 22-24	634.6	486.5	280.7	146.8	76.0	48.7	29.3	14.1	4.3	1721.0
2002	Div. IV+Div. IIIa	69.6	577.7	168.3	134.6	53.1	12.0	7.5	2.4	2.0	1027.3
	Subdiv. 22-24	80.6	81.4	113.6	186.7	119.2	45.1	31.1	11.4	6.3	675.4
2003	Div. IV+Div. IIIa	52.1	63.0	182.5	64.0	62.2	20.3	5.9	3.8	1.6	455.5
	Subdiv. 22-24	1.4	63.9	82.3	95.8	125.1	82.2	22.9	13.1	7.0	493.6
2004	Div. IV+Div. IIIa	25.7	209.3	96.0	94.0	18.2	16.8	4.5	1.5	0.6	466.7
	Subdiv. 22-24	217.9	248.4	101.8	70.8	75.0	74.4	44.5	13.4	10.4	856.5
2005	Div. IV+Div. IIIa	95.3	96.9	203.3	75.4	46.9	9.3	11.5	3.5	1.4	543.5
	Subdiv. 22-24	11.6	207.6	115.9	102.5	83.5	51.3	54.2	27.8	11.2	665.5
2006 c	Div. IV+Div. IIIa	7.3	104.1	115.6	114.2	48.9	55.7	11.1	10.3	5.2	472.5
	Subdiv. 22-24	0.6	44.8	72.1	119.0	101.7	43.0	31.4	22.1	12.2	446.8
2007	Div. IV+Div. IIIa	1.6	103.9	90.9	36.9	30.8	12.8	9.4	6.2	2.7	295.2
	Subdiv. 22-24	19.0	668.5	158.3	169.7	112.8	65.1	24.6	5.9	1.8	1206.8
2008	Div. IV+Div. IIIa	4.9	101.8	71.1	38.9	13.5	15.1	7.7	4.5	1.3	258.8
	Subdiv. 22-24	19.0	668.5	158.3	169.7	112.8	65.1	24.6	5.9	1.8	1206.8
2009	Div. IV+Div. IIIa	14.8	149.6	132.3	45.9	24.4	10.9	7.8	7.7	5.3	398.6
	Subdiv. 22-24	5.9	31.5	110.7	55.5	45.5	37.2	31.9	13.2	7.2	338.7
2010	Div. IV+Div. IIIa	9.1	48.6	106.1	45.2	20.8	8.6	5.9	7.2	5.9	257.4
	Subdiv. 22-24	3.3	26.5	31.3	39.3	28.5	22.4	13.9	8.0	7.5	180.6
2011	Div. IV+Div. IIIa	6.2	83.1	29.9	21.0	13.4	6.0	3.0	1.0	1.1	164.6
	Subdiv. 22-24	5.6	15.5	16.4	17.8	35.9	21.6	19.6	11.2	8.2	152.0
2012	Div. IV+Div. IIIa	1.5	30.5	94.3	20.7	9.5	7.1	4.2	2.2	8.6	178.7
	Subdiv. 22-24	0.5	46.3	36.5	43.8	37.8	28.4	14.0	9.0	8.4	224.6

Data for 1995-2001 for the North Sea and Division IIIa was revised in 2003.

[c] values have been corrected in 2007

Table 3.2.16 **WESTERN BALTIC HERRING.**

Mean weight (g) and SOP (tons) of *Western Baltic Spring Spawners* in Division IIIa + North Sea + Subdivisions 22-24 in the years 1993 - 2012

	W-rings	0	1	2	3	4	5	6	7	8+	SOP
Year	Area										
1993	Div. IV+Div. IIIa	15.1	25.9	81.4	127.5	150.1	171.1	195.9	209.1	239.0	104,498
	Subdiv. 22-24	16.2	24.5	44.5	73.6	94.1	122.4	149.4	168.5	178.7	80,512
1994	Div. IV+Div. IIIa	20.2	42.6	94.8	122.7	150.3	168.7	194.7	209.9	220.2	106,013
	Subdiv. 22-24	12.9	28.2	54.2	76.4	95.0	117.7	133.6	154.3	173.9	66,425
1995	Div. IV+Div. IIIa	17.9	41.5	97.8	138.0	163.1	198.5	207.0	228.8	234.3	76,674
	Subdiv. 22-24	9.3	16.3	42.8	68.3	88.9	125.4	150.4	193.3	207.4	74,157
1996	Div. IV+Div. IIIa	10.5	27.6	90.1	134.9	164.9	186.6	204.1	208.5	220.2	64,449
	Subdiv. 22-24	12.1	22.9	45.8	74.0	92.1	116.3	120.8	139.0	182.5	56,817
1997	Div. IV+Div. IIIa	19.2	49.7	76.7	127.2	154.4	175.8	184.4	192.0	208.0	48,075
	Subdiv. 22-24	30.4	24.7	58.4	101.0	120.7	155.2	181.3	197.1	208.8	67,513
1998	Div. IV+Div. IIIa	27.8	51.3	71.5	108.8	142.6	171.7	194.4	184.2	230.0	55,121
	Subdiv. 22-24	13.3	26.3	52.2	78.6	103.0	125.2	150.0	162.1	179.5	51,911
1999	Div. IV+Div. IIIa	11.5	51.0	83.6	114.9	121.2	145.2	169.6	123.8	152.3	47,179
	Subdiv. 22-24	11.1	26.9	50.4	81.6	112.0	148.4	151.4	167.8	161.0	50,060
2000	Div. IV+Div. IIIa	22.6	31.9	67.4	107.7	140.2	170.0	157.0	185.0	210.1	56,010
	Subdiv. 22-24	16.5	22.2	42.8	80.4	123.5	133.2	143.4	155.4	151.4	53,904
2001	Div. IV+Div. IIIa	9.0	51.2	76.2	108.9	145.3	171.4	188.2	187.2	203.3	42,079
	Subdiv. 22-24	12.9	22.3	46.8	69.0	93.5	150.8	145.1	146.3	153.1	63,724
2002	Div. IV+Div. IIIa	10.2	20.4	78.2	117.7	143.8	169.8	191.9	198.2	215.5	53,544
	Subdiv. 22-24	10.8	27.3	57.8	81.7	108.8	132.1	186.6	177.8	157.7	52,647
2003	Div. IV+Div. IIIa	13.0	37.4	76.5	112.7	132.1	140.8	151.9	167.4	158.2	37,075
	Subdiv. 22-24	22.4	25.8	46.4	75.3	95.2	117.2	125.9	157.1	162.6	40,315
2004	Div. IV+Div. IIIa	27.1	43.2	81.9	117.1	145.4	157.4	170.7	184.4	187.1	35,078
	Subdiv. 22-24	3.7	14.3	47.4	77.7	96.4	125.5	150.4	165.8	151.0	41,736
2005	Div. IV+Div. IIIa	14.1	54.9	85.6	121.6	148.3	162.7	176.3	178.3	200.6	50,765
	Subdiv. 22-24	13.6	14.2	48.3	73.3	89.3	115.5	143.6	159.9	170.2	37,013
2006 c	Div. IV+Div. IIIa	16.6	36.9	82.9	113.0	142.5	175.2	198.2	209.5	220.0	25,965
	Subdiv. 22-24	21.2	34.0	56.7	84.0	102.2	125.3	143.9	175.8	170.0	70,911
2007	Div. IV+Div. IIIa	25.2	65.6	85.0	115.7	138.4	159.2	190.8	178.6	211.9	28,632
	Subdiv. 22-24	11.9	27.8	57.3	74.9	106.3	121.3	140.8	162.7	185.5	39,548
2008	Div. IV+Div. IIIa	19.2	71.5	91.1	114.5	142.2	171.2	181.4	200.0	196.4	25,368
	Subdiv. 22-24	16.3	49.5	65.2	88.1	110.5	133.2	140.3	156.7	172.2	43,116
2009	Div. IV+Div. IIIa	13.4	52.0	90.3	118.6	167.5	181.4	213.9	228.9	259.5	36,230
	Subdiv. 22-24	10.5	28.3	48.1	90.5	123.7	145.2	160.4	171.2	181.8	31,032
2010	Div. IV+Div. IIIa	8.2	59.3	84.7	129.8	165.9	196.2	221.8	234.3	257.2	27,465
	Subdiv. 22-24	12.2	22.2	52.2	87.1	119.8	154.8	170.6	191.9	194.1	17,917
2011	Div. IV+Div. IIIa	8.4	33.7	89.0	120.4	140.2	170.2	185.9	216.3	211.8	11,941
	Subdiv. 22-24	12.4	23.0	55.1	78.1	113.2	136.6	147.6	161.2	168.0	15,830
2012	Div. IV+Div. IIIa	9.3	47.0	76.1	134.2	165.1	182.0	204.1	222.0	225.6	17,553
	Subdiv. 22-24	18.1	15.9	55.0	95.4	115.1	150.3	167.6	177.4	191.2	21,095

Data for 1995-2001 for the North Sea and Division IIIa was revised in 2003.

[c] values have been corrected in 2007

Table 3.2.17 WESTERN BALTIC HERRING.
Transfers of *North Sea autumn spawners* from Div. IIIa to the North Sea
Numbers ('000) and mean weight, SOP in (tonnes) 1993-2012.

Year	W-Rings	0	1	2	3	4	5	6	7	8+	Total
1993	Number	2,795.4	2,032.5	237.6	26.5	7.7	3.6	2.7	2.2	0.7	5,109.0
	Mean W.	12.5	28.6	79.7	141.4	132.3	233.4	238.5	180.6	203.1	
	SOP	34,903	58,107	18,939	3,749	1,016	850	647	390	133	118,734
1994	Number	481.6	1,086.5	201.4	26.9	6.0	2.9	1.6	0.4	0.2	1,807.5
	Mean W.	16.0	42.9	83.4	110.7	138.3	158.6	184.6	199.1	213.9	
	SOP	7,723	46,630	16,790	2,980	831	460	287	75	37	75,811
1995	Number	1,144.5	1,189.2	161.5	13.3	3.5	1.1	0.6	0.4	0.3	2,514.4
	Mean W.	11.2	39.1	88.3	145.7	165.5	204.5	212.2	236.4	244.3	
	SOP	12,837	46,555	14,267	1,940	573	225	133	86	65	76,680
1996	Number	516.1	961.1	161.4	17.0	3.4	1.6	0.7	0.4	0.3	1,661.9
	Mean W.	11.0	23.4	80.2	126.6	165.0	186.5	216.1	216.3	239.1	
	SOP	5,697	22,448	12,947	2,151	565	307	145	77	66	44,403
1997	Number	67.6	305.3	131.7	21.2	1.7	0.8	0.2	0.1	0.1	528.7
	Mean W.	19.3	47.7	68.5	124.4	171.5	184.7	188.7	188.7	192.4	
	SOP	1,304	14,571	9,025	2,643	285	146	40	16	25	28,057
1998	Number	51.3	745.1	161.5	26.6	19.2	3.0	3.1	1.2	0.5	1,011.6
	Mean W.	27.4	56.4	79.8	117.8	162.9	179.7	197.2	178.9	226.3	
	SOP	1,409	41,994	12,896	3,137	3,136	547	608	211	108	64,045
1999	Number	598.8	303.0	148.6	47.2	13.4	6.2	1.2	0.5	0.5	1,119.4
	Mean W.	10.4	50.5	87.7	113.7	137.4	156.5	188.1	187.3	198.8	
	SOP	6,255	15,297	13,037	5,369	1,841	974	230	90	92	43,186
2000	Number	235.3	984.3	116.0	21.9	22.9	7.5	3.3	0.6	0.1	1,391.8
	Mean W.	21.3	28.5	76.1	108.8	163.1	190.3	183.9	189.4	200.2	
	SOP	5,005	28,012	8,825	2,377	3,731	1,436	601	114	13	50,115
2001	Number	807.8	563.6	150.0	17.2	1.4	0.3	0.5	0.0	0.0	1,540.8
	Mean W.	8.7	49.4	75.3	108.2	130.1	147.1	219.1	175.8	198.1	
	SOP	7,029	27,849	11,300	1,856	177	43	109	8	5	48,376
2002	Number	478.5	362.6	56.7	5.6	0.7	0.2	0.1	0.0	0.0	904.5
	Mean W.	12.2	38.0	100.6	121.5	142.7	160.9	178.7	177.4	218.6	
	SOP	5,859	13,790	5,705	684	106	26	21	8	5	26,205
2003	Number	21.6	445.0	182.3	13.0	16.2	1.8	1.1	1.2	0.2	682.4
	Mean W.	20.5	33.7	67.0	123.2	150.3	163.5	190.2	214.6	186.8	
	SOP	442	14,992	12,219	1,606	2,436	293	213	264	33	32,498
2004	Number	88.4	70.9	179.9	20.7	6.0	9.7	1.8	2.0	0.9	380.4
	Mean W.	22.5	55.3	70.2	120.6	140.9	151.7	170.6	186.6	178.5	
	SOP	1,993	3,921	12,638	2,498	851	1,479	312	367	154	24,214
2005	Number	96.4	307.5	159.2	16.2	5.4	2.4	2.3	0.5	0.2	589.9
	Mean W.	16.5	50.5	71.0	105.9	154.6	173.5	184.5	200.2	208.9	
	SOP	1,595	15,527	11,304	1,712	828	412	420	95	34	31,927
2006	Number	35.1	150.1	50.2	10.2	3.3	3.3	0.6	0.4	0.2	253.3
	Mean W.	14.3	53.5	79.2	117.6	140.2	185.5	190.4	215.6	206.9	
	SOP	503	8,035	3,975	1,200	456	620	107	81	37	15,015
2007	Number	67.7	189.3	76.9	2.1	0.4	1.4	0.3	0.6	0.0	338.7
	Mean W.	26.7	62.6	71.1	108.1	124.4	151.7	183.7	174.7	153.8	
	SOP	1,807	11,857	5,464	224	55	219	48	110	3	19,788
2008	Number	85.7	86.6	72.0	1.9	0.3	0.1	0.1	0.3	0.1	247.0
	Mean W.	16.2	57.6	86.4	109.1	138.7	167.7	175.4	203.1	197.7	
	SOP	1,386	4,986	6,222	205	35	25	10	67	13	12,949
2009	Number	116.8	77.5	7.0	0.4	0.2	0.0	0.0	0.0	0.1	202.0
	Mean W.	9.4	59.8	101.0	81.3	206.4	0.0	0.0	0.0	268.5	
	SOP	1,095	4,635	710	29	46	0	0	0	28	6,542
2010	Number	48.6	197.0	43.3	0.3	0.1	0.1	0.0	0.1	0.0	289.6
	Mean W.	7.5	50.6	76.8	122.3	149.3	191.3	221.5	216.3	204.5	
	SOP	364	9,975	3,325	35	22	19	4	13	3	13,759
2011	Number	203.8	35.4	61.5	3.2	0.3	0.2	0.1	0.1	0.0	304.6
	Mean W.	7.5	35.1	83.6	113.3	133.9	191.5	193.2	234.3	248.3	
	SOP	1,524	1,244	5,137	364	37	33	23	22	5	8,388
2012	Number	145.83	174.74	43.05	1.85	1.14	0.19	0.20	0.11	0.03	367
	Mean W.	12.29	39.70	66.75	123.69	169.16	174.56	199.39	219.78	215.93	
	SOP	1,792	6,937	2,873	229	193	33	39	24	6	12,128

Corrections for the years 1991-1998 was made in HAWG 2001, but are NOT included in the North Sea assessment.

Table 3.3.1 **WESTERN BALTIC HERRING. German acoustic survey (GERAS) on the Spring Spawning Herring in Subdivisions 21 (Southern Kattegat, 41G0-42G2) - 24 in autumn 1994-2012 (September/October).**

Year	1994	1995	1996	1997	1998	1999	2000	2001*	2002**	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Numbers in millions												***	***	***	***	***	***	***	***
W-rings																			
0	5,475	5,108	1,833	2,859	2,490	5,994	1,009	2,478	4,103	3,777	2,555	3,056	4,159	2,589	2,150	2,821	4,561	2,929	4,103
1	416	1,675	1,439	1,955	801	1,339	1,430	1,126	838	1,238	969	750	941	559	393	271	535	1,207	755
2	884	329	590	738	679	287	454	1,227	421	223	592	591	227	260	165	96	306	360	294
3	560	358	434	395	394	233	329	844	575	217	346	296	280	117	166	44	215	210	194
4	444	354	295	162	237	156	202	367	341	260	163	143	212	77	102	18	107	116	125
5	189	254	306	119	100	52	79	131	64	97	143	79	140	44	82	9	86	58	70
6	60	127	119	99	51	8	39	86	25	38	79	79	97	12	30	3	47	51	45
7	24	46	47	33	24	1	6	19	10	9	23	26	67	9	11	2	25	29	23
8+	2	27	19	48	9	2	4	10	13	10	12	15	28	9	9	2	15	15	21
Total	8,053	8,277	5,083	6,409	4,785	8,072	3,551	6,288	6,389	5,869	4,882	5,033	6,151	3,677	3,109	3,265	5,897	4,976	5,630
3+ group	1,279	1,166	1,220	856	815	452	658	1,457	1,028	631	766	637	824	268	401	77	495	479	478
Biomass ('000 tonnnes)																			
W-rings																			
0	66.9	58.5	16.6	28.5	23.8	71.8	13.8	31.2	38.2	33.9	23.1	32.8	43.0	25.2	23.7	29.4	36.8	35.1	47.0
1	14.5	58.6	46.6	76.4	39.9	51.1	57.5	48.2	34.2	44.8	35.9	29.8	38.2	22.8	17.6	10.5	21.3	46.4	29.8
2	41.0	20.9	29.1	43.5	50.1	22.0	28.4	75.9	30.0	16.1	34.5	46.5	18.0	20.6	10.4	7.1	24.6	29.6	20.4
3	40.7	30.1	31.0	35.9	35.3	27.5	27.7	77.1	56.8	22.0	27.7	31.9	32.0	11.4	15.3	4.4	23.5	24.4	22.1
4	43.0	40.1	21.2	22.3	28.0	16.7	24.1	37.9	40.4	34.2	18.4	20.4	31.3	9.7	11.1	2.0	15.2	16.4	18.7
5	24.2	27.3	37.1	16.7	11.4	6.8	9.3	18.5	9.0	14.6	17.3	12.8	24.9	6.7	11.6	1.4	15.4	9.9	11.5
6	12.3	14.9	16.1	14.0	6.2	0.9	5.6	13.3	3.5	5.7	12.2	13.8	17.7	1.9	4.8	0.6	9.0	8.4	8.0
7	5.3	9.3	6.1	5.3	3.7	0.3	1.2	3.9	1.1	1.3	3.4	5.1	13.4	1.6	1.8	0.4	4.7	5.3	4.4
8+	0.6	6.6	2.9	10.6	2.2	0.5	0.8	2.1	1.9	1.6	2.0	3.4	6.3	1.7	1.3	0.3	3.0	3.0	3.9
Total	248.5	266.3	206.8	253.3	200.5	197.5	168.4	308.0	215.0	174.2	174.6	196.5	224.7	101.7	97.6	56.0	153.6	178.3	165.6
3+ group	126.2	128.2	114.4	104.9	86.8	52.6	68.7	152.8	112.6	79.4	81.1	87.4	125.5	33.1	45.8	9.1	70.9	67.3	68.5
Mean weight (g)																			
W-rings																			
0	12.2	11.5	9.0	10.0	9.5	12.0	13.7	12.6	9.3	9.0	9.0	10.7	10.3	9.7	11.0	10.4	8.1	12.0	11.4
1	34.8	35.0	32.4	39.1	49.8	38.2	40.2	42.8	40.8	36.2	37.0	39.7	40.6	40.8	44.8	38.7	39.9	38.4	39.5
2	46.4	63.7	49.4	58.9	73.8	76.6	62.6	61.8	71.1	72.3	58.3	78.7	79.4	79.1	63.2	73.7	80.5	82.0	69.3
3	72.8	84.1	71.5	91.1	89.5	118.2	84.3	91.4	98.7	101.3	80.1	107.8	114.3	96.9	92.0	101.8	109.7	115.9	113.8
4	97.0	113.3	71.7	137.2	118.4	106.9	119.4	103.4	118.3	131.2	112.6	143.0	147.3	126.2	108.6	110.4	141.5	141.1	149.8
5	127.7	107.6	121.6	140.8	114.1	130.3	117.3	140.4	141.8	150.2	121.0	162.6	177.9	153.1	141.0	153.6	180.2	170.6	163.3
6	203.9	117.7	134.6	141.0	120.8	106.6	145.5	154.8	142.6	150.2	154.7	174.9	181.8	157.7	162.2	190.9	191.3	165.0	177.4
7	225.2	199.6	129.9	160.2	157.2	237.9	204.5	198.5	110.9	156.6	151.0	199.9	199.5	177.4	153.5	197.4	189.0	181.1	197.5
8+	269.1	241.2	154.9	222.3	232.6	218.5	180.7	217.2	142.6	163.3	169.2	229.6	228.3	196.6	140.7	162.9	196.8	204.1	181.1
Total	30.9	32.2	40.7	39.5	41.9	24.5	47.4	49.0	33.6	29.7	35.8	39.0	36.5	27.7	31.4	17.2	26.1	35.8	29.4

*incl. mean for Sub-division 23, which was not covered by RV SOLEA

**incl. mean for Sub-division 21, which was not covered by RV SOLEA

***** excl. Central Baltic Herring in SD 24 (SD 23) based on SF (Gröhsler et al. 2012)**

Table 3.3.2 WESTERN BALTIC HERRING. Acoustic surveys on the Western Baltic Spring Spawning Herring in the North Sea/Division IIIa in 1991-2012 (July).

Year	1991	1992*	1993*	1994*	1995*	1996*	1997	1998	999**	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Numbers in millions																						
W-rings																						
0		3,853	372	964														112				1
1		277	103	5	2,199	1,091	128	138	1,367	1,509	66	3,346	1,833	1,669	2,687	2,081	3,918	5,852	565	999	2,980	1,018
2	1,864	2,092	2,768	413	1,887	1,005	715	1,682	1,143	1,891	641	1,577	1,110	930	1,342	2,217	3,621	1,160	398	511	473	1,081
3	1,927	1,799	1,274	935	1,022	247	787	901	523	674	452	1,393	395	726	464	1,780	933	843	205	254	259	236
4	866	1,593	598	501	1,270	141	166	282	135	364	153	524	323	307	201	490	499	333	161	115	163	87
5	350	556	434	239	255	119	67	111	28	186	96	88	103	184	103	180	154	274	82	65	70	76
6	88	197	154	186	174	37	69	51	3	56	38	40	25	72	84	27	34	176	86	24	53	33
7	72	122	63	62	39	20	80	31	2	7	23	18	12	22	37	10	26	45	39	28	22	14
8+	10	20	13	34	21	13	77	53	1	10	12	17	5	18	21	0.1	14	44	65	34	46	60
Total	**5,177**	**10,509**	**5,779**	**3,339**	**6,867**	**2,673**	**2,088**	**3,248**	**3,201**	**4,696**	**1,481**	**7,002**	**3,807**	**3,926**	**4,939**	**6,786**	**9,199**	**8,839**	**1,601**	**2,030**	**4,066**	**2,606**
+ group	**5,177**	**4,287**	**2,536**	**1,957**	**2,781**	**577**	**1,245**	**1,428**	**691**	**1,295**	**774**	**2,079**	**864**	**1,328**	**910**	**2,487**	**1,660**	**1,715**	**638**	**520**	**613**	**506**
Biomass ('000 tonnnes)																						
W-rings																						
0		34.3	1	8.7																		0.0
1		26.8	7	0.4	77.4	52.9	4.7	7.1	74.8	61.4	3.5	137.2	79.0	63.9	105.9	112.6	193.2	284.4	26.8	53.0	90.0	44.0
2	177.1	169.0	139	33.2	108.9	87.0	52.2	136.1	101.6	138.1	55.8	107.2	91.5	75.6	100.1	160.5	273.4	100.9	48.8	34.0	47.0	87.0
3	219.7	206.3	112	114.7	102.6	27.6	81.0	84.8	59.5	68.8	51.2	126.9	41.4	89.4	46.6	158.6	90.9	101.8	30.6	28.0	31.0	26.0
4	116.0	204.7	69	76.7	145.5	17.9	21.5	35.2	14.7	45.3	21.5	55.9	41.7	41.5	28.9	56.3	59.6	47.1	29.4	17.0	25.0	12.0
5	51.1	83.3	65	41.8	33.9	17.8	9.8	13.1	3.4	25.1	17.9	12.8	13.9	29.3	16.5	23.7	18.5	45.3	17.5	11.0	12.0	13.0
6	19.0	36.6	26	38.1	27.4	5.8	9.8	6.9	0.5	10.0	6.9	7.4	4.2	11.7	14.9	4.1	4.6	30.9	21.4	5.0	10.0	6.0
7	13.0	24.4	16	13.1	6.7	3.3	14.9	4.8	0.3	1.4	4.7	3.5	2.0	4.1	7.5	1.6	2.6	9.4	10.6	6.0	5.0	3.0
8+	2.0	5.0	2	7.8	3.8	2.7	13.6	9.0	0.1	1.3	2.7	3.1	0.9	3.2	4.9	0.0	1.9	8.7	19.8	8.0	10.0	14.0
Total	597.9	756.1	436.5	325.8	506.2	215.1	207.5	297.0	254.9	351.4	164.2	454.0	274.5	318.8	325.3	517.5	644.7	628.5	204.9	162.0	230.0	205.0
+ group	420.9	560.3	291.0	292.3	319.9	75.2	150.6	153.7	78.5	151.9	104.9	209.6	104.0	179.3	119.3	244.4	178.2	243.2	129.3	75.0	93.0	74.0
Mean weight (g)																						
W-rings																						
0		8.9	4.0	9.0														6.3				3.0
1		96.8	66.3	80.0	35.2	48.5	36.9	51.9	54.7	40.7	54.0	41.0	43.1	38.3	39.4	54.1	49.3	48.6	47.5	52.7	30.2	42.9
2	95.0	80.8	50.1	80.3	57.7	86.6	73.0	80.9	88.9	73.1	87.0	68.0	82.5	81.3	74.6	72.4	75.5	87.0	122.7	65.8	98.8	80.4
3	114.0	114.7	87.9	122.7	100.4	111.9	103.0	94.1	113.8	102.2	113.2	91.1	104.9	123.2	100.5	89.1	97.4	120.8	149.1	111.4	121.2	110.6
4	134.0	128.5	116.2	153.0	114.6	126.8	129.6	124.7	109.1	124.4	140.5	106.6	128.8	135.2	143.7	114.8	119.5	141.4	182.9	150.9	150.6	142.9
5	146.0	149.8	149.9	175.1	132.9	149.4	145.0	118.7	120.0	135.4	185.2	145.8	134.2	159.4	160.9	131.6	120.0	165.5	213.3	175.6	168.7	170.8
6	216.0	185.7	169.6	205.0	157.2	157.3	143.1	135.8	179.9	179.2	182.6	186.5	165.4	162.9	177.7	153.2	136.6	175.6	248.3	198.0	190.8	182.0
7	181.0	199.7	256.9	212.0	172.9	166.8	185.6	156.4	179.9	208.8	206.3	198.7	167.2	191.6	202.3	169.2	101.5	208.5	272.1	215.9	211.0	194.0
8+	200.0	252.0	164.2	230.3	183.1	212.9	178.0	168.0	181.7	135.2	226.9	183.4	170.3	178.0	229.2	178.0	138.3	196.7	304.7	234.8	228.5	228.6
Total	116	123.9	75.8	100.2	73.7	80.5	99.4	91.4	78.5	74.8	110.9	64.8	72.1	81.2	65.9	76.3	70.1	71.1	128.0	79.8	56.6	78.5

* revised in 1997

**the survey only covered the Skagerrak area by Norway. Additional estimates for the Kattegat area were added

(see ICES 2000/ACFM:10, Table 3.5.8)

Table 3.3.3 **WESTERN BALTIC HERRING.**

- **N20 Larval Abundance Index.**
- Estimation of 0-Group herring reaching 20 mm in length in Greifswalder Bodden and adjacent waters (March/April to June).

Year	N20 (millions)
1992	1,060
1993	3,044
1994	12,515
1995	7,930
1996	21,012
1997	4,872
1998	16,743
1999	20,364
2000	3,026
2001	4,845
2002	11,324
2003	5,507
2004	5,640
2005	3,887
2006	3,774
2007*	1,829
2008*	1,622
2009	6,464
2010	7,037
2011	4,444
2012	1,140

* small revision during HAWG 2010

TABLE 3.6.1 WBSS HERRING. CATCH IN NUMBER (thousands)

year

age	1991	1992	1993	1994	1995	1996	1997	1998	1999
0	118958	145090	206102	263202	541302	171144	376795	549774	569599
1	825969	456707	530707	249398	1660683	638877	668616	623072	616124
2	541246	602624	495950	364980	438136	400585	289336	430903	334339
3	564430	364864	415108	382650	226810	199681	276919	182860	246212
4	279767	333993	260950	267033	194870	144155	75283	146685	90259
5	177486	183200	210497	168142	84123	130086	43119	45322	55919
6	46487	139835	102768	118416	60096	65274	39916	23759	15481
7	13241	52660	63922	49504	32878	30705	21211	15400	9478
8	4933	22574	24535	33088	20459	25111	24134	14112	6084
age	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**
0	152581	756285	150271	53489	243554	106906	7946	10721	9610
1	934545	523163	659130	126876	457754	305171	148909	172044	149436
2	496396	488816	281840	264855	197812	319225	187674	184735	136988
3	186615	257837	321311	161251	164766	177833	233214	143904	135753
4	128625	108097	172285	189432	93214	130394	150654	126861	92305
5	71727	68376	57160	103648	91242	60639	98751	64996	89436
6	38262	39092	38532	29117	48957	65695	42459	30199	45930
7	13777	18307	13842	17452	14876	31231	32418	21256	17216
8	10689	6687	8329	8819	11013	12620	17312	14759	17410
age	**2009**	**2010**	**2011**	**2012**					
0	20734	12394	11813	2000					
1	181083	75083	98516	76854					
2	243007	136419	46282	130803					
3	101330	82970	38787	64468					
4	69937	46833	49324	47322					
5	48091	29979	27630	35444					
6	39750	18589	22632	18169					
7	20907	10996	12236	11238					
8	12529	11262	9335	17001					

TABLE 3.6.2 WBSS HERRING. WEIGHTS AT AGE IN THE CATCH (kg)

year

age	1991	1992	1993	1994	1995	1996	1997	1998	1999
0	0.02957	0.01519	0.01535	0.01458	0.01010	0.01056	0.02962	0.01426	0.01112
1	0.03476	0.03447	0.02545	0.03704	0.02092	0.02458	0.02748	0.03333	0.03433
2	0.06685	0.06732	0.06797	0.08328	0.06843	0.08090	0.06845	0.06634	0.06583
3	0.09490	0.09435	0.10204	0.10323	0.09841	0.09702	0.11807	0.09423	0.09814
4	0.12342	0.11630	0.11428	0.12213	0.12349	0.11254	0.13420	0.11779	0.11642
5	0.13901	0.14169	0.13615	0.14115	0.15196	0.13283	0.16198	0.13673	0.14713
6	0.15560	0.16511	0.16795	0.15648	0.17041	0.13687	0.18170	0.16628	0.15660
7	0.17091	0.17576	0.18228	0.17046	0.20626	0.15425	0.19671	0.16523	0.15382
8	0.18256	0.19152	0.19890	0.18596	0.21696	0.19100	0.20872	0.18701	0.15756
age	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**
0	0.02113	0.01229	0.01053	0.01325	0.00618	0.01401	0.01700	0.01389	0.01776
1	0.02550	0.02432	0.02127	0.03152	0.02754	0.02719	0.03605	0.05062	0.06466
2	0.05775	0.05931	0.06998	0.06711	0.06419	0.07208	0.07283	0.07092	0.07879
3	0.09501	0.08618	0.09678	0.09075	0.10017	0.09378	0.09818	0.08538	0.09601
4	0.13013	0.10886	0.11956	0.10792	0.10596	0.11057	0.11527	0.11409	0.11525
5	0.14280	0.15673	0.14003	0.12234	0.13139	0.12280	0.15345	0.12879	0.14036
6	0.14633	0.15597	0.18763	0.13188	0.15228	0.14933	0.15811	0.15640	0.14807
7	0.15829	0.15560	0.18141	0.16029	0.16768	0.16192	0.18654	0.16734	0.16671
8	0.15908	0.17132	0.17170	0.16252	0.15295	0.17355	0.18485	0.19030	0.17041
age	**2009**	**2010**	**2011**	**2012**					
0	0.01260	0.00928	0.01033	0.01141					
1	0.04789	0.04619	0.03199	0.02822					
2	0.07105	0.07688	0.07699	0.07024					
3	0.10319	0.10873	0.10092	0.10790					
4	0.13903	0.13535	0.12051	0.12513					
5	0.15341	0.16464	0.14385	0.15666					
6	0.17088	0.18078	0.15263	0.17606					
7	0.19236	0.19751	0.16584	0.18626					
8	0.21459	0.20551	0.17326	0.20851					

TABLE 3.6.3 WBSS HERRING. WEIGHTS AT AGE IN THE STOCK (kg)

year

age	1991	1992	1993	1994	1995	1996	1997	1998	1999
0	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010
1	0.03085	0.02029	0.01563	0.01855	0.01305	0.01815	0.01310	0.02209	0.02106
2	0.05277	0.04513	0.04020	0.05288	0.04590	0.05456	0.05147	0.05578	0.05668
3	0.07873	0.08176	0.09671	0.08357	0.07081	0.09051	0.10633	0.08293	0.08705
4	0.10412	0.10751	0.10793	0.10767	0.13269	0.11703	0.13334	0.11280	0.10813
5	0.12447	0.13127	0.14087	0.13921	0.16745	0.11974	0.16618	0.13378	0.14801
6	0.14492	0.15934	0.16715	0.15656	0.18923	0.15383	0.19429	0.16779	0.16015
7	0.15943	0.17102	0.18273	0.17676	0.20970	0.14667	0.20895	0.16832	0.14394
8	0.16398	0.18693	0.18906	0.20275	0.23377	0.12803	0.22635	0.18432	0.15043

age	2000	2001	2002	2003	2004	2005	2006	2007	2008
0	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010
1	0.01398	0.01686	0.01645	0.01444	0.01306	0.01260	0.01846	0.01500	0.01800
2	0.04313	0.05088	0.06368	0.04447	0.04561	0.05136	0.06210	0.05500	0.06800
3	0.08370	0.07829	0.09046	0.07926	0.08106	0.08000	0.09527	0.08000	0.08600
4	0.12504	0.11594	0.12388	0.10509	0.10925	0.10657	0.11740	0.11400	0.11000
5	0.14365	0.16904	0.17365	0.12681	0.14399	0.13221	0.16593	0.14300	0.13900
6	0.16287	0.17627	0.19830	0.15061	0.16285	0.15733	0.17102	0.17100	0.14300
7	0.16503	0.16808	0.19801	0.17287	0.19321	0.16766	0.18584	0.17500	0.14100
8	0.18311	0.18052	0.20363	0.18471	0.20759	0.18205	0.18708	0.18800	0.15800

age	2009	2010	2011	2012
0	0.00010	0.00010	0.00010	0.00010
1	0.02300	0.01404	0.00900	0.01200
2	0.05200	0.06265	0.05800	0.05000
3	0.09000	0.09735	0.09500	0.09200
4	0.13000	0.12833	0.12600	0.11400
5	0.15600	0.16176	0.15600	0.15800
6	0.17400	0.18131	0.17300	0.17800
7	0.18500	0.20229	0.18500	0.19100
8	0.19900	0.20447	0.19200	0.20100

TABLE 3.6.4 WBSS HERRING. NATURAL MORTALITY

year

age	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
0	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
1	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
4	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
5	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
6	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
7	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
8	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2

age	2006	2007	2008	2009	2010	2011	2012
0	0.3	0.3	0.3	0.3	0.3	0.3	0.3
1	0.5	0.5	0.5	0.5	0.5	0.5	0.5
2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
3	0.2	0.2	0.2	0.2	0.2	0.2	0.2
4	0.2	0.2	0.2	0.2	0.2	0.2	0.2
5	0.2	0.2	0.2	0.2	0.2	0.2	0.2
6	0.2	0.2	0.2	0.2	0.2	0.2	0.2
7	0.2	0.2	0.2	0.2	0.2	0.2	0.2
8	0.2	0.2	0.2	0.2	0.2	0.2	0.2

TABLE 3.6.5 WBSS HERRING. PROPORTION MATURE

age \ year	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
3	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
4	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
5	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
6	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
7	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
8	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

age	2006	2007	2008	2009	2010	2011	2012
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.20	0.20	0.20	0.20	0.20	0.20	0.20
3	0.75	0.75	0.75	0.75	0.75	0.75	0.75
4	0.90	0.90	0.90	0.90	0.90	0.90	0.90
5	1.00	1.00	1.00	1.00	1.00	1.00	1.00
6	1.00	1.00	1.00	1.00	1.00	1.00	1.00
7	1.00	1.00	1.00	1.00	1.00	1.00	1.00
8	1.00	1.00	1.00	1.00	1.00	1.00	1.00

TABLE 3.6.6 WBSS HERRING. FRACTION OF HARVEST BEFORE SPAWNING

age \ year	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
3	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
4	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
5	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
6	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
7	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
8	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1

age	2006	2007	2008	2009	2010	2011	2012
0	0.1	0.1	0.1	0.1	0.1	0.1	0.1
1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
2	0.1	0.1	0.1	0.1	0.1	0.1	0.1
3	0.1	0.1	0.1	0.1	0.1	0.1	0.1
4	0.1	0.1	0.1	0.1	0.1	0.1	0.1
5	0.1	0.1	0.1	0.1	0.1	0.1	0.1
6	0.1	0.1	0.1	0.1	0.1	0.1	0.1
7	0.1	0.1	0.1	0.1	0.1	0.1	0.1
8	0.1	0.1	0.1	0.1	0.1	0.1	0.1

TABLE 3.6.7 WBSS HERRING. FRACTION OF NATURAL MORTALITY BEFORE SPAWNING

Year

age	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
0	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
1	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
2	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
3	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
4	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
5	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
6	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
7	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
8	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25

age	2006	2007	2008	2009	2010	2011	2012
0	0.25	0.25	0.25	0.25	0.25	0.25	0.25
1	0.25	0.25	0.25	0.25	0.25	0.25	0.25
2	0.25	0.25	0.25	0.25	0.25	0.25	0.25
3	0.25	0.25	0.25	0.25	0.25	0.25	0.25
4	0.25	0.25	0.25	0.25	0.25	0.25	0.25
5	0.25	0.25	0.25	0.25	0.25	0.25	0.25
6	0.25	0.25	0.25	0.25	0.25	0.25	0.25
7	0.25	0.25	0.25	0.25	0.25	0.25	0.25
8	0.25	0.25	0.25	0.25	0.25	0.25	0.25

TABLE 3.6.8 WBSS HERRING. SURVEY INDICES

HERAS (number in thousands)

year

age	1991	1992	1993	1994	1995	1996
1	-1	277000000	103000000	5000000	2199000000	1091000000
2	1864000000	2092000000	2768000000	413000000	1887000000	1005000000
3	1927000000	1799000000	1274000000	935000000	1022000000	247000000
4	866000000	1593000000	598000000	501000000	1270000000	141000000
5	350000000	556000000	434000000	239000000	255000000	119000000
6	88000000	197000000	154000000	186000000	174000000	37000000
7	72000000	122000000	63000000	62000000	39000000	20000000
8	10000000	20000000	13000000	34000000	21000000	13000000

age	1997	1998	1999	2000	2001	2002
1	128000000	138000000	-1	1509200000	65500000	3346200000
2	715000000	1682000000	-1	1891100000	641200000	1576600000
3	787000000	901000000	-1	673600000	452300000	1392800000
4	166000000	282000000	-1	363900000	153100000	524300000
5	67000000	111000000	-1	185700000	96400000	87500000
6	69000000	51000000	-1	55600000	37600000	39500000
7	80000000	31000000	-1	6900000	23000000	17800000
8	77000000	53000000	-1	9600000	11900000	17100000

age	2003	2004	2005	2006	2007	2008
1	1833100000	1668600000	2687000000	2081100000	3918000000	5852000000
2	1110000000	929600000	1342100000	2217000000	3621000000	1160000000
3	394600000	726000000	463500000	1780400000	933000000	843000000
4	323400000	306900000	201300000	490000000	499000000	333000000
5	103400000	183700000	102500000	180400000	154000000	274000000
6	25200000	72100000	83600000	27000000	34000000	176000000
7	12000000	21500000	37200000	9500000	26000000	45000000
8	5400000	18000000	21400000	100000	14000000	44000000

age	2009	2010	2011	2012
1	565000000	999000000	2980000000	1018000000
2	398000000	511000000	473000000	1081000000
3	205000000	254000000	259000000	236000000
4	161000000	115000000	163000000	87000000
5	82000000	65000000	70000000	76000000
6	86000000	24000000	53000000	33000000
7	39000000	28000000	22000000	14000000
8	65000000	34000000	46000000	60000000

continued

TABLE 3.6.8 WBSS HERRING. SURVEY INDICES

GERAS (number in thousands)

age	1991	1992	1993	1994	1995	1996	1997	1998	1999
0	-1	-1	-1	5474540	5107780	1833130	2859220	2490090	5993820
1	-1	-1	-1	415730	1675340	1439460	1955400	801350	1338710
2	-1	-1	-1	883810	328610	590010	738180	678530	287240
3	-1	-1	-1	559720	357960	434090	394530	394070	232510
4	-1	-1	-1	443730	353850	295170	162430	236830	155950
5	-1	-1	-1	189420	253510	305550	118910	100190	51940
6	-1	-1	-1	60400	126760	119260	99290	50980	8130
7	-1	-1	-1	23510	46430	46980	33280	23640	1470
8	-1	-1	-1	2330	27240	18910	47850	9330	2100

age	2000	2001	2002	2003	2004	2005	2006	2007	2008
0	1008910	-1	4102588	3776780	2554680	3055595	4159311	2588922	2150306
1	1429880	-1	837549	1238480	968860	750199	940892	558851	392737
2	453980	-1	421393	222530	592360	590756	226959	260402	165347
3	328960	-1	575356	217270	346230	295659	279618	117412	166301
4	201590	-1	341119	260350	163150	142778	212201	76782	102018
5	78930	-1	63678	96960	143320	78541	139813	43919	82174
6	38610	-1	24520	38040	79030	79018	97261	12144	29727
7	5920	-1	9690	8580	22600	25564	66937	9262	11443
8	4190	-1	13380	9890	11770	15013	27789	8839	9262

age	2009	2010	2011	2012
0	2821022	4561405	2929434	4103180
1	270959	534633	1206762	755034
2	95866	305540	360354	294242
3	43553	214539	210455	193974
4	17761	107364	115984	124548
5	9016	85635	57840	70135
6	3227	47140	50844	45017
7	1947	25021	29234	22520
8	1704	15309	14774	21404

N20 (number in thousands)

age	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
0	1060	3044	12515	7930	21012	4872	16743	20364	3026	4845	11324	5507

age	2004	2005	2006	2007	2008	2009	2010	2011	2012
0	5640	3887	3774	1829	1622	6464	7037	4444	1140

IBTS Q1 (number per hour)

age	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
1	32.72	69.61	400.08	101.33	90.41	165.10	528.05	53.90	93.69	284.45
2	224.30	29.12	87.09	60.93	17.51	177.97	30.31	159.97	35.79	45.18
3	103.73	10.57	10.13	37.13	7.71	44.62	46.90	34.76	15.44	4.49
4	19.78	6.12	1.99	3.60	5.57	10.64	2.22	13.21	3.79	1.19

age	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
1	106.82	506.44	201.08	69.75	97.88	150.21	145.01	58.44	788.51	57.17
2	140.29	27.52	186.59	47.76	180.02	27.11	66.55	20.38	67.17	42.41
3	14.57	29.60	6.28	8.75	11.93	15.55	8.80	4.24	1.87	9.24
4	0.53	3.13	1.27	1.00	1.99	2.00	1.72	0.58	1.53	2.43

age	2011	2012
1	165.62	84.87
2	167.28	318.00
3	55.92	18.96
4	14.29	3.56

continued

TABLE 3.6.8 WBSS HERRING. SURVEY INDICES

IBTS Q3 (number per hour)

age	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
1	21.99	74.44	297.95	37.82	87.31	130.24	12.04	33.14	41.43	0.05
2	16.87	26.36	26.94	24.10	21.56	46.97	20.98	16.92	10.17	0.04
3	18.81	16.12	3.54	17.32	13.28	4.03	12.72	3.85	3.08	0.00
4	6.33	12.70	3.48	6.26	13.91	1.96	2.18	3.68	1.15	0.00

age	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
1	18.00	382.77	80.78	283.34	53.07	110.21	81.35	37.05	203.14	33.32
2	24.12	22.42	37.34	50.12	41.63	25.04	17.03	7.75	62.45	12.88
3	6.98	12.64	10.45	13.03	10.59	14.63	4.43	4.55	12.78	6.93
4	1.81	2.43	3.64	2.38	2.42	1.63	4.13	1.20	4.29	3.25

age	2011	2012
1	224.61	14.77
2	15.49	3.56
3	4.92	0.00
4	3.05	0.05

TABLE 3.6.9 WBSS HERRING. STOCK OBJECT CONFIGURATION

```
      min       max plusgroup   minyear   maxyear   minfbar   maxfbar
        0         8         8      1991      2012         3         6
```

TABLE 3.6.10 WBSS HERRING. FLICA CONFIGURATION SETTINGS

```
An object of class "FLSAM.control"
Slot "name":
"WBSSher"
Slot "desc":
character(0)
Slot "range":
      min       max plusgroup   minyear   maxyear   minfbar   maxfbar
        0         8         8      1991      2012         3         6
Slot "fleets":
  catch   HERAS   GerAS     N20 IBTS Q1 IBTS Q3
      0       2       2       2       2       2
Slot "plus.group":
plusgroup
     TRUE
Slot "states":
         age
fleet      0  1  2  3  4  5  6  7  8
  catch    1  2  3  4  5  6  6  6  6
  HERAS   NA NA NA NA NA NA NA NA NA
  GerAS   NA NA NA NA NA NA NA NA NA
  N20     NA NA NA NA NA NA NA NA NA
  IBTS Q1 NA NA NA NA NA NA NA NA NA
  IBTS Q3 NA NA NA NA NA NA NA NA NA
Slot "logN.vars":
0 1 2 3 4 5 6 7 8
1 1 1 1 1 1 1 1 1
Slot "catchabilities":
         age
fleet      0  1  2  3  4  5  6  7  8
  catch   NA NA NA NA NA NA NA NA NA
  HERAS   NA  1  2  3  4  5  6  7  7
  GerAS    8  9 10 11 12 13 14 15 15
  N20     16 NA NA NA NA NA NA NA NA
  IBTS Q1 NA 17 18 19 20 NA NA NA NA
  IBTS Q3 NA 21 22 23 24 NA NA NA NA
Slot "power.law.exps":
         age
fleet      0  1  2  3  4  5  6  7  8
  catch   NA NA NA NA NA NA NA NA NA
  HERAS   NA NA NA NA NA NA NA NA NA
  GerAS   NA NA NA NA NA NA NA NA NA
  N20     NA NA NA NA NA NA NA NA NA
  IBTS Q1 NA NA NA NA NA NA NA NA NA
  IBTS Q3 NA NA NA NA NA NA NA NA NA
Slot "f.vars":
         age
fleet      0  1  2  3  4  5  6  7  8
  catch    1  2  2  2  2  2  2  2  2
  HERAS   NA NA NA NA NA NA NA NA NA
  GerAS   NA NA NA NA NA NA NA NA NA
  N20     NA NA NA NA NA NA NA NA NA
  IBTS Q1 NA NA NA NA NA NA NA NA NA
  IBTS Q3 NA NA NA NA NA NA NA NA NA
Slot "obs.vars":
         age
fleet      0  1  2  3  4  5  6  7  8
  catch    1  2  2  2  2  3  3  3  3
  HERAS   NA  4  5  6  6  6  6  7  7
  GerAS    8  8  8  8  9  9 10 10 10
  N20     11 NA NA NA NA NA NA NA NA
```

```
  IBTS Q1 NA 12 12 12 12 NA NA NA NA
  IBTS Q3 NA 13 13 14 14 NA NA NA NA
```

continued

TABLE 3.6.10 WBSS HERRING. FLICA CONFIGURATION SETTINGS

```
Slot "srr":
[1] 0
Slot "cor.F":
[1] TRUE
Slot "nohess":
[1] FALSE
Slot "timeout":
[1] 3600
Slot "sam.binary":
[1] "model/sam"
```

TABLE 3.6.11 WBSS HERRING. FLR, R SOFTWARE VERSIONS

```
Package: FLSAM
Type: Package
Title: FLSAM, an implementation of the State-space Assessment Model
for
        FLR
Version: 0.99-99
Date: 2013-03-21
Author: M.R. Payne <mpa@aqua.dtu.dk>, N.T. Hintzen
        <niels.hintzen@wur.nl>
Maintainer: M.R. Payne <mpa@aqua.dtu.dk>, N.T. Hintzen
        <niels.hintzen@wur.nl>
Description: FLR wrapper to the SAM state-space assessment model
Depends: R(>= 2.13.0), FLCore(>= 2.4), utils, MASS
Suggests: methods, reshape, plyr, ellipse
License: GPL
LazyLoad: yes
Packaged: 2013-03-17 17:17:40 UTC; mpayne
Built: R 2.14.1; ; 2013-03-17 17:23:49 UTC; unix
-- File: /home/valerio/R/x86_64-unknown-linux-gnu-
library/2.14/FLSAM/Meta/package.rds
```

TABLE 3.6.12 WBSS HERRING. STOCK SUMMARY

	Year	Recruitment	TSB	SSB	F3-6	Landings
[1,]	1991	3843908	543323.7	304746.57	0.3964962	191573.11
[2,]	1992	3576875	466377.8	314614.40	0.5143980	194408.22
[3,]	1993	3485075	397255.7	282657.68	0.5628640	185009.63
[4,]	1994	4316692	332489.1	229615.42	0.5948701	172438.90
[5,]	1995	4193306	288077.0	197425.95	0.5584636	150819.64
[6,]	1996	4032915	252518.7	136115.67	0.6201248	121260.28
[7,]	1997	3828563	246800.9	148826.29	0.5698005	115584.91
[8,]	1998	4065308	234131.8	117808.64	0.5673122	107032.95
[9,]	1999	4159893	226667.3	114885.54	0.4943822	97234.40
[10,]	2000	3365207	218676.1	121524.01	0.5850758	109912.73
[11,]	2001	3388846	234782.2	127962.64	0.5767403	105805.51
[12,]	2002	3020703	269026.8	162426.94	0.5369911	106195.13
[13,]	2003	2978707	201581.9	128445.63	0.4830596	78310.20
[14,]	2004	2576648	210582.1	135905.22	0.4753011	76813.13
[15,]	2005	2206681	215653.5	132129.11	0.5165299	88403.76
[16,]	2006	1895513	242017.2	158431.82	0.5262094	90548.30
[17,]	2007	1718565	185084.7	123994.81	0.4885734	68178.86
[18,]	2008	1652831	165229.2	106982.10	0.5237385	69489.30
[19,]	2009	1699764	148129.4	92059.63	0.5262872	67258.93
[20,]	2010	1968928	136622.3	88217.63	0.3702848	42213.70
[21,]	2011	1928012	127956.8	85680.57	0.3170904	27770.72
[22,]	2012	1901208	141883.4	87935.75	0.3311143	38646.30

TABLE 3.6.13 WBSS HERRING. ESTIMATED FISHING MORTALITY

year

age	1991	1992	1993	1994	1995	1996	1997
0	0.0309866	0.0599766	0.0781989	0.0905005	0.0888594	0.1156832	0.0982245
1	0.2254628	0.2732413	0.2983763	0.3174611	0.3275220	0.3541623	0.3277841
2	0.3026132	0.3716139	0.3981406	0.4208832	0.4165120	0.4449515	0.4123058
3	0.3438671	0.4210263	0.4574581	0.4799468	0.4732365	0.5174564	0.4785953
4	0.3830116	0.4710458	0.5133230	0.5464350	0.5332313	0.5873643	0.5384180
5	0.4295531	0.5827599	0.6403374	0.6765493	0.6136933	0.6878393	0.6310943
6	0.4295531	0.5827599	0.6403374	0.6765493	0.6136933	0.6878393	0.6310943
7	0.4295531	0.5827599	0.6403374	0.6765493	0.6136933	0.6878393	0.6310943
8	0.4295531	0.5827599	0.6403374	0.6765493	0.6136933	0.6878393	0.6310943

age	1998	1999	2000	2001	2002	2003	2004
0	0.1028689	0.0695576	0.1011248	0.0881690	0.0591783	0.0337222	0.0286959
1	0.3292296	0.2867628	0.3211972	0.2999618	0.2606179	0.2093181	0.2003880
2	0.4204961	0.3765630	0.4288363	0.4107420	0.3723764	0.3217115	0.3098398
3	0.4776343	0.4265439	0.4838550	0.4673953	0.4294886	0.3772376	0.3682070
4	0.5405220	0.4737289	0.5456487	0.5371811	0.4977238	0.4443379	0.4384322
5	0.6255463	0.5386281	0.6553997	0.6511925	0.6103761	0.5553315	0.5472826
6	0.6255463	0.5386281	0.6553997	0.6511925	0.6103761	0.5553315	0.5472826
7	0.6255463	0.5386281	0.6553997	0.6511925	0.6103761	0.5553315	0.5472826
8	0.6255463	0.5386281	0.6553997	0.6511925	0.6103761	0.5553315	0.5472826

age	2005	2006	2007	2008	2009	2010	2011
0	0.0277034	0.0203373	0.0144249	0.0161151	0.0164439	0.0056914	0.0032138
1	0.2031115	0.1895694	0.1737739	0.1788335	0.1755555	0.1198997	0.0974321
2	0.3275875	0.3257256	0.3109261	0.3367212	0.3456599	0.2424887	0.1943295
3	0.3907841	0.3907919	0.3729541	0.3996804	0.4034269	0.2844209	0.2341953
4	0.4704950	0.4717670	0.4483415	0.4853136	0.4961584	0.3600545	0.3074017
5	0.6024202	0.6211392	0.5664990	0.6049799	0.6027818	0.4183320	0.3633822
6	0.6024202	0.6211392	0.5664990	0.6049799	0.6027818	0.4183320	0.3633822
7	0.6024202	0.6211392	0.5664990	0.6049799	0.6027818	0.4183320	0.3633822
8	0.6024202	0.6211392	0.5664990	0.6049799	0.6027818	0.4183320	0.3633822

age	2012
0	0.0031745
1	0.0975588
2	0.1978789
3	0.2399319
4	0.3196272
5	0.3824490
6	0.3824490
7	0.3824490
8	0.3824490

TABLE 3.6.14 WBSS HERRING. ESTIMATED POPULATION ABUNDANCE

year

age	1991	1992	1993	1994	1995	1996	1997	1998	1999
0	3843908	3576875	3485075	4316692	4193306	4032915	3828563	4065308	4159893
1	4118502	2949069	2599943	1943498	3616438	2782889	2949069	2433887	2879134
2	2154351	1966960	1636385	1193022	966078	1494048	1133703	1334410	1027871
3	1970898	1291093	1114593	1048635	656055	509406	795718	626560	686252
4	945057	1116825	705033	594217	589482	311141	236097	388481	315212
5	564107	510936	539825	365127	260667	266199	124617	112533	169228
6	166542	314268	234685	235155	156843	121297	97052	56727	46911
7	50312	102642	137173	99012	86769	69148	48485	36607	24125
8	16367	42916	59695	73130	59101	59576	52997	35739	22607

age	2000	2001	2002	2003	2004	2005	2006	2007	2008
0	3365207	3388846	3020703	2978707	2576648	2206681	1895513	1718565	1652831
1	3282120	2237792	2518062	1810294	2450984	1808485	1519664	1270600	1207424
2	1362729	1553467	986580	1091431	944112	1294972	828192	773747	562418
3	564107	764517	947896	534453	643064	606828	791749	474018	436263
4	362580	275957	455887	502324	304980	365127	373996	416649	254995
5	173338	172474	139944	243775	268069	167209	202400	192144	218382
6	86163	78511	82951	68665	125618	144351	89054	80580	106192
7	24884	37949	32860	39616	35454	64537	67508	45026	38716
8	22203	17511	22049	23389	29231	30455	38871	41648	40215

age	2009	2010	2011	2012
0	1699764	1968928	1928012	1901208
1	1184700	1027871	1524230	1322454
2	618468	552937	489432	837352
3	297152	351512	291560	323838
4	215346	169736	214058	166542
5	121419	109864	99111	123130
6	92503	60658	69355	58747
7	47430	38600	39379	39222
8	32435	35918	38716	51021

TABLE 3.6.15 WBSS HERRING. SURVIVORS AFTER TERMINAL YEAR

```
[1] NA NA NA NA NA NA NA NA NA
```

TABLE 3.6.16 WBSS HERRING. FITTED SELECTION PATTERN

	1991	1992	1993	1994	1995	1996	1997
0	0.0781511	0.1165958	0.1389303	0.1521349	0.1591140	0.1865482	0.1723840
1	0.5686380	0.5311866	0.5301036	0.5336646	0.5864698	0.5711145	0.5752613
2	0.7632183	0.7224248	0.7073478	0.7075212	0.7458176	0.7175192	0.7235968
3	0.8672646	0.8184836	0.8127329	0.8068095	0.8473901	0.8344391	0.8399348
4	0.9659906	0.9157225	0.9119841	0.9185787	0.9548184	0.9471711	0.9449238
5	1.0833724	1.1328970	1.1376415	1.1373059	1.0988958	1.1091949	1.1075707
6	1.0833724	1.1328970	1.1376415	1.1373059	1.0988958	1.1091949	1.1075707
7	1.0833724	1.1328970	1.1376415	1.1373059	1.0988958	1.1091949	1.1075707
8	1.0833724	1.1328970	1.1376415	1.1373059	1.0988958	1.1091949	1.1075707

	1998	1999	2000	2001	2002	2003	2004
0	0.1813268	0.1406960	0.1728405	0.1528747	0.1102035	0.06980952	0.06037421
1	0.5803323	0.5800426	0.5489840	0.5200986	0.4853299	0.43331738	0.42160213
2	0.7412077	0.7616839	0.7329586	0.7121784	0.6934499	0.66598719	0.65188101
3	0.8419249	0.8627816	0.8269955	0.8104085	0.7998058	0.78093384	0.77468156
4	0.9527769	0.9582240	0.9326120	0.9314089	0.9268752	0.91984064	0.92243052
5	1.1026491	1.0894972	1.1201963	1.1290913	1.1366595	1.14961276	1.15144396
6	1.1026491	1.0894972	1.1201963	1.1290913	1.1366595	1.14961276	1.15144396
7	1.1026491	1.0894972	1.1201963	1.1290913	1.1366595	1.14961276	1.15144396
8	1.1026491	1.0894972	1.1201963	1.1290913	1.1366595	1.14961276	1.15144396

	2005	2006	2007	2008	2009	2010	2011
0	0.05363369	0.03864863	0.02952451	0.03076932	0.03124513	0.01537031	0.01013529
1	0.39322320	0.36025474	0.35567623	0.34145575	0.33357357	0.32380389	0.30726906
2	0.63420826	0.61900379	0.63639591	0.64291859	0.65678941	0.65487086	0.61285219
3	0.75655663	0.74265485	0.76335322	0.76312978	0.76655268	0.76811392	0.73857584
4	0.91087656	0.89653865	0.91765441	0.92663348	0.94275216	0.97237162	0.96944504
5	1.16628340	1.18040325	1.15949618	1.15511837	1.14534758	1.12975723	1.14598956
6	1.16628340	1.18040325	1.15949618	1.15511837	1.14534758	1.12975723	1.14598956
7	1.16628340	1.18040325	1.15949618	1.15511837	1.14534758	1.12975723	1.14598956
8	1.16628340	1.18040325	1.15949618	1.15511837	1.14534758	1.12975723	1.14598956

	2012
0	0.009587374
1	0.294637858
2	0.597615160
3	0.724619726
4	0.965307788
5	1.155036243
6	1.155036243
7	1.155036243
8	1.155036243

TABLE 3.6.17 WBSS HERRING. PREDICTED CATCH IN NUMBERS

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
0	101407	180088	226817	323256	308785	381627	310178	344345	242002	280240	247583
1	660267	561406	534133	421553	806049	663046	657500	544651	571432	719348	462176
2	512625	556989	490117	373996	300289	489921	349654	418110	294078	433913	477300
3	522981	404902	373697	365309	225867	188038	276426	217358	217510	197758	260772
4	274388	383234	258849	228685	222660	126513	89877	148286	108597	139427	104893
5	179728	206427	233818	164539	109404	121419	53391	47906	64441	76359	75652
6	53088	126957	101692	105948	65854	55326	41610	24161	17863	37949	34413
7	16037	41465	59445	44614	36432	31511	20771	15582	9185	10957	16645
8	5217	17351	25846	32939	24820	27165	22711	15223	8606	9782	7678

	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
0	150151	85408	63032	52146	32985	21267	22841	23952	9653	5345	5208
1	459319	271278	353239	263867	208147	160604	156733	151236	91876	111793	97139
2	279596	273594	229143	329720	209882	188358	146591	164753	108380	78614	136749
3	302096	153185	180557	179118	233585	134618	131177	89994	79213	55409	62887
4	163407	164506	98834	125129	128489	137407	89554	76988	46784	51596	41523
5	58536	95054	103352	69265	85768	76024	90771	50307	34279	27529	35682
6	34679	26761	48426	59772	37737	31873	44108	38327	18923	19261	17028
7	13746	15439	13663	26734	28593	17808	16083	19663	12039	10937	11368
8	9219	9120	11273	12612	16469	16473	16715	13437	11207	10758	14796

TABLE 3.6.18 WBSS HERRING SURVEY STANDARDIZED RESIDUALS HERAS

	1991	1992	1993	1994	1995	1996	1997	1998	2000
1	NA	-0.7257	-1.1901	-2.6833	0.3171	0.0856	-1.1302	-0.9831	0.1617
2	-0.4712	-0.0533	0.7532	-1.8815	1.0132	-0.7435	-0.8861	0.2830	0.4526
3	-0.2627	0.7406	0.3039	-0.2804	1.1006	-1.7370	-0.0229	0.9073	0.4533
4	0.0186	1.2582	0.0287	0.0674	2.3833	-1.4165	-0.3982	-0.3147	0.4995
5	-0.5693	1.0681	0.4032	-0.0528	0.8513	-0.9860	-0.6125	0.8899	1.1410
6	-0.5381	0.1272	0.3287	0.8513	1.5960	-1.5053	0.5140	1.0904	0.3116
7	0.8789	0.7921	-0.0962	0.2269	-0.1327	-0.5151	1.1396	0.4892	-0.5758
8	0.0533	-0.1168	-0.8191	-0.0615	-0.3609	-0.7890	1.0159	1.0321	-0.1454

	2001	2002	2003	2004	2005	2006	2007	2008	2009
1	-1.3559	0.7235	0.5567	0.3356	0.7646	0.7153	1.1552	1.4048	0.1319
2	-1.5970	0.6311	-0.1799	-0.2466	-0.1425	1.4453	2.3664	1.0202	-0.9216
3	-1.3210	0.8862	-0.9093	0.1354	-0.8043	1.8859	1.5251	1.5209	-1.0370
4	-0.9907	0.7626	-0.7637	0.3389	-1.1089	1.0477	0.7888	1.0617	-0.3117
5	-0.4866	-0.2700	-1.3228	-0.1402	-0.3315	0.6295	0.2805	1.4557	-0.0890
6	-0.4373	-0.5144	-1.2495	-0.1488	-0.0396	-1.6234	-0.8841	2.5829	1.1394
7	0.1795	0.0460	-0.5508	0.1177	0.1016	-1.2544	0.0821	0.7838	0.4461
8	0.2908	0.3947	-0.8148	0.1318	0.2940	-5.1366	-0.4428	0.7246	1.3109

	2010	2011	2012
1	0.5032	0.8790	0.3677
2	-0.4238	-0.3992	0.0895
3	-1.1064	-0.6720	-1.1563
4	-0.7674	-0.5584	-1.4790
5	-0.7064	-0.3504	-0.6557
6	-1.2755	0.2788	-0.4585
7	0.2133	-0.0733	-0.4964
8	0.4711	0.6581	0.6596

TABLE 3.6.19 WBSS HERRING SURVEY STANDARDIZED RESIDUALS GerAs

	1994	1995	1996	1997	1998	1999	2000	2002	2003
0	0.2582	0.1625	-2.0215	-0.9283	-1.3700	0.5080	-2.9905	0.3564	0.1539
1	-1.4792	0.2893	0.5874	1.1031	-0.4803	0.2254	0.1387	-0.5806	0.9602
2	1.5918	-0.1799	0.2095	1.2828	0.7377	-0.6973	-0.2058	0.2566	-1.5119
3	0.4329	0.4723	1.5628	0.2647	0.8015	-0.6929	0.6407	0.6338	-0.3695
4	0.7718	0.3940	1.2199	0.6253	0.4291	-0.0038	0.2834	0.7094	0.0339
5	0.2088	1.1639	1.5337	1.1553	1.0335	-0.8395	-0.0345	-0.0951	-0.3904
6	-0.5537	0.7236	1.0205	1.0141	0.8581	-1.1408	0.0752	-0.4512	0.2291
7	-0.2234	0.6651	1.0128	0.9719	0.8956	-1.9369	-0.2405	-0.0328	-0.4434
8	-2.5637	0.4909	0.1252	1.2910	-0.1607	-1.4453	-0.5110	0.8089	0.3357

	2004	2005	2006	2007	2008	2009	2010	2011	2012
0	-0.4127	0.3417	1.3718	0.5096	0.1794	0.7329	1.4694	0.5086	1.3028
1	-0.3004	-0.1860	0.6972	-0.1054	-0.7804	-1.5852	0.1756	1.0877	0.3463
2	1.0136	0.3232	-0.8354	-0.3958	-0.6558	-2.0894	0.6030	1.1662	-0.5037
3	0.2518	0.0648	-0.6632	-1.5006	-0.4752	-2.6331	0.3839	0.6715	0.2591
4	0.0780	-0.3965	0.2190	-1.6673	-0.3391	-2.9322	0.2516	-0.0734	0.4739
5	0.0876	-0.0531	0.6080	-1.2892	-0.4161	-3.0968	0.5398	-0.0101	-0.0246
6	0.3696	0.2594	1.0812	-1.2773	-0.5198	-2.9490	0.4958	0.3769	0.4460
7	0.8074	0.3039	1.3911	-0.4927	-0.0346	-2.3380	0.7067	0.8135	0.5317
8	0.2710	0.5591	1.0095	-0.4563	-0.3259	-2.0497	0.2176	0.0373	0.1653

TABLE 3.6.20 WBSS HERRING SURVEY STANDARDIZED RESIDUALS N20

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
0	-2.4455	-0.9682	0.6672	0.0855	1.4765	-0.4468	1.1496	1.3662	-0.9162	-0.2939

	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
0	0.999	0.0251	0.2515	-0.0444	0.1181	-0.735	-0.8448	0.995	0.9051	0.308	-1.5207

TABLE 3.6.21 WBSS HERRING SURVEY STANDARDIZED RESIDUALS IBTS Q1

	1991	1992	1993	1994	1995	1996	1997	1998	1999
1	-2.3109	-1.0992	0.9810	-0.2153	-1.0281	-0.0676	1.1522	-1.1616	-0.7410
2	0.4996	-1.6506	-0.2294	-0.2721	-1.4197	0.6687	-0.9904	0.6722	-0.7022
3	0.9048	-1.1442	-1.0235	0.4849	-0.7363	1.4938	1.0495	0.9822	-0.0242
4	1.0932	-0.3780	-1.1071	-0.2560	0.2344	1.6652	0.2292	1.6531	0.4929

	2000	2001	2002	2003	2004	2005	2006	2007	2008
1	0.3475	-0.3155	1.2722	0.6076	-0.9021	-0.1899	0.4752	0.6326	-0.3166
2	-0.7499	0.3578	-0.9482	1.0516	-0.2982	0.8232	-0.7784	0.2896	-0.6642
3	-1.1670	-0.2025	0.3393	-0.7503	-0.5886	-0.1788	-0.1794	-0.2448	-0.9576
4	-0.9350	-1.5298	-0.1251	-1.2379	-0.9511	-0.3837	-0.4050	-0.6942	-1.3492

	2009	2010	2011	2012
1	2.5846	-0.1713	0.5674	-0.0159
2	0.5527	0.1529	1.8008	1.9178
3	-1.4378	0.1288	2.3215	1.0085
4	-0.0872	0.6703	2.3677	1.1080

TABLE 3.6.22 WBSS HERRING SURVEY STANDARDIZED RESIDUALS IBTS Q3

	1991	1992	1993	1994	1995	1996	1997	1998	1999
1	-0.8569	0.0657	0.9572	-0.0697	0.0595	0.4550	-0.9761	-0.2735	-0.2566
2	-0.4019	-0.0636	0.0664	0.1938	0.2503	0.4603	0.1394	-0.0779	-0.2383
3	-0.4148	0.0053	-1.7770	0.4240	0.6888	-0.5185	0.3804	-0.8865	-1.3447
4	-0.1509	0.6231	-0.4473	0.5849	1.6417	-0.0629	0.4032	0.4393	-0.8792

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
1	-4.2375	-0.5910	1.1081	0.3749	0.9261	0.1280	0.6505	0.5723	0.1454	1.1469
2	-3.6120	0.0369	0.2449	0.4647	0.7164	0.4304	0.3939	0.2037	-0.0600	1.1043
3	NA	-0.3710	0.0996	0.5629	0.6032	0.4232	0.4996	-0.4184	-0.2509	1.6285
4	NA	-0.0509	-0.3585	0.0047	0.0977	-0.0916	-0.6461	0.4231	-0.5327	1.3860

	2010	2011	2012
1	0.1557	1.0303	-0.4735
2	0.2116	0.3728	-0.7961
3	0.4976	0.2491	NA
4	1.2216	0.7868	-4.3141

TABLE 3.6.23 WBSS HERRING. FIT PARAMETERS

	name	value	std.dev
1	logFpar	6.348800	0.411230
2	logFpar	7.358100	0.139100
3	logFpar	7.330200	0.099633
4	logFpar	7.177000	0.099172
5	logFpar	7.053000	0.099147
6	logFpar	6.879300	0.106500
7	logFpar	6.753500	0.172610
8	logFpar	0.436460	0.122900
9	logFpar	-0.235560	0.119050
10	logFpar	-0.505600	0.117340
11	logFpar	-0.275290	0.116570
12	logFpar	-0.162050	0.152060
13	logFpar	-0.081576	0.152330
14	logFpar	-0.182820	0.212920
15	logFpar	-0.544920	0.160590
16	logFpar	-6.178200	0.171640
17	logFpar	-9.565100	0.198280
18	logFpar	-9.558700	0.197230
19	logFpar	-10.602000	0.196880
20	logFpar	-11.689000	0.196640
21	logFpar	-10.217000	0.369400
22	logFpar	-10.754000	0.368960
23	logFpar	-10.907000	0.175090
24	logFpar	-11.436000	0.171230
25	logSdLogFsta	-0.672420	0.282230
26	logSdLogFsta	-1.825900	0.219300
27	logSdLogN	-1.867800	0.203610
28	logSdLogObs	-0.209860	0.200650
29	logSdLogObs	-1.389500	0.124030
30	logSdLogObs	-1.787400	0.265800
31	logSdLogObs	0.600750	0.159630
32	logSdLogObs	-0.516160	0.161560
33	logSdLogObs	-0.912400	0.088277
34	logSdLogObs	0.030463	0.111420
35	logSdLogObs	-0.817980	0.094334
36	logSdLogObs	-0.501130	0.125630
37	logSdLogObs	-0.153080	0.100230
38	logSdLogObs	-0.305690	0.159160
39	logSdLogObs	-0.101820	0.078037
40	logSdLogObs	0.539800	0.107330
41	logSdLogObs	-0.280640	0.114600
42	rho	0.794560	0.152650

TABLE 3.9.1 WBSS HERRING. Input table for short term predictions

[1] 2013

	N	M	Mat	PF	PM	Sel	SWt	CWt
0	1789058	0.3	0.00	0.25	0.1	0.012	0.000	0.010
1	1321166	0.5	0.00	0.25	0.1	0.309	0.012	0.035
2	727552	0.2	0.20	0.25	0.1	0.623	0.057	0.075
3	562486	0.2	0.75	0.25	0.1	0.745	0.095	0.106
4	208578	0.2	0.90	0.25	0.1	0.969	0.123	0.127
5	99049	0.2	1.00	0.25	0.1	1.143	0.159	0.155
6	68772	0.2	1.00	0.25	0.1	1.143	0.177	0.170
7	32812	0.2	1.00	0.25	0.1	1.143	0.193	0.183
8	50404	0.2	1.00	0.25	0.1	1.143	0.199	0.196

[1] 2014

	N	M	Mat	PF	PM	Sel	SWt	CWt
0	1789058	0.3	0.00	0.25	0.1	0.012	0.000	0.010
1	NA	0.5	0.00	0.25	0.1	0.309	0.012	0.035
2	NA	0.2	0.20	0.25	0.1	0.623	0.057	0.075
3	NA	0.2	0.75	0.25	0.1	0.745	0.095	0.106
4	NA	0.2	0.90	0.25	0.1	0.969	0.123	0.127
5	NA	0.2	1.00	0.25	0.1	1.143	0.159	0.155
6	NA	0.2	1.00	0.25	0.1	1.143	0.177	0.170
7	NA	0.2	1.00	0.25	0.1	1.143	0.193	0.183
8	NA	0.2	1.00	0.25	0.1	1.143	0.199	0.196

[1] 2015

	N	M	Mat	PF	PM	Sel	SWt	CWt
0	1789058	0.3	0.00	0.25	0.1	0.012	0.000	0.010
1	NA	0.5	0.00	0.25	0.1	0.309	0.012	0.035
2	NA	0.2	0.20	0.25	0.1	0.623	0.057	0.075
3	NA	0.2	0.75	0.25	0.1	0.745	0.095	0.106
4	NA	0.2	0.90	0.25	0.1	0.969	0.123	0.127
5	NA	0.2	1.00	0.25	0.1	1.143	0.159	0.155
6	NA	0.2	1.00	0.25	0.1	1.143	0.177	0.170
7	NA	0.2	1.00	0.25	0.1	1.143	0.193	0.183
8	NA	0.2	1.00	0.25	0.1	1.143	0.199	0.196

M = Natural mortality

Mat = Maturity ogive

PF = Proportion of F before spawning

PM = Proportion of M before spawning

SWt = Weight in stock (kg)

Sel = Exploit. Pattern

Cwt = Weight in catch (kg)

N2013/2014/2015 Age 0:
 Geometric Mean of age 0 from SAM for the years 2007-2011

N2013 Age 1 = N2012 Age 0 * exp(-(F2012 Age 0+ M2012 Age 0))

N2013 Age 2-8+
 Output from SAM

Natural Mortality (M) = Average for 2010-2012

Weight in the Catch/Stock (CWt/SWt)= Average for 2010-2012

Expoitation pattern (Sel):= Average for 2010-2012

Table 3.9.2 **WESTERN BALTIC HERRING.**
Short-term prediction multiple option table, TAC constraint.

R function 'fwd' within FLR
Run: Intermediate year: WBSS_TAC constraint_quota-transfer
Western Baltic Herring (combined sex; plus group)
Time and date: 19/03/2013 14:05
Fbar age range: 3-6

2013 Biomass	SSB	FMult	FBar	Landings	GM Recr.
165,084	106,053	1.1399	0.39	49,954	1,789,058

2014 Biomass	SSB	FMult	FBar	Landings	2015 Biomass	SSB
176,210	117,082	0.0000	0.00	0	233,472	167,409
	116,706	0.1000	0.03	5,267	227,357	162,181
	116,332	0.2000	0.07	10,389	221,432	157,127
	115,958	0.3000	0.10	15,370	215,691	152,241
	115,586	0.4000	0.14	20,214	210,128	147,517
	115,215	0.5000	0.17	24,927	204,736	142,950
	114,845	0.6000	0.20	29,511	199,510	138,534
	114,477	0.7000	0.24	33,970	194,445	134,263
	114,110	0.8000	0.27	38,309	189,535	130,134
	113,744	0.9000	0.31	42,531	184,775	126,140
	113,379	1.0000	0.34	46,639	180,160	122,278
	113,015	1.1000	0.37	50,638	175,685	118,542
	112,653	1.2000	0.41	54,529	171,345	114,929
	112,292	1.3000	0.44	58,316	167,137	111,433
	111,932	1.4000	0.48	62,003	163,055	108,052
	111,573	1.5000	0.51	65,593	159,095	104,780
	111,215	1.6000	0.54	69,088	155,254	101,615
	110,859	1.7000	0.58	72,490	151,527	98,553
	110,504	1.8000	0.61	75,804	147,911	95,590
	110,149	1.9000	0.65	79,031	144,403	92,722
	109,797	2.0000	0.68	82,174	140,998	89,948
zero catch	117,082	0.0000	0.00	0	233,472	167,409
$F_{3\text{-}6}$=$F_{MSY\text{-}framework}$	**113,825**	**0.8778**	**0.298**	**41,602**	**185,821**	**127,016**
TAC -15%	112,357	1.2813	0.44	57,632	169,836	113,552
TAC as in 2013	111,386	1.5523	0.53	67,433	160,085	105,400
TAC +15%	110,348	1.8439	0.63	77,234	150,353	97,317

Input units are thousands and kg - output in tonnes

TABLE 3.10.1 WBSS HERRING. plotMSY outcomes

Ricker

1000/1000 Iterations resulted in feasible parameter estimates

	Fcrash	Fmsy	Bmsy	MSY	ADMB Alpha	ADMB Beta	Unscaled Alpha	Unscaled Beta	AICc
Deterministic	0.7064	0.3180	294.5460	107.8460	0.6630	0.8808	30.9724	0.0029	11.4478
Mean	0.7143	0.3202	358.7258	124.1149	0.6852	0.8449	30.9180	0.0028	13.6716
5%ile	0.5483	0.2463	211.6367	88.8773	0.5284	0.3692	23.1650	0.0012	11.5376
25%ile	0.6421	0.2881	257.5633	100.7828	0.6156	0.6482	27.4233	0.0021	12.0375
50%ile	0.7059	0.3167	302.7930	111.3960	0.6763	0.8592	30.6870	0.0028	12.9732
75%ile	0.7847	0.3513	386.9868	129.1633	0.7514	1.0266	33.6867	0.0034	14.6699
95%ile	0.9145	0.4039	641.7298	187.4164	0.8710	1.2884	39.8109	0.0042	17.9612
CV	0.1590	0.1544	0.6833	0.4765	0.1501	0.3324	0.1587	0.3324	0.1564
N	1000	1000	1000	1000	1000	1000	1000	1000	1000

Beverton-Holt

1000/1000 Iterations resulted in feasible parameter estimates

	Fcrash	Fmsy	Bmsy	MSY	ADMB Alpha	ADMB Beta	Unscaled Alpha	Unscaled Beta	AICc
Deterministic	0.7956	0.2203	486.4840	121.8410	0.9021	1.4392	6545.8000	181.5760	12.1092
Mean	0.8746	0.2311	573.8751	137.4372	0.9452	1.4764	7674.0953	241.8488	14.4030
5%ile	0.5613	0.1727	264.2928	86.2252	0.4138	1.1569	3897.9310	53.4673	12.2448
25%ile	0.6915	0.2011	365.6320	101.4215	0.7116	1.3377	5088.2575	112.9328	12.8017
50%ile	0.8214	0.2223	464.9285	119.0675	0.9382	1.4707	6294.1250	171.8315	13.6831
75%ile	0.9755	0.2489	629.8005	146.0388	1.1605	1.6143	8297.6925	271.1658	15.2979
95%ile	1.3806	0.3141	1110.3755	231.1138	1.5149	1.8192	14270.2650	559.7473	18.7499
CV	0.3570	0.2098	0.9709	0.6984	0.3630	0.1378	0.9131	1.4510	0.1576
N	997	1000	1000	1000	1000	1000	1000	1000	1000

Combining all SRRs

Automatically specified weights

	Ricker	Beverton-Holt
	0.6481	0.3519

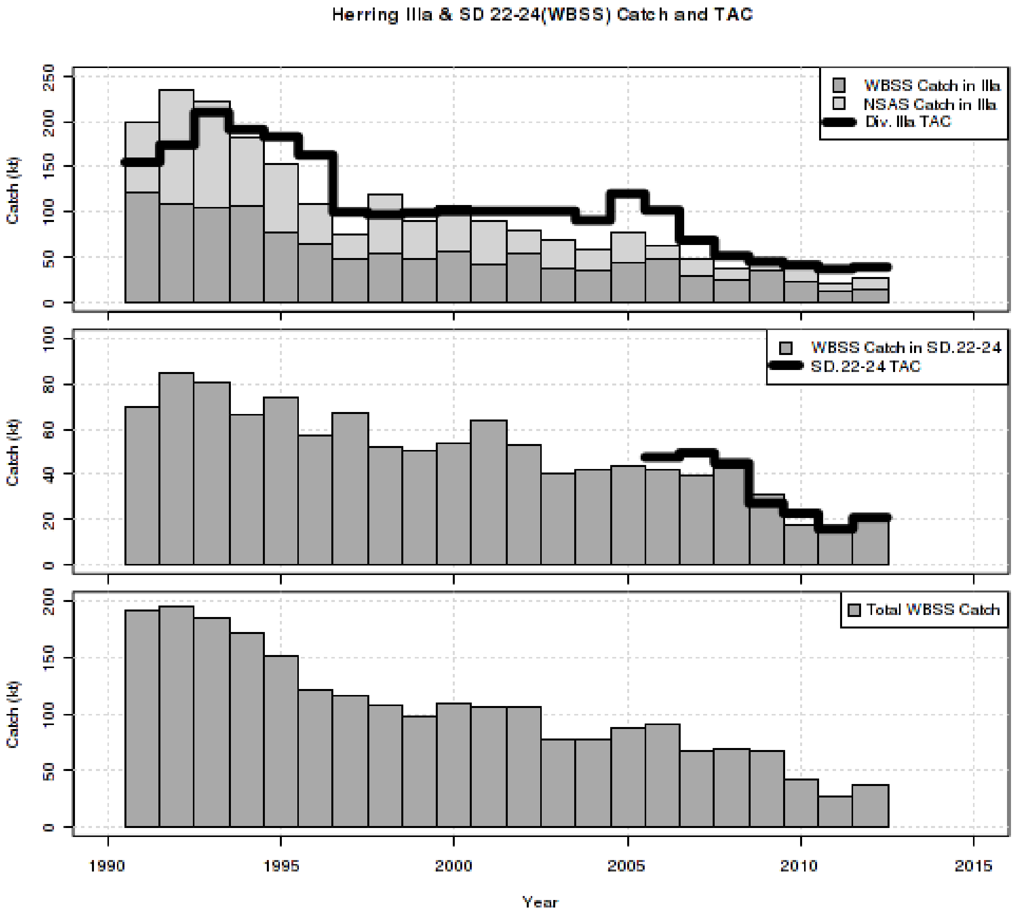


Figure 3.1.1 WESTERN BALTIC SPRING SPAWNING HERRING. Catches and TACs by area. Top panel) Catches of Western Baltic Spring Spawning (WBSS) and North Sea Autumn Spawning (NSAS) herring in division IIIa, and the total TAC for both stocks. Middle panel) Catches and TACs of WBSS herring in subdivisions 22-24. Bottom panel). Total catch of WBSS herring in Div IVa, Div IIIa and SD 22-24.

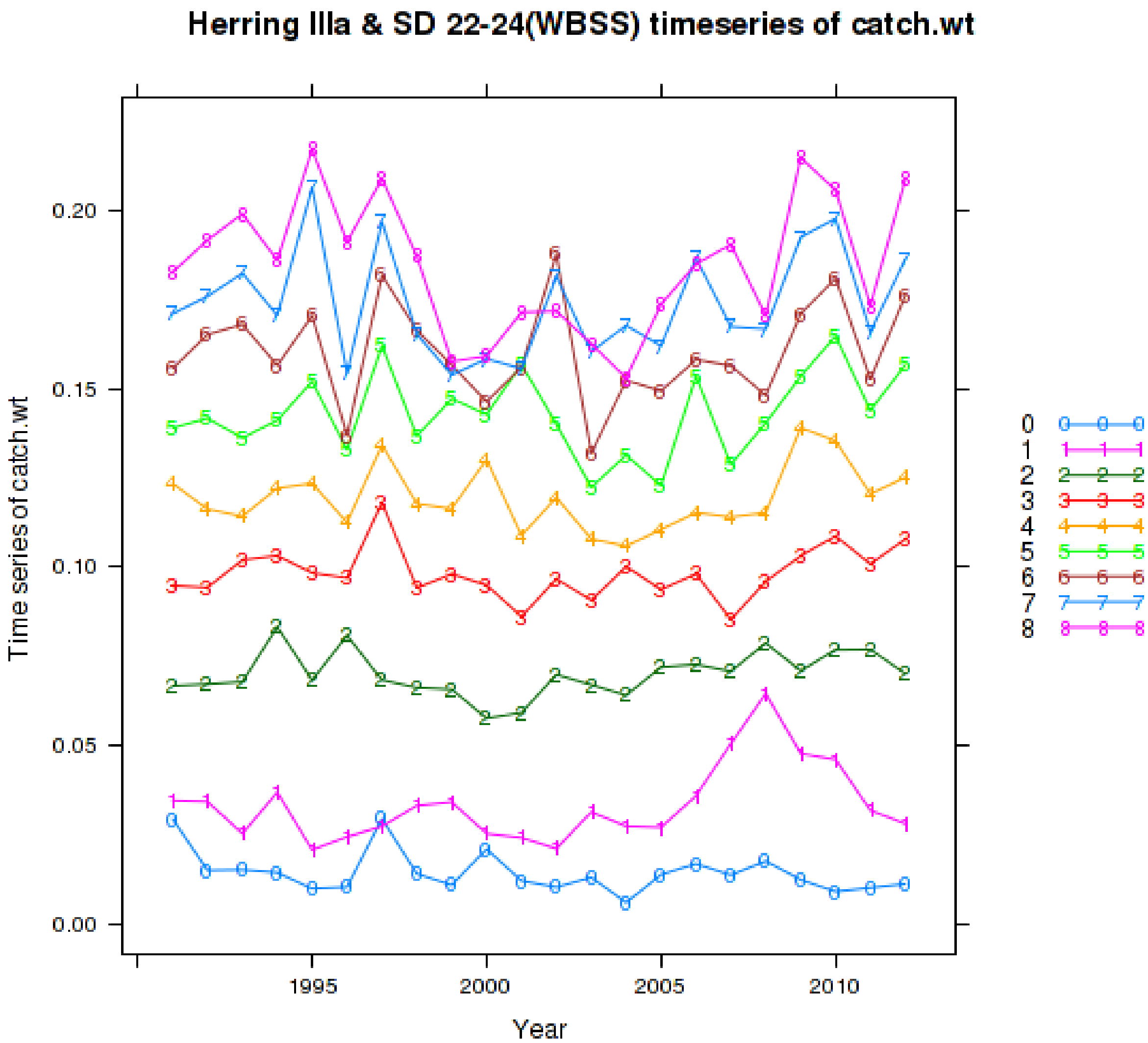


Figure 3.6.1.1 WESTERN BALTIC SPRING SPAWNING HERRING. Weight at age (in winter rings, kg) in the catch.

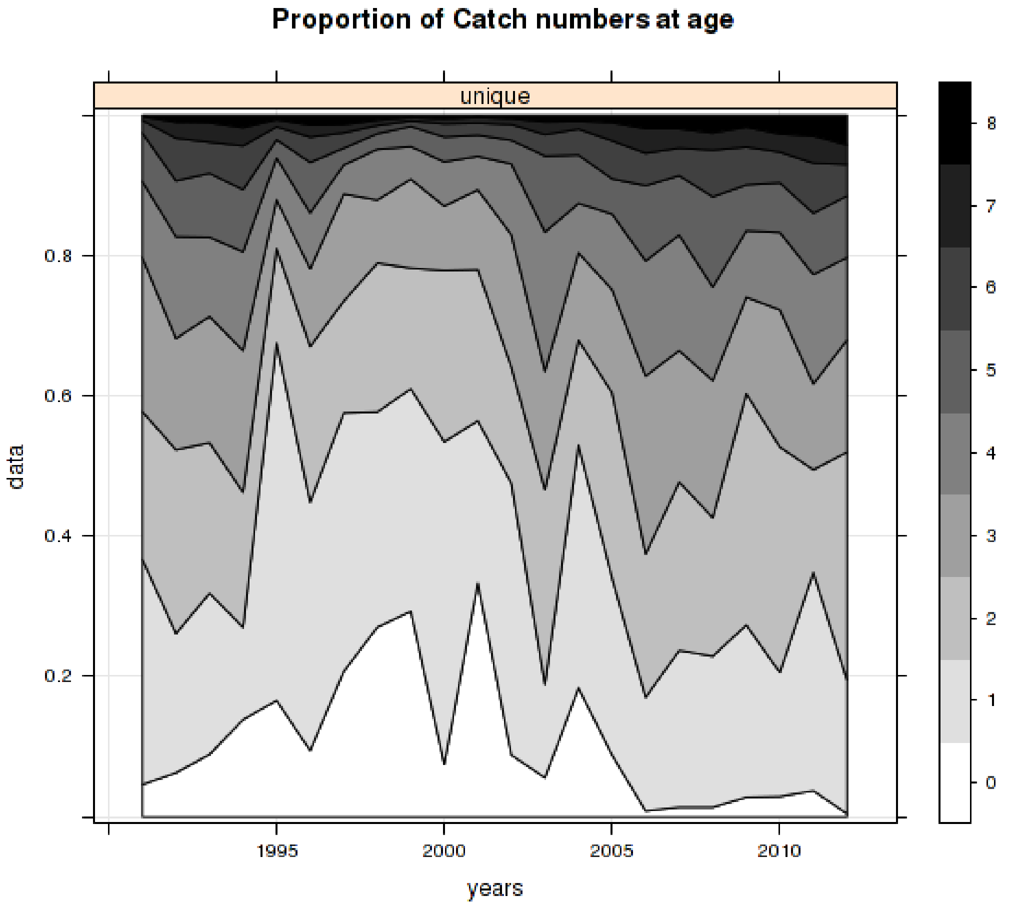


Figure 3.6.1.2 WESTERN BALTIC SPRING SPAWNING HERRING. Proportion (by numbers) of a given age (in winter rings) in the catch.

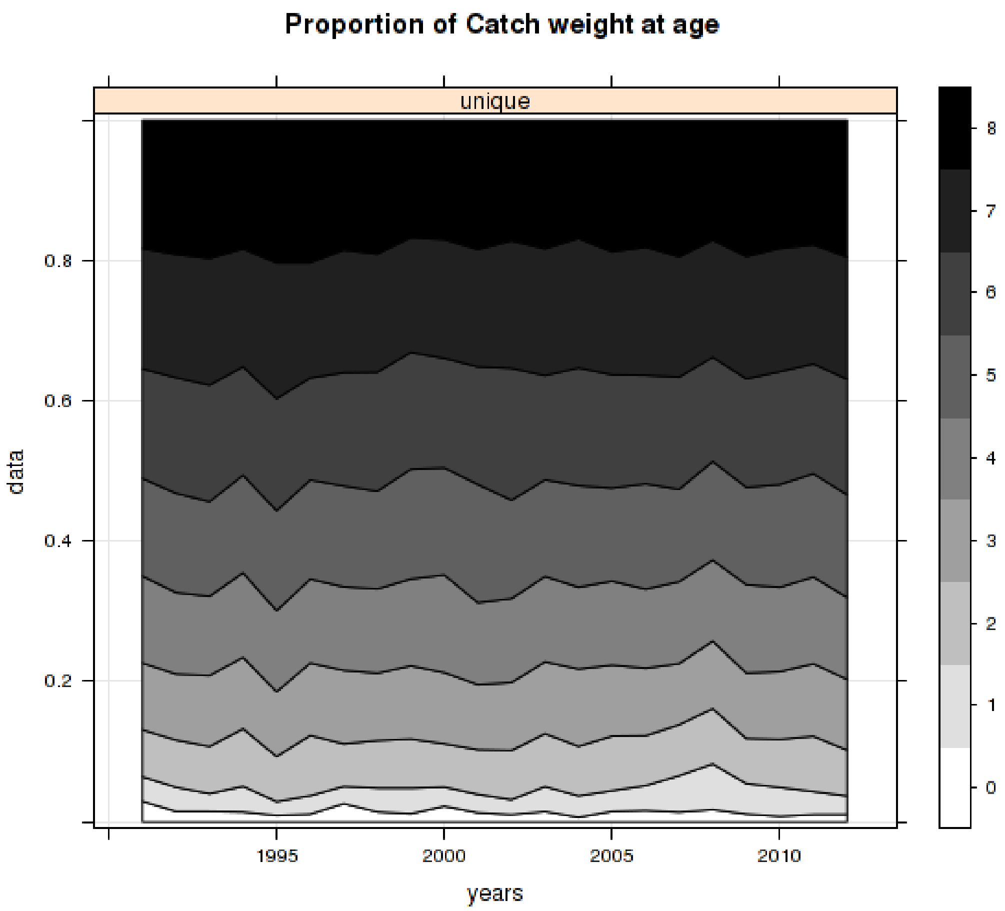


Figure 3.6.1.3 WESTERN BALTIC SPRING SPAWNING HERRING. Proportion (by weight) of a given age (in winter rings) in the catch.

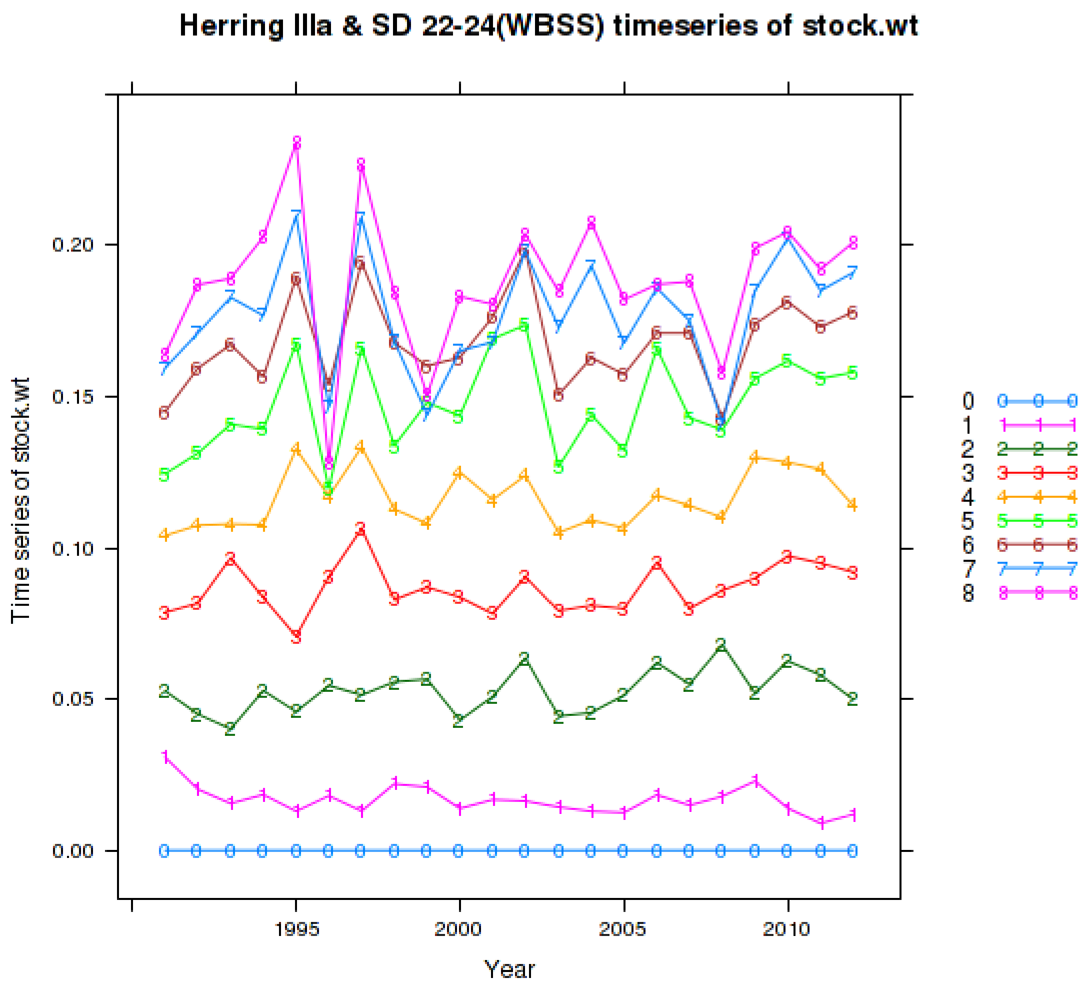


Figure 3.6.1.4 WESTERN BALTIC SPRING SPAWNING HERRING. Weight at age (in winter rings, kg) in the stock.

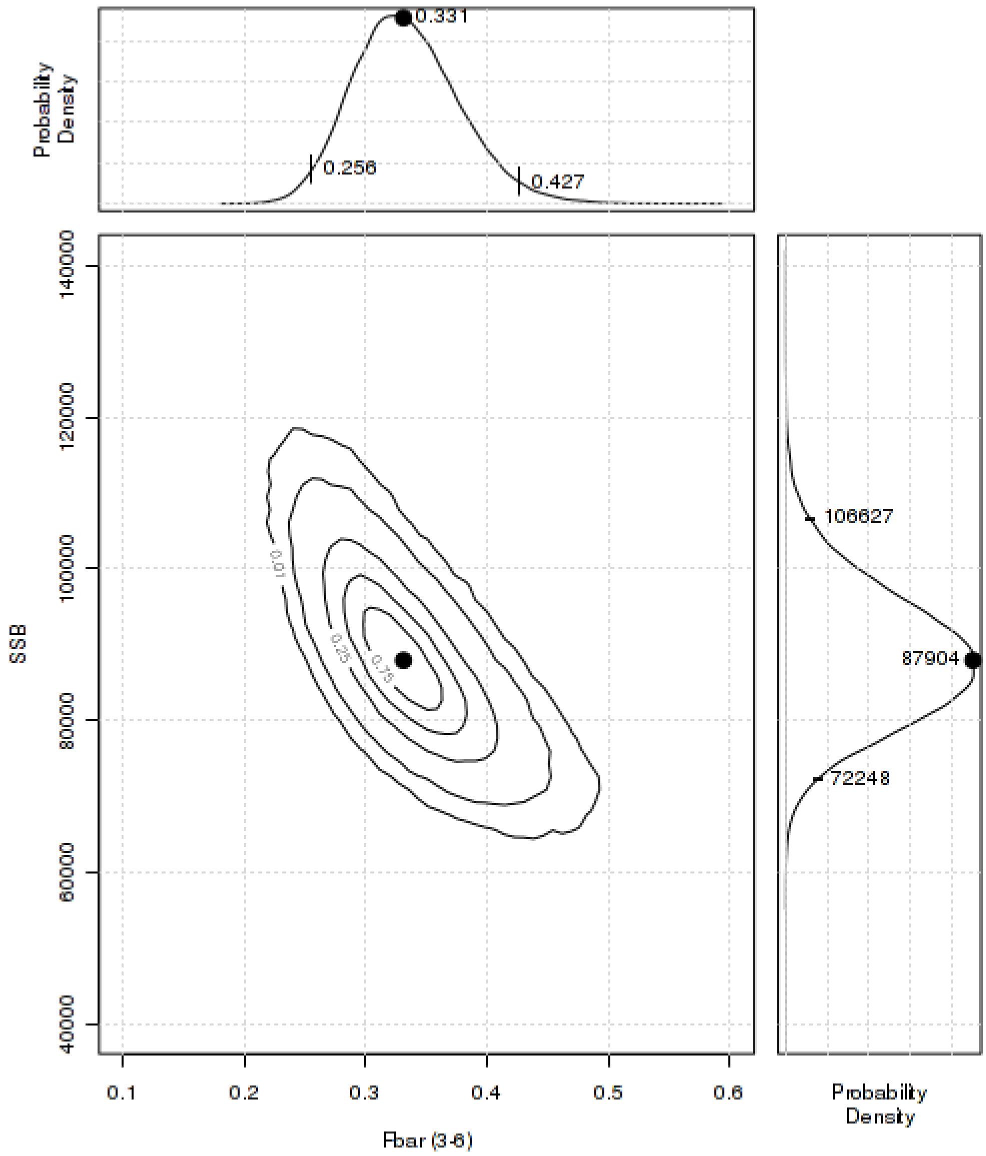


Figure 3.6.4.1 WESTERN BALTIC SPRING SPAWNING HERRING. FINAL RUN. "Otolith" plot. The main figure depicts the uncertainty in the estimated spawning stock biomass and average fishing mortality, and their correlation. Contour lines give the 1%, 5%, 25%, 50% and 75% confidence intervals for the two estimated parameters and are estimated from a parametric bootstrap based on the variance covariance matrix in the parameters returned by the assessment model. The plots to the right and top of the main plot give the probability distribution in the SSB and mean fishing mortality respectively. The SSB and fishing mortality estimated by the method is plotted on all three plots with a heavy dot. 95% confidence intervals, with their corresponding values, are given on the plots to the right and top of the main plot.

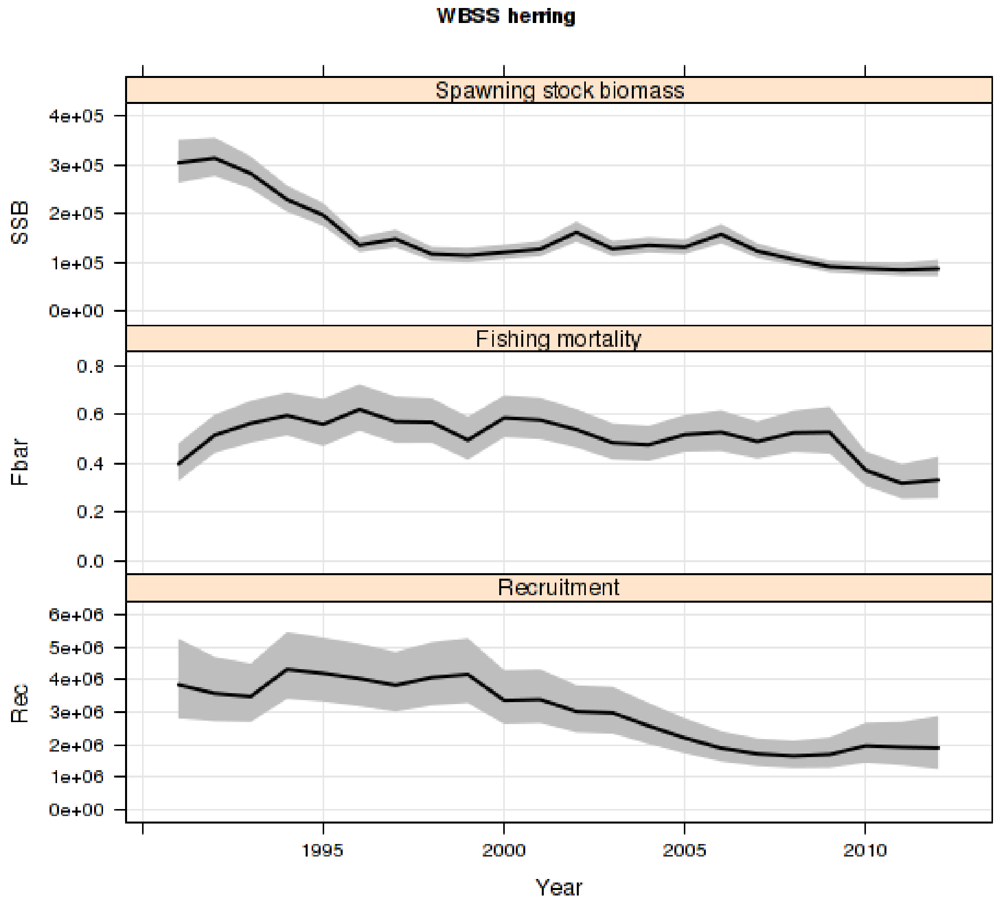


Figure 3.6.4.2 **WESTERN BALTIC SPRING SPAWNING HERRING. FINAL RUN. Stock summary plot. Top panel: Spawning stock biomass. Second panel: Recruitment (at age 0-wr) as a function of time. Bottom panel:: Mean annual fishing mortality on ages 3-6 ringers as a function of time.**

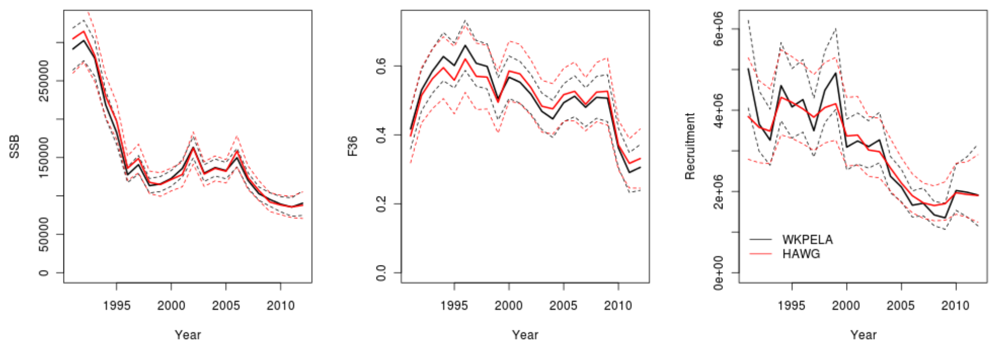


Figure 3.6.4.3 **WESTERN BALTIC SPRING SPAWNING HERRING. Comparison of SSB, F and R from SAM using the settings proposed in the benchmark (WKPELA 2013) and the revised settings adopted by the working group for the current assessment. Continuous line is the mean estimate with dotted line as 95% CI.**

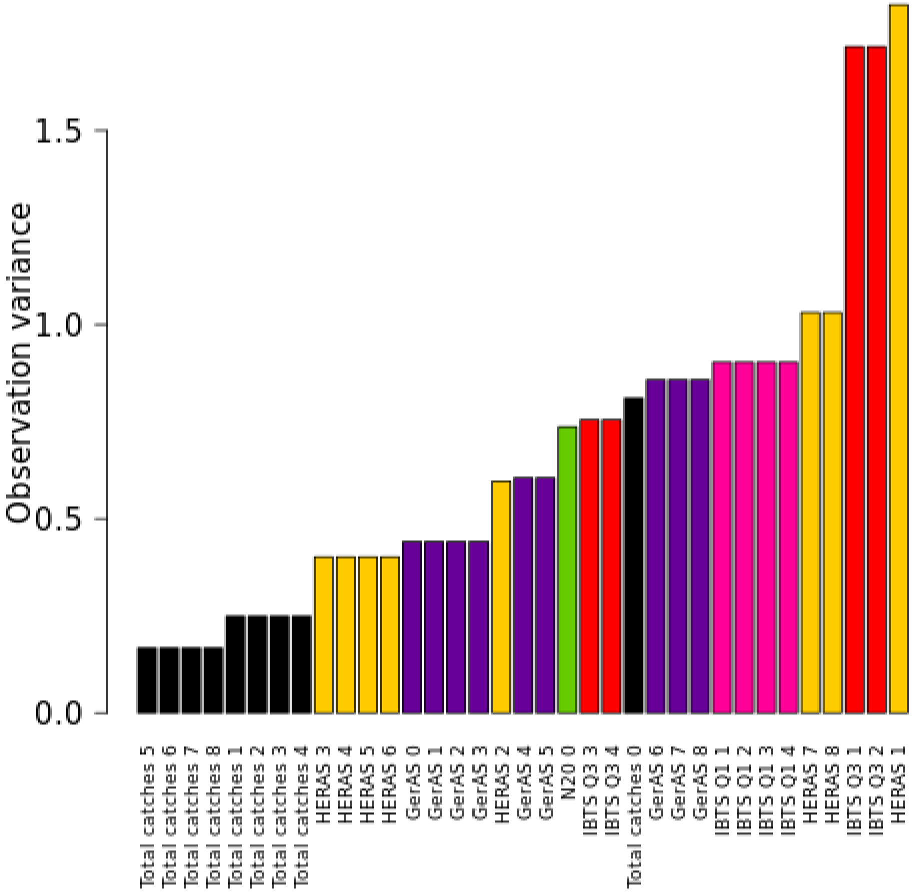


Figure 3.6.4.4 WESTERN BALTIC SPRING SPAWNING HERRING. Estimated observation variance for the WBSS assessment.

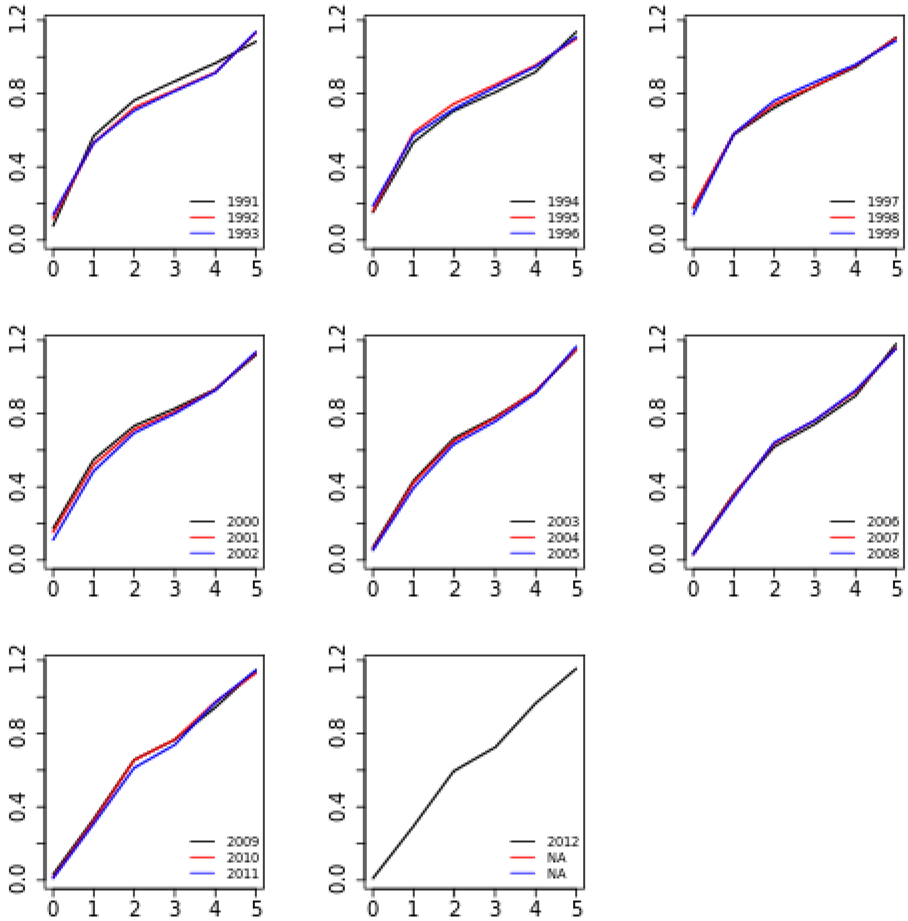


Figure 3.6.4.5 WESTERN BALTIC SPRING SPAWNING HERRING. FINAL RUN. Estimated selection pattern at age of the fisheries for the whole time period of the assessment.

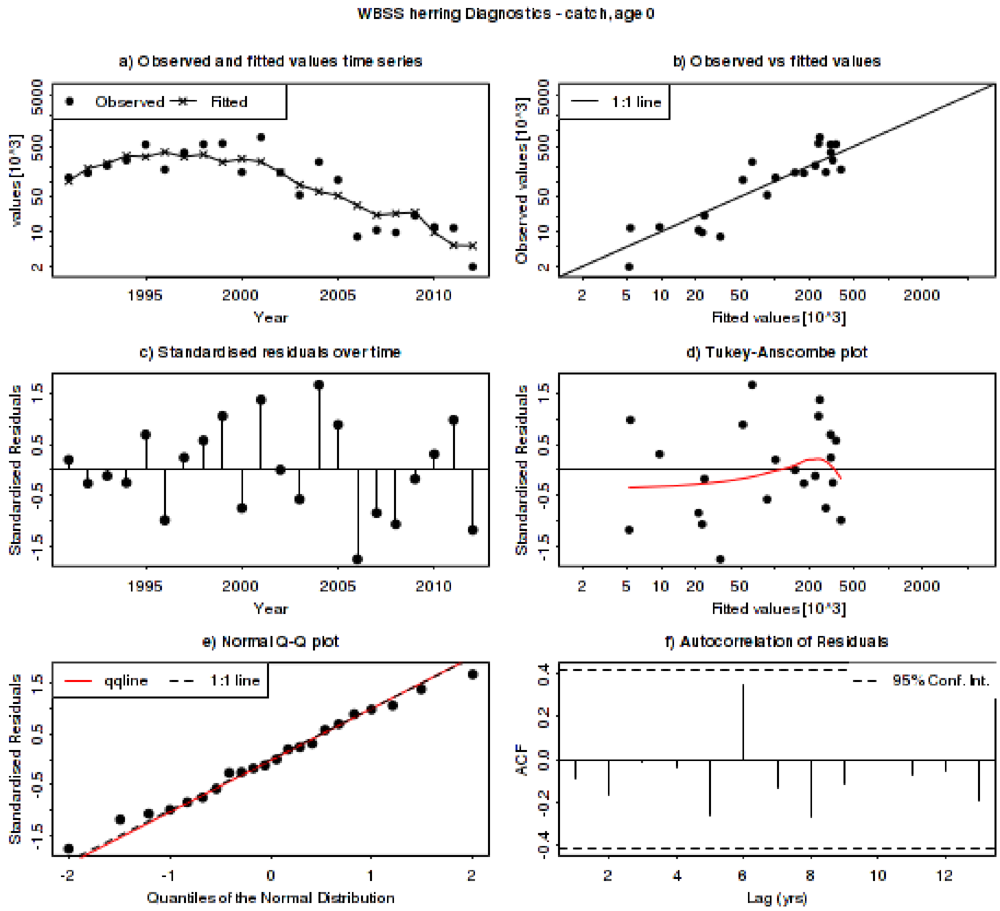


Figure 3.6.4.6 WESTERN BALTIC SPRING SPAWNING HERRING. FINAL RUN. Diagnostics of the commercial catches fit at 0 wr from the assessment. a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus model estimates of stock numbers at age. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log siduals of catchability model fitted by the model as a function of time. d). Log residuals from the catchability model against the estimated stock size at age. e). Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line).

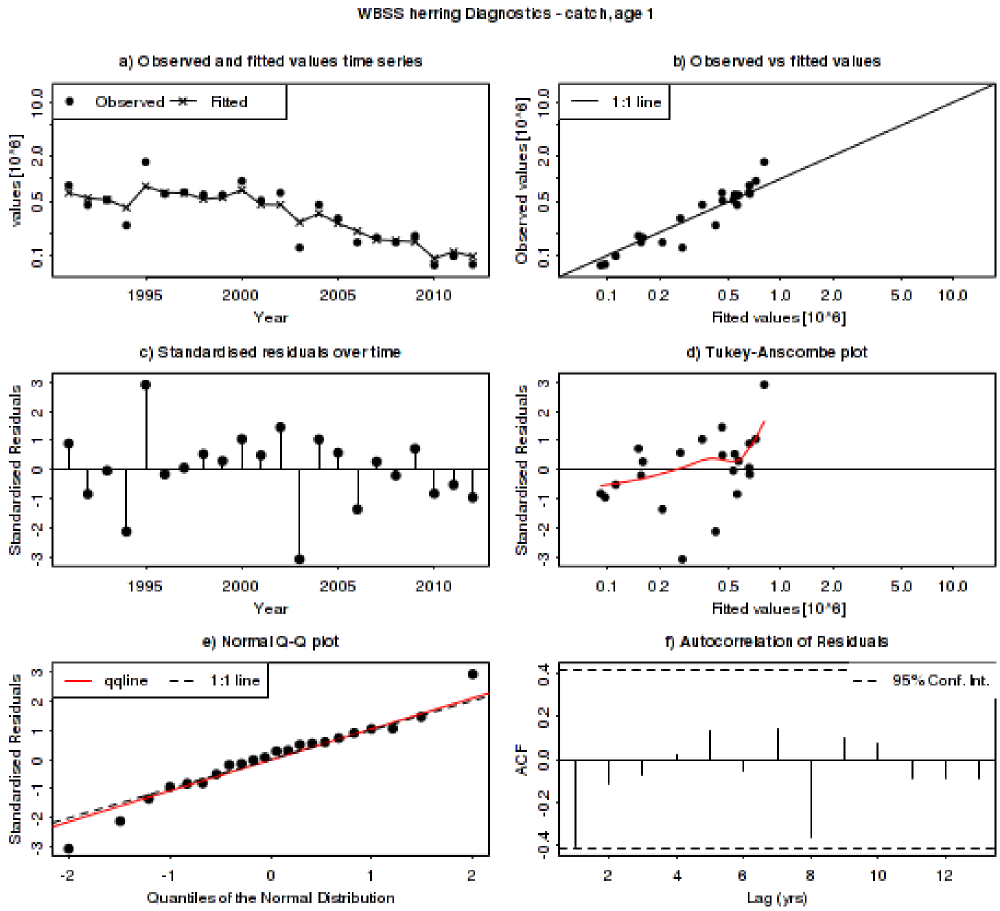


Figure 3.6.4.7 WESTERN BALTIC SPRING SPAWNING HERRING. FINAL RUN. Diagnostics of the commercial catches fit at 1 wr from the assessment. a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus model estimates of stock numbers at age. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log siduals of catchability model fitted by the model as a function of time. d). Log residuals from the catchability model against the estimated stock size at age. e). Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line).

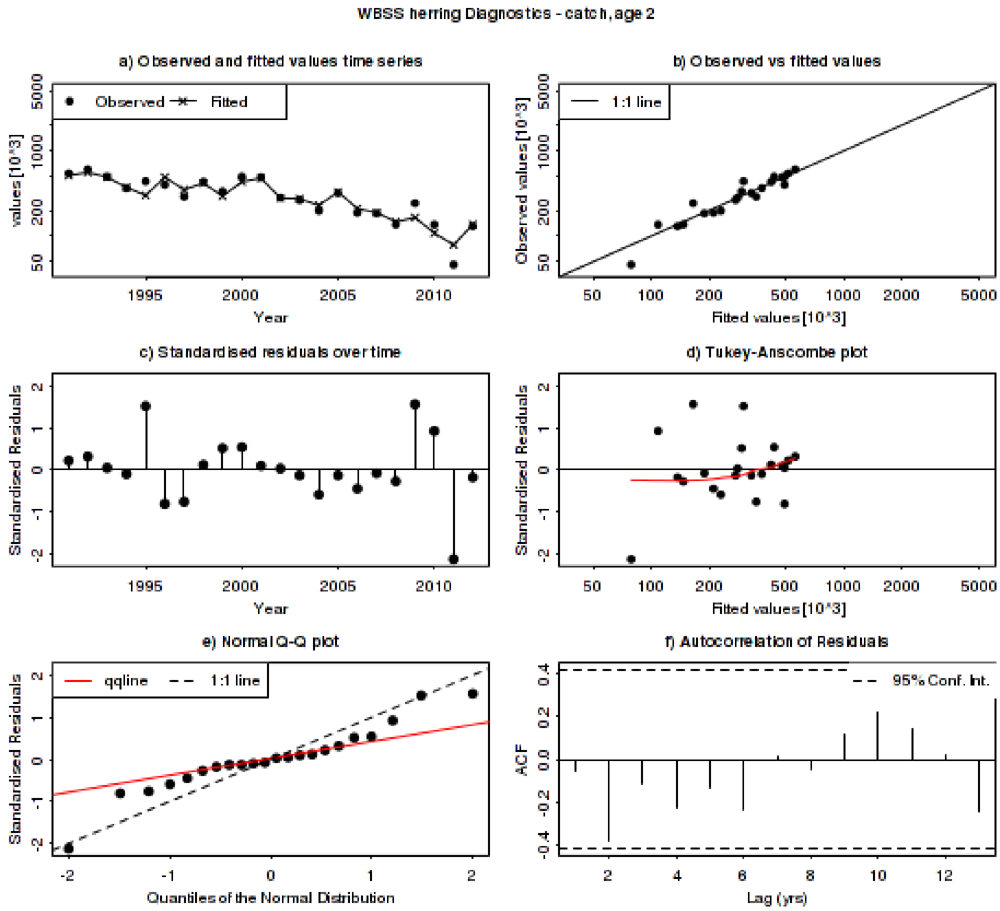


Figure 3.6.4.8 WESTERN BALTIC SPRING SPAWNING HERRING. FINAL RUN. Diagnostics of the commercial catches fit at 2 wr from the assessment. a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus model estimates of stock numbers at age. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log siduals of catchability model fitted by the model as a function of time. d). Log residuals from the catchability model against the estimated stock size at age. e). Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line).

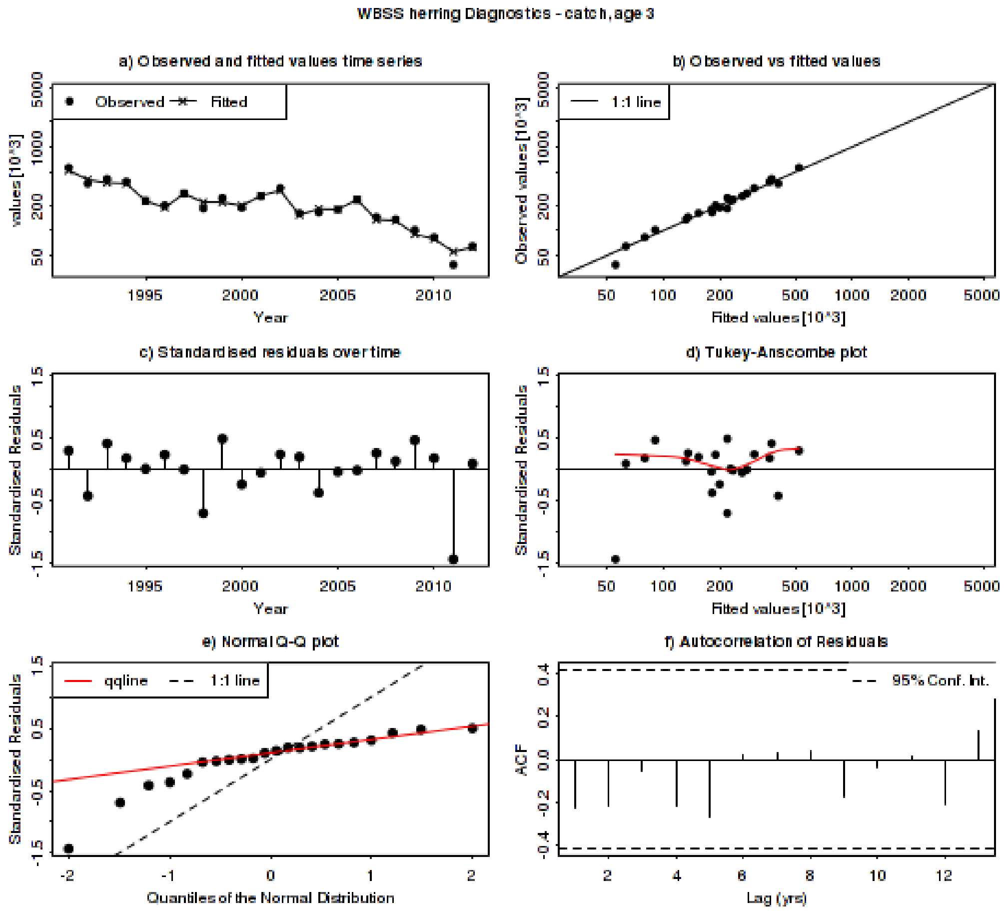


Figure 3.6.4.9 WESTERN BALTIC SPRING SPAWNING HERRING. FINAL RUN. Diagnostics of the commercial catches fit at 3 wr from the assessment. a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus model estimates of stock numbers at age. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log siduals of catchability model fitted by the model as a function of time. d). Log residuals from the catchability model against the estimated stock size at age. e). Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line).

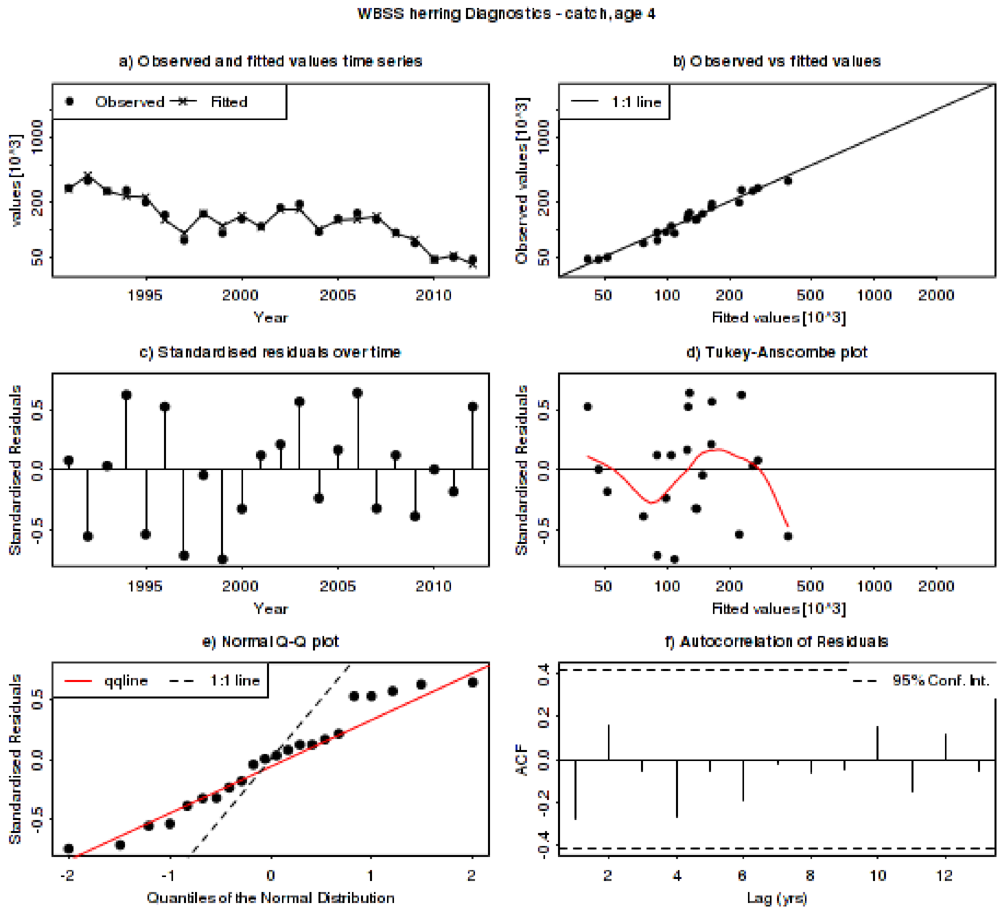


Figure 3.6.4.10 WESTERN BALTIC SPRING SPAWNING HERRING. FINAL RUN. Diagnostics of the commercial catches fit at 4 wr from the assessment. a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus model estimates of stock numbers at age. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log siduals of catchability model fitted by the model as a function of time. d). Log residuals from the catchability model against the estimated stock size at age. e). Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line).

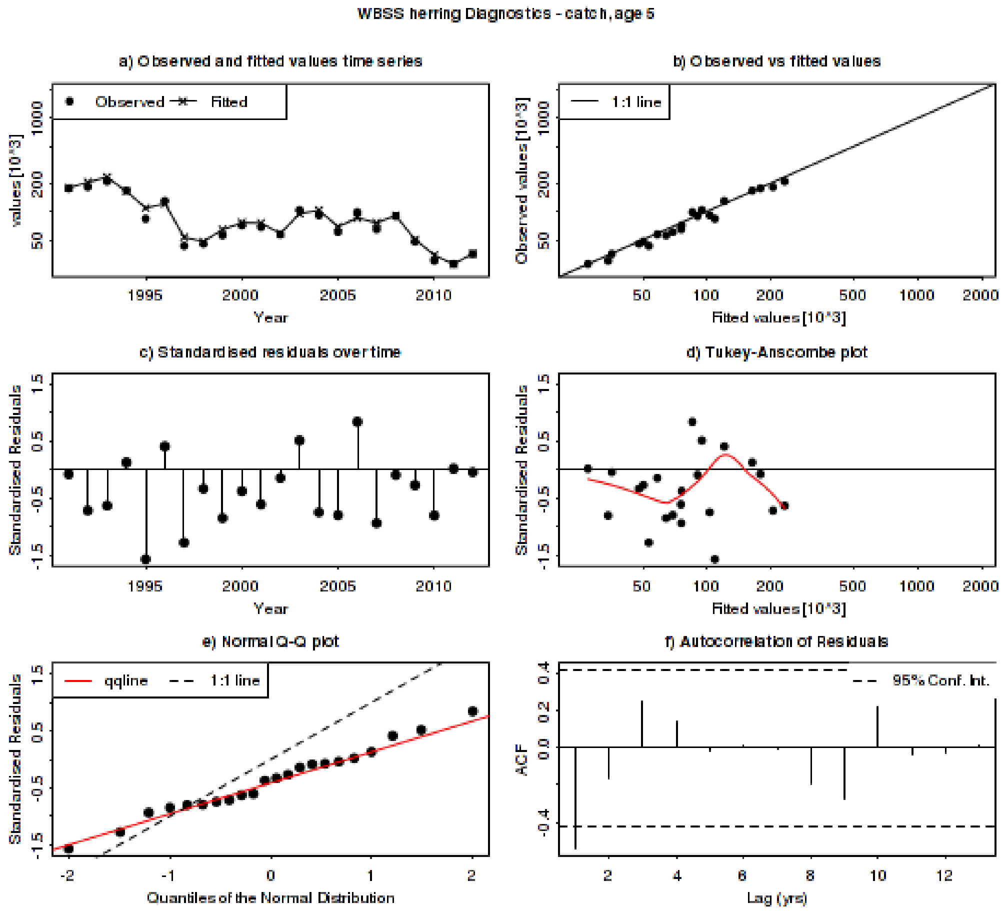


Figure 3.6.4.11 WESTERN BALTIC SPRING SPAWNING HERRING. FINAL RUN. Diagnostics of the commercial catches fit at 5 wr from the assessment. a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus model estimates of stock numbers at age. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log siduals of catchability model fitted by the model as a function of time. d). Log residuals from the catchability model against the estimated stock size at age. e). Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line).

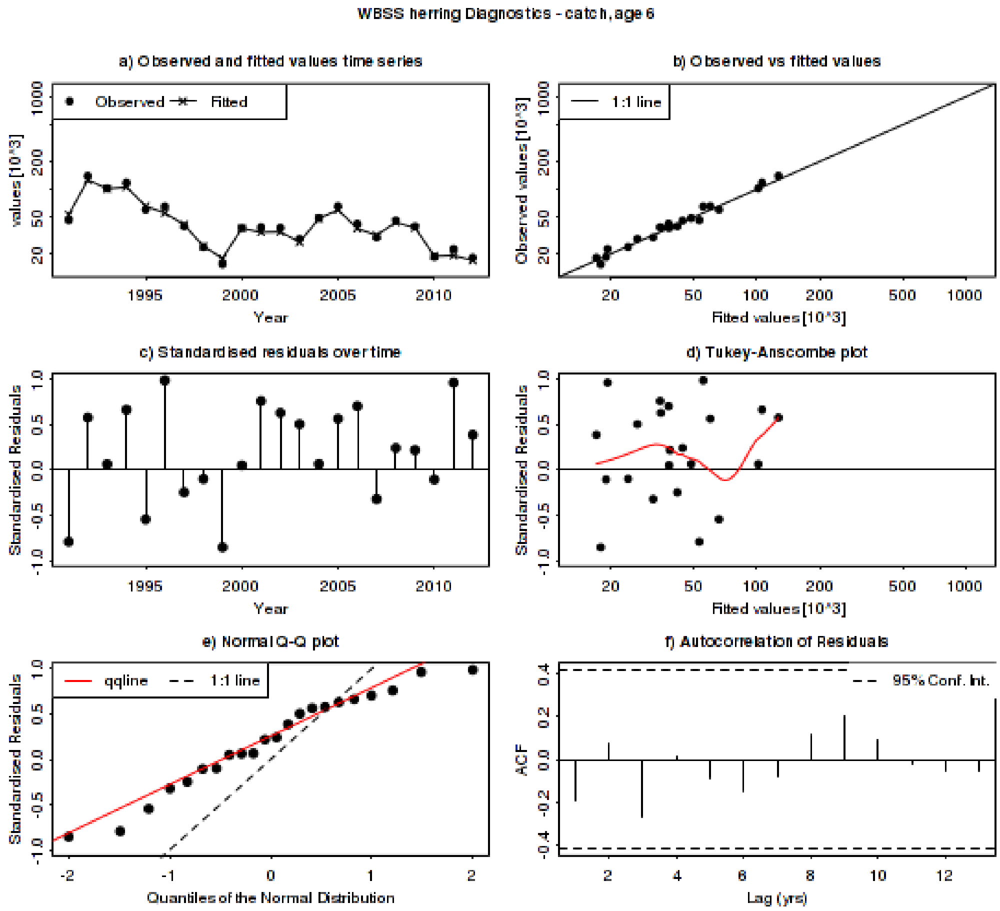


Figure 3.6.4.12 WESTERN BALTIC SPRING SPAWNING HERRING. FINAL RUN. Diagnostics of the commercial catches fit at 6 wr from the assessment. a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus model estimates of stock numbers at age. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log siduals of catchability model fitted by the model as a function of time. d). Log residuals from the catchability model against the estimated stock size at age. e). Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line).

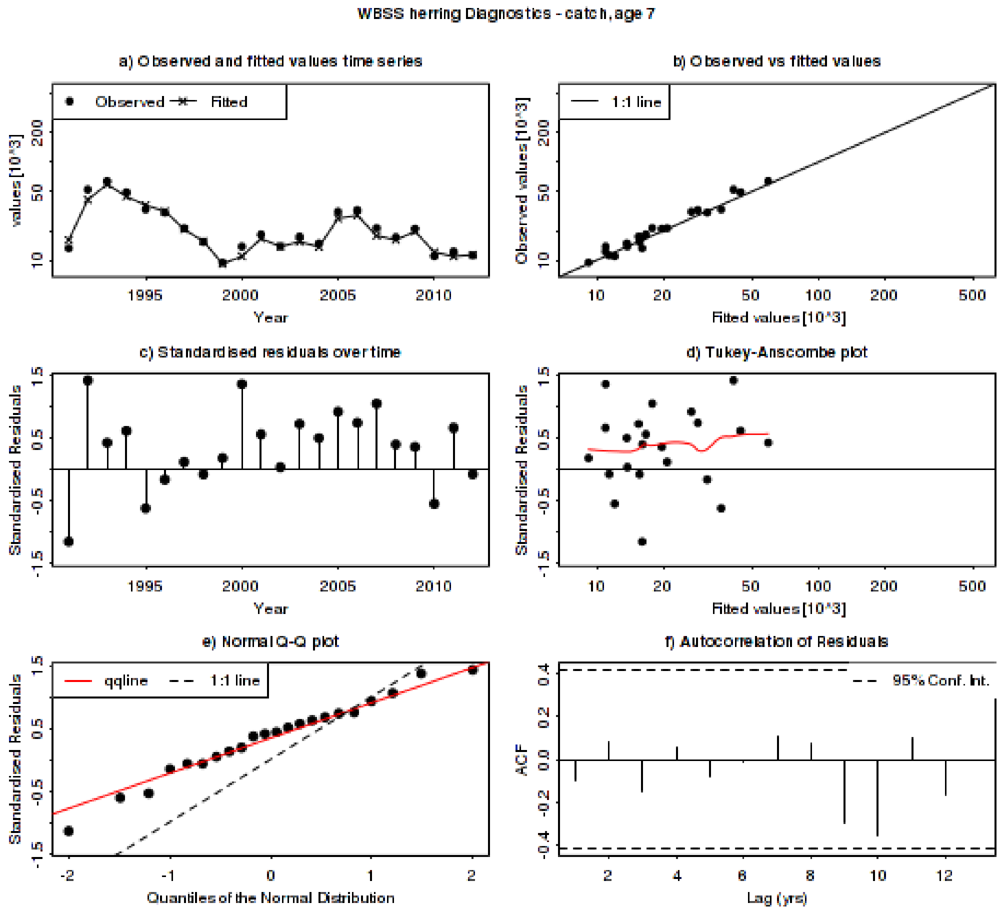


Figure 3.6.4.13 WESTERN BALTIC SPRING SPAWNING HERRING. FINAL RUN. Diagnostics of the commercial catches fit at 7 wr from the assessment. a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus model estimates of stock numbers at age. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log siduals of catchability model fitted by the model as a function of time. d). Log residuals from the catchability model against the estimated stock size at age. e). Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line).

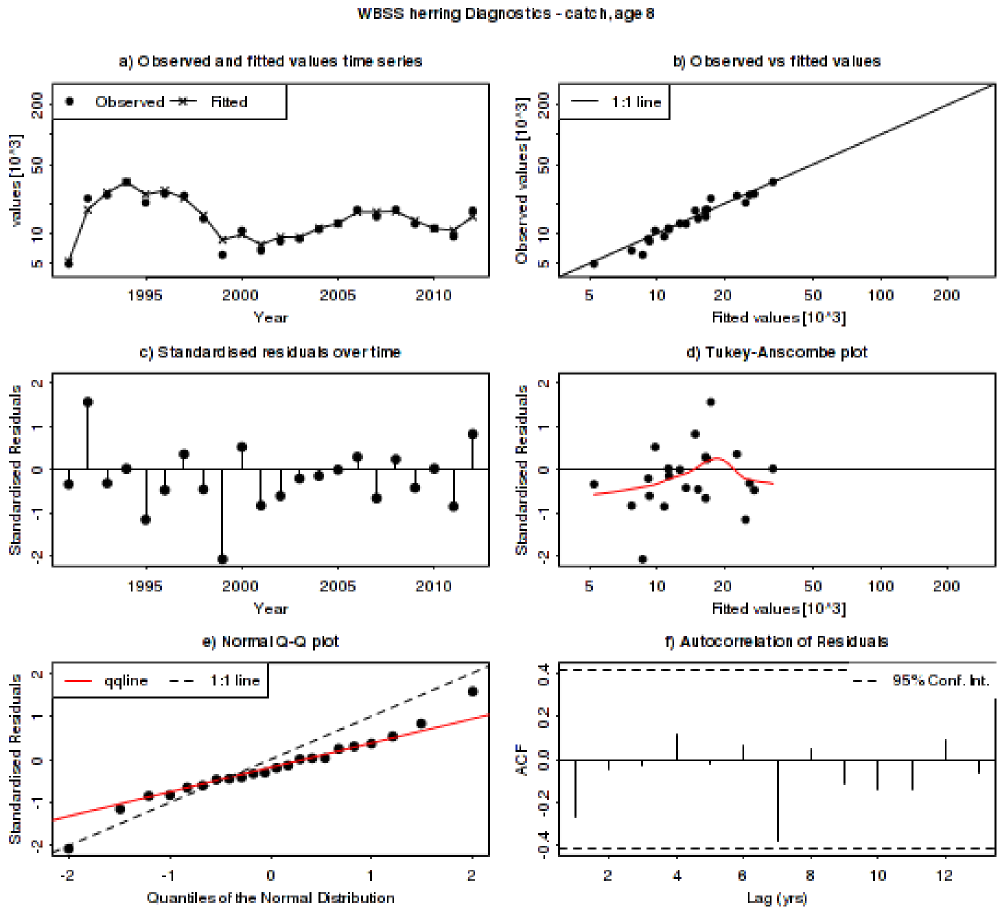


Figure 3.6.4.14 WESTERN BALTIC SPRING SPAWNING HERRING. FINAL RUN. Diagnostics of the commercial catches fit at 7 wr from the assessment. a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus model estimates of stock numbers at age. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log siduals of catchability model fitted by the model as a function of time. d). Log residuals from the catchability model against the estimated stock size at age. e). Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line).

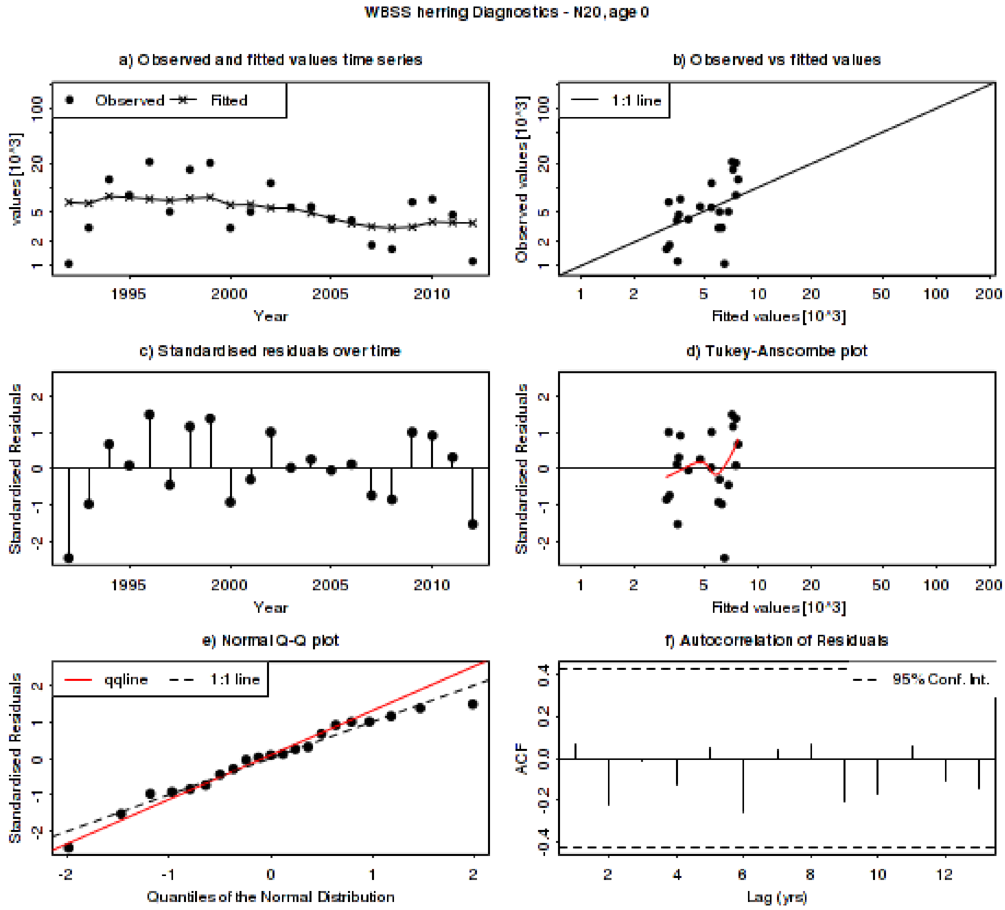


Figure 3.6.4.15 WESTERN BALTIC SPRING SPAWNING HERRING. FINAL RUN. Diagnostics of the N20 larval index. a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus model estimates of stock numbers at age. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log siduals of catchability model fitted by the model as a function of time. d). Log residuals from the catchability model against the estimated stock size at age. e). Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line).

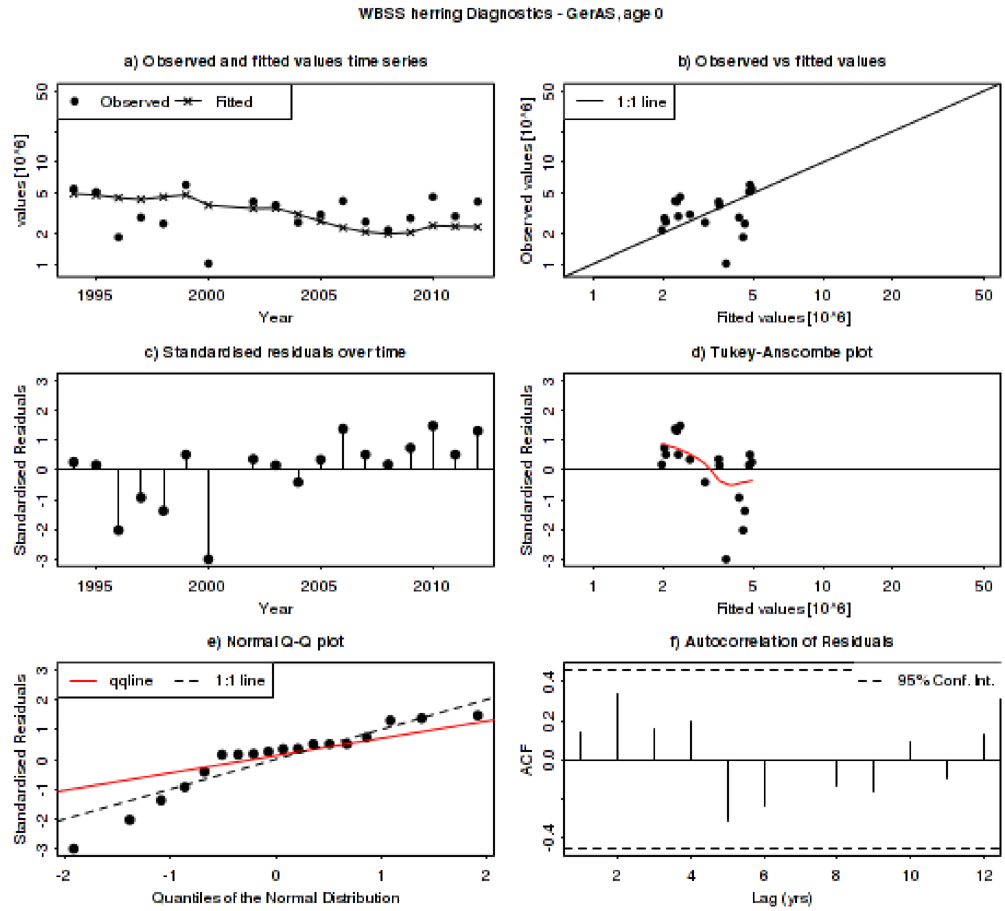


Figure 3.6.4.16 WESTERN BALTIC SPRING SPAWNING HERRING. FINAL RUN. Diagnostics of the German acoustic survey in subdivision 21-24 (GERAS) fit at 0 wr from the assessment. a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus model estimates of stock numbers at age. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log siduals of catchability model fitted by the model as a function of time. d). Log residuals from the catchability model against the estimated stock size at age. e). Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line).

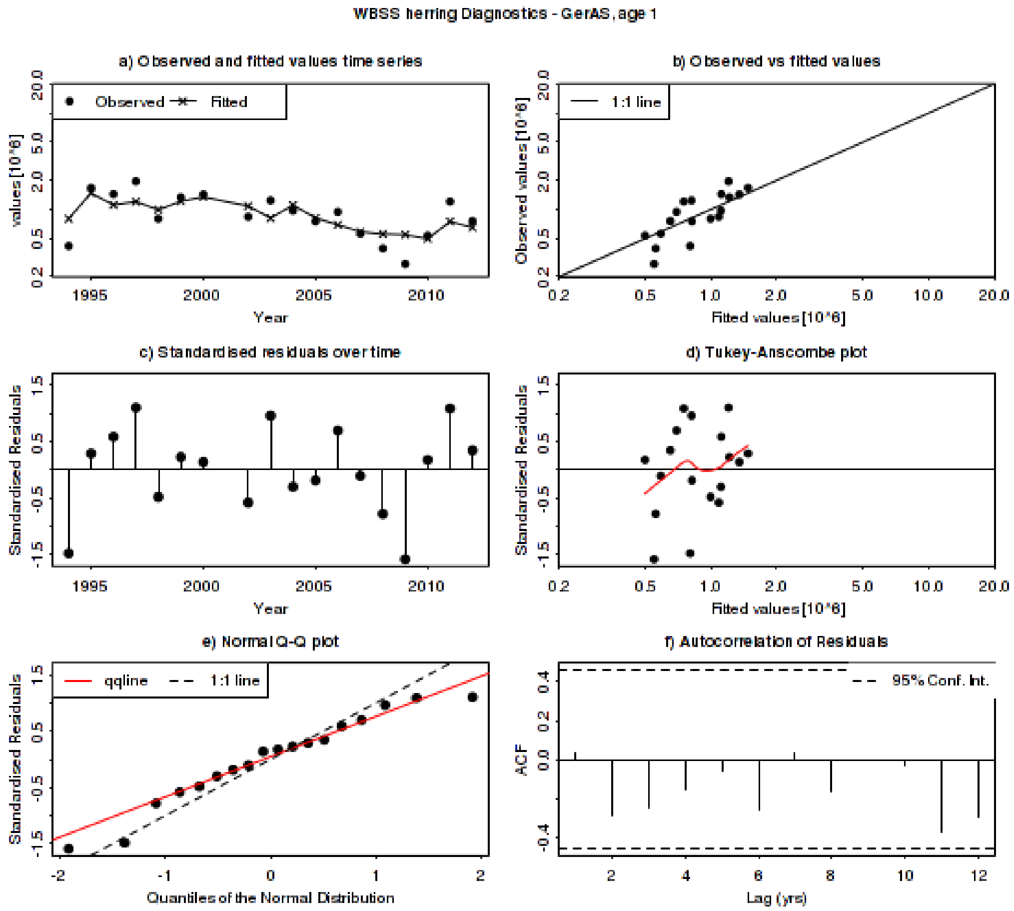


Figure 3.6.4.17 WESTERN BALTIC SPRING SPAWNING HERRING. FINAL RUN. Diagnostics of the German acoustic survey in subdivision 21-24 (GERAS) fit at 1 wr from the assessment. a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus model estimates of stock numbers at age. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log siduals of catchability model fitted by the model as a function of time. d). Log residuals from the catchability model against the estimated stock size at age. e). Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line).

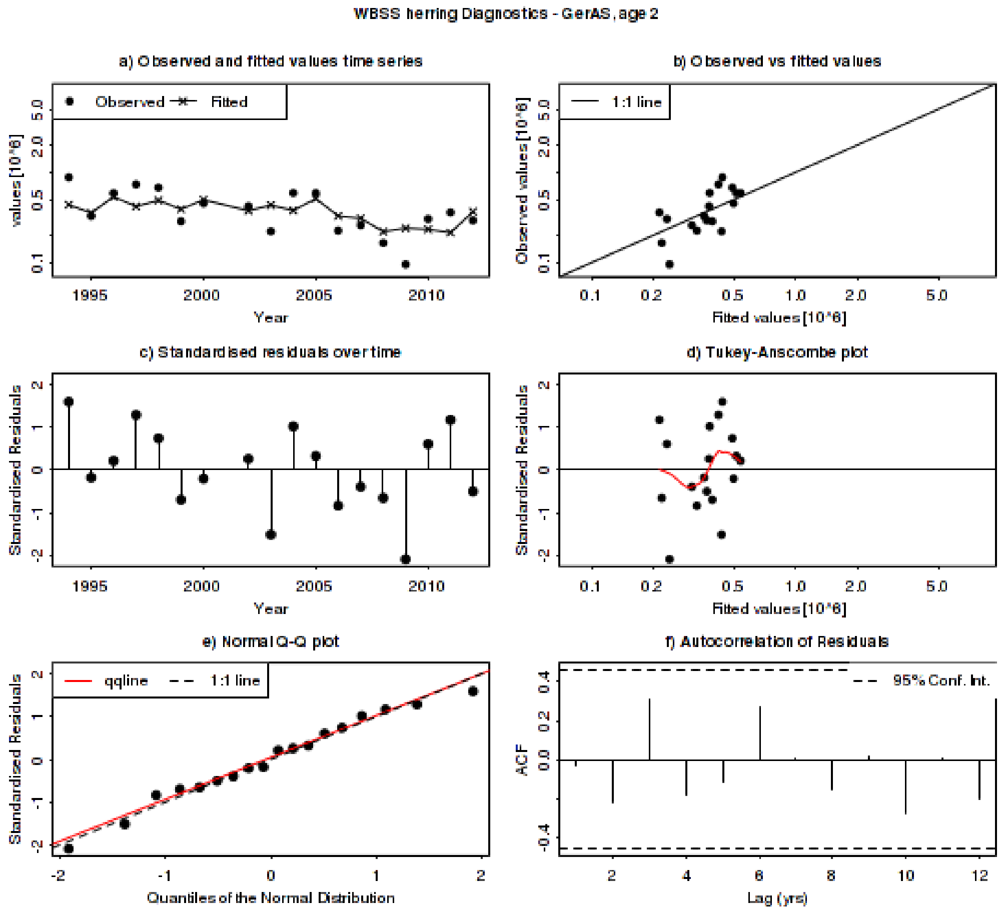


Figure 3.6.4.18 WESTERN BALTIC SPRING SPAWNING HERRING. FINAL RUN. Diagnostics of the German acoustic survey in subdivision 21-24 (GERAS) fit at 2 wr from the assessment. a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus model estimates of stock numbers at age. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log siduals of catchability model fitted by the model as a function of time. d). Log residuals from the catchability model against the estimated stock size at age. e). Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line).

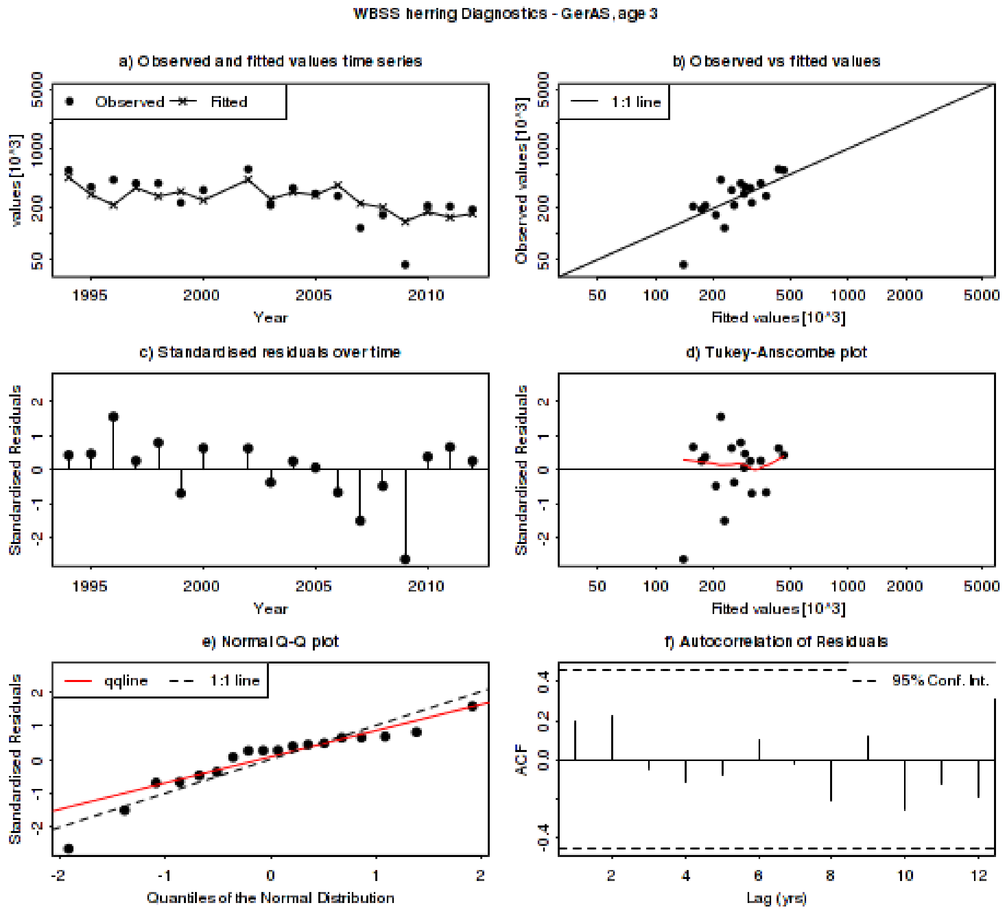


Figure 3.6.4.19 WESTERN BALTIC SPRING SPAWNING HERRING. FINAL RUN. Diagnostics of the German acoustic survey in subdivision 21-24 (GERAS) fit at 3 wr from the assessment. a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus model estimates of stock numbers at age. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log siduals of catchability model fitted by the model as a function of time. d). Log residuals from the catchability model against the estimated stock size at age. e). Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line).

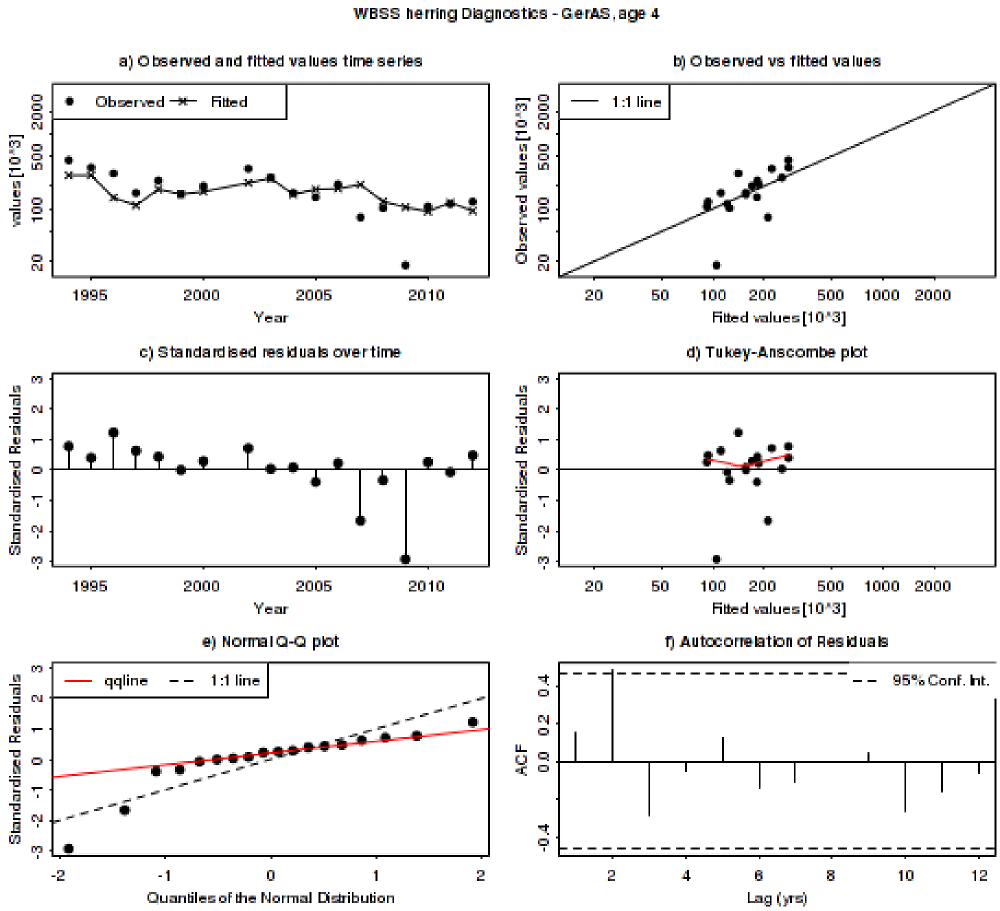


Figure 3.6.4.20 WESTERN BALTIC SPRING SPAWNING HERRING. FINAL RUN. Diagnostics of the German acoustic survey in subdivision 21-24 (GERAS) fit at 4 wr from the assessment. a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus model estimates of stock numbers at age. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log siduals of catchability model fitted by the model as a function of time. d). Log residuals from the catchability model against the estimated stock size at age. e). Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line).

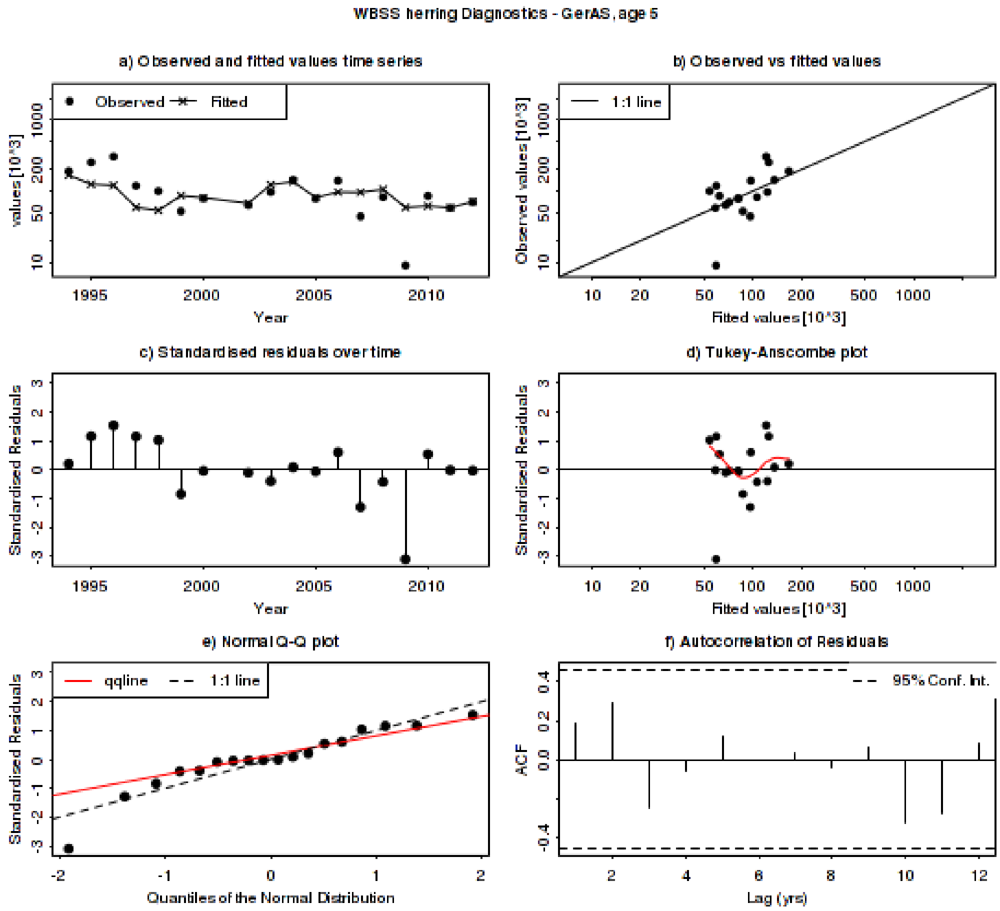


Figure 3.6.4.21 WESTERN BALTIC SPRING SPAWNING HERRING. FINAL RUN. Diagnostics of the German acoustic survey in subdivision 21-24 (GERAS) fit at 5 wr from the assessment. a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus model estimates of stock numbers at age. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log siduals of catchability model fitted by the model as a function of time. d). Log residuals from the catchability model against the estimated stock size at age. e). Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line).

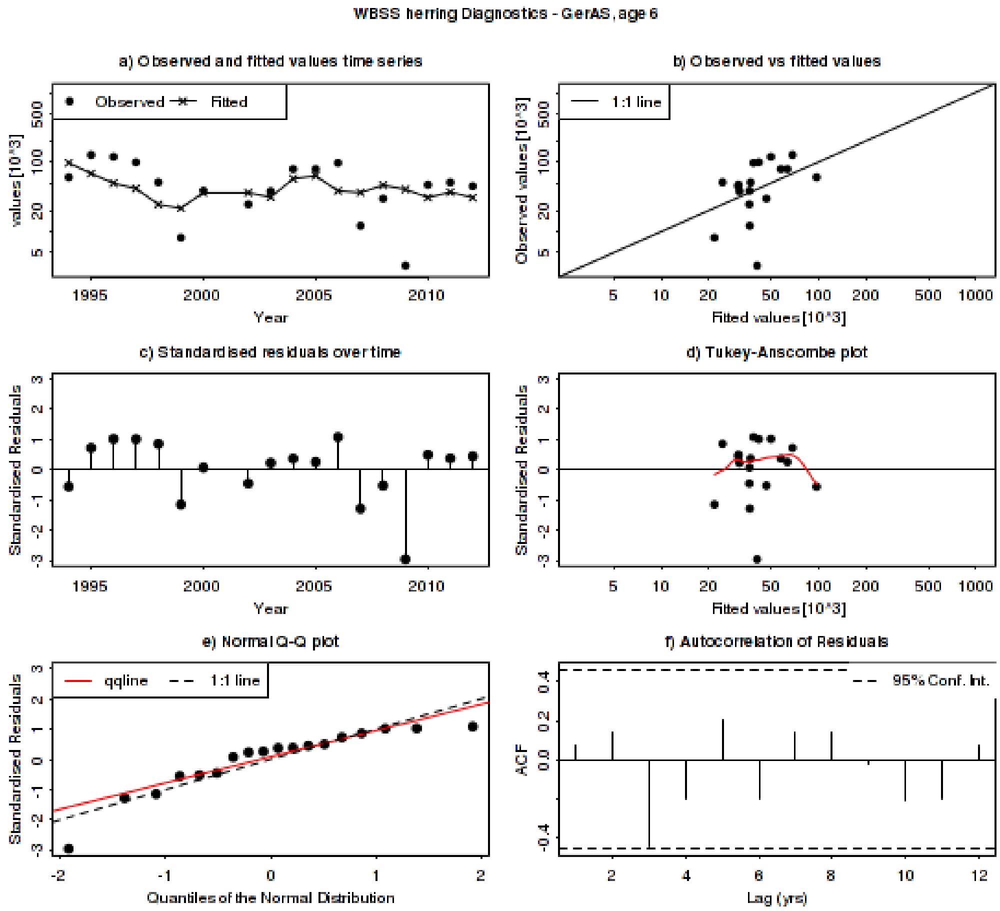


Figure 3.6.4.22 WESTERN BALTIC SPRING SPAWNING HERRING. FINAL RUN. Diagnostics of the German acoustic survey in subdivision 21-24 (GERAS) fit at 6 wr from the assessment. a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus model estimates of stock numbers at age. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log siduals of catchability model fitted by the model as a function of time. d). Log residuals from the catchability model against the estimated stock size at age. e). Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line).

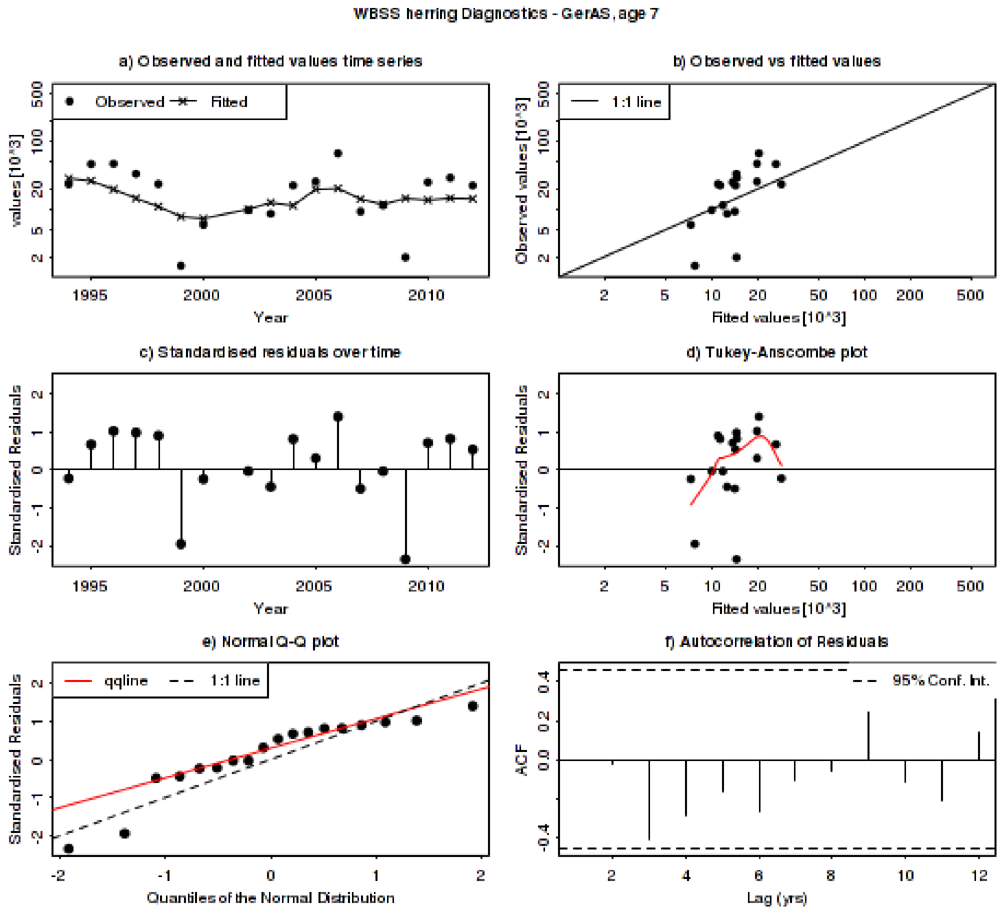


Figure 3.6.4.23 WESTERN BALTIC SPRING SPAWNING HERRING. FINAL RUN. Diagnostics of the German acoustic survey in subdivision 21-24 (GERAS) fit at 7 wr from the assessment. a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus model estimates of stock numbers at age. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log siduals of catchability model fitted by the model as a function of time. d). Log residuals from the catchability model against the estimated stock size at age. e). Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line).

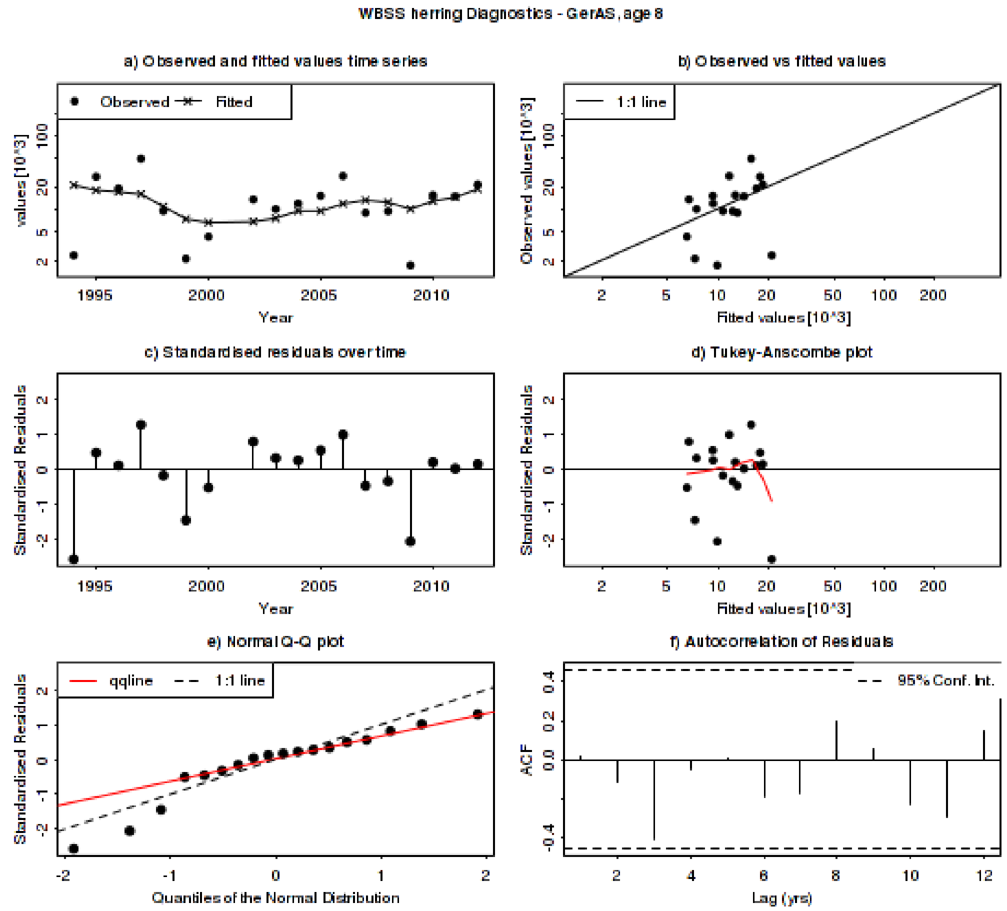


Figure 3.6.4.24 WESTERN BALTIC SPRING SPAWNING HERRING. FINAL RUN. Diagnostics of the German acoustic survey in subdivision 21-24 (GERAS) fit at 8 wr from the assessment. a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus model estimates of stock numbers at age. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log siduals of catchability model fitted by the model as a function of time. d). Log residuals from the catchability model against the estimated stock size at age. e). Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line).

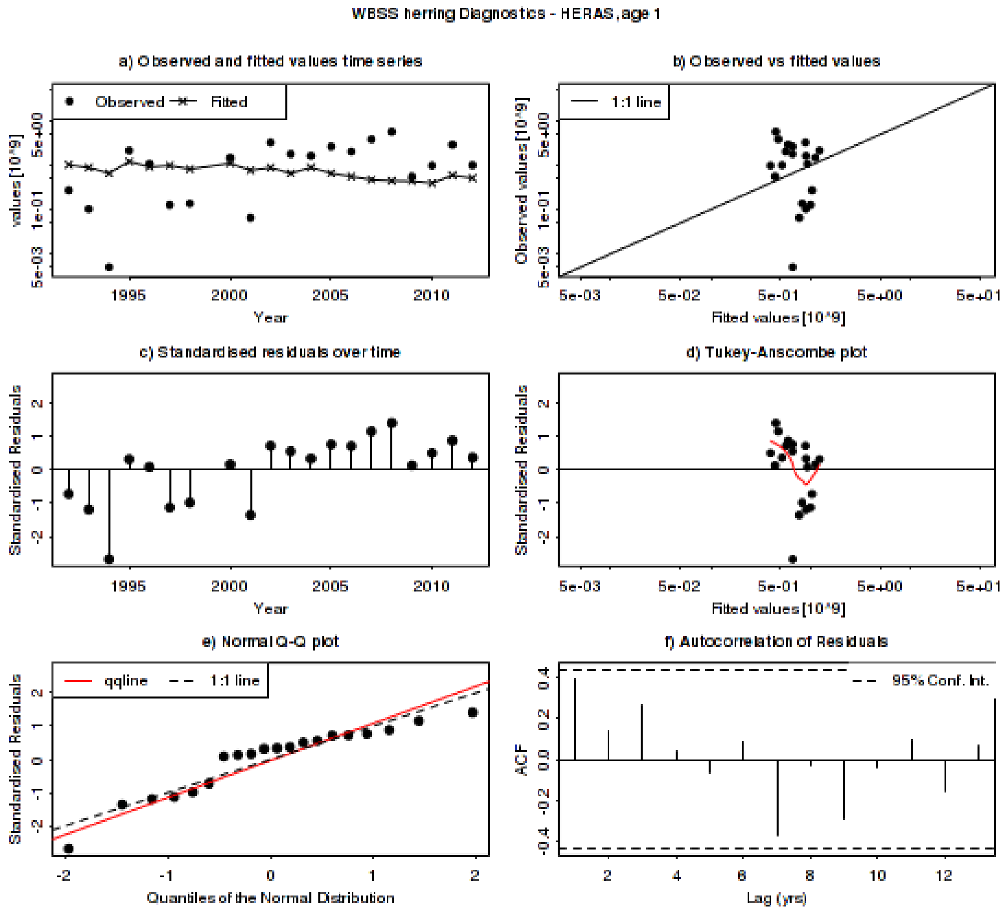


Figure 3.6.4.25 WESTERN BALTIC SPRING SPAWNING HERRING. FINAL RUN. Diagnostics of the Herring acoustic survey in the North Sea and division IIIa (HERAS) fit at 1 wr from the assessment. a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus model estimates of stock numbers at age. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log siduals of catchability model fitted by the model as a function of time. d). Log residuals from the catchability model against the estimated stock size at age. e). Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line).

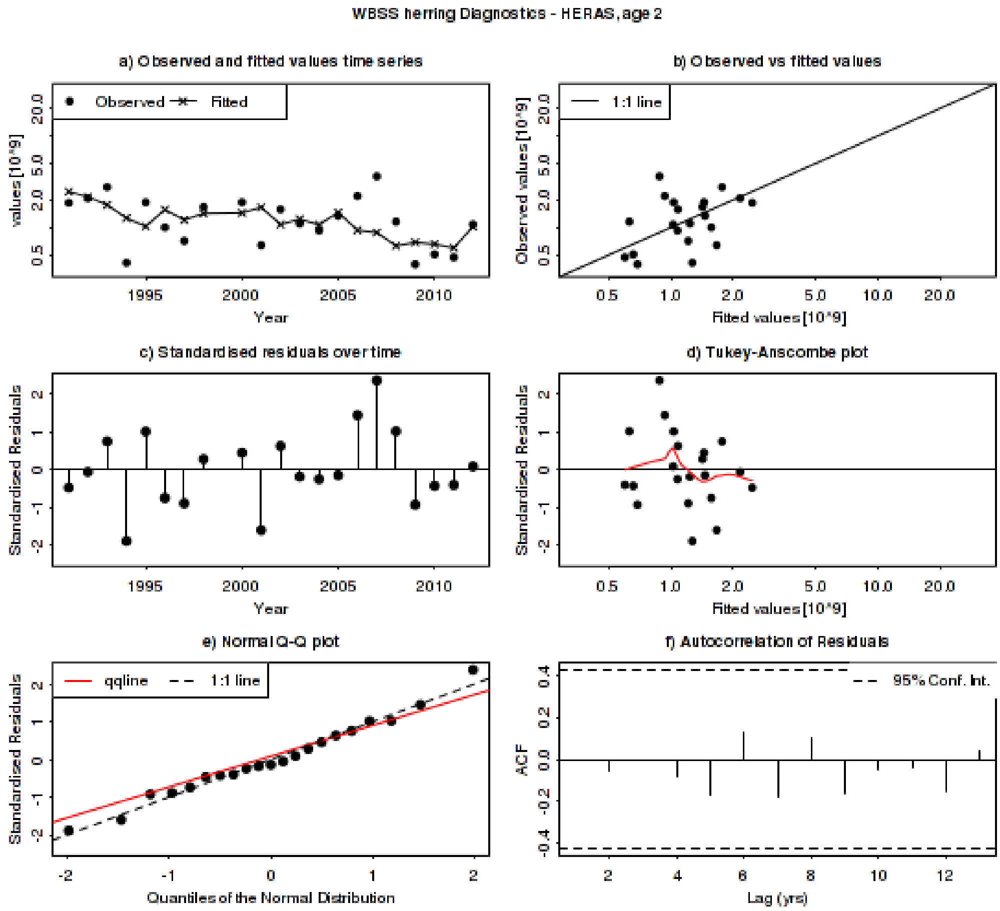


Figure 3.6.4.26 WESTERN BALTIC SPRING SPAWNING HERRING. FINAL RUN. Diagnostics of the Herring acoustic survey in the North Sea and division IIIa (HERAS) fit at 2 wr from the assessment. a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus model estimates of stock numbers at age. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log siduals of catchability model fitted by the model as a function of time. d). Log residuals from the catchability model against the estimated stock size at age. e). Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line).

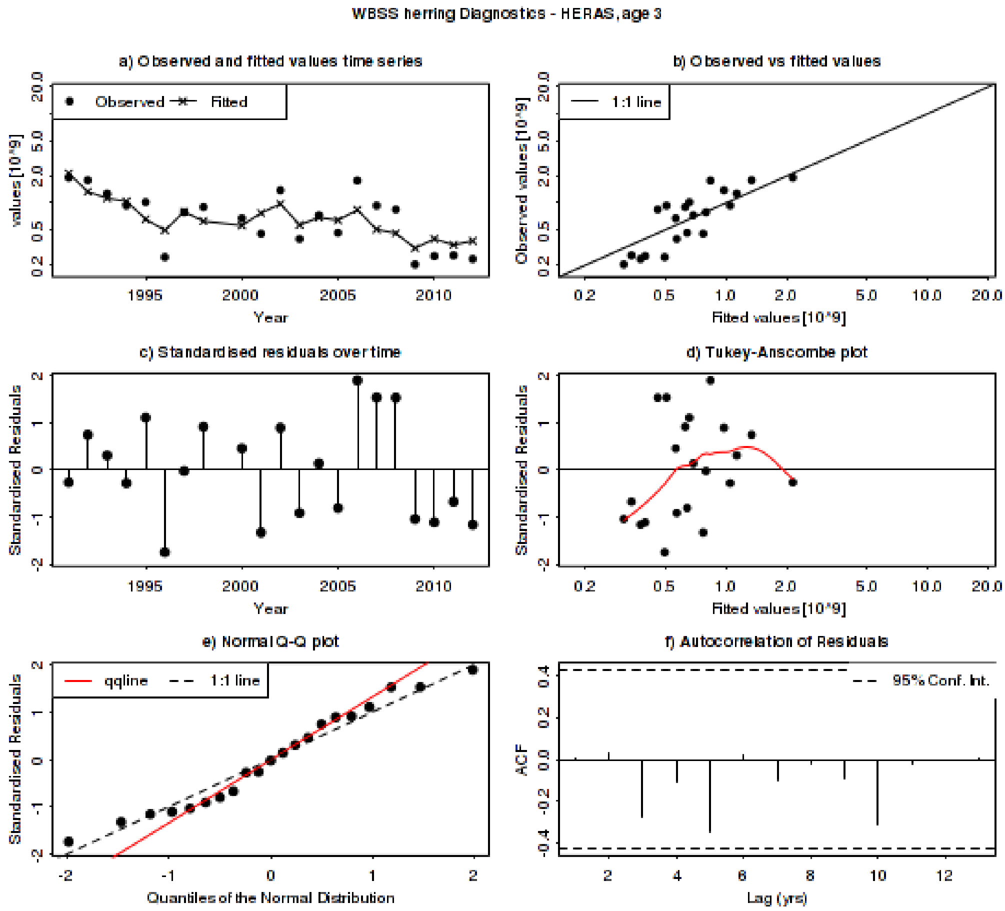


Figure 3.6.4.27 WESTERN BALTIC SPRING SPAWNING HERRING. FINAL RUN. Diagnostics of the Herring acoustic survey in the North Sea and division IIIa (HERAS) fit at 3 wr from the assessment. a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus model estimates of stock numbers at age. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log siduals of catchability model fitted by the model as a function of time. d). Log residuals from the catchability model against the estimated stock size at age. e). Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line).

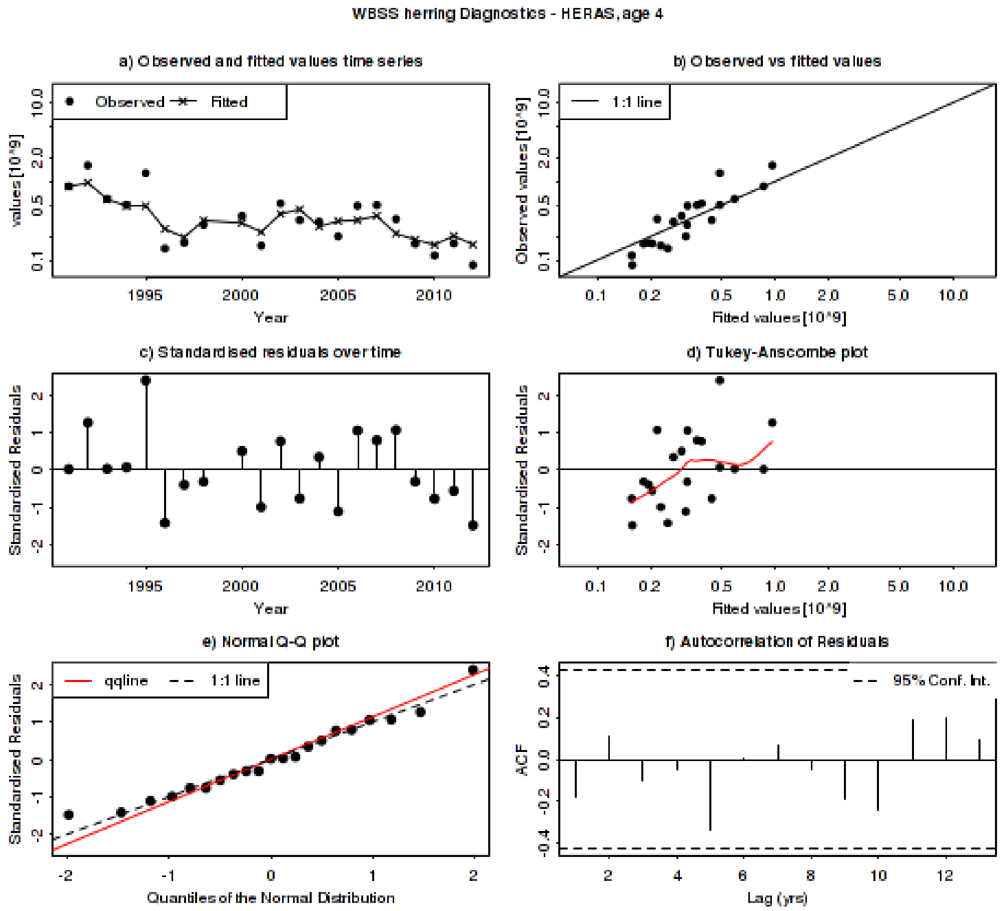


Figure 3.6.4.28 WESTERN BALTIC SPRING SPAWNING HERRING. FINAL RUN. Diagnostics of the Herring acoustic survey in the North Sea and division IIIa (HERAS) fit at 4 wr from the assessment. a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus model estimates of stock numbers at age. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log siduals of catchability model fitted by the model as a function of time. d). Log residuals from the catchability model against the estimated stock size at age. e). Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line).

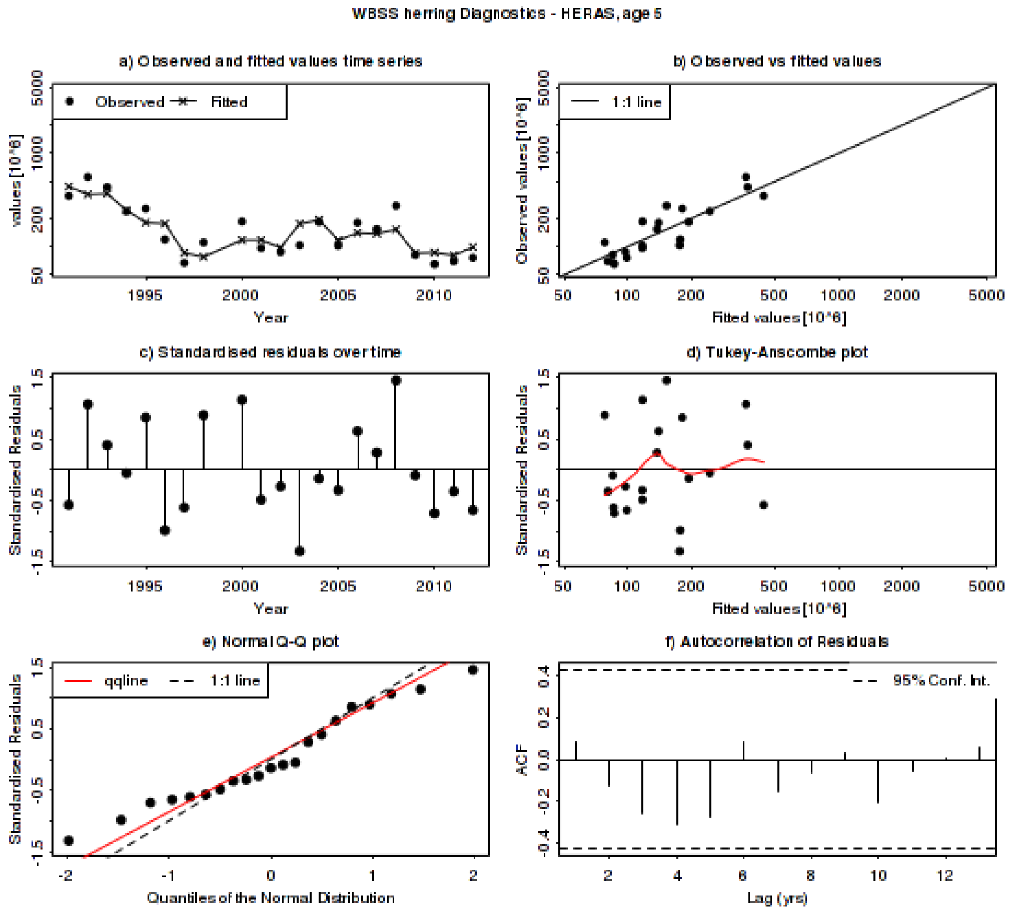


Figure 3.6.4.29 WESTERN BALTIC SPRING SPAWNING HERRING. FINAL RUN. Diagnostics of the Herring acoustic survey in the North Sea and division IIIa (HERAS) fit at 5 wr from the assessment. a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus model estimates of stock numbers at age. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log siduals of catchability model fitted by the model as a function of time. d). Log residuals from the catchability model against the estimated stock size at age. e). Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line).

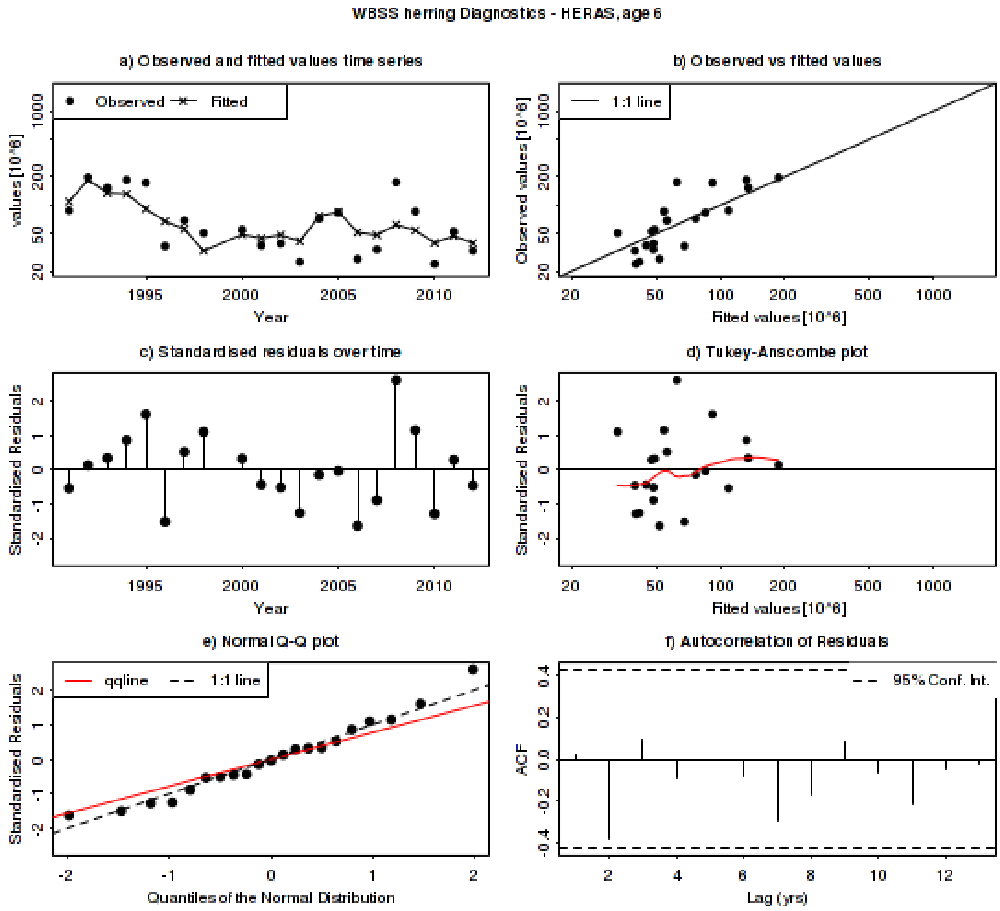


Figure 3.6.4.30 WESTERN BALTIC SPRING SPAWNING HERRING. FINAL RUN. Diagnostics of the Herring acoustic survey in the North Sea and division IIIa (HERAS) fit at 6 wr from the assessment. a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus model estimates of stock numbers at age. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log siduals of catchability model fitted by the model as a function of time. d). Log residuals from the catchability model against the estimated stock size at age. e). Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line).

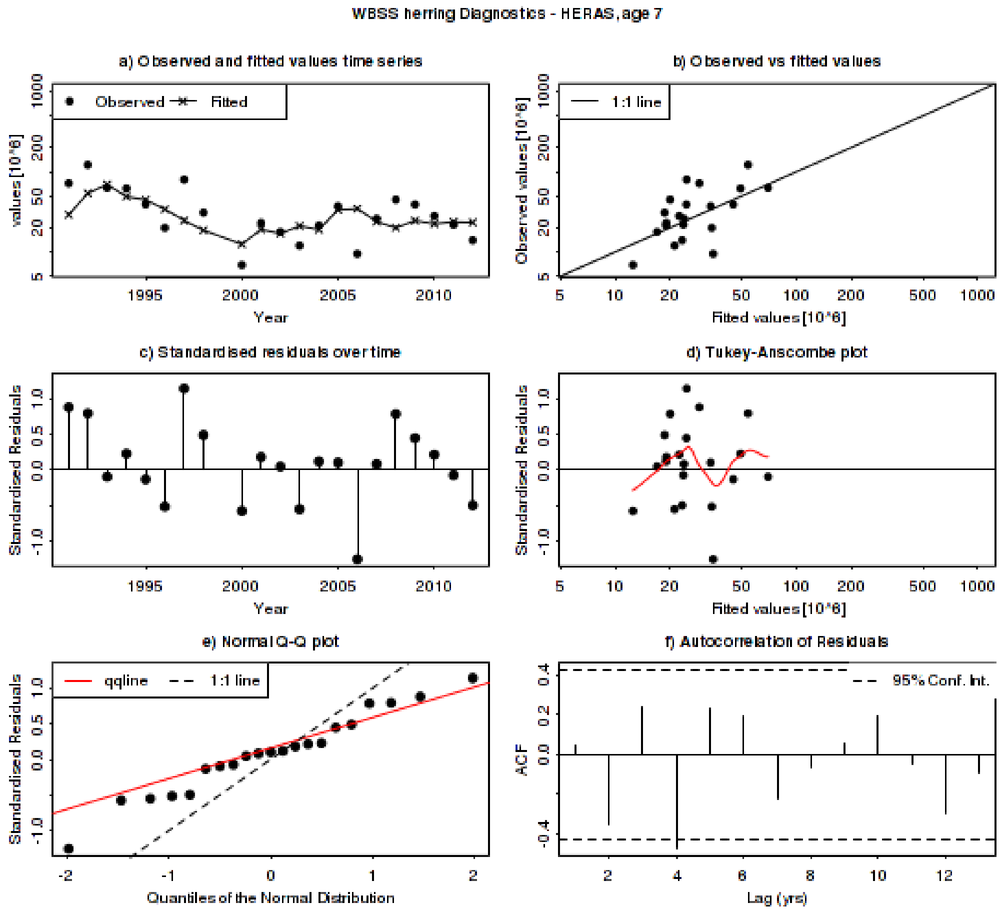


Figure 3.6.4.31 WESTERN BALTIC SPRING SPAWNING HERRING. FINAL RUN. Diagnostics of the Herring acoustic survey in the North Sea and division IIIa (HERAS) fit at 7 wr from the assessment. a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus model estimates of stock numbers at age. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log siduals of catchability model fitted by the model as a function of time. d). Log residuals from the catchability model against the estimated stock size at age. e). Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line).

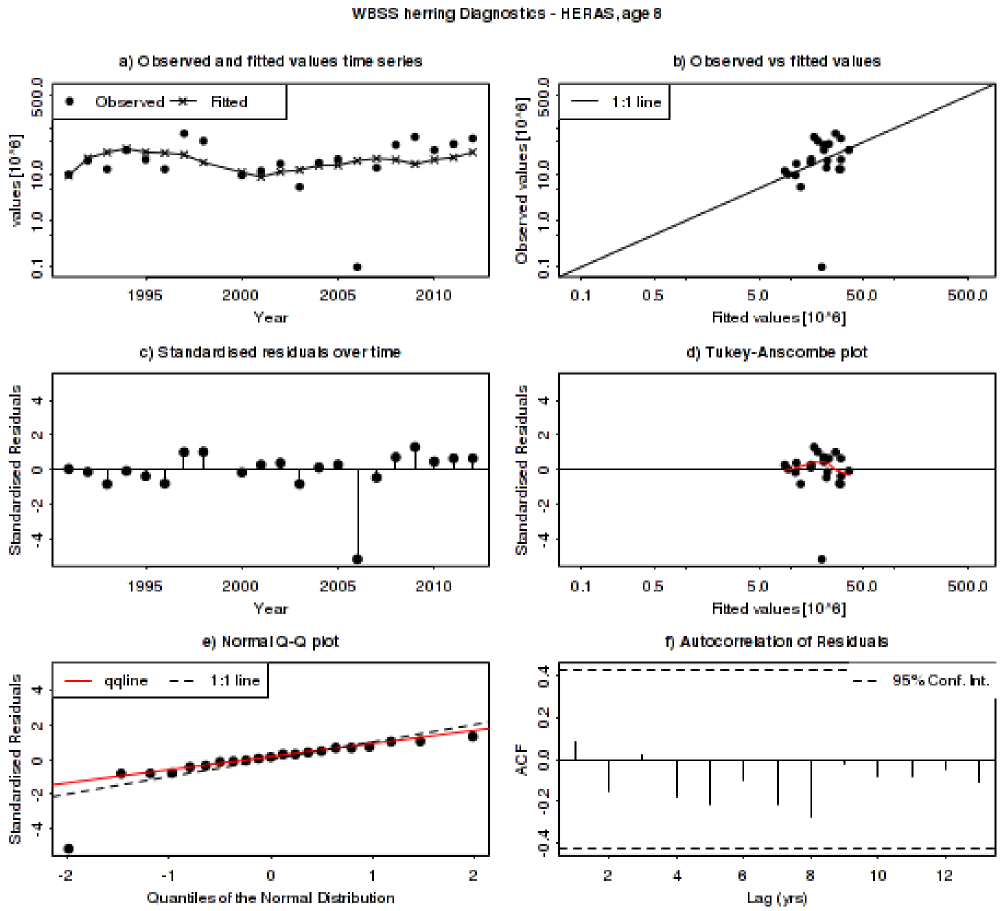


Figure 3.6.4.32 WESTERN BALTIC SPRING SPAWNING HERRING. FINAL RUN. Diagnostics of the Herring acoustic survey in the North Sea and division IIIa (HERAS) fit at 8 wr from the assessment. a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus model estimates of stock numbers at age. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log siduals of catchability model fitted by the model as a function of time. d). Log residuals from the catchability model against the estimated stock size at age. e). Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line).

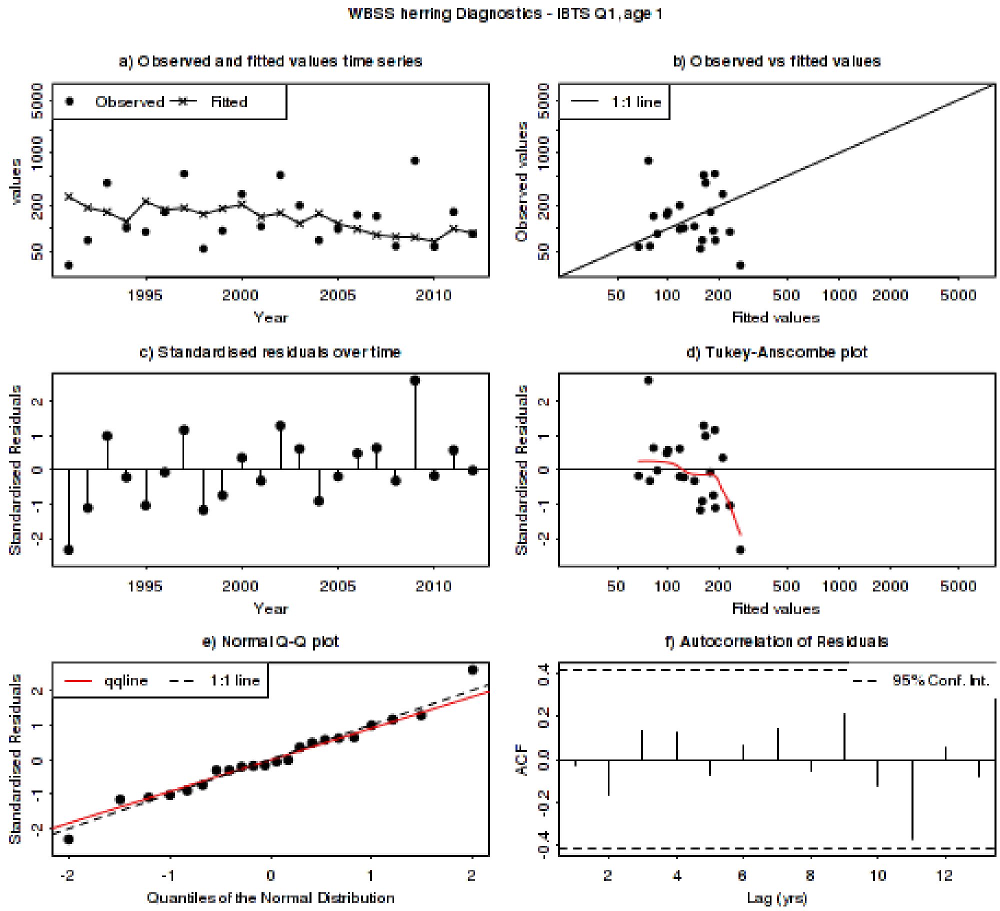


Figure 3.6.4.33 WESTERN BALTIC SPRING SPAWNING HERRING. FINAL RUN. Diagnostics of the International Bottom Trawl Survey in Division IIIa in quarter 1 (IBTS Q1) fit at 1 wr from the assessment. a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus model estimates of stock numbers at age. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log siduals of catchability model fitted by the model as a function of time. d). Log residuals from the catchability model against the estimated stock size at age. e). Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line).

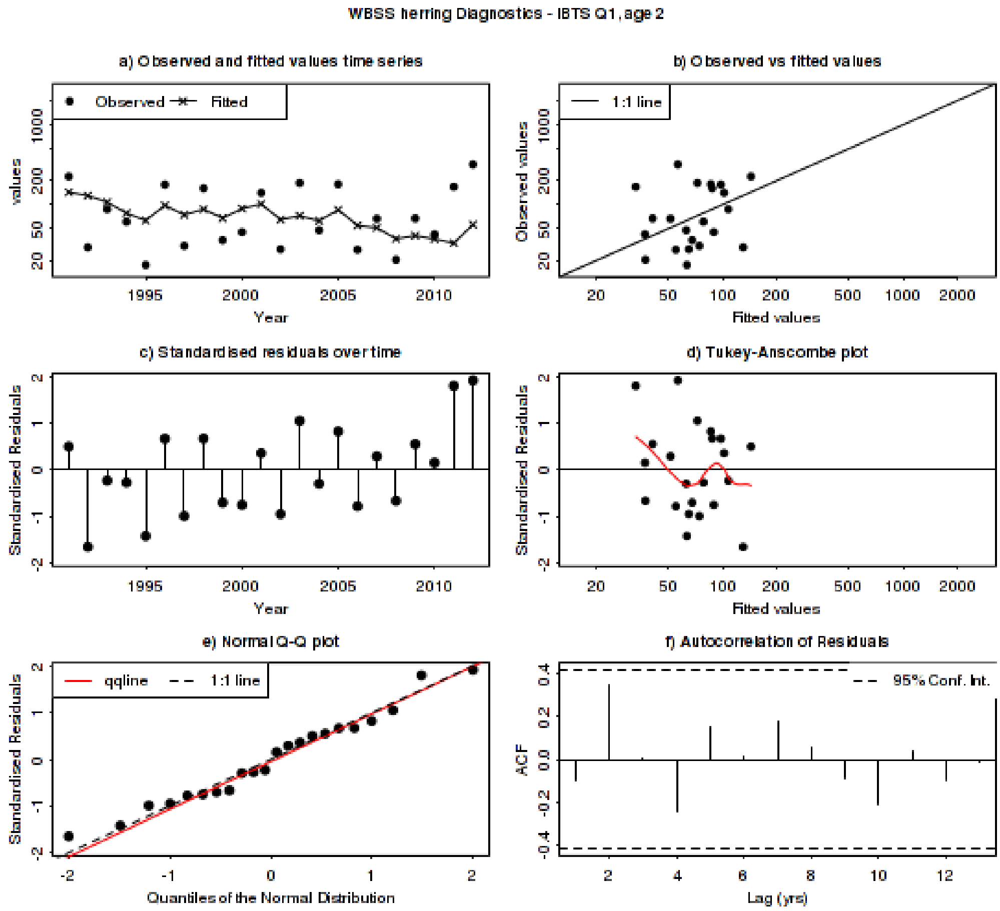


Figure 3.6.4.34 WESTERN BALTIC SPRING SPAWNING HERRING. FINAL RUN. Diagnostics of the International Bottom Trawl Survey in Division IIIa in quarter 1 (IBTS Q1) fit at 2 wr from the assessment. a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus model estimates of stock numbers at age. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log siduals of catchability model fitted by the model as a function of time. d). Log residuals from the catchability model against the estimated stock size at age. e). Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line).

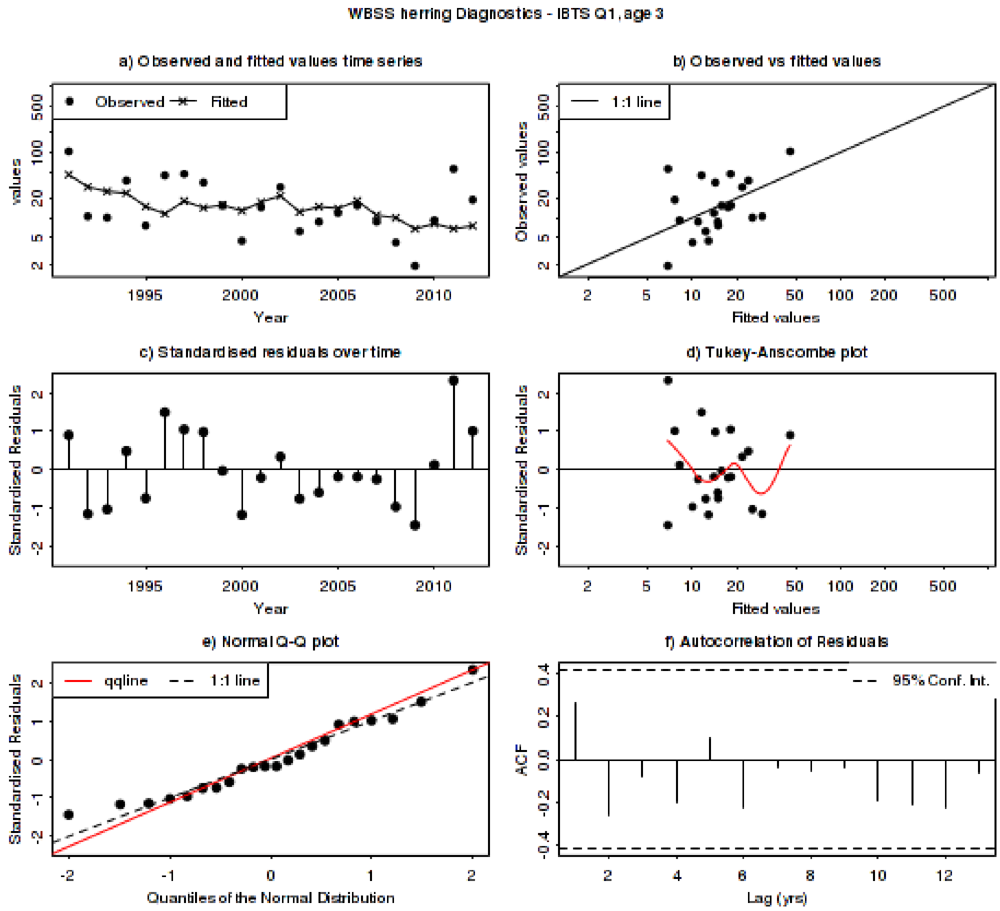


Figure 3.6.4.35 WESTERN BALTIC SPRING SPAWNING HERRING. FINAL RUN. Diagnostics of the International Bottom Trawl Survey in Division IIIa in quarter 1 (IBTS Q1) fit at 3 wr from the assessment. a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus model estimates of stock numbers at age. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log siduals of catchability model fitted by the model as a function of time. d). Log residuals from the catchability model against the estimated stock size at age. e). Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line).

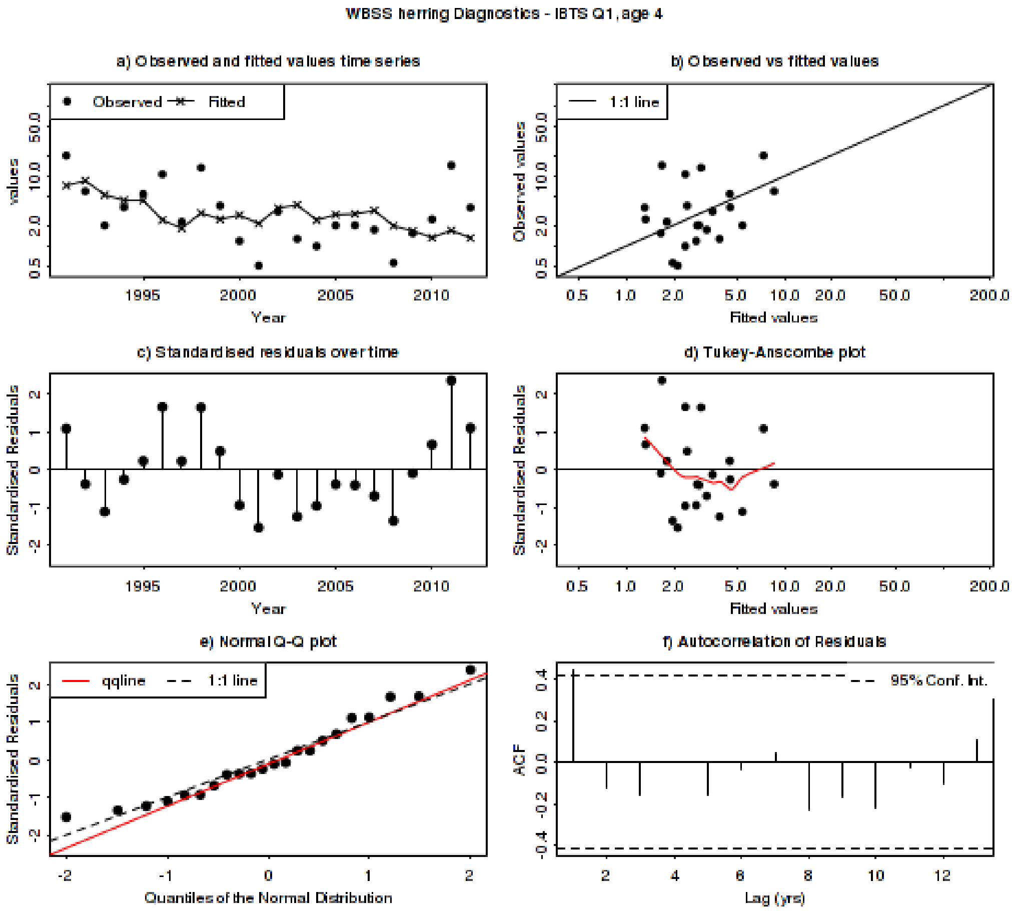


Figure 3.6.4.36 WESTERN BALTIC SPRING SPAWNING HERRING. FINAL RUN. Diagnostics of the International Bottom Trawl Survey in Division IIIa in quarter 1 (IBTS Q1) fit at 4 wr from the assessment. a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus model estimates of stock numbers at age. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log siduals of catchability model fitted by the model as a function of time. d). Log residuals from the catchability model against the estimated stock size at age. e). Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line).

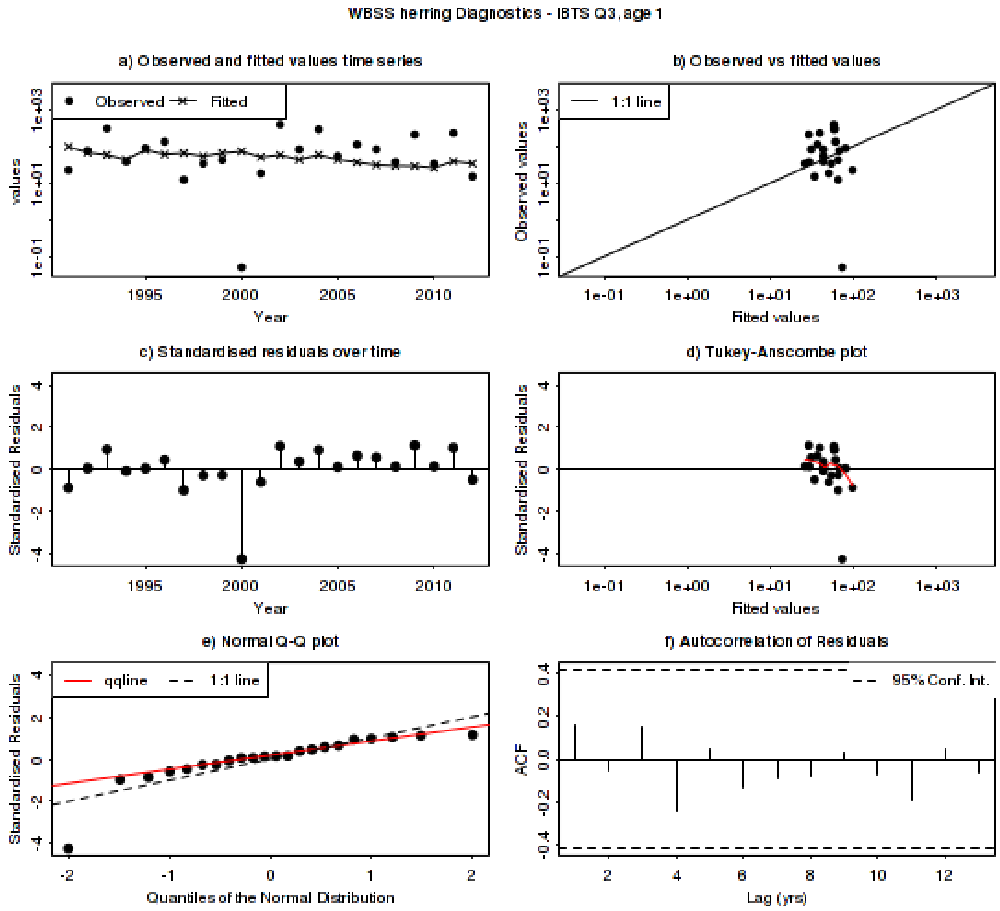


Figure 3.6.4.37 WESTERN BALTIC SPRING SPAWNING HERRING. FINAL RUN. Diagnostics of the International Bottom Trawl Survey in Division IIIa in quarter 3 (IBTS Q3) fit at 1 wr from the assessment. a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus model estimates of stock numbers at age. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log siduals of catchability model fitted by the model as a function of time. d). Log residuals from the catchability model against the estimated stock size at age. e). Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line).

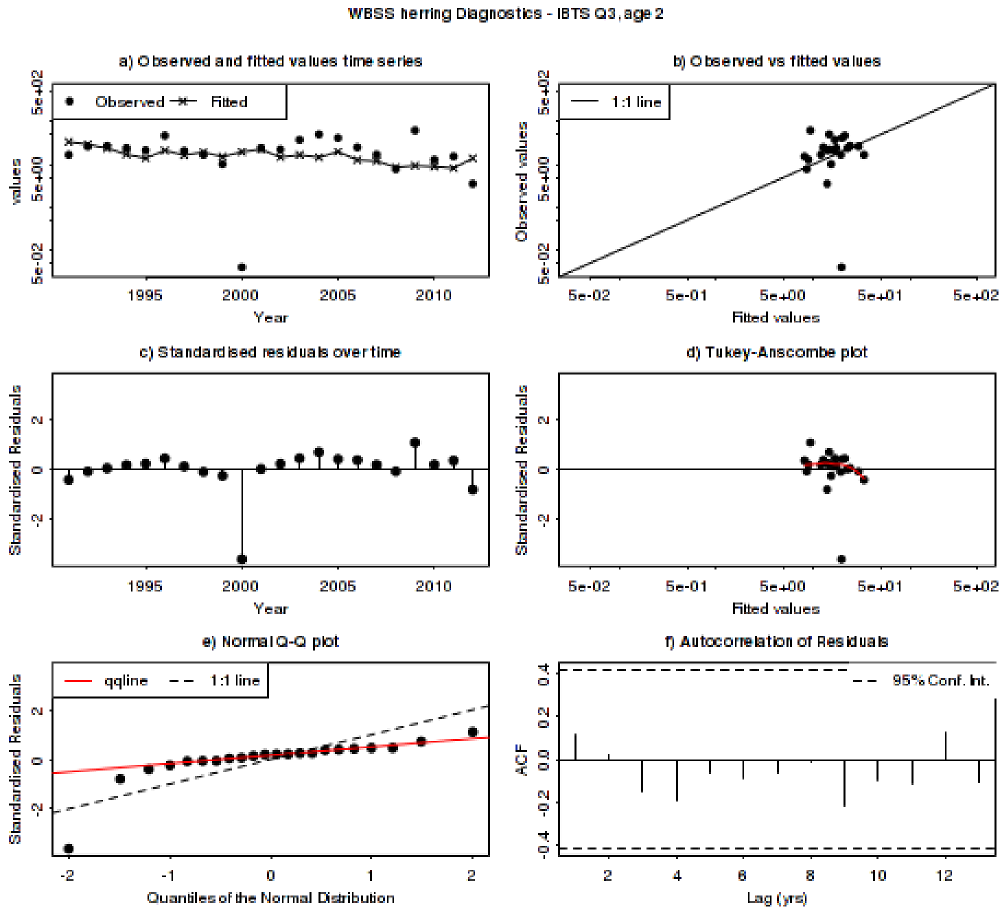


Figure 3.6.4.38 WESTERN BALTIC SPRING SPAWNING HERRING. FINAL RUN. Diagnostics of the International Bottom Trawl Survey in Division IIIa in quarter 3 (IBTS Q3) fit at 2 wr from the assessment. a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus model estimates of stock numbers at age. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log siduals of catchability model fitted by the model as a function of time. d). Log residuals from the catchability model against the estimated stock size at age. e). Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line).

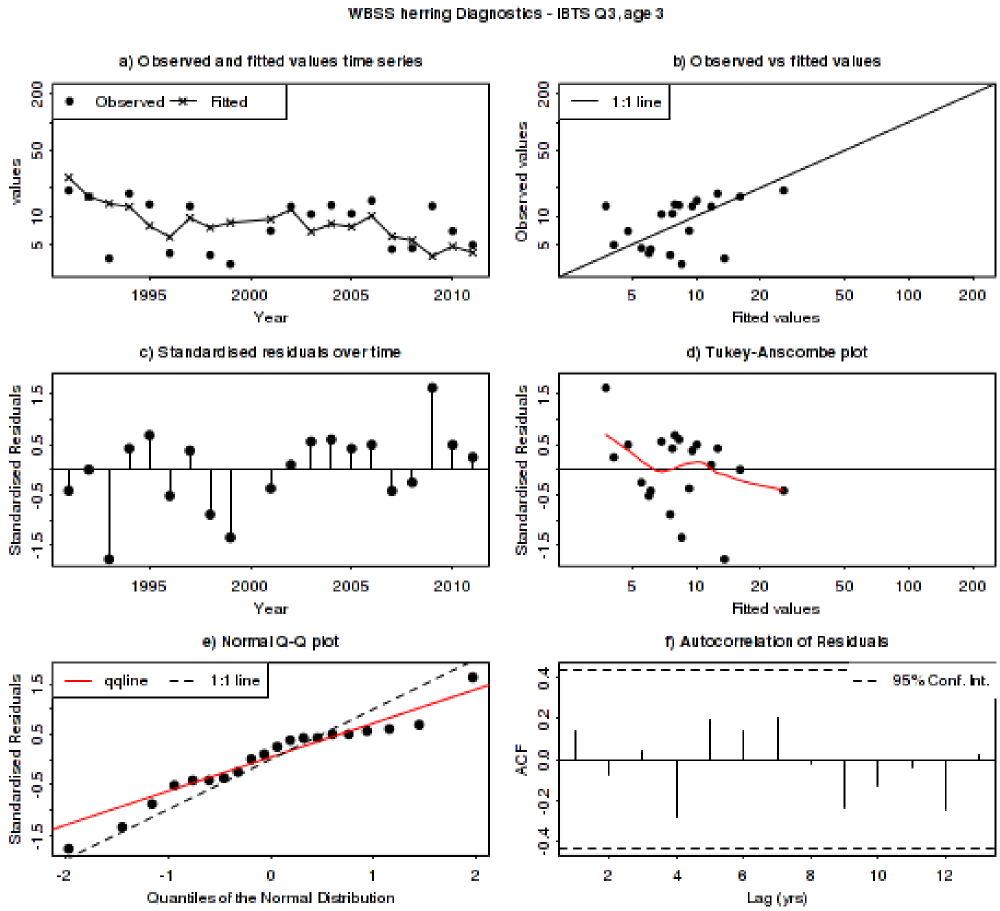


Figure 3.6.4.39 WESTERN BALTIC SPRING SPAWNING HERRING. FINAL RUN. Diagnostics of the International Bottom Trawl Survey in Division IIIa in quarter 3 (IBTS Q3) fit at 3 wr from the assessment. a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus model estimates of stock numbers at age. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log siduals of catchability model fitted by the model as a function of time. d). Log residuals from the catchability model against the estimated stock size at age. e). Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line).

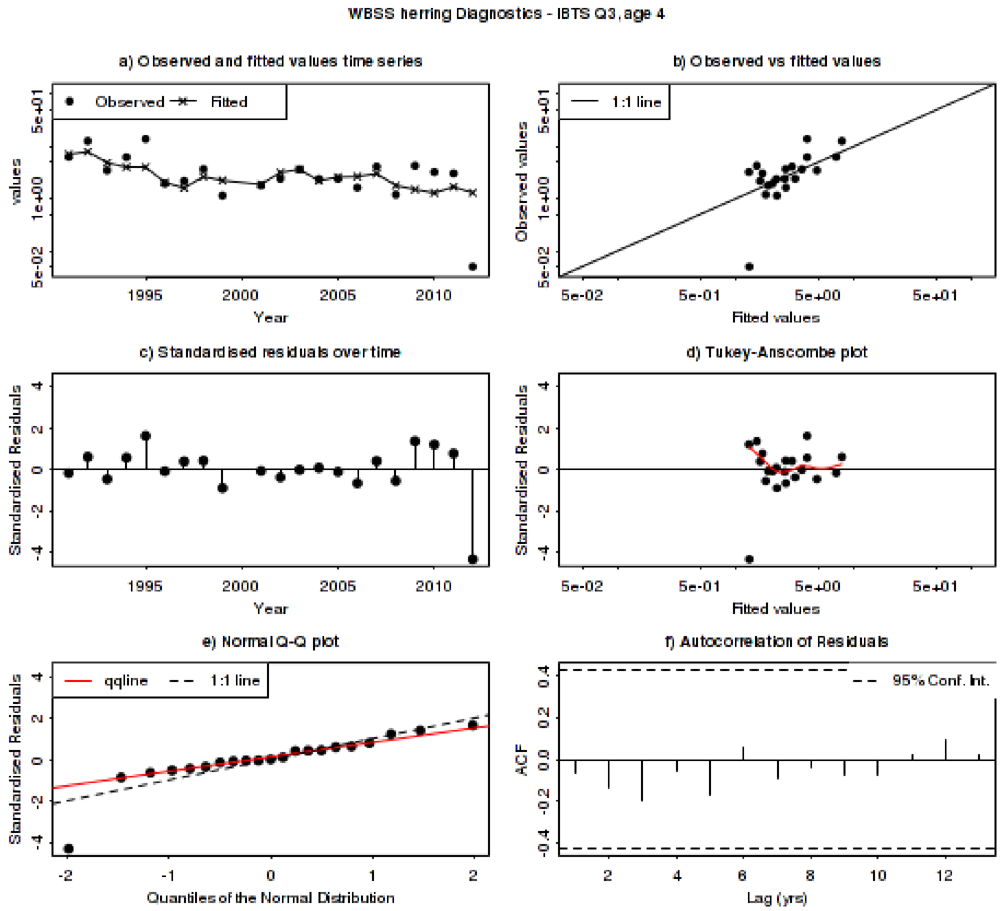


Figure 3.6.4.40 WESTERN BALTIC SPRING SPAWNING HERRING. FINAL RUN. Diagnostics of the International Bottom Trawl Survey in Division IIIa in quarter 3 (IBTS Q3) fit at 4 wr from the assessment. a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus model estimates of stock numbers at age. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log siduals of catchability model fitted by the model as a function of time. d). Log residuals from the catchability model against the estimated stock size at age. e). Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line).

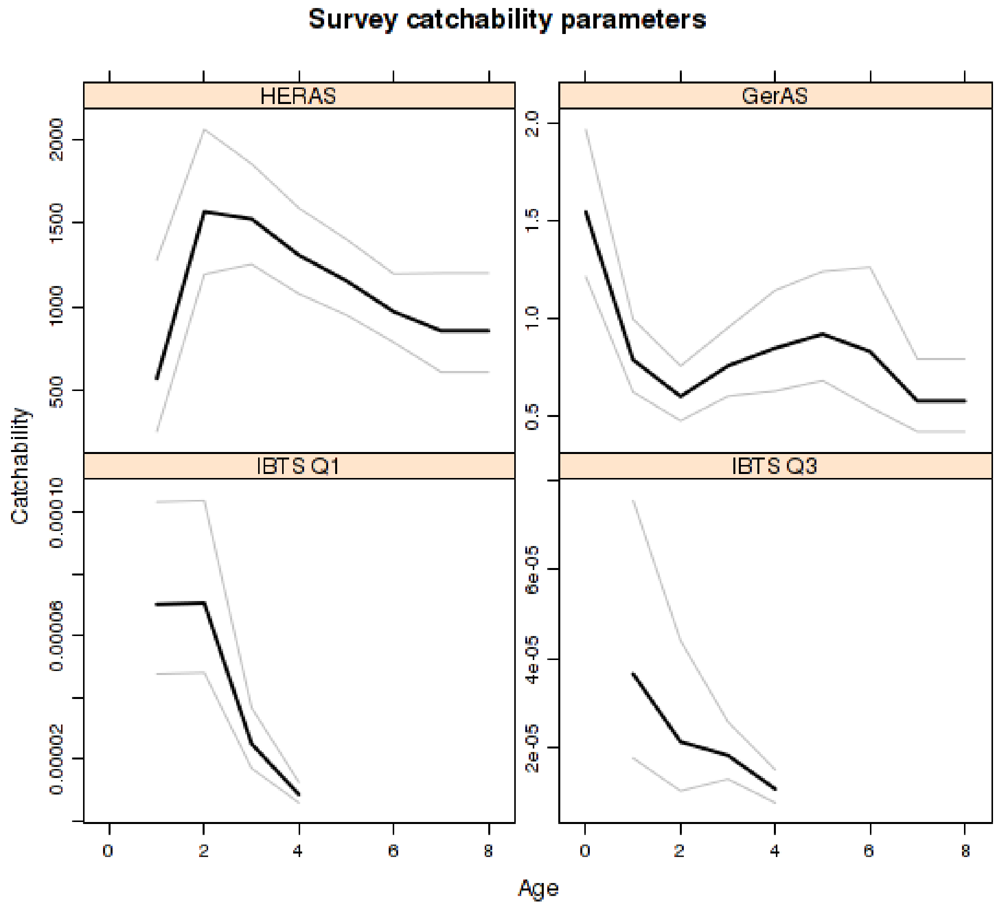


Figure 3.6.4.41 **WESTERN BALTIC SPRING SPAWNING HERRING. FINAL RUN. Estimated survey catchabilities with 95% CI.**

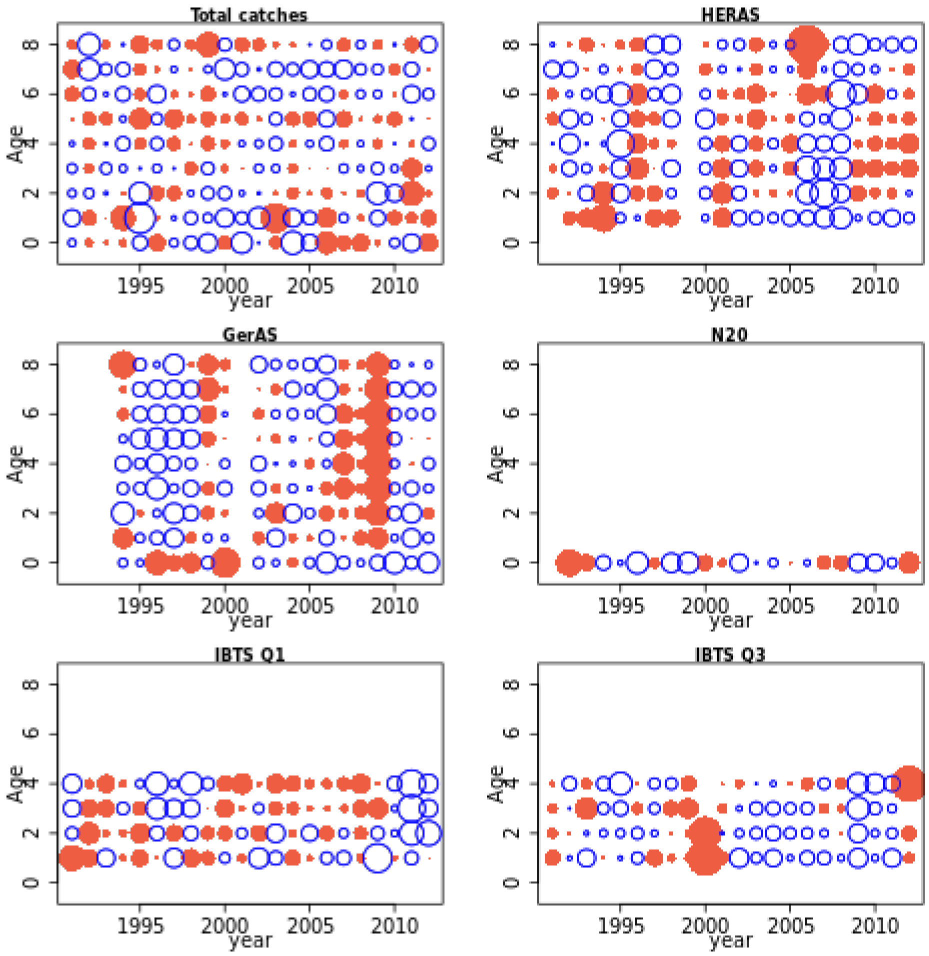


Figure 3.6.4.42 WESTERN BALTIC SPRING SPAWNING HERRING. FINAL RUN. Bubble plot showing the weighted residuals for each piece of fitted information. Individual values are weighted following the procedures employed internally with SAM in calculating the objective function. The bubble scale is consistent between all panels.

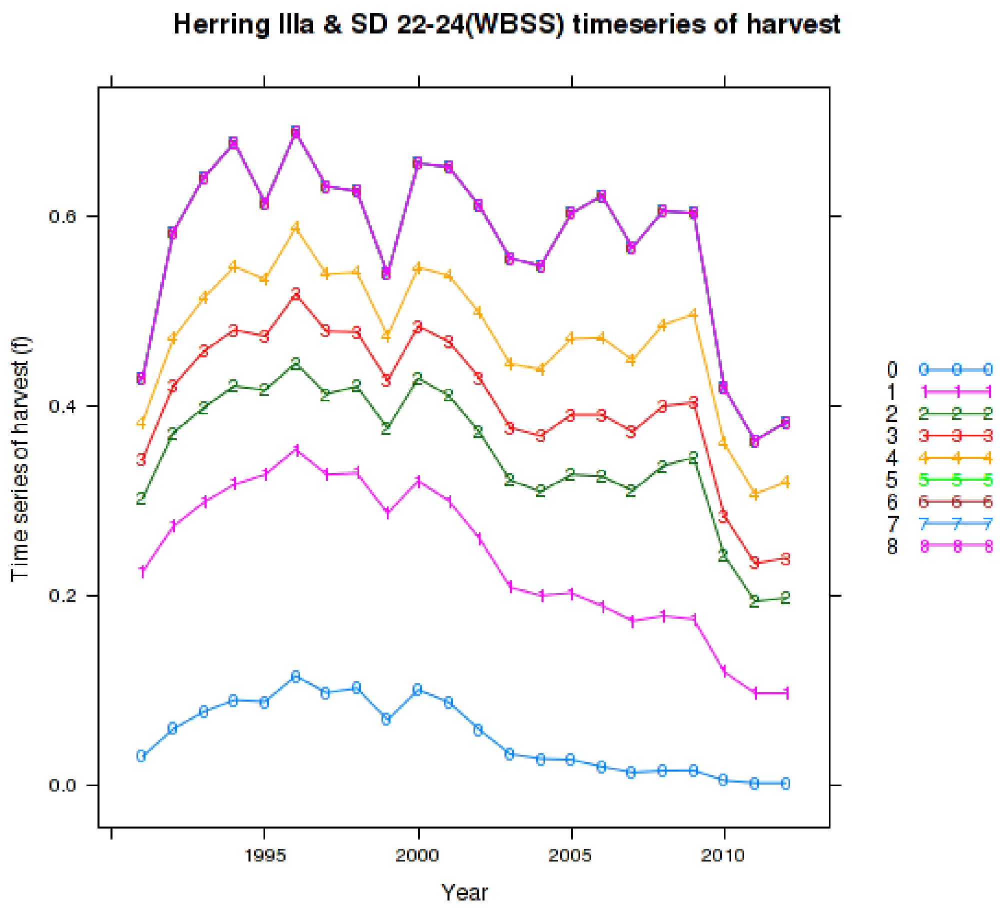


Figure 3.6.4.43 **Time-series of fishing mortality-at-age as estimated by the assessment model.**

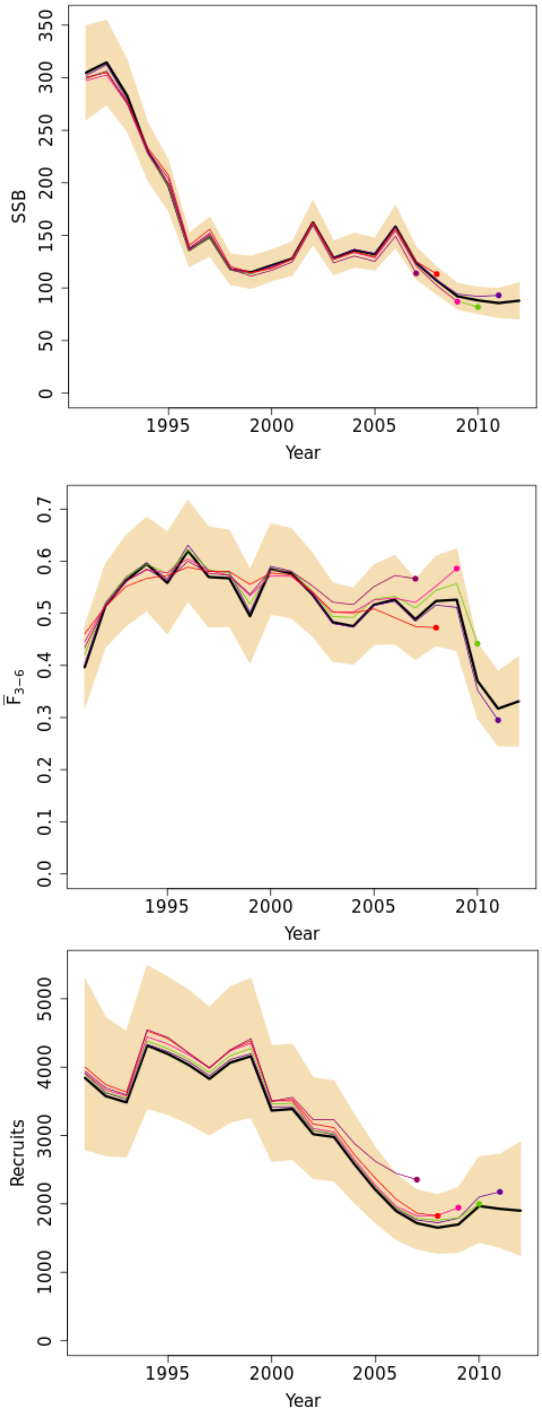


Figure 3.6.4.44 WESTERN BALTIC SPRING SPAWNING HERRING. FINAL RUN. Analytical retrospective pattern over 5 years, in the assessment for spawning stock biomass, recruitment and mean fishing mortality in the ages 3-6 ringer. The shaded area shows 95% CI on the final assessment.

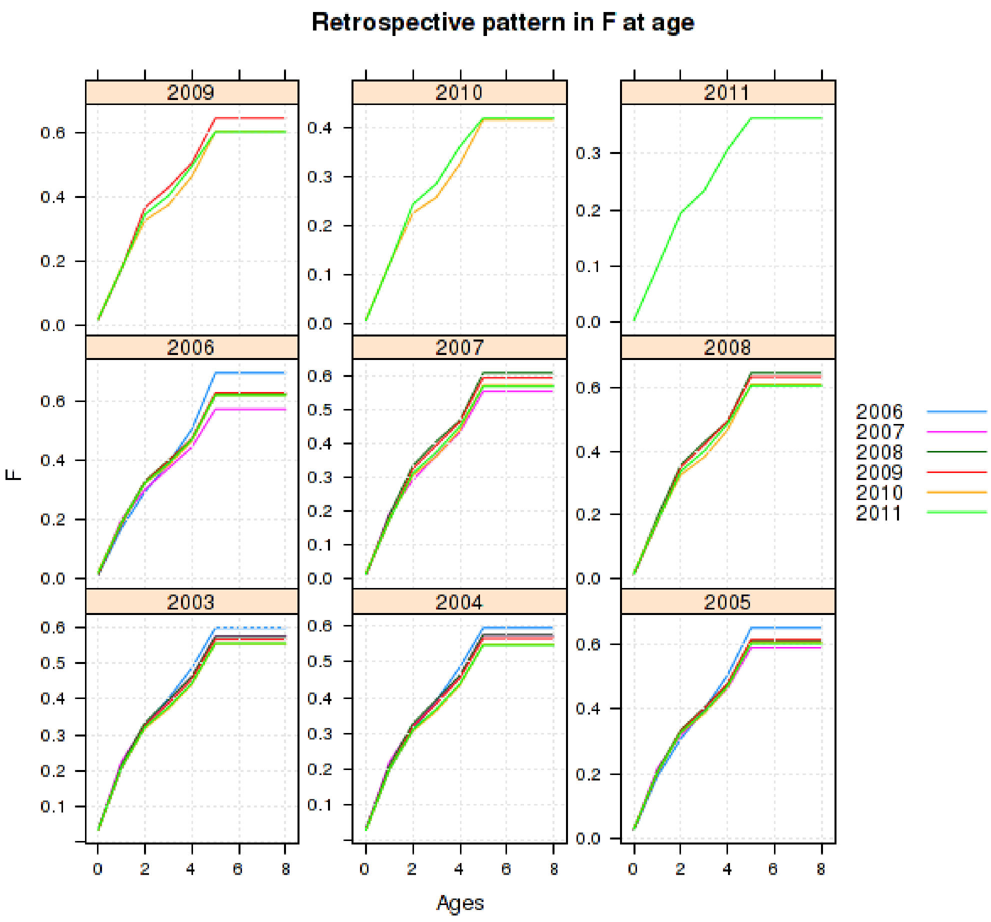


Figure 3.6.4.45 WESTERN BALTIC SPRING SPAWNING HERRING. FINAL RUN. Retrospective selectivity pattern

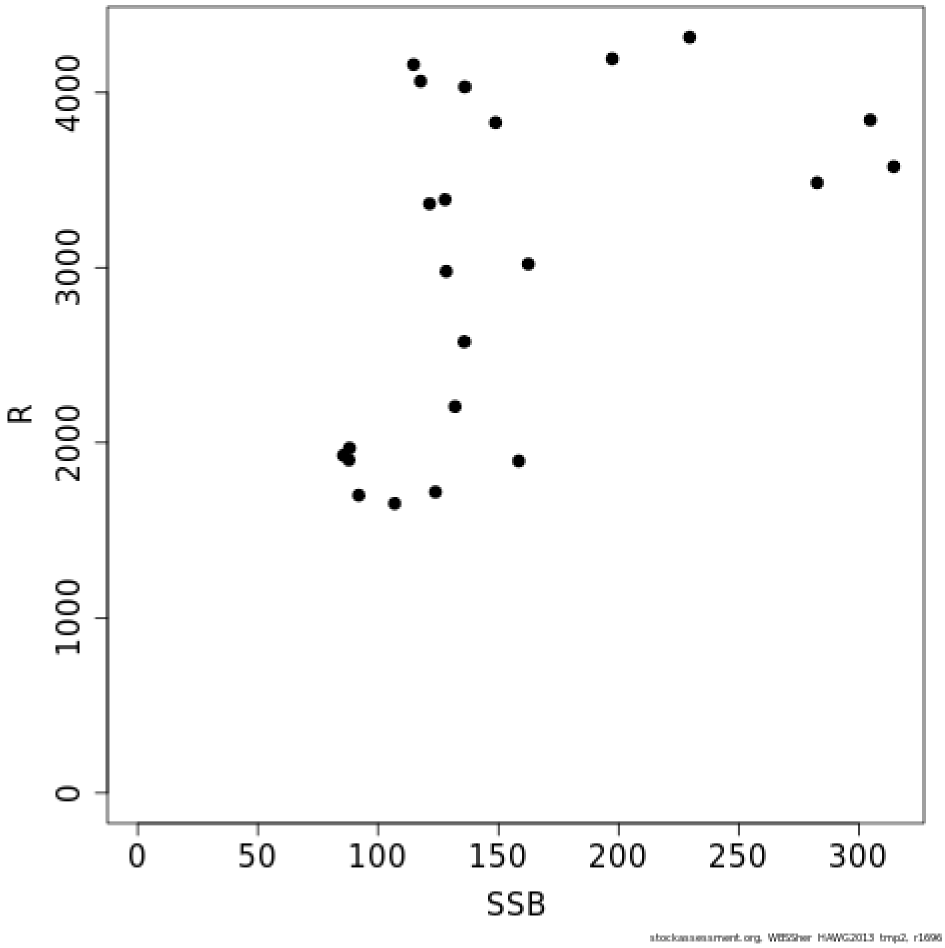


Figure 3.6.4.46 WESTERN BALTIC SPRING SPAWNING HERRING. FINAL RUN. Recruitment at age 0-wr (in thousands) is plotted against spawning stock biomass ('1000 tonnes) as estimated by the assessment.

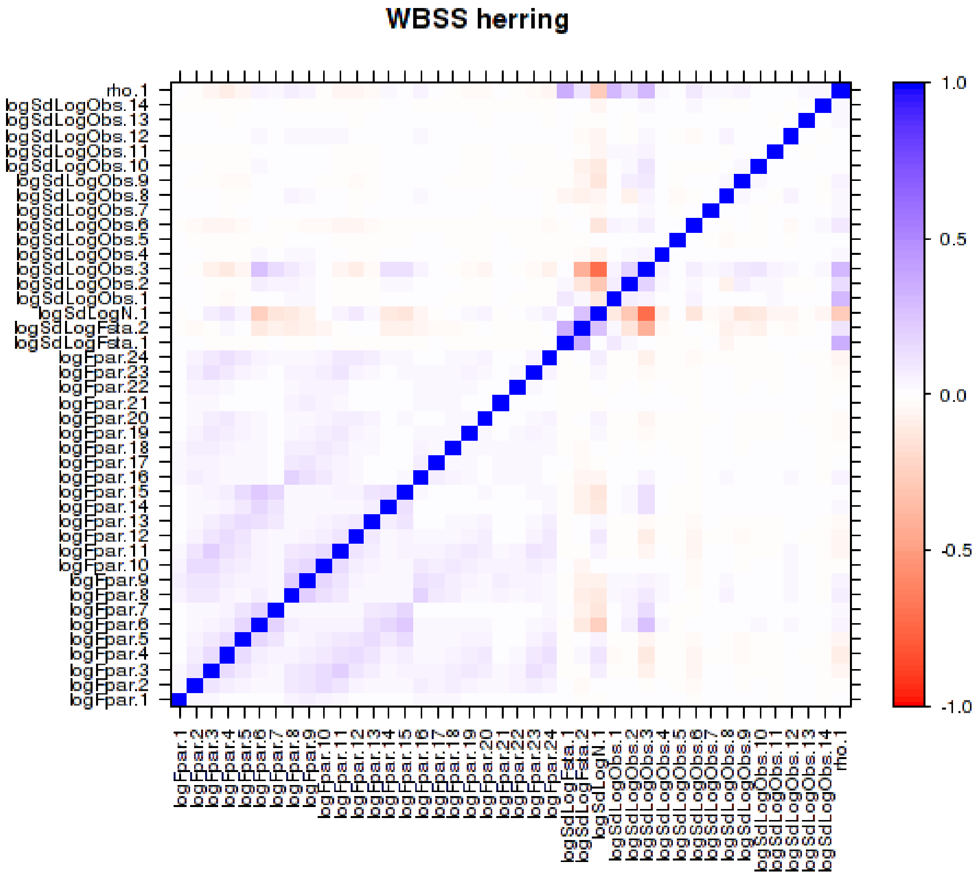


Figure 3.6.4.47 WESTERN BALTIC SPRING SPAWNING HERRING. Plot of all the estimated parameters cross-correlation.

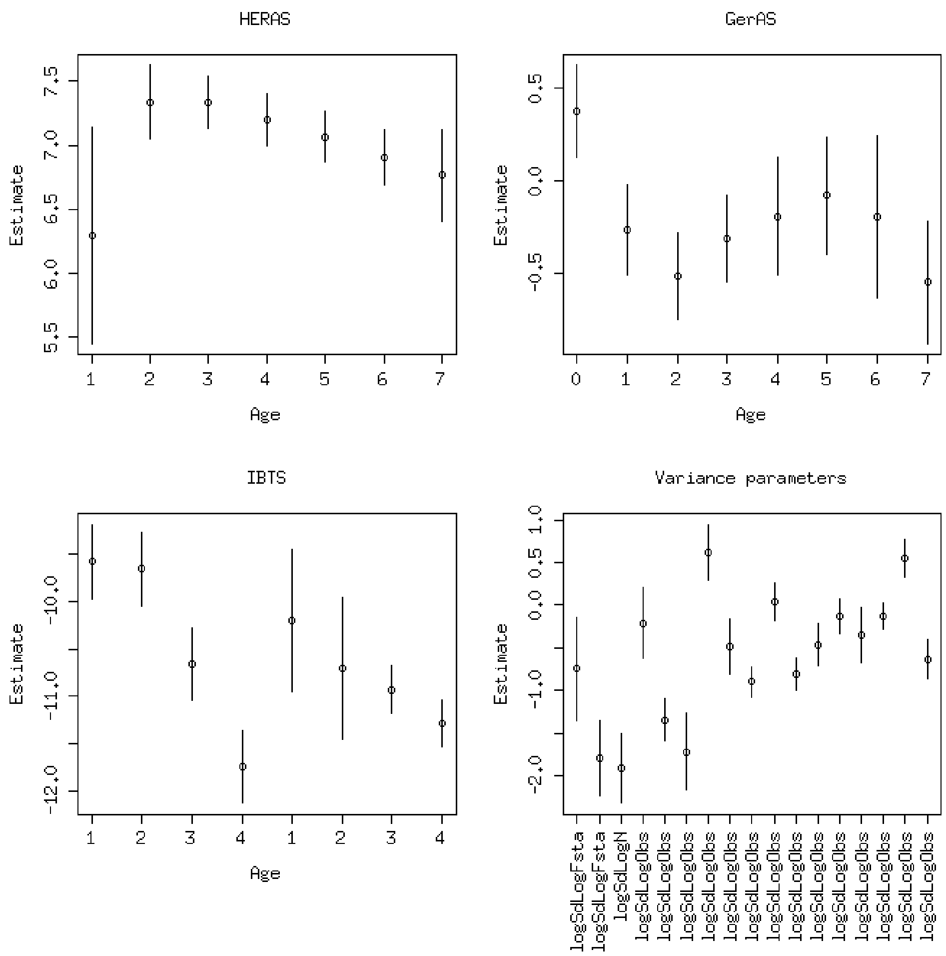


Figure 3.6.4.48 WESTERN BALTIC SPRING SPAWNING HERRING. Plot of the model estimates (in log scale) with associated 95% CI from the primary run.

4 Herring in the Celtic Sea (Division VIIa South of 52° 30’ N and VIIg,h,j,)

The assessment year for this stock runs from the 1st April – 31st March. Unless otherwise stated, year and year class are referred to by the first year in the season i.e. 2012 refers to the 2012/2013 season.

4.1 The Fishery

4.1.1 Advice and management applicable to 2012 – 2013

The TAC is set by calendar year and in 2012 was 21 000 t and for 2013 is 17 200 t (based on the long term management plan).

Long Term Management Plan

A long term management plan has been proposed by the Pelagic RAC. This plan was evaluated by ICES in 2012 and found to be consistent with the precautionary approach. It was also found to deliver long term sustainable yield, at the expense of maximising yield in any one year. The proposed target F is 0.23 and the trigger biomass point is 61 000 t. The plan was adopted as the basis for the 2013 TAC.

4.1.2 The fishery in 2012/2013

In 2012/2013, 68 vessels took part in the Irish fishery. These are categorised as follows:

- 31 vessels less than 65ft in length, but greater than 35 ft and 7 in the under 35ft category
- 13 vessels between 65 and 80ft in length
- 17 vessels over 80ft in length

The fishery took place entirely in the third and fourth quarter of 2012 as there was no fishery in the first quarter of 2013. In the third quarter, fishing took place in VIIg and VIIj and in the fourth quarter it occurred in VIIj, VIIg and VIIaS. On average, vessels under 65ft reported landings of about 60 t for the season, while the vessels over 80ft reported mean landings of around 550 t.

The third quarter fishery took place in VIIg and VIIj, landing a total of 2 500 t in September. The fourth quarter fishery took place mainly in VIIg, with smaller catches further east in VIIaS. There were no landings reported from VIIj in the fourth quarter.

The fishery was not opened in the first quarter of 2013. This was partly because of lack of demand from processors for the lower yielding fish caught at this time of year.

The distribution of the total landings is presented in Figure 4.1.2.1.

4.1.3 The catches in 2012/2013

The estimated national catches from 1988–2012 for the combined areas by year and by season (1st April–31st March) are given in Table 4.1.3.1 and Table 4.1.3.2 respectively. The catch taken during the 2012/2013 season increased to over 21 500 t, the largest since 1996 and almost four times that in 2009, which was the lowest estimate in the series (Figure 4.1.3.1). Catches from foreign vessels have become a feature of the fishery again in 2012.

The catch data include discards until 1997; however there are no recent estimates of discards for this fishery. Statements from fishermen suggest that discarding has become a feature of this fishery since 2010 (see section 4.1.6), reaching a peak in 2011 and declining again in 2012.

The catch estimates for 2012, available to the working group are not as reliable as for previous years. It is known that a relaxation of controls during the fourth quarter of 2012 was accompanied by an expansion of extra-quota fishing. Controls were tightened again in response to this, and the problem is thought to have been eliminated. No estimate of this additional catch was available, but is likely to be less than 10% of the catch during those weeks, and consequently a much lower percentage of the catch for the entire season.

It should also be noted that the reported landings of sprat in VIIaS were much higher than in previous years (Chapter 10).Though there was a substantial increase in sprat catches in this area, it is known that a certain amount of misreporting of herring as sprat occurs. Another concern is that sprat catches may contain an unknown component of juvenile herring.

4.1.4 Regulations and their effects

Under the rebuilding plan, the closure of Sub Division VIIaS from the 2007-2011, except for a sentinel fishery, meant that only small dry hold vessels, no more than 50 feet total length, could fish in that area. In 2012 local quota management arrangements were adopted to restrict fishing in VIIaS to vessels under 50 feet, but the total quota allocation increased from 8% to 11%. Therefore in 2012 there was an increase in landings from this area.

There is evidence that closure of Sub Division VIIaS, under the rebuilding plan, has helped to reduce fishing mortality substantially (HAWG 2011). This area has been the dominant spawning area, and before the closure a large proportion of the catch was taken from it. Closing this area seems to have had a positive effect of keeping fishing mortality down. This has served to reduce the efficiency of the fleets. Under the long term management plan if the SSB falls below 41,000 t Sub Division VIIaS will be closed with only a small scale sentinel fishery permitted.

4.1.5 Changes in fishing technology and fishing patterns

The stock is exploited by three types of vessels, larger boats with RSW or bulk storage and smaller dry hold vessels. The smaller vessels are confined to the spawning grounds (VIIaS and VIIg) during the winter period. The refrigerated seawater (RSW) tank vessels target the stock inshore in winter and offshore during the summer feeding phase (VIIg). These boats were excluded from VIIaS under the terms of the rebuilding plan.

There has been an increase in the number of vessels using RSW tanks. Until recently, there was a cap on the number of vessels that could carry RSW tanks. This has now been removed. The result of this measure is that more demersal vessels are switching to pelagic fishing, and former demersal boats are increasingly participating in this fishery.

Under the rebuilding plan, only 8% of the Irish quota could be taken in the sentinel fishery. In 2012, the percentage of the Irish quota allowable in VIIaS has been increased to 11%, but vessels of over 50 feet length are still excluded. VIIaS spawning areas represent the most fishable aggregations of the stock. The exclusion of larger boats from this area shifted effort onto the Smalls ground, just south of the 52°N line. This has become the main fishing area in the past three years. The abundance of herring in the closed box has attracted more vessels to target herring in this area and it can be expected that this trend may continue.

The overall increases in the TAC in the past 3 years have attracted more Irish vessels to fish this stock. Irish quota is allocated to vessels on a weekly basis. The large number of vessels involved has led to individual quotas being reduced. This led to increased discarding due to vessels being unable to catch their small allocations without extra-quota catches that are often slipped. However in 2012, flexibility was introduced to the system, whereby a vessel could use some of the following week's quota to avoid slippage. Anecdotal reports suggest that this has reduced the level of discarding in the past season.

The increase in the TAC in recent years has seen a return of the continental freezer trawler fleets to the fishery. In 2012, Dutch vessels landed 2 719 t in VIIj, and also 416 t in VIIh. German vessels reported 230 t from VIIh. The catches from VIIh may not belong to the Celtic Sea stock however, as there are other spawning areas that are closer to VIIh (Cornwall and Brittany).

4.1.6 Discarding

It is thought that discarding has increased in extent in the past 4 years. This is due to the increases in the TAC, and consequent increase in the number of vessels, leading to smaller quotas per boat, in the weekly quota allocation system used by the Irish vessels. Many larger vessels use nets that can take individual hauls of herring greater than the weekly quota. In addition, there are instances of small vessels using nets that can catch hauls exceeding their storage capacity. The effect of this quota-mediated discarding may be reduced to some extent by sharing of catches between fishing partners and neighbouring vessels. The extent of the problem is not known. However, anecdotal reports suggest that the amount of discarding has reduced in 2012, due to the flexibility incorporated into the weekly quota system.

In 2012, the HAWG received a submission by a fisherman noting the problem and suggested that discarding of 15 t per week was on the conservative side. This led to HAWG performing a sensitivity analysis on the assessment, up-scaling the catches by applying various discard rates to the larger boats participating in the fishery. Subsequent discussions with industry suggest that the results are not realistic and are too high.

In 2012, the Celtic Sea Herring Management Advisory Committee commissioned an independent study of byctach and discards in the fishery. Ten trips were observed over the period 6th October to the 5th November, representing 633 t of herring caught. Only one instance of discarding was observed, 5 t. This represents an overall discarding rate of less than 1%. The only by-catch observed was blue shark, of which 5 were recorded overall.

As part of the Irish discard sampling programme a total of 9 directed herring discard trips were carried out in 2012 with no discards observed during these trips.

Like all pelagic fisheries, estimation of discarding is very difficult. Individual instances of discarding may be quite infrequent in occurrence. However individual slippages could result in considerable quantities of herring being discarded. The estimates produced by the HAWG in 2012 provide a sensitivity analysis of the assessment to maximum possible discarding. Though these estimates are considered to be too high, they do highlight that if discarding on that scale were to happen it would have a strong negative impact on SSB and cause fishing mortality to rise. However it seems likely that there has been a reduction in the level of discarding in 2012. Final estimates of discards are unavailable, though it is expected that a certain amount of discarding takes place. It seems likely that the discard rate is less than 10% of the total catch, and probably lower than 5%.

4.2 Biological composition of the catch

4.2.1 Catches in numbers-at-age

Catch numbers-at-age are available for the period 1958 to 2012. In 2012, the most abundant age classes were 2 ringers (2009 year class 34%), 3 ringers (2008 year class 24%) and 4 ringers (2007 year class 20%). The 2007 and 2008 cohorts were also strong in the previous season (Table 4.2.1.1). The strong 2005 year class can be seen as 6 ringers in 2012.

The yearly mean standardised catch numbers-at-age for 6+ and 7+ are shown in Figures 4.2.1.1 and 4.2.1.2 and show the 2009 year class as the strongest cohort in 2012. The weak 2001/2002 year class has now disappeared from the catches. The strong 2005 year class is now 6-ringer and is a significant component of the plus group.

The overall proportions-at-age were similar in all sampled metiers (division*quarter, Figure 4.2.1.3). The age profiles show greater agreement than in 2011. 2-ringers are the dominant age group in all metiers and are seen in the highest proportions in VIIg Q3. As expected the survey caught slightly greater amounts of 1-ring fish. In 2011 the age structure in the survey and the commercial fishery differed for the first time, in the current series. This was probably due to the exclusion of the main fleet from the Closed Area. The closed area is dominated by recruits to the spawning stock.

Table 4.2.1.2 and Figure 4.2.1.4 show the length frequency data by area and quarter. A similar length range was found in VIIg and VIIaS Q4. Two distinct peaks can be seen in the length frequency data from VIIg Q3.

4.2.2 Quality of catch and biological data

Biological sampling of the catches was comprehensive throughout the area exploited by the Irish fishery (Table 4.2.2.1). Under the Data Collection Framework the sampling of this stock is well above that required by the Minimum Programme (Section 1.5).

The quality of catch data has varied over time. A rudimentary history of the Irish fishery since 1958 is presented in the Stock Annex. In 2012/2013 only preliminary data were available at the time of the Working Group. Best estimates of small boat catches were used for the VIIaS sentinel fishery. This is because not all the vessels are required to make logbook returns, being less than 10 m in total length.

4.3 Fishery Independent Information

4.3.1 Acoustic Surveys

The Celtic Sea herring acoustic survey (CSHAS) time series currently used in the assessment runs from 2002-2012 is presented in Table 4.3.1.1.

The acoustic survey of the 2012/2013 season was carried out in October 2012, on the *Celtic Explorer* (O'Donnell, *et al* in WGIPS (ICES CM 2012/SSGESST:22)). The adaptive stratum covering the 'Smalls' ground, which was first covered in 2011, was continued in 2012. Survey effort and geographical coverage remained the same for all core areas with the exception of the Smalls stratum where the area covered was increased by 285 nmi^2 to the east. The Smalls is a traditional prawn fishing ground which since 2009 has been increasingly targeted by the RSW fleet searching for offshore herring aggregations in addition to the traditional areas such as the Labadie Bank and the Rigs areas.

The survey takes place during the height of the fishing season. A fishing industry representative was onboard the research vessel for the duration of the survey and maintained regular contact with fishing vessels targeting herring. The survey track began at the northern boundary of VIIj, covering only the SW bays in zig-zags and parallel transects (Figure 4.3.1.1a). As in previous seasons, very little herring was registered in the bays of VIIj (Figure 4.3.1.1b) and in 2012 survey effort in this area was reduced. The main broad scale survey in VIIg and VIIaS had a parallel transect design and showed the greatest concentrations of herring close inshore on the spawning grounds.

The 2012 survey estimate of SSB was 246 000 t, which is an increase of 101% on the 2011 estimate of 122 000 t. The distribution of herring was more concentrated than in 2011 with a large proportion coming from the inshore grounds and also a significant amount from the Smalls area. The stock was considered to be well contained within the survey area.

A possible cause for the large increase in biomass estimate is double counting of the very dense herring schools in the spawning grounds in VIIaS. The very narrow transect spacing in the survey strata covering these grounds (1 nautical mile) could result in the same schools being registered more than once. This is of particular concern as the stock grows and it is possible that the phenomenon may have occurred in 2011 too.

An exercise was carried out to examine the possible impact on the biomass estimate of double counting in the strata where a significant proportion of the biomass was encountered. If double counting did indeed occur it was most likely in two inshore strata with transect spacing of 1 and 2 nm. These strata together accounted for 57% of the estimated SSB. The entire survey estimate was recalculated twice: once excluding every second transect and its associated acoustic data from these strata, and a second time omitting the inverse. Both new estimates were comparable to the original biomass estimate (SSB within 5%). The CV increased to 35 in both cases, compared to 25 in the original estimate. In light of these results it was decided to keep the 2012 survey estimate in the assessment. Further work is needed to fully explore the possibility that double counting could occur due to the current survey design. This will be addressed by the benchmark in 2014.

This survey shows quite good internal consistency for the age groups used in the assessment (Figure 4.3.1.2). The worst coherence is shown by 2-ringers. This may be due to the variation in immigration from the Irish Sea.

4.4 Mean weights-at-age and maturity-at-age

The mean weights in the catch and mean weights in the stock at spawning time are presented in Figures 4.4.1.1-2 and Tables 4.6.2.2-3. There has been an overall downward trend in mean weights-at-age in the catch since the mid-1980s (with a slight increase around 2008 in the main age groups 2-8). The 2012/2013 mean weights-at-age have continued the downward trend, having decreased slightly for most age groups except 1 ringers, where a slight increase can be seen.

Mean weights in the stock at spawning time were calculated from biological samples from the fourth quarter (Figure 4.4.1.2). Small decreases in mean weight can be seen in all age groups with the exception of 5 and 6 -ringers, where a more stable pattern can be seen.

In the assessment, 50% of 1-ringers are considered mature. Sampling data from the Celtic Sea catches suggest that greater than 50% of 1-ringers are mature (Lynch, 2011).

4.5 Recruitment

At present there are no independent recruitment estimates for this stock.

4.6 Assessment

In 2013, this stock is scheduled as an update assessment. However some data exploration was conducted. These investigations related to excluding the 2012 survey estimates and extending the plus group from 6+ to 7+.

4.6.1 Data Exploration

Exploratory analyses were performed to investigate the effect of including the very large biomass estimate detected by the 2012 acoustic survey due to the uncertainty in this estimate. Using the same settings as in 2012, assessments were run with and without the 2012 acoustic survey. Including the 2012 survey gave a very high increase in spawning stock biomass of 90% from the 2011 assessment estimate. The exclusion of the 2012 survey led to a smaller increase of 63% (Figure 4.6.1.3). The diagnostics from both runs were similar. The survey residuals showed that there were year effects early in the time series and in 2010 but there were no year effects visible in the 2011 or 2012 surveys. Based on the assessment diagnostics and the results of the exercise to investigate possible double counting it was decided to include the 2012 survey estimate.

Additional exploratory assessments were conducted to explore the effects of increasing the plus group from age 6 to 7. In 2009 HAWG reduced the plus group (ICES 2009) used in the assessment to 6+. This improved the model diagnostics appreciably. Furthermore, at that time, there was significant truncation in the age structure, with few fish older than 6 ring in catches. In 2011, HAWG re-examined the question of whether the plus group should be extended, given that the strong 2003 year class had entered the plus group. HAWG decided, based on model diagnostics, not to extend the plus group at that time. In the 2012/2013 season the plus group accounts for 12% of catch numbers at age and so the comparison between assessments with 6+ and 7+ was repeated. Furthermore, the relatively strong 2005 year class is now a component of the plus group. The catch diagnostics from the 6+ and 7+ runs are presented in Figures 4.6.1.1 and 4.6.1.2. Slightly larger residuals are seen in the 7+ run. A comparison of the stock summaries from the 6+ and 7+ runs is shown in Figure 4.6.1.3. The 7+ runs are associated with lower SSB and higher F in recent years.

HAWG decided to proceed on the basis of maintaining the plus group at 6+. It was felt the most appropriate time to consider changing the plus group would be during a future benchmark exercise.

HAWG decided to proceed on the basis of the SPALY assessment. The model diagnostics show good agreement between the survey and catch data.

4.6.2 Stock Assessment

This update assessment was carried out using FLICA. The same settings as the 2012 assessment were used (Table 4.6.2.10) and the assessment was tuned using the Celtic Sea herring acoustic survey (CSHAS). The input and output data are presented in Tables 4.6.2.1 to 4.6.2.21.

The fitted catch diagnostics are shown in Figure 4.6.1.3. Catch residuals are similar to those in the 2012 assessment and show no discernible pattern.

The survey diagnostics at-age are presented in Figures 4.6.2.1 – 4.6.2.4. The model fit underestimates the quantity of 3 and 4 winter ring fish. For 2 and 5 ringers there is a good fit between the modelled and observed value.

The catch and survey residual patterns are shown in Figure 4.6.2.5. Year effects can be seen in the acoustic surveys in the early part of the time series. In more recent years the survey is performing better in the assessment with smaller residuals. No age effects are seen in the time series.

A plot which depicts the uncertainty in the estimated spawning stock biomass and average fishing mortality is presented in Figure 4.6.2.6. This figure shows that there is considerable uncertainty in the estimates of SSB with a wide range of values shown. The incoming recruitment of 1-ringers is poorly estimated in the assessment and leads to greater uncertainty of the estimation of SSB given that 50% of 1-ringers are mature.

A Taylor diagram is presented in Figure 4.6.1.7 to show the statistical comparison of observations from the acoustic survey data and the model estimates. The agreement between the model and the observations is best for 3- and 5-ringers.

Retrospective plots by cohort are shown in Figure 4.6.2.8. This plot shows that there is good internal consistency in estimating year class strength. The analytical retrospective pattern is displayed in Figure 4.6.2.9. There is a significant upward revision in SSB this year due primarily to the increased survey abundance and increased landings. A corresponding downward revision can be seen in fishing mortality. A historical retrospective is presented in Figure 4.6.2.10. This compares the final assessments in 2010 - 2013. Significant upward and downward revisions in SSB can be seen between years. The stock summary from the final assessment is presented in Figure 4.6.2.11.

4.6.3 State of the stock

The stock has increased considerably in size in recent years with the highest estimate in the time series recorded in 2012 (159 776 t). Despite the uncertainty in the recent survey estimates, there is evidence that the stock is at a high level. Several strong cohorts (2003, 2005, 2007 and possibly 2008 and 2009) have entered the fishery recently, and as they gain weight, they maintain the stock at a high level. Fishing mortality declined between 2003 and 2009 but started to rise again in 2010 due to increased catches. It is currently estimated to be 0.15, which is below $F_{0.1}$ (0.17) and F_{MSY} (0.25).

4.7 Short term projections

4.7.1 Deterministic Short Term Projections

A deterministic short term forecast was performed, using FLR. The input data are presented in Table 4.7.1.1. Mean weights in the catch and in the stock were calculated as means over the last three years. Recruits (1-ring) are poorly represented in the catch and only one observation of their abundance is available. The population numbers at 1-ring are replaced by geometric mean from 1981-2010. This time period was used because this represents the current perceived recruitment regime where recruitment has been fluctuating around the mean. Population numbers of 2-ringers in the intermediate season (2013) were calculated by the degradation of geometric mean recruitment (1981-2010) using the equation below.

$$N_{t+1} = N_t * e^{-Ft+Mt}$$

The short term forecast was performed using the predicted catch in the interim season 2013/2014. There was no quarter 1 fishery in 2013 and it is assumed this will also be the case in 2014. Thus, the interim catch was taken as the 2013 total quota (17 152 t) plus the carryover of Irish quota from 2012 (1 911t).

The results of the short term projection are presented in Table 4.7.1.2 and 4.7.1.3. Fishing according to the proposed management plan which has a 30% constraint on TAC change implies catches of 22 360 t in 2014. All scenarios show SSB will be above B_{pa} in 2015.

4.7.2 Yield Per Recruit

No yield per recruit analysis was conducted at HAWG 2013.

4.1 Long term simulations

The long term management plan has been evaluated for Celtic Sea herring and simulations have been carried out in conjunction with this work. HCS10_3 (Skagen 2010) was used to project the stock forward twenty years and screen over a range of possible trigger points, F values and % constraints on TAC change. It was agreed by the Irish industry that a target F of 0.23 would be proposed and that 61 000 t would be used as a trigger biomass. Once the stock falls to this level, reductions in F would be implemented. A 30% constraint in TAC change would also apply. These simulations considered risk to B_{lim} (26 000 t) and also the changepoint in the hockey stick S/R relationship (39 000 t). The proposed plan performs well, with low risk to the stock within the most likely conditions pertaining in the fishery system. This was evaluated over a range of implementation and observation errors and biases (ICES CM 2012/ACOM:75).

4.2 Precautionary and yield based reference points

Reference points are defined for this stock, B_{pa} is currently at 44 000 t (low probability of low recruitment) and B_{lim} at 26 000 t (B_{loss}) for this stock. F_{pa} and F_{lim} are not defined. 0.25 is suggested as a possible option for F_{MSY}. The calculation of F_{MSY} is based on work carried out by HAWG in 2010 using HCS10 (ICES CM 2010/ACOM:06).

In previous years HAWG has proposed increasing B_{lim} to the S/R changepoint with consequent increases in B_{pa}. This may not be necessary, based on ICES SGPA 2003 guidelines. It should also be noted that the changepoint in the segmented regression has been quite volatile over time (39 000 t – 45 000 t) in various studies conducted in recent years. This volatility is considered a good reason not to use changepoint as a basis for B_{lim} (ICES, 2012 ADGCSHER).

HAWG has not considered candidate values for a $B_{MSYtrigger}$ in great detail. HAWG considered that there is a range of biologically appropriate biomass triggers. The proposed management plan has a trigger biomass of 61 000 t. In 2010 ACOM endorsed the approach taken by HAWG, and ICES WKFRAME II also endorsed the approach in 2011. Reference points will be examined in detail at the 2014 benchmark meeting.

4.3 Quality of the Assessment

This assessment is an update of the 2012 assessment. A significant upward revision of the perception of SSB is a feature of the 2013 assessment. This is associated with the significant increase in the 2012 acoustic survey biomass estimate and increased catches. SSB, catch and F estimated in last year's assessment and short term forecast are compared with this year's assessment in the text table below and are shown in the historical retrospective in Figure 4.6.2.10.

2012 Assessment				**2013 Assessment**				**Percentage change in the Estimates**	
Year	SSB	Catch	F 2-5	Year	SSB	Catch	F 2-5	SSB	F 2-5
2010	84263	8370	0.13	2010	113374	8370	0.1041	+35%	-20%
2011	84232	11470	0.15	2011	157338	11470	0.1087	+87%	-28%
2012*	84281	18326	0.224	2012	159776	21604	0.151	+90%	-33%

* From Intermediate year in STF

Assessment outputs are sensitive to discarding which is difficult to quantify but understood to have taken place in 2010 2011 and to a lesser extent 2012.

The review group comments (ICES HAWG 2011 and 2012) recommended further analysis of stock mixing with herring in the Irish Sea. This matter will be addressed and will be dealt with at the next benchmark.

4.4 Management Considerations

Fishing mortality on this stock was high for many years, well above F_{MSY} = 0.25. F was reduced substantially from 2004 to 2009. It has risen slightly since 2009 but is still below F_{MSY}. The current estimate of F is 0.15. SSB is well above B_{pa} (44 000 t).

There is good evidence to show that the stock has increased substantially in recent years and is at a high level. The rebuilding plan which was in place until 2011 can be considered to be successful because the stock has been shown to be above B_{pa} for three consecutive years. The stock should now be managed according to a long term management plan.

The long term management plan, proposed by the Pelagic RAC, has been endorsed by ICES and implemented for setting the 2013 TAC by the Council European Union. The proposed target F is 0.23 and the trigger biomass point is 61 000 t. The European Commission used the management plan to set its TAC proposal for 2013. Given that the plan has the support of the European Commission for TAC setting and given that it has been evaluated by ICES and found to be precautionary. ICES advice will now be based on the long term management plan. However it should be noted that the plan will not enter into law until it has been endorsed by all three European institutions, including the Parliament.

The closure of the Sub Division VIIaS as a measure to protect first time spawners has been in place since 2007/2008. This area was reopened in January 2012. Currently only vessels of no more than 50 feet in registered length are permitted to fish in this area. A maximum catch limitation of 11% of the Irish quota is allocated to this fishery.

The extent of discarding in this stock is not fully known. Anecdotal reports suggest that the amount of discarding that was of concern in 2011 has been reduced in 2012 due to the flexibility introduced to the weekly quota system (see Section 4.1.6).

4.5 Ecosystem considerations

Herring are an important prey species in the ecosystem and also one of the dominant planktivorous fish.

The spawning grounds for herring in the Celtic Sea are well known and are located inshore close to the coast. These spawning grounds may contain one or more spawning beds on which herring deposit their eggs. Individual spawning beds within the spawning grounds have been mapped and consist of either gravel or flat stone (Breslin 1998). Spawning grounds tend to be vulnerable to anthropogenic influences such as dredging, sand and gravel extraction, dumping of dredge spoil and waste from fish cages. There have been several proposals for extraction of gravel and to dump dredge spoil in recent years. Many of these proposals relate to known herring spawning grounds. ICES have consistently advised that activities that perturb herring spawning grounds should be avoided.

Herring fisheries tend to be clean with little bycatch of other fish. Mega-fauna by catch is unquantified. Anecdotal reports suggest that seals and blue sharks are caught from time to time.

4.6 Changes in the environment

Temperatures in this area have been increasing over the last number of decades. There are indications that salinity is also increasing (ICES 2006). It is considered that this could have implications for herring that is at the southern edge of its distribution in this area. It is known that similar environmental changes have affected the North Sea herring. However, there is no evidence that changes in the environmental regime in the Celtic Sea have had any effect on productivity of this stock.

Table 4.1.3.1. Herring in the Celtic Sea. Landings by quota year (t), 1988–2012. (Data provided by Working Group members). These figures may not in all cases correspond to the official statistics and cannot be used for management purposes.

Year	France	Germany	Ireland	Netherlands	U.K.	Unallocated	Discards	Total
1988	-	-	16,800	-	-	-	2,400	19,200
1989	+	-	16,000	1,900	-	1,300	3,500	22,700
1990	+	-	15,800	1,000	200	700	2,500	20,200
1991	+	100	19,400	1,600	-	600	1,900	23,600
1992	500	-	18,000	100	+	2,300	2,100	23,000
1993	-	-	19,000	1,300	+	-1,100	1,900	21,100
1994	+	200	17,400	1,300	+	-1,500	1,700	19,100
1995	200	200	18,000	100	+	-200	700	19,000
1996	1,000	0	18,600	1,000	-	-1,800	3,000	21,800
1997	1,300	0	18,000	1,400	-	-2,600	700	18,800
1998	+	-	19,300	1,200	-	-200	-	20,300
1999		200	17,900	1300	+	-1300	-	18,100
2000	573	228	18,038	44	1	-617	-	18,267
2001	1,359	219	17,729	-	-	-1578	-	17,729
2002	734	-	10,550	257	-	-991	-	10,550
2003	800	-	10,875	692	14	-1,506	-	10,875
2004	801	41	11,024	-	-	-801	-	11,065
2005	821	150	8452	799	-	-1770	-	8,452
2006	-	-	8,530	518	5	-523	-	8,530
2007	581	248	8,268	463	63	-1355	-	8,268
2008	503	191	6,853	291		-985	-	6,853
2009	364	135	5,760			-499	-	5,760
2010	636	278	8,406	325		-1239	na	8,406
2011	241		11,503	7		-248	na	11,503
2012	3	230	16,132	3,135		2,104	na	21,604

Table 4.1.3.2. Herring in the Celtic Sea. Landings (t) by assessment year (1st April–31st March) 1988/1989-2012/2013. (Data provided by Working Group members). These figures may not in all cases correspond to the official statistics and cannot be used for management purposes.

Year	France	Germany	Ireland	Netherlands	U.K.	Unallocated	Discards	Total
1988	-	-	16,800	-	-	-	2,400	19,200
1989	+	-	16,000	1,900	-	1,300	3,500	22,700
1990	+	-	15,800	1,000	200	700	2,500	20,200
1991	+	100	19,400	1,600	-	600	1,900	23,600
1992	500	-	18,000	100	+	2,300	2,100	23,000
1993	-	-	19,000	1,300	+	-1,100	1,900	21,100
1994	+	200	17,400	1,300	+	-1,500	1,700	19,100
1995	200	200	18,000	100	+	-200	700	19,000
1996	1,000	0	18,600	1,000	-	-1,800	3,000	21,800
1997	1,300	0	18,000	1,400	-	-2,600	700	18,800
1998	+	-	19,300	1,200	-	-200	-	20,300
1999		200	17,900	1300	+	-1300	-	18,100
2000	573	228	18,038	44	1	-617	-	18,267
2001	1,359	219	17,729	-	-	-1578	-	17,729
2002	734	-	10,550	257	-	-991	-	10,550
2003	800	-	10,875	692	14	-1,506	-	10,875
2004	801	41	11,024	-	-	-801	-	11,065
2005	821	150	8452	799	-	-1770	-	8,452
2006	-	-	8,530	518	5	-523	-	8,530
2007	581	248	8,268	463	63	-1355	-	8,268
2008	503	191	6,853	291		-985	-	6,853
2009	364	135	5,760			-499	-	5,760
2010	636	278	8,406	325		-1239	na	8,406
2011	241		11,503	7		-248	na	11,503
2012	3	230	16,132	3,135		2,104	na	21,604

Table 4.2.1.1. Herring in the Celtic Sea. Comparison of age distributions (percentages) in the catches of Celtic Sea and VIIj herring from 1970-2012.

	1	2	3	4	5	6
1970	1%	24%	33%	17%	12%	13%
1971	8%	15%	24%	27%	12%	14%
1972	4%	67%	9%	8%	7%	5%
1973	16%	26%	38%	5%	7%	8%
1974	5%	43%	17%	22%	4%	8%
1975	18%	22%	25%	11%	13%	11%
1976	26%	22%	14%	14%	6%	19%
1977	20%	31%	22%	13%	4%	9%
1978	7%	35%	31%	14%	4%	9%
1979	21%	26%	23%	16%	5%	7%
1980	11%	47%	18%	10%	4%	8%
1981	40%	22%	22%	6%	5%	6%
1982	20%	55%	11%	6%	2%	6%
1983	9%	68%	18%	2%	1%	1%
1984	11%	53%	24%	9%	1%	1%
1985	14%	44%	28%	12%	2%	0%
1986	3%	39%	29%	22%	6%	1%
1987	4%	42%	27%	15%	9%	3%
1988	2%	61%	23%	7%	4%	3%
1989	5%	27%	44%	13%	5%	5%
1990	2%	35%	21%	30%	7%	6%
1991	1%	40%	24%	11%	18%	6%
1992	8%	19%	25%	20%	7%	20%
1993	1%	72%	7%	8%	3%	8%
1994	10%	29%	50%	3%	2%	7%
1995	6%	49%	14%	23%	2%	5%
1996	3%	46%	29%	6%	12%	5%
1997	3%	26%	37%	22%	6%	6%
1998	5%	34%	22%	23%	11%	6%
1999	11%	27%	28%	11%	12%	10%
2000	7%	58%	14%	9%	4%	7%
2001	12%	49%	28%	5%	3%	3%
2002	6%	46%	32%	9%	2%	4%
2003	3%	41%	27%	16%	6%	7%
2004	5%	10%	50%	24%	9%	2%
2005	19%	38%	7%	23%	9%	3%
2006	3%	58%	19%	4%	11%	5%
2007	12%	17%	56%	9%	2%	4%
2008	3%	31%	20%	38%	6%	2%
2009	24%	11%	30%	12%	20%	4%
2010	4%	33%	13%	25%	8%	18%
2011	7%	19%	38%	8%	15%	13%
2012	6%	34%	24%	20%	3%	12%

Table 4.2.1.2. Herring in the Celtic Sea. Length frequency distributions of the Irish catches (raised numbers in '000s) in the 2012/2013 season in the Celtic Sea and VIIj fishery.

	2012			
Length	VIIg Q3	VIIg Q4	VIIaS Q4	Total
14.5		14.686		
15				
15.5				
16				
16.5				
17				
17.5	64.239		38.172	
18		44.059	50.896	95
18.5	64.239	146.863	101.791	313
19	64.239	396.53	241.754	703
19.5	256.955	631.512	356.27	1,245
20	513.909	1321.767	407.165	2,243
20.5	1092.057	2085.454	458.061	3,636
21	1991.399	3994.673	750.71	6,737
21.5	2698.024	4743.674	1106.982	8,549
22	1605.967	6741.01	1234.221	9,581
22.5	1670.205	6197.616	1043.361	8,911
23	1413.251	7240.344	1145.153	9,799
23.5	1605.967	7166.913	1170.601	9,943
24	2441.069	8811.778	1514.147	12,767
24.5	2055.636	9986.681	1641.386	13,684
25	1798.683	13291.1	1755.9	16,846
25.5	1477.489	12762.39	1794.072	16,034
26	642.386	10618.19	1374.183	12,635
26.5	1027.818	7636.874	903.399	9,568
27	449.671	4582.124	737.986	5,770
27.5	128.477	2540.73	254.478	2,924
28	64.24	704.942	165.41	935
28.5	0	205.608	12.724	218
29	64.24	88.118	0	152
29.5		14.686	25.448	40
30		0		0
30.5				0
	23,190	111,954	18,284	153,326

Table 4.2.2.1 Herring in the Celtic Sea. Sampling intensity of commercial catches (2012/2013). Only Ireland provides samples of this stock.

ICES Area	Year	Quarter	Landings (t)	No. Samples	No. aged	No. Measured	Aged/1000 t
VIIg	2012	3	2157	2	100	361	46
VIIg	2012	4	13928	36	1090	7624	78
Sub-total			16085	38	1190	7985	74
VIIaS	2012	4	2006	11	543	1437	0.54
Sub-total			2006	11	543	1437	271
VIIj	2012	4	145	0	0	0	
Sub-total			145	0	0	0	
Total Celtic Sea		18236	49	1733	9422	95	

Table 4.3.1.1. Herring in the Celtic Sea. Revised acoustic index of abundance used in the assessment. Total stock numbers-at-age (10^6) estimated using combined acoustic surveys (age refers in winter rings, biomass and SSB in 000's tonnes). Only 2-5 ring abundances are used in tuning.

	2002 **2003**	**2003** **2004**	**2004** **2005**	**2005** **2006**	**2006** **2007**	**2007** **2008**	**2008** **2009**	**2009** **2010**	**2010** **2011**	**2011^** **2012**	**2012^** **2013**
0	0	24	-	2	-	1	99	239	5	0	31
1	42	13	-	65	21	106	64	381	346	342	270
2	185	62	-	137	211	70	295	112	549	479	856
3	151	60	-	28	48	220	111	210	156	299	615
4	30	17	-	54	14	31	162	57	193	47	330
5	7	5	-	22	11	9	27	125	65	71	49
6	7	1	-	5	1	13	6	12	91	24	121
7	3	0	-	1	-	4	5	4	7	33	25
8	0	0	-	0	-	1		6	3	4	23
9	0	0	-	0	-	0		1		2	3
							-				
Abundance	423	183	-	312	305	454	769	1,147	1,414	1,300	2,322
SSB	41	20	-	33	36	46	90	91	122	122	246
CV	49	34	-	48	35	25	20	24	20	28	25
Design	AR	AR		R	R	R	R	R	R	AR	AR

*AR Adaptive random; R random

^Including stratum 20

Table 4.6.2.1. Celtic Sea and Division VIIj Herring. Catch in numbers.

Units : thousands

year

age	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969
1	1642	1203	2840	2129	772	297	7529	57	7093	7599	12197	9472
2	3742	25717	72246	16058	18567	51935	15058	70248	19559	39991	54790	93279
3	33094	2274	24658	32044	19909	13033	17250	9365	59893	20062	39604	55039
4	25746	19262	3779	5631	48061	4179	6658	15757	9924	49113	11544	33145
5	12551	11015	13698	2034	8075	20694	1719	3399	13211	9218	22599	12217
6	55010	34748	19057	14363	21304	9353	12790	25536	21776	26650	15345	28242

year

age	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
1	1319	12658	8422	23547	5507	12768	13317	8159	2800	11335	7162	39361
2	37260	23313	137690	38133	42808	15429	11113	12516	13385	13913	30093	21285
3	50087	37563	17855	55805	17184	17783	7286	8610	11948	12399	11726	21861
4	26481	41904	15842	7012	22530	7333	7011	5280	5583	8636	6585	5505
5	18763	18759	14531	9651	4225	9006	2872	1585	1580	2889	2812	4438
6	19746	21900	11051	12216	8445	7494	9777	3794	3356	3785	5215	5410

year

age	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
1	15339	13540	19517	17916	4159	5976	2307	8260	2702	1912	10410	1608
2	42725	102871	92892	57054	56747	67000	82027	42413	41756	63854	26752	94061
3	8728	26993	41121	36258	42881	43075	30962	68399	24634	38342	35019	9372
4	4817	3225	16043	16032	32930	23014	9398	19601	35258	16916	27591	10221
5	1497	1862	2450	2306	8790	14323	5963	8205	8116	28405	10139	4491
6	4492	1939	1872	618	1266	4651	4299	7875	6636	9004	28056	10085

year

age	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
1	12130	9450	3476	3849	5818	14274	9953	15724	3495	2711	4276	15419
2	35768	79159	61923	37440	41510	34072	77378	62153	26472	37006	9470	30710
3	61737	22591	38244	53040	27102	36086	18952	35816	18532	24444	46243	5766
4	3289	36541	7943	31442	28274	14642	12060	5953	5309	14763	21863	18666
5	3025	3686	16114	8318	13178	15515	5230	4249	1416	5719	8638	7349
6	8665	8772	6195	8720	7405	13305	9787	3771	2061	6628	2151	2495

year

age	2006	2007	2008	2009	2010	2011	2012
1	1460	8043	1306	10171	2468	6384	11596
2	33894	11028	12638	4465	20929	17151	61909
3	10914	36223	8255	12859	8183	33453	44375
4	2469	5509	15777	4887	15917	7301	37129
5	6261	1365	2360	8458	4846	13087	6241
6	2997	2509	921	1578	11592	11738	21037

Table 4.6.2.2. Celtic Sea and Division VIIj Herring. Weights at age in the catch.

Units : kg

age	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969
1	0.096	0.087	0.093	0.098	0.109	0.103	0.105	0.103	0.122	0.119	0.119	0.122
2	0.115	0.119	0.122	0.127	0.146	0.139	0.139	0.143	0.154	0.158	0.166	0.164
3	0.162	0.166	0.156	0.156	0.170	0.194	0.182	0.180	0.191	0.185	0.196	0.200
4	0.185	0.185	0.191	0.185	0.187	0.205	0.215	0.212	0.212	0.217	0.215	0.217
5	0.205	0.200	0.205	0.207	0.210	0.217	0.225	0.232	0.237	0.243	0.235	0.237
6	0.224	0.220	0.222	0.224	0.234	0.241	0.235	0.249	0.250	0.257	0.257	0.252

age	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
1	0.128	0.117	0.132	0.125	0.141	0.137	0.137	0.134	0.127	0.127	0.117	0.115
2	0.162	0.166	0.170	0.174	0.180	0.187	0.174	0.185	0.189	0.174	0.174	0.172
3	0.200	0.200	0.194	0.205	0.210	0.215	0.205	0.212	0.217	0.212	0.207	0.210
4	0.225	0.225	0.220	0.215	0.225	0.240	0.235	0.222	0.240	0.230	0.237	0.245
5	0.240	0.245	0.245	0.245	0.237	0.251	0.259	0.243	0.279	0.253	0.259	0.267
6	0.262	0.261	0.265	0.269	0.264	0.269	0.278	0.271	0.288	0.282	0.273	0.287

age	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
1	0.115	0.109	0.093	0.104	0.112	0.096	0.097	0.106	0.099	0.092	0.096	0.092
2	0.154	0.148	0.142	0.140	0.155	0.138	0.132	0.129	0.137	0.128	0.123	0.129
3	0.194	0.198	0.185	0.170	0.172	0.186	0.168	0.151	0.153	0.168	0.150	0.155
4	0.237	0.220	0.213	0.201	0.187	0.192	0.203	0.169	0.167	0.182	0.177	0.180
5	0.262	0.276	0.213	0.234	0.215	0.204	0.209	0.194	0.188	0.190	0.191	0.201
6	0.279	0.305	0.249	0.256	0.252	0.245	0.224	0.208	0.214	0.219	0.205	0.211

age	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
1	0.097	0.088	0.088	0.093	0.099	0.090	0.092	0.082	0.096	0.089	0.080	0.077
2	0.135	0.126	0.118	0.124	0.121	0.120	0.111	0.107	0.115	0.102	0.130	0.102
3	0.168	0.151	0.147	0.141	0.153	0.149	0.148	0.139	0.139	0.128	0.134	0.142
4	0.179	0.178	0.159	0.157	0.163	0.167	0.168	0.162	0.156	0.146	0.151	0.147
5	0.190	0.188	0.185	0.172	0.173	0.180	0.185	0.177	0.185	0.165	0.159	0.158
6	0.214	0.210	0.210	0.198	0.194	0.191	0.193	0.194	0.201	0.191	0.186	0.174

age	2006	2007	2008	2009	2010	2011	2012
1	0.093	0.074	0.091	0.078	0.075	0.070	0.072
2	0.105	0.106	0.120	0.122	0.108	0.104	0.094
3	0.127	0.123	0.144	0.146	0.129	0.127	0.124
4	0.151	0.141	0.156	0.160	0.142	0.141	0.138
5	0.155	0.166	0.172	0.169	0.155	0.154	0.152
6	0.168	0.164	0.193	0.188	0.159	0.165	0.160

Table 4.6.2.3. Celtic Sea and Division VIIj Herring. Weights at age in the stock.

Units : kg

year

age	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969
1	0.096	0.087	0.093	0.098	0.109	0.103	0.105	0.103	0.122	0.119	0.119	0.122
2	0.115	0.119	0.122	0.127	0.146	0.139	0.139	0.143	0.154	0.158	0.166	0.164
3	0.162	0.166	0.156	0.156	0.170	0.194	0.182	0.180	0.191	0.185	0.196	0.200
4	0.185	0.185	0.191	0.185	0.187	0.205	0.215	0.212	0.212	0.217	0.215	0.217
5	0.205	0.200	0.205	0.207	0.210	0.217	0.225	0.232	0.237	0.243	0.235	0.237
6	0.224	0.220	0.222	0.224	0.234	0.241	0.235	0.249	0.250	0.257	0.257	0.252

year

age	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
1	0.128	0.117	0.132	0.125	0.141	0.137	0.137	0.134	0.127	0.127	0.117	0.115
2	0.162	0.166	0.170	0.174	0.180	0.187	0.174	0.185	0.189	0.174	0.174	0.172
3	0.200	0.200	0.194	0.205	0.210	0.215	0.205	0.212	0.217	0.212	0.207	0.210
4	0.225	0.225	0.220	0.215	0.225	0.240	0.235	0.222	0.240	0.230	0.237	0.245
5	0.240	0.245	0.245	0.245	0.237	0.251	0.259	0.243	0.279	0.253	0.259	0.267
6	0.262	0.261	0.265	0.269	0.264	0.269	0.278	0.271	0.288	0.282	0.273	0.287

year

age	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
1	0.115	0.109	0.093	0.104	0.112	0.096	0.097	0.106	0.099	0.092	0.096	0.092
2	0.154	0.148	0.142	0.140	0.155	0.138	0.132	0.129	0.137	0.128	0.123	0.129
3	0.194	0.198	0.185	0.170	0.172	0.186	0.168	0.151	0.153	0.168	0.150	0.155
4	0.237	0.220	0.213	0.201	0.187	0.192	0.203	0.169	0.167	0.182	0.177	0.180
5	0.262	0.276	0.213	0.234	0.215	0.204	0.209	0.194	0.188	0.190	0.191	0.201
6	0.279	0.305	0.249	0.256	0.252	0.245	0.224	0.208	0.213	0.219	0.205	0.211

year

age	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
1	0.097	0.088	0.088	0.093	0.099	0.090	0.092	0.082	0.096	0.078	0.077	0.074
2	0.135	0.126	0.118	0.124	0.121	0.120	0.111	0.107	0.115	0.100	0.127	0.103
3	0.168	0.151	0.147	0.141	0.153	0.149	0.148	0.139	0.139	0.130	0.133	0.145
4	0.179	0.178	0.159	0.157	0.163	0.167	0.168	0.162	0.156	0.141	0.151	0.143
5	0.190	0.188	0.185	0.172	0.173	0.180	0.185	0.177	0.184	0.156	0.156	0.155
6	0.214	0.210	0.210	0.198	0.194	0.191	0.193	0.194	0.201	0.168	0.187	0.167

year

age	2006	2007	2008	2009	2010	2011	2012
1	0.085	0.066	0.083	0.076	0.076	0.067	0.061
2	0.104	0.102	0.117	0.117	0.106	0.108	0.094
3	0.123	0.116	0.140	0.142	0.127	0.127	0.125
4	0.153	0.135	0.156	0.158	0.139	0.138	0.138
5	0.150	0.151	0.170	0.168	0.152	0.148	0.149
6	0.159	0.160	0.180	0.178	0.159	0.167	0.161

Table 4.6.2.4. Celtic Sea and Division VIIj Herring. Natural mortality.

Units : NA

year

age	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972
1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
4	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
5	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
6	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1

year

age	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
4	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
5	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
6	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1

year

age	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
4	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
5	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
6	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1

year

age	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
4	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
5	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
6	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1

Table 4.6.2.5. Celtic Sea and Division VIIj Herring. Proportion mature.

Units : NA

age \ year	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972
1	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
2	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
3	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
4	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
5	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
6	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0

age \ year	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
1	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
2	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
3	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
4	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
5	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
6	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0

age \ year	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
1	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
2	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
3	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
4	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
5	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
6	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0

age \ year	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
1	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
2	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
3	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
4	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
5	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
6	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0

Table 4.6.2.6. Celtic Sea and Division VIIj Herring. Fraction of harvest before spawning.

Units : NA

age	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972
1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
4	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
5	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
6	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2

age	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
4	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
5	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
6	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2

age	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
4	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
5	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
6	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2

age	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
1	0.551	0.551	0.551	0.551	0.551	0.551	0.551	0.551	0.551	0.551
2	0.551	0.551	0.551	0.551	0.551	0.551	0.551	0.551	0.551	0.551
3	0.551	0.551	0.551	0.551	0.551	0.551	0.551	0.551	0.551	0.551
4	0.551	0.551	0.551	0.551	0.551	0.551	0.551	0.551	0.551	0.551
5	0.551	0.551	0.551	0.551	0.551	0.551	0.551	0.551	0.551	0.551
6	0.551	0.551	0.551	0.551	0.551	0.551	0.551	0.551	0.551	0.551

Table 4.6.2.7. Celtic Sea and Division VIIj Herring. Fraction of natural mortality before spawning.

Units : NA

age	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972
1	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
2	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
3	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
4	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
6	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5

age	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
1	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
2	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
3	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
4	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
6	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5

age	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
1	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
2	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
3	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
4	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
6	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5

age	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
1	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
2	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
3	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
4	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
6	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5

Table 4.6.2.8. Celtic Sea and Division VIIj Herring. Survey indices.

FLT02: Celtic revised acoustic - Configuration

Celtic Sea and Division VIIj herring . Imported from VPA file.

min	max	plusgroup	minyear	maxyear	startf	endf
2	5	NA	2002	2012	1	1

Index type : number

FLT02: Celtic revised acoustic - Index Values

Units : NA

year

age	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
2	185200	61700	-1	137100	210500	70000	295000	112000	549000	479000	856000
3	150600	60400	-1	28200	47800	220000	111000	210000	156000	299000	615000
4	29700	17200	-1	54200	13500	31000	162000	57000	193000	47000	330000
5	6600	5400	-1	21600	11000	9000	27000	125000	65000	71000	49000

FLT02: Celtic revised acoustic - Index Variance (Inverse Weights)

Units : NA

year

age	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
2	1	1	1	1	1	1	1	1	1	1	1
3	1	1	1	1	1	1	1	1	1	1	1
4	1	1	1	1	1	1	1	1	1	1	1
5	1	1	1	1	1	1	1	1	1	1	1

Table 4.6.2.9. Celtic Sea and Division VIIj Herring. Stock object configuration.

min	max	plusgroup	minyear	maxyear	minfbar	maxfbar
1	6	6	1958	2012	2	5

Table 4.6.2.10. Celtic Sea and Division VIIj Herring. FLICA configuration settings.

```
sep.2       : NA
sep.gradual : TRUE
sr          : FALSE
sr.age      : 1
lambda.age  : 0.1 1 1 1 1 0
lambda.yr   : 1 1 1 1 1 1
lambda.sr   : 0
index.model : linear
index.cor   : 1
sep.nyr     : 6
sep.age     : 3
sep.sel     : 1
```

Table 4.6.2.11 Celtic Sea and Division VIIj Herring. FLR, R Software Versions.

```
R version 2.8.1 (2008-12-22)

Package  : FLICA
Version  : 1.4-12
Packaged : 2009-10-08 15:16:26 UTC; mpa
Built    : R 2.9.1; ; 2009-10-08 15:16:27 UTC; windows

Package  : FLAssess
Version  : 1.99-102
Packaged : Mon Mar 23 08:18:19 2009; mpa
Built    : R 2.8.0; i386-pc-mingw32; 2009-03-23 08:18:21; windows

Package  : FLCore
Version  : 2.2
Packaged : Tue May 19 19:23:18 2009; Administrator
Built    : R 2.8.1; i386-pc-mingw32; 2009-05-19 19:23:22; windows
```

Table 4.6.2.12. Celtic Sea and Division VIIj Herring. Stock summary.

Year	Recruitment Age 1	TSB	SSB	Fbar (Ages 2-5) f	Landings tonnes	Landings SOP
1958	288373	103700	73614	0.3966	22978	1.114
1959	837830	128408	69732	0.3408	15086	1.124
1960	185856	82550	58650	0.4947	18283	1.131
1961	210142	71131	49703	0.3100	15372	0.776
1962	537886	109309	59144	0.6557	21552	1.014
1963	270227	82363	53377	0.4526	17349	1.002
1964	1043566	159436	76250	0.2782	10599	1.023
1965	327806	141067	101991	0.2548	19126	1.162
1966	679877	182800	110738	0.3004	27030	0.962
1967	702422	191042	116417	0.3773	27658	1.109
1968	829536	206978	121112	0.3497	30236	0.994
1969	438644	171065	111653	0.5428	44389	1.006
1970	212938	119642	84961	0.4754	31727	1.004
1971	852710	164750	81779	0.7148	31396	1.038
1972	263048	112910	70178	0.7560	38203	0.994
1973	290193	87998	50778	0.7579	26936	1.046
1974	128521	56925	35244	0.8379	19940	1.023
1975	143143	45867	26301	0.7687	15588	0.930
1976	173512	45273	24406	0.6606	9771	1.060
1977	168125	43278	23658	0.5733	7833	0.998
1978	133883	40641	24429	0.5329	7559	1.088
1979	236786	51778	26336	0.6773	10321	0.995
1980	146966	43350	25628	0.7143	13130	0.930
1981	402717	68337	29930	1.0221	17103	0.986
1982	665373	104604	45077	0.7256	13000	0.987
1983	734069	129830	62115	0.7206	24981	0.955
1984	564655	112412	62120	0.9030	26779	1.009
1985	508250	108687	61286	0.5227	20426	0.976
1986	529559	119222	65520	0.6779	25024	0.999
1987	956849	148814	72186	0.7809	26200	1.004
1988	388948	109853	70550	0.4351	20447	0.996
1989	471462	110838	64580	0.5623	23254	0.998
1990	425497	98532	59496	0.4726	18404	1.010
1991	177221	70596	47619	0.7155	25562	0.987
1992	939386	125591	53654	1.0371	21127	1.047
1993	324272	87125	54981	0.6151	18618	0.999
1994	694262	120157	63426	0.4582	19300	1.005
1995	676645	119982	66791	0.5753	23305	0.998
1996	339848	91363	59809	0.4168	18816	0.998
1997	370991	83718	49968	0.6341	20496	1.004
1998	240786	65760	40753	0.6537	18041	1.002
1999	506060	77994	38459	0.8944	18485	1.002
2000	442034	73450	37066	0.9068	17191	1.000
2001	393052	62587	32913	0.8120	15269	1.006
2002	527809	80799	40574	0.3288	7465	0.999
2003	105670	47981	31500	0.4337	11536	0.998
2004	274962	50633	25520	0.6077	12743	1.008
2005	848467	86480	35251	0.4820	9494	0.998
2006	313288	71712	43986	0.2458	6944	0.998
2007	698959	87587	47422	0.2005	7636	1.000
2008	308671	90849	63421	0.1127	5872	1.000
2009	1263455	163298	87849	0.0828	5745	0.996
2010	1125320	187401	113374	0.1041	8370	0.998
2011	2402231	288026	157338	0.1087	11470	0.999
2012	474106	296392	159776	0.1510	21604	1.000

Table 4.6.2.13. Celtic Sea and Division VIIj Herring. Estimated fishing mortality.

Units : f

age	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967
1	0.00904	0.00227	0.0244	0.0161	0.00227	0.00174	0.0115	0.000275	0.0166	0.0172
2	0.18030	0.32966	0.3145	0.3234	0.32881	0.35922	0.1921	0.239488	0.2068	0.2073
3	0.42253	0.16812	0.6549	0.2379	0.92846	0.43382	0.2055	0.186079	0.3522	0.3609
4	0.54766	0.44194	0.4364	0.2847	0.63103	0.47477	0.3916	0.277934	0.2907	0.5165
5	0.43579	0.42333	0.5732	0.3939	0.73432	0.54274	0.3238	0.315593	0.3520	0.4246
6	0.43579	0.42333	0.5732	0.3939	0.73432	0.54274	0.3238	0.315593	0.3520	0.4246

age	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978
1	0.0235	0.0347	0.00984	0.0237	0.0518	0.136	0.0698	0.150	0.128	0.0793	0.0336
2	0.2849	0.4436	0.32088	0.4220	0.7157	0.640	0.7383	0.511	0.331	0.2958	0.3134
3	0.3472	0.5538	0.48908	0.6719	0.7269	0.794	0.7380	0.882	0.522	0.4953	0.5483
4	0.3451	0.5186	0.53787	0.9522	0.6400	0.676	0.8496	0.788	1.059	0.8639	0.6632
5	0.4218	0.6554	0.55365	0.8129	0.9415	0.922	1.0255	0.895	0.731	0.6384	0.6067
6	0.4218	0.6554	0.55365	0.8129	0.9415	0.922	1.0255	0.895	0.731	0.6384	0.6067

age	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
1	0.0782	0.0797	0.166	0.037	0.0295	0.056	0.0571	0.0125	0.00992	0.00942	0.0280
2	0.4075	0.5560	0.664	0.493	0.6859	0.519	0.4048	0.4585	0.50758	0.31511	0.4197
3	0.5763	0.7855	1.176	0.694	0.7296	0.712	0.4211	0.6580	0.83642	0.50232	0.5062
4	0.9540	0.6607	1.063	0.871	0.5678	1.361	0.6427	0.8061	0.87546	0.40864	0.6577
5	0.7715	0.8553	1.185	0.845	0.8992	1.020	0.6221	0.7890	0.90428	0.51427	0.6656
6	0.7715	0.8553	1.185	0.845	0.8992	1.020	0.6221	0.7890	0.90428	0.51427	0.6656

age	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
1	0.0101	0.0172	0.0177	0.00787	0.0280	0.0223	0.0163	0.0165	0.0388	0.0455
2	0.3344	0.6340	0.6454	0.38219	0.4248	0.4538	0.3452	0.4286	0.4370	0.6087
3	0.4953	0.6314	0.9794	0.53049	0.5002	0.5634	0.4438	0.6046	0.6893	0.9424
4	0.5055	0.7199	1.3341	0.84324	0.3388	0.5949	0.3731	0.7653	0.7280	0.9828
5	0.5552	0.8769	1.1897	0.70437	0.5691	0.6893	0.5050	0.7377	0.7604	1.0436
6	0.5552	0.8769	1.1897	0.70437	0.5691	0.6893	0.5050	0.7377	0.7604	1.0436

age	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
1	0.0362	0.065	0.0105	0.0413	0.0249	0.0291	0.0074	0.0129	0.00723	0.00531
2	0.6833	0.601	0.2545	0.2504	0.3444	0.4406	0.1381	0.1070	0.06015	0.04419
3	0.9159	0.880	0.3843	0.4218	0.6086	0.3898	0.2940	0.2253	0.12668	0.09306
4	0.9508	0.804	0.2829	0.5708	0.7902	0.5037	0.2724	0.2443	0.13735	0.10089
5	1.0773	0.963	0.3937	0.4919	0.6876	0.5941	0.2786	0.2253	0.12668	0.09306
6	1.0773	0.963	0.3937	0.4919	0.6876	0.5941	0.2786	0.2253	0.12668	0.09306

age	2010	2011	2012
1	0.00668	0.00697	0.0097
2	0.05554	0.05799	0.0806
3	0.11696	0.12212	0.1698
4	0.12680	0.13240	0.1840
5	0.11696	0.12212	0.1698
6	0.11696	0.12212	0.1698

Table 4.6.2.14. Celtic Sea and Division VIIj Herring. Estimated population abundance.

Units : NA

year

age	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967
1	288373	837830	185856	210142	537886	270227	1043566	327806	679877	702422
2	26136	105132	307520	66723	76070	197428	99238	379529	120560	245990
3	105216	16168	56011	166349	35770	40562	102120	60667	221283	72628
4	63867	56457	11189	23823	107363	11573	21521	68080	41236	127383
5	37202	33420	32837	6544	16215	51686	6514	13163	46653	27899
6	163054	105426	45683	46209	42778	23360	48464	98889	76900	80658

year

age	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977
1	829536	438644	212938	852710	263048	290193	128521	143143	173512	168125
2	253991	298084	155871	77568	306342	91889	93204	44094	45319	56162
3	148119	141511	141716	83776	37682	110939	35887	33000	19601	24122
4	41448	85699	66594	71147	35032	14914	41071	14046	11185	9523
5	68762	26559	46164	35189	24842	16714	6864	15889	5782	3511
6	46691	61396	48582	41081	18893	21157	13721	13222	19684	8405

year

age	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
1	133883	236786	146966	402717	665373	734069	564655	508250	529559	956849
2	57132	47628	80554	49925	125552	235877	262188	196418	176597	192396
3	30952	30936	23473	34224	19030	56819	88010	115596	97076	82716
4	12035	14646	14234	8762	8645	7786	22427	35344	62117	41161
5	3632	5610	5105	6652	2739	3275	3993	5205	16817	25102
6	7714	7350	9467	8109	8218	3410	3051	1395	2422	8151

year

age	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
1	388948	471462	425497	177221	939386	324272	694262	676645	339848	370991
2	348530	141744	168645	154961	64085	339531	118358	248362	243434	123003
3	85796	188409	69015	89426	60894	24898	171637	57333	116872	127696
4	29341	42507	92985	34434	38939	18723	11993	85215	26722	61393
5	15519	17643	19925	50752	15168	9280	7290	7733	42532	16650
6	11188	16934	16292	16088	41971	20840	20882	18403	16351	17455

year

age	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
1	240786	506060	442034	393052	527809	105670	274962	848467	313288	698959
2	134243	85205	177893	156840	135493	192138	37301	98669	303181	114403
3	59358	64239	34341	66543	63680	77820	110804	19582	47049	195639
4	57111	24393	20495	11251	22590	35503	41786	49363	10858	28709
5	25842	24954	8261	7167	4557	15405	18153	17156	26992	7482
6	14521	21399	15458	6360	6633	17853	4520	5825	12920	13045

year

age	2008	2009	2010	2011	2012
1	308671	1263455	1125320	2402231	474106
2	253846	112735	462336	411227	877591
3	76152	177075	79906	324004	287481
4	127862	54930	132094	58201	234777
5	20347	100847	44932	105289	46132
6	8125	18646	110255	107189	141392

Table 4.6.2.15. Celtic Sea and Division VIIj Herring. Survivors after terminal year.

Units : NA

age	2013
1	NA
2	172732
3	599786
4	198622
5	176725
6	143187

Table 4.6.2.16. Celtic Sea and Division VIIj Herring. Fitted selection pattern.

Units : NA

age	2007	2008	2009	2010	2011	2012
1	0.0571	0.0571	0.0571	0.0571	0.0571	0.0571
2	0.4748	0.4748	0.4748	0.4748	0.4748	0.4748
3	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
4	1.0842	1.0842	1.0842	1.0842	1.0842	1.0842
5	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
6	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

Table 4.6.2.17. Celtic Sea and Division VIIj Herring. Predicted catch in numbers.

Units : NA

age	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969
1	1642	1203	2840	2129	772	297	7529	57	7093	7599	12197	9472
2	3742	25717	72246	16058	18567	51935	15058	70248	19559	39991	54790	93279
3	33094	2274	24658	32044	19909	13033	17250	9365	59893	20062	39604	55039
4	25746	19262	3779	5631	48061	4179	6658	15757	9924	49113	11544	33145
5	12551	11015	13698	2034	8075	20694	1719	3399	13211	9218	22599	12217
6	55010	34748	19057	14363	21304	9353	12790	25536	21776	26650	15345	28242

age	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
1	1319	12658	8422	23547	5507	12768	13317	8159	2800	11335	7162	39361

2	37260	23313	137690	38133	42808	15429	11113	12516	13385	13913	30093	21285
3	50087	37563	17855	55805	17184	17783	7286	8610	11948	12399	11726	21861
4	26481	41904	15842	7012	22530	7333	7011	5280	5583	8636	6585	5505
5	18763	18759	14531	9651	4225	9006	2872	1585	1580	2889	2812	4438
6	19746	21900	11051	12216	8445	7494	9777	3794	3356	3785	5215	5410

year												
age	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
1	15339	13540	19517	17916	4159	5976	2307	8260	2702	1912	10410	1608
2	42725	102871	92892	57054	56747	67000	82027	42413	41756	63854	26752	94061
3	8728	26993	41121	36258	42881	43075	30962	68399	24634	38342	35019	9372
4	4817	3225	16043	16032	32930	23014	9398	19601	35258	16916	27591	10221
5	1497	1862	2450	2306	8790	14323	5963	8205	8116	28405	10139	4491
6	4492	1939	1872	618	1266	4651	4299	7875	6636	9004	28056	10085

year												
age	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
1	12130	9450	3476	3849	5818	14274	9953	15724	3495	2711	4276	15419
2	35768	79159	61923	37440	41510	34072	77378	62153	26472	37006	9470	30710
3	61737	22591	38244	53040	27102	36086	18952	35816	18532	24444	46243	5766
4	3289	36541	7943	31442	28274	14642	12060	5953	5309	14763	21863	18666
5	3025	3686	16114	8318	13178	15515	5230	4249	1416	5719	8638	7349
6	8665	8772	6195	8720	7405	13305	9787	3771	2061	6628	2151	2495

year							
age	2006	2007	2008	2009	2010	2011	2012
1	1460	5653	1407	4234	4737	10557	11596
2	33894	10056	12823	4215	21608	20045	58835
3	10914	35906	8230	14283	8009	33827	40795
4	2469	5933	15633	5021	14986	6876	37615
5	6261	1439	2306	8534	4724	11530	6864
6	2997	2509	921	1578	11592	11738	21037

Table 4.6.2.18. Celtic Sea and Division VIIj Herring. Catch residuals.

Units : thousands NA

year					
age	2007	2008	2009	2010	2011
1	0.3525	-0.074486622540329589	0.8764	-0.651944060621564403	-0.5030
2	0.0923	-0.014501360722790102	0.0577	-0.031929032787329684	-0.1559
3	0.0088	0.003058886448506862	-0.1051	0.021458024479200744	-0.0111
4	-0.0742	0.009184684134889109	-0.0270	0.060266197910096866	0.0600
5	-0.0529	0.023005831586475969	-0.0090	0.025468568476948450	0.1267
6	0.0000	-0.000000000000000111	0.0000	0.000000000000000222	0.0000

year	
age	2012
1	-0.000000033618923988
2	0.050924862243690146
3	0.084109158953640364
4	-0.012997752338640258
5	-0.095109889004664591
6	0.000000000000000222

Table 4.6.2.19. Celtic Sea and Division VIIj Herring. Predicted index values.

Celtic Sea Herring Acoustic

Units : NA NA

age	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
2	111342	158535	NA	67316	279913	108956	253353	114327	463575	411319	858155
3	74010	87108	NA	22634	59848	266543	114508	275366	121327	489422	414051
4	23616	27829	NA	41379	11470	31192	154601	68883	161411	70721	270923
5	3749	11488	NA	11552	24914	7284	21863	112066	48752	113651	47479

Table 4.6.2.20. Celtic Sea and Division VIIj Herring. Index residuals.

Celtic Sea Herring Acoustic

Units : NA

age	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
2	0.509	-0.944	NA	0.711	-0.285	-0.44245	0.1522	-0.0206	0.169	0.152	-0.00251
3	0.710	-0.366	NA	0.220	-0.225	-0.19191	-0.0311	-0.2710	0.251	-0.493	0.39563
4	0.229	-0.481	NA	0.270	0.163	-0.00619	0.0468	-0.1894	0.179	-0.409	0.19726
5	0.566	-0.755	NA	0.626	-0.818	0.21149	0.2110	0.1092	0.288	-0.470	0.03153

Table 4.6.2.21. Celtic Sea and Division VIIj Herring. Fit parameters.

	Value	Std.dev	Lower.95.pct.CL	Upper.95.pct.CL
F, 2007	0.2253	0.169	0.1619	0.314
F, 2008	0.1267	0.169	0.0910	0.176
F, 2009	0.0931	0.165	0.0674	0.129
F, 2010	0.1170	0.163	0.0850	0.161
F, 2011	0.1221	0.171	0.0874	0.171
F, 2012	0.1698	0.193	0.1163	0.248
Selectivity at age 1	0.0571	0.303	0.0315	0.103
Selectivity at age 2	0.4748	0.122	0.3739	0.603
Selectivity at age 4	1.0842	0.101	0.8893	1.322
Terminal year pop, age 1	1900424.2867	0.728	456310.7789	7914808.582
Terminal year pop, age 2	877590.2366	0.251	536846.4146	1434608.861
Terminal year pop, age 3	287480.0970	0.189	198418.3134	416518.036
Terminal year pop, age 4	234776.2940	0.169	168638.4362	326852.582
Terminal year pop, age 5	46130.6984	0.162	33594.3358	63345.242
Last true age pop, 2007	7481.1094	0.219	4867.9889	11496.944
Last true age pop, 2008	20346.0181	0.185	14146.3802	29262.641
Last true age pop, 2009	100845.8428	0.171	72081.2794	141089.116
Last true age pop, 2010	44931.4929	0.154	33217.2557	60776.816
Last true age pop, 2011	105288.4091	0.155	77669.7573	142728.000
Index 1, age 2 numbers, Q	1.4308	0.146	1.0750	1.904
Index 1, age 3 numbers, Q	2.0846	0.145	1.5678	2.772
Index 1, age 4 numbers, Q	1.5330	0.148	1.1464	2.050
Index 1, age 5 numbers, Q	1.3479	0.153	0.9985	1.819

Table 4.7.1.1. Herring in the Celtic Sea. Inputs to the Short Term Forecast.

2013

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
1	474106	1	0.5	0.551	0.5	0.068	0.008	0.072
2	172732	0.3	1	0.551	0.5	0.103	0.065	0.102
3	599786	0.2	1	0.551	0.5	0.126	0.136	0.127
4	198622	0.1	1	0.551	0.5	0.138	0.148	0.140
5	176725	0.1	1	0.551	0.5	0.150	0.136	0.154
6	143187	0.1	1	0.551	0.5	0.162	0.136	0.161

2014

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
1	474106	1	0.5	0.551	0.5	0.068	0.008	0.072
2	-	0.3	1	0.551	0.5	0.103	0.065	0.102
3	-	0.2	1	0.551	0.5	0.126	0.136	0.127
4	-	0.1	1	0.551	0.5	0.138	0.148	0.140
5	-	0.1	1	0.551	0.5	0.150	0.136	0.154
6	-	0.1	1	0.551	0.5	0.162	0.136	0.161

2015

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
1	474106	1	0.5	0.551	0.5	0.068	0.0078	0.0723
2	-	0.3	1	0.551	0.5	0.103	0.065	0.102
3	-	0.2	1	0.551	0.5	0.126	0.136	0.127
4	-	0.1	1	0.551	0.5	0.138	0.148	0.140
5	-	0.1	1	0.551	0.5	0.150	0.136	0.154
6	-	0.1	1	0.551	0.5	0.162	0.136	0.161

Population vector (N) in 2013 is taken from the final assessment with 1 ringers replaced by geometric mean recruitment from 1981 to 2010. Numbers of 2 ringers are derived from geometric mean reduced by natural and fishing mortality at age 1 from the assessment. Mean weights in the catch (CWt) and stock (SWt), natural mortality (M) and mortality proportions (PM, PF) are means over the last 3 years. The selection vector (Sel) is that from the assessment.

Table 4.7.1.2. Herring in the Celtic Sea. Single Option Tables from the Short Term Forecast.

a). Catch(2014) = Zero

Age	N(2013)	N(2014)	N(2015)	F(2013)	F(2014)	F(2015)
1	474106	474106	474106	0.008	0.00	0.00
2	172732	173106	174414	0.063	0.00	0.00
3	599786	120197	128240	0.132	0.00	0.00
4	198622	430407	98409	0.143	0.00	0.00
5	176725	155783	389449	0.132	0.00	0.00
6	143187	253713	370527	0.132	0.00	0.00

b). Catch(2014) = 2013 TAC -15% (14620 t)

Age	N(2013)	N(2014)	N(2015)	F(2013)	F(2014)	F(2015)
1	474106	474106	474106	0.01	0.01	0.01
2	172732	173106	173370	0.06	0.05	0.05
3	599786	120197	121994	0.13	0.11	0.11
4	198622	430407	88586	0.14	0.11	0.11
5	176725	155783	347486	0.13	0.11	0.11
6	143187	253713	333542	0.13	0.11	0.11

c). Catch(2014) = 2013 TAC sq (17200 t)

Age	N(2013)	N(2014)	N(2015)	F(2013)	F(2014)	F(2015)
1	474106	474106	474106	0.008	0.007	0.007
2	172732	173106	173175	0.063	0.059	0.059
3	599786	120197	120856	0.132	0.125	0.125
4	198622	430407	86855	0.143	0.135	0.135
5	176725	155783	340129	0.132	0.125	0.125
6	143187	253713	327024	0.132	0.125	0.125

d). Catch(2014) = 2013 TAC +15% (19780 t)

Age	N(2013)	N(2014)	N(2015)	F(2013)	F(2014)	F(2015)
1	474105.8	474105.8	474105.8	0.007527	0.008279723	0.00828
2	172731.5	173105.8	172975.6	0.062605	0.068861288	0.068861
3	599786.4	120197.2	119706.4	0.131842	0.145017782	0.145018
4	198621.9	430407.3	85124.6	0.14294	0.15722545	0.157225
5	176724.7	155782.8	332788.3	0.131842	0.145017782	0.145018
6	143186.6	253712.6	320508.2	0.131842	0.145017782	0.145018

e). Catch(2014) = 2013 TAC + 25% (21500 t)

Age	N(2013)	N(2014)	N(2015)	F(2013)	F(2014)	F(2015)
1	474105.8	474105.8	474105.8	0.007527	0.009058508	0.009059
2	172731.5	173105.8	172841	0.062605	0.075338331	0.075338
3	599786.4	120197.2	118933.5	0.131842	0.158658051	0.158658
4	198621.9	430407.3	83971.36	0.14294	0.172013962	0.172014
5	176724.7	155782.8	327903	0.131842	0.158658051	0.158658
6	143186.6	253712.6	316166	0.131842	0.158658051	0.158658

f). Catch(2014) = 2013 TAC + 30% (22360 t)

Age	N(2013)	N(2014)	N(2015)	F(2013)	F(2014)	F(2015)
1	474105.8	474105.8	474105.8	0.007527	0.009451828	0.009452
2	172731.5	173105.8	172773	0.062605	0.07860952	0.07861
3	599786.4	120197.2	118545.1	0.131842	0.165546981	0.165547
4	198621.9	430407.3	83394.88	0.14294	0.179482806	0.179483
5	176724.7	155782.8	325463.1	0.131842	0.165546981	0.165547
6	143186.6	253712.6	313995.5	0.131842	0.165546981	0.165547

g). Fbar(2014) = 0.25

Age	N(2013)	N(2014)	N(2015)	F(2013)	F(2014)	F(2015)
1	474105.8	474105.8	474105.8	0.007527	0.016042173	0.016042
2	172731.5	173105.8	171638.1	0.062605	0.133420485	0.13342
3	599786.4	120197.2	112222.4	0.131842	0.280975617	0.280976
4	198621.9	430407.3	74303.51	0.14294	0.304628281	0.304628
5	176724.7	155782.8	287178.4	0.131842	0.280975617	0.280976
6	143186.6	253712.6	279765	0.131842	0.280975617	0.280976

h). Fbar(2014) = 0.23

Age	N(2013)	N(2014)	N(2015)	F(2013)	F(2014)	F(2015)
1	474106	474106	474106	0.008	0.015	0.015
2	172732	173106	171859	0.063	0.123	0.123
3	599786	120197	113427	0.132	0.258	0.258
4	198622	430407	75993	0.143	0.280	0.280
5	176725	155783	294263	0.132	0.258	0.258
6	143187	253713	286125	0.132	0.258	0.258

i). Fbar(2013) = 0.19

Age	N(2013)	N(2014)	N(2015)	F(2013)	F(2014)	F(2015)
1	474106	474106	474106	0.008	0.012	0.012
2	172732	173106	172300	0.063	0.101	0.101
3	599786	120197	115874	0.132	0.214	0.214
4	198622	430407	79487	0.143	0.232	0.232
5	176725	155783	308961	0.132	0.214	0.214
6	143187	253713	299281	0.132	0.214	0.214

j). Fbar(2014) = 0.15

Age	N(2013)	N(2014)	N(2015)	F(2013)	F(2014)	F(2015)
1	474105.8	474105.8	474105.8	0.008	0.010	0.010
2	172731.5	173105.8	172743.1	0.063	0.080	0.080
3	599786.4	120197.2	118374.2	0.132	0.169	0.169
4	198621.9	430407.3	83141.88	0.143	0.183	0.183
5	176724.7	155782.8	324392.8	0.132	0.169	0.169
6	143186.6	253712.6	313042.9	0.132	0.169	0.169

Table 4.7.1.3. Herring in the Celtic Sea. Catch option table from the Short Term Forecast.

Rationale	Fbar (2013)	Catch (2013)	SSB (2013)	Fbar (2014)	Catch (2014)	SSB (2014)	SSB (2015)
Catch(2014) = Zero	0.12	19063	156355	0	0	156805	165458
Catch(2014) = 2013 TAC -15% (14620 t)	0.12	19063	156355	0.09	14620	148682	144047
Catch(2014) = 2013 TAC sq (17200 t)	0.12	19063	156355	0.11	17200	147209	140396
Catch(2014) = 2013 TAC +15% (19780 t)	0.12	19063	156355	0.13	19780	145724	136784
Catch(2014) = 2013 TAC + 25% (21500 t)	0.12	19063	156355	0.14	21500	144727	134398
Catch(2014) = 2013 TAC + 30% (22360 t)	**0.12**	**19063**	**156355**	**0.15**	**22360**	**144226**	**133211**
Fbar(2014) = 0.25	0.12	19063	156355	0.25	35942	136113	115063
Fbar(2014) = 0.23	0.12	19063	156355	0.23	33416	137652	118353
Fbar(2013) = 0.19	0.12	19063	156355	0.19	28194	140790	125279
Fbar(2014) = 0.15	0.12	19063	156355	0.15	22737	144006	132692

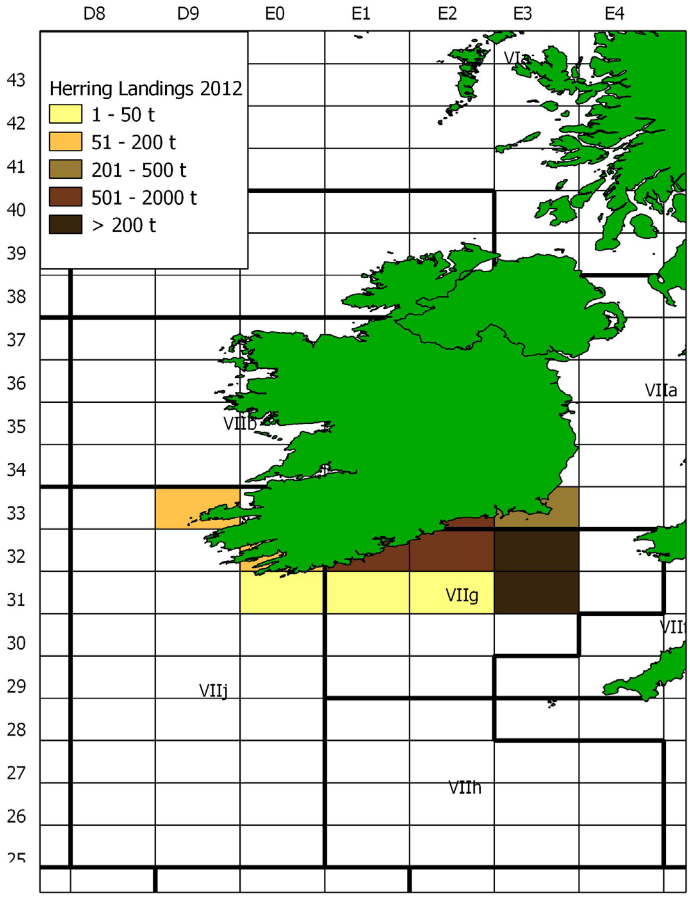


Figure 4.1.2.1. Herring in the Celtic Sea. Irish official herring catches by statistical rectangle in 2012/2013.

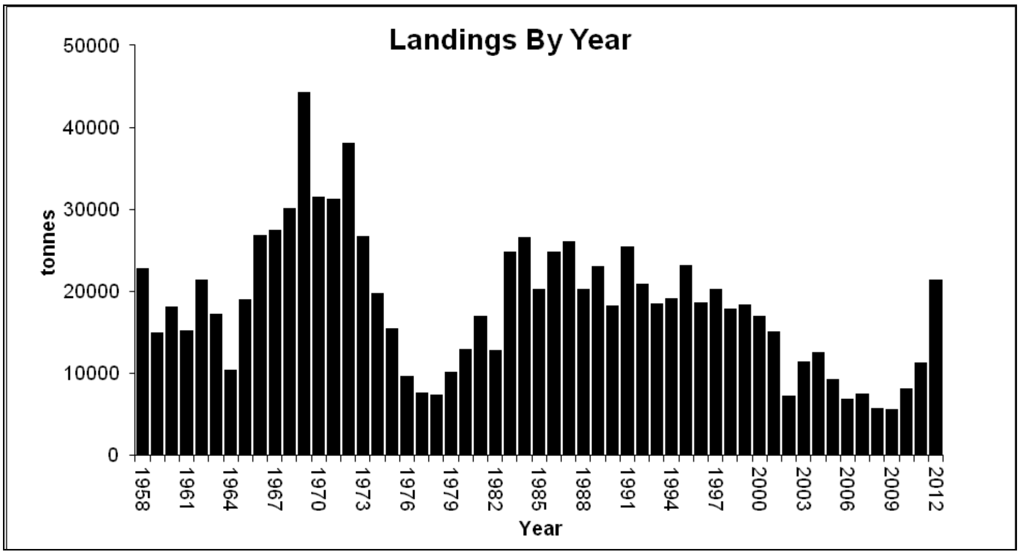


Figure 4.1.3.1. Herring in the Celtic Sea. Working Group estimates of herring landings per season.

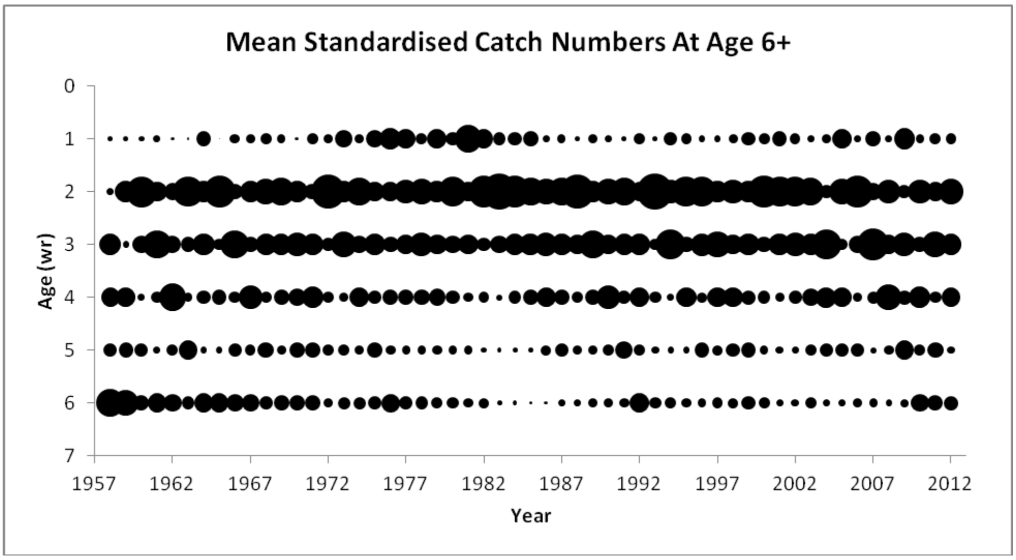


Figure 4.2.1.1. Herring in the Celtic Sea. Catch numbers-at-age standardised by yearly mean. 6-ringer is the plus group.

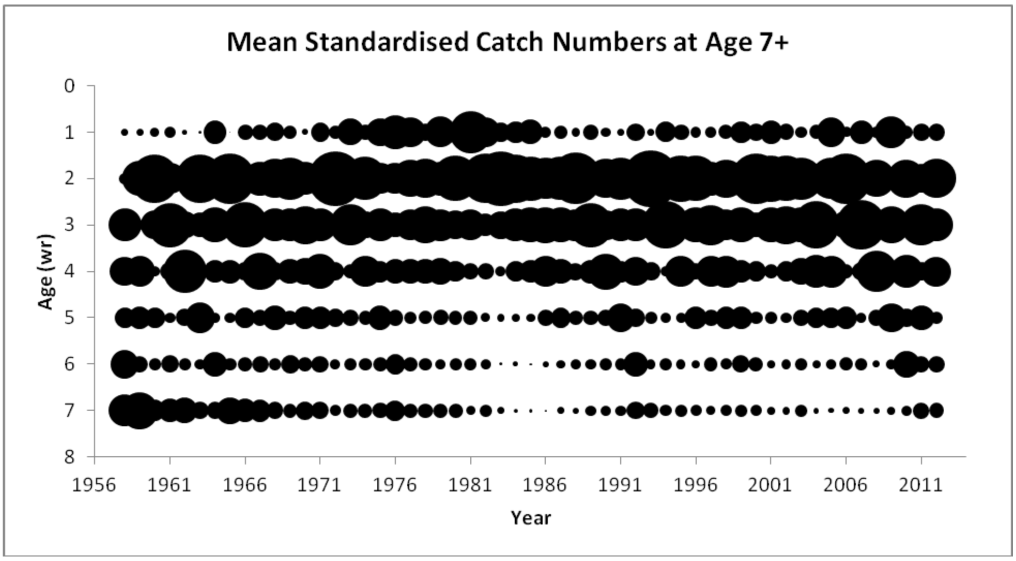


Figure 4.2.1.2. Herring in the Celtic Sea. Catch numbers-at-age standardised by yearly mean. 7-ringer is the plus group.

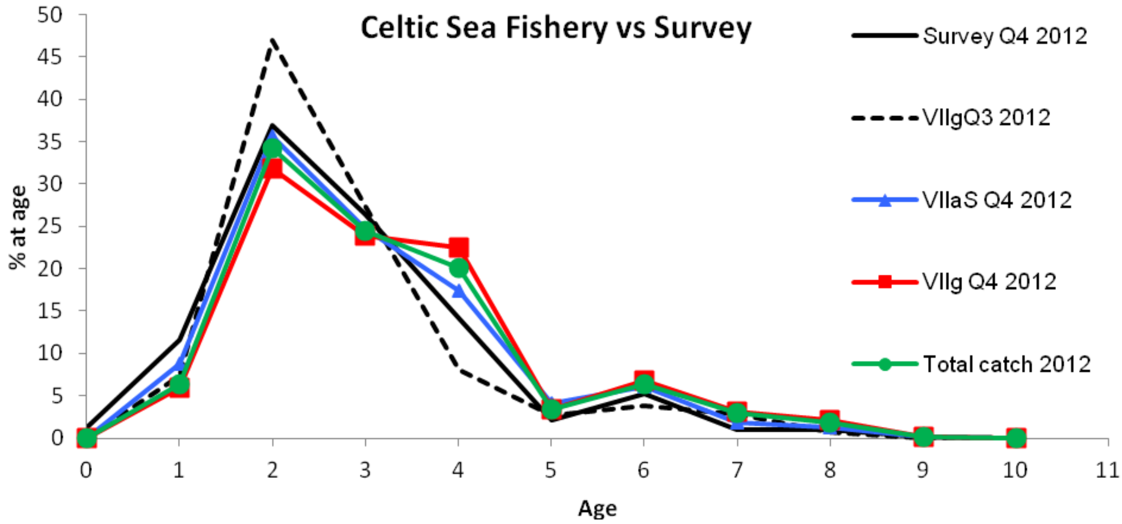


Figure 4.2.1.3. Herring in the Celtic Sea. The percentage age composition in the survey and the commercial fishery 2012/2013.

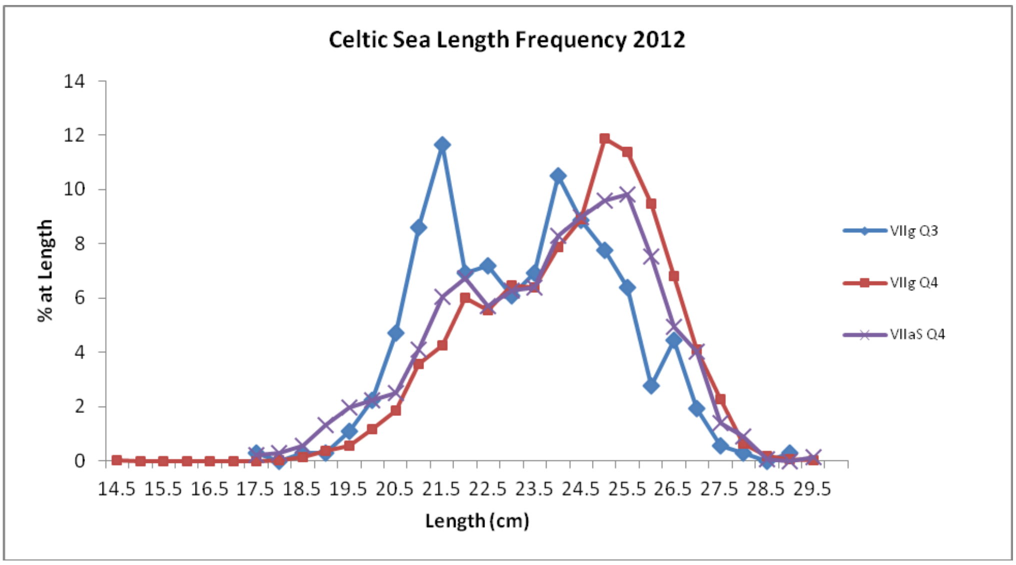


Figure 4.2.1.4. Herring in the Celtic Sea. Length-frequency data from sampling in 2012/2013.

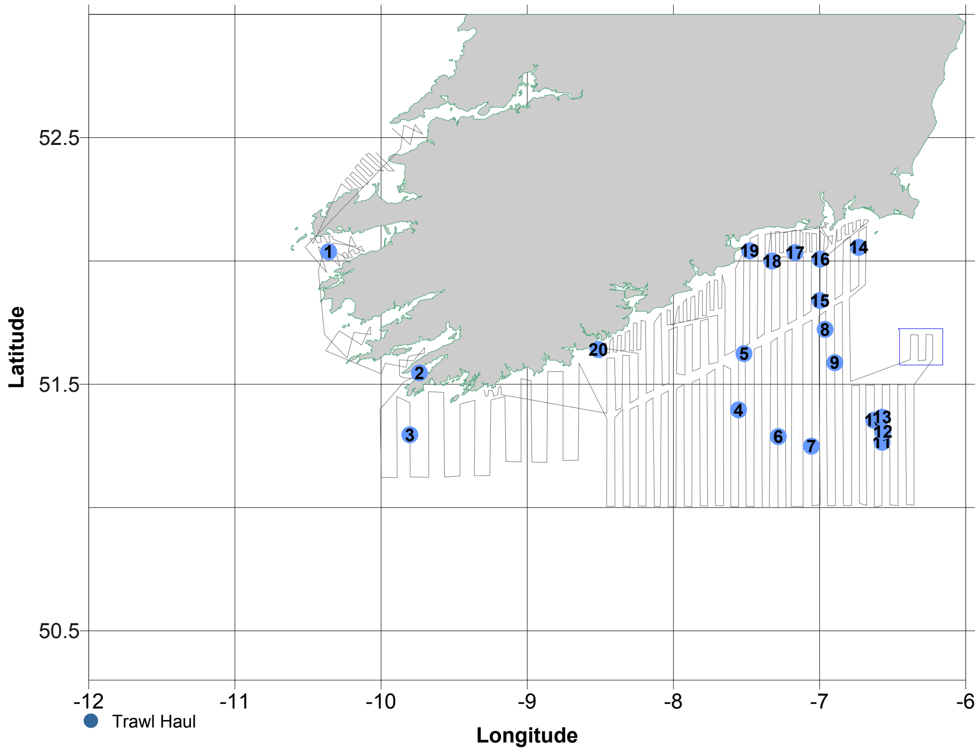


Figure 4.3.1.1a. Herring in the Celtic Sea. Acoustic survey track and haul positions from acoustic survey, October 2012.

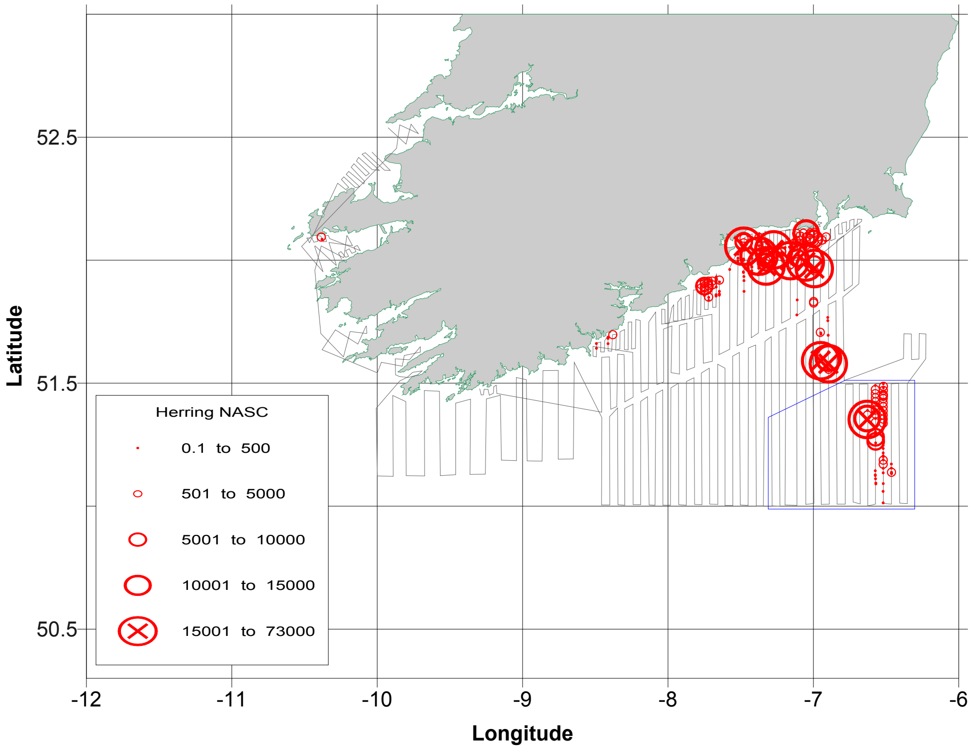


Figure 4.3.1.1b. Herring in the Celtic Sea. Acoustic survey total Sa values attributed to herring in the acoustic survey, October 2012. The blue box indicates the location the additional smalls stratum.

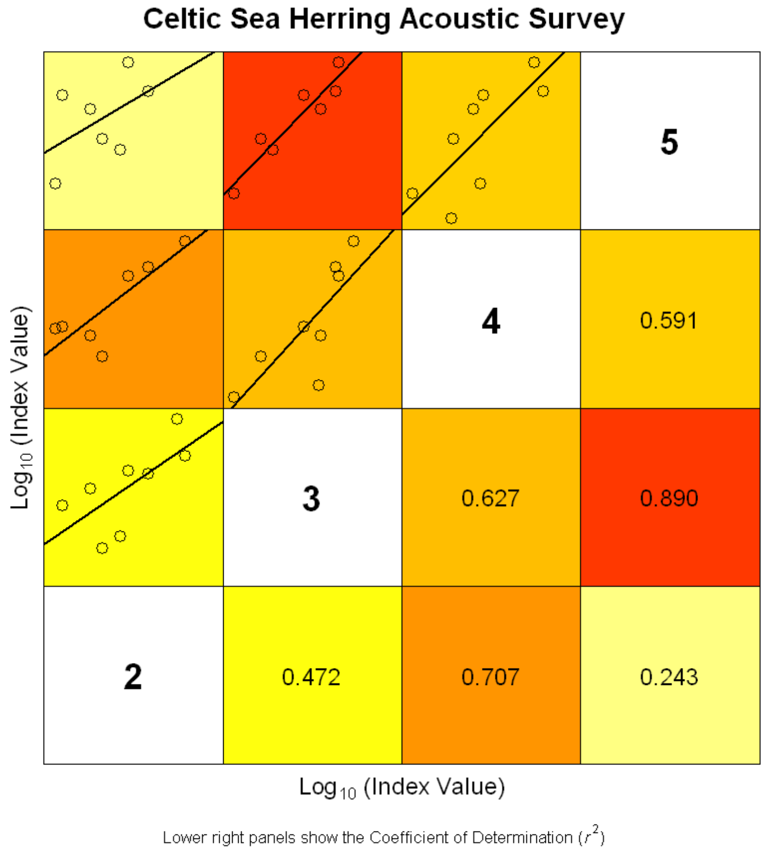


Figure 4.3.1.2. Herring in the Celtic Sea. Internal consistency between ages in the Celtic Sea Herring Acoustic survey time series.

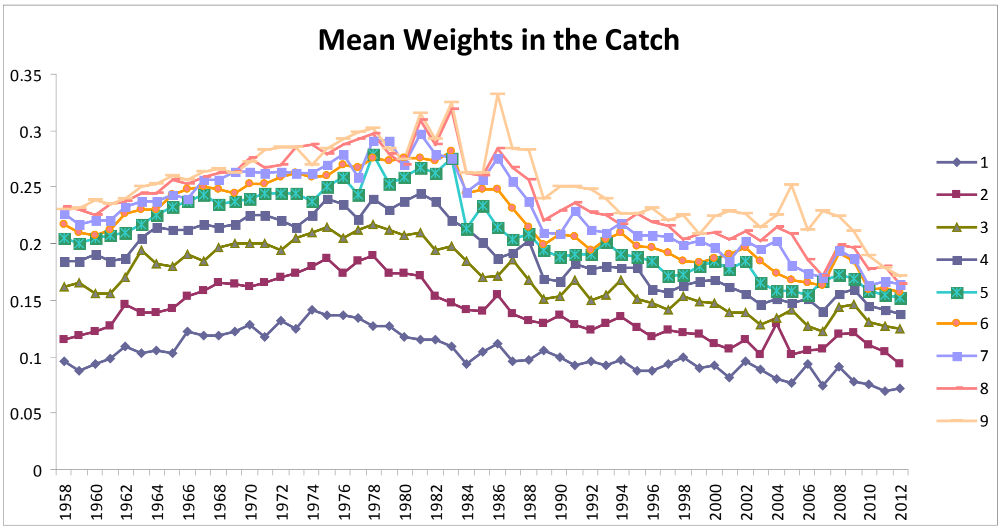


Figure 4.4.1.1. Herring in the Celtic Sea. Trends over time in mean weight-at-age in the catch from 1-9+.

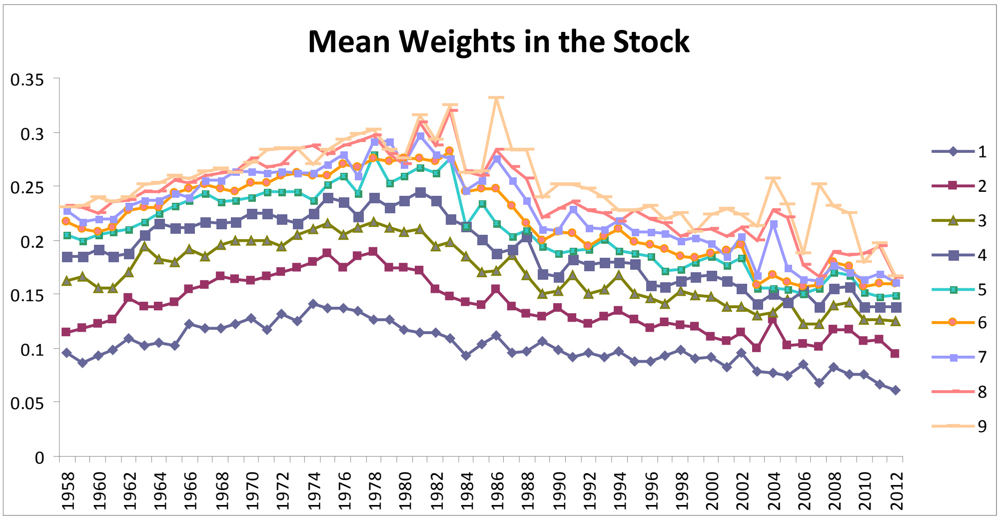


Figure 4.4.1.2. Herring in the Celtic Sea. Trends over time in mean weight-at-age in the stock at spawning time from 1-9+.

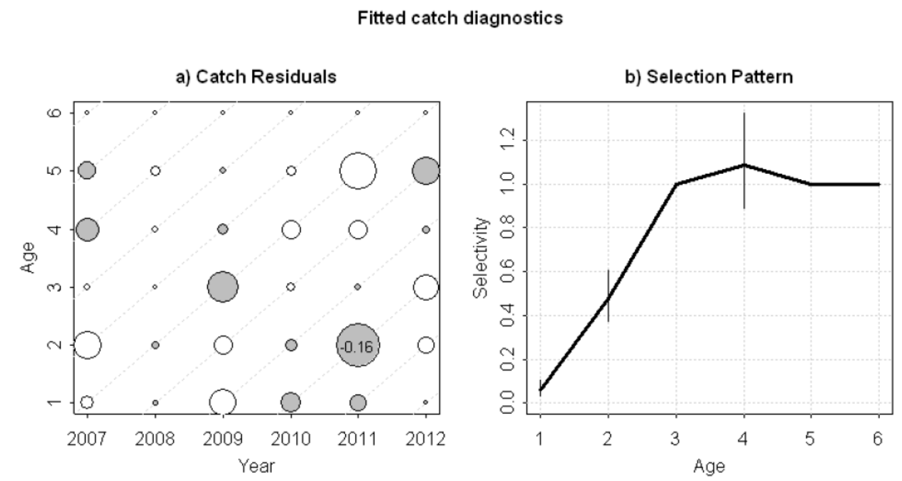


Figure 4.6.1.1. Herring in the Celtic Sea. Illustration of model diagnostics for 6+ run with the 2012 survey a) bubble plot of catch residuals in separable period; b) estimated selection relative to 3-ringers with 95% confidence intervals.

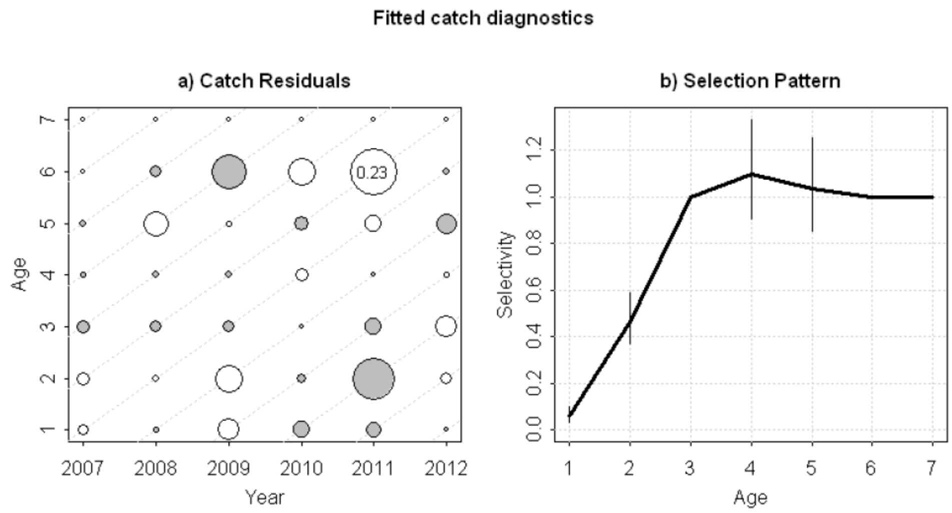


Figure 4.6.1.2. Herring in the Celtic Sea. Illustration of model diagnostics for 7+ run with the 2012 survey a) bubble plot of catch residuals in separable period; b) estimated selection relative to 3-ringers with 95% confidence intervals.

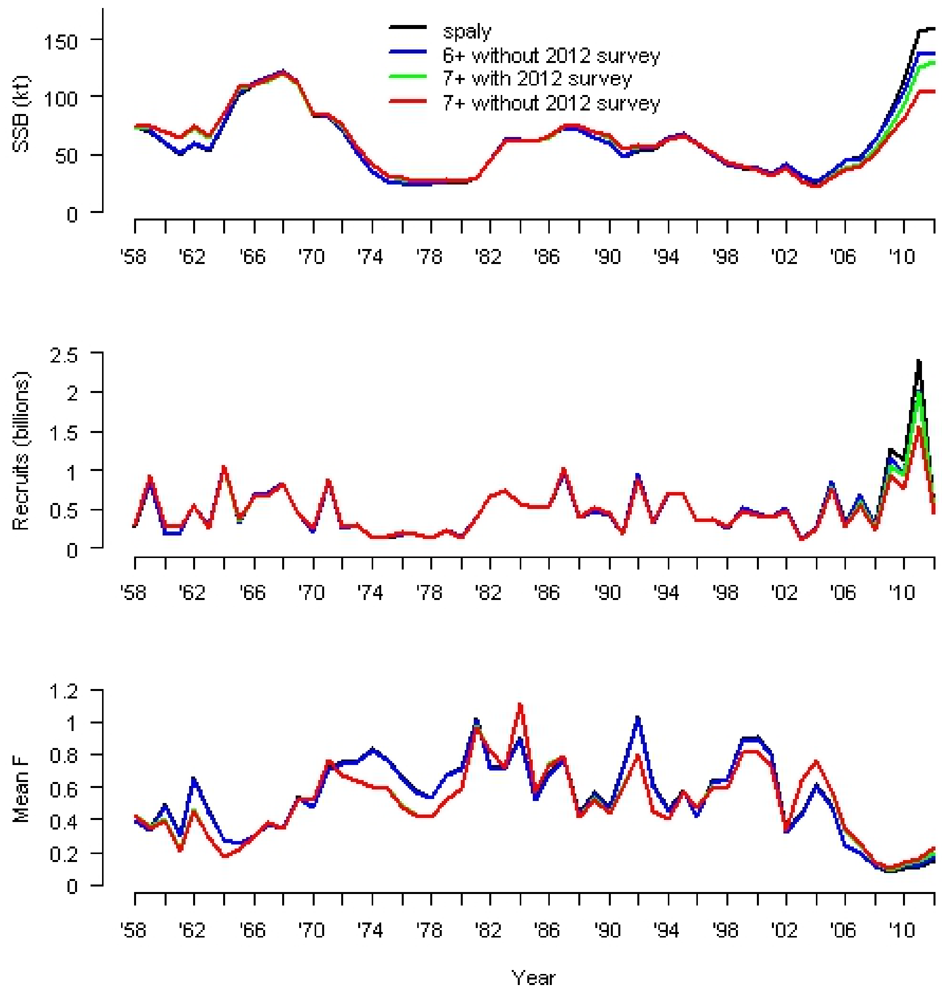


Figure 4.6.1.3. Herring in the Celtic Sea. Stock summary plots for the assessment runs using 6+ and 7+. SSB (top), Recruitment (middle), Mean F 2-5 (bottom).

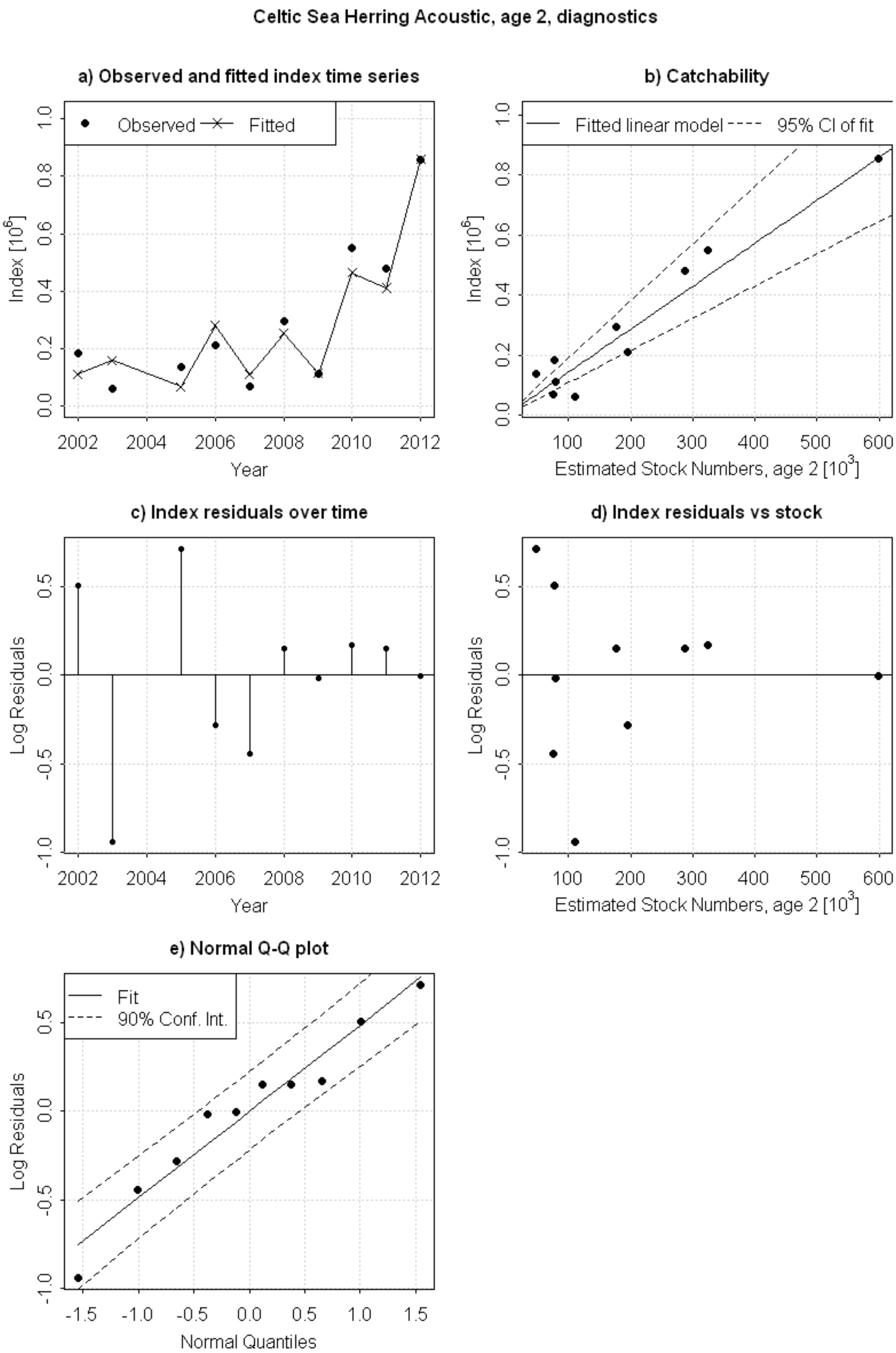


Figure 4.6.2.1. Herring in the Celtic Sea. Diagnostics from the Celtic Sea Herring Acoustic survey age 2 from the final run.

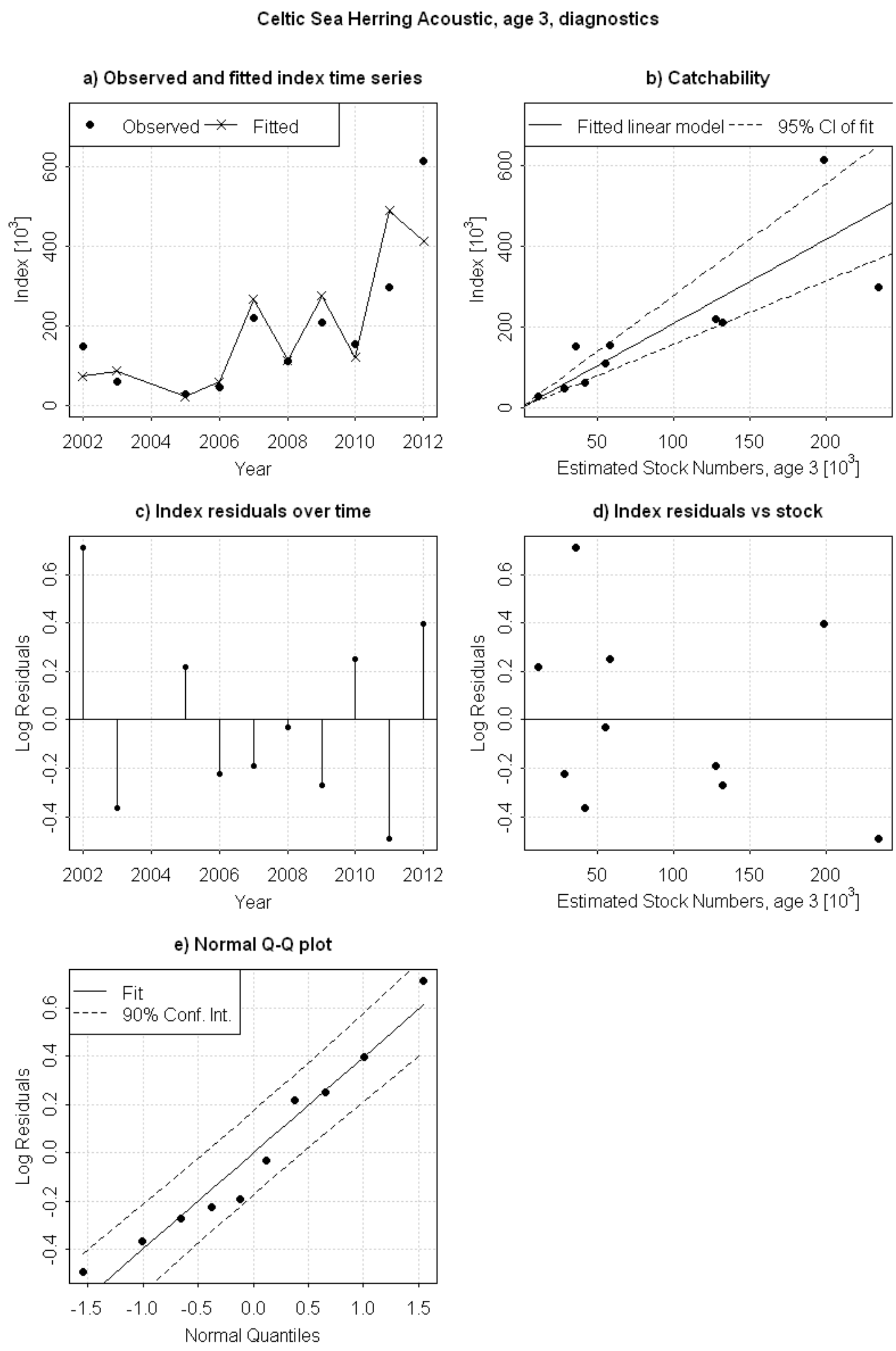


Figure 4.6.2.2. Herring in the Celtic Sea. Diagnostics from the Celtic Sea Herring Acoustic survey age 3 from the final run.

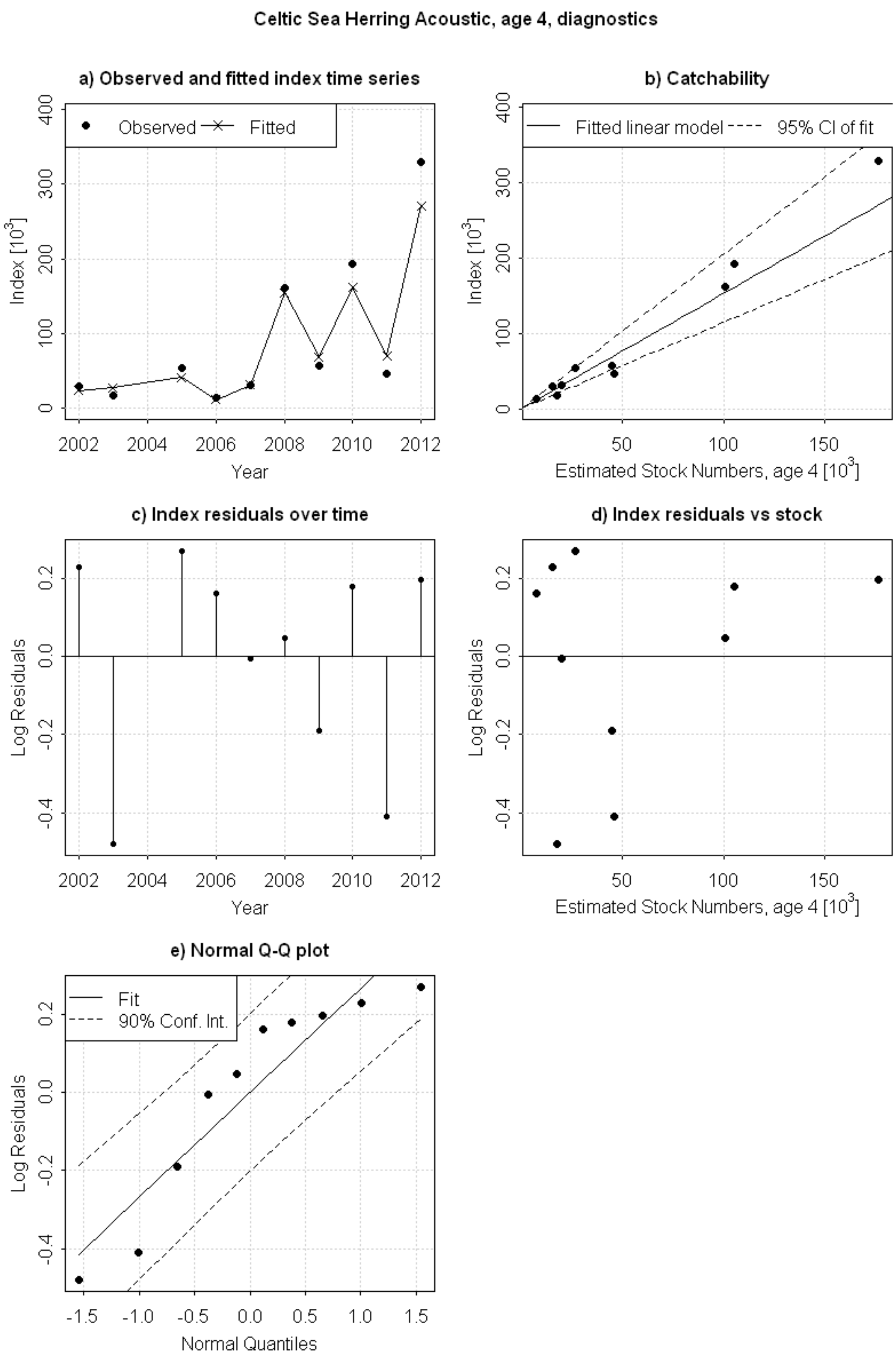


Figure 4.6.2.3. Herring in the Celtic Sea. Diagnostics from the Celtic Sea Herring Acoustic survey age 4 from the final run.

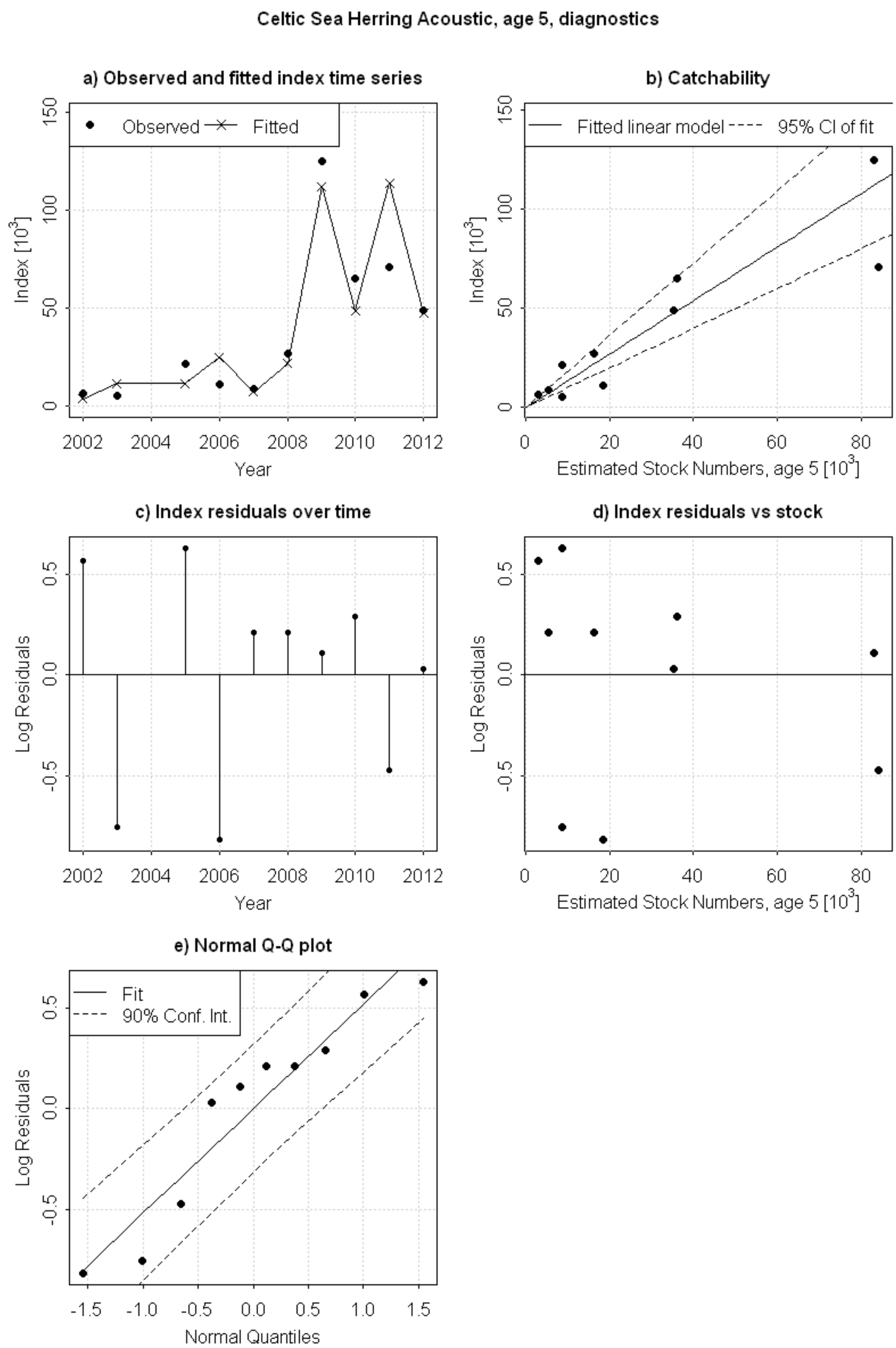


Figure 4.6.2.4. Herring in the Celtic Sea. Diagnostics from the Celtic Sea Herring Acoustic survey age 5 from the final run.

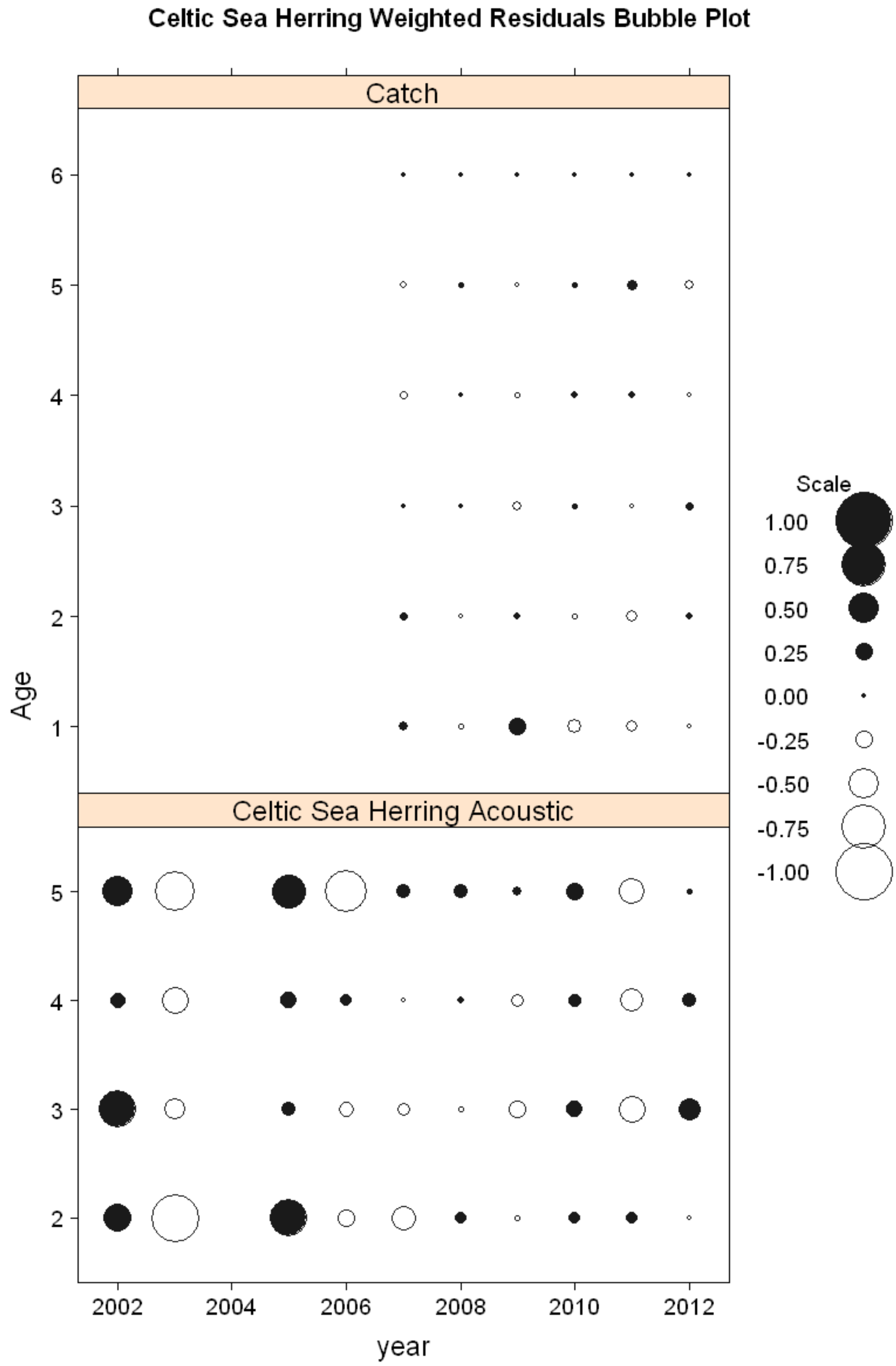


Figure 4.6.2.5. Herring in the Celtic Sea. Weighted catch and survey residuals from the final assessment.

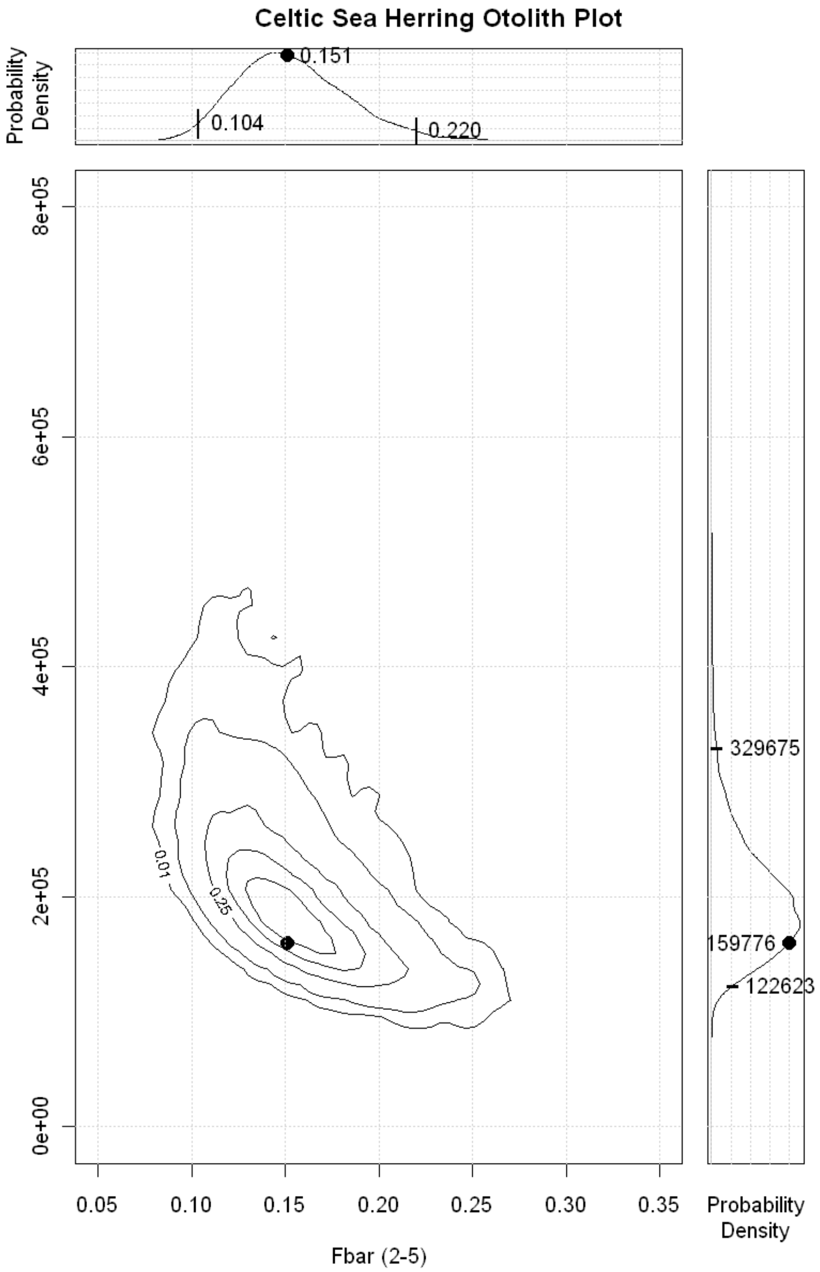


Figure 4.6.2.6. Herring in the Celtic Sea. Uncertainty plot showing the results of parametric boot-strapping from FLICA.

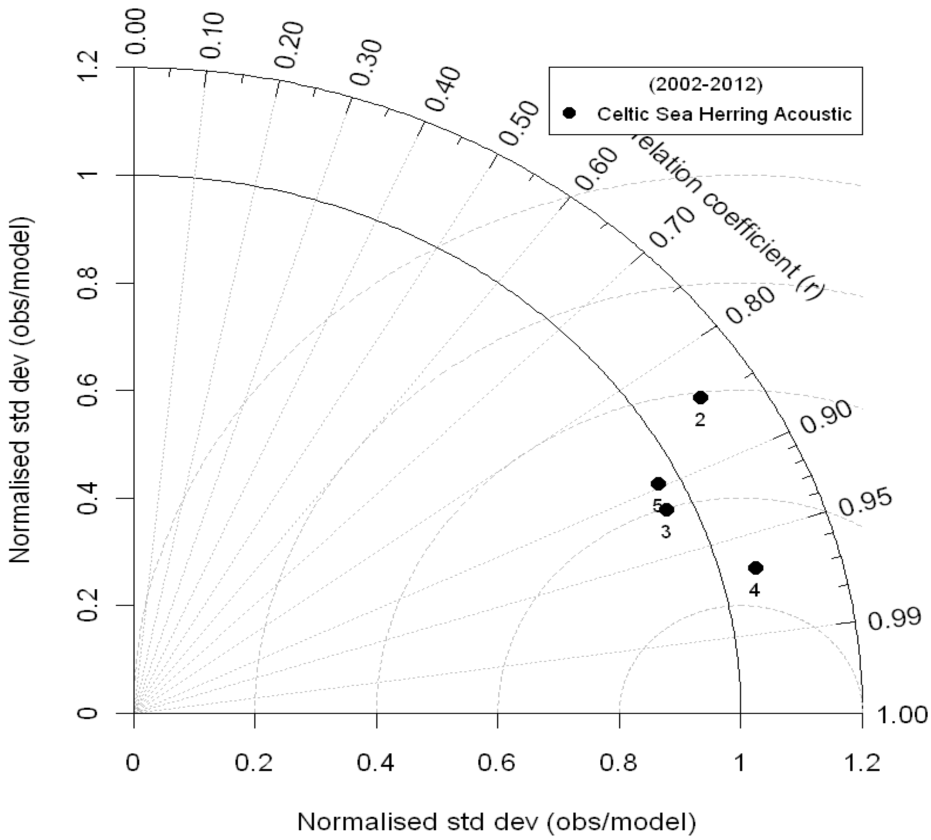


Figure 4.6.2.7. Herring in the Celtic Sea. Taylor Diagram. The plot is not Cartesian but rather polar in nature: the angular axis plots the correlation coefficient between observations and the modelled values. The radial axis represents the standard deviation of the observations normalized by the standard deviation of the modelled values. The point corresponding to 1.0 on the horizontal axis represents a perfect fit between the model and the observations – the closer to this point the better. Points are labelled according to the survey and the age of the time series. All time series are truncated to allow comparison on a common basis.

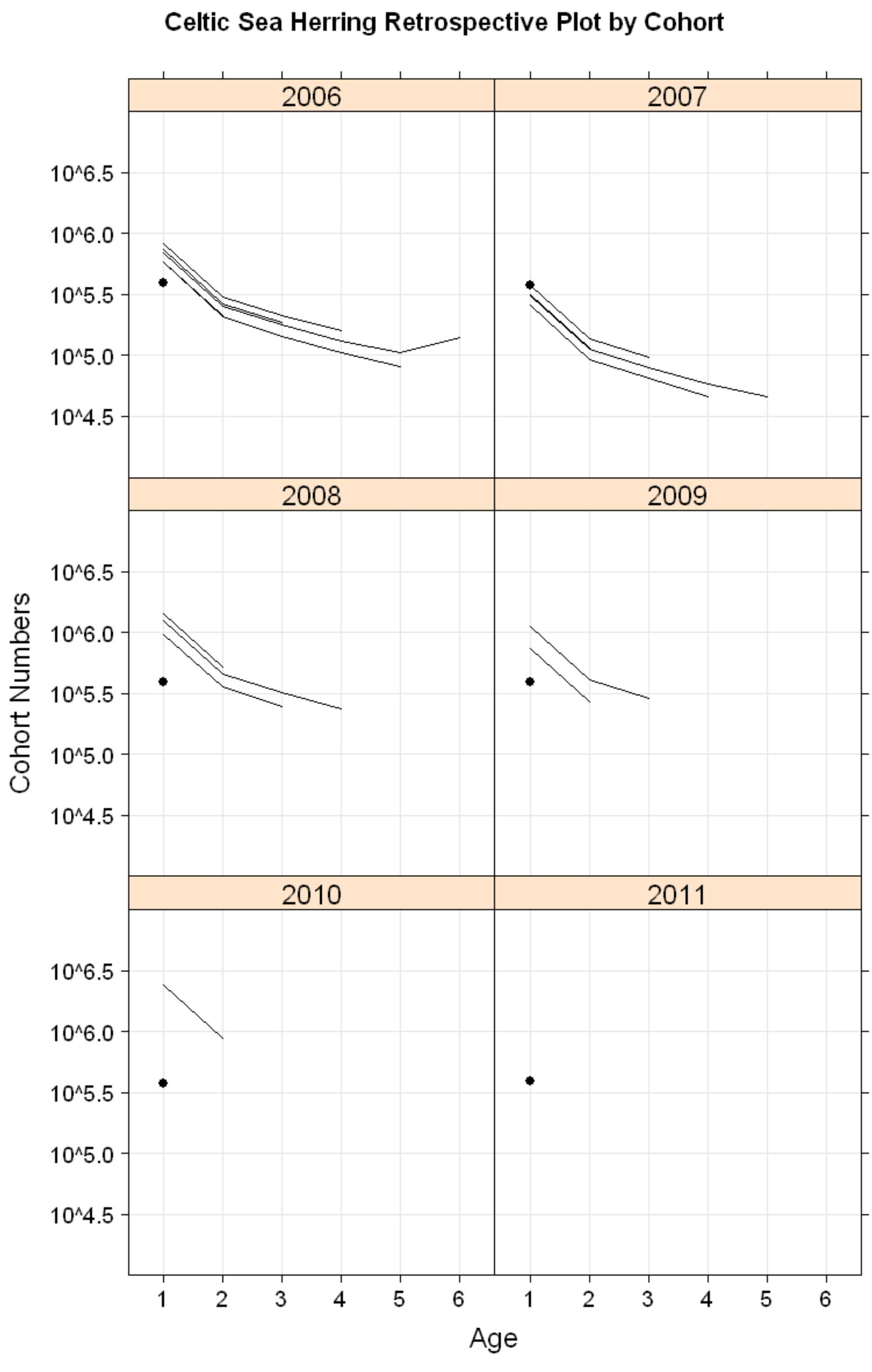


Figure 4.6.2.8. Herring in the Celtic Sea. Retrospectives by cohort.

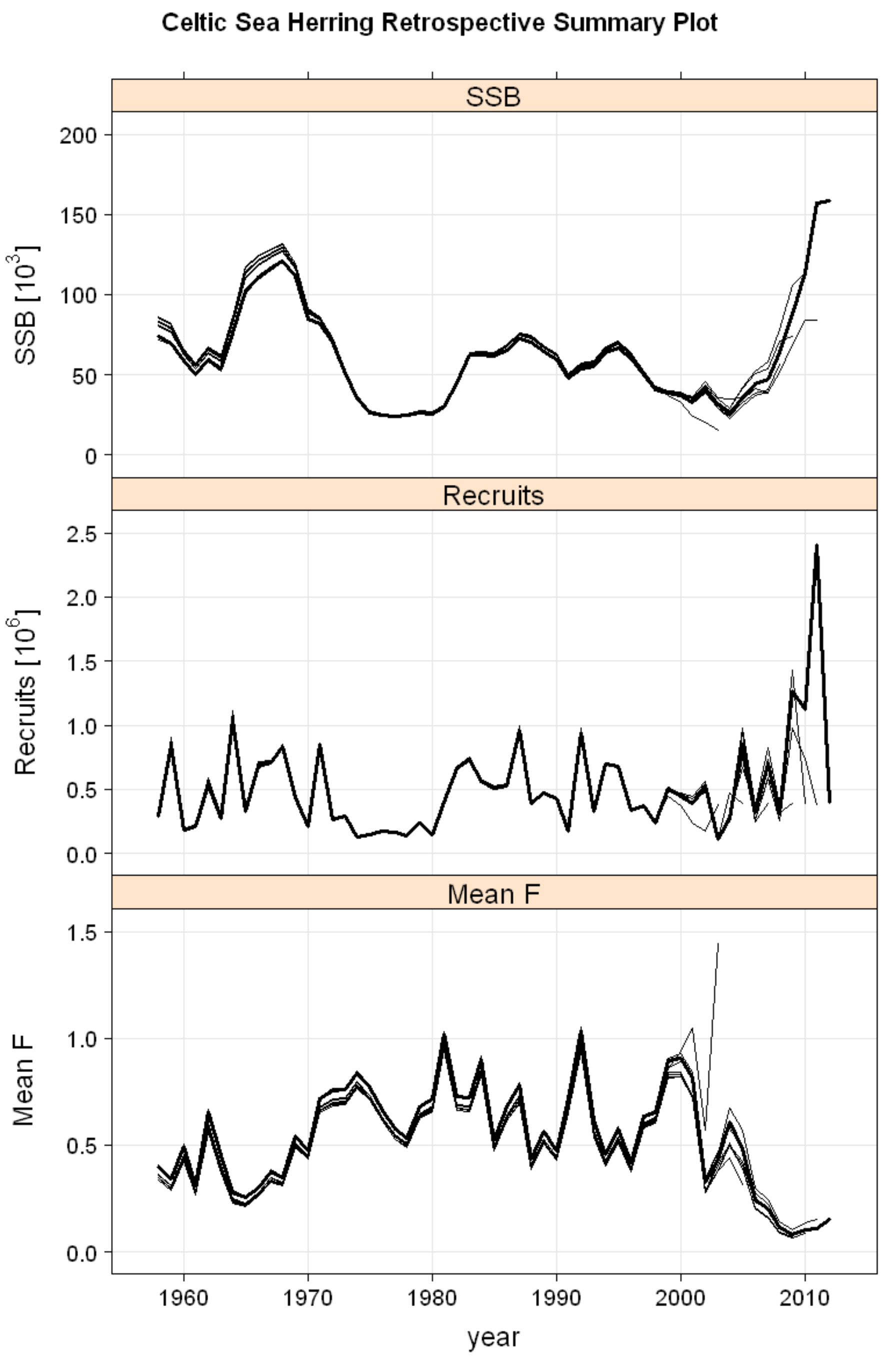


Figure 4.6.2.9. Herring in Celtic Sea. Analytical retrospective pattern. This retrospective includes 2003 and 2005-2012. 2004 data are excluded.

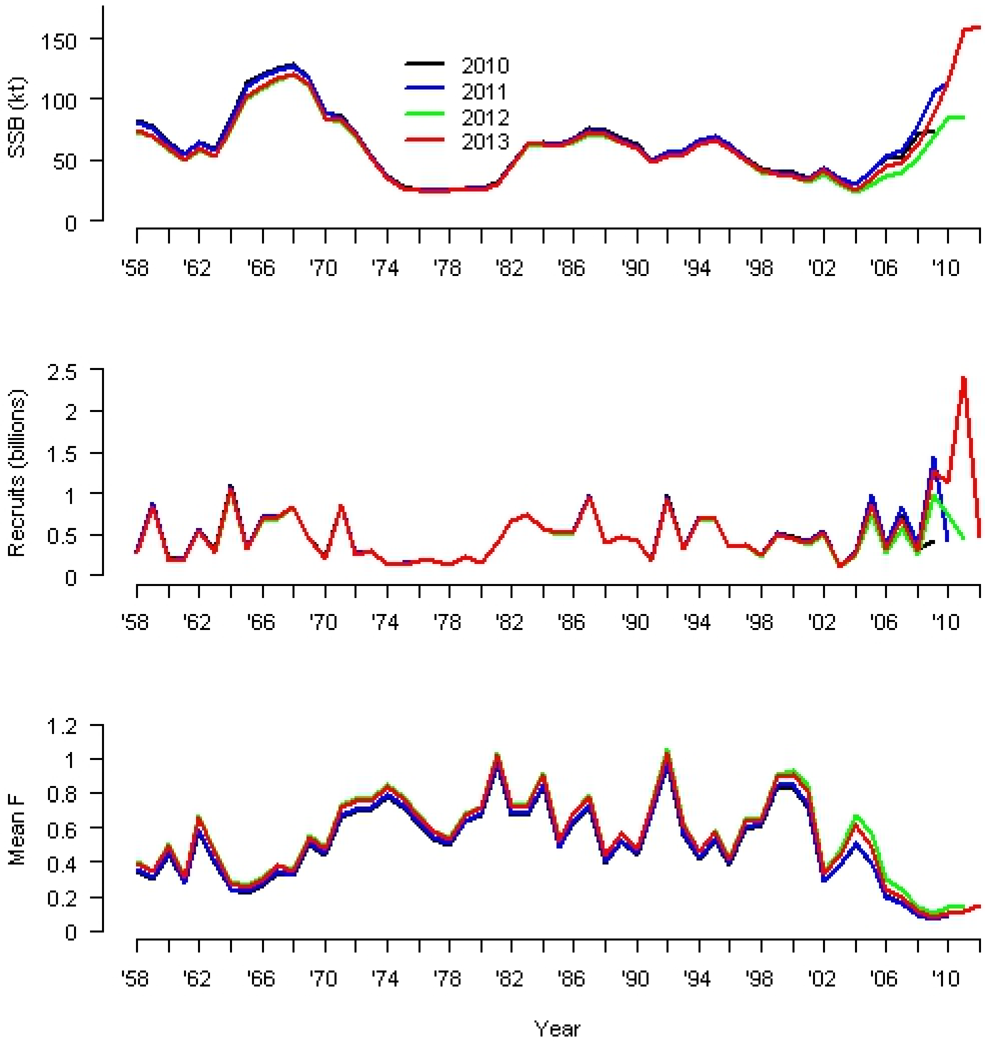


Figure 4.6.2.10. Herring in the Celtic Sea. Historical Retrospective based on the final assessments in 2010, 2011 2012 and 2013. SSB (top), Recruitment (middle), Mean F 2-5 (bottom).

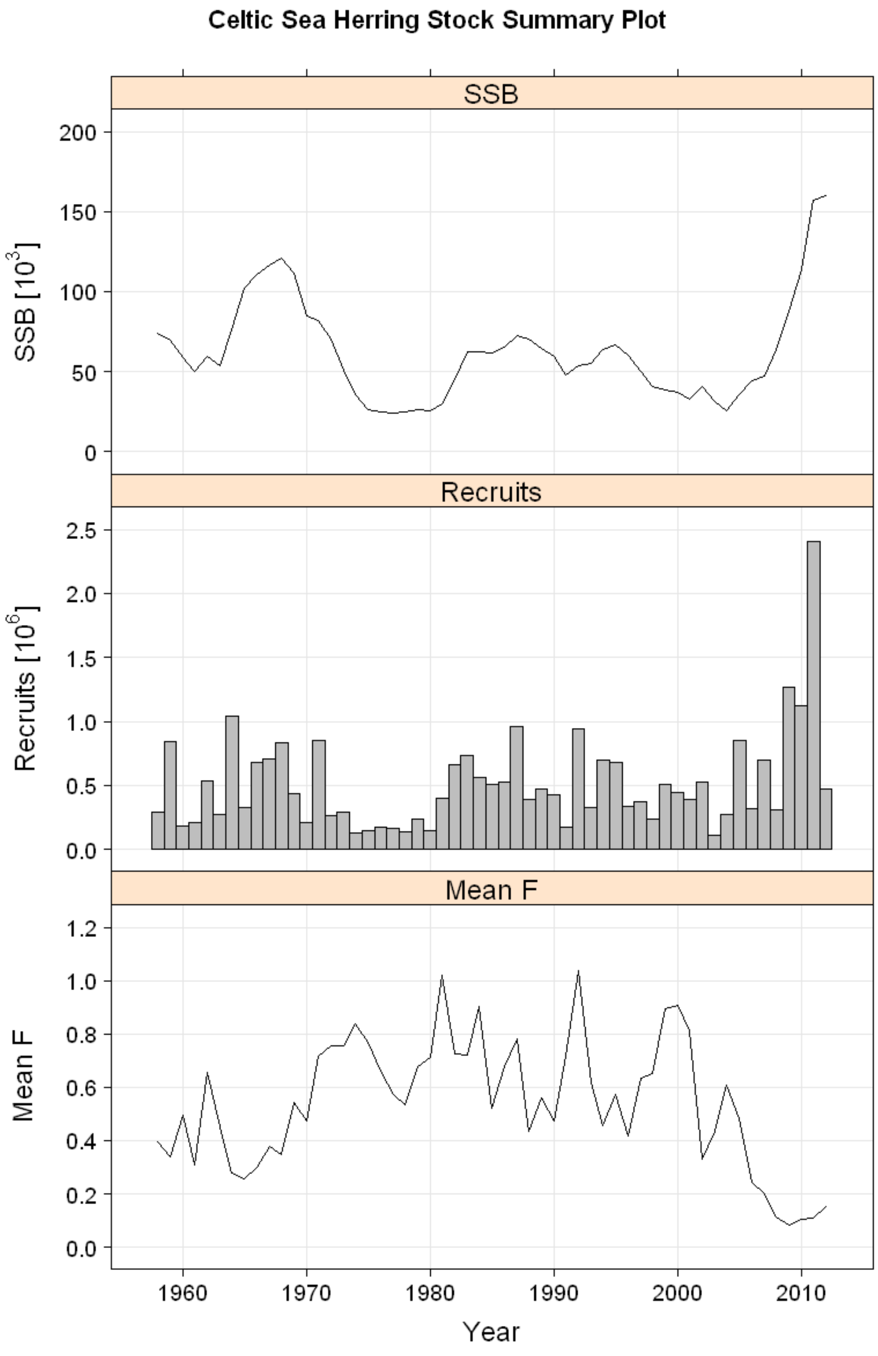


Figure 4.6.1.11. Herring in the Celtic Sea. Stock Summary plot for 6+ run including the 2012 survey.

5 Herring in Division VIa (North)

The location of the area occupied by the stock is shown in Figure 5.1.1.

5.1 The Fishery

5.1.1 Advice applicable to 2012 and 2013

ICES reported in 2012 that the stock over recent years had been fluctuating at a low level and was being exploited close to F_{MSY}.

The basis for the advice was the management plan accepted by the European Commission on 18 December 2008 (Council Regulation (EC) 1300/2008).

The International TAC for 2013 is 27 480 t, which is in accordance with the agreed plan (see Section H.1 in the Stock Annex). The International TAC in 2012 was 22 900 t.

5.1.2 Changes in the VIa (North) fishery.

Historically, catches have been taken from this area by three fisheries, (i) a Scottish domestic pair trawl fleet and the Northern Irish fleet; (ii) the Scottish single boat trawl and purse seine fleets and (iii) an international freezer-trawler fishery. The details of these fleets are described in the Stock Annex. In recent years the fisheries prosecuted by these latter two fleets have become more similar both temporally and spatially.

In 2012, the Scottish trawl fleet fished predominantly in areas similar to the freezer trawler fishery, and hardly in the coastal areas in the southern part of VIa (N) (Figure 5.1.2). Recently (since 2006) the majority of the fishery has been prosecuted in quarter 3. This pattern has continued in 2012, with 85% of catches taken in quarter 3. Since 2006, the quarter 3 fishery has concentrated in the northern part of the area. This trend has continued in 2012, with around 97% of the quarter 3 catches taken north of the Hebrides and to the north of Scotland. Prior to 2006 there was a much more even distribution of effort, both temporally and spatially. The contraction is believed to be related to the economics of fishing rather than a contraction of the stock.

5.1.3 Regulations and their affects

New sources of information on catch misreporting from the UK became available in 2006 (see the 2007 HAWG report). This information was associated with a stricter enforcement regime that may have been responsible for the lack of that area misreporting since 2006. In 2012 there was little evidence of misreporting of catch from IVa into VIa (North).

There are no new changes to the regulations relevant to the fishery in VIa (North).

5.1.4 Catches in 2012 and allocation of catches to area for VIa (N)

For 2012 the preliminary report of official catches corresponding to the VIa (N) herring stock unit total 21 296 t, compared with the TAC of 22 900 t. The Working Group's estimates of reallocated catches are 2 780 t. Various observer programs suggest that discarding is not a problem (see, for example, Van Helmond & Van Overzee WD to HAWG 2013). In 2012, there was no reported discarding.

The Working Group's best estimate of removals from the stock in 2012 is 18 516 t (Table 5.1.1).

5.2 Biological Composition of the Catch

Catch and sample data, by country and by period (quarter), are detailed in Table 5.2.1. The number of samples used to allocate an age-distribution for the VIa (N) catches declined again in 2012, after reasonable sampling levels in the last couple of years. There were only 14 samples available in 2012, obtained from the Scottish (12), Irish (1), and Northern Irish (1) fleets. 53% of the catch was taken by the Scottish and Northern Irish RSW fleet; 43% was taken by the international freezer trawler fleet; the remaining 4% was caught by the Irish fleet. 12 of the 14 samples obtained came from quarter 3; all from the RSW fleet. However, in 2012 the international freezer trawler fleet and RSW fleets fished in very similar areas. The available samples were used to allocate a mean age distribution (using the sample number weighting) to unsampled catches, in the same or adjacent quarters, as no sampling data were available for other quarters. The allocation of age distributions to unsampled catches, and the calculation of total international catch-at-age and mean weight-at-age in the catches were made using the ‘sallocl’ programme (Patterson 1998a).

Catch number- and weight-at-age information is given in the ICA stock report section 5.6 (cf Table 5.6.1 and 5.6.2 respectively). One large year class (2008) dominated the catch (49% of the catch); at 3-rings in 2012; see the catch-at-age bubble plot in 2012 (Figure 5.2.1). The 2009 year class (as 2-ringers in 2012) contributed 16% of the catch. Two further year classes (2006 and 2007 at 5- and 4-ringers respectively in 2012) comprised an additional 20% of the catch. The plus group remains larger than normal as this group contains the large 2000 year class, at 11-ringer in 2012. The 2003 year class still appears relatively weak; the weak 2002 year class has now moved into the plus group. 1-ring herring in the catch are observed intermittently and are rarely representative of year class strength.

5.3 Fishery Independent Information

5.3.1 Acoustic survey – MSHAS_N

The survey values for number-, weight- and proportion mature-at-age in the stock were revised in 2009 and reported in the 2010 HAWG (see Section 5.6.1 in Anon (2010). The 2012 survey values are in Table 5.3.1.

The 2012 acoustic survey was carried out on three separate vessels (see text table below), with Celtic Explorer surveying the area south from 58°30’ N to 56°N, part of the area surveyed in the past by Scotland. Further details are available in the Report of the Working Group for International Pelagic Surveys (ICES 2012/ SSGESST:22).

VESSEL	DATES	AREA SURVEYED	RECTANGLES
R/V Scotia (UK Scotland)	30 June – 23 July	58°30’-62°N, 4°W-2°E	46E2-F1, 47E3-F1, 48E4-F1, 49E5-F1, 50E7-F1, 51E8-F1
M/V Krossfjord (UK Scotland)	30 June – 23 July	58°30’-62°N, 4°W-2°E	46E2-F1, 47E3-F1, 48E4-F1, 49E5-F1, 50E7-F1, 51E8-F1
R/V Celtic Explorer (Ireland)	09 – 26 July	53°-58.6°N ,12°-7°W	35D8-D9, 36D8-D9, 37D9-E1, 38D9-E1, 39E0-E2, 40E0-E2,41E0-E3, 42E0-E3, 43E0-E3, 44E0-E3, 45E0-E4

The combined spawning stock biomass estimate for VIa (North) from the acoustic survey (Table 5.3.2) has decreased by approximately 18% from 2011 (from 457 900 tonnes to 374 913 tonnes); the eight lowest estimate in the 22 year time series

In 2012 there were some different patterns in year class proportions seen in the catch and the survey (Figure 5.3.1). Although the catch and survey both showed high proportions of 3-ringers, the survey showed higher proportions of 1-ringers. High abundance in the survey at 1-ring is unusual and does not equate to a strong year class in the stock (ICES 2012/SSGESST:22).

The survey shows reasonable internal consistency (Figure 5.3.2) for the older ages (5- to 9-ringers), but not for the 1- to 4-ringers.

5.4 Mean Weights-At-Age and Maturity-At-Age

5.4.1 Mean weight-at-age

Weights-at-age in the stock are obtained from the acoustic surveys and are given in Tables 5.3.1 (for the current year) and 5.6.3 (for the time series); weights-at-age in the catches are given in Section 5.6.1 (cf. Table 5.6.2) and are used in the assessment. The weights-at-age in the catch in 2012 are similar to those in 2011, with a slight decrease at ages of 4-rings and above. The weights-at-age in the stock have increased for 1- and 2-ringers in 2012, and decreased for all older ages (cf. Table 5.6.3).

5.4.2 Maturity ogive

The maturity ogive is obtained from the acoustic survey (Table 5.3.1). The survey provides estimated values for the period 1992 to 2012 (cf. Table 5.6.5). In 2012, 85% of the 2-ring fish were mature, compared to 46% in 2011. It is not unusual for 2-ringer maturity to be variable for this stock.

5.5 Recruitment

There are no specific recruitment indices for this stock. Although both catch and acoustic survey generally have some catches at 1-ring, both the fishery and survey encounter this age group only incidentally. The first reliable appearance of a cohort appears at 2-ring in both the catch and the stock.

5.6 Assessment of VIa (North) herring

5.6.1 Stock assessment

This is an update assessment using FLICA (Kell 2007; Patterson 1998b) with the same settings as in 2012, using the revised catch data, post HAWG 2010, with the 8 year separable period moved forward one year to 2005 – 2012. However, it is tuned using the revised survey time series (1991-2012) – see Stock Annex. The assessment uses catch data from 1957 to 2012 giving an estimate of fishing mortality from 1957 to 2012 and numbers-at-age from 1 Jan 1957 to 2013. The input data are given in Tables 5.6.1-8, the run settings are presented in Tables 5.6.9-11.

The results of the assessment are given as the stock summary in Table 5.6.12 and Figure 5.6.1. The output values are in Tables 5.6.13-17. Run diagnostics are given in Tables 5.6.18–20 and Figures 5.6.2-12. The parameter estimates are given in Table 5.6.21.

The 2008 year class is dominant in the catch and survey data in 2012.

The separable model diagnostics (Table 5.6.18 and Figure 5.6.2) show that the total residuals by age and year between the catch and separable model are reasonably trend-free. The fits between survey and assessment are illustrated in Figures 5.6.3-11 for ages 1 to 9+ winter rings. The poor fit at age 1 supports the downweighting of this index. The best fits are to middle ages 3-5.

The assessment shows continuing low levels of recruitment (the 2002, 2003, 2005 and 2006 year classes are weak). The tuning diagnostics (Figures 5.6.3 to 5.6.12 and Table 5.6.17-21) show year effects in the survey that the assessment is sensitive to, especially around 2004 to 2005. The assessment fits between negative and positive residuals in the penultimate two years of the assessment but these residuals are small and more balanced than in the past. Final year residuals are more balanced. The analytical retrospective (Figure 5.6.13) plots show that the assessment has been noisy but is perceived to be more stable over the last five years. It now shows a reasonably stable but historically low stock level. Although the assessment is noisy, it gives a clear indication of the state of the stock in its historical context. The Taylor diagram (Figure 5.6.14) shows a clear indication that there is no signal in the 1-ring data in the survey. It also reflects the patterns of internal consistency seen in Figure 5.3.1, showing no signal for the 1-ringers but a good agreement between the observations and model for the older age classes.

In conclusion, this assessment is driven by a noisy survey, giving quite variable year-on-year SSB estimates. Point estimates of SSB and F from the survey are therefore not that informative and should only be used to indicate medium term trends and for guidance. The current management agreement that restricts large inter-annual changes in TACs is appropriate for such a noisy assessment.

5.6.1.1 State of the stock

The assessment gives an SSB for 2012 of around 102 000 t and a mean fishing mortality (3 to 6-ringers) of 0.16. SSB has returned to around the same level as 2005 to 2008, slightly below the average of the last 20 years. SSB in 2012 is around 24% higher than in 2011. F decreased in 2012, to F=0.16 (compared to F=0.18 in 2011, F=0.27 in 2010, F=0.22 in 2009 and F=0.16 in 2008). Catch in 2012 increased by 4% compared to 2011 (which had decreased by 11% compared to 2010). The 2008 year class is the strongest since 2000. This year class has a high abundance in the catch data. There is insufficient data to evaluate later year classes.

5.7 Short Term Projections

5.7.1 Deterministic short-term projections

Deterministic short-term projections are presented, which provide options including those based on the management agreement, the target F of which is considered to be F_{MSY}.

The Advice Drafting Group in 2010 recommended that the basis for the projection should be an average F of the last three years (i.e., for the calculation of F in the intermediate year - 2013) and not a TAC constraint. This is because the WG catch for this stock is consistently below the TAC. This continues to be the case (see text table below) so the average $F_{3\text{-}6}$ for the years 2010 to 2012 was considered to be appropriate again.

HAWG data year	TAC	Caton	% below TAC
2010	24 420	19 877	19
2011	22 481	17 759	21
2012	22 900	18 516	19

Short-term projections were carried out using MFDP (Smith 2000), with the same settings as in the advice last year (F constraint of average $F_{3\text{-}6}$ 2010 to 2012). Input data are stock numbers on 1st January in 2013 from the 2013 ICA assessment (Section 5.6.1, Table 5.7.1.1). Geometric mean recruitment of 1-ringers (1989-2011) replaced recruitment for 1-ringers in both 2012 and 2013. This period has been chosen as it represents the lower productivity regime experienced by the stock in this recent period. Population numbers of 2-ringers in the intermediate year (2013) were calculated by the degradation of geometric mean recruitment (1989-2011) using the equation below:

$N_{t+1} = N_t * e^{(-Ft+Mt)}$

The retrospective assessment of recruitment estimates in the 2003 Working Group (ICES 2003/ACFM:17) showed the substantial revision of 1- and 2-ring herring abundance (1st January survivors) in subsequent assessments, justifying the use of geometric means for these ages. The selection pattern used is taken from the final year of the ICA assessment (Table 5.6.16, and Figure 5.6.2), and is therefore effectively the mean of the last 8 years. It is not scaled by the Fbar (3-6) to the level of the last year. For the projections, data for maturity, natural mortality, mean weights-at-age in the catch and in the stock are means of the three previous years (i.e., 2010 - 2012). An F constraint of 0.199 in 2013 (average $F_{3\text{-}6}$ for the years 2010 to 2012) is used for the basis for the intermediate year in the projection, this implies an SSB in 2013 of 101 920 t. All the input values are summarised in Table 5.7.1.1.

The results of the short-term projection using the F constraint are given in Tables 5.7.1.2 – 5.7.1.3. HAWG considers that, as the management plan was based on extensive investigation of maximum yield in the long-term (considering different productivity regimes: Simmonds and Keltz 2007; ICES 2009/ACOM:27), the F target in the accepted management plan is consistent with the MSY approach.

The catch option consistent with the management plan implies a TAC increase of 2%. This is consistent with an SSB in 2014 of 100 984 t and a catch of 28 067 t. This is coherent with a biomass in 2014 above $B_{trigger}$. The SSB is expected to fall to 97 875 t in 2015.

5.7.2 Yield Per Recruit

No yield per recruit analysis was conducted at HAWG 2013.

5.8 Precautionary and Yield Based Reference Points

B_{lim} is agreed at 50 000t (based on B_{loss}). There are no other agreed precautionary reference points for this stock. The agreed management rule has a $B_{trigger}$ at 75 000 t.

In 2010, HAWG defined F_{MSY} for this stock as 0.25. HAWG has not considered candidate values for a $B_{MSYtrigger}$ in great detail. HAWG considers that the values of 50 000 t, the B_{lim} for the stock, and 75 000 t, the $B_{trigger}$ for the stock, are appropriate. In 2010 ACOM endorsed the approach taken by HAWG, and ICES WKFRAME II also endorsed the approach in 2011.

The RG in 2012 commented that the value for F_{MSY} was (a) not well documented and (b) higher than estimates of $F_{0.1}$ and $F_{35\%}$. They thought this might impair productivity and impede stocks rebuilding to historic high SSB levels. Estimates of $F_{0.1}$ and $F_{35\%}$ were based on the time series including periods of both high and low productivity whereas F_{MSY} estimations have been based on the recent low productivity time series (1989 to present).

As an exploration, yield-per-recruit and MSY reference points and their associated uncertainties were estimated by means of the "plotMSY" software (WKMSYREF, 2013); input files given in Table 5.8.1. Estimates of F_{MSY} based on the three common stock recruit relationships: Ricker, Beverton and Holt and Hockey stick (approximated by a continuous function as suggested by Mesnil and Rochet (2010)) were compared. Weighting the estimates by likelihood (Table 5.8.2) gives an estimate of F_{MSY} around 0.19, lower than the currently defined value for F_{MSY} of F=0.25.

However, the currently defined value for F_{MSY} (F=0.25) is in accordance with the maximum F in the VIaN management plan which was recommended to give an increased probability of allowing expansion of the stock (ICES 2005/ACFM:16) and is considered to be consistent with the MSY approach.

5.9 Quality of the Assessment

This year's estimate of SSB for 2011 is around 77 000 t, compared with some 82 000 t in last year's final assessment run, a decrease of 6.3%.

The HAWG accepted this year's assessment. The quality of the assessment is the same as last year's. The precision of the assessment estimated through parametric bootstrap is shown in Figure 5.9.1. SSB, catch and F estimated in last year's assessment and short term forecast are compared with this year's assessment in the text table below and in Figure 5.9.2.

	2012 Assessment		**2013 Assessment**		**Percentage change in estimate 2012-2013**	
Year	**SSB**	**$F_{3\text{-}6}$**	**SSB**	**$F_{3\text{-}6}$**	**SSB**	**$F_{3\text{-}6}$**
2010	63 785	0.252	64 021	0.251	0.4	-0.5
2011	82 158	0.178	76 985	0.187	-6.3	5.1
2012*	101 313	0.216	102 008	0.161	0.7	-25.7

*projected values from the intermediate year in the deterministic short term projection, assuming catch constraint with small overshoot. (Recruits are defined as age 1).

Retrospective analyses of the assessment from 2012 to 2008 (Figure 5.9.2) support the perception of an uncertain but fairly well balanced assessment.

The Review Group comments were evaluated by the HAWG. For this stock, the HAWG found that many of the concerns raised are answered in the section below. As noted by the Review Group, the survey time series estimates are variable, leading to annual revisions of SSB and F. The HAWG believes much of this variability is due to mixing of fish from three separate stocks. Discarding and misreporting are now believed to be low within the stock. The management plan should be continued because it is designed to cope with the annual assessment revisions by applying a constraint on TAC changes.

5.10 Management Considerations

The forecast shows that SSB (in 2013) is approx. twice the B_{lim}. ICES considers that the stock is currently fluctuating at a low level and is currently being exploited below F_{MSY}. Recruitment has been low since 1998, and the 2002, 2003, 2005 and 2006 year classes are all weak. The 2008 year class appears stronger.

There has been considerable uncertainty in the amount of landings from this stock in the past. Area misreporting is less of a problem than in the past, but almost all countries still take catches of herring in other areas and report it into VIa (N). Increased observer coverage and use of VMS and electronic log books is helping to reduce these problems.

The assessment is noisy, leading to annual revisions of SSB and F. The management plan has been designed to cope with this by applying a constraint on year-on-year change in TAC. Revisions in SSB can be upwards or downwards, so it is important to maintain the restrictions on change in TAC both when the stock is revised upwards or downwards. Asymmetrical changes in TAC have not been tested.

The stock identity of herring west of the British Isles was reviewed by the EU-funded project WESTHER. This identified Division VIa (N) as an area where catches comprise a mixture of fish from Divisions VIa (N), VIa (S), and VIIa (N). Concerning the management plan for Division VIa (N), ICES has advised that herring components should be managed separately to afford maximum protection. If there is an increasing catch on the mixed fishery in Division VIa (N), this should be considered in the management of the Division VIa (S) component which is in a depleted state. It will be a number of years before ICES can provide a fully operational integrated strategy for these units. In this context HAWG recommends that the management plan for Division VIa (N) should be continued.

5.11 Ecosystem Considerations

Herring are an important prey species in the ecosystem and also one of the dominant planktivorous fish.

Observers monitor some of the fleets. Herring fisheries tend to be clean with little bycatch of other fish. Scottish discard observer programs since 1999 and more recently Dutch observers indicate that discarding of herring in these directed fisheries is at a low level. The Scottish discard observer program has recorded occasional catches of seals and zero catches of cetaceans in the past. Unfortunately the Scottish discard observer program is no longer active.

5.12 Changes in the Environment

Temperatures in this area have been increasing over the last number of decades. There are indications that salinity is also increasing (ICES 2006/LRC:03). It is considered that this may have implications for herring. It is known that similar environmental changes have affected the North Sea herring. There is evidence that there have been recent changes of the productivity of this stock (ICES 2007/ACFM:11).

Herring are thought to be a source of food for seals. Grey seals (*Halichoerus grypus*) are common in many parts of the Celtic Seas area. The majority of individuals are found in the Hebrides and in Orkney (SCOS 2005). A study (Hammond & Harris 2006) of seal diets off western Scotland revealed that grey seals may be an important predator for cod, herring and sandeels in this area. Common seals (*Phoca vitulina*) are also widespread in the northern part of the ecoregion with around 15 000 animals estimated (SCOS 2005). The numbers of seals in VIa (N) is thought to have increased over the last decades. The seal consumption of herring is estimated with great uncertainty and the impact of increased predation is not known, but there is a possibility that seal predation could influence natural mortality.

Table 5.1.1. Herring in VIa (North). Catch in tonnes by country, 1989-2012. These figures do not in all cases correspond to the official statistics and cannot be used for management purposes.

Country	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**
Denmark								
Faroes		326	482			274		2297
France	1342	1287	1168	119	818	5087	3672	7836
Germany	4290	7096	6450	5640	4693	7938	3733	9721
Ireland	8000	10000	8000	7985	8236	6093	3548	9396
Netherlands	5860	7693	7979	8000	6132	8183	7808	6223
Norway		1607	3318	2389	7447	30676	4840	46639
UK	29874	38253	32628	32730	32602	-4287	42661	-17753
Unallocated	2123	2397	-10597	-5485	-3753	700	-4541	
Discards	1550	1300	1180	200				64359
Total	53039	69959	50608	51578	56175	54664	61271	-38254
Area-Misreported	-19013	-25266	-22079	-22593	-24397	-30234	-32146	26105
WG Estimate	34026	44693	28529	28985	31778	24430	29575	1997
Source (WG)	1991	1993	1993	1994	1995	1996	1997	

Country	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**
Faroes						800	400	228
France	3093	1903	463	870	760	1340	1370	625
Germany	8873	8253	6752	4615	3944	3810	2935	1046
Ireland	1875	11199	7915	4841	4311	4239	3581	1894
Netherlands	9873	8483	7244	4647	4534	4612	3609	8232
Norway	4962	5317	2695					
UK	44273	42302	36446	22816	21862	20604	16947	17706
Unallocated	-8015	-11748	-8155			878	-7	
Discards	62	90						123
Total	64995	65799	61514	37789	35411	36283	28835	29854
Area-Misreported	-29766	-32446	-23623	-19467	-11132	-8735	-3581	-7218
WG Estimate	35233*	33353	29736	18322$	24556$	32914$	28081$	25021$
Source (WG)	1998	1999	2000	2001	2002	2003	2004	2005

Country	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**
Faroes	1810	570	484	927	1544	70		
France	613	701	703	564	1049	511	504	244
Germany	2691	3152	1749	2526	27	3583	3518	1829
Ireland	2880	4352	5129	3103	1935	2728	3956	3451
Netherlands	5132	7008	8052	4133	5675	3600	1684	3523
Norway								
UK	17494	18284	17618	13963	11076	12018	11696	12249
Unallocated								
Discards	772	163				95		
Total	31392	34230	33735	25216	21306	22510	21358	
Area-Misreported	-17263	-6884	-4119	-9162	-2798	-2728	-3599	-2780
WG Estimate	14129$	27346	29616	16054	18508	19877	17759	18516
Source (WG)	2006	2007	2008	2009	2010	2011	2012	2013

$Revised at HAWG 2007

Table 5.2.1. Herring in VIa (North). Catch and sampling effort by nations participating in the fishery in 2012.

Summary of Sampling by Country

AREA : VIa(N)

Country	Sampled Catch	Official Catch	No. of samples	No. measured	No. aged	SOP %
England & Wales	0.00	2330.00	0	0	0	0.00
France	0.00	244.00	0	0	0	0.00
Germany	0.00	1829.00	0	0	0	0.00
Ireland	671.00	3451.00	1	215	61	00.11
N. Ireland	464.00	1671.00	1	144	47	99.92
Netherlands	0.00	3523.00	0	0	0	0.00
Scotland	7946.00	8248.00	12	683	192	00.00
Total VIa(N)	9081.00	21296.00	14	1042	300	00.00

Sum of Offical Catches : 21296.00
Unallocated Catch : -2780.00
Working Group Catch : 18516.00

PERIOD : 1

Country	Sampled Catch	Official Catch	No. of samples	No. measured	No. aged	SOP %
N. Ireland	0.00	371.00	0	0	0	0.00
Scotland	0.00	190.00	0	0	0	0.00
Period Total	0.00	561.00	0	0	0	0.00

Sum of Offical Catches : 561.00
Unallocated Catch : 0.00
Working Group Catch : 561.00

PERIOD : 2

Country	Sampled Catch	Official Catch	No. of samples	No. measured	No. aged	SOP %
England & Wales	0.00	334.00	0	0	0	0.00
France	0.00	97.00	0	0	0	0.00
Period Total	0.00	431.00	0	0	0	0.00

Sum of Offical Catches : 431.00
Unallocated Catch : 0.00
Working Group Catch : 431.00

PERIOD : 3

Country	Sampled Catch	Official Catch	No. of samples	No. measured	No. aged	SOP %
England & Wales	0.00	1996.00	0	0	0	0.00
France	0.00	147.00	0	0	0	0.00
Germany	0.00	1829.00	0	0	0	0.00
N. Ireland	0.00	836.00	0	0	0	0.00
Netherlands	0.00	2998.00	0	0	0	0.00
Scotland	7946.00	7946.00	12	683	192	100.00
Period Total	7946.00	15752.00	12	683	192	100.02

Sum of Offical Catches : 15752.00
Unallocated Catch : 0.00
Working Group Catch : 15752.00

PERIOD : 4

Country	Sampled Catch	Official Catch	No. of samples	No. measured	No. aged	SOP %
Ireland	671.00	3451.00	1	215	61	100.11
N. Ireland	464.00	464.00	1	144	47	99.92
Netherlands	0.00	525.00	0	0	0	0.00
Scotland	0.00	112.00	0	0	0	0.00
Period Total	1135.00	4552.00	2	359	108	100.03

Sum of Offical Catches : 4552.00
Unallocated Catch : -2780.00
Working Group Catch : 1772.00

Table 5.3.1. Herring in VIa (North). Estimates of abundance, biomass, maturity, weight- and length-at-age from the 2012 acoustic survey in VIa (North). Thousands of fish at age and spawning biomass (SSB, thousand tonnes). N.B. In this table "age" refers to number of rings (winter rings in the otolith). N.B. these results are from the combined surveys by Scotland and Ireland in VIaN, within the original survey boundaries, to retain consistency with previous year's survey results.

AGE (RING)	NUMBERS	BIOMASS	MATURITY	WEIGHT(G)	LENGTH (CM)
1	792	52	0	65.9	19.5
2	179	27	0.85	150.1	25
3	729	133	1	182.8	27
4	471	89	1	188.8	27.7
5	241	50	1	205.9	28.4
6	107	23	1	216.4	29.2
7	107	23	1	213.5	29.3
8	56	12	1	217.9	29.2
9+	105	22	1	214.4	29.3
Immature	824	57		68.9	19.7
Mature	1964	375		190.9	27.7
Total	2788	432	0.7	154.84	25.29

Table 5.3.2. Herring in VIa (North). Estimates of abundance and SSB for the time series of acoustic surveys in the historically surveyed area of VIa (N), not including Clyde and North Channel. Thousands of fish at age and spawning biomass (SSB, tonnes). N.B. In this table "age" refers to number of rings (winter rings in the otolith).

Year/Age	1	2	3	4	5	6	7	8	9+	SSB
1991	338312	294484	327902	367830	488288	176348	98741	89830	58043	410 000
1992	74310	503430	210980	258090	414750	240110	105670	56710	63440	351 460
1993	2357	579320	689510	688740	564850	900410	295610	157870	161450	845 452
1994	494150	542080	607720	285610	306760	268130	406840	173740	131880	533 740
1995	441200	1103400	473300	450300	153000	187200	169200	236700	201700	452 300
1996	41220	576460	802530	329110	95360	60600	77380	78190	114810	370 300
1997	792320	641860	286170	167040	66100	49520	16280	28990	24440	175 000
1998	1221700	794630	666780	471070	179050	79270	28050	13850	36770	375 890
1999	534200	322400	1388000	432000	308000	138700	86500	27600	35400	460 200
2000	447600	316200	337100	899500	393400	247600	199500	95000	65000	444 900
2001	313100	1062000	217700	172800	437500	132600	102800	52400	34700	359 200
2002	424700	436000	1436900	199800	161700	424300	152300	67500	59500	548 800
2003	438800	1039400	932500	1471800	181300	129200	346700	114300	75200	739 200
2004	564000	274500	760200	442300	577200	55700	61800	82200	76300	395 900
2005	50200	243400	230300	423100	245100	152800	12600	39000	26800	222 960
2006	112300	835200	387900	284500	582200	414700	227000	21700	59300	471 700
2007	-1	126000	294400	202500	145300	346900	242900	163500	32100	298 860
2008	47840	232570	911950	668870	339920	272230	720860	365890	263740	788 200
2009	345821	186741	264040	430293	373499	219033	186558	499695	456039	578 800
2010	119788	493908	483152	171452	163436	93289	64076	53116	223311	308 055
2011	22239	184919	733384	451487	204324	219863	198768	112646	263185	457 900
2012	792479	179425	728758	471381	240832	107492	106779	56071	104571	374 913

Tables 5.6.1. – 5.6.21. Herring in VIa (North). Input data, FLICA run settings and results for the maximum-likelihood ICA calculation for the 8 year separable period. N.B. In these tables "age" refers to number of rings (winter rings in the otolith).

TABLE 5.6.1 HERRING in VIa (N). CATCH IN NUMBER
Units : Thousands

year

age	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967
1	6496	15616	53092	3561	13081	55048	11796	26546	299483	211675	207947
2	74622	30980	67972	102124	45195	92805	78247	82611	19767	500853	27416
3	58086	145394	35263	60290	61619	22278	53455	70076	62642	33456	218689
4	25762	39070	116390	22781	33125	67454	11859	26680	59375	60502	37069
5	33979	24908	24946	48881	22501	44357	40517	7283	22265	40908	39246
6	19890	27630	17332	11631	12412	19759	26170	24227	5120	19344	29793
7	8885	17405	16999	10347	5345	24139	8687	18637	22891	5563	11770
8	1427	9857	7372	6346	4814	6147	13662	8797	18925	17811	5533
9	4423	7159	8595	4617	2582	7082	6088	15103	19531	27083	25799

year

age	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978
1	220255	37706	238226	207711	534963	51170	309016	172879	69053	34836	22525
2	94438	92561	99014	335083	621496	235627	124944	202087	319604	47739	46284
3	20998	71907	253719	412816	175137	808267	151025	89066	101548	95834	20587
4	159122	23314	111897	302208	54205	131484	519178	63701	35502	22117	40692
5	13988	211243	27741	101957	66714	63071	82466	188202	25195	10083	6879
6	23582	21011	142399	25557	25716	54642	49683	30601	76289	12211	3833
7	15677	42762	21609	154424	10342	18242	34629	12297	10918	20992	2100
8	6377	26031	27073	16818	55763	6506	22470	13121	3914	2758	6278
9	10814	26207	24082	31999	16631	32223	21042	13698	12014	1486	1544

year

age	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
1	247	2692	36740	13304	81923	2207	40794	33768	19463	1708	6216
2	142	279	77961	250010	77810	188778	68845	154963	65954	119376	36763
3	77	95	105600	72179	92743	49828	148399	86072	45463	41735	109501
4	19	51	61341	93544	29262	35001	17214	118860	32025	28421	18923
5	13	13	21473	58452	42535	14948	15211	18836	50119	19761	18109
6	8	9	12623	23580	27318	11366	6631	18000	8429	28555	7589
7	4	8	11583	11516	14709	9300	6907	2578	7307	3252	15012
8	1	1	1309	13814	8437	4427	3323	1427	3508	2222	1622
9	0	0	1326	4027	8484	1959	2189	1971	5983	2360	3505

year

age	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
1	14294	26396	5253	17719	1728	266	1952	1193	9092	7635	3568.58
2	40867	23013	24469	95288	36554	82176	37854	55810	74167	35252	18161.91
3	40779	25229	24922	18710	40193	30398	30899	34966	34571	93910	17263.76
4	74279	28212	23733	10978	6007	21272	9219	31657	31905	25078	40673.54
5	26520	37517	21817	13269	7433	5376	7508	23118	22872	13364	12264.30
6	13305	13533	33869	14801	8101	4205	2501	17500	14372	7529	7120.78
7	9878	7581	6351	19186	10515	8805	4700	10331	8641	3251	3083.08
8	21456	6892	4317	4711	12158	7971	8458	5213	2825	1257	1451.93
9	5522	4456	5511	3740	10206	9787	31108	9883	3327	1089	455.93

year

age	2001	2002	2003	2004	2005	2006	2007	2008
1	142.98	992.20	56.12	0.00	182.500	132.46	130.75	0.00
2	81030.48	38481.61	33331.97	6843.91	9632.710	6691.49	34326.00	7898.43
3	14942.91	93975.06	46865.58	22223.20	23236.710	9186.07	17754.83	13039.08
4	9305.89	9014.41	53766.66	27815.23	20602.390	13644.88	6555.14	5427.59
5	24482.25	18113.71	7462.99	45782.43	10237.930	41067.79	14264.99	3219.52
6	9280.71	28016.08	4344.55	3916.10	9783.180	27781.86	30566.16	5688.56
7	6624.96	9040.10	12818.38	7641.76	1014.997	20972.98	21517.07	14832.27
8	4610.61	1547.86	9187.62	8481.01	1194.960	3041.71	13585.45	8142.31
9	1000.53	1422.68	1407.96	4008.01	1430.760	5088.99	4242.60	8968.60

year

age	2009	2010	2011	2012
1	1923.62	10074.12	1667.19	979.53
2	11508.54	20339.85	40587.92	14952.63
3	10475.63	16331.31	15782.93	46647.39
4	16586.96	9957.96	10333.90	9704.45
5	8332.17	14608.15	7190.29	8097.30
6	5688.68	6322.33	5071.43	6311.66
7	7514.70	4322.24	3164.16	3873.67
8	11793.98	5388.91	2611.38	1129.80
9	9443.85	13199.28	7225.68	4013.80

TABLE 5.6.2 HERRING in VIa (N). WEIGHTS AT AGE IN THE CATCH

Units : Kg

age \ year	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968
1	0.079	0.079	0.079	0.079	0.079	0.079	0.079	0.079	0.079	0.079	0.079	0.079
2	0.104	0.104	0.104	0.104	0.104	0.104	0.104	0.104	0.104	0.104	0.104	0.104
3	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130
4	0.158	0.158	0.158	0.158	0.158	0.158	0.158	0.158	0.158	0.158	0.158	0.158
5	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164
6	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170
7	0.180	0.180	0.180	0.180	0.180	0.180	0.180	0.180	0.180	0.180	0.180	0.180
8	0.183	0.183	0.183	0.183	0.183	0.183	0.183	0.183	0.183	0.183	0.183	0.183
9	0.185	0.185	0.185	0.185	0.185	0.185	0.185	0.185	0.185	0.185	0.185	0.185

age \ year	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
1	0.079	0.079	0.079	0.079	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090
2	0.104	0.104	0.104	0.104	0.121	0.121	0.121	0.121	0.121	0.121	0.121	0.121
3	0.130	0.130	0.130	0.130	0.158	0.158	0.158	0.158	0.158	0.158	0.158	0.158
4	0.158	0.158	0.158	0.158	0.175	0.175	0.175	0.175	0.175	0.175	0.175	0.175
5	0.164	0.164	0.164	0.164	0.186	0.186	0.186	0.186	0.186	0.186	0.186	0.186
6	0.170	0.170	0.170	0.170	0.206	0.206	0.206	0.206	0.206	0.206	0.206	0.206
7	0.180	0.180	0.180	0.180	0.218	0.218	0.218	0.218	0.218	0.218	0.218	0.218
8	0.183	0.183	0.183	0.183	0.224	0.224	0.224	0.224	0.224	0.224	0.224	0.224
9	0.185	0.185	0.185	0.185	0.224	0.224	0.224	0.224	0.224	0.224	0.000	0.000

age \ year	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
1	0.090	0.080	0.080	0.080	0.069	0.113	0.073	0.080	0.082	0.079	0.084	0.091
2	0.121	0.140	0.140	0.140	0.103	0.145	0.143	0.112	0.142	0.129	0.118	0.119
3	0.158	0.175	0.175	0.175	0.134	0.173	0.183	0.157	0.145	0.173	0.160	0.183
4	0.175	0.205	0.205	0.205	0.161	0.196	0.211	0.177	0.191	0.182	0.203	0.196
5	0.186	0.231	0.231	0.231	0.182	0.215	0.220	0.203	0.190	0.209	0.211	0.227
6	0.206	0.253	0.253	0.253	0.199	0.230	0.238	0.194	0.213	0.224	0.229	0.219
7	0.218	0.270	0.270	0.270	0.213	0.242	0.241	0.240	0.216	0.228	0.236	0.244
8	0.224	0.284	0.284	0.284	0.223	0.251	0.253	0.213	0.204	0.237	0.261	0.256
9	0.224	0.295	0.295	0.295	0.231	0.258	0.256	0.228	0.243	0.247	0.271	0.256

age \ year	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
1	0.089	0.083	0.106	0.081	0.089	0.097	0.076	0.0834	0.049	0.107	0.060	NaN
2	0.128	0.142	0.142	0.134	0.136	0.138	0.130	0.1373	0.140	0.146	0.145	0.154
3	0.158	0.167	0.181	0.178	0.177	0.159	0.158	0.1637	0.163	0.163	0.160	0.173
4	0.197	0.190	0.191	0.210	0.205	0.182	0.175	0.1829	0.183	0.173	0.169	0.195
5	0.206	0.195	0.198	0.230	0.222	0.199	0.191	0.2014	0.192	0.160	0.186	0.216
6	0.228	0.201	0.214	0.233	0.223	0.218	0.210	0.2147	0.196	0.179	0.200	0.220
7	0.223	0.244	0.208	0.262	0.219	0.227	0.225	0.2394	0.205	0.187	0.194	0.199
8	0.262	0.234	0.227	0.247	0.238	0.212	0.223	0.2812	0.225	0.245	0.186	0.190
9	0.263	0.266	0.277	0.291	0.263	0.199	0.226	0.2526	0.272	0.281	0.294	0.311

age \ year	2005	2006	2007	2008	2009	2010	2011	2012
1	0.1084	0.0908	0.1152	NaN	0.1121	0.0818	0.0613	0.0725
2	0.1327	0.1580	0.1667	0.1705	0.1726	0.1549	0.1550	0.1469
3	0.1632	0.1676	0.1881	0.2060	0.2141	0.1883	0.1894	0.1894
4	0.1845	0.1929	0.1968	0.2310	0.2379	0.2129	0.2178	0.2076
5	0.2108	0.2076	0.2105	0.2309	0.2457	0.2337	0.2340	0.2161
6	0.2258	0.2251	0.2214	0.2489	0.2535	0.2394	0.2388	0.2261
7	0.2341	0.2443	0.2161	0.2529	0.2599	0.2369	0.2470	0.2408
8	0.2556	0.2615	0.2618	0.2840	0.2549	0.2400	0.2463	0.2817
9	0.2496	0.2750	0.3030	0.2877	0.2730	0.2549	0.2522	0.2467

TABLE 5.6.3 HERRING in VIa (N). WEIGHTS AT AGE IN THE STOCK

Units : Kg

age \ year	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968
1	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090
2	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164
3	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208
4	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.233
5	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.246
6	0.252	0.252	0.252	0.252	0.252	0.252	0.252	0.252	0.252	0.252	0.252	0.252
7	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258
8	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269
9	0.292	0.292	0.292	0.292	0.292	0.292	0.292	0.292	0.292	0.292	0.292	0.292

TABLE 5.6.3 continued. HERRING in VIa (N). WEIGHTS AT AGE IN THE STOCK

age \ year	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
1	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090
2	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164
3	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208
4	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.233
5	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.246
6	0.252	0.252	0.252	0.252	0.252	0.252	0.252	0.252	0.252	0.252	0.252	0.252
7	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258
8	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269
9	0.292	0.292	0.292	0.292	0.292	0.292	0.292	0.292	0.292	0.292	0.000	0.000

age \ year	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
1	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.068
2	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.152
3	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.186
4	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.206
5	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.233
6	0.252	0.252	0.252	0.252	0.252	0.252	0.252	0.252	0.252	0.252	0.252	0.253
7	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.273
8	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.299
9	0.292	0.292	0.292	0.292	0.292	0.292	0.292	0.292	0.292	0.292	0.292	0.302

age \ year	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
1	0.073	0.052	0.042	0.045	0.054	0.066	0.054	0.062	0.062	0.062	0.064	0.059
2	0.164	0.150	0.144	0.140	0.142	0.138	0.137	0.141	0.132	0.153	0.138	0.138
3	0.196	0.192	0.191	0.180	0.180	0.176	0.166	0.173	0.170	0.177	0.176	0.159
4	0.206	0.220	0.202	0.209	0.199	0.194	0.188	0.183	0.190	0.198	0.190	0.180
5	0.225	0.221	0.225	0.219	0.213	0.214	0.203	0.194	0.198	0.212	0.204	0.189
6	0.234	0.233	0.227	0.222	0.222	0.226	0.219	0.204	0.212	0.215	0.213	0.202
7	0.253	0.241	0.247	0.229	0.231	0.234	0.225	0.211	0.220	0.225	0.217	0.213
8	0.259	0.270	0.260	0.242	0.242	0.225	0.235	0.222	0.236	0.243	0.223	0.214
9	0.276	0.296	0.293	0.263	0.263	0.249	0.245	0.230	0.254	0.259	0.228	0.206

age \ year	2005	2006	2007	2008	2009	2010	2011	2012
1	0.0751	0.075	0.0750	0.0546	0.1013	0.0642	0.0570	0.0659
2	0.1296	0.135	0.1675	0.1721	0.1734	0.0923	0.1323	0.1501
3	0.1538	0.166	0.1830	0.1913	0.2064	0.1677	0.1597	0.1828
4	0.1665	0.185	0.1914	0.2083	0.2233	0.1983	0.2078	0.1888
5	0.1802	0.192	0.1951	0.2143	0.2331	0.2114	0.2356	0.2059
6	0.1911	0.204	0.1951	0.2139	0.2313	0.2148	0.2447	0.2164
7	0.2125	0.211	0.2021	0.2206	0.2318	0.2091	0.2379	0.2135
8	0.2030	0.224	0.2034	0.2242	0.2323	0.2193	0.2224	0.2179
9	0.2284	0.231	0.2138	0.2385	0.2382	0.2153	0.2526	0.2144

TABLE 5.6.4 HERRING in VIa (N). NATURAL MORTALITY
Units : NA

age \ year	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971
1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
4	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
5	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
6	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
7	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
8	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
9	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1

age \ year	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
4	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
5	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
6	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
7	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
8	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
9	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1

TABLE 5.6.4 continued. HERRING in VIa (N). NATURAL MORTALITY

year

age	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
4	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
5	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
6	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
7	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
8	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
9	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1

year

age	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
4	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
5	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
6	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
7	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
8	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
9	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1

TABLE 5.6.5 HERRING in VIa (N). PROPORTION MATURE

Units : NA

year

age	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57
3	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96
4	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
5	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
6	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
7	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
8	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
9	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

year

age	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57
3	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96
4	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
5	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
6	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
7	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
8	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
9	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

year

age	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.57	0.57	0.57	0.57	0.57	0.47	0.93	0.59	0.21	0.76	0.55	0.85	0.57	0.45	0.93
3	0.96	0.96	0.96	0.96	0.96	1.00	0.96	0.93	0.98	0.94	0.95	0.97	0.98	0.92	0.99
4	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
5	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
6	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
7	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
8	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
9	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

year

age	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
1	0.00	0.00	0.00	0.00	0.00	0	0.00	0.0	0.00	0.00	0.00
2	0.92	0.76	0.83	0.84	0.81	1	0.98	0.7	0.79	0.46	0.85
3	1.00	1.00	0.97	1.00	0.97	1	1.00	1.0	1.00	0.92	1.00
4	1.00	1.00	1.00	1.00	1.00	1	1.00	1.0	1.00	1.00	1.00
5	1.00	1.00	1.00	1.00	1.00	1	1.00	1.0	1.00	1.00	1.00
6	1.00	1.00	1.00	1.00	1.00	1	1.00	1.0	1.00	1.00	1.00
7	1.00	1.00	1.00	1.00	1.00	1	1.00	1.0	1.00	1.00	1.00
8	1.00	1.00	1.00	1.00	1.00	1	1.00	1.0	1.00	1.00	1.00
9	1.00	1.00	1.00	1.00	1.00	1	1.00	1.0	1.00	1.00	1.00

TABLE 5.6.6 HERRING in VIa (N). FRACTION OF HARVEST BEFORE SPAWNING
Units : NA

age \ year	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971
1	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
2	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
3	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
4	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
5	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
6	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
7	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
8	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
9	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67

age \ year	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
1	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
2	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
3	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
4	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
5	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
6	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
7	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
8	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
9	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67

age \ year	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
2	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
3	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
4	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
5	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
6	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
7	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
8	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
9	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67

age \ year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
1	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
2	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
3	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
4	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
5	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
6	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
7	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
8	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
9	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67

TABLE 5.6.7 HERRING in VIa (N). FRACTION OF NATURAL MORTALITY BEFORE SPAWNING
Units : NA

age \ year	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971
1	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
2	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
3	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
4	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
5	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
6	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
7	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
8	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
9	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67

age \ year	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
1	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
2	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
3	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
4	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
5	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
6	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
7	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
8	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
9	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67

TABLE 5.6.7 continued. HERRING in VIa (N). FRACTION OF NATURAL MORTALITY BEFORE SPAWNING

age \ year	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
2	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
3	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
4	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
5	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
6	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
7	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
8	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
9	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67

age \ year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
1	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
2	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
3	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
4	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
5	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
6	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
7	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
8	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
9	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67

TABLE 5.6.8 HERRING in VIa (N). SURVEY INDICES
West of Scotland Summer Acoustic Survey - Configuration

"Herring in Division VIa (North)(runname:ICAPGF08) . Imported from VPA file."

min	max	plusgroup	minyear	maxyear	startf	endf
1.00	9.00	9.00	1991.00	2012.00	0.52	0.57

Index type : number

West of Scotland Summer Acoustic Survey - Index Values

Units : number

age \ year	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
1	338312	74310	2357	494150	441200	41220	792320	1221700	534200	447600
2	294484	503430	579320	542080	1103400	576460	641860	794630	322400	316200
3	327902	210980	689510	607720	473300	802530	286170	666780	1388000	337100
4	367830	258090	688740	285610	450300	329110	167040	471070	432000	899500
5	488288	414750	564850	306760	153000	95360	66100	179050	308000	393400
6	176348	240110	900410	268130	187200	60600	49520	79270	138700	247600
7	98741	105670	295610	406840	169200	77380	16280	28050	86500	199500
8	89830	56710	157870	173740	236700	78190	28990	13850	27600	95000
9	58043	63440	161450	131880	201700	114810	24440	36770	35400	65000

age \ year	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
1	313100	424700	438800	564000	50200	112300	-1	47840	345821	119788
2	1062000	436000	1039400	274500	243400	835200	126000	232570	186741	493908
3	217700	1436900	932500	760200	230300	387900	294400	911950	264040	483152
4	172800	199800	1471800	442300	423100	284500	202500	668870	430293	171452
5	437500	161700	181300	577200	245100	582200	145300	339920	373499	163436
6	132600	424300	129200	55700	152800	414700	346900	272230	219033	93289
7	102800	152300	346700	61800	12600	227000	242900	720860	186558	64076
8	52400	67500	114300	82200	39000	21700	163500	365890	499695	53116
9	34700	59500	75200	76300	26800	59300	32100	263740	456039	223311

age \ year	2011	2012
1	22239	792479
2	184919	179425
3	733384	728758
4	451487	471381
5	204324	240832
6	219863	107492
7	198768	106779
8	112646	56071
9	263185	104571

TABLE 5.6.8 continued. HERRING in VIa (N). SURVEY INDICES

West of Scotland Summer Acoustic Survey - Index Variance (Inverse Weights)

Units : NA

age	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
1	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
4	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
5	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
6	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
7	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
8	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
9	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

age	2006	2007	2008	2009	2010	2011	2012
1	10	10	10	10	10	10	10
2	1	1	1	1	1	1	1
3	1	1	1	1	1	1	1
4	1	1	1	1	1	1	1
5	1	1	1	1	1	1	1
6	1	1	1	1	1	1	1
7	1	1	1	1	1	1	1
8	1	1	1	1	1	1	1
9	1	1	1	1	1	1	1

TABLE 5.6.9 HERRING in VIa (N). STOCK OBJECT CONFIGURATION

min	max	plusgroup	minyear	maxyear	minfbar	maxfbar
1	9	9	1957	2012	3	6

TABLE 5.6.10 HERRING in VIa (N). FLICA CONFIGURATION SETTINGS

```
sep.2       : NA
sep.gradual : TRUE
sr          : FALSE
sr.age      : 1
lambda.age  : 0.1 1 1 1 1 1 1 1 0
lambda.yr   : 1 1 1 1 1 1 1 1
lambda.sr   : 0.01
index.model : linear
index.cor   : 1
sep.nyr     : 8
sep.age     : 4
sep.sel     : 1
```

TABLE 5.6.11 HERRING in VIa (N). FLR, R SOFTWARE VERSIONS

R version 2.8.1 (2008-12-22)

```
Package  : FLICA
Version  : 1.4-12
Packaged : 2009-10-08 15:16:26 UTC; mpa
Built    : R 2.9.1; ; 2009-10-08 15:16:27 UTC; windows

Package  : FLAssess
Version  : 1.99-102
Packaged : Mon Mar 23 08:18:19 2009; mpa
Built    : R 2.8.0; i386-pc-mingw32; 2009-03-23 08:18:21; windows

Package  : FLCore
Version  : 2.2
Packaged : Tue May 19 19:23:18 2009; Administrator
Built    : R 2.8.1; i386-pc-mingw32; 2009-05-19 19:23:22; windows
```

TABLE 5.6.12 HERRING in VIa (N). STOCK SUMMARY

Year	Recruitment Age 1	TSB	SSB	Fbar (Ages 3-6) f	Landings Tonnes	Landings SOP
1957	1088006	405110	184234	0.2834	43438	0.7258
1958	2101199	495444	200601	0.3305	59669	0.7470
1959	2136613	532906	213380	0.3028	65221	0.7248
1960	626496	427963	247465	0.1948	63759	0.5679
1961	1285229	435271	247715	0.1294	46353	0.5846
1962	2293268	540413	237068	0.2059	58195	0.7727
1963	2110018	572370	259863	0.1833	49030	0.6970
1964	978157	522945	305370	0.1535	64234	0.5774
1965	7839269	1115364	312179	0.1592	68669	0.8586
1966	1066330	848510	426183	0.1932	100619	1.0136
1967	2498686	829562	456838	0.1903	90400	0.8072
1968	4100166	952511	434826	0.1435	84614	0.7964
1969	2998773	980072	471939	0.2419	107170	0.7573
1970	3439855	1000107	441946	0.3587	165930	0.7343
1971	9570759	1514872	315271	0.7883	207167	1.0162
1972	2675642	1115411	443058	0.3651	164756	1.0239
1973	1074227	802001	385421	0.6056	210270	1.0438
1974	1672447	576306	203879	0.9572	178160	1.1255
1975	2102769	434633	107030	0.9101	114001	1.0108
1976	606435	263563	73358	1.0693	93642	0.9984
1977	620881	162765	51826	0.9950	41341	0.9154
1978	911556	170356	48384	0.6777	22156	1.0056
1979	1216825	215739	72243	0.0007	60	1.0011
1980	885161	252021	121982	0.0004	306	1.0007
1981	1660162	364259	131719	0.3632	51420	0.9698
1982	769613	305358	109385	0.6767	92360	1.0347
1983	2971919	426039	80836	0.7156	63523	1.0277
1984	1132803	352884	119689	0.5180	56012	0.9494
1985	1200030	348143	147291	0.3164	39142	1.0058
1986	891147	314164	132897	0.5284	70764	1.0479
1987	2096144	379992	123159	0.3454	44360	0.9725
1988	902230	334343	147692	0.2855	35591	1.0236
1989	838396	317626	163914	0.2474	34026	1.0199
1990	431693	269463	154325	0.3485	44693	0.9889
1991	378816	207886	125735	0.2593	28529	1.0693
1992	792035	192409	97898	0.2864	28985	1.0018
1993	580238	182555	98523	0.2492	31778	0.9912
1994	852565	177308	91108	0.2300	24430	0.9984
1995	606827	156988	72006	0.2673	29575	1.0001
1996	945694	194589	112492	0.1727	26105	1.0477
1997	1478749	207795	71103	0.5168	35233	1.0079
1998	483440	186104	100631	0.5001	33353	0.9992
1999	309652	143978	84196	0.3107	29736	1.0015
2000	1699208	205590	71766	0.2453	18322	0.9997
2001	1163240	231314	117823	0.1969	24556	1.0049
2002	1261566	271054	139460	0.3503	32914	1.0021
2003	500703	229446	141591	0.2452	28081	1.0074
2004	289252	180050	125948	0.2129	25021	1.0172
2005	299687	150525	106730	0.1176	14129	1.0021
2006	487235	168782	103289	0.2112	27346	0.9997
2007	321578	151578	97849	0.2609	29616	1.0004
2008	393522	143883	101432	0.1363	16054	1.0022
2009	490750	164109	85295	0.2072	18508	1.0492
2010	1267874	167515	64021	0.2507	19877	0.9951
2011	513121	160497	76985	0.1870	17759	1.0008
2012	616136	197434	102008	0.1606	18516	1.0010

TABLE 5.6.13 HERRING in VIa (N). ESTIMATED FISHING MORTALITY

Units : f

age \ year	1957	1958	1959	1960	1961	1962
1	0.009482764	0.01181532	0.03996982	0.009025915	0.01621060	0.03858930
2	0.099319619	0.09456451	0.10838117	0.169438438	0.25821234	0.26060805
3	0.319070721	0.30261231	0.15691267	0.140060005	0.15499768	0.20753690
4	0.213870410	0.34925892	0.39995205	0.136812467	0.10118423	0.24031935
5	0.299574994	0.29388272	0.34951627	0.259432024	0.17434275	0.17136938
6	0.300914218	0.37642927	0.30475361	0.243059080	0.08690905	0.20431881
7	0.189287809	0.41433774	0.37221455	0.268066229	0.15064513	0.21684433
8	0.232084383	0.29474233	0.27520739	0.206170668	0.17221789	0.23130873
9	0.232084383	0.29474233	0.27520739	0.206170668	0.17221789	0.23130873

age \ year	1963	1964	1965	1966	1967	1968	1969
1	0.008876851	0.04372150	0.06201388	0.3637128	0.1394519	0.08814407	0.02005864
2	0.117941060	0.13224738	0.06861226	0.2390379	0.1233251	0.14643115	0.08057968
3	0.249954198	0.15583206	0.14857563	0.1678267	0.1651013	0.13862640	0.16798016
4	0.154472368	0.18069632	0.18198803	0.1985945	0.2687378	0.16505535	0.21338537
5	0.198933656	0.12036948	0.20166147	0.1648798	0.1714150	0.13778885	0.30515478
6	0.130024700	0.15723931	0.10468793	0.2413916	0.1558215	0.13262924	0.28097485
7	0.116786953	0.11574744	0.19571010	0.1421204	0.2029127	0.10325214	0.33372949
8	0.164321014	0.14920185	0.14812501	0.2056415	0.1836927	0.14476061	0.22240237
9	0.164321014	0.14920185	0.14812501	0.2056415	0.1836927	0.14476061	0.22240237

age \ year	1970	1971	1972	1973	1974	1975	1976
1	0.1148895	0.03483505	0.3667698	0.07782964	0.3347256	0.1376632	0.1951534
2	0.1117115	0.41594040	0.2361264	0.50236764	0.4955296	0.7376757	0.7732179
3	0.3493423	0.98269542	0.4277178	0.58695382	0.7723983	0.8842623	1.2185978
4	0.4018751	0.86421206	0.2995104	0.62928367	0.9112576	0.8553063	1.0868060
5	0.3745150	0.68701459	0.4098457	0.59413399	0.9311892	0.9061730	0.8936548
6	0.3090177	0.61917036	0.3231918	0.61211126	1.2139063	0.9948515	1.0782550
7	0.4591856	0.56746226	0.4842914	0.35528773	0.8916603	1.0447362	1.1129373
8	0.3246437	0.69378008	0.3643063	0.56715218	0.8635256	0.9225825	1.0446287
9	0.3246437	0.69378008	0.3643063	0.56715218	0.8635256	0.9225825	1.0446287

age \ year	1977	1978	1979	1980	1981	1982
1	0.0922180	0.03974382	0.0003211644	0.0048208948	0.03553185	0.02766428
2	0.3544227	0.29481196	0.0005101313	0.0007218981	0.32328074	0.65978851
3	0.6055405	0.27055107	0.0007396245	0.0004393425	0.42956807	0.60471408
4	0.9438809	0.53337591	0.0003351146	0.0005702500	0.39896530	0.80568619
5	0.9605699	0.77732732	0.0002499343	0.0002534782	0.30754220	0.72351874
6	1.4698489	1.12960810	0.0015218663	0.0001912716	0.31653850	0.57277698
7	0.8932714	1.01791379	0.0024408021	0.0016846187	0.31658593	0.46994995
8	0.8477831	0.64991841	0.0009383426	0.0006754375	0.36237734	0.67226957
9	0.8477831	0.64991841	0.0009383426	0.0006754375	0.36237734	0.67226957

age \ year	1983	1984	1985	1986	1987	1988
1	0.04442216	0.003086086	0.05502262	0.06149724	0.01477978	0.002998574
2	0.39136826	0.232853662	0.21170988	0.55073480	0.28223272	0.199614170
3	0.59578634	0.502922184	0.30841021	0.47533567	0.32788696	0.309253100
4	0.50098708	0.445920893	0.30675132	0.41124045	0.30761445	0.332600013
5	0.97133826	0.457743847	0.31496052	0.56777105	0.27092907	0.281928970
6	0.79419144	0.665434908	0.33531170	0.65930761	0.47528461	0.218188428
7	0.75975995	0.610509289	1.00286826	0.18799222	0.54331277	0.300859493
8	0.66353595	0.476943316	0.40468074	0.50369862	0.37187564	0.278490700
9	0.66353595	0.476943316	0.40468074	0.50369862	0.37187564	0.278490700

age \ year	1989	1990	1991	1992	1993	1994	1995
1	0.0117869	0.05356163	0.1156305	0.0105384	0.0493110	0.003210695	0.0006936533
2	0.1371392	0.16787289	0.1937142	0.2570792	0.4749256	0.231978469	0.3588835786
3	0.3021132	0.23532549	0.1571473	0.3531642	0.3405661	0.402884779	0.3277614513
4	0.2129375	0.32707328	0.2407171	0.2062660	0.2457386	0.165096020	0.3660993578
5	0.3255621	0.45699338	0.2434990	0.2646917	0.1526974	0.233785617	0.1954083727
6	0.1489441	0.37445217	0.3958293	0.3214398	0.2577530	0.118044972	0.1800115384
7	0.1528486	0.26242924	0.3370119	0.2904671	0.2710786	0.262453052	0.1630477382
8	0.2152108	0.30183750	0.2631729	0.2907642	0.3232889	0.246047540	0.2895184719
9	0.2152108	0.30183750	0.2631729	0.2907642	0.3232889	0.246047540	0.2895184719

TABLE 5.6.13 continued. HERRING in VIa (N). ESTIMATED FISHING MORTALITY.

age	1996	1997	1998	1999	2000	2001
1	0.003269812	0.001276962	0.03012806	0.03965591	0.003327000	0.0001944649
2	0.217345150	0.204987753	0.17118758	0.26772119	0.211954065	0.1624412185
3	0.235625101	0.340346005	0.20047138	0.36192858	0.215714159	0.2877645855
4	0.147818771	0.381121845	0.56347363	0.20778523	0.249212128	0.1640482278
5	0.189591444	0.579670448	0.46233327	0.43186194	0.133417445	0.2086633743
6	0.117689059	0.766175071	0.77393042	0.24108305	0.383005585	0.1271181423
7	0.278964718	0.836586300	0.98692874	0.34684072	0.131809729	0.6516205492
8	0.208174011	0.500370633	0.50500335	0.31751550	0.229204186	0.2647454864
9	0.208174011	0.500370633	0.50500335	0.31751550	0.229204186	0.2647454864

age	2002	2003	2004	2005	2006	2007
1	0.001244845	0.0001773248	0.00000000	0.001262351	0.002266406	0.002800101
2	0.109617042	0.0867073693	0.04391751	0.069850226	0.125408063	0.154939268
3	0.305078081	0.2002009798	0.08095776	0.115586452	0.207522209	0.256389728
4	0.267351806	0.2719302729	0.16644287	0.110801188	0.198930817	0.245775226
5	0.482056405	0.3289126975	0.34798492	0.119697734	0.214903544	0.265509226
6	0.346881992	0.1798420907	0.25617173	0.124346075	0.223249107	0.275820010
7	0.157690874	0.2355497462	0.48135286	0.123530769	0.221785319	0.274011528
8	0.271741150	0.2128965424	0.21597542	0.110801188	0.198930817	0.245775226
9	0.271741150	0.2128965424	0.21597542	0.110801188	0.198930817	0.245775226

age	2008	2009	2010	2011	2012
1	0.001463081	0.002223796	0.002690768	0.002006832	0.001723408
2	0.080957333	0.123050338	0.148889485	0.111044963	0.095362106
3	0.133966223	0.203620703	0.246378693	0.183754501	0.157802890
4	0.128420039	0.195190833	0.236178647	0.176147088	0.151269871
5	0.138731253	0.210863266	0.255142110	0.190290444	0.163415763
6	0.144118742	0.219051929	0.265050297	0.197680183	0.169761850
7	0.143173792	0.217615661	0.263312430	0.196384044	0.168648765
8	0.128420039	0.195190833	0.236178647	0.176147088	0.151269871
9	0.128420039	0.195190833	0.236178647	0.176147088	0.151269871

TABLE 5.6.14 HERRING in VIa (N). ESTIMATED POPULATION ABUNDANCE

Units : NA

age	1957	1958	1959	1960	1961	1962	1963
1	1088005.62	2101198.86	2136612.76	626495.59	1285228.65	2293267.76	2110017.65
2	911299.99	396477.32	763908.51	755218.58	228403.96	465206.47	811710.50
3	233364.40	611278.41	267215.20	507789.43	472278.46	130699.85	265568.62
4	140347.20	138868.92	369791.82	187006.18	361407.76	331149.88	86952.90
5	137589.83	102539.59	88612.38	224300.83	147573.92	295545.45	235627.40
6	80231.49	92268.43	69156.10	56529.09	156578.29	112166.73	225304.59
7	54055.45	53731.63	57298.40	46136.88	40112.83	129884.69	82737.06
8	7225.96	40476.54	32125.95	35732.41	31930.01	31219.76	94613.74
9	22396.93	29397.54	37455.58	25996.93	17125.74	35968.49	42161.36

age	1964	1965	1966	1967	1968	1969	1970
1	978157.33	7839269.34	1066329.64	2498686.42	4100166.08	2998773.10	3439855.04
2	769372.11	344450.03	2710496.30	272670.74	799565.58	1381104.32	1081278.99
3	534431.03	499360.04	238253.87	1581057.32	178562.71	511648.26	943936.60
4	169341.79	374417.18	352394.66	164928.17	1097453.46	127270.34	354127.58
5	67416.80	127896.68	282416.41	261427.56	114065.43	841926.23	93030.57
6	174743.31	54083.26	94590.90	216697.60	199286.25	89925.66	561458.36
7	179007.65	135108.58	44072.54	67233.37	167784.65	157923.86	61436.77
8	66611.73	144269.21	100521.20	34595.25	49662.84	136924.43	102348.48
9	114361.37	148888.88	152850.25	161309.02	84217.34	137850.20	91041.12

age	1971	1972	1973	1974	1975	1976
1	9570759.46	2675641.59	1074226.81	1672446.92	2102768.70	606434.685
2	1128105.71	3400347.09	682098.90	365595.23	440238.87	674078.751
3	716363.97	551341.69	1989236.85	305762.00	165008.53	155966.575
4	544962.35	219530.89	294310.97	905559.08	115631.53	55797.826
5	214386.86	207785.16	147228.02	141932.74	329407.29	44482.790
6	57882.39	97589.27	124793.33	73541.40	50610.75	120436.411
7	372978.18	28197.77	63916.38	61224.52	19765.58	16933.815
8	35121.83	191341.09	15720.28	40539.95	22711.86	6291.541
9	66825.04	57066.40	77859.58	37963.58	23710.62	19311.848

TABLE 5.6.14 continued. HERRING in VIa (N). ESTIMATED POPULATION ABUNDANCE

age	1977	1978	1979	1980	1981	1982
1	620880.953	911556.041	1216824.546	885161.050	1660161.698	769612.515
2	183542.026	208287.921	322276.300	447500.989	324066.490	589419.668
3	230471.928	95394.501	114905.425	238626.393	331277.652	173758.773
4	37752.206	102985.542	59588.932	94007.049	195284.951	176511.986
5	17029.189	13292.008	54664.401	53900.230	85012.603	118568.929
6	16468.469	5896.500	5528.053	49450.035	48758.584	56557.472
7	37072.183	3426.703	1724.179	4994.383	44735.684	32147.760
8	5034.807	13730.169	1120.399	1556.298	4511.498	29493.962
9	2712.735	3376.773	8081.407	8318.329	4570.089	8597.958

age	1983	1984	1985	1986	1987	1988
1	2971918.90	1132803.095	1200030.05	891146.944	2096144.37	902230.147
2	275399.53	1045803.700	415450.87	417831.925	308281.12	759815.119
3	225732.33	137944.940	613811.14	249050.200	178456.43	172221.145
4	77707.66	101856.360	68301.55	369177.327	126762.95	105262.528
5	71357.51	42604.795	59006.21	45475.836	221414.53	84327.191
6	52038.08	24443.500	24391.21	38965.716	23322.30	152796.591
7	28860.69	21280.354	11369.44	15782.651	18235.58	13119.838
8	18181.29	12215.680	10457.04	3773.720	11833.32	9583.681
9	18282.57	5405.583	6888.49	5212.335	20182.08	10178.888

age	1989	1990	1991	1992	1993	1994	1995
1	838395.522	431692.61	378816.11	792034.50	580237.53	852564.92	606827.38
2	330918.150	304814.40	150528.46	124141.29	288318.73	203186.96	312635.71
3	461029.010	213733.92	190915.36	91875.83	71118.05	132839.41	119360.47
4	103495.308	279037.95	138297.40	133577.64	52840.28	41420.46	72693.80
5	68296.429	75685.66	182048.75	98365.42	98338.62	37394.93	31774.98
6	57556.979	44625.05	43362.52	129124.30	68306.00	76379.89	26782.52
7	111154.279	44872.78	27766.86	26410.62	84718.64	47762.68	61416.25
8	8786.935	86320.80	31230.72	17936.38	17873.14	58454.99	33241.25
9	18987.797	22215.86	20192.12	22897.25	14189.25	49069.88	40814.46

age	1996	1997	1998	1999	2000	2001
1	945693.72	1478748.97	483439.660	309651.736	1699207.756	1163240.048
2	223084.52	346765.56	543307.118	172569.222	109485.523	623027.336
3	161766.68	132980.91	209277.515	339165.155	97814.933	65617.227
4	70413.61	104640.43	77467.583	140216.803	193360.938	64545.028
5	45611.36	54957.92	64677.161	39900.384	103069.610	136366.547
6	23647.81	34143.27	27851.795	36858.080	23441.876	81612.884
7	20241.56	19021.72	14359.192	11622.780	26206.090	14461.912
8	47210.99	13856.76	7455.823	4842.647	7434.462	20783.971
9	173639.09	26270.17	8780.716	4195.420	2334.544	4510.246

age	2002	2003	2004	2005	2006	2007	2008
1	1261565.556	500703.398	289252.36	299687.21	487235.00	321577.81	393522.18
2	427848.889	463526.653	184165.83	106410.00	110109.68	178837.96	117971.07
3	392347.990	284050.781	314868.95	130571.25	73512.05	71957.01	113470.27
4	40288.807	236765.712	190366.67	237745.02	95233.58	48907.32	45589.58
5	49566.483	27902.656	163226.83	145839.86	192558.03	70626.24	34610.32
6	100151.405	27695.182	18170.68	104287.96	117074.61	140540.26	49003.54
7	65031.320	64058.780	20934.87	12725.88	83330.10	84737.85	96512.64
8	6820.262	50258.421	45798.50	11705.55	10176.76	60402.14	58297.01
9	6268.687	7701.869	21643.75	14321.66	29595.50	20418.17	78117.60

age	2009	2010	2011	2012
1	490750.06	1267874.48	513121.46	616135.74
2	144557.07	180135.83	465171.60	188388.39
3	80598.67	94691.48	114987.30	308388.83
4	81253.56	53831.64	60597.00	78340.69
5	36279.73	60484.30	38462.46	45975.02
6	27260.00	26586.29	42403.96	28771.70
7	38389.11	19813.60	18455.19	31486.58
8	75678.96	27942.76	13777.77	13721.47
9	55874.53	65806.18	46944.94	30007.10

TABLE 5.6.15 HERRING in VIa (N). SURVIVORS AFTER TERMINAL YEAR

Units : NA

age \ year	2013
1	NA
2	368665.40
3	126867.55
4	215628.82
5	60934.36
6	35328.23
7	21968.96
8	24068.71
9	34012.62

TABLE 5.6.16 HERRING in VIa (N). FITTED SELECTION PATTERN

Units : NA

age \ year	2005	2006	2007	2008	2009	2010
1	0.01139294	0.01139294	0.01139294	0.01139294	0.01139294	0.01139294
2	0.63041044	0.63041044	0.63041044	0.63041044	0.63041044	0.63041044
3	1.04318784	1.04318784	1.04318784	1.04318784	1.04318784	1.04318784
4	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000
5	1.08029287	1.08029287	1.08029287	1.08029287	1.08029287	1.08029287
6	1.12224496	1.12224496	1.12224496	1.12224496	1.12224496	1.12224496
7	1.11488669	1.11488669	1.11488669	1.11488669	1.11488669	1.11488669
8	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000
9	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000

age \ year	2011	2012
1	0.01139294	0.01139294
2	0.63041044	0.63041044
3	1.04318784	1.04318784
4	1.00000000	1.00000000
5	1.08029287	1.08029287
6	1.12224496	1.12224496
7	1.11488669	1.11488669
8	1.00000000	1.00000000
9	1.00000000	1.00000000

TABLE 5.6.17 HERRING in VIa (N). PREDICTED CATCH IN NUMBERS

Units : NA

age \ year	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967
1	6496	15616	53092	3561	13081	55048	11796	26546	299483	211675	207947
2	74622	30980	67972	102124	45195	92805	78247	82611	19767	500853	27416
3	58086	145394	35263	60290	61619	22278	53455	70076	62642	33456	218689
4	25762	39070	116390	22781	33125	67454	11859	26680	59375	60502	37069
5	33979	24908	24946	48881	22501	44357	40517	7283	22265	40908	39246
6	19890	27630	17332	11631	12412	19759	26170	24227	5120	19344	29793
7	8885	17405	16999	10347	5345	24139	8687	18637	22891	5563	11770
8	1427	9857	7372	6346	4814	6147	13662	8797	18925	17811	5533
9	4423	7159	8595	4617	2582	7082	6088	15103	19531	27083	25799

age \ year	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978
1	220255	37706	238226	207711	534963	51170	309016	172879	69053	34836	22525
2	94438	92561	99014	335083	621496	235627	124944	202087	319604	47739	46284
3	20998	71907	253719	412816	175137	808267	151025	89066	101548	95834	20587
4	159122	23314	111897	302208	54205	131484	519178	63701	35502	22117	40692
5	13988	211243	27741	101957	66714	63071	82466	188202	25195	10083	6879
6	23582	21011	142399	25557	25716	54642	49683	30601	76289	12211	3833
7	15677	42762	21609	154424	10342	18242	34629	12297	10918	20992	2100
8	6377	26031	27073	16818	55763	6506	22470	13121	3914	2758	6278
9	10814	26207	24082	31999	16631	32223	21042	13698	12014	1486	1544

age \ year	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
1	247	2692	36740	13304	81923	2207	40794	33768	19463	1708	6216
2	142	279	77961	250010	77810	188778	68845	154963	65954	119376	36763
3	77	95	105600	72179	92743	49828	148399	86072	45463	41735	109501
4	19	51	61341	93544	29262	35001	17214	118860	32025	28421	18923
5	13	13	21473	58452	42535	14948	15211	18836	50119	19761	18109
6	8	9	12623	23580	27318	11366	6631	18000	8429	28555	7589
7	4	8	11583	11516	14709	9300	6907	2578	7307	3252	15012
8	1	1	1309	13814	8437	4427	3323	1427	3508	2222	1622
9	0	0	1326	4027	8484	1959	2189	1971	5983	2360	3505

TABLE 5.6.17 continued. HERRING in VIa (N). PREDICTED CATCH IN NUMBERS

age	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
1	14294	26396	5253	17719	1728	266	1952	1193	9092	7635	3568.58
2	40867	23013	24469	95288	36554	82176	37854	55810	74167	35252	18161.91
3	40779	25229	24922	18710	40193	30398	30899	34966	34571	93910	17263.76
4	74279	28212	23733	10978	6007	21272	9219	31657	31905	25078	40673.54
5	26520	37517	21817	13269	7433	5376	7508	23118	22872	13364	12264.30
6	13305	13533	33869	14801	8101	4205	2501	17500	14372	7529	7120.78
7	9878	7581	6351	19186	10515	8805	4700	10331	8641	3251	3083.08
8	21456	6892	4317	4711	12158	7971	8458	5213	2825	1257	1451.93
9	5522	4456	5511	3740	10206	9787	31108	9883	3327	1089	455.93

age	2001	2002	2003	2004	2005	2006	2007
1	142.98	992.20	56.12	0.00	239.0116	697.3723	568.5275
2	81030.48	38481.61	33331.97	6843.91	6213.1344	11247.2058	22262.3604
3	14942.91	93975.06	46865.58	22223.20	12942.7484	12529.4451	14812.6449
4	9305.89	9014.41	53766.66	27815.23	23751.1570	16375.5536	10162.2342
5	24482.25	18113.71	7462.99	45782.43	15672.1466	35499.1321	15706.9274
6	9280.71	28016.08	4344.55	3916.10	11616.1044	22333.0980	32312.5395
7	6624.96	9040.10	12818.38	7641.76	1408.7293	15802.7261	19371.3122
8	4610.61	1547.86	9187.62	8481.01	1169.4061	1749.9087	12550.6914
9	1000.53	1422.68	1407.96	4008.01	1430.7600	5088.9900	4242.6000

age	2008	2009	2010	2011	2012
1	363.724	689.2102	2154.091	650.3796	1092.825
2	7942.019	14504.1308	21608.728	42355.3115	14838.946
3	12923.316	13503.5708	18818.448	17547.6214	40910.224
4	5234.092	13733.3856	10797.449	9326.9797	10478.984
5	4271.406	6575.2024	12989.326	6352.4625	6604.969
6	6266.371	5112.4871	5903.713	7249.8903	4280.984
7	12266.276	7157.3586	4374.500	3136.5638	4656.693
8	6693.019	12791.1732	5604.706	2120.6490	1835.407
9	8968.600	9443.8500	13199.280	7225.6800	4013.800

TABLE 5.6.18 HERRING in VIa (N). CATCH RESIDUALS

Units : Thousands NA

age	2005	2006	2007	2008	2009	2010
1	-0.26976200	-1.6610388	-1.46976265	-Inf	1.02641784	1.54260091
2	0.43849910	-0.5192832	0.43300571	-0.005503475	-0.23134412	-0.06051529
3	0.58519770	-0.3103933	0.18117639	0.008917889	-0.25390254	-0.14175353
4	-0.14222416	-0.1824252	-0.43842885	0.036301861	0.18878707	-0.08093764
5	-0.42578558	0.1457159	-0.09629357	-0.282710862	0.23681857	0.11745168
6	-0.17172786	0.2183135	-0.05556186	-0.096740188	0.10679223	0.06850636
7	-0.32780244	0.2830525	0.10505336	0.189951467	0.04872010	-0.01201846
8	0.02161672	0.5528562	0.07922361	0.196008924	-0.08116611	-0.03926350
9	0.00000000	0.0000000	0.00000000	0.000000000	0.00000000	0.00000000

age	2011	2012
1	0.941338619	-0.10944818
2	-0.042623348	0.00763199
3	-0.105989430	0.13123696
4	0.102518511	-0.07678718
5	0.123888966	0.20370846
6	-0.357363512	0.38821573
7	0.008759747	-0.18410310
8	0.208156668	-0.48522544
9	0.000000000	0.00000000

TABLE 5.6.19 HERRING in VIa (N). PREDICTED INDEX VALUES

WoS Summer Acoustic Survey
Units : NA NA

age	1991	1992	1993	1994	1995	1996	1997
1	104950.74	232367.55	166671.01	251126.9	178989.1	278549.44	436031.56
2	280336.75	223346.82	460653.30	370595.8	532115.6	410145.19	641843.33
3	731364.54	316299.85	246524.11	445098.6	416649.4	593754.86	461021.25
4	591828.09	582464.66	225506.03	184712.1	290537.5	316975.99	414809.43
5	717989.61	383492.41	407517.66	148266.2	128646.6	185251.99	180464.67
6	151836.42	470843.69	257870.50	311164.0	105486.0	96357.52	97703.30
7	102537.29	100034.63	324294.72	183692.4	249352.7	77150.43	53500.82
8	116327.34	65811.86	64427.58	219773.3	122051.0	181201.04	45354.37
9	80769.02	90222.66	54927.95	198121.4	160931.6	715695.35	92338.61

age	1998	1999	2000	2001	2002	2003
1	140325.62	89415.55	500477.694	343201.38	371998.25	147728.50
2	1024327.05	308679.65	201883.536	1180240.54	834174.32	915089.60
3	782999.01	1162075.87	362940.959	234096.56	1386598.30	1062915.23
4	278040.58	610908.69	823644.178	287999.13	169926.77	996121.99
5	226404.69	142011.60	431634.697	548129.99	171654.15	105041.13
6	79363.67	140417.48	82658.801	330842.72	360166.98	109090.73
7	37209.68	42691.24	108224.781	44989.99	264801.99	250005.11
8	24342.01	17511.38	28209.118	77349.26	25285.58	192401.59
9	30786.05	16292.06	9512.728	18025.65	24958.10	31663.51

age	2004	2005	2006	2007	2008	2009	2010
1	85349.82	88368.02	143591.2	NA	116024.2	144630.4	373564.07
2	372156.76	212012.40	212840.5	340172.17	233628.3	279786.1	343772.47
3	1257350.08	511655.52	273985.9	261141.82	440212.0	301037.8	345528.37
4	848305.91	1092050.88	416929.0	208717.20	207408.6	356450.8	230936.94
5	608122.65	615331.69	771365.8	275224.41	144521.9	145652.9	237037.63
6	68657.54	423402.24	450373.0	525372.47	196818.7	105106.3	99970.86
7	71459.72	52792.44	327665.0	323850.15	396112.9	151294.5	76166.24
8	175033.96	47375.83	39256.8	227127.67	233690.4	292526.9	105622.99
9	88831.43	62247.42	122601.0	82451.31	336284.3	231935.7	267127.72

age	2011	2012
1	151241.47	295932.82
2	906236.66	370164.32
3	434155.43	1180963.57
4	268606.05	351998.08
5	156157.01	189411.93
6	165412.34	113955.44
7	73579.84	127447.28
8	53811.72	54323.38
9	196901.92	127577.27

TABLE 5.6.20 HERRING in VIa (N). INDEX RESIDUALS
WoS Summer Acoustic Survey

Units : NA

age	1991	1992	1993	1994	1995	1996
1	1.17047746	-1.14007485	-4.2586323	0.6768807	0.9021731	-1.910671985
2	0.04923312	0.81271885	0.2292093	0.3803017	0.7292909	0.340394725
3	-0.80219724	-0.40492730	1.0285214	0.3114184	0.1274842	0.301302702
4	-0.47559533	-0.81396015	1.1165169	0.4358289	0.4381814	0.037566016
5	-0.38554970	0.07835610	0.3264759	0.7270561	0.1733689	-0.664057798
6	0.14965553	-0.67342901	1.2503927	-0.1488483	0.5735989	-0.463770584
7	-0.03772629	0.05480463	-0.0926117	0.7951575	-0.3877868	0.002971214
8	-0.25848911	-0.14884951	0.8962301	-0.2350365	0.6623543	-0.840465372
9	-0.33040935	-0.35218605	1.0781731	-0.4069876	0.2258021	-1.829976001

age	1997	1998	1999	2000	2001	2002
1	0.59725072793	2.164033046	1.78747569	-0.11166305	-0.09179477	0.13249389
2	0.00002597518	-0.253914540	0.04348900	0.44868395	-0.10556435	-0.64880016
3	-0.47685809187	-0.160671271	0.17765591	-0.07386055	-0.07261573	0.03563454
4	-0.90958590270	0.527239632	-0.34652191	0.08810044	-0.51082259	0.16194929
5	-1.00436625489	-0.234658948	0.77419106	-0.09275272	-0.22543576	-0.05973890
6	-0.67955866127	-0.001180929	-0.01230663	1.09709323	-0.91430603	0.16387300
7	-1.18975956609	-0.282580341	0.70615077	0.61160387	0.82634528	-0.55313007
8	-0.44755566765	-0.563918521	0.45496491	1.21423164	-0.38942448	0.98189338
9	-1.32924125349	0.177620736	0.77603387	1.92175654	0.65494375	0.86877784

TABLE 5.6.20 continued. HERRING in VIa (N). INDEX RESIDUALS

year						
age	2003	2004	2005	2006	2007	2008
1	1.0886676	1.88829589	-0.5654951	-0.24579636	NA	-0.885936797
2	0.1273769	-0.30436389	0.1380614	1.36712805	-0.99316996	-0.004540052
3	-0.1309015	-0.50318012	-0.7982688	0.34767076	0.11987577	0.728328735
4	0.3903717	-0.65125293	-0.9482042	-0.38218270	-0.03024033	1.170898856
5	0.5458011	-0.05218776	-0.9204952	-0.28134865	-0.63878624	0.855279432
6	0.1691817	-0.20915079	-1.0191928	-0.08252067	-0.41507092	0.324364085
7	0.3269785	-0.14523056	-1.4326712	-0.36704167	-0.28763108	0.598745784
8	-0.5207582	-0.75582472	-0.1945505	-0.59281239	-0.32869929	0.448335579
9	0.8649864	-0.15206757	-0.8427152	-0.72632626	-0.94335196	-0.242993156

year				
age	2009	2010	2011	2012
1	0.8717395	-1.13736601	-1.9170302	0.98503354
2	-0.4043029	0.36236926	-1.5893826	-0.72418973
3	-0.1311354	0.33525654	0.5242668	-0.48274425
4	0.1882701	-0.29784133	0.5193008	0.29204096
5	0.9416891	-0.37179745	0.2688450	0.24017541
6	0.7342498	-0.06917659	0.2845633	-0.05839103
7	0.2095140	-0.17284838	0.9937672	-0.17694154
8	0.5354414	-0.68739788	0.7387588	0.03166404
9	0.6761183	-0.17916148	0.2901515	-0.19885597

TABLE 5.6.21 HERRING in VIa (N). FIT PARAMETERS

	Value	Std.dev	Lower.95.pct.CL
F, 2005	0.11080019	0.1391997	0.084343438
F, 2006	0.19892982	0.1329074	0.153308707
F, 2007	0.24577423	0.1333110	0.189260378
F, 2008	0.12841904	0.1377256	0.098038131
F, 2009	0.19518983	0.1405375	0.148193527
F, 2010	0.23617765	0.1524850	0.175162437
F, 2011	0.17614609	0.1718756	0.125767823
F, 2012	0.15126887	0.1965184	0.102912881
Selectivity at age 1	0.01139194	0.3217048	0.006063967
Selectivity at age 2	0.63040944	0.1284317	0.490116673
Selectivity at age 3	1.04318684	0.1174846	0.828623394
Selectivity at age 5	1.08029187	0.1061573	0.877360686
Selectivity at age 6	1.12224396	0.1027538	0.917532552
Selectivity at age 7	1.11488569	0.1039476	0.909386233
Terminal year pop, age 1	1003864.04276630	0.7848677	215566.861144048
Terminal year pop, age 2	188387.39419466	0.2907744	106546.611035293
Terminal year pop, age 3	308387.82535463	0.2309929	196097.519046044
Terminal year pop, age 4	78339.69255682	0.2045674	52462.692195364
Terminal year pop, age 5	45974.02131906	0.1907059	31635.909191444
Terminal year pop, age 6	28770.70127834	0.1828203	20106.231390730
Terminal year pop, age 7	31485.58357142	0.1801648	22118.331762583
Terminal year pop, age 8	13720.46654398	0.1806637	9629.081115066
Last true age pop, 2005	11704.55493860	0.2530581	7127.669279486
Last true age pop, 2006	10175.75981925	0.1938227	6959.557243448
Last true age pop, 2007	60401.13834322	0.1719320	43121.477907759
Last true age pop, 2008	58296.01019086	0.1654031	42154.593000424
Last true age pop, 2009	75677.96326825	0.1572877	55601.104266977
Last true age pop, 2010	27941.76106480	0.1559988	20580.925342312
Last true age pop, 2011	13776.76747779	0.1664768	9941.213200350
Index 1, age 1 numbers, Q	0.50888097	0.4872388	0.195825917
Index 1, age 2 numbers, Q	2.43735544	0.1545385	1.800416688
Index 1, age 3 numbers, Q	4.65400033	0.1538198	3.442646155
Index 1, age 4 numbers, Q	5.15259584	0.1535915	3.813171881
Index 1, age 5 numbers, Q	4.75590757	0.1537662	3.518398136
Index 1, age 6 numbers, Q	4.58795942	0.1543867	3.390025283
Index 1, age 7 numbers, Q	4.68588528	0.1555955	3.454189230
Index 1, age 8 numbers, Q	4.54003752	0.1570827	3.336936566
Index 1, age 9 numbers, Q	4.87553796	0.1553836	3.595484179

TABLE 5.6.21 continued. HERRING in VIa (N). FIT PARAMETERS

	Upper.95.pct.CL
F, 2005	0.14555586
F, 2006	0.25812671
F, 2007	0.31916332
F, 2008	0.16821465
F, 2009	0.25708998
F, 2010	0.31844659
F, 2011	0.24670416
F, 2012	0.22234604
Selectivity at age 1	0.02140120
Selectivity at age 2	0.81086011
Selectivity at age 3	1.31330927
Selectivity at age 5	1.33016051
Selectivity at age 6	1.37262870
Selectivity at age 7	1.36682308
Terminal year pop, age 1	4674851.27821060
Terminal year pop, age 2	333091.87356226
Terminal year pop, age 3	484978.34796487
Terminal year pop, age 4	116980.41356785
Terminal year pop, age 5	66810.49131398
Terminal year pop, age 6	41168.99064580
Terminal year pop, age 7	44819.92509534
Terminal year pop, age 8	19550.27690959
Last true age pop, 2005	19220.39322238
Last true age pop, 2006	14878.25795189
Last true age pop, 2007	84605.11304740
Last true age pop, 2008	80618.13819762
Last true age pop, 2009	103004.32338412
Last true age pop, 2010	37935.22392297
Last true age pop, 2011	19092.16896488
Index 1, age 1 numbers, Q	1.32239819
Index 1, age 2 numbers, Q	3.29962591
Index 1, age 3 numbers, Q	6.29159027
Index 1, age 4 numbers, Q	6.96250908
Index 1, age 5 numbers, Q	6.42868031
Index 1, age 6 numbers, Q	6.20920785
Index 1, age 7 numbers, Q	6.35677996
Index 1, age 8 numbers, Q	6.17690515
Index 1, age 9 numbers, Q	6.61131275

Table 5.7.1.1. Herring in VIa (North). Input data for short-term predictions, numbers-at-age from the assessment with age 1-ring in 2012 and 2013 replaced by geometric mean values (1989-2011) and age 2-ring in 2013 replaced by a the value calculated by the exponential degradation of geometric mean recruitment (1989-2011); natural mortality (M), proportion mature (Mat), proportion of fishing mortality prior to spawning (PF), proportion of natural mortality prior to spawning (PM), mean weights at age in the stock (SWt), selection pattern (Sel), mean weights at age in the catch (CWt). All biological data are taken as mean of the last 3 years. VIa (N) herring appears to have considerable annual variability in mean weights and in fraction mature. The last year's values are not applicable. N.B. In this table "age" refers to number of rings (winter rings in the otolith).

2013

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
1	616136	1	0	0.67	0.67	0.062367	0.002140	0.071867
2	226302.5	0.3	0.85	0.67	0.67	0.124900	0.118432	0.152267
3	126867.6	0.2	1	0.67	0.67	0.170067	0.195979	0.189033
4	215628.8	0.1	1	0.67	0.67	0.198300	0.187865	0.212767
5	60934.36	0.1	1	0.67	0.67	0.217633	0.202949	0.227933
6	35328.23	0.1	1	0.67	0.67	0.225300	0.210831	0.234767
7	21968.96	0.1	1	0.67	0.67	0.220167	0.209448	0.241567
8	24068.71	0.1	1	0.67	0.67	0.219867	0.187865	0.256000
9	34012.62	0.1	1	0.67	0.67	0.227433	0.187865	0.251267

2014

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
1	616136	1	0	0.67	0.67	0.062367	0.002140	0.071867
2	.	0.3	0.85	0.67	0.67	0.124900	0.118432	0.152267
3	.	0.2	1	0.67	0.67	0.170067	0.195979	0.189033
4	.	0.1	1	0.67	0.67	0.198300	0.187865	0.212767
5	.	0.1	1	0.67	0.67	0.217633	0.202949	0.227933
6	.	0.1	1	0.67	0.67	0.225300	0.210831	0.234767
7	.	0.1	1	0.67	0.67	0.220167	0.209448	0.241567
8	.	0.1	1	0.67	0.67	0.219867	0.187865	0.256000
9	.	0.1	1	0.67	0.67	0.227433	0.187865	0.251267

2015

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
1	616136	1	0	0.67	0.67	0.062367	0.002140	0.071867
2	.	0.3	0.85	0.67	0.67	0.124900	0.118432	0.152267
3	.	0.2	1	0.67	0.67	0.170067	0.195979	0.189033
4	.	0.1	1	0.67	0.67	0.198300	0.187865	0.212767
5	.	0.1	1	0.67	0.67	0.217633	0.202949	0.227933
6	.	0.1	1	0.67	0.67	0.225300	0.210831	0.234767
7	.	0.1	1	0.67	0.67	0.220167	0.209448	0.241567
8	.	0.1	1	0.67	0.67	0.219867	0.187865	0.256000
9	.	0.1	1	0.67	0.67	0.227433	0.187865	0.251267

Table 5.7.1.2. Herring in VIa (North). Short-term prediction single option table, with F constraint (Fsq (avg 2010-2012)). Fbar is $F_{3\text{-}6}$ N.B. In this table "age" refers to number of rings (winter rings in the otolith).

Year:	2013	F multiplier:	1	Fbar:	0.1994				
Age	F	CatchNos	Yield	StockNos	Biomass	SSNos(Jan)	SSB(Jan)	SSNos(ST)	SSB(ST)
1	0.0021	833	60	616136	38426	0	0	0	0
2	0.1184	21901	3335	226303	28265	192357	24025	145330	18152
3	0.196	20531	3881	126868	21576	126868	21576	97304	16548
4	0.1879	35200	7489	215629	42759	215629	42759	177805	35259
5	0.2029	10669	2432	60934	13261	60934	13261	49741	10825
6	0.2108	6402	1503	35328	7959	35328	7959	28686	6463
7	0.2094	3958	956	21969	4837	21969	4837	17855	3931
8	0.1879	3929	1006	24069	5292	24069	5292	19847	4364
9	0.1879	5552	1395	34013	7736	34013	7736	28046	6379
Total		108974	22057	1361248	170112	711166	127446	564614	101920

Year:	2014	F multiplier:	1	Fbar:	0.1994				
Age	F	CatchNos	Yield	StockNos	Biomass	SSNos(Jan)	SSB(Jan)	SSNos(ST)	SSB(ST)
1	0.0021	833	60	616136	38426	0	0	0	0
2	0.1184	21889	3333	226179	28250	192252	24012	145250	18142
3	0.196	24100	4556	148925	25327	148925	25327	114221	19425
4	0.1879	13938	2966	85385	16932	85385	16932	70407	13962
5	0.2029	28311	6453	161692	35190	161692	35190	131989	28725
6	0.2108	8156	1915	45008	10140	45008	10140	36547	8234
7	0.2094	4664	1127	25890	5700	25890	5700	21042	4633
8	0.1879	2632	674	16122	3545	16122	3545	13294	2923
9	0.1879	7110	1786	43553	9905	43553	9905	35913	8168
Total		111633	22869	1368890	173415	718827	130751	568663	104211

Year:	2015	F multiplier:	1	Fbar:	0.1994				
Age	F	CatchNos	Yield	StockNos	Biomass	SSNos(Jan)	SSB(Jan)	SSNos(ST)	SSB(ST)
1	0.0021	833	60	616136	38426	0	0	0	0
2	0.1184	21889	3333	226179	28250	192252	24012	145250	18142
3	0.196	24087	4553	148843	25313	148843	25313	114159	19415
4	0.1879	16362	3481	100229	19875	100229	19875	82648	16389
5	0.2029	11210	2555	64027	13934	64027	13934	52265	11375
6	0.2108	21642	5081	119432	26908	119432	26908	96978	21849
7	0.2094	5942	1435	32984	7262	32984	7262	26808	5902
8	0.1879	3102	794	18999	4177	18999	4177	15667	3445
9	0.1879	7305	1835	44748	10177	44748	10177	36899	8392
Total		112372	23128	1371577	174324	721515	131660	570673	104908

Table 5.7.1.3. Herring in VIa (North). Short-term prediction multiple option table, with F constraint (Fsq (avg 2010-2012)). Fbar is F_{3-6}

2013				
Biomass	SSB	FMult	FBar	Landings
170112	101920	1	0.1994	22057

2014					2015	
Biomass	SSB	FMult	FBar	Landings	Biomass	SSB
173415	117927	0	0	0	195585	138454
.	116475	0.1	0.0199	2478	193277	134616
.	115043	0.2	0.0399	4912	191011	130895
.	113628	0.3	0.0598	7302	188787	127287
.	112231	0.4	0.0798	9649	186604	123788
.	110851	0.5	0.0997	11953	184461	120396
.	109489	0.6	0.1196	14216	182358	117105
.	108145	0.7	0.1396	16438	180293	113915
.	106817	0.8	0.1595	18621	178266	110820
.	105506	0.9	0.1795	20764	176277	107819
.	104211	1	0.1994	22869	174324	104908
.	102933	1.1	0.2193	24936	172406	102085
.	101671	1.2	0.2393	26966	170524	99346
.	100425	1.3	0.2592	28959	168677	96690
.	99195	1.4	0.2792	30917	166863	94113
.	97980	1.5	0.2991	32840	165083	91613
.	96780	1.6	0.319	34729	163335	89188
.	95596	1.7	0.339	36584	161619	86835
.	94426	1.8	0.3589	38406	159934	84553
.	93271	1.9	0.3789	40196	158280	82338
.	92131	2	0.3988	41953	156657	80189

Table 5.8.1. Herring in VIa (North). Extracts of the relevant information from the sen and sum files used by PlotMSY.

Herring input files.

(a) Sen file

```
sH1   0.002185521 0.3217048
sH2   0.1209324   0.1284317
sH3   0.2001161   0.1174846
sH4   0.1918313   0.1061573
sH5   0.207234    0.1061573
sH6   0.2152817   0.1027538
sH7   0.2138701   0.1039476
sH8   0.1918313   0.1039476
sH9   0.1918313   0.1039476
WH1   0.0725      0.197928153
WH2   0.1469      0.102413968
WH3   0.1894      0.094456923
WH4   0.2076      0.088095453
WH5   0.2161      0.09181714
WH6   0.2261      0.075192111
WH7   0.2408      0.088421187
WH8   0.2817      0.109474499
WH9   0.2467      0.093201182
WS1   0.0659      0.22268272
WS2   0.1501      0.121832175
WS3   0.1828      0.088730839
WS4   0.1888      0.087079763
WS5   0.2059      0.087507623
WS6   0.2164      0.081899477
WS7   0.2135      0.083066106
WS8   0.2179      0.10227152
WS9   0.2144      0.118253388
M1    1     0.1
M2    0.3   0.1
M3    0.2   0.1
M4    0.1   0.1
M5    0.1   0.1
M6    0.1   0.1
M7    0.1   0.1
M8    0.1   0.1
M9    0.1   0.1
MT1   0     0
MT2   0.85  0.2869497
MT3   1     0.027712
MT4   1     0
MT5   1     0
MT6   1     0
MT7   1     0
MT8   1     0
MT9   1     0
```

[Column 1: sH=human consumption selection, WH=human consumption mean weights, WS=stock mean weights, M=natural mortality, MT=maturity; Column 2: point estimates; Column 3: estimates of precision (CV)]

(b) Sum file (year as year class)

1957	2136613	184234	405110	43438	43438	0	0	0.2834	0.2834	0	0
1958	626496	200601	495444	59669	59669	0	0	0.3305	0.3305	0	0
1959	1285229	213380	532906	65221	65221	0	0	0.3028	0.3028	0	0
1960	2293268	247465	427963	63759	63759	0	0	0.1948	0.1948	0	0
1961	2110018	247715	435271	46353	46353	0	0	0.1294	0.1294	0	0
1962	978157	237068	540413	58195	58195	0	0	0.2059	0.2059	0	0
1963	7839269	259863	572370	49030	49030	0	0	0.1833	0.1833	0	0
1964	1066330	305370	522945	64234	64234	0	0	0.1535	0.1535	0	0
1965	2498686	312179	1115364	68669	68669	0	0	0.1592	0.1592	0	0
1966	4100166	426183	848510	100619	100619	0	0	0.1932	0.1932	0	0
1967	2998773	456838	829562	90400	90400	0	0	0.1903	0.1903	0	0
1968	3439855	434826	952511	84614	84614	0	0	0.1435	0.1435	0	0
1969	9570759	471939	980072	107170	107170	0	0	0.2419	0.2419	0	0
1970	2675642	441946	1000107	165930	165930	0	0	0.3587	0.3587	0	0
1971	1074227	315271	1514872	207167	207167	0	0	0.7883	0.7883	0	0
1972	1672447	443058	1115411	164756	164756	0	0	0.3651	0.3651	0	0
1973	2102769	385421	802001	210270	210270	0	0	0.6056	0.6056	0	0
1974	606435	203879	576306	178160	178160	0	0	0.9572	0.9572	0	0
1975	620881	107030	434633	114001	114001	0	0	0.9101	0.9101	0	0
1976	911556	73358	263563	93642	93642	0	0	1.0693	1.0693	0	0
1977	1216825	51826	162765	41341	41341	0	0	0.995	0.995	0	0
1978	885161	48384	170356	22156	22156	0	0	0.6777	0.6777	0	0
1979	1660162	72243	215739	60	60	0	0	0.0007	0.0007	0	0
1980	769613	121982	252021	306	306	0	0	0.0004	0.0004	0	0
1981	2971919	131719	364259	51420	51420	0	0	0.3632	0.3632	0	0
1982	1132803	109385	305358	92360	92360	0	0	0.6767	0.6767	0	0
1983	1200030	80836	426039	63523	63523	0	0	0.7156	0.7156	0	0
1984	891147	119689	352884	56012	56012	0	0	0.518	0.518	0	0
1985	2096144	147291	348143	39142	39142	0	0	0.3164	0.3164	0	0
1986	902230	132897	314164	70764	70764	0	0	0.5284	0.5284	0	0
1987	838396	123159	379992	44360	44360	0	0	0.3454	0.3454	0	0
1988	431693	147692	334343	35591	35591	0	0	0.2855	0.2855	0	0
1989	378816	163914	317626	34026	34026	0	0	0.2474	0.2474	0	0
1990	792035	154325	269463	44693	44693	0	0	0.3485	0.3485	0	0
1991	580238	125735	207886	28529	28529	0	0	0.2593	0.2593	0	0
1992	852565	97898	192409	28985	28985	0	0	0.2864	0.2864	0	0
1993	606827	98523	182555	31778	31778	0	0	0.2492	0.2492	0	0
1994	945694	91108	177308	24430	24430	0	0	0.23	0.23	0	0
1995	1478749	72006	156988	29575	29575	0	0	0.2673	0.2673	0	0
1996	483440	112492	194589	26105	26105	0	0	0.1727	0.1727	0	0
1997	309652	71103	207795	35233	35233	0	0	0.5168	0.5168	0	0
1998	1699208	100631	186104	33353	33353	0	0	0.5001	0.5001	0	0
1999	1163240	84196	143978	29736	29736	0	0	0.3107	0.3107	0	0
2000	1261566	71766	205590	18322	18322	0	0	0.2453	0.2453	0	0
2001	500703	117823	231314	24556	24556	0	0	0.1969	0.1969	0	0
2002	289252	139460	271054	32914	32914	0	0	0.3503	0.3503	0	0
2003	299687	141591	229446	28081	28081	0	0	0.2452	0.2452	0	0
2004	487235	125948	180050	25021	25021	0	0	0.2129	0.2129	0	0
2005	321578	106730	150525	14129	14129	0	0	0.1176	0.1176	0	0
2006	393522	103289	168782	27346	27346	0	0	0.2112	0.2112	0	0
2007	490750	97849	151578	29616	29616	0	0	0.2609	0.2609	0	0
2008	1267874	101432	143883	16054	16054	0	0	0.1363	0.1363	0	0
2009	513121	85295	164109	18508	18508	0	0	0.2072	0.2072	0	0
2010	616136	64021	167515	19877	19877	0	0	0.2507	0.2507	0	0

[Col2=Recruitment, Col3=SSB, Col4=TSB, Col5=total catch, Col6=human consumption landings, Col7=discards, Col8=industrial bycatch, Col9=total F, Col10=human consumption F, Col11=discards F, Col12=industrial bycatch F]

Table 5.8.2. Herring in VIa (North). Reference point estimates and associated percentiles based on Ricker, Beverton and Holt and Smooth hockey stick functions. Yield-per-recruit reference points are also shown, as is is the AICc for small sample sizes. Estimates of stock and recruitment parameters alpha and beta (scaled and unscaled) are shown for each function

Ricker									
1000/1000 Iterations resulted in feasible parameter estimates									
	Fcrash	Fmsy	Bmsy	MSY	ADMB Alpha	ADMB Beta	Unscaled Alpha	Unscaled Beta	AICc
Deterministic	0.6249	0.2010	523268	88899.3	0.8226	0.2358	8.8395	1.28E-06	120.849
Mean	0.5423	0.1825	2309718.1	367645.58	0.8366	0.2568	9.2602	1.39E-06	122.683
5%ile	0.2497	0.1092	261929.1	47790.115	0.7039	0.0489	7.0407	2.65E-07	120.946
25%ile	0.3433	0.1400	355884.25	65003.8	0.7802	0.1529	8.1442	8.30E-07	121.359
50%ile	0.4616	0.1743	483821.5	84404.9	0.8362	0.2489	9.0665	1.35E-06	122.177
75%ile	0.6438	0.2114	760206.25	122801.5	0.8890	0.3462	10.1763	1.88E-06	123.297
95%ile	1.0695	0.2880	2173639	312145.55	0.9771	0.5035	12.2056	2.73E-06	126.330
CV	0.5675	0.3197	18.657242	18.859249	0.1005	0.5327	0.1687	0.5327	0.015
N	1000	1000	1000	1000	1000	1000	1000	1000	1000
Beverton-Holt									
1000/1000 Iterations resulted in feasible parameter estimates									
	Fcrash	Fmsy	Bmsy	MSY	ADMB Alpha	ADMB Beta	Unscaled Alpha	Unscaled Beta	AICc
Deterministic	0.7864	0.1574	600702	82760.4	0.3993	1.2424	3916640	389002	120.268
Mean	0.7253	0.1520	1148747.6	131158.31	0.4770	1.2969	7972942.564	1027247.913	122.324
5%ile	0.2590	0.0883	204005.45	38675.59	0.1002	1.0888	1621313.5	88997.45	120.389
25%ile	0.3932	0.1161	334399.75	52645.2	0.2735	1.1999	2403750	193092	120.899
50%ile	0.5613	0.1401	503099.5	69813.6	0.4487	1.2942	3485415	339778	121.690
75%ile	0.8510	0.1712	838054.25	103785.75	0.6506	1.3829	5717442.5	632682.5	123.023
95%ile	1.7270	0.2472	2297202.5	248766.95	0.9646	1.5450	15614480	2178331.5	126.765
CV	0.7950	0.4114	4.8714128	3.8687888	0.5576	0.1071	4.69251946	5.8789	0.016
N	959	1000	1000	1000	1000	1000	1000	1000	1000
Smooth hockeystick									
1000/1000 Iterations resulted in feasible parameter estimates									
	Fcrash	Fmsy	Bmsy	MSY	ADMB Alpha	ADMB Beta	Unscaled Alpha	Unscaled Beta	AICc
Deterministic	0.5186	0.5182	229425	80682.5	0.4669	1.2925	3.9633	229335	124.384
Mean	0.3807	0.3802	341696.36	107065.35	0.4432	1.9233	3.7619	341278.2109	124.359
5%ile	0.2009	0.2009	222109.6	65571.13	0.3617	1.2453	3.0707	220975.3	122.780
25%ile	0.2687	0.2686	290586.5	85855.05	0.4042	1.6362	3.4312	290338.75	123.168
50%ile	0.3437	0.3436	338584	104099	0.4360	1.9071	3.7006	338404	123.647
75%ile	0.4473	0.4474	400965	123790.5	0.4697	2.2583	3.9869	400721.25	124.905
95%ile	0.6784	0.6790	457598.8	157382.5	0.5272	2.5785	4.4748	457534.4	127.990
CV	0.4385	0.4267	0.218235	0.2670831	0.1705	0.2205	0.1705	0.2205	0.015
N	998	999	999	999	1000	1000	1000	1000	1000
Per recruit									
	F20	F25	F30	F35	F40	F01	Fmax	Bmsypr	MSYpr
Deterministic	0.5765	0.3960	0.2922	0.2247	0.1772	0.1853	3.0000	0.1262	0.0444
Mean	0.4750	0.3370	0.2546	0.1993	0.1594	0.1868	1.3015	0.1358	0.0427
5%ile	0.2932	0.2287	0.1834	0.1497	0.1226	0.1540	0.6924	0.1117	0.0337
25%ile	0.3759	0.2813	0.2179	0.1740	0.1407	0.1731	0.9855	0.1263	0.0387
50%ile	0.4492	0.3244	0.2463	0.1939	0.1560	0.1864	1.2347	0.1347	0.0427
75%ile	0.5581	0.3859	0.2868	0.2216	0.1760	0.1999	1.5910	0.1461	0.0460
95%ile	0.7133	0.4745	0.3429	0.2617	0.2049	0.2208	2.1650	0.1642	0.0510
CV	0.2771	0.2261	0.1950	0.1743	0.1598	0.1079	0.3413	0.1232	0.1352
N	1000	1000	1000	1000	1000	1000	216	216	216
Combining all SRRs									
Automatically specified weights									
	Ricker	Beverton-Holt	Smooth hockeystick						
	0.31237	0.59903	0.0886048						
Percentage	Fmsy	Fcrash	MSY	Bmsy	Fmsy_w	Fcrash_w	MSY_w	Bmsy_w	
5%	0.0993	0.2213	44436.01	229240.3	0.0934	0.2535	42868.55	257538.5	
25%	0.1400	0.3183	65918.3	316622.5	0.1274	0.3753	62121	355944	
50%	0.1911	0.4379	88358	409013	0.1591	0.5288	78466.7	479612	
75%	0.2922	0.6296	119224.5	600377	0.1973	0.7481	120784	802425	
95%	0.5244	1.2398	220342.3	1771509	0.3236	1.2893	341746.5	2617575	

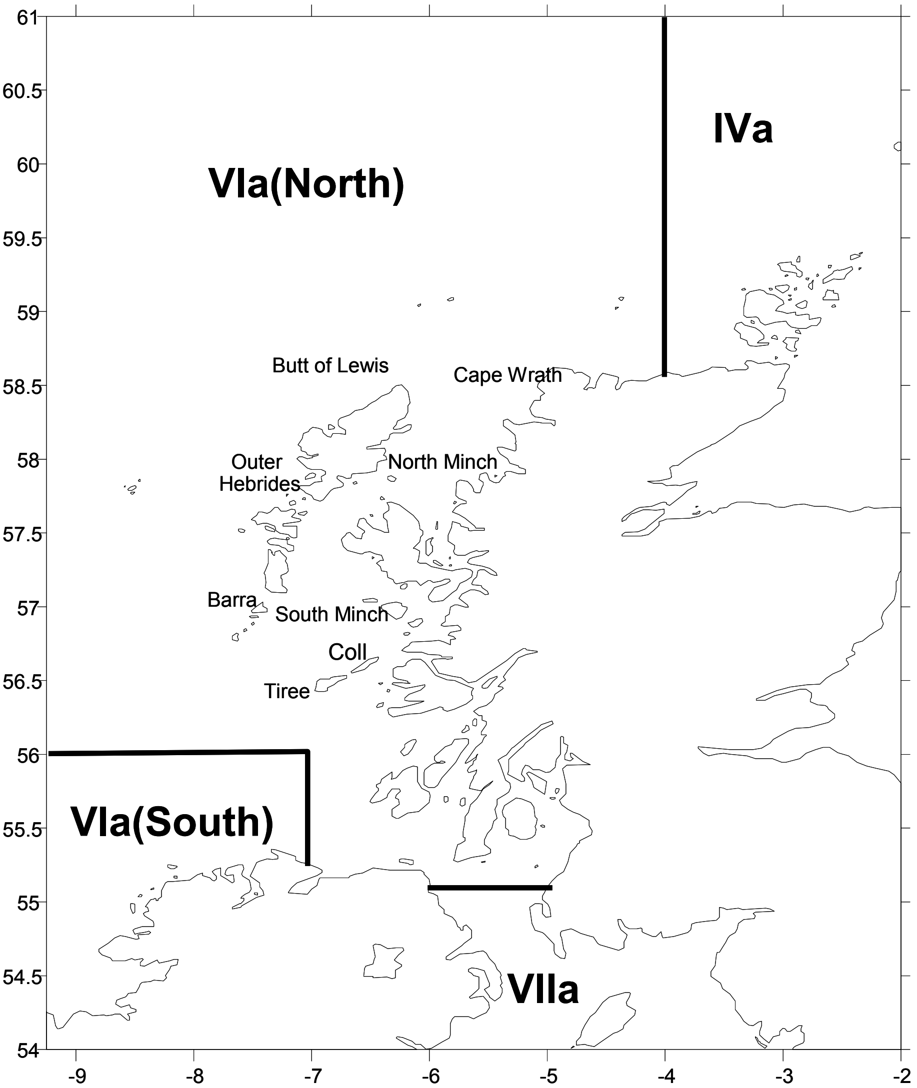


Figure 5.1.1. Location of ICES area VIa (North) and adjacent areas, with place names.

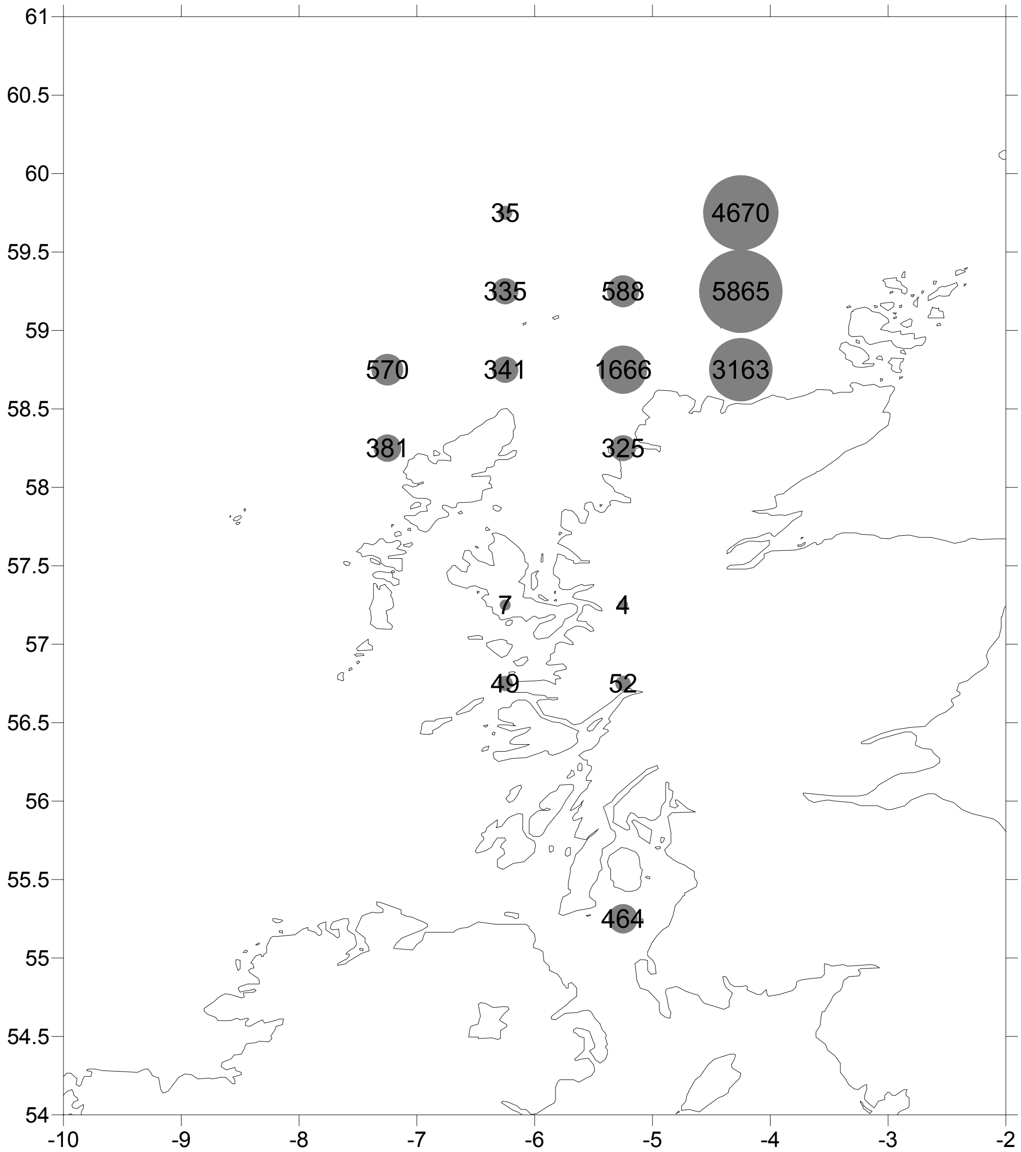


Figure 5.1.2. Herring in VIa (North).Herring catches in tonnes) in all quarters in 2012 by statistical rectangle. WG estimates (if available).

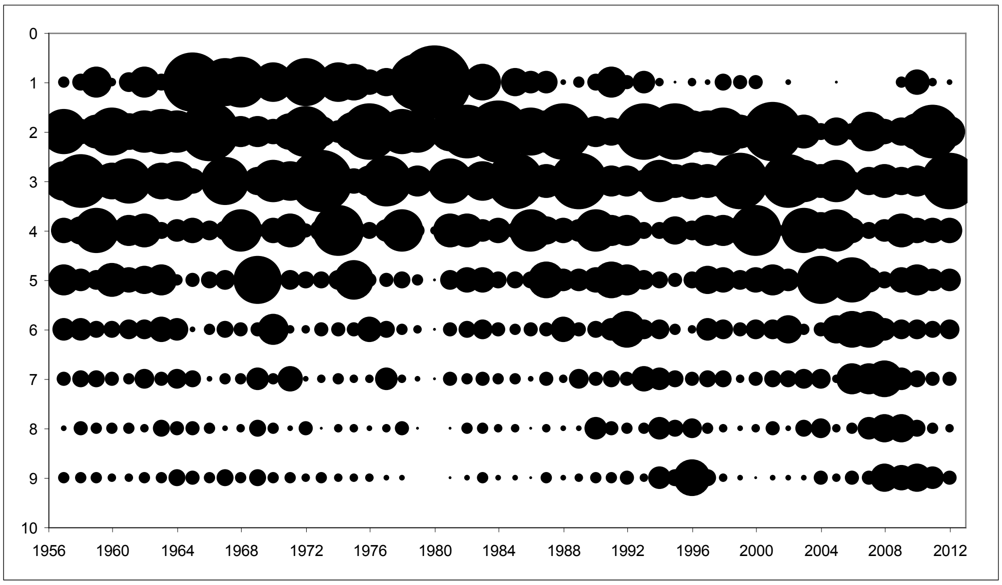


Figure 5.2.1. Herring in VIa (North). Mean standardised catch numbers-at-age standardised by year for the fishery, 1957 to 2012.

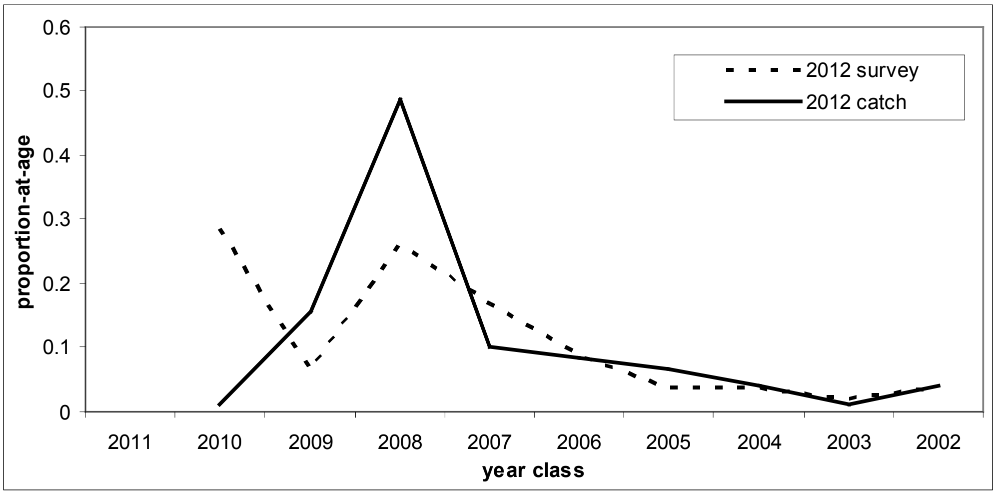


Figure 5.3.1. Herring in VIa (North). Comparison of the proportions-at-age, by year class, in the 2012 acoustic survey (MSHAS_N) and the catch.

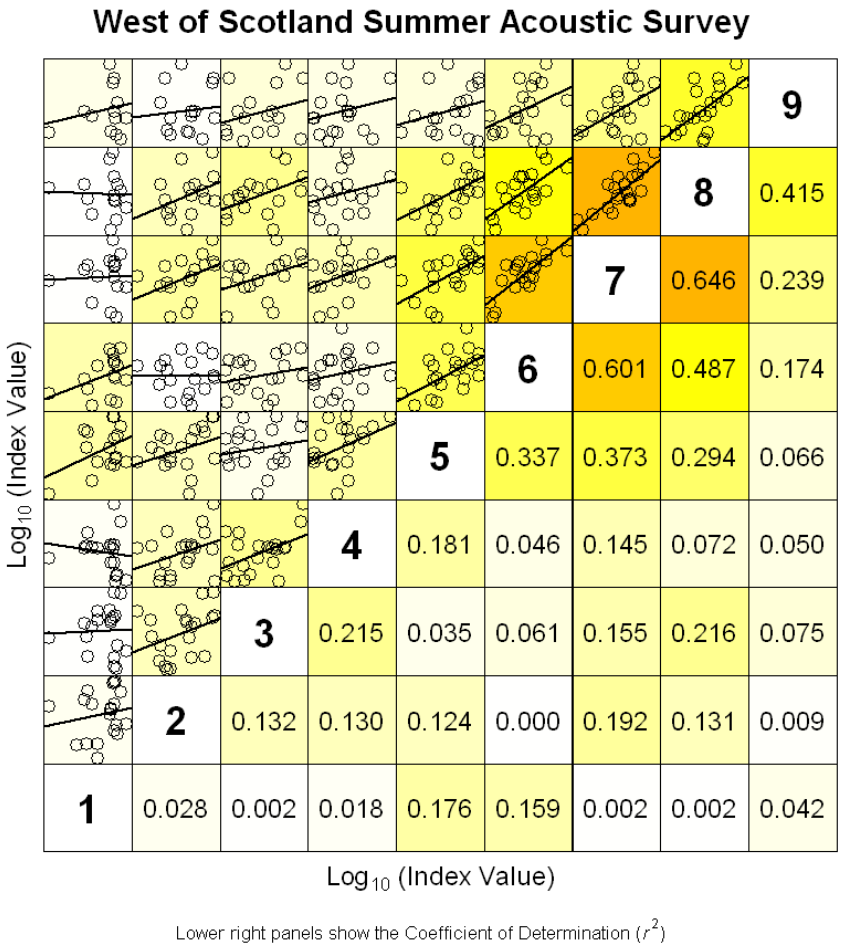


Figure 5.3.2. Herring in VIa (North). Internal consistency between ages in the West of Scotland acoustic survey time series.

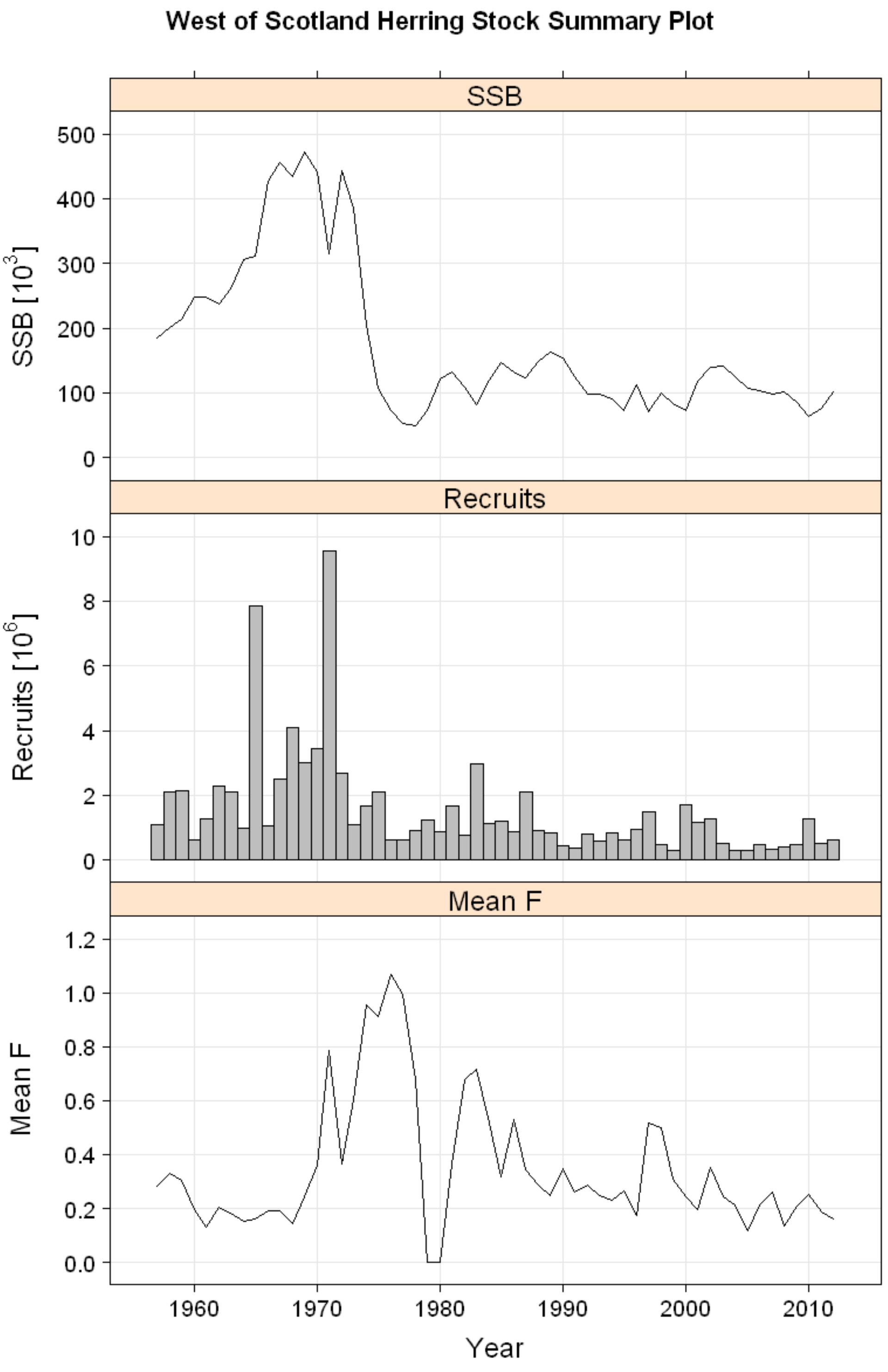


Figure 5.6.1. Herring in VIa (North). Illustration of stock trends from the assessment (8 year separable period) 1957-2012. Summary of estimates of landings, spawning stock biomass at spawning time, fishing mortality at F_{3-6}, recruitment at 1-ring, in the final assessment run. The 2012 estimate for recruitment is given as geometric mean (1989-2011) because there are no data to support its estimation.

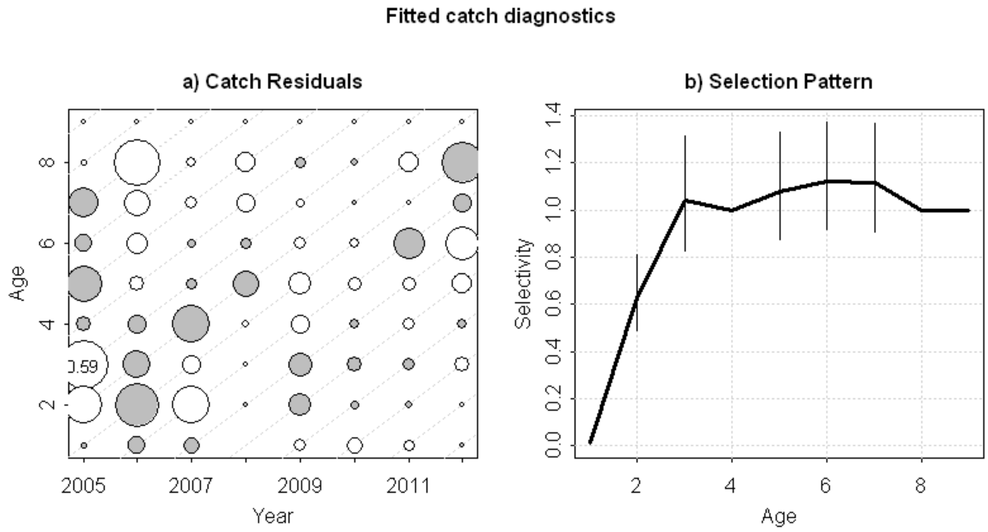


Figure 5.6.2. Herring in VIa (North). Illustration of selection patterns diagnostics, from deterministic calculation (8-year separable period). Top left, a bubble plot of selection pattern residuals. Top right, estimated selection (relative to 4-ringers) +/- standard deviation.

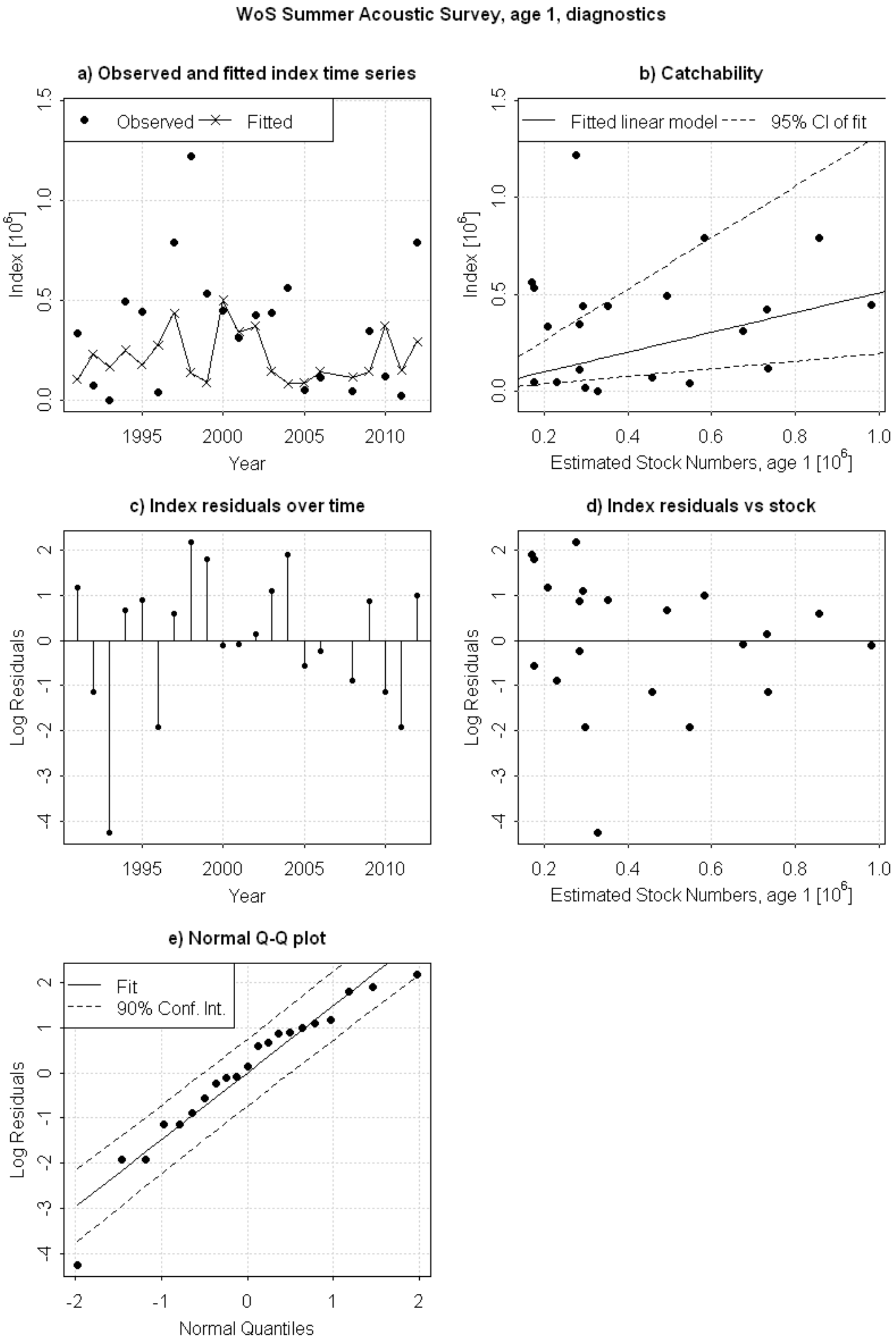


Figure 5.6.3. Herring in VIa (North). Diagnostics of the VIaN acoustic survey fit at 1 wr from the FLICA assessment (8-year separable period). a) Comparison of observed (points) and fitted (line) index value. b) Scatter plot of index observations versus FLICA estimates of stock numbers at age. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log residuals of catchability model fitted by FLICA as a function of time. d) Log residuals from the catchability model against stock size at age estimated by the FLICA assessment method. e) Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line).

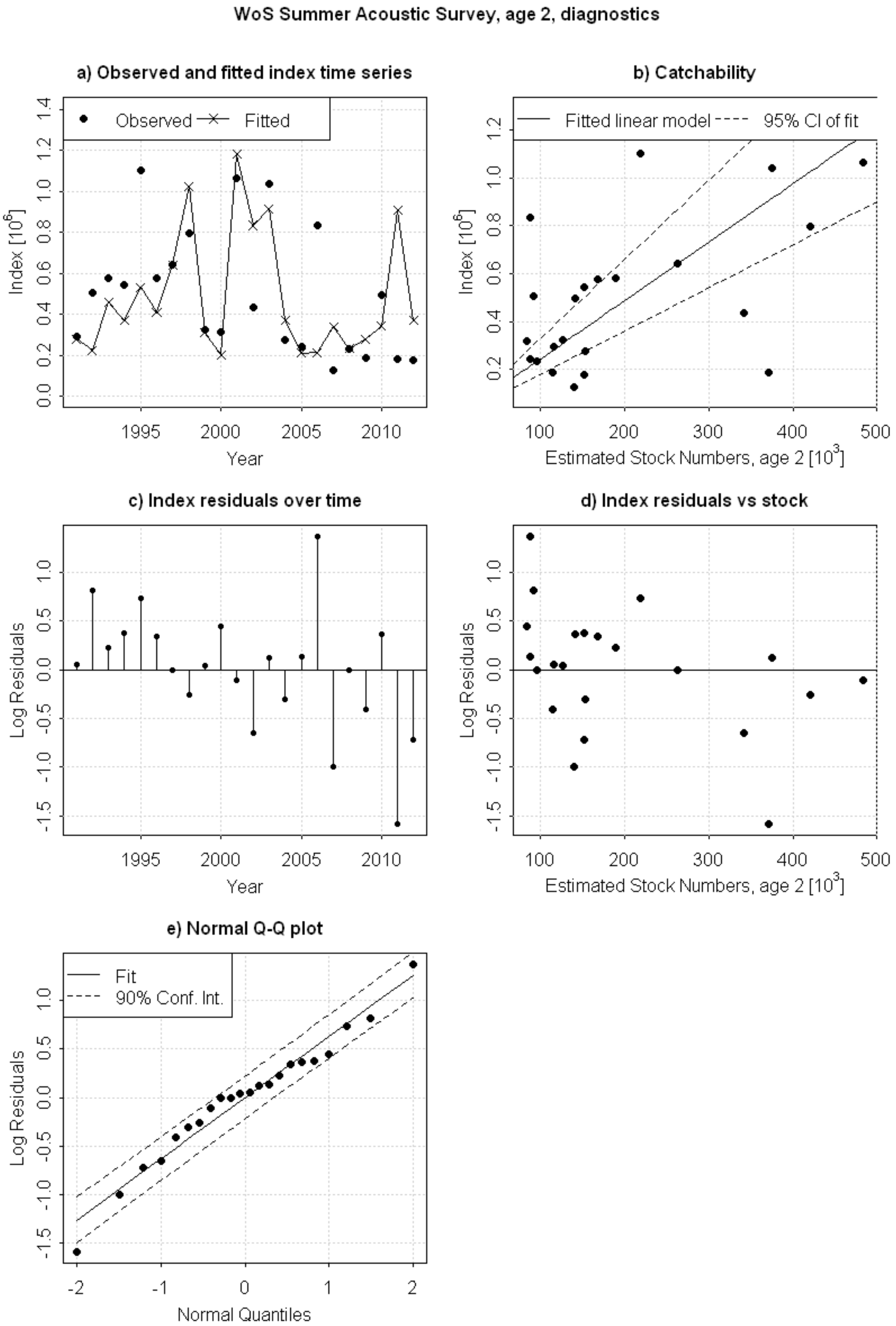


Figure 5.6.4. Herring in VIa (North). Diagnostics of the VIaN acoustic survey fit at 2 wr from the FLICA assessment (8-year separable period). a) Comparison of observed (points) and fitted (line) index value. b) Scatter plot of index observations versus FLICA estimates of stock numbers at age. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log residuals of catchability model fitted by FLICA as a function of time. d) Log residuals from the catchability model against stock size at age estimated by the FLICA assessment method. e) Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line).

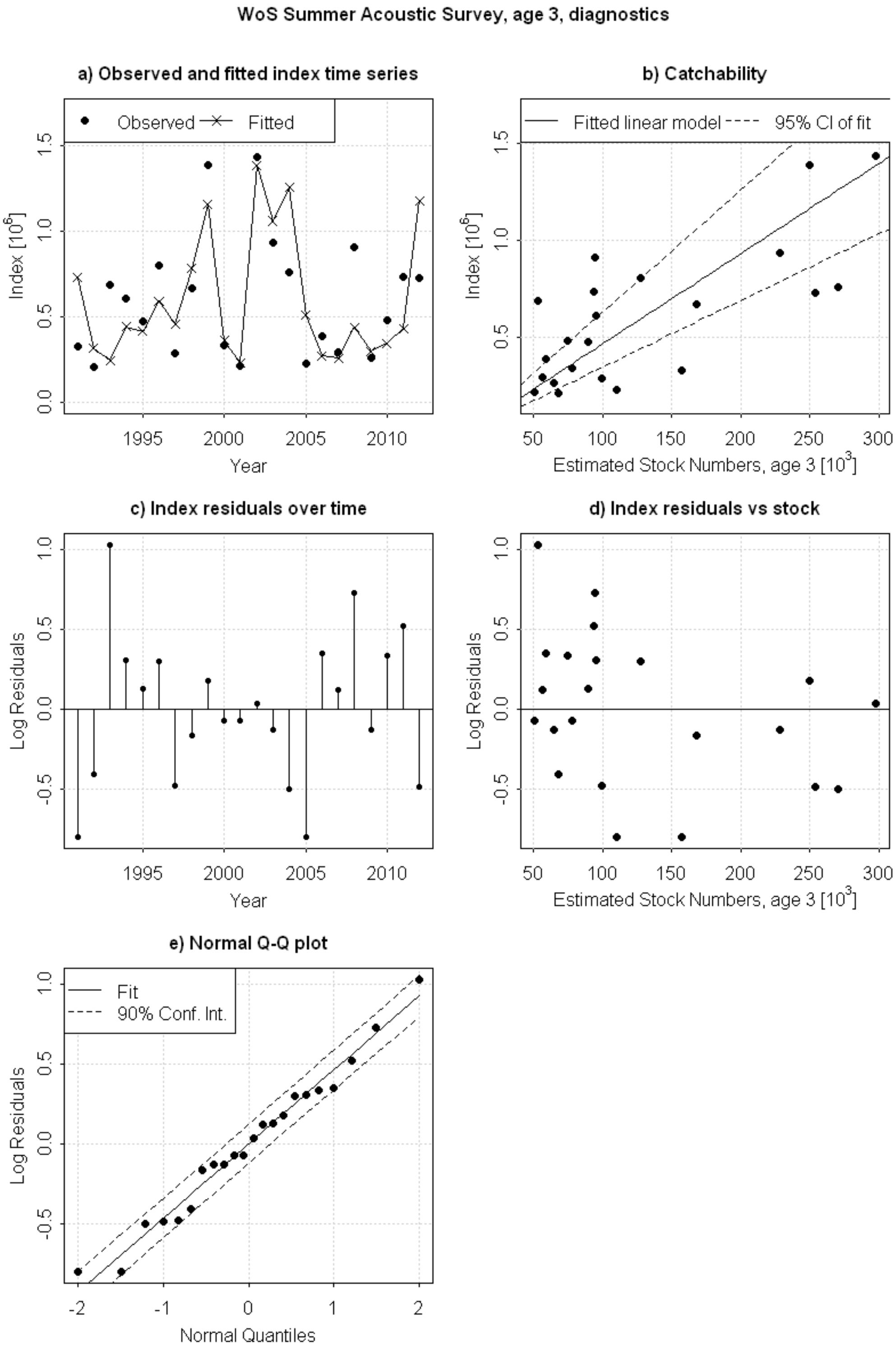


Figure 5.6.5. Herring in VIa (North). Diagnostics of the VIaN acoustic survey fit at 3 wr from the FLICA assessment (8-year separable period). a) Comparison of observed (points) and fitted (line) index value. b) Scatter plot of index observations versus FLICA estimates of stock numbers at age. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log residuals of catchability model fitted by FLICA as a function of time. d) Log residuals from the catchability model against stock size at age estimated by the FLICA assessment method. e) Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line).

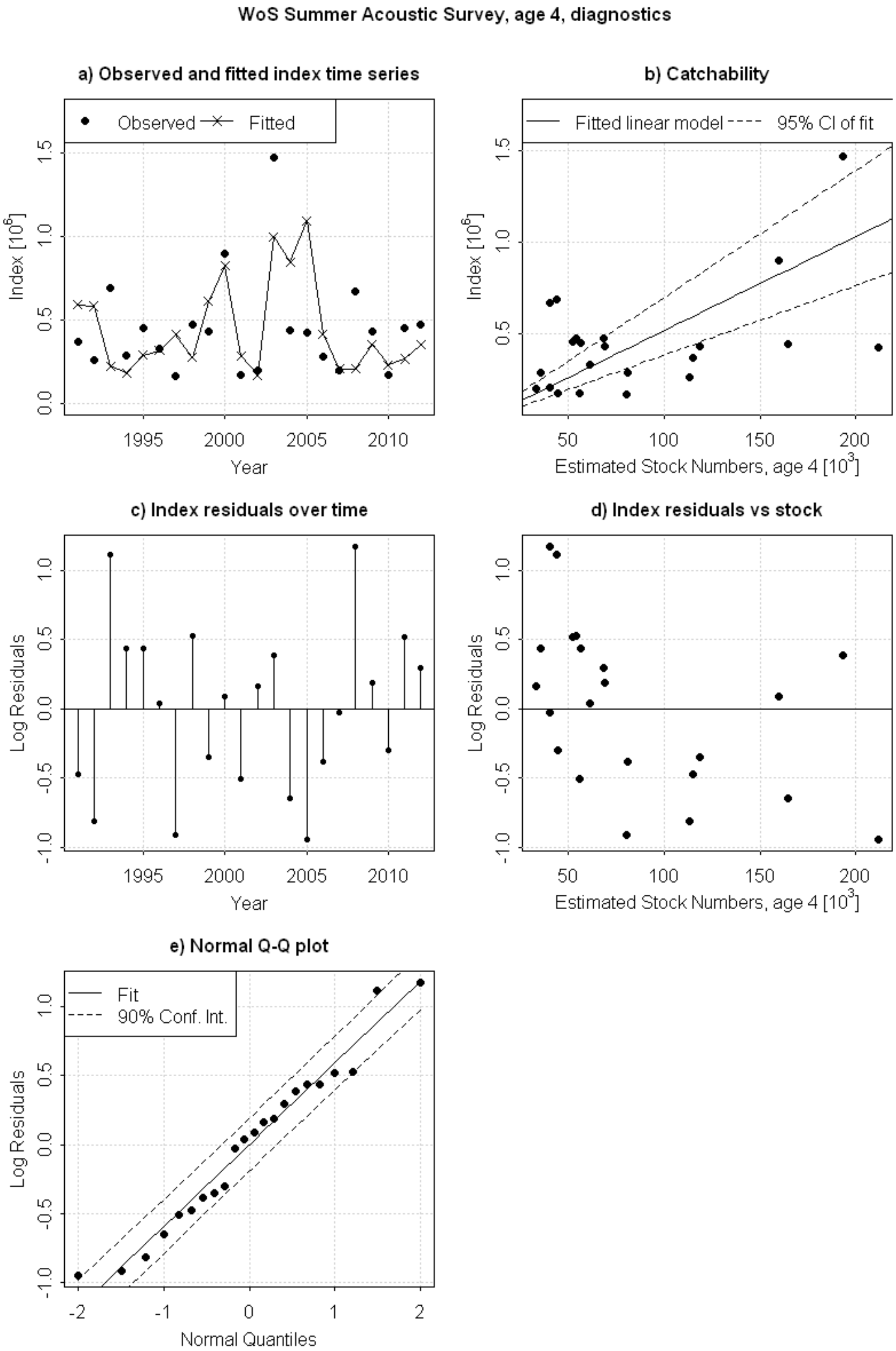


Figure 5.6.6. Herring in VIa (North). Diagnostics of the VIaN acoustic survey fit at 4 wr from the FLICA assessment (8-year separable period). a) Comparison of observed (points) and fitted (line) index value. b) Scatter plot of index observations versus FLICA estimates of stock numbers at age. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log residuals of catchability model fitted by FLICA as a function of time. d) Log residuals from the catchability model against stock size at age estimated by the FLICA assessment method. e) Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line).

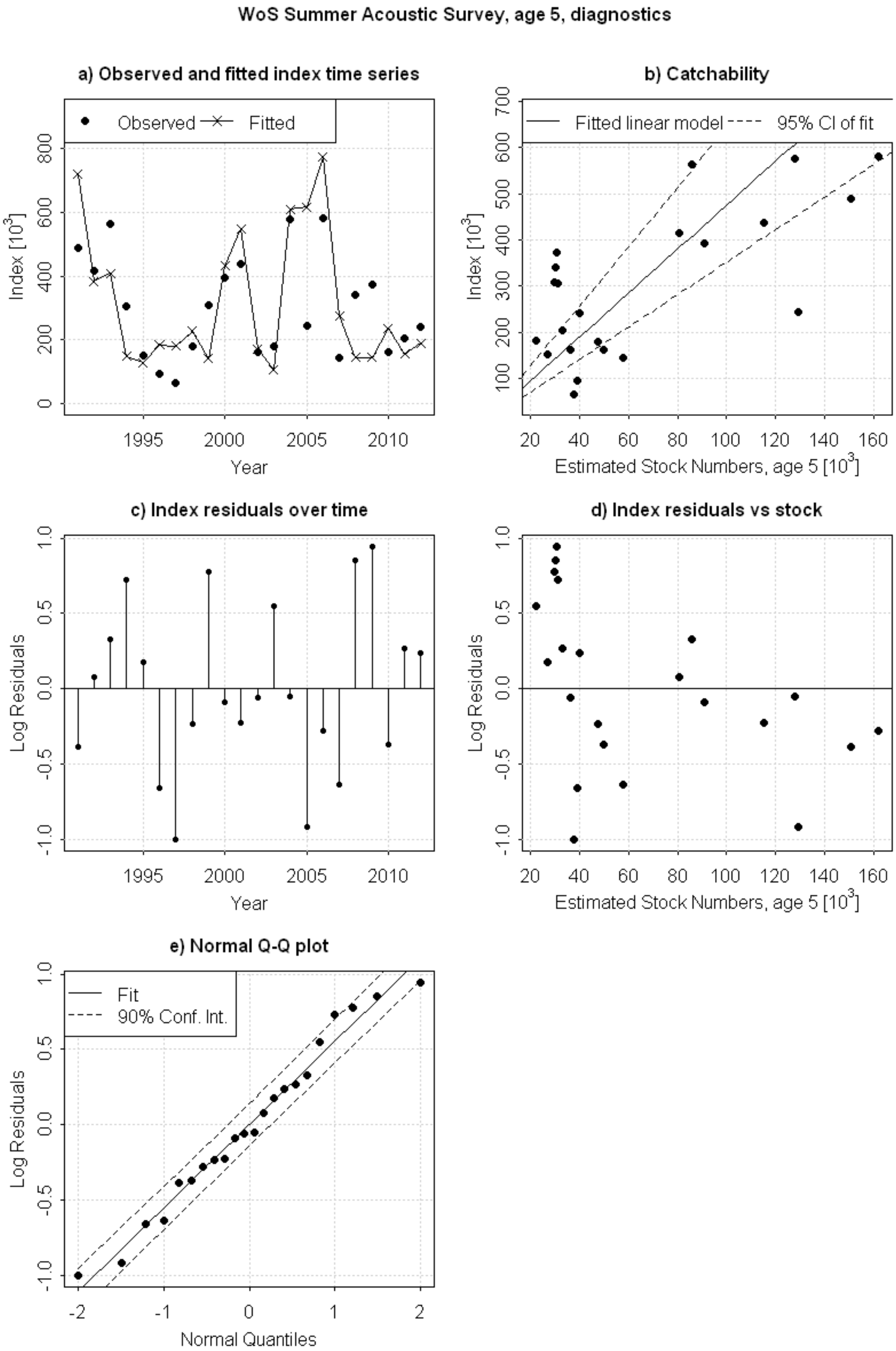


Figure 5.6.7. Herring in VIa (North). Diagnostics of the VIaN acoustic survey fit at 5 wr from the FLICA assessment (8-year separable period). a) Comparison of observed (points) and fitted (line) index value. b) Scatter plot of index observations versus FLICA estimates of stock numbers at age. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log residuals of catchability model fitted by FLICA as a function of time. d) Log residuals from the catchability model against stock size at age estimated by the FLICA assessment method. e) Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line).

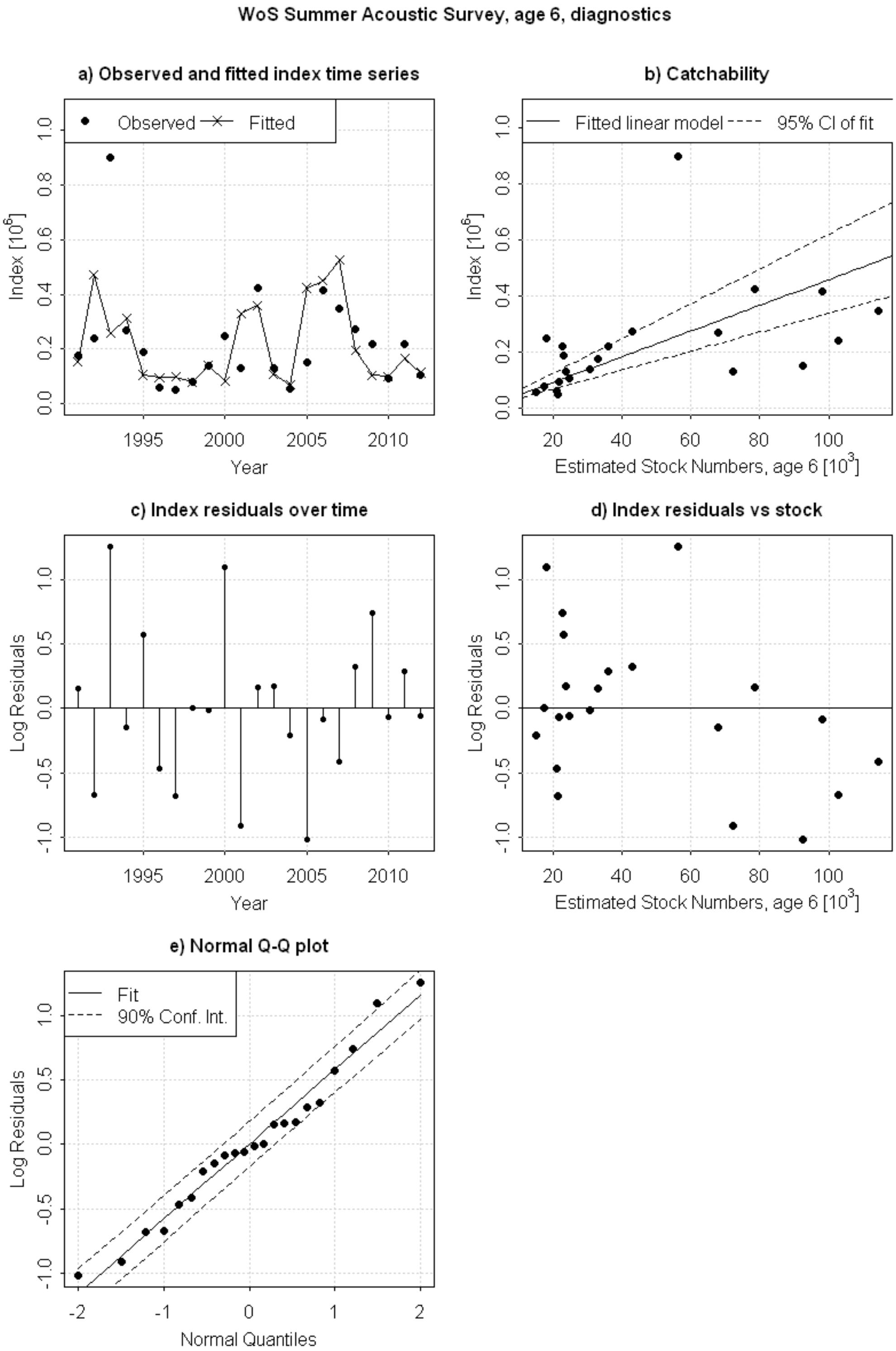


Figure 5.6.8. Herring in VIa (North). Diagnostics of the VIaN acoustic survey fit at 6 wr from the FLICA assessment (8-year separable period). a) Comparison of observed (points) and fitted (line) index value. b) Scatter plot of index observations versus FLICA estimates of stock numbers at age. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log residuals of catchability model fitted by FLICA as a function of time. d) Log residuals from the catchability model against stock size at age estimated by the FLICA assessment method. e) Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line).

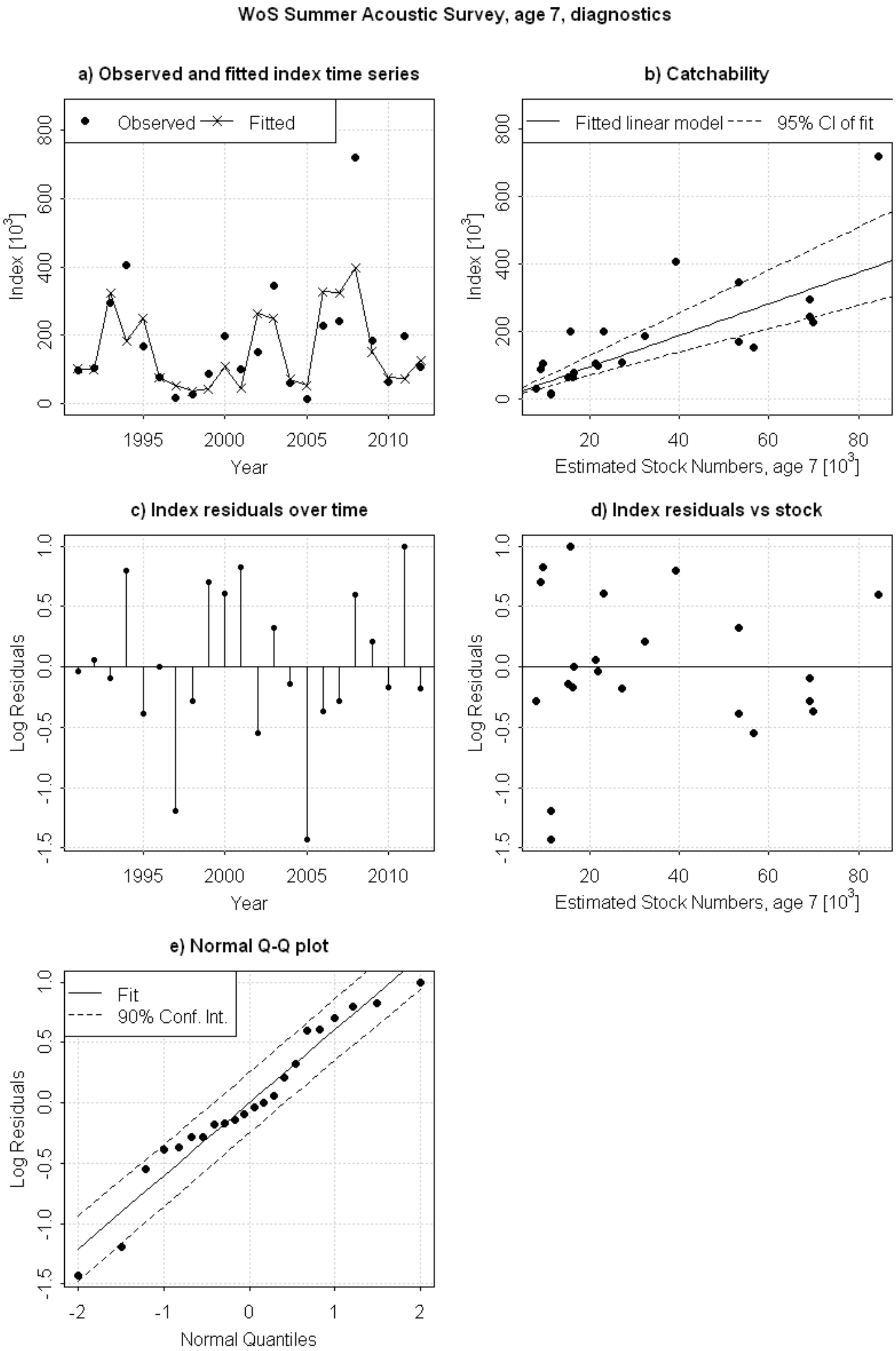


Figure 5.6.9. Herring in VIa (North). Diagnostics of the VIaN acoustic survey fit at 7 wr from the FLICA assessment (8-year separable period). a) Comparison of observed (points) and fitted (line) index value. b) Scatter plot of index observations versus FLICA estimates of stock numbers at age. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log residuals of catchability model fitted by FLICA as a function of time. d) Log residuals from the catchability model against stock size at age estimated by the FLICA assessment method. e) Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line).

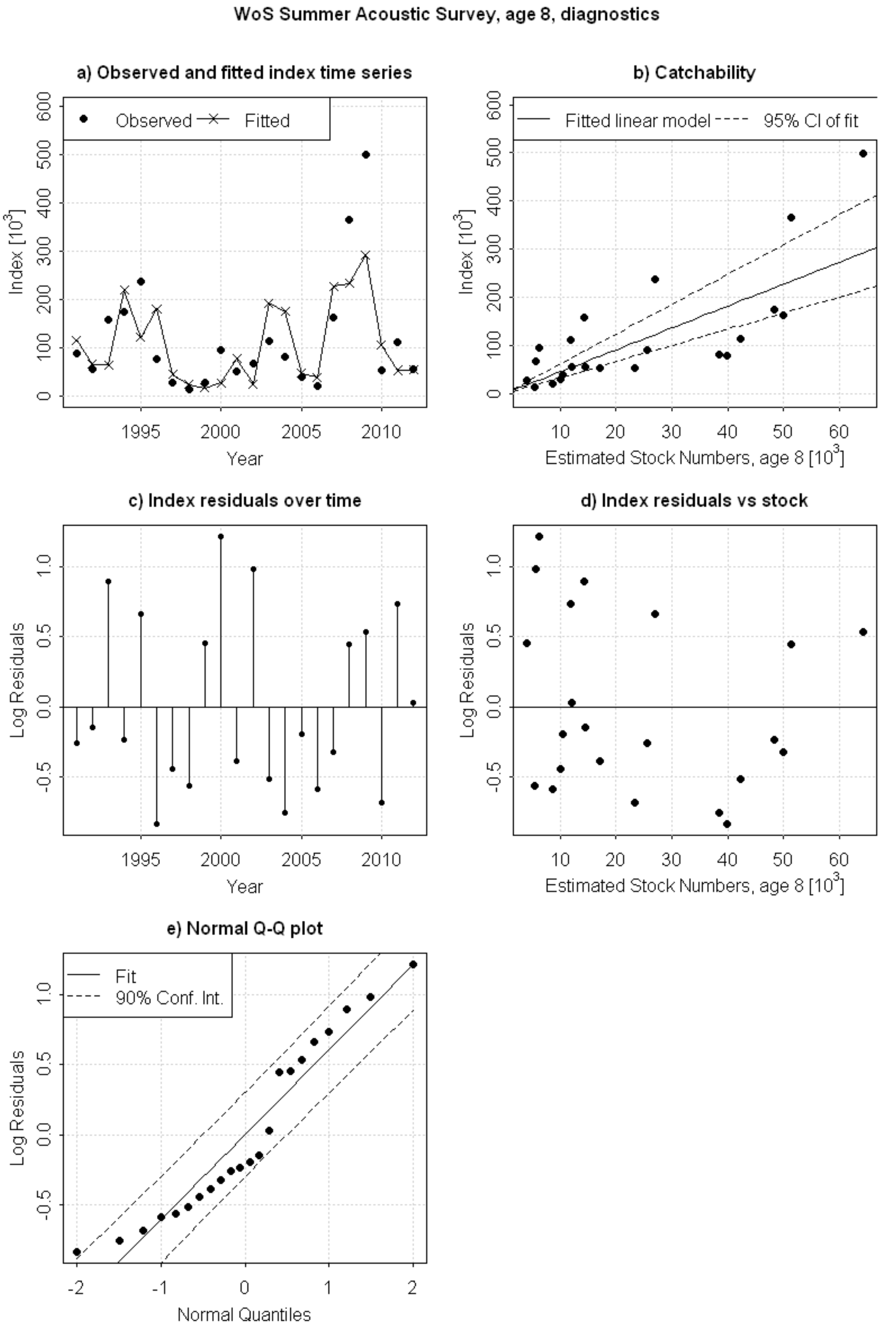


Figure 5.6.10. Herring in VIa (North). Diagnostics of the VIaN acoustic survey fit at 8 wr from the FLICA assessment (8-year separable period). a) Comparison of observed (points) and fitted (line) index value. b) Scatter plot of index observations versus FLICA estimates of stock numbers at age. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log residuals of catchability model fitted by FLICA as a function of time. d) Log residuals from the catchability model against stock size at age estimated by the FLICA assessment method. e) Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line).

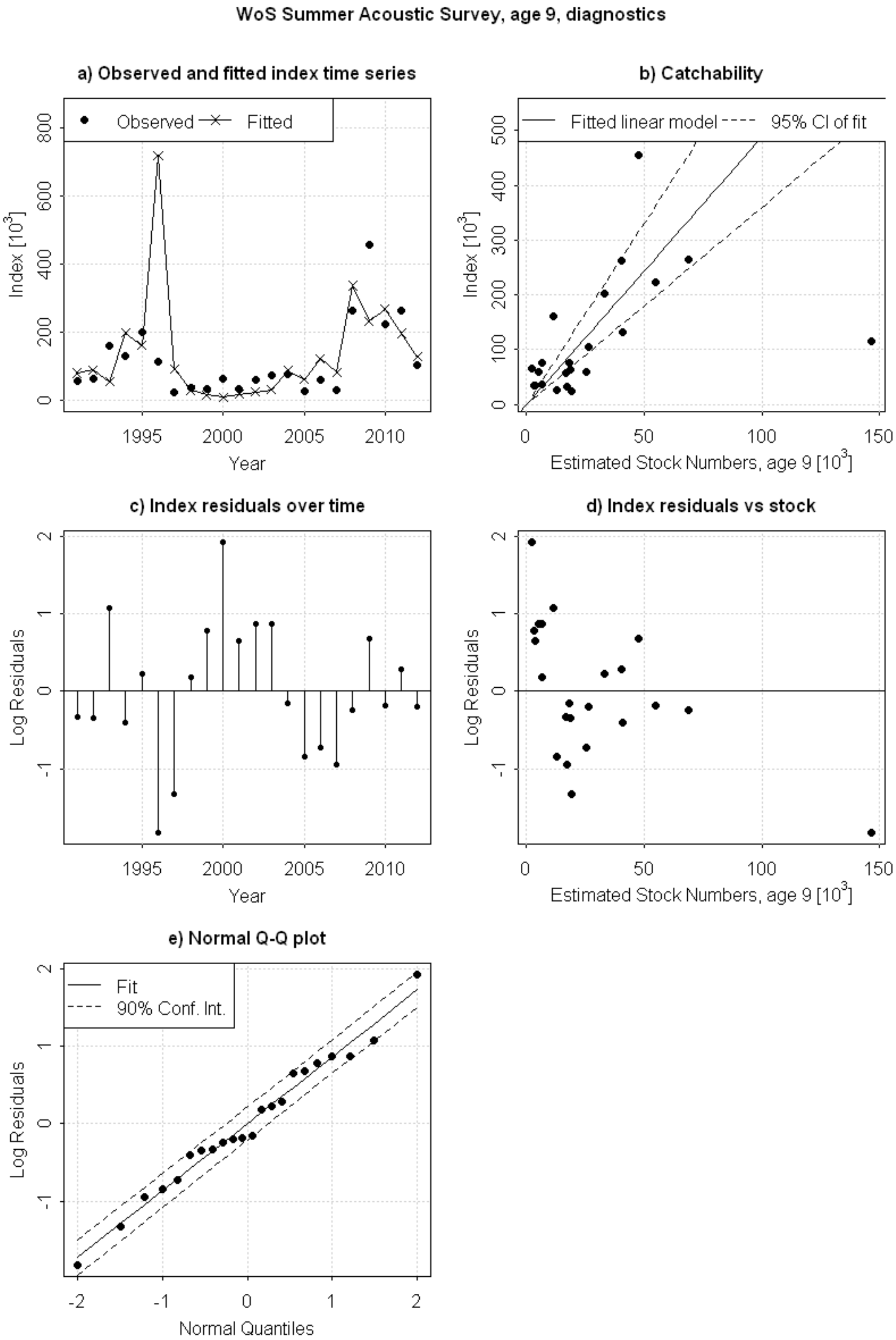


Figure 5.6.11. Herring in VIa (North). Diagnostics of the VIaN acoustic survey fit at 9 wr from the FLICA assessment (8-year separable period). a) Comparison of observed (points) and fitted (line) index value. b) Scatter plot of index observations versus FLICA estimates of stock numbers at age. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log residuals of catchability model fitted by FLICA as a function of time. d) Log residuals from the catchability model against stock size at age estimated by the FLICA assessment method. e) Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line).

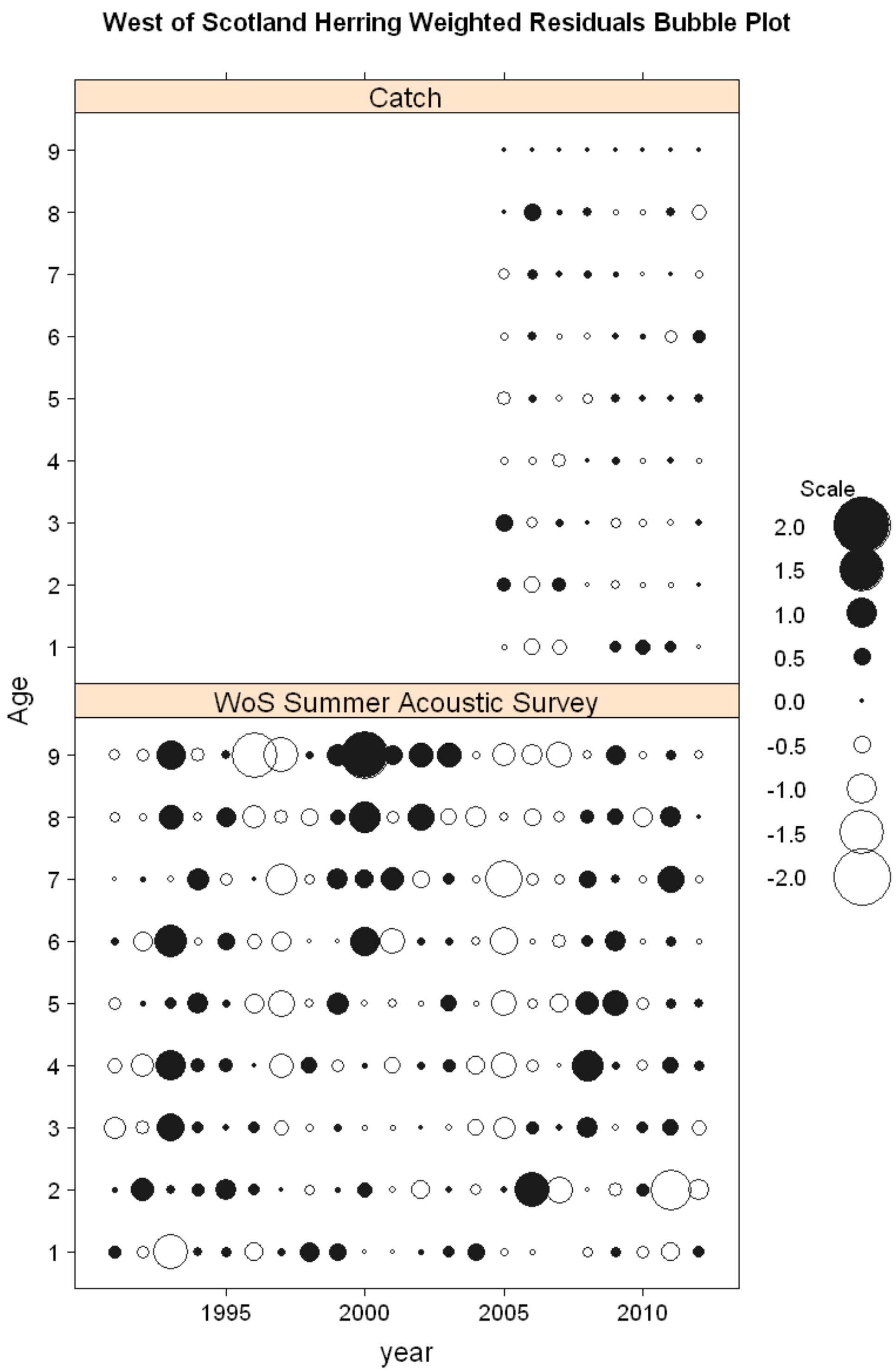


Figure 5.6.12. Herring in VIa (North). Comparison of residuals in the catch (top) and survey (bottom) Note the year effects in the survey, particularly in 2005 and 2008. The assessment effectively smoothes an otherwise noisy survey.

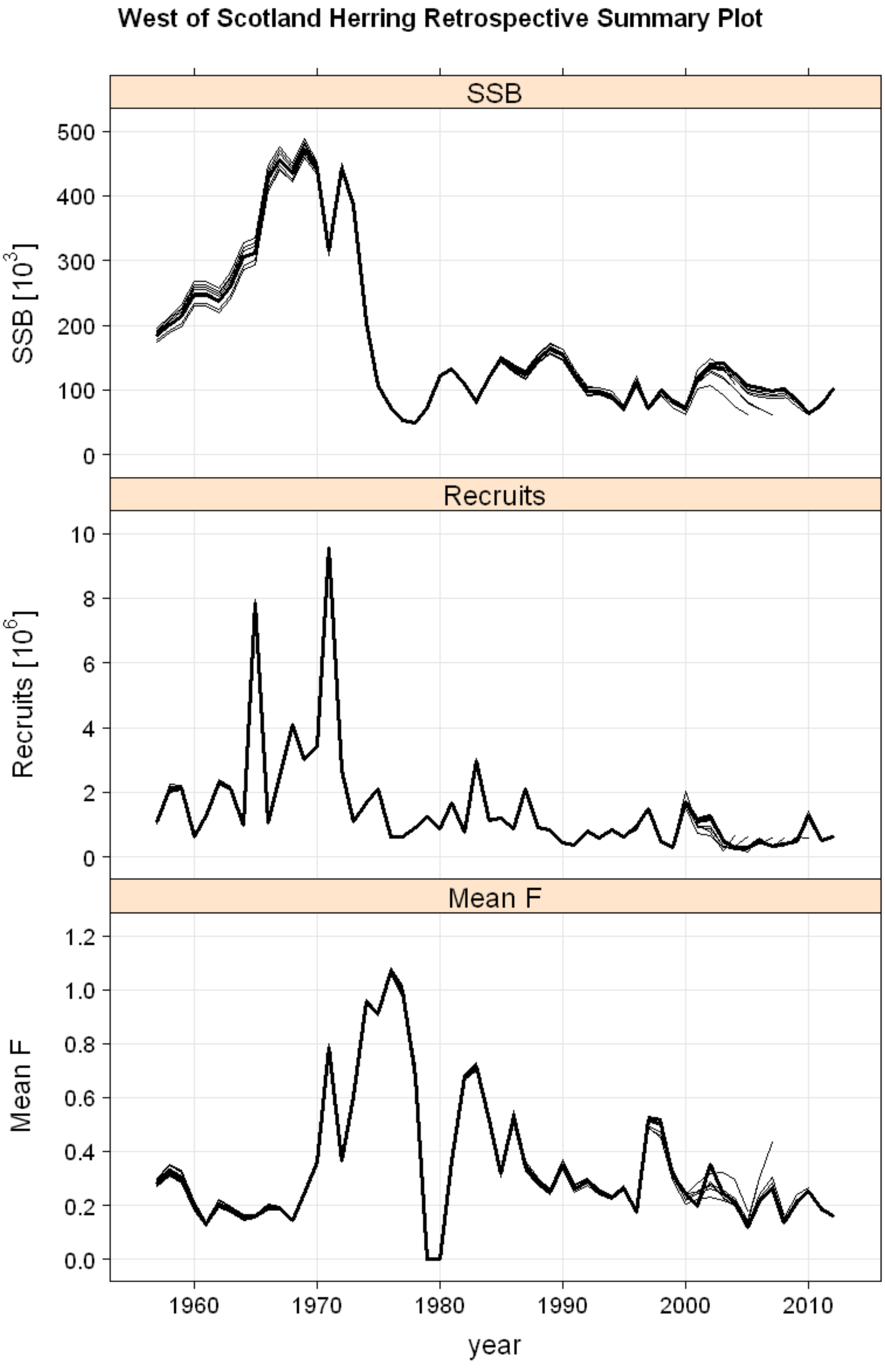


Figure 5.6.13. Herring in VIa (North). Analytical retrospective patterns (2012 to 2008) of SSB, recruitment and mean F_{3-6} from the final assessment. The terminal estimates for recruitment are given as geometric mean (1989 to one year prior to the last data year) because there are no data to support its estimation.

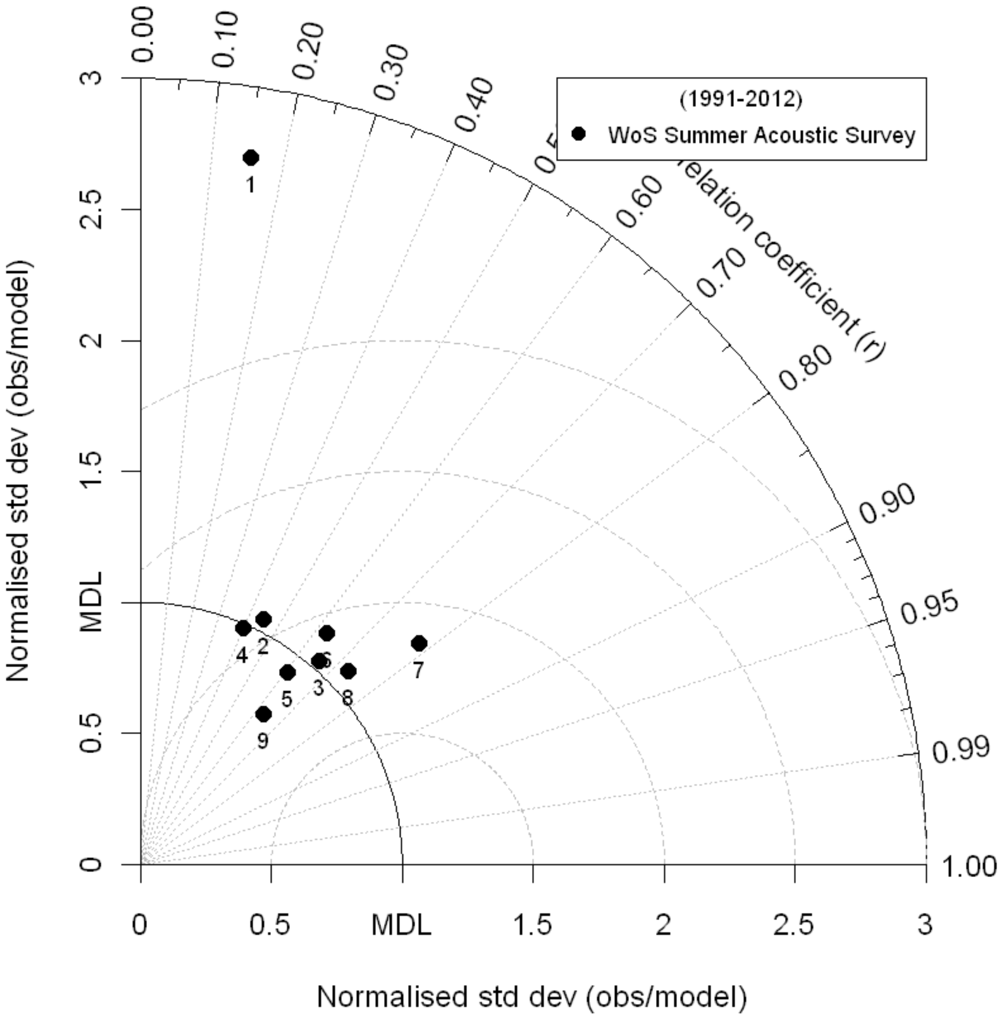


Figure 5.6.14. Herring in VIa (North). Taylor diagram. The plot is not Cartesian but rather polar in nature: the angular axis plots the correlation coefficient between observations and the modeled values. The radial axis represents the standard deviation of the observations normalized by the standard deviation of the modeled values. The point corresponding to 1.0 on the horizontal axis represents a perfect fit between the model and the observations – the closer to this point the better. Points are labeled according to the survey and the age of the time series. All time series are truncated to allow comparison on a common basis.

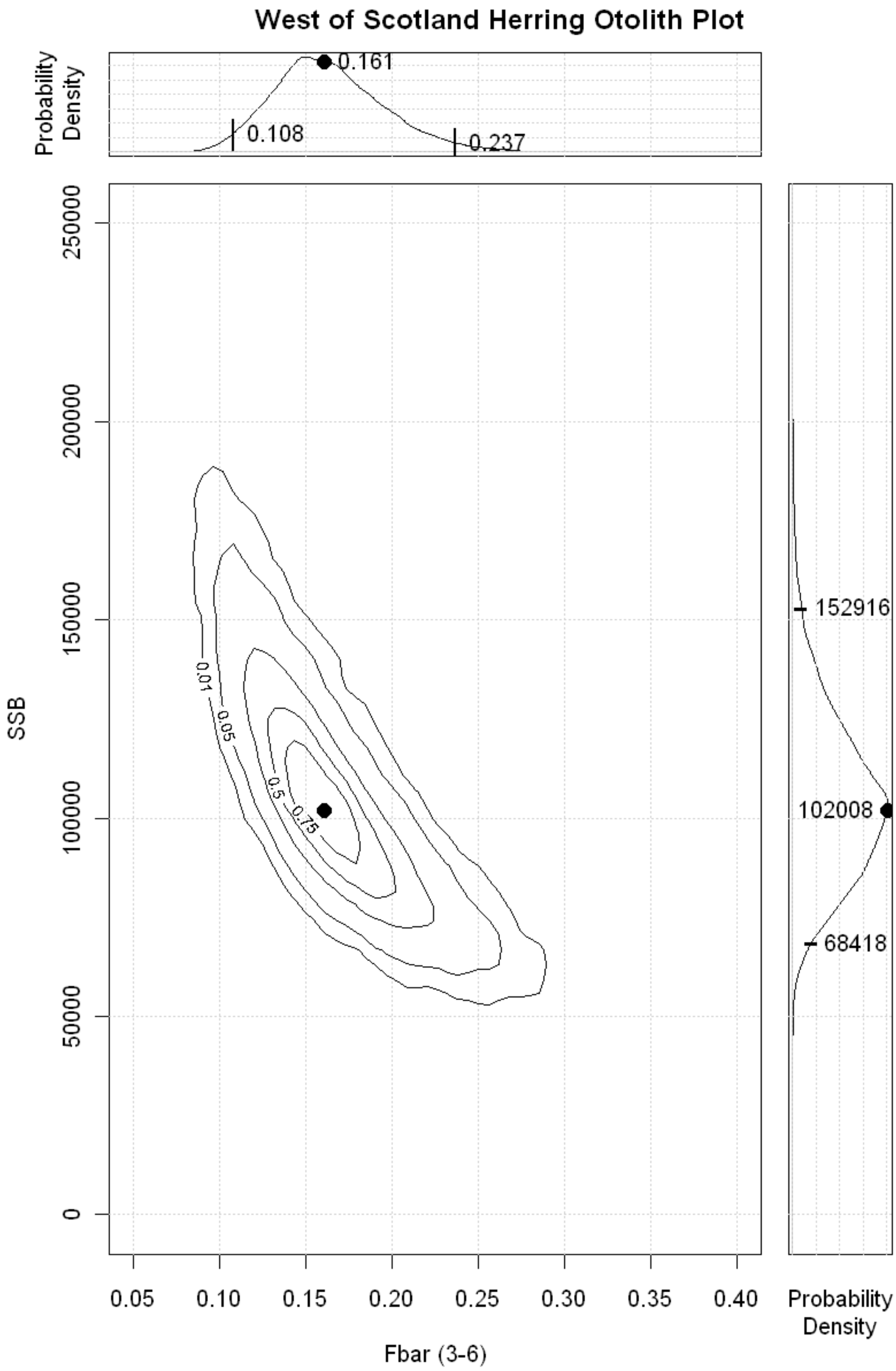


Figure 5.9.1. Herring in VIa (North). Results of parametric bootstrapping from FLICA. The main figure depicts the uncertainty in the estimated spawning stock biomass and average fishing mortality, and their correlation. Contour lines give the 1%, 5%, 25%, 50% and 75% confidence intervals for the two estimated parameters and are estimated from a parametric bootstrap based on the variance covariance matrix in the parameters returned by FLICA. The plots to the right and top of the main plot give the probability distribution in the SSB and mean fishing mortality respectively. The SSB and fishing mortality estimated by the method is plotted on all three plots with a heavy dot. 95% confidence intervals, with their corresponding values, are given on the plots to the right and top of the main plot.

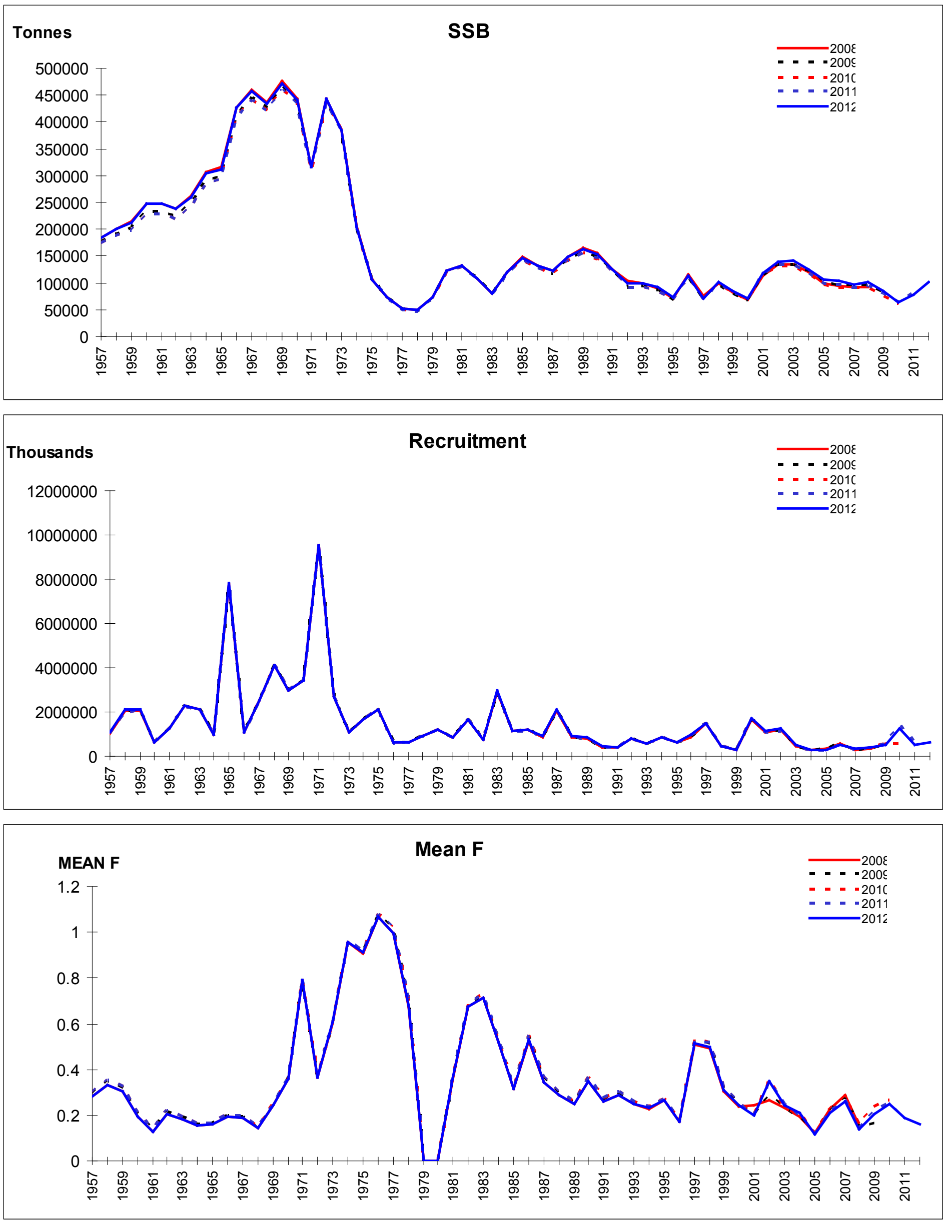


Figure 5.9.2. Herring in VIa (North). Historical retrospective patterns (2013 to 2009 assessments) of SSB, recruitment and mean F_{3-6} from the final assessment. The final estimate for recruitment in each year is given as geometric mean (1989 to one year prior to the last data year) because there are no data to support its estimation.

6 Herring in Divisions VIa (South) and VIIb,c

This management unit has existed since 1982 when it was separated from VIaN. Until that time, VIIb,c was a separate management unit. The stock comprises autumn, winter, and spring spawning components.

6.1 The Fishery

6.1.1 Advice and management applicable to 2012–2013

The TAC for this area in 2012 was 4 247 t. In 2013 the TAC is set at 1 500 t, based on the rebuilding plan proposed by the Pelagic RAC, and subject to an evaluation by STECF. For 2013, ICES advised that, on the basis of MSY approach, there should be no catches of this stock unless a rebuilding plan is implemented.

Rebuilding plan

A third rebuilding plan was developed by the Federation of Irish Fishermens' Organisations and the Pelagic RAC in 2012. This plan was developed in response to the STECF criticisms of the previous plan proposed in 2011. The new plan contains a harvest control rule. F is reduced if the SSB is < Bpa. STECF evaluated the plan and provided a short term forecast that was used to set the TAC for 2013 (1 500 t). The plan also makes provision for trans-boundary catches in VIaN.

6.1.2 Catches in 2012

The Working Group estimates of landings recorded by each country from this fishery from 1988 – 2012 are given in Table 6.1.2.1. Irish catch estimates for this WG have been based on the preliminary official reported data from the EU Logbook Scheme. The total official catch recorded from logbooks for 2012 was 3 791 t compared with 4,274 t in 2011 and 7 513 t in 2010. The total working group estimates of catches in these areas from 1957 –2012 are shown in Figure 6.1.2.1. The working group estimates of catch have declined from about 19 000 t in 2006 to about 6 500 t in 2012. The Irish official catch was close to the quota.

There were no estimates of discards available for 2012, and discarding is not considered to be a major feature of the Irish fishery at present. As part of the Irish discard observer programme a total of 9 directed herring trips were carried out with no reported discards. Information from the Dutch freezer trawlers in this area showed that some discarding took place in VIIb in 2012 (van Helmond and van Oversee 2012 WD).

The assessment period runs concurrently with the annual quota. It is thought that the Dutch freezer trawler fleet takes some catches of this stock, though data are lacking. In 2012 all of the catches were reported from the fourth quarter with no fishery in the first quarter. The majority of the catch was taken in VIaS, with only 64 t reported from VIIb. Fishing opened in the fourth quarter in late October and closed in late December. The distribution of the landings from this area is presented in Figure 6.1.3.1.

A total of 51 boats, categorised as follows, caught greater than 5 t of herring in VIaS, VIIb,c in 2012:

- 7 vessels less than 65ft in length
- 9 vessels between 65 and 80ft in length

- 35 vessels over 80ft in length

6.1.3 Regulations and their effects

The reduction in quotas in recent years has meant that searching and fishing times have been reduced. In effect, the boat-quotas were taken in one or two hauls in many cases. Quota is often taken on an opportunistic basis, and only in two main areas.

23 of the large (RSW) vessels are not permitted to fish within the Irish 12 mile limit. The stricter enforcement of this in recent years has meant that these vessels fish offshore. However, they still operate in proximity to the spawning grounds.

6.1.4 Changes in fishing technology and fishing pattern

There have been no significant changes in the fishing technology of the fleets in this area in recent years. The pattern of this fishery has changed over time. In the early part of the 20th century the main spawning components were the winter spawners off the north coast, and this was where the main fishery took place. In the 1970s and 1980s the west of Ireland autumn-spawning components were dominant and the fishery was mainly distributed along the coasts of VIIb,c and VIaS. More recently the northern grounds have become important again, and in 2012 a large part of the catch came from this area in the autumn, targeting pre-spawners.

Only two main areas have been fished in the past two seasons. This is due to restrictive quotas, fuel prices and other factors that led to decisions to avoid long distances from the main fishing port.

6.2 Biological composition of the catch

6.2.1 Catch in numbers-at-age

The time series was extended in 2011 to include data from 1957 (Clarke WD 09 to HAWG 2011), with details of the extension included in an adjunct to the stock annex. Catch-at-age data for this fishery are shown in Table 6.2.1.1 with percentages since 1996 shown in Table 6.2.1.2. In 2012 the fishery was dominated by 1-, 2- and 3-ringers, accounting for 12%, 31% and 40% respectively (Figure 6.2.1.1). This year’s 3-ringers also represented the dominant age group in the previous year as 2- ringers (2008 year class). At 12%, 2012 has the highest percentage of 1-ringers in the time series (2010 year class). 1-ringers are usually not well represented in the catch and normally do not show up in the catch until the third quarter. The abundance of 1-ringers in the catches were very low in the previous seven years of the time series.

6.2.2 Quality of the catch and biological data

The management of the Irish fishery in recent years has tightened considerably and the accuracy of reported catches is believed to have improved. The numbers of samples and the associated biological data are shown in Table 6.2.2.1. As Ireland is the main participant in this fishery all of the sampling is carried out by Ireland. No samples were collected from VIIb in 2012 and overall landings from this area were very small.

Mixing of autumn, winter and spring spawners takes place in this area which may lead to ageing difficulties regarding counting of winter rings.

6.3 Fishery Independent Information

6.3.1 Acoustic Surveys

The stock area is covered by a constituent survey of the Malin Shelf Survey (Figure 2.3.1.2), the "MSHAS_S" survey. However this survey component does not contain the stock at the time of year of the survey. The entire Malin Shelf Survey (MSHAS) is considered likely to contain this stock, but also covers the VIaN stock. Currently it is not possible to determine the level of mixing of these two stocks in the MSHAS survey. This survey is described in the WGIPS report (ICES 2012) and in Section 1 of this report.

Table 6.3.1.1 shows the abundance at age and biomass estimates from surveys of this stock, south of the 56°N boundary, from 1999 to 2012. The surveys have been conducted at different times (Table 6.3.1.2). The current series of summer-feeding phase surveys (2008-2012) is comparable with those conducted from 1994-1996. From 1999 to 2001 surveys were conducted in autumn and from 2002 to 2007 in winter.

Comparing the numbers at age from VIIb and VIaS (MSHAS-S) only, the 2012 age structure shows high numbers of 2-ringers. The 2012 age structure from this survey does not show any strong cohorts from the previous season (Figure 6.3.1.1). The proportions-at-age in the catch and survey data from 2010-2012 are presented in Figure 6.3.1.2 and show that there is little agreement between the data sources within years. Nor is there good representation of particular cohorts between years for the commercial catch-at-age. There are two stocks mixing in the survey area at this time and it may explain why the age compositions vary between the survey and the catch.

For the purposes of tuning the FLICA assessment, the total Malin Shelf Survey (MSHAS) was used for the period 2008-2012, over ages 3-6 (Section 6.6).

Assignment of acoustic abundance by stock

Work has been initiated to investigate how to segregate the abundance estimate by stock in the Malin Shelf Herring Acoustic Survey (Table 6.3.1.3). Otolith and body morphometrics from fish of known origin will be used to classify herring from mixed stocks to their natal origin using discriminant analysis. Body and otolith morphology data were collected from a number of haul samples during the Irish and Scottish sections of the survey in 2010, 2011 and 2012. It is hoped that this can be used to provide a tuning index for herring in VIaS, VIIb,c.

6.4 Mean weights-at-age and maturity-at-age

6.4.1 Mean Weights-at-Age

The mean weights-at-age (kg) in the catches in 2012 are based on Irish catches (Figure 6.4.1.1). In contrast to 2011, in 2012 there were slight increases in the mean weights of all age groups except 1- and 9-ringers. Generally the oldest and youngest ages are poorly represented in the catch data.

The mean weights in the stock at spawning time have been calculated from Irish samples taken during the main spawning period that extends from October to February (Figure 6.4.1.2). The mean weights in the stock for 1- to 7-ringers have increased since 2011, while those of 8- and 9+ ringers have decreased. Similar to the mean weight in the catch, the largest increase was in 3-ringers.

6.4.2 Maturity Ogive

One ringers are considered to be immature. All older ages are assumed to be 100% mature.

6.5 Recruitment

There is little information on terminal year recruitment in the catch-at-age data and there are as yet no recruitment indices from the surveys. Numbers of 1-ringers in the catches vary widely but, with the exception of the current year, have been consistently low in recent years. Since the mid 1990s recruitment has been uniformly low, based on exploratory assessments. However there is evidence from surveys that the 2007 and 2008 year classes were stronger than those in the previous 10 years.

In the catch data, numbers of 1-ringers in 2012 (2010 year class) are slightly higher than in previous years. This year class was also evident in the Irish groundfish survey data. The length frequency data from the 2009 -2012 Irish groundfish surveys are presented in Figure 6.5.1.1. A small peak in 0 group fish at ~11cm can be seen in 2012. 0 group fish would not be evident in the catch data yet.

6.6 Stock Assessment

6.6.1 Data Exploration

Separable VPAs

Following the procedure of recent years, a separable VPA was used to screen over four terminal fishing mortalities, 0.2, 0.4, 0.5 and 0.6. This was achieved using the Lowestoft VPA software (Darby and Flatman 1994). The reference ages for calculation of fishing mortality was 3-6 and terminal selection was fixed at 1, relative to 3 winter rings.

Four exploratory assessments using the separable VPA were performed, based on the four initial values for terminal F. Recruitment, SSB and mean F from each run are shown in Figure 6.6.1.1. Outputs from separable VPAs with terminal Fs of 0.2, 0.4, 0.5 and 0.6 are presented in Tables 6.6.1.1-4. Residual plots for the four trial assessments are presented in Figure 6.6.1.2. Large residuals can be seen in 1-ringers, reflecting the poor estimation of this age group. These residuals are also presented in Tables 6.6.1.5 – 6.6.1.8. There is little pattern in these residuals.

The various sVPA runs differ in their estimation of recent F. Using a terminal F of 0.2 or 0.4 shows a decline from a secondary peak in 2006 of 0.86. The rise in F in 2006, associated with an increased catch in that year. Using a terminal F of 0.5 or 0.6 shows a new high of F=1.17 in 2011. F is estimated to have declined in 2012. Even the lowest estimate of F is above F_{MSY}.

Recruitment has been stable at a very low level or declining in recent years. In 2011 and 2012 the assessments suggested there was a significant increase in recruitment, though this was replaced with geometric mean. In 2012, with the replacement of the final year value with geometric mean, a small increase in recruitment can be seen for all runs.

All of the runs show that the SSB is at the lowest level in the series. All runs show the stock to be considerably lower than B_{pa} (110 000 t) and B_{lim} (81 000 t).

Historical retrospective analyses were performed for each of the terminal F initial values. Using a terminal F = 0.2 as a starting value (Figure 6.6.1.3) shows a bias towards overestimation of SSB and underestimation of F. Using a terminal F = 0.4 (Figure 6.6.1.4) displays a more stable estimation of SSB with underestimation of F. The retrospective assessment using F=0.5 (Figures 6.6.1.5) shows stability in SSB estimation, with a slight over and underestimation in F. The scenario for F=0.6 (Figure 6.6.1.6) shows a bias towards a slight underestimation of SSB and an over and underestimation of F.

The results of the analytical retrospective analysis suggest that using an initial terminal F of 0.5 produces more stable estimates of SSB and F. The mean F generated by this “most-consistent-over-time” run is 0.65 in 2012, and mean F in the non converged VPA (2006-2012) is 0.61-1.17. This suggests that recent F has been well above $F_{0.1}$ and F_{MSY}, estimated to be around 0.2 and 0.25 respectively (ICES 2010 ACFM:06).

Historical retrospective analyses of the separable VPA assessments using a terminal F of 0.5 from the 2008-2013 WGs are presented in Figure 6.6.1.7. The estimation of SSB and F appears balanced and without bias. Retrospective analyses of recruitment using geometric mean leads to overestimation of terminal recruitment. These analyses suggest a perception of a stock that is over exploited and well outside safe biological limits.

FLICA Assessment of VIaS and VIIbc

Given that 5 years of the Malin Shelf Survey are now available for tuning, it was considered appropriate to apply FLICA (Patterson. 1998b, Kell, *et al*, 2007) to the assessment. This was conducted for the first time by the HAWG in 2012 and repeated in 2013. The results in 2012 were encouraging. However, the Malin shelf survey also covers other mixed herring stocks, but it is the only index currently available to tune the VIaS, VIIbc assessment. Biological data to split this biological index is not yet available.

In 2013, a number of exploratory runs were performed to examine the effect of the following:

- Varying the selection pattern between 1.0 and 1.5 relative to age 4
- Inclusion of various ranges of ages in the tuning series

In all cases, the plus group was set at 7+, following from last year.

The final exploratory assessment used the following configuration

- Catch data with a 7+ plus group. Age 1 down-weighted to 0.1
- Ages 3-6 from the total Malin shelf survey data (2008-2012)
- Reference age 4
- Terminal selection on plus group and oldest true age = 1.0 relative to 4-ring.

The choice of selection pattern was based on the optimal assessment diagnostics with 1.0 showing the best fit. Reference age at 4-ring was considered as the first fully selected age group (Stock Annex).

The tuning series diagnostics for ages 3-6 are presented in Figures 6.6.1.8-11. The diagnostics show a reasonably good fit to the data across these ages but only 5 years of data are available. The catch diagnostics are presented in Figure 6.6.1.12.

Trends in survey residuals were well balanced, and the model fitted the index quite well. However, year effects were present in the tuning index, increasingly so in 2010 and 2011, with the 2012 survey performing slightly better. The catch residuals were randomly distributed with no clear trend (Figure 6.6.1.13).

The uncertainty plot (Figure 6.6.1.14) shows a wide range of possible values for SSB, with the 95% confidence interval ranging from 23 449 t to 107 218 t (below B_{lim} and B_{pa}). The 2012 SSB estimate is 50 924 t, which is below B_{lim} but has been increasing since 2010. F was estimated in the range of 0.07 to 0.3, with the 2012 estimate being 0.14, which is below $F_{0.1}$ and F_{MSY}. The stock summary plot shows a small increase in SSB, a decrease in F. Recruitment is stable at a low level (Figure 6.6.1.15).

The retrospectives by cohort are presented in Figure 6.6.1.16 and show good estimates of year class strength. The analytical retrospective is presented in Figure 6.6.1.17.

A comparison between the FLICA and VPA outputs (terminal F = 0.5) are shown in Figure 6.6.1.18. There was good agreement between the two approaches in the early part of the time series. In the most recent years FLICA predicts higher SSB and recruitment and lower F than the separable VPA. FLICA predicts an increase in SSB since 2010. The estimates of SSB from both FLICA and the separable VPA are likely to be below B_{lim}. F is estimated to have decreased since 2007 by FLICA. In contrast, the sVPA predicted a huge increase in F in 2011, the highest in the series. There is no evidence for this increase either in the catches, or in the catch at age. The catch in 2011 was one of the lowest in the series.

The FLICA exploratory assessment is considered to be a better indicator of stock development for the following reasons:

- It includes fisheries independent survey information
- It does not rely on using subjective choices of terminal F
- The sVPA does not provide a realistic estimate of F in 2012.

Though more work is required to refine the splitting of the Malin Shelf survey it is considered the best available indicator of stock status. This assessment indicates that F has decreased considerably in recent years, with a concomitant decrease in landings. SSB has increased from the lowest observed in 2010, though it is estimated to be currently below B_{lim}. There is no information on the strength of the most recent recruitment. However the evidence from the catch at age and the FLICA assessment suggests that no above average recruitments have occurred in recent years.

6.6.2 State of the Stock

The results of the exploratory assessments continue to suggest that SSB has been low since the mid 1990s, though it has increased since 2010. The absolute level is uncertain but is likely to be below B_{lim}.

F is estimated to have reduced considerably in the past 3 years, concomitant with declining landings.

Recruitment has been below average in recent years.

6.7 Short term projections

In 2013 an exploratory short term forecast was carried out using FLICA. This forecast was used to explore possible reactions of the stock in the short term. This was conducted in 2012 also.

The forecast was based on a low recruitment regime with the strong year classes of 1963, 1981, 1983 and 1985 removed and geometric mean recruitment calculated from 1957-2010. Inputs to the forecasts are shown in Table 6.7.1.

The interim catch used in each forecast consisted of the Irish quota for VIaS, VIIbc in 2013 plus the quota for VIaN, which is traditionally taken on the boundary of the two areas (56°N) and is considered to be the southern stock. The catch was calculated as 5 515 t.

The FLICA forecast was used to test the effect of implementing the harvest rule in the proposed rebuilding plan (Table 6.7.2). When SSB is below B_{pa} then F is calculated using the equation $F=SSB*(F_{0.1}/B_{pa})$. Because only an exploratory assessment is available the TAC setting is downweighted using an uncertainty parameter G, where G=exp(-1.645a). Based on the proposed rebuilding plan F in 2014 would be 0.109, which implies catches of around 4 528 t in 2014.

6.8 Medium term simulations

No yield per recruit was performed in 2013.

6.9 Long term simulations

Work was conducted on simulating the long term dynamics of this stock for HAWG 2011. This work focused on using the converged part of the separable VPA exploratory assessments and projecting forward. The analysis aimed to define a range of target F, $B_{trigger}$ and percentage TAC constraints that would be appropriate for this stock. Results are in broad agreement with the work conducted by HAWG in 2010, in developing the MSY approach for this stock (ICES 2010, ACOM:06).

6.10 Precautionary and yield based reference points

Analysis of stock recruit data for the period (1957-2007), excluding periods of high productivity (1981-1985) found a breakpoint in the segmented regression of 76 000 t. When all of the data, including the periods of low and high productivity, are used the breakpoint is 79 000 t, which is in general agreement with the existing B_{lim} (81 000 t) (Clarke *et al*. WD02 to HAWG 2012). HAWG considers that 76 000 t may be a better basis for B_{lim} for this stock.

In 2010, HAWG estimated $F_{0.1}$ as 0.2 and F_{MSY} as 0.25. Further analysis using the "plotMSY" program estimated F_{MSY} around 0.25.

HAWG has not considered candidate values for a $B_{trigger}$ in great detail. HAWG considered that there is a range of biologically appropriate biomass triggers that may be appropriate, suggesting 95 000 t as one possible value. The final choice should be made based on management plan development. As such the trigger biomass will be subject to evaluation by ICES. In 2010 ACOM endorsed the approach taken by HAWG, and ICES WKFRAME II also endorsed the approach in 2011.

6.11 Quality of the Assessment

Comparisons of the age structures from the catch and survey data each year show a mismatch between the data sources regarding the main ages present. This lack of coherence in the catch-at-age matrix from year to year has been an ongoing feature of this assessment.

The various assessments presented are more indicative of the general state of the stock, but cannot provide precise estimates of current stock size. The separable VPAs rely on the catch data only, and the incoherence in cohort tracking in the catches is reflected in these assessments. The spatially and temporally truncated fishing season results in catch at age data that may be less informative of overall population age structure. The VPAs were run for a range of terminal F values and the current perception of the stock is highly influenced by that choice. There is no information on recent recruitment levels both because the selectivity of the fishery appears to be low for the juveniles and also due to the lack of a recruitment index. The retrospective analysis suggests that the terminal F = 0.5 produces the most stable retrospective pattern implying that F may have been in the region of 0.5. There are however, concerns about the underlying assumptions of the separable VPA. The assumption of a constant selection pattern throughout the series is invalid.

The FLICA assessment is quite uncertain, with wide confidence intervals for F and SSB. However the entire confidence interval for SSB is below B_{lim}. The survey used for tuning (Malin Shelf Herring Acoustic Survey, MSHAS 2008-2012) is known to also contain other mixed, and therefore is not an optimal tuning index for this stock. However, if it is possible to disaggregate the index according to stock, then it could provide a basis for an assessment in the future. The FLICA assessment is considered to be the best indicator of stock development because it includes fisheries independent information.

Work has commenced to examine the mixing of components of this fishery. This work will continue in 2013. The mixture of spawning components may affect the ageing procedure with possible difficulties in interpreting the winter ring. This will also be investigated in greater detail. It is unlikely that a strong cohort entering the fishery would be missed due to difficulties of this kind. The low level of SSB ($<B_{lim}$) is clear and is unlikely due to such methodological issues.

6.12 Management Considerations

Since 2000, reported landings have been much lower than previously. In recent years landings have been reduced year on year. However SSB is estimated to remain below B_{lim}. This implies that a rebuilding plan is urgently required and should aim to keep catches at a low level until stock recovery can be confirmed. A rebuilding plan has been proposed by the Pelagic RAC. This plan was evaluated by STECF in November 2012. STECF have recommended that this plan requires a full evaluation. A simulation study should be carried out using an MSE algorithm to test the full range of factors and evaluate alternative harvest control rules taking into account the range of uncertainties (STECF, 2012, PLEN-12-03).

Evidence from the survey of a good incoming year class needs to be further corroborated in the next years. Strong year classes often do not fully recruit to the fishery until the 4^{th} or 5^{th} winter ring. Until a better basis for assessing the stock is found, and until there is firm evidence of good recruiting year classes, rebuilding measures should be implemented. These should include restrictions on catch. Such measures should apply in all areas where the stock is being caught.

6.13 Environment

6.13.1 Ecosystem Considerations

Grainger (1978; 1980) found significant negative correlations between sea surface temperature (SST) and catches from the west of Ireland component of this stock at a time lag of 3-4 years later. This indicates that recruitment responds favourably to cooler temperatures. Cannaby and Hosrevoglu (2009) present long time series of sea surface temperature for this stock area. In Figure 6.13.1 these data are combined with periods of good recruitment. It can be seen that strong historic herring recruitments/fisheries (Clarke *et al.*, WD02 to HAWG 2012) correspond with cooler temperatures.

6.13.2 Changes in the Environment

Since the mid 1990s the AMO has been in a positive phase, indicating warmer sea temperatures in this area. However since 2010, there is some evidence that AMO may be entering a negative phase again, see http://www.esrl.noaa.gov/psd/data/timeseries/AMO/ (Figure, 6.13.2). Colder temperatures implied by such a negative phase may be associated with improved recruitment in this stock.

Table 6.1.2.1. Herring in Divisions VIa(S) and VIIb,c. Estimated Herring catches in tonnes, 1989–2012. These data do not in all cases correspond to the official statistics and cannot be used for management purposes.

Country	1989	1990	1991	1992	1993	1994	1995	1996
France	-	+	-	-	-	-	-	-
Germany, Fed.Rep.	-	-	-	250	-	-	11	-
Ireland	18,200	25,000	22,500	26,000	27,600	24,400	25,450	23,800
Netherlands	2,900	2,533	600	900	2,500	2,500	1,207	1,800
UK (N.Ireland)	-	80	-	-	-	-	-	-
UK (England + Wales)	-	-	-	-	-	50	24	-
UK Scotland	+	-	+	-	200	-	-	-
Total landings	21,100	27,613	23,100	27,150	30,300	26,950	26,692	25,600
Unallocated/ area misreported	7,100	13,826	11,200	4,600	6,250	6,250	1,100	6,900
Discards	1,000	2,530	3,400	100	250	700	-	-
WG catch	29,200	43,969	37,700	31,850	36,800	33,900	27,792	32,500

Country	1997	1998	1999	2000	2001	2002	2003	2004
France	-	-	-	-	-	515	-	-
Germany, Fed.Rep.	-	-	-	-	-	-	-	-
Ireland	24,400	25,200	16,325	10,164	11,278	13,072	12,921	10,950
Netherlands	3,400	2,500	1,868	1,234	2,088	366	-	64
UK (N.Ireland)	-	-	-	-	-	-	-	-
UK (England + Wales)	-	-	-	-	-	-	-	-
UK Scotland	-	-	-	-	-	-	-	-
Total landings	27,800	27,700	18,193	11,398	13,366	13,953	12,921	11,014
Area misreported	-700	11,200	7,916	8,448	1,390	3,873	3,581	2,813
Unallocated								
Discards	50		-	-	-	-	-	-
WG catch	27,150	38,900	26,109	19,846	14,756	17,826	16,502	13,827

Country	2005	2006	2007	2008	2009	2010	2011	2012
France	-	-	-	-	-	-	-	-
Germany, Fed.Rep.	-	-	-	-	-	-	-	-
Ireland	13,351	14,840	12,662	10,237	8,533	7,513	4,247	3,791
Netherlands	-	353	13	-	-	-	-	-
UK (N.Ireland)	-	-	-	-	-	-	-	-
UK (England + Wales)	-	-	-	-	-	-	-	-
UK Scotland	-	6	-	-		-	-	-
Total landings	13,351	15,199	12,675	10,237	8,533	7,513	4,247	3,791
Area misreported	2,880	4,353	5,129	3,103	1,935	2,728	2,672	2,780
Unallocated		-353	-13	-	-	-	-	-
Discards	-	-	-	-	-	-	-	-
WG catch	16,231	19,193	17,791	13,340	10,468	10,241	6919	6,571

Table 6.2.1.1. Herring in Divisions VIa(S) and VIIb,c. Catch in numbers-at-age (winter rings) from 1957 to 2012.

	1	2	3	4	5	6	7	8	9+
1957	0	7709	9965	1394	6235	2062	943	287	490
1958	100	3349	9410	6130	4065	5584	3279	1192	2195
1959	1060	7251	3585	8642	3222	1757	2002	858	839
1960	516	18221	7373	3551	2284	770	1020	578	326
1961	1768	7129	14342	6598	2481	2392	566	706	387
1962	259	7170	5535	10427	5235	3322	4111	1653	1525
1963	132	6446	5929	2032	3192	3541	2079	1293	2517
1964	88	7030	5903	4048	2195	3972	3779	1830	3559
1965	234	3847	10135	9008	2426	2019	6349	2737	4276
1966	0	16809	11894	10319	7392	3356	7112	2987	6109
1967	0	1232	55013	12681	9071	6348	3455	4862	8165
1968	574	10192	4702	78638	5316	4534	1889	839	3340
1969	1495	15038	13013	4410	54809	4918	3234	1954	3136
1970	135	35114	26007	13243	3895	40181	2982	1667	1911
1971	883	6177	7038	10856	8826	3938	40553	2286	2160
1972	1001	28786	20534	6191	11145	10057	4243	47182	4305
1973	6423	40390	47389	16863	7432	12383	9191	1969	50980
1974	3374	29406	41116	44579	17857	8882	10901	10272	30549
1975	7360	41308	25117	29192	23718	10703	5909	9378	32029
1976	16613	29011	37512	26544	25317	15000	5208	3596	15703
1977	4485	44512	13396	17176	12209	9924	5534	1360	4150
1978	10170	40320	27079	13308	10685	5356	4270	3638	3324
1979	5919	50071	19161	19969	9349	8422	5443	4423	4090
1980	2856	40058	64946	25140	22126	7748	6946	4344	5334
1981	1620	22265	41794	31460	12812	12746	3461	2735	5220
1982	748	18136	17004	28220	18280	8121	4089	3249	2875
1983	1517	43688	49534	25316	31782	18320	6695	3329	4251
1984	2794	81481	28660	17854	7190	12836	5974	2008	4020
1985	9606	15143	67355	12756	11241	7638	9185	7587	2168
1986	918	27110	27818	66383	14644	7988	5696	5422	2127
1987	12149	44160	80213	41504	99222	15226	12639	6082	10187
1988	0	29135	46300	41008	23381	45692	6946	2482	1964
1989	2241	6919	78842	26149	21481	15008	24917	4213	3036
1990	878	24977	19500	151978	24362	20164	16314	8184	1130
1991	675	34437	27810	12420	100444	17921	14865	11311	7660
1992	2592	15519	42532	26839	12565	73307	8535	8203	6286
1993	191	20562	22666	41967	23379	13547	67265	7671	6013
1994	11709	56156	31225	16877	21772	13644	8597	31729	10093
1995	284	34471	35414	18617	19133	16081	5749	8585	14215
1996	4776	24424	69307	31128	9842	15314	8158	12463	6472
1997	7458	56329	25946	38742	14583	5977	8351	3418	4264
1998	7437	72777	80612	38326	30165	9138	5282	3434	2942
1999	2392	51254	61329	34901	10092	5887	1880	1086	949
2000	4101	34564	38925	30706	13345	2735	1464	690	1602
2001	2316	21717	21780	17533	18450	9953	1741	1027	508
2002	4058	32640	37749	18882	11623	10215	2747	1605	644
2003	1731	32819	28714	24189	9432	5176	2525	923	303
2004	1401	15122	32992	19720	9006	4924	1547	975	323
2005	209	28123	30896	26887	10774	5452	1348	858	243
2006	598	22036	36700	30581	21956	9080	2418	832	369
2007	76	24577	43958	23399	13738	5474	1825	231	131
2008	483	12265	19661	28483	11110	5989	2738	745	267
2009	202	12574	12077	12096	12574	5239	2040	853	17
2010	1271	13507	20127	6541	7588	6780	2563	661	189
2011	121	14207	9315	9114	3386	3780	2871	980	95
2012	5142	12844	16387	4042	1776	553	541	103	21

Table 6.2.1.2. Herring in Divisions VIa(S) and VIIb,c. Percentage age composition (winter rings).

	1	2	3	4	5	6	7	8	9+
1996	3%	13%	38%	17%	5%	8%	4%	7%	4%
1997	5%	34%	16%	23%	9%	4%	5%	2%	3%
1998	3%	29%	32%	15%	12%	4%	2%	1%	1%
1999	1%	30%	36%	21%	6%	3%	1%	1%	1%
2000	3%	27%	30%	24%	10%	2%	1%	1%	1%
2001	2%	23%	23%	18%	19%	10%	2%	1%	1%
2002	3%	27%	31%	16%	10%	9%	2%	1%	1%
2003	2%	31%	27%	23%	9%	5%	2%	1%	0%
2004	2%	18%	38%	23%	10%	6%	2%	1%	0%
2005	0%	27%	29%	26%	10%	5%	1%	1%	0%
2006	0%	18%	29%	25%	18%	7%	2%	1%	0%
2007	0.1%	22%	39%	21%	12%	5%	2%	0%	0%
2008	1%	15%	24%	35%	14%	7%	3%	1%	0%
2009	0%	22%	21%	21%	22%	9%	4%	1%	0%
2010	2%	23%	34%	11%	13%	11%	4%	1%	0%
2011	0%	32%	21%	21%	8%	9%	7%	2%	0%
2012	12%	31%	40%	10%	4%	1%	1%	0%	0%

Table 6.2.2.1. Herring in Divisions VIa(S) and VIIb,c. Sampling intensity of catches in 2012

ICES area	Year	Quarter	Landings (t)	No. Samples	No. aged	No. Measured	Aged/1000 t
VIaS	2012	4	6507	13	960	2795	147.54
VIIb	2012	4	64	0	0	0	0
Total			6571	13	960	2795	

Table 6.3.1.1. Herring in Divisions VIa(S) and VIIb,c. Time series of acoustic surveys 1999-2007 (upper table). The 2008-2012 surveys are part of a new summer survey of the Malin Shelf stock complex (lower table).

Winter rings	1999	2000	2001	2002	2003	2004	2005	2006	2007
0	-	-	5	0	-	0	1	0	-
1	19	11	23	36	10		8	2	0
2	105	61	52	14	26	4	57	7	4
3	33	49	6	24	30	62	94	87	60
4	11	26	6	14	11	55	110	58	22
5	2	9	3	6	3	80	101	28	12
6	1	2	2	6	1	47	57	16	6
7	0	1	0	5	1	14	21	5	2
8	0	0	0	3	0	12	25	5	-
9+	0	1	0	4	0	-	13	1	-
Abundance (millions)	171	160	98	111	83	274	485	203	105
Total Biomass (t)	23762	21048	11062	8867	10300	41700	71253	27770	14222
SSB (t)	22788	20500	9800	6978	9500	41300	66138	27200	13974
CV	-	-	-	-	-	-	-	49%	44%

Winter rings	2008	2009	2010	2011	2012
0	-	-	-	-	-
1	6.1	416.4	16.5	44.6	25.9
2	75.9	81.3	292.8	86.3	360.9
3	64.7	11.4	85.2	146.8	92.8
4	38.4	15.1	63.2	28.9	42.9
5	22.3	7.7	43.2	5.7	8.0
6	26.2	7.1	27.3	4.3	3.7
7	9.1	7.5	19.0	4.8	3.5
8	5.0	0.4	12.5	2.1	2.1
9	3.7	0.9	5.5	1.4	1.3
10+	-	-	-	0.8	1.1
TSN (mil)	251.4	547.7	565.2	325.7	542.2
TSB (t)	44,611	46,460	82,100	40,700	68,300
SSB (t)	43,006	20,906	81,400	28,600	42,600
CV	34.2	32.2	24.7*	22.4*	22.8*

Survey coverage: VIaS & VIIb

*CV represents an area north of 56°N also

Table 6.3.1.2. Herring in Divisions VIa(S) and VIIb,c. Details of all acoustic surveys conducted on this stock.

Year	Type	Biomass	SSB
1994	Feeding phase	-	353,772
1995	Feeding phase	137,670	125,800
1996	Feeding phase	34,290	12,550
1997	-	-	-
1998	-	-	-
1999	Autumn spawners	23,762	22,788
2000	Autumn spawners	21,000	20,500
2001	Autumn spawners	11,100	9,800
2002	Winter spawners	8,900	7,200
2003	Winter spawners	10,300	9,500
2004	Winter spawners	41,700	41,399
2005	Winter spawners	71,253	66,138
2006	Winter spawners	27,770	27,200
2007	Winter spawners	14,222	13,974
2008	Feeding phase	44,611	43,006
2009	Feeding Phase	46,460	20,906
2010	Feeding Phase	82,100	81,400
2011	Feeding Phase	40,700	28,600
2012	Feeding Phase	68,300	42,600

Table 6.3.1.3. Herring in Divisions VIa(S) and VIIb,c. Abundance at age (millions) in the Malin Shelf Survey (MSHAS), 2008-2012. This survey is thought to contain the VIaS, VIIbc stock, but also covers the VIaN stock.

	1	2	3	4	5	6	7	8	9+
2008	312	290	998	720	363	331	744	386	274
2009	928	265	274	444	380	225	193	500	456
2010	300	376	374	242	173	146	102	100	297
2011	63	257	900	485	213	228	205	113	264
2012	808	550	832	517	249	115	111	57	105

Table 6.6.1.1. Herring in Divisions VIa(S) and VIIb,c. VPA run with a terminal F value of 0.2.

Year	Recruitment	SSB	Landings	Mean F 3-6
1957	168296	28425	5070	0.2337
1958	321203	27764	6825	0.3373
1959	466501	36516	5226	0.2145
1960	255078	48988	5401	0.1002
1961	201669	49923	6182	0.1251
1962	279658	53802	7399	0.14
1963	305107	64841	5059	0.0882
1964	290369	66768	6169	0.0935
1965	2361596	72475	8016	0.13
1966	164053	180732	12215	0.2033
1967	463359	108543	18881	0.2385
1968	541567	150293	20731	0.1743
1969	351143	138516	19607	0.1734
1970	405987	114893	20306	0.1955
1971	820794	98137	15044	0.1708
1972	738276	104252	23474	0.2059
1973	537056	135115	36719	0.287
1974	591919	90173	36589	0.4508
1975	409948	97890	38764	0.4385
1976	691702	68101	32767	0.5001
1977	578961	77177	20567	0.3183
1978	1057412	72614	19715	0.2628
1979	980281	105133	22608	0.2725
1980	533896	100540	30124	0.3933
1981	675883	101472	24922	0.3137
1982	701965	112176	19209	0.2265
1983	2312772	107526	32988	0.3635
1984	958563	182055	27450	0.2063
1985	1228668	186536	23343	0.1727
1986	945188	220962	28785	0.1827
1987	3220585	192604	48600	0.3474
1988	479159	298516	29100	0.2733
1989	715414	222960	29210	0.1837
1990	811196	192451	43969	0.2625
1991	504539	166011	37700	0.2464
1992	418061	132751	31856	0.2769
1993	620908	113910	36763	0.3577
1994	809785	94854	33908	0.3648
1995	460912	83935	27792	0.4705
1996	839420	62595	32534	0.5847
1997	827688	64248	27225	0.537
1998	531552	52436	38895	1.0408
1999	389527	44684	26109	0.7095
2000	440188	37108	19846	0.5334
2001	448203	34360	14756	0.643
2002	548229	32844	17826	0.7147
2003	449948	37671	16502	0.656
2004	467638	39489	13727	0.5966
2005	513167	39233	16231	0.6068
2006	288979	37098	19193	0.8626
2007	149513	29138	17791	0.6669
2008	206355	20651	13340	0.688
2009	152034	19625	10468	0.6393
2010	347129	14220	10241	0.7622
2011	371817	17717	6919	0.7497
2012	11648178	29869	6571	0.2725
Mean	513684*	91309	21558	0.3796

***Geometric Mean recruitment 1957- 2011**

Table 6.6.1.2. Herring in Divisions VIa(S) and VIIb,c. VPA run using a terminal F or 0.4.

Year	Recruitment	SSB	Landings	Mean F 3-6
1957	190562	32948	5070	0.1993
1958	364651	33426	6825	0.2767
1959	521046	44086	5226	0.1744
1960	281698	58142	5401	0.0833
1961	222528	58972	6182	0.1053
1962	304654	64176	7399	0.1183
1963	327749	77492	5059	0.0756
1964	309563	78242	6169	0.0814
1965	2483605	84704	8016	0.1156
1966	171051	199022	12215	0.1798
1967	478614	119667	18881	0.2106
1968	557201	164936	20731	0.1572
1969	356597	150906	19607	0.159
1970	413545	124790	20306	0.1842
1971	834437	106503	15044	0.1611
1972	750581	112223	23474	0.1963
1973	546766	146934	36719	0.2743
1974	605726	96149	36589	0.4286
1975	423503	105485	38764	0.4098
1976	711819	73997	32767	0.4652
1977	602661	83746	20567	0.2939
1978	1105087	78917	19715	0.2434
1979	1030320	113453	22608	0.2493
1980	558624	109440	30124	0.3574
1981	709812	112354	24922	0.2803
1982	737694	123676	19209	0.2024
1983	2414776	120314	32988	0.3276
1984	1002923	198969	27450	0.1858
1985	1272492	202414	23343	0.1565
1986	971766	238201	28785	0.1664
1987	3306705	209258	48600	0.3182
1988	489334	318248	29100	0.2514
1989	723425	237677	29210	0.1708
1990	816312	205301	43969	0.2464
1991	504815	175857	37700	0.2329
1992	417336	140665	31856	0.2665
1993	617901	120497	36763	0.3468
1994	804621	100172	33908	0.3557
1995	458551	85796	27792	0.4595
1996	833684	63597	32534	0.5763
1997	823073	64946	27225	0.5283
1998	528177	52745	38895	1.0135
1999	387424	45054	26109	0.6906
2000	441465	37591	19846	0.524
2001	446471	34787	14756	0.6258
2002	546183	33260	17826	0.6929
2003	447910	38121	16502	0.6356
2004	465367	39881	13727	0.5762
2005	511494	39507	16231	0.5691
2006	289814	37405	19193	0.8413
2007	149533	29637	17791	0.6532
2008	205291	21006	13340	0.6729
2009	147876	19977	10468	0.6216
2010	316758	14441	10241	0.7301
2011	285347	16875	6919	0.7002
2012	3797093	25198	6571	0.2757
Mean	524549*	98603	21558	0.3588

***Geometric mean recruitment: 1957-2011**

Table 6.6.1.3. Herring in Divisions VIa(S) and VIIb,c. VPA run using a terminal F or 0.5.

Year	Recruitment	SSB	Landings	Mean F 3-6
1957	175035	29605	5070	0.2237
1958	334545	29247	6825	0.3183
1959	483127	38621	5226	0.2011
1960	262908	51655	5401	0.0943
1961	207384	52635	6182	0.1181
1962	286854	56940	7399	0.1323
1963	311539	68642	5059	0.0838
1964	295696	70269	6169	0.0894
1965	2398901	76203	8016	0.1252
1966	165998	186356	12215	0.1954
1967	467097	111917	18881	0.2289
1968	544310	154695	20731	0.1685
1969	350895	142238	19607	0.1685
1970	406447	117839	20306	0.1917
1971	821830	100591	15044	0.1678
1972	739502	106540	23474	0.2031
1973	538189	138470	36719	0.2835
1974	593233	91726	36589	0.4443
1975	412251	99781	38764	0.4299
1976	695167	69665	32767	0.4882
1977	583445	78928	20567	0.3101
1978	1068757	74338	19715	0.2565
1979	994125	107457	22608	0.2651
1980	541049	103124	30124	0.3812
1981	683312	104671	24922	0.3022
1982	711052	115511	19209	0.2184
1983	2341228	111375	32988	0.3506
1984	970610	187033	27450	0.1992
1985	1238781	191287	23343	0.1672
1986	951309	226044	28785	0.1774
1987	3238964	197620	48600	0.337
1988	481007	304113	29100	0.2655
1989	716019	227173	29210	0.1794
1990	809513	196137	43969	0.2571
1991	502888	168677	37700	0.2419
1992	415472	134870	31856	0.2737
1993	616187	115611	36763	0.3543
1994	802983	96121	33908	0.362
1995	457753	84097	27792	0.4676
1996	831805	62596	32534	0.5825
1997	820655	64048	27225	0.5358
1998	526653	52237	38895	1.031
1999	386516	44546	26109	0.7026
2000	436156	37060	19846	0.5305
2001	444252	34245	14756	0.638
2002	543141	32708	17826	0.7089
2003	445267	37458	16502	0.6525
2004	460864	39183	13727	0.5957
2005	503977	38763	16231	0.6097
2006	279962	36445	19193	0.8687
2007	141074	28294	17791	0.6784
2008	182609	19597	13340	0.7129
2009	116490	17574	10468	0.6875
2010	196498	10972	10241	0.897
2011	159239	9459	6919	1.1766
2012	3837659	11583	6571	0.6583
Mean	498780*	92761	21558	0.3927

*** Geometric mean recruitment 1957-2011**

Table 6.6.1.4. Herring in Divisions VIa(S) and VIIb,c. VPA run using a terminal F or 0.6.

Year	Recruitment	SSB	Landings	Mean F 3-6
1957	176383	29847	5070	0.2219
1958	337196	29543	6825	0.315
1959	486505	39037	5226	0.1987
1960	264509	52181	5401	0.0933
1961	208578	53169	6182	0.1169
1962	288331	57554	7399	0.1309
1963	312892	69385	5059	0.083
1964	296834	70955	6169	0.0887
1965	2406875	76934	8016	0.1243
1966	166437	187483	12215	0.194
1967	468057	112590	18881	0.2273
1968	545210	155579	20731	0.1674
1969	351299	142996	19607	0.1676
1970	406891	118445	20306	0.1911
1971	822820	101103	15044	0.1672
1972	740483	107034	23474	0.2026
1973	538975	139179	36719	0.2828
1974	594179	92080	36589	0.4431
1975	413145	100205	38764	0.4283
1976	696661	70002	32767	0.4861
1977	584865	79306	20567	0.3087
1978	1071908	74708	19715	0.2554
1979	997429	107965	22608	0.2638
1980	542754	103665	30124	0.3791
1981	685269	105321	24922	0.3002
1982	713288	116199	19209	0.217
1983	2347936	112148	32988	0.3485
1984	973345	188053	27450	0.198
1985	1241624	192260	23343	0.1662
1986	953126	227105	28785	0.1764
1987	3244261	198642	48600	0.3353
1988	481649	305291	29100	0.2642
1989	716685	228060	29210	0.1786
1990	809954	196917	43969	0.2561
1991	503050	169265	37700	0.2411
1992	415551	135342	31856	0.2731
1993	616286	116004	36763	0.3537
1994	803118	96433	33908	0.3615
1995	457829	84225	27792	0.4671
1996	831925	62673	32534	0.5821
1997	820804	64108	27225	0.5354
1998	526755	52272	38895	1.0298
1999	386568	44578	26109	0.7016
2000	436147	37094	19846	0.53
2001	444207	34268	14756	0.6372
2002	543046	32724	17826	0.708
2003	445109	37469	16502	0.6519
2004	460520	39184	13727	0.5955
2005	503431	38745	16231	0.61
2006	279289	36404	19193	0.8696
2007	140316	28225	17791	0.6797
2008	180187	19499	13340	0.7158
2009	112569	17367	10468	0.6931
2010	179522	10619	10241	0.9148
2011	136496	8520	6919	1.2588
2012	3084861	9544	6571	0.7847
Mean	496978*	93134	21558	0.3959

*** Geometric mean recruitment 1957-2011**

Table 6.6.1.5 Herring in Divisions VIa(S) and VIIb,c. Matrix of residuals from the 0.2 VPA

Years	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967
1	-1.43	-0.474	0.748	1.43	3.041	0.351	0.25	0.545	0.319	-0.624	-3.191
2	0.692	-0.032	-0.159	0.583	0.977	0.046	0.616	0.257	-0.251	-0.459	-1.073
3	0.884	-0.392	-0.612	0.002	0.588	0.404	0.47	-0.242	0.408	0.19	-0.573
4	-0.83	-0.005	0.556	0.11	0.361	0.445	-0.12	0.559	0.486	0.235	0.5
5	0.316	0.153	0.631	-0.314	-0.183	-0.367	-0.276	0.115	-0.056	0.232	0.295
6	-0.336	0.255	-0.333	-0.029	-0.501	-0.359	-0.188	-0.504	-1.06	-0.023	0.738
7	-0.58	0.07	-0.156	-0.492	-1.544	-0.203	-0.524	-0.237	0.442	-0.112	0.433

Years	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978
1	0.987	1.03	0.014	1.097	0.669	2.957	1.682	2.901	2.65	1.736	2.534
2	0.267	-0.108	1.709	-0.362	0.097	0.651	0.502	0.501	0.565	0.642	1.099
3	0.098	-0.061	0.498	0.493	0.291	0.199	0.12	-0.236	-0.01	-0.372	0.152
4	0.243	-0.073	-0.122	0.19	-0.251	-0.097	0.212	-0.245	-0.224	-0.079	0.034
5	-0.067	0.084	-0.566	0.058	-0.21	-0.264	0.036	0.008	-0.124	0.229	-0.119
6	0.118	0.197	-0.639	0.041	-0.095	-0.046	-0.166	0.168	-0.168	0.161	-0.456
7	-0.756	-0.141	-0.88	-0.529	0.102	-0.737	-0.871	-0.485	-0.303	-0.752	-0.962

Years	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
1	2.516	1.797	1.501	0.543	-0.516	2.365	3.176	0.915	2.787	-2.697	2.029
2	0.375	0.015	0.423	-0.174	0.119	0.515	-0.124	-0.06	-0.155	-0.621	-0.351
3	-0.154	0.252	0.045	-0.071	0.203	0.663	0.031	0.136	0.053	0.466	-0.457
4	-0.156	0.021	0.031	0.045	0.268	0.168	-0.268	-0.021	-0.214	0.389	0.115
5	0.092	-0.145	-0.09	0.124	-0.121	-0.38	0.188	0.309	-0.049	0.158	0.077
6	0.012	0.02	0.509	0.238	0.007	-0.058	0.067	-0.188	-0.124	0.245	-0.147
7	-0.42	-0.343	-1.066	-0.216	-0.423	-1.144	-0.209	-0.266	0.211	-0.367	0.561

Years	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
1	0.453	1.021	2.357	-1.537	3.036	0.073	1.632	2.31	1.806	1.111	2.446
2	0.249	0.179	0.264	-0.075	0.772	-0.012	0.159	0.273	-0.084	0.156	0.711
3	0.306	-0.074	0.145	0.103	0.293	0.259	0.198	-0.404	-0.143	-0.061	0.46
4	0.106	-0.284	0.102	0.284	-0.531	0.578	0.159	0.003	0.069	-0.027	-0.037
5	-0.036	0.008	-0.151	0.121	-0.148	0.108	-0.169	0.135	0.263	0.241	-0.316
6	-0.119	0.354	-0.073	-0.052	0.323	0.471	-0.169	-0.324	0.067	0.209	-0.261
7	-0.55	-0.285	-0.522	-0.227	-1.012	-1.411	-0.34	0.087	-0.352	-0.63	-0.801

Years	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
1	1.679	1.851	1.762	1.182	-0.172	0.126	-0.965	0.749	0.03	1.638	-1.551
2	-0.121	0.166	0.056	-0.391	0.303	-0.79	0.429	0.115	-0.157	0.485	-0.879
3	-0.03	-0.148	-0.161	-0.052	-0.039	-0.32	0.009	-0.047	0.294	0.248	-0.506
4	0.023	-0.131	0.237	0.144	-0.068	-0.224	0.089	0.052	-0.083	-0.132	0.071
5	0.133	-0.092	-0.167	-0.019	-0.176	0.276	0.096	-0.091	-0.01	-0.179	0.184
6	0.722	0.381	0.284	0.673	0.357	0.364	-0.156	0.118	-0.027	-0.139	0.204
7	-0.896	-0.362	-0.425	-0.474	-0.359	0.68	-0.37	-0.221	-0.02	-0.447	1.08

Table 6.6.1.6 Herring in Divisions VIa(S) and VIIb,c. Matrix of residuals from the 0.4 VPA

	Years	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967
1		-2.431	-1.483	-0.241	0.456	2.065	-0.621	-0.714	-0.419	-0.651	-1.603	-4.172
2		0.547	-0.188	-0.298	0.459	0.852	-0.078	0.5	0.139	-0.373	-0.59	-1.208
3		0.829	-0.455	-0.665	-0.044	0.542	0.357	0.429	-0.285	0.363	0.14	-0.627
4		-0.87	-0.049	0.513	0.068	0.32	0.402	-0.161	0.518	0.445	0.193	0.456
5		0.32	0.156	0.626	-0.322	-0.189	-0.376	-0.288	0.104	-0.064	0.228	0.291
6		-0.356	0.236	-0.369	-0.075	-0.544	-0.407	-0.241	-0.555	-1.103	-0.057	0.704
7		-0.224	0.45	0.218	-0.13	-1.188	0.164	-0.167	0.12	0.798	0.247	0.801

	Years	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978
1		0.008	0.051	-0.959	0.122	-0.314	1.962	0.677	1.884	1.638	0.741	1.544
2		0.134	-0.243	1.578	-0.492	-0.044	0.498	0.335	0.324	0.388	0.489	0.953
3		0.046	-0.114	0.445	0.443	0.233	0.132	0.043	-0.318	-0.094	-0.437	0.091
4		0.201	-0.117	-0.167	0.148	-0.296	-0.142	0.162	-0.294	-0.279	-0.126	-0.012
5		-0.071	0.08	-0.572	0.054	-0.21	-0.258	0.046	0.022	-0.115	0.231	-0.118
6		0.084	0.165	-0.677	0.007	-0.117	-0.053	-0.161	0.183	-0.165	0.144	-0.477
7		-0.393	0.224	-0.51	-0.172	0.466	-0.373	-0.492	-0.106	0.102	-0.373	-0.592

	Years	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
1		1.517	0.797	0.512	-0.454	-1.51	1.39	2.202	-0.072	1.799	-3.674	1.048
2		0.224	-0.142	0.279	-0.32	-0.032	0.385	-0.252	-0.198	-0.301	-0.754	-0.486
3		-0.217	0.184	-0.015	-0.13	0.139	0.613	-0.019	0.082	-0.01	0.413	-0.511
4		-0.2	-0.026	-0.015	0.003	0.22	0.125	-0.311	-0.062	-0.262	0.345	0.072
5		0.097	-0.141	-0.092	0.128	-0.122	-0.386	0.181	0.31	-0.051	0.153	0.074
6		0	0.006	0.483	0.222	-0.018	-0.097	0.028	-0.211	-0.15	0.211	-0.176
7		-0.056	0.04	-0.692	0.142	-0.036	-0.779	0.153	0.087	0.593	-0.001	0.922

	Years	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
1		-0.529	0.041	1.371	-2.526	2.049	-0.923	0.63	1.287	0.779	0.102	1.445
2		0.108	0.04	0.12	-0.228	0.62	-0.173	-0.017	0.079	-0.304	-0.032	0.54
3		0.247	-0.133	0.084	0.035	0.224	0.186	0.11	-0.501	-0.268	-0.159	0.376
4		0.06	-0.33	0.057	0.236	-0.58	0.531	0.103	-0.049	-0.004	-0.088	-0.09
5		-0.038	0.006	-0.149	0.124	-0.146	0.118	-0.157	0.16	0.285	0.254	-0.306
6		-0.145	0.328	-0.09	-0.064	0.311	0.476	-0.153	-0.276	0.121	0.231	-0.251
7		-0.181	0.084	-0.158	0.149	-0.636	-1.045	0.051	0.459	0.092	-0.216	-0.413

	Years	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
1		0.669	0.841	0.761	0.184	-1.186	-0.89	-1.979	-0.265	-0.992	0.603	-2.564
2		-0.3	-0.021	-0.119	-0.559	0.119	-0.99	0.241	-0.074	-0.349	0.281	-1.063
3		-0.117	-0.244	-0.248	-0.133	-0.13	-0.428	-0.087	-0.144	0.199	0.145	-0.597
4		-0.029	-0.19	0.18	0.092	-0.12	-0.289	0.031	-0.006	-0.138	-0.19	0.011
5		0.149	-0.078	-0.157	-0.01	-0.156	0.294	0.113	-0.076	0.01	-0.156	0.191
6		0.745	0.405	0.294	0.682	0.39	0.401	-0.127	0.145	0.006	-0.098	0.206
7		-0.515	0.043	-0.027	-0.091	0.016	1.101	0.026	0.182	0.371	-0.042	1.509

Table 6.6.1.7 Herring in Divisions VIa(S) and VIIb,c. Matrix of residuals from the 0.5 VPA

Years	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967
1	-1.57	-0.61	0.614	1.301	2.912	0.224	0.125	0.42	0.192	-0.75	-3.32
2	0.629	-0.1	-0.22	0.525	0.92	-0.01	0.561	0.201	-0.31	-0.52	-1.13
3	0.871	-0.41	-0.63	-0.01	0.575	0.39	0.458	-0.26	0.395	0.177	-0.59
4	-0.82	0.002	0.562	0.114	0.366	0.449	-0.12	0.563	0.49	0.241	0.505
5	0.339	0.177	0.652	-0.3	-0.16	-0.35	-0.26	0.132	-0.04	0.252	0.316
6	-0.29	0.302	-0.29	0.012	-0.46	-0.32	-0.15	-0.46	-1.02	0.019	0.78
7	-0.56	0.089	-0.14	-0.47	-1.53	-0.18	-0.51	-0.22	0.461	-0.09	0.452

Years	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978
1	0.857	0.9	-0.11	0.969	0.538	2.823	1.545	2.76	2.511	1.601	2.401
2	0.208	-0.17	1.65	-0.42	0.036	0.588	0.435	0.432	0.494	0.577	1.036
3	0.084	-0.07	0.484	0.481	0.278	0.185	0.106	-0.25	-0.03	-0.39	0.138
4	0.249	-0.07	-0.12	0.196	-0.25	-0.09	0.221	-0.23	-0.22	-0.07	0.04
5	-0.05	0.104	-0.55	0.078	-0.19	-0.24	0.062	0.035	-0.1	0.252	-0.1
6	0.159	0.239	-0.6	0.081	-0.05	-0	-0.12	0.213	-0.12	0.205	-0.41
7	-0.74	-0.12	-0.86	-0.51	0.119	-0.72	-0.86	-0.47	-0.29	-0.74	-0.95

Years	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
1	2.38	1.661	1.368	0.408	-0.65	2.236	3.048	0.783	2.654	-2.83	1.899
2	0.312	-0.05	0.36	-0.24	0.054	0.456	-0.18	-0.12	-0.22	-0.68	-0.41
3	-0.17	0.237	0.03	-0.08	0.187	0.65	0.018	0.124	0.038	0.453	-0.47
4	-0.15	0.029	0.037	0.052	0.275	0.173	-0.26	-0.01	-0.21	0.394	0.121
5	0.115	-0.12	-0.07	0.146	-0.1	-0.36	0.207	0.33	-0.03	0.178	0.097
6	0.055	0.066	0.553	0.281	0.053	-0.02	0.108	-0.15	-0.08	0.287	-0.11
7	-0.4	-0.33	-1.05	-0.2	-0.4	-1.13	-0.19	-0.25	0.23	-0.35	0.578

Years	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
1	0.323	0.891	2.226	-1.67	2.905	-0.06	1.496	2.168	1.663	0.973	2.311
2	0.188	0.119	0.203	-0.14	0.709	-0.08	0.091	0.203	-0.16	0.085	0.644
3	0.293	-0.09	0.132	0.089	0.279	0.246	0.183	-0.42	-0.16	-0.08	0.445
4	0.112	-0.28	0.109	0.292	-0.52	0.587	0.169	0.016	0.083	-0.02	-0.03
5	-0.02	0.029	-0.13	0.144	-0.13	0.133	-0.14	0.165	0.299	0.271	-0.29
6	-0.08	0.396	-0.03	-0.01	0.366	0.513	-0.12	-0.28	0.119	0.257	-0.22
7	-0.53	-0.27	-0.51	-0.21	-1	-1.4	-0.33	0.097	-0.34	-0.62	-0.79

Years	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
1	1.541	1.714	1.628	1.049	-0.31	-0	-1.08	0.649	-0.03	1.702	-1.32
2	-0.19	0.095	-0.01	-0.46	0.236	-0.86	0.368	0.062	-0.19	0.508	-0.75
3	-0.04	-0.16	-0.18	-0.07	-0.05	-0.34	-0.01	-0.06	0.286	0.25	-0.47
4	0.034	-0.12	0.246	0.154	-0.06	-0.21	0.099	0.06	-0.08	-0.14	0.054
5	0.161	-0.06	-0.14	0.006	-0.15	0.306	0.122	-0.07	0.002	-0.19	0.139
6	0.766	0.428	0.329	0.716	0.399	0.41	-0.12	0.152	-0.01	-0.16	0.133
7	-0.88	-0.35	-0.41	-0.46	-0.35	0.691	-0.36	-0.21	-0.01	-0.44	1.031

Table 6.6.1.8 Herring in Divisions VIa(S) and VIIb,c. Matrix of residuals from the 0.6 VPA

Years	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967
1	-1.59	-0.64	0.589	1.277	2.887	0.199	0.101	0.396	0.168	-0.78	-3.35
2	0.618	-0.11	-0.23	0.515	0.909	-0.02	0.551	0.191	-0.32	-0.53	-1.14
3	0.868	-0.41	-0.63	-0.01	0.573	0.388	0.456	-0.26	0.393	0.175	-0.59
4	-0.82	0.003	0.563	0.115	0.367	0.45	-0.12	0.563	0.491	0.241	0.506
5	0.342	0.181	0.655	-0.29	-0.16	-0.35	-0.26	0.135	-0.04	0.255	0.319
6	-0.29	0.31	-0.28	0.02	-0.45	-0.31	-0.14	-0.46	-1.01	0.027	0.788
7	-0.56	0.092	-0.13	-0.47	-1.52	-0.18	-0.5	-0.22	0.464	-0.09	0.455

Years	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978
1	0.833	0.876	-0.14	0.944	0.513	2.797	1.519	2.734	2.484	1.576	2.376
2	0.197	-0.18	1.639	-0.43	0.026	0.577	0.423	0.42	0.482	0.566	1.025
3	0.082	-0.08	0.482	0.479	0.276	0.183	0.103	-0.25	-0.03	-0.39	0.135
4	0.25	-0.07	-0.12	0.196	-0.24	-0.09	0.223	-0.23	-0.21	-0.07	0.041
5	-0.04	0.107	-0.54	0.081	-0.19	-0.24	0.066	0.04	-0.09	0.256	-0.09
6	0.167	0.247	-0.59	0.089	-0.05	0.004	-0.11	0.222	-0.11	0.214	-0.4
7	-0.74	-0.12	-0.86	-0.51	0.122	-0.72	-0.85	-0.47	-0.28	-0.73	-0.94

Years	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
1	2.355	1.635	1.343	0.382	-0.68	2.212	3.023	0.758	2.629	-2.85	1.874
2	0.301	-0.06	0.349	-0.25	0.042	0.446	-0.19	-0.13	-0.23	-0.69	-0.42
3	-0.17	0.234	0.028	-0.09	0.185	0.648	0.016	0.121	0.035	0.451	-0.47
4	-0.15	0.03	0.038	0.053	0.276	0.174	-0.26	-0.01	-0.21	0.395	0.122
5	0.119	-0.12	-0.07	0.15	-0.09	-0.36	0.21	0.333	-0.02	0.181	0.1
6	0.064	0.075	0.561	0.289	0.061	-0.01	0.116	-0.14	-0.07	0.295	-0.1
7	-0.4	-0.32	-1.04	-0.2	-0.4	-1.12	-0.19	-0.25	0.233	-0.35	0.581

Years	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
1	0.298	0.867	2.201	-1.69	2.88	-0.09	1.47	2.141	1.636	0.947	2.285
2	0.177	0.108	0.193	-0.15	0.698	-0.09	0.079	0.19	-0.18	0.072	0.632
3	0.29	-0.09	0.129	0.087	0.276	0.244	0.18	-0.42	-0.17	-0.08	0.442
4	0.113	-0.28	0.11	0.293	-0.52	0.589	0.17	0.019	0.085	-0.01	-0.03
5	-0.01	0.032	-0.13	0.148	-0.12	0.137	-0.14	0.171	0.305	0.276	-0.29
6	-0.07	0.404	-0.02	-0	0.374	0.521	-0.12	-0.27	0.129	0.266	-0.21
7	-0.53	-0.26	-0.5	-0.21	-0.99	-1.39	-0.32	0.099	-0.34	-0.61	-0.78

Years	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
1	1.515	1.688	1.602	1.024	-0.33	-0.03	-1.11	0.627	-0.05	1.708	-1.26
2	-0.2	0.083	-0.02	-0.47	0.224	-0.87	0.356	0.052	-0.2	0.509	-0.72
3	-0.05	-0.17	-0.18	-0.07	-0.06	-0.34	-0.01	-0.06	0.284	0.249	-0.47
4	0.036	-0.12	0.248	0.155	-0.06	-0.21	0.1	0.062	-0.08	-0.14	0.05
5	0.166	-0.06	-0.14	0.011	-0.14	0.311	0.126	-0.07	0.005	-0.19	0.128
6	0.775	0.437	0.338	0.724	0.407	0.418	-0.11	0.159	-0	-0.16	0.114
7	-0.88	-0.35	-0.41	-0.46	-0.35	0.693	-0.36	-0.21	-0.01	-0.43	1.023

Table 6.7.1. Herring in Divisions VIa(S) and VIIb,c. Inputs to exploratory deterministic FLICA short term forecasts.

2013

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
1	473928.3	1	0	0.67	0.67	0.086	0.001	0.096
2	174280.4	0.3	1	0.67	0.67	0.127	0.139	0.129
3	164559.8	0.2	1	0.67	0.67	0.158	0.307	0.163
4	78775.12	0.1	1	0.67	0.67	0.190	0.360	0.186
5	22217.59	0.1	1	0.67	0.67	0.207	0.361	0.203
6	12870.99	0.1	1	0.67	0.67	0.220	0.360	0.217
7	8437.227	0.1	1	0.67	0.67	0.230	0.360	0.223

2014

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
1	473928.3	1	0	0.67	0.67	0.086	0.001	0.096
2	-	0.3	1	0.67	0.67	0.127	0.139	0.129
3	-	0.2	1	0.67	0.67	0.158	0.307	0.163
4	-	0.1	1	0.67	0.67	0.190	0.360	0.186
5	-	0.1	1	0.67	0.67	0.207	0.361	0.203
6	-	0.1	1	0.67	0.67	0.220	0.360	0.217
7	-	0.1	1	0.67	0.67	0.230	0.360	0.223

2015

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
1	473928.3	1	0	0.67	0.67	0.086	0.001	0.096
2	-	0.3	1	0.67	0.67	0.127	0.139	0.129
3	-	0.2	1	0.67	0.67	0.158	0.307	0.163
4	-	0.1	1	0.67	0.67	0.190	0.360	0.186
5	-	0.1	1	0.67	0.67	0.207	0.361	0.203
6	-	0.1	1	0.67	0.67	0.220	0.360	0.217
7	-	0.1	1	0.67	0.67	0.230	0.360	0.223

Table 6.7.2. Herring in Divisions VIa(S) and VIIb,c. Results of exploratory short term forecast in ICA.

Rationale	Fbar (2013)	Catch (2013)	SSB (2013)	Fbar (2014)	Catch (2014)	SSB (2014)	SSB (2015)
Catch(2014) = Zero	0.11	5515	60013	0	0	76630	94054
Catch(2014) = 2013 TAC -15% (275t)	0.11	5515	60013	0.02	1275	75792	91769
Catch(2014) = 2013 TAC sq (1500 t)	0.11	5515	60013	0.02	1500	75644	91369
Catch(2014) = 2013 TAC +15% (1725t)	0.11	5515	60013	0.03	1725	75496	90969
Catch(2014) = 2013 TAC + 25% (1875 t)	0.11	5515	60013	0.03	1875	75397	90703
Catch(2014) = 2013 TAC + 30% (1950t)	0.11	5515	60013	0.03	1950	75347	90570
Fbar(2014) = 0.20	0.11	5515	60013	0.20	12244	68389	73250
Fbar(2014) = 0.25	0.11	5515	60013	0.25	14977	66484	68958
Fbar(2014) = 0.33	0.11	5515	60013	0.33	19103	63556	62723
Fbar(2014) = 0.127	0.11	5515	60013	0.13	8028	71279	80125
Fbar(2014) = 0.231	0.11	5515	60013	0.23	13952	67201	70551
Fbar(2014) = 0.158	0.11	5515	60013	0.16	9852	70036	77113
Fbar(2014) = 0.110	0.11	5515	60013	0.11	7006	71971	81837
Fbar(2014) = 0.109	0.11	5515	60013	0.11	6945	72012	81939

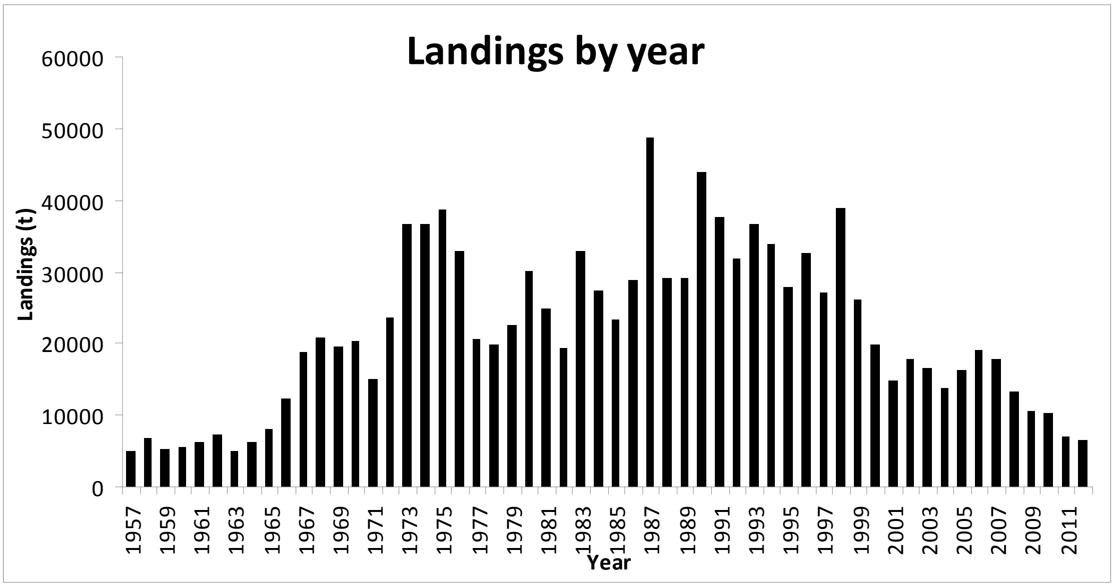


Figure 6.1.2.1. Herring in Divisions VIa(S) and VIIb,c. Working group estimate of catches from 1957-2012.

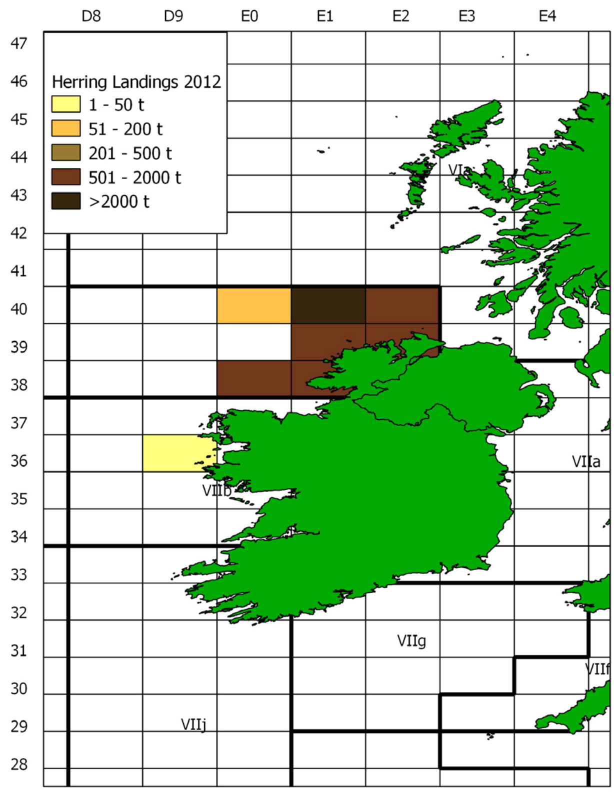


Figure 6.1.3.1. Herring in Divisions VIa(S) and VIIb,c. Herring landings by statistical rectangle in VIaS and VIIb,c in 2012.

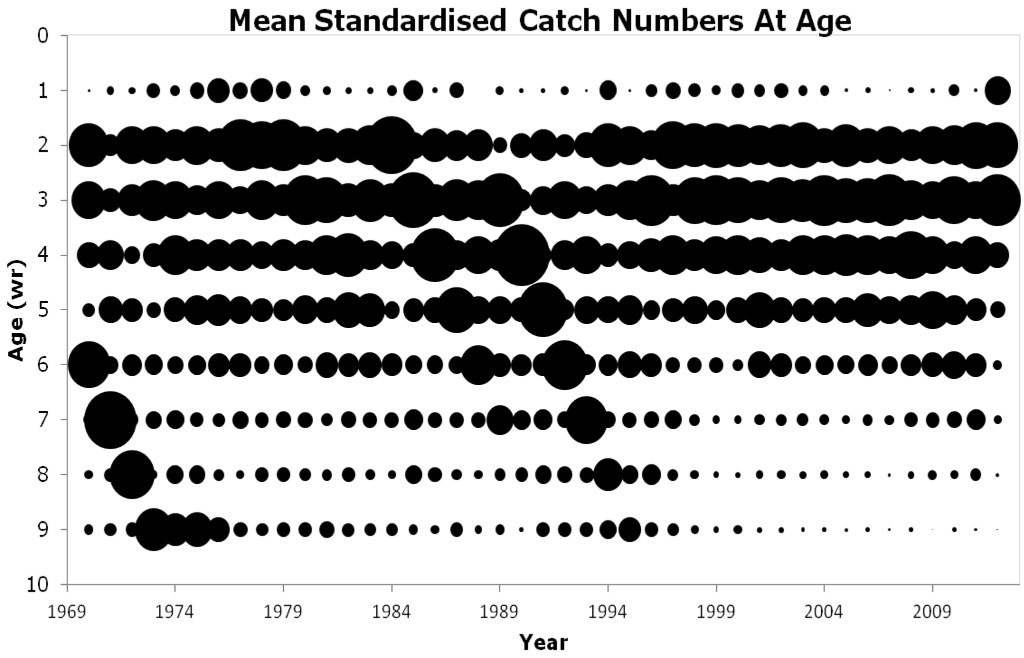


Figure 6.2.1.1. Herring in Divisions VIa(S) and VIIb,c. Mean standardised catch numbers at age standardised by year for the fishery.

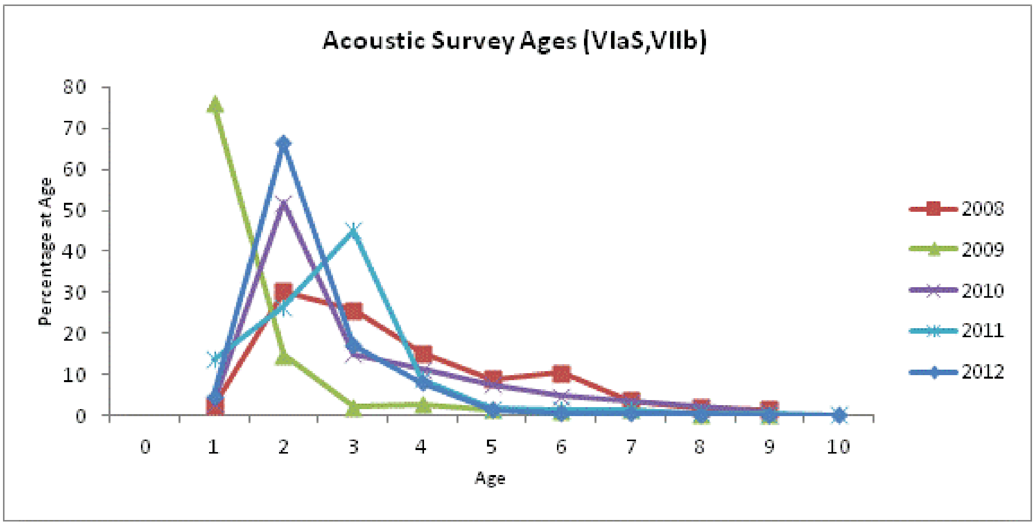


Figure 6.3.1.1. Herring in Divisions VIa(S) and VIIb,c. Age profiles from the acoustic surveys that were carried out in VIaS and VIIb in 2008-12

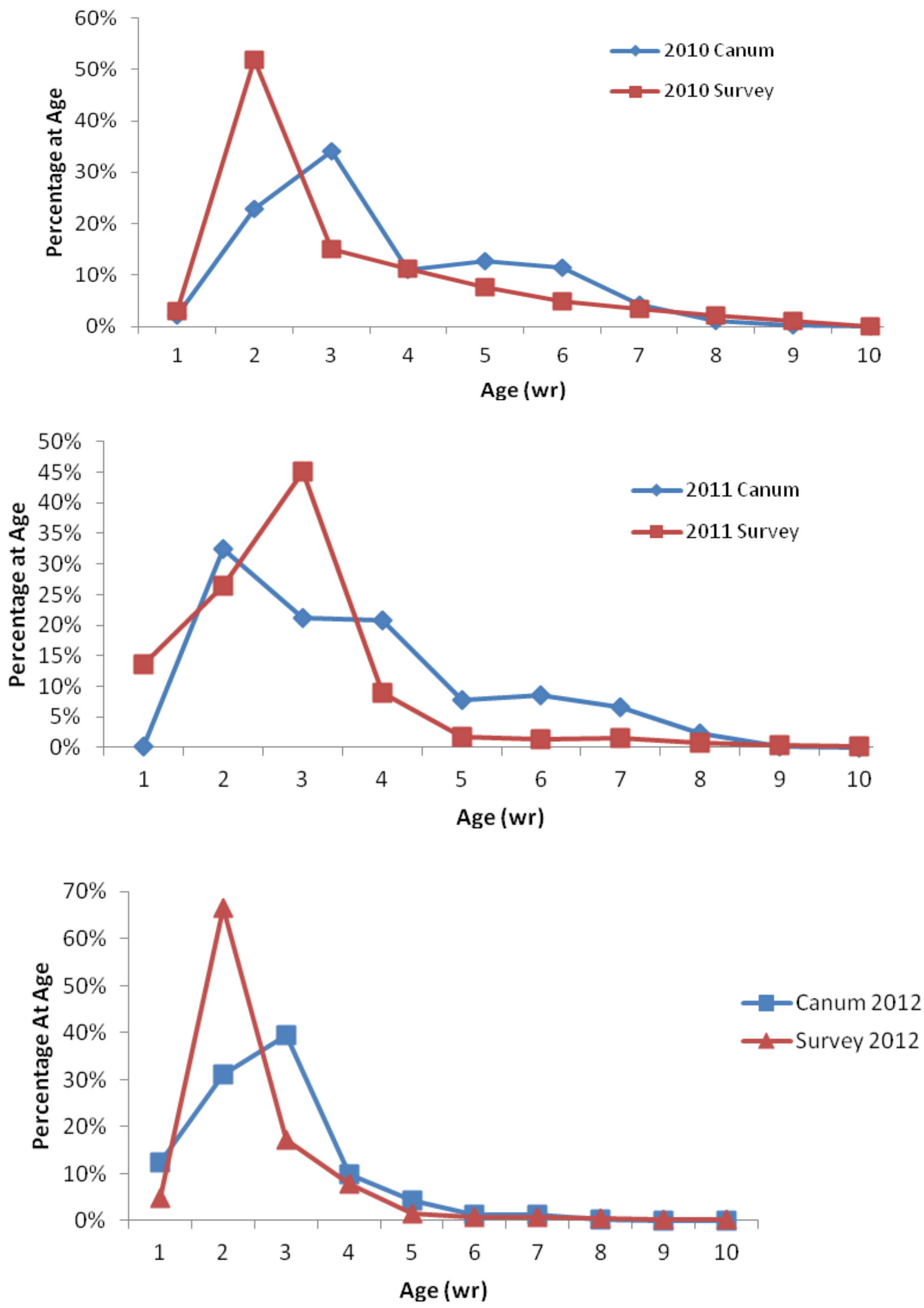


Figure 6.3.1.2. Herring in Divisions VIa(S) and VIIb,c. Proportions at age in the catch and survey data, 2008-2012.

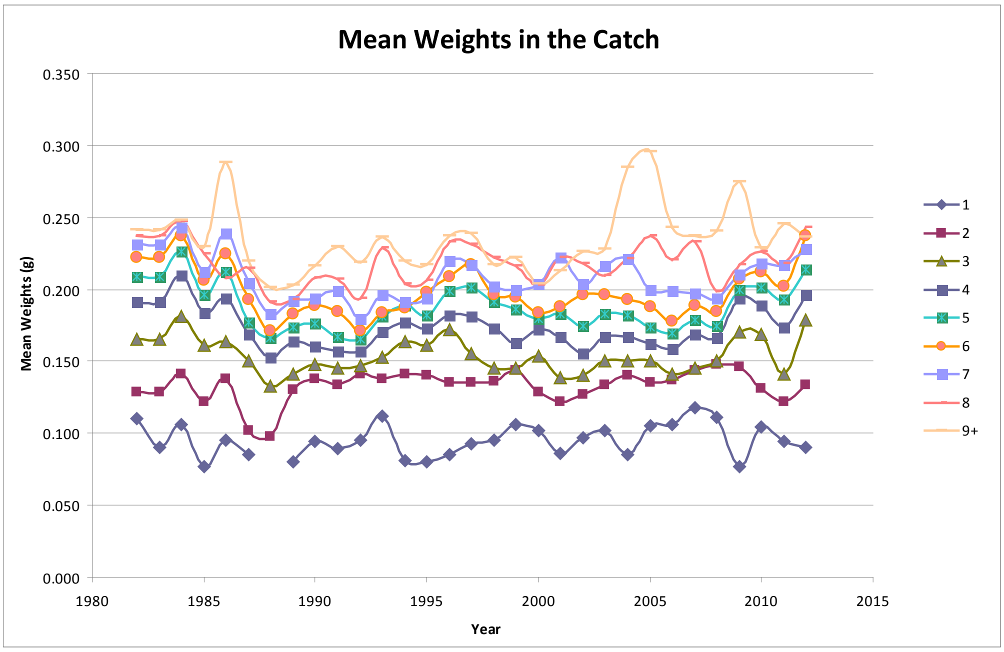


Figure 6.4.1.1. Herring in Divisions VIa(S) and VIIb,c. Mean Weights in the Catch (kg) by age in winter rings.

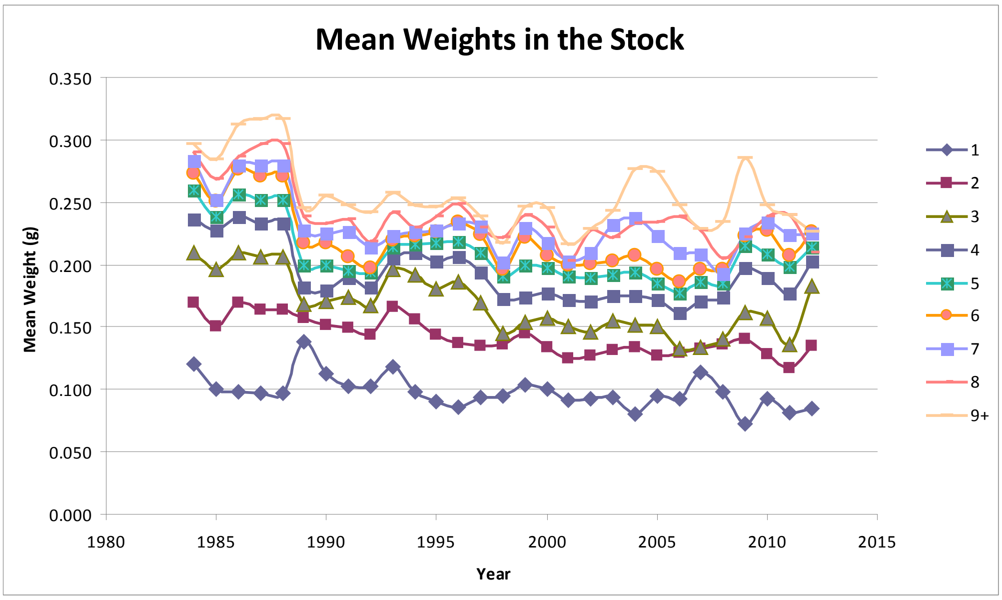
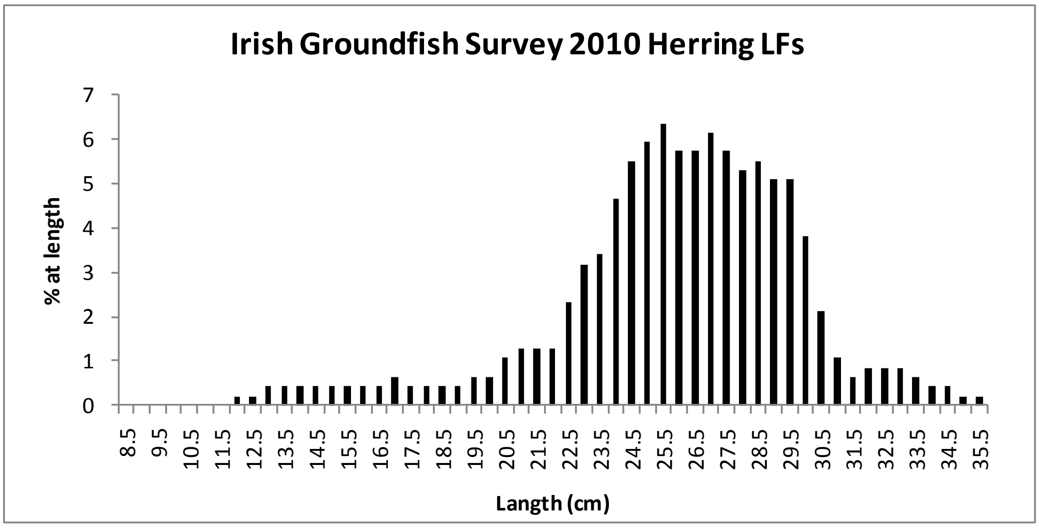
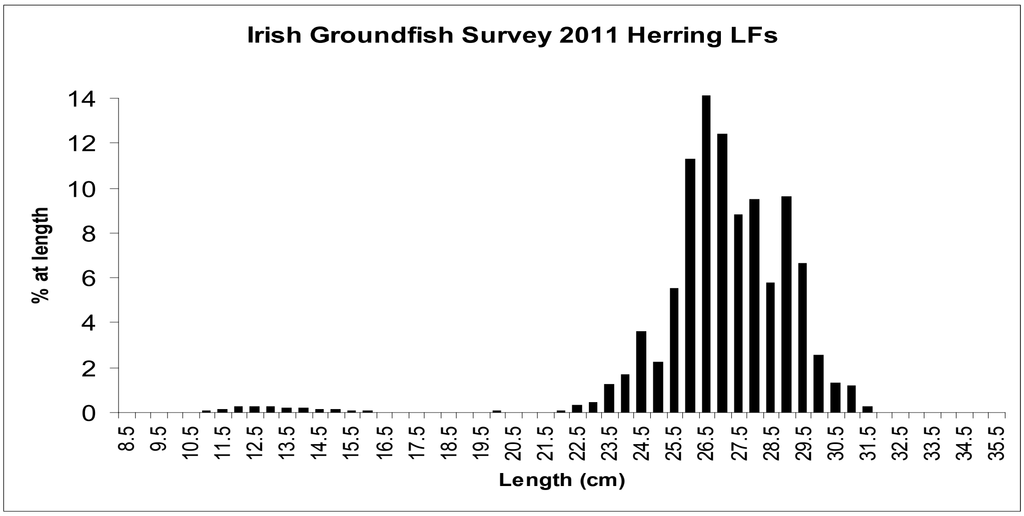


Figure 6.4.1.2. Herring in Divisions VIa(S) and VIIb,c. Mean weights in the stock (kg) by age in winter rings.





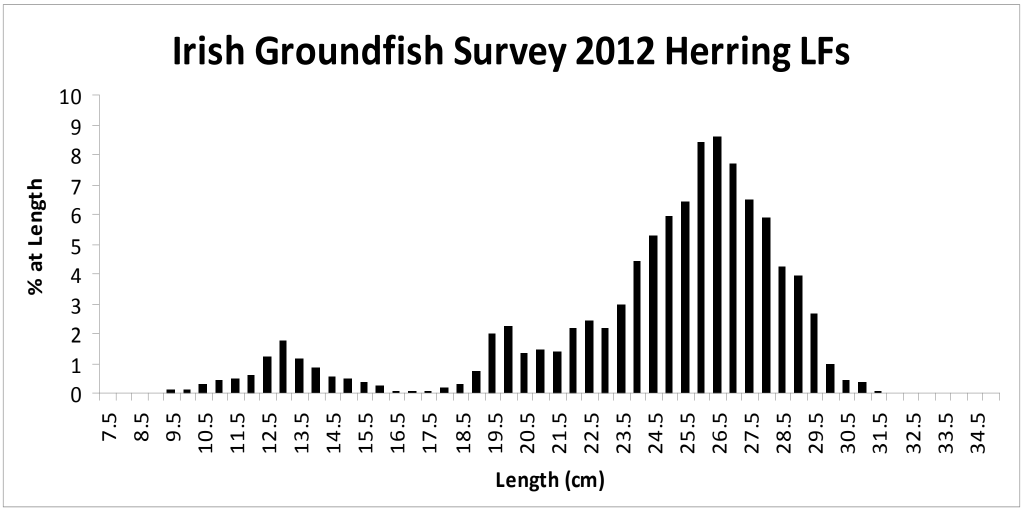


Figure 6.5.1.1. Herring in Divisions VIa(S) and VIIb,c. Irish Groundfish survey length frequency data 2010-2012.

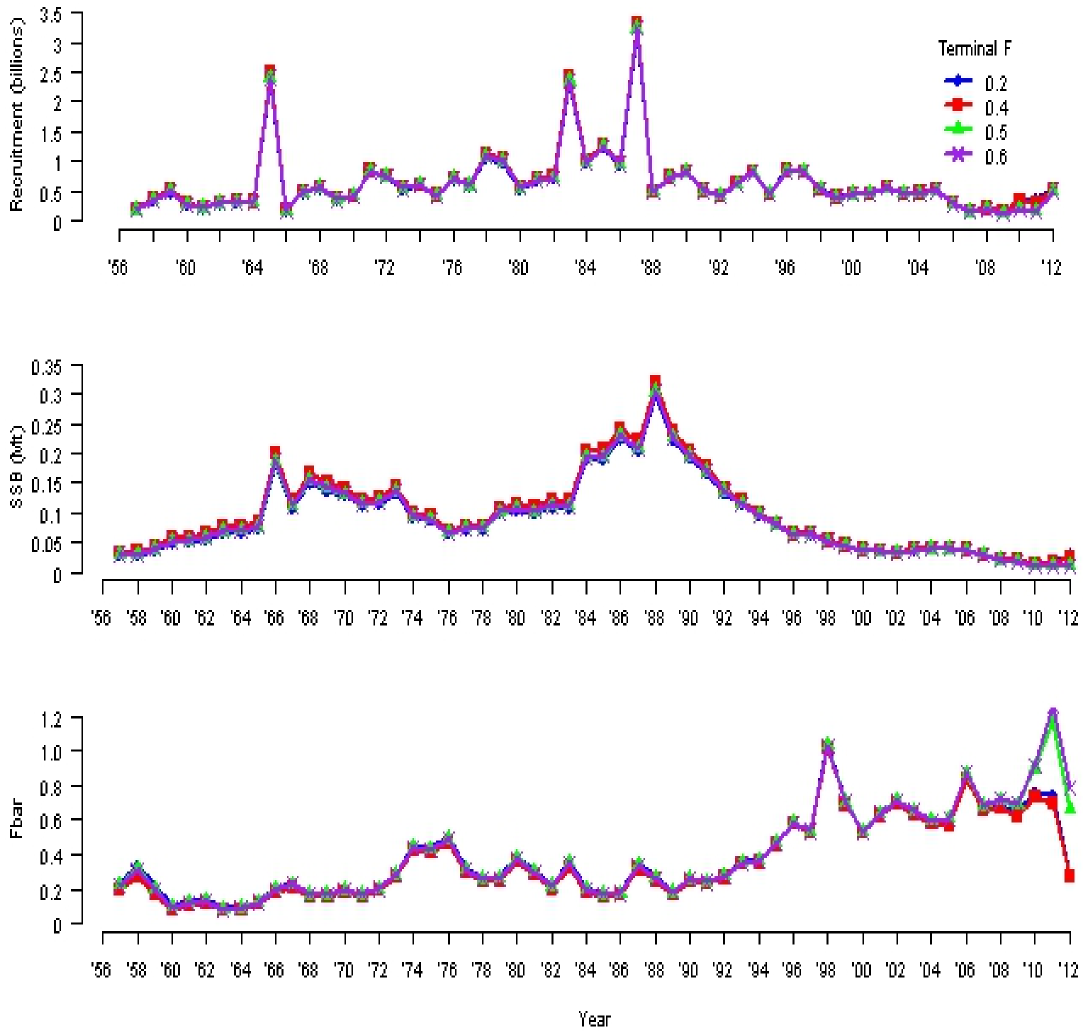


Figure 6.6.1.1. Herring in Divisions VIa(S) and VIIb,c. Results of the separable VPA assessment showing four separable VPAs, based on differing initial values of terminal F, over the period 1957-2012. Recruitment (top), SSB (middle) and mean F (bottom).

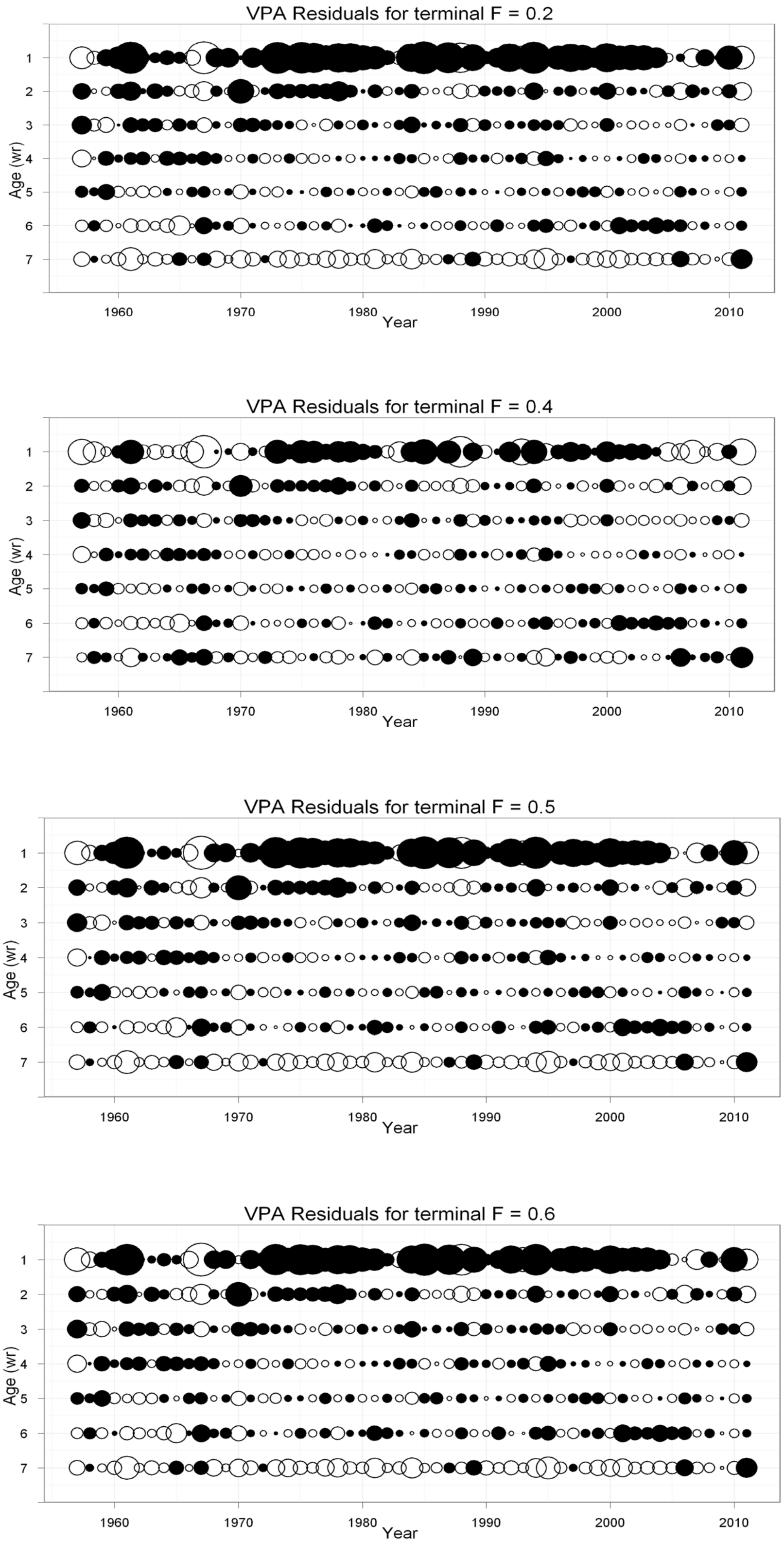


Figure 6.6.1.2. Herring in Divisions VIa(S) and VIIb,c. Residuals from the four separable VPA runs using terminal F values of 0.2 , 0.4, 0.5 and 0.6 . Black indicates positive residuals, white indicates negative.

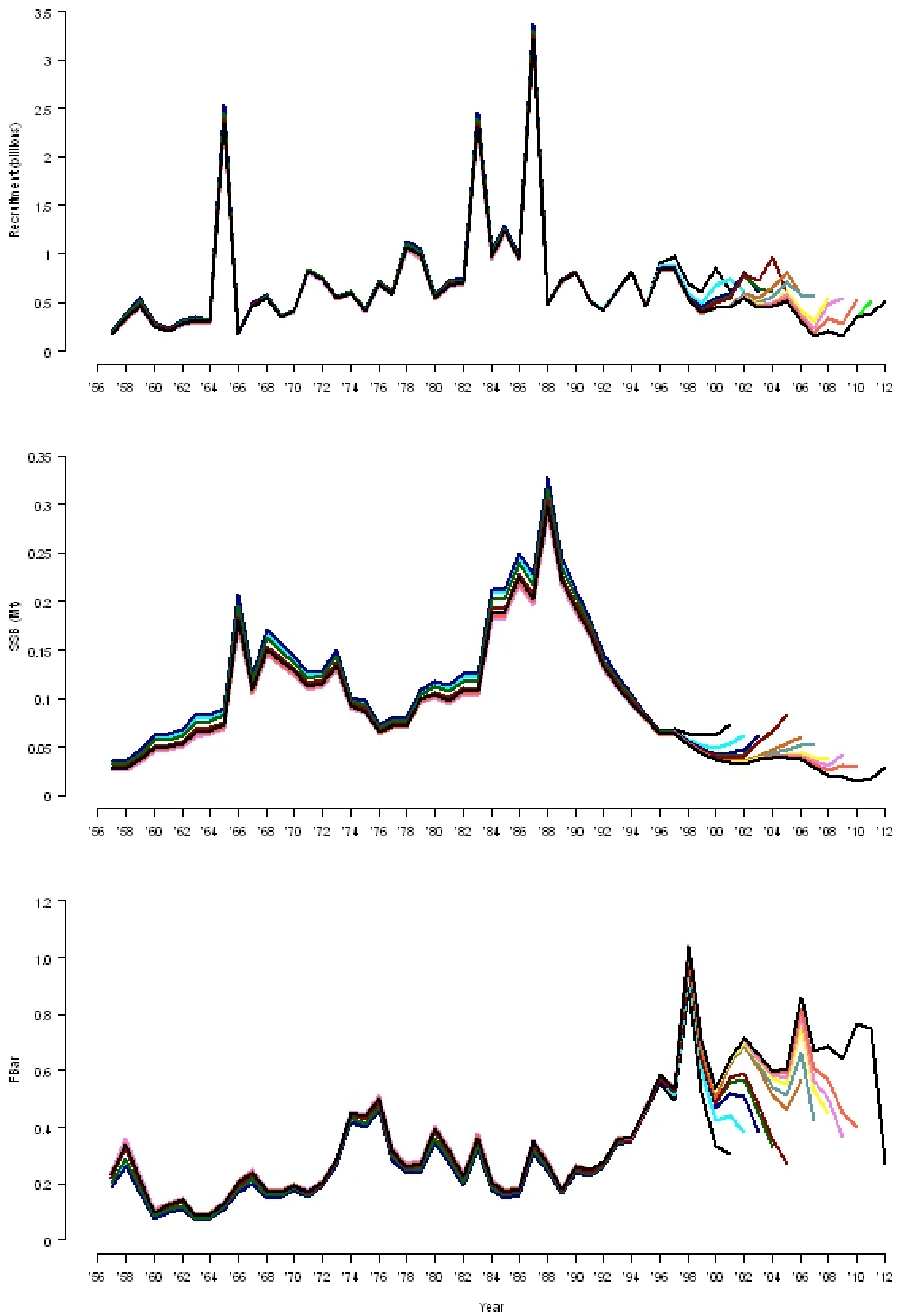


Figure 6.6.1.3. Herring in Divisions VIa(S) and VIIb,c. Historical retrospective separable VPA assessment using an initial terminal F=0.2. Recruitment (top), SSB (Middle), Mean F (Bottom).

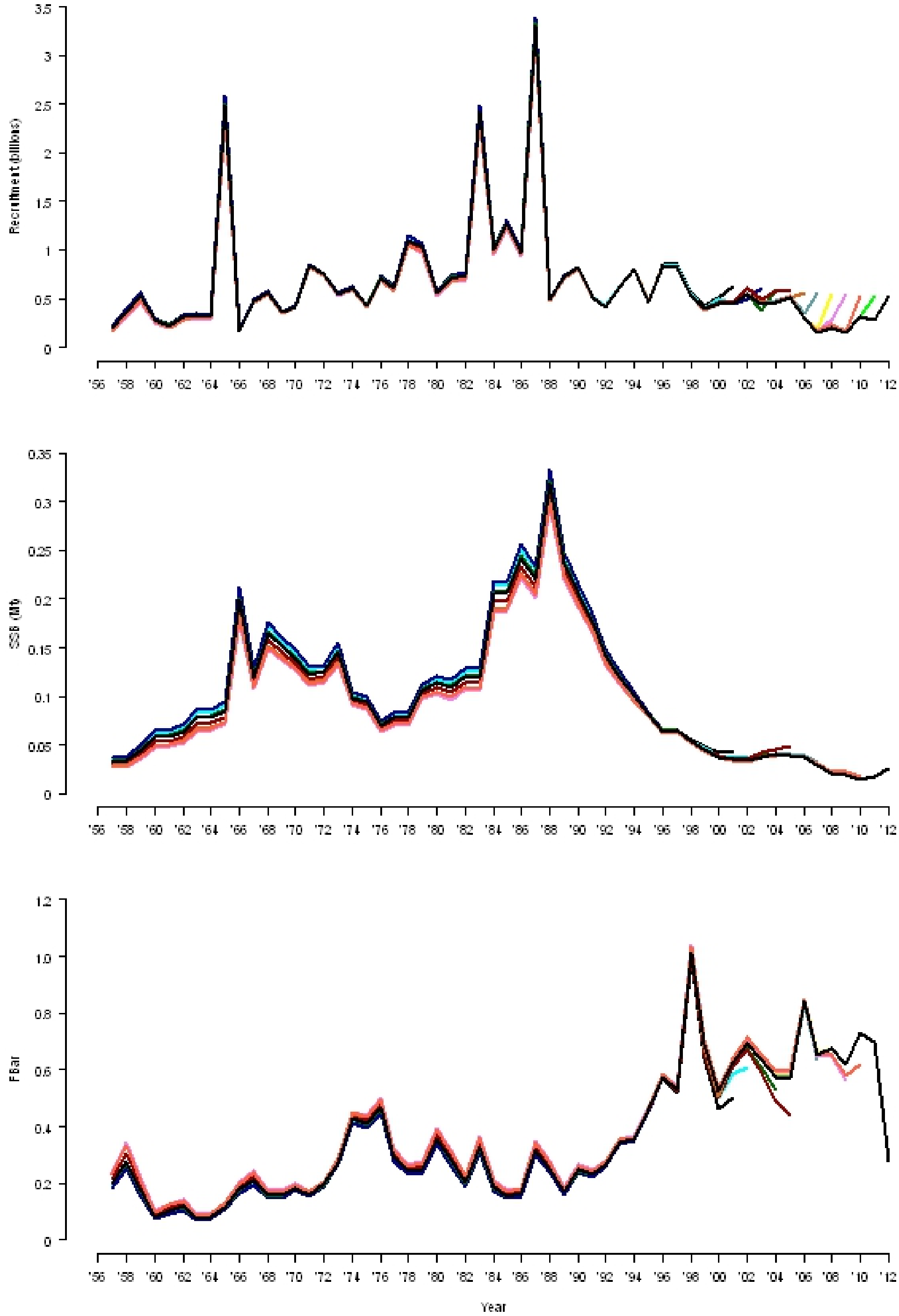


Figure 6.6.1.4. Herring in Divisions VIa(S) and VIIb,c. Historical retrospective separable VPA assessment using an initial terminal F =0.4. Recruitment (top), SSB (Middle), Mean F (Bottom).

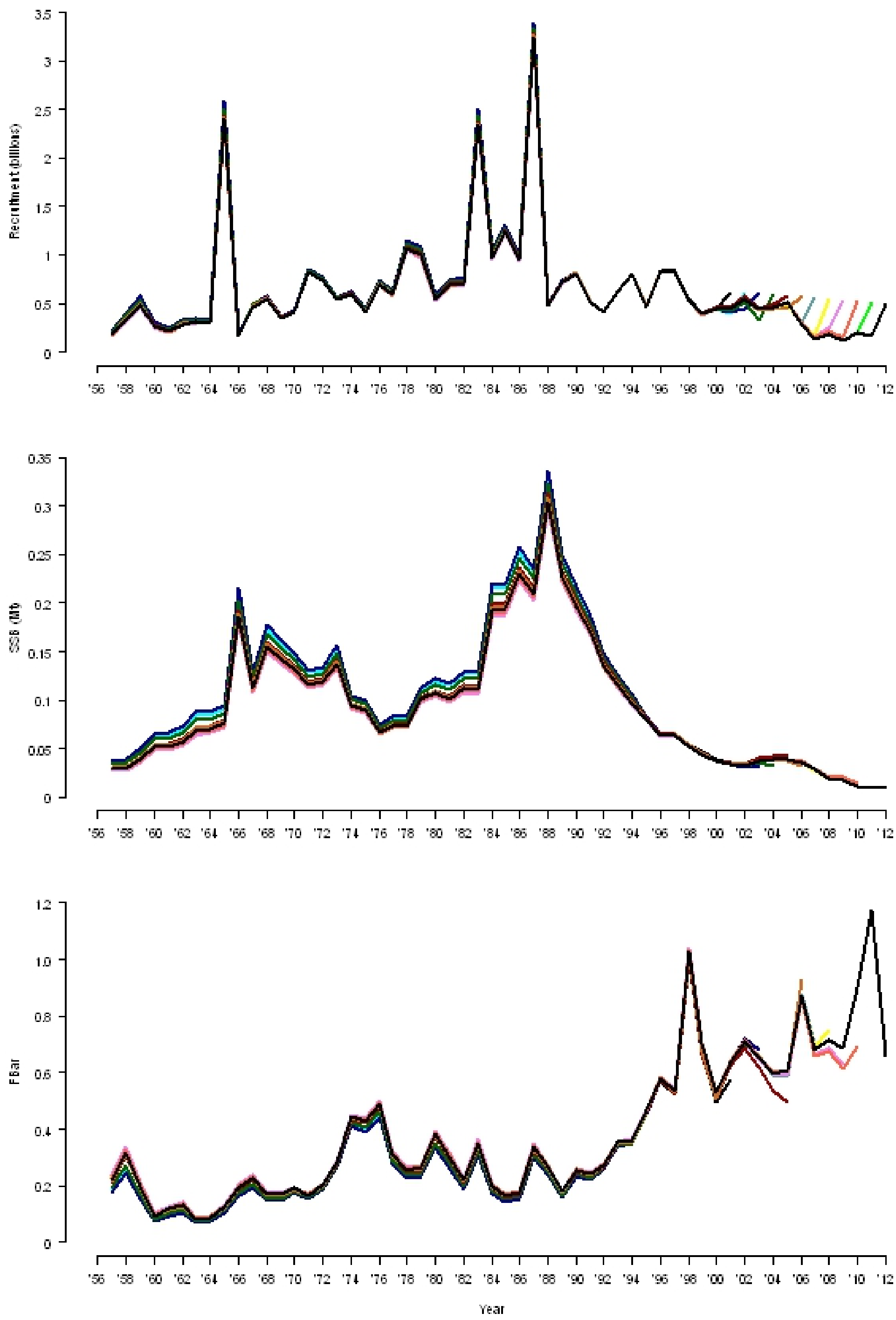


Figure 6.6.1.5. Herring in Divisions VIa(S) and VIIb,c. Historical retrospective separable VPA assessment using an initial terminal F =0.5. Recruitment (top), SSB (Middle), Mean F (Bottom).

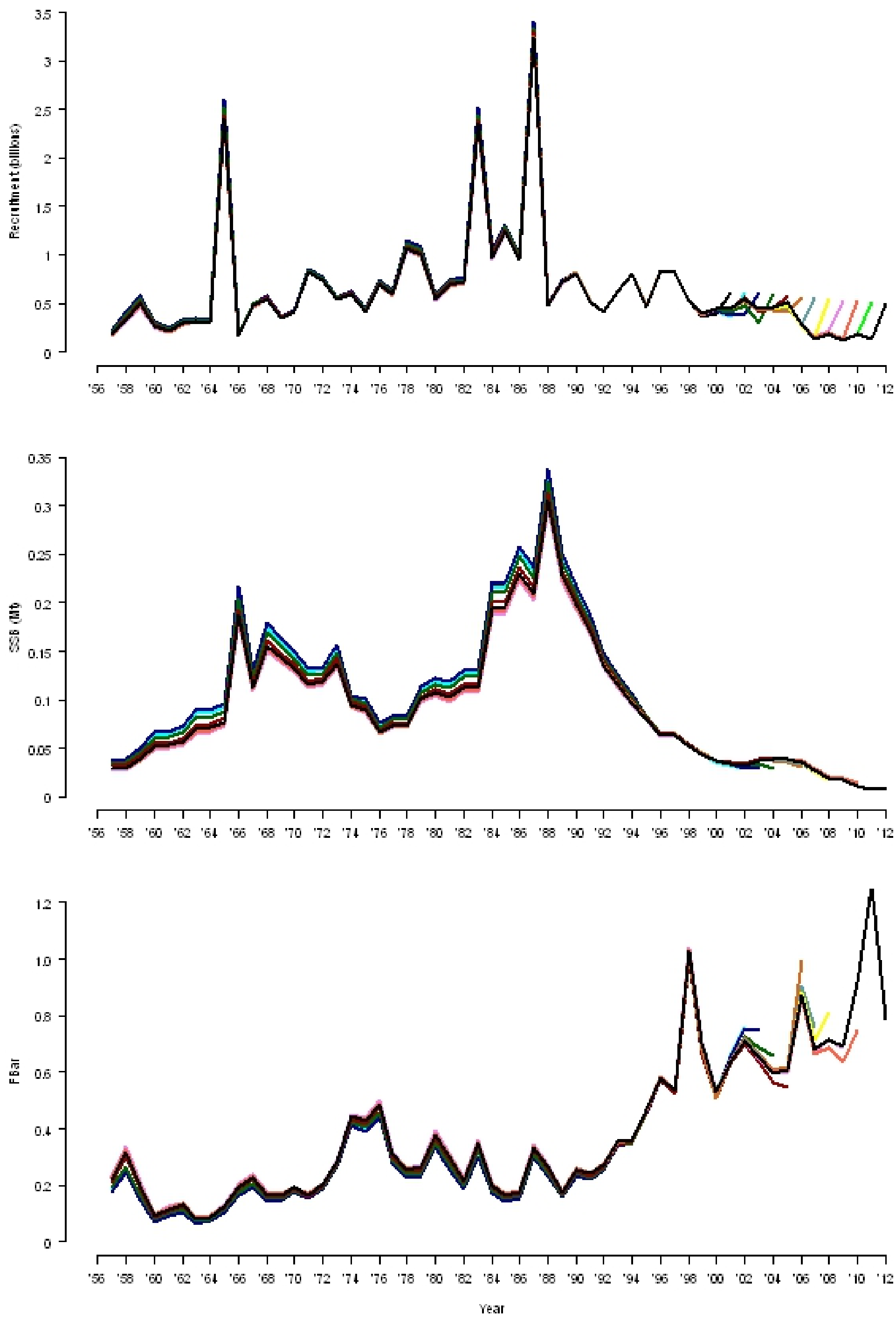


Figure 6.6.1.6. Herring in Divisions VIa(S) and VIIb,c. Historical retrospective separable VPA assessment using an initial terminal F =0.6. Recruitment (top), SSB (Middle), Mean F (Bottom).

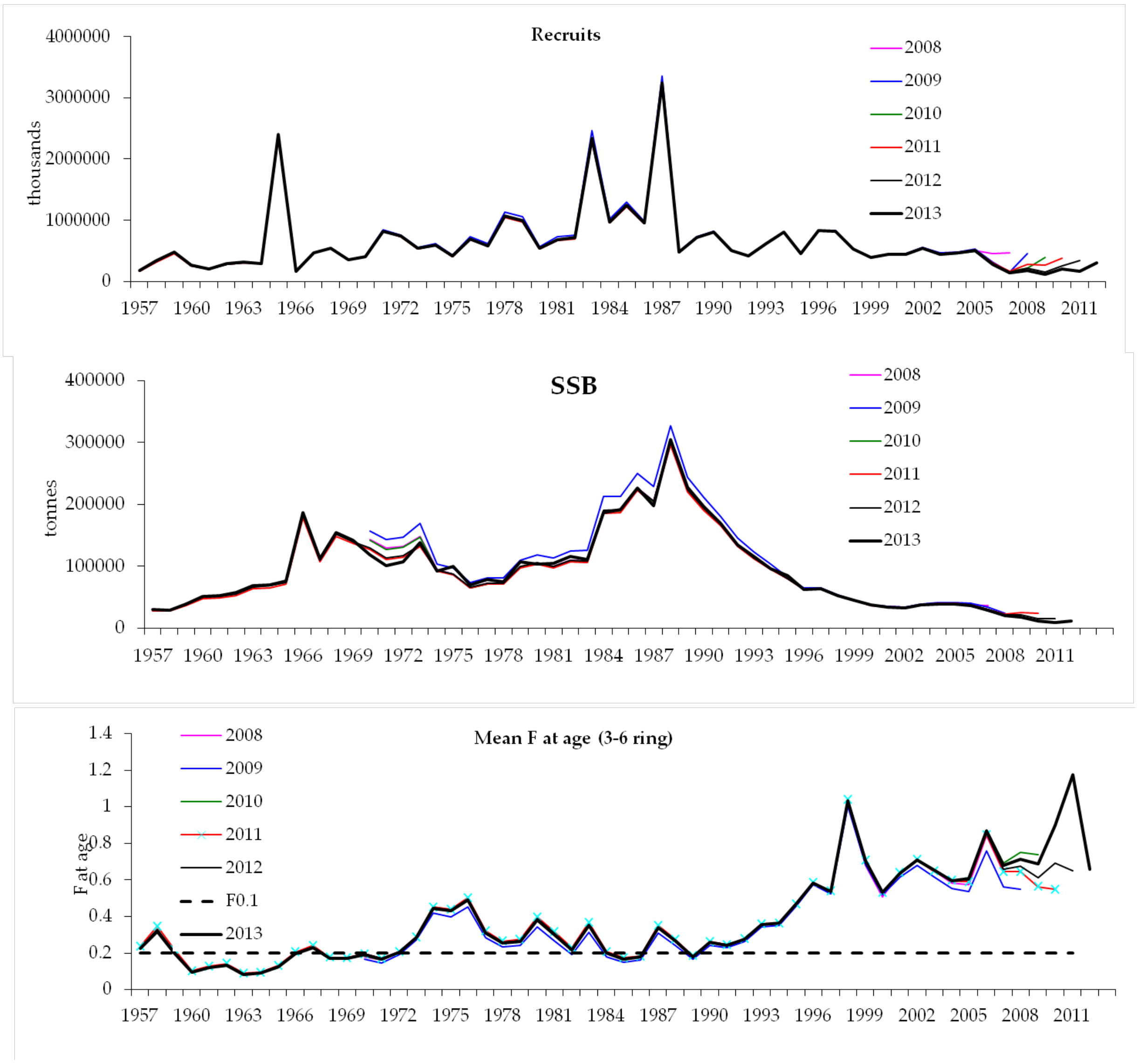


Figure 6.6.1.7. Herring in Divisions VIa(S) and VIIb,c. Historical retrospective patterns from "best-estimate" separable VPA 0.5 from working groups 2008-2013.

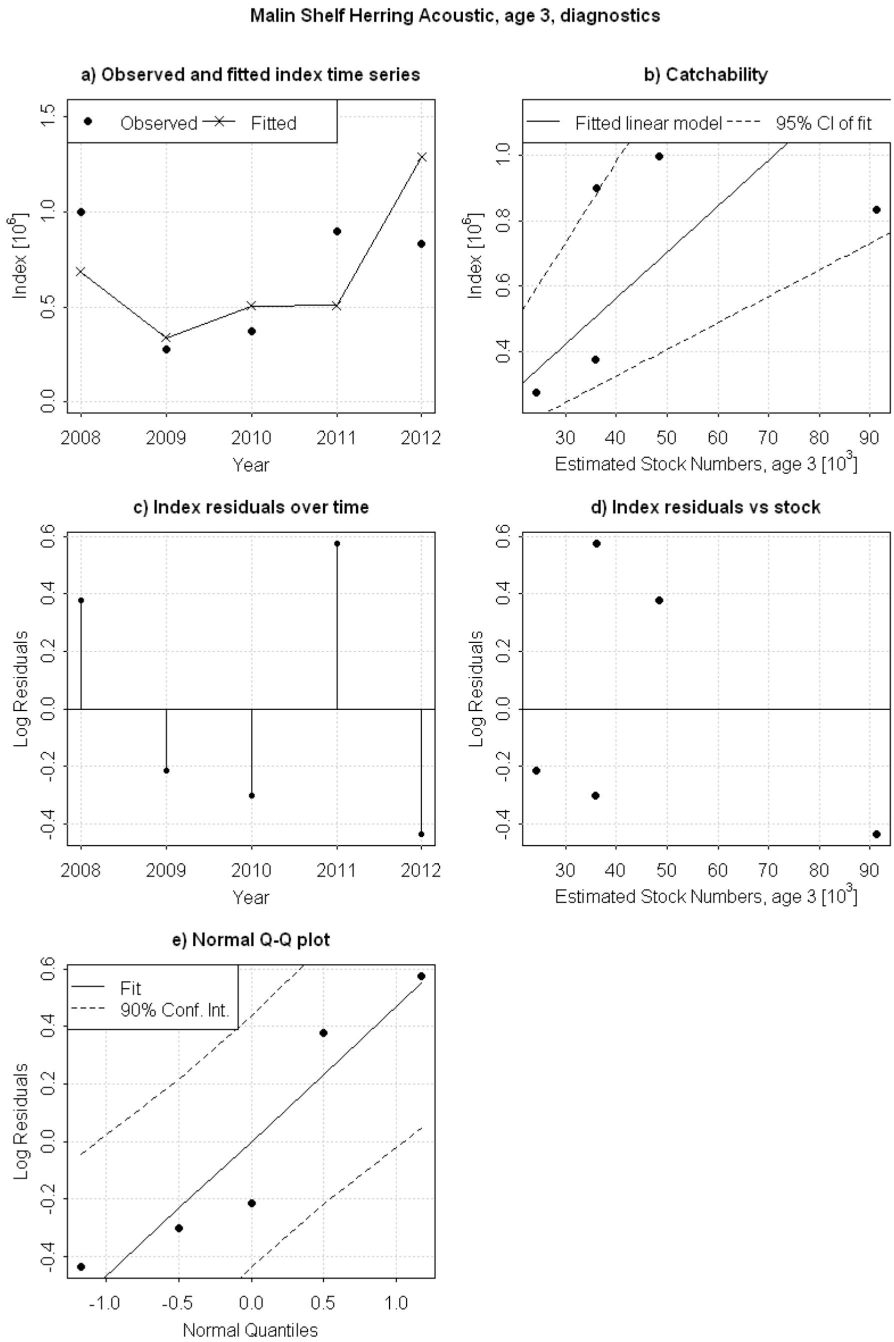


Figure 6.6.1.8. Herring in Divisions VIa(S) and VIIb,c. Diagnostics from the Malin Shelf Acoustic survey age 3 from the exploratory FLICA assessment.

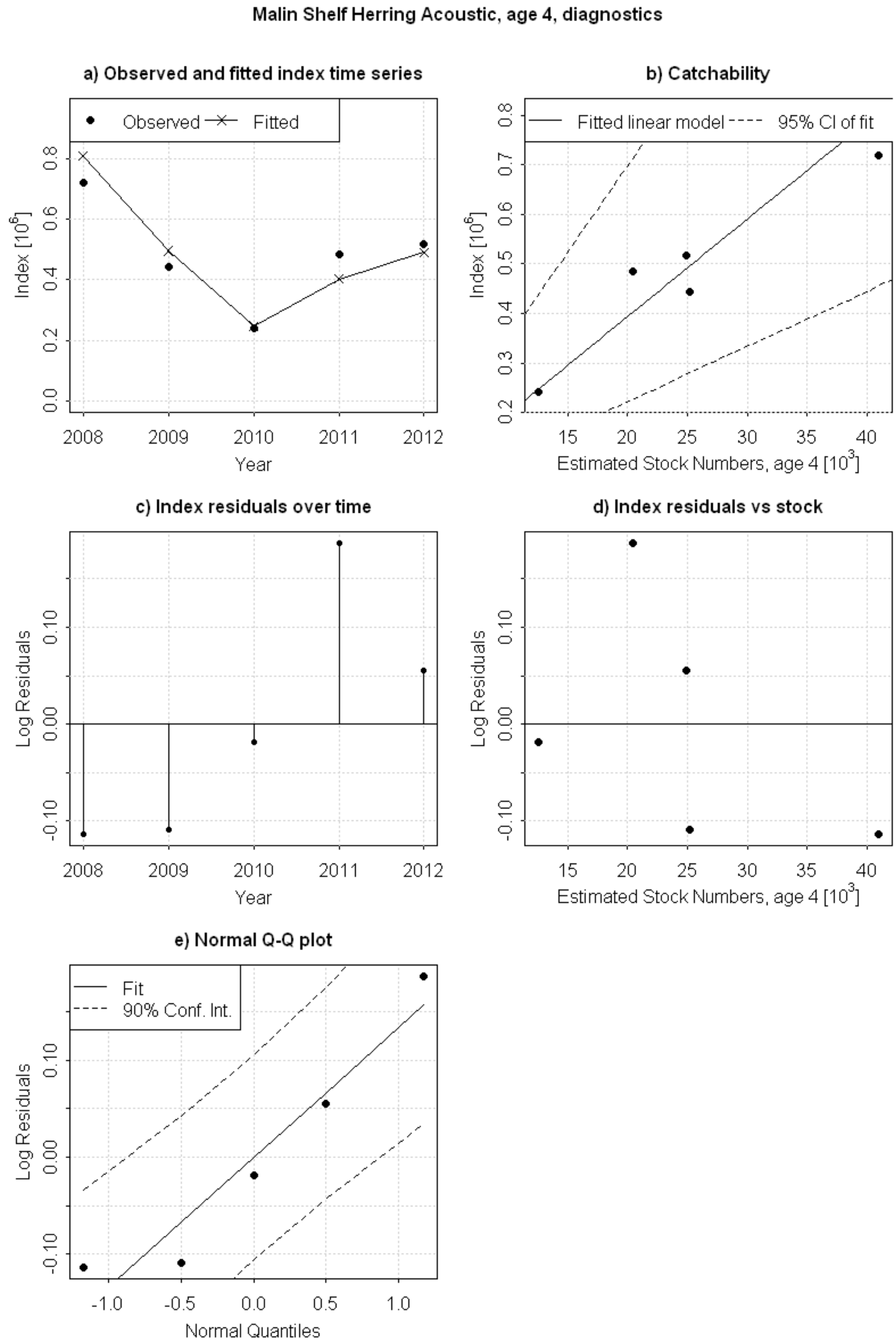


Figure 6.6.1.9. Herring in Divisions VIa(S) and VIIb,c. Diagnostics from the Malin Shelf Acoustic survey age 4 from the exploratory FLICA assessment.

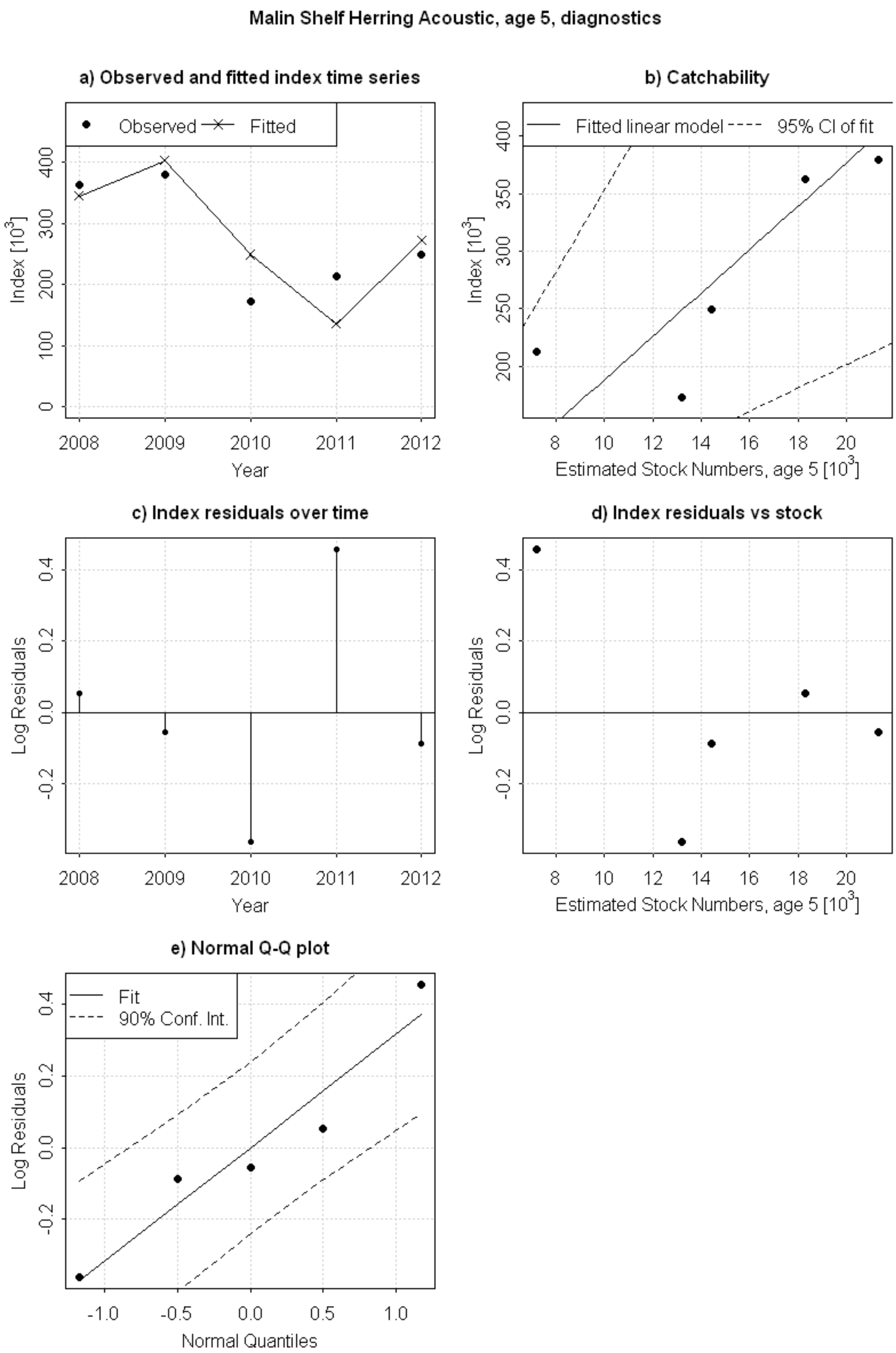


Figure 6.6.1.10. Herring in Divisions VIa(S) and VIIb,c. Diagnostics from the Malin Shelf Acoustic survey age 5 from the exploratory FLICA assessment

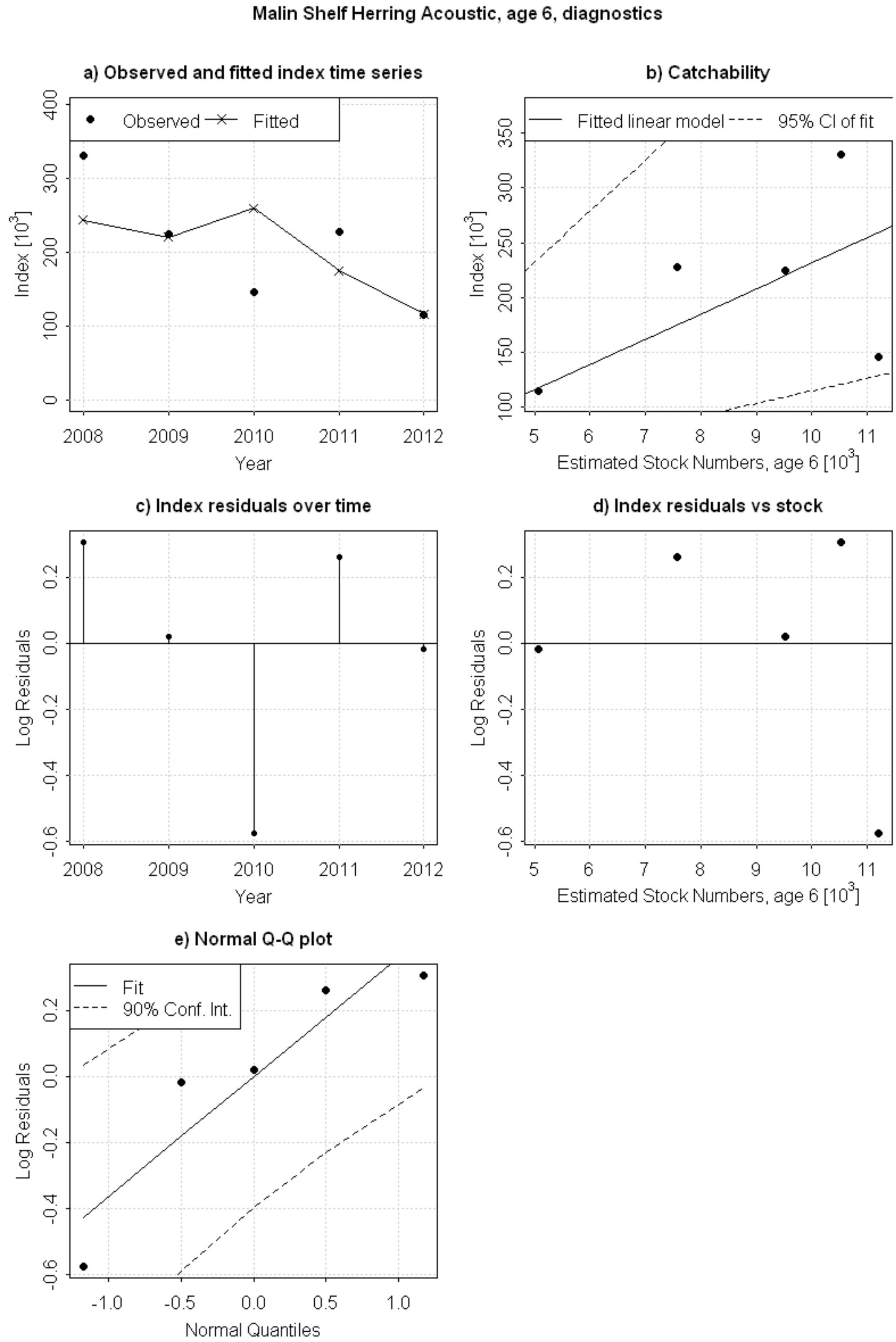


Figure 4.6.2.11 Herring in Divisions VIa(S) and VIIb,c. Diagnostics from the Malin Shelf Acoustic survey age 6 from the exploratory FLICA assessment.

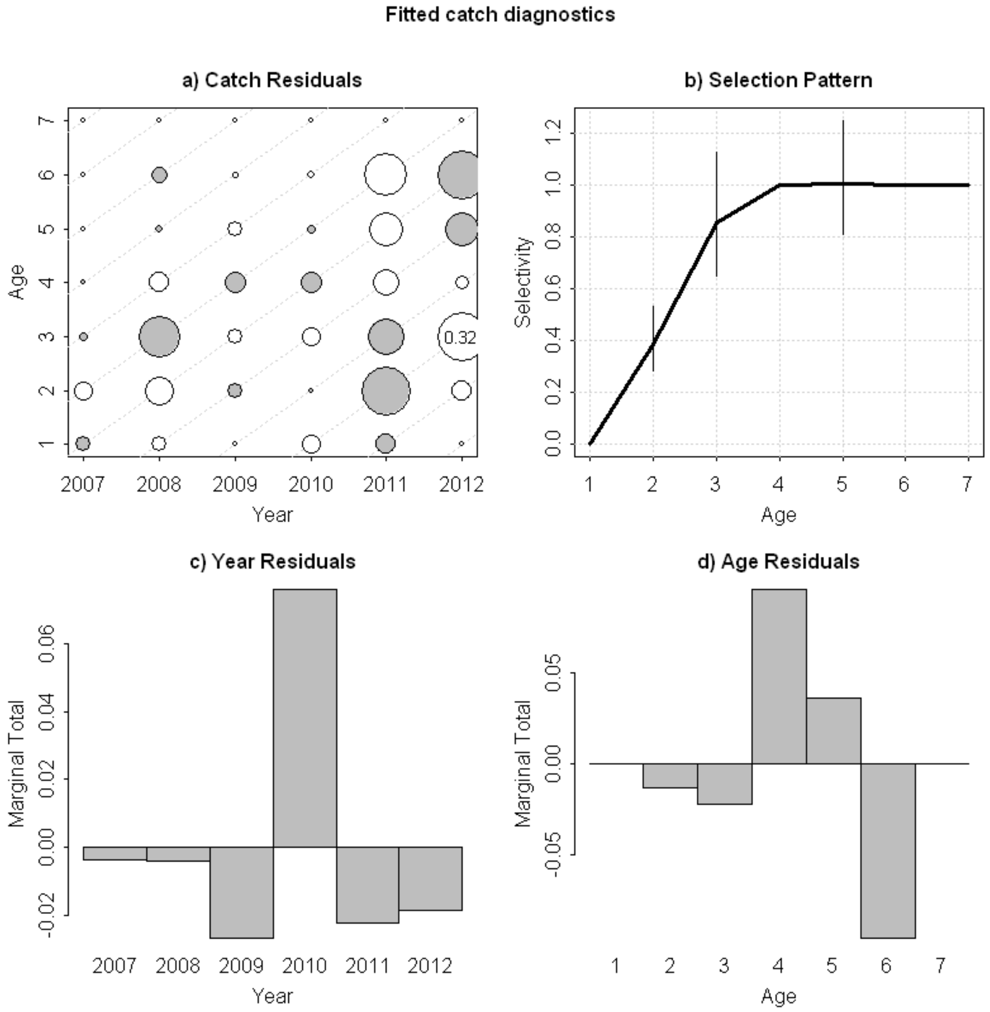


Figure 6.6.1.12. Herring in Divisions VIa(S) and VIIb,c. Catch diagnostics plot for exploratory FLICA assessment.

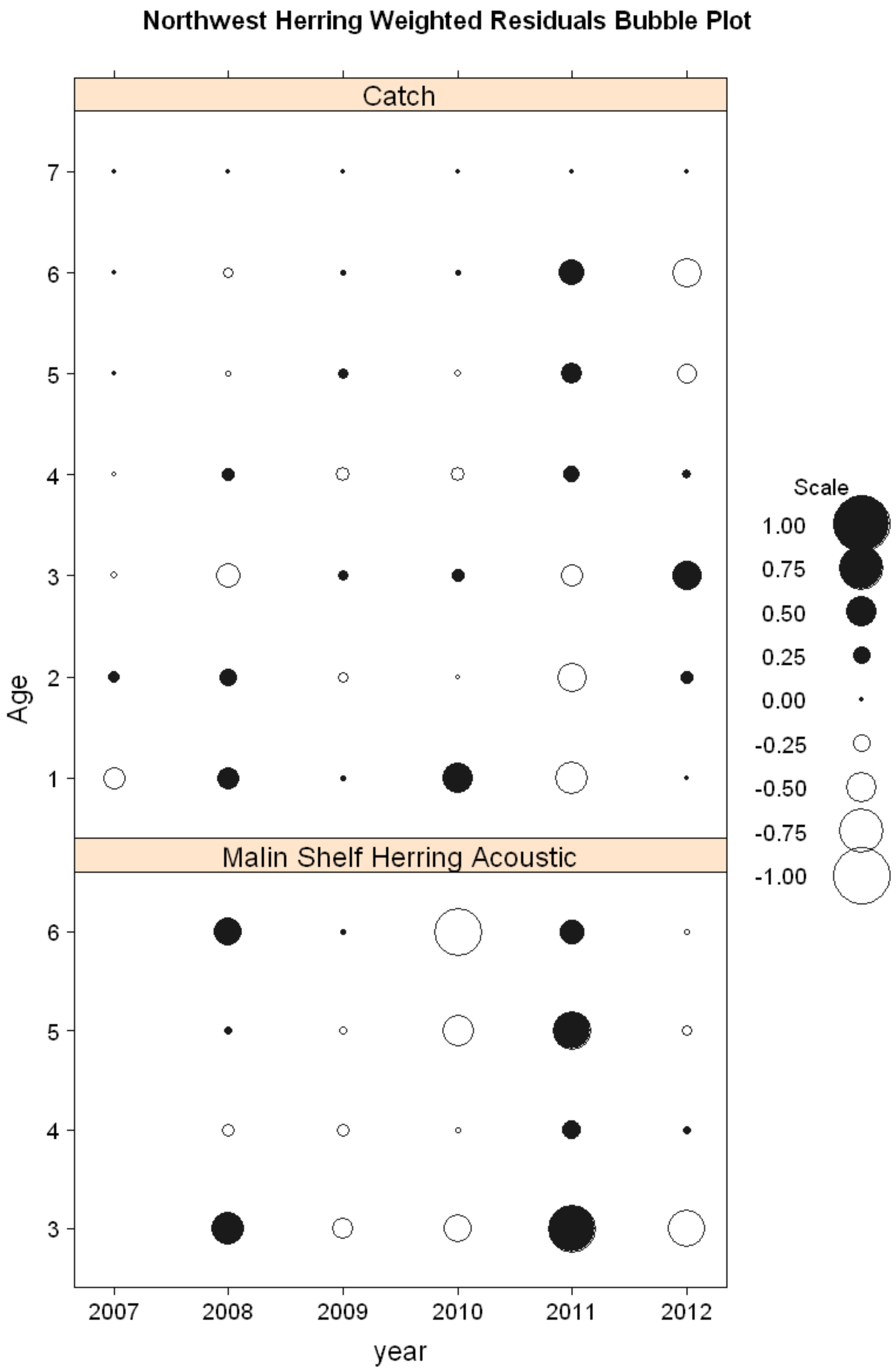


Figure 6.6.1.13 Herring in Divisions VIa(S) and VIIb,c. Catch and survey residuals for exploratory FLICA assessment.

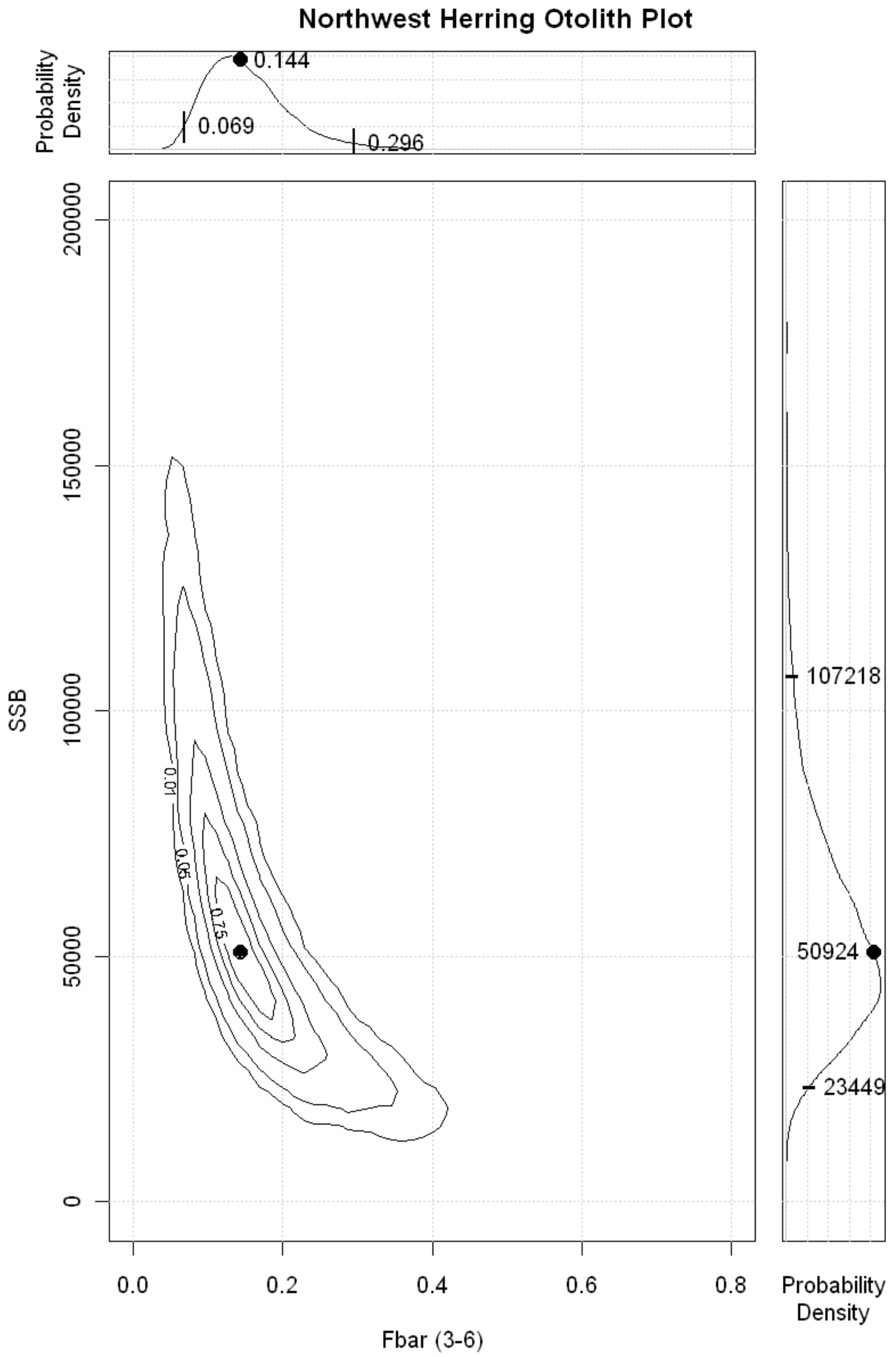


Figure 6.6.1.14 Herring in Divisions VIa(S) and VIIb,c. Uncertainty plot showing the results of parametric bootstrapping from the exploratory FLICA assessment.

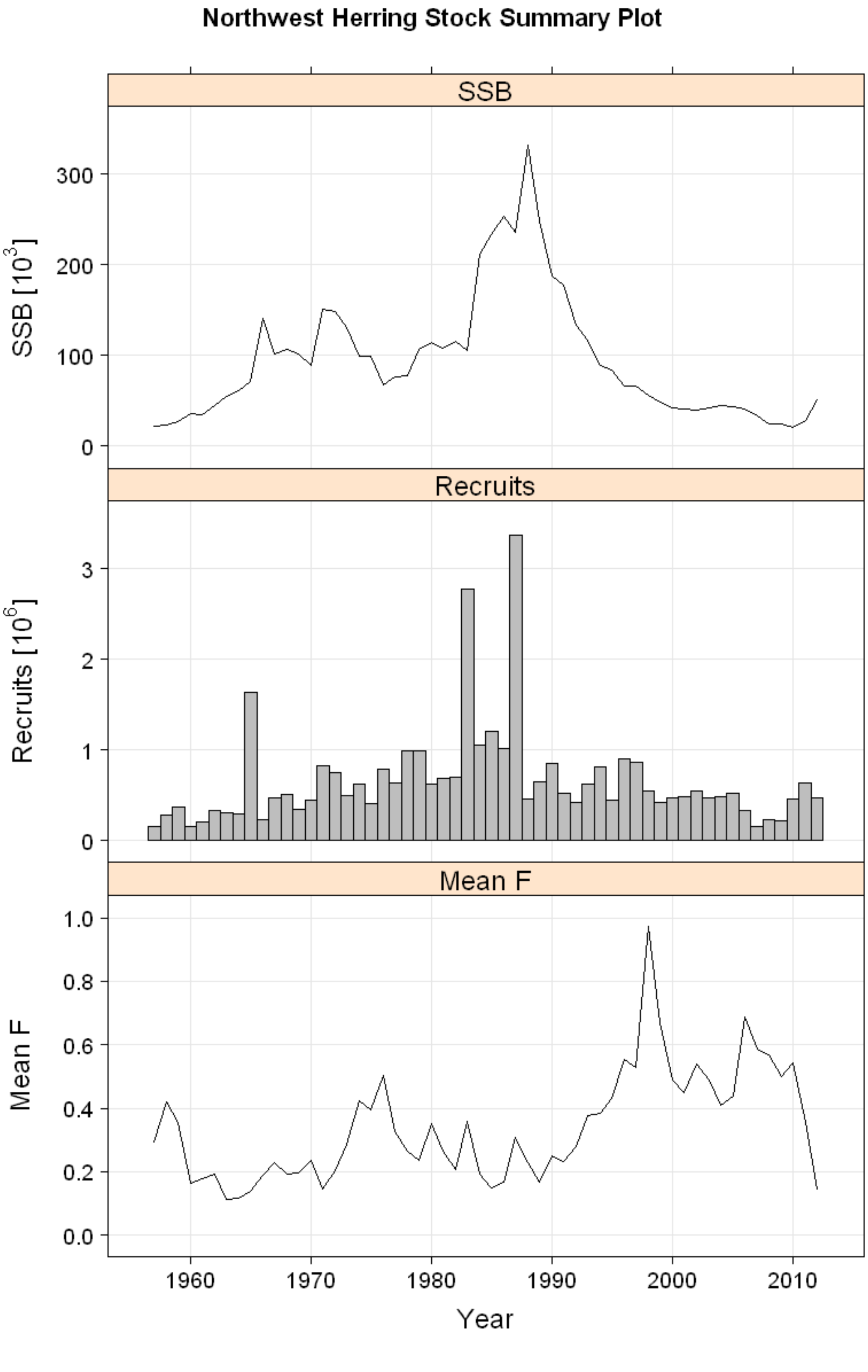


Figure 6.6.1.15. Herring in Divisions VIa(S) and VIIb,c. Stock summery plot for the exploratory FLICA assessment.

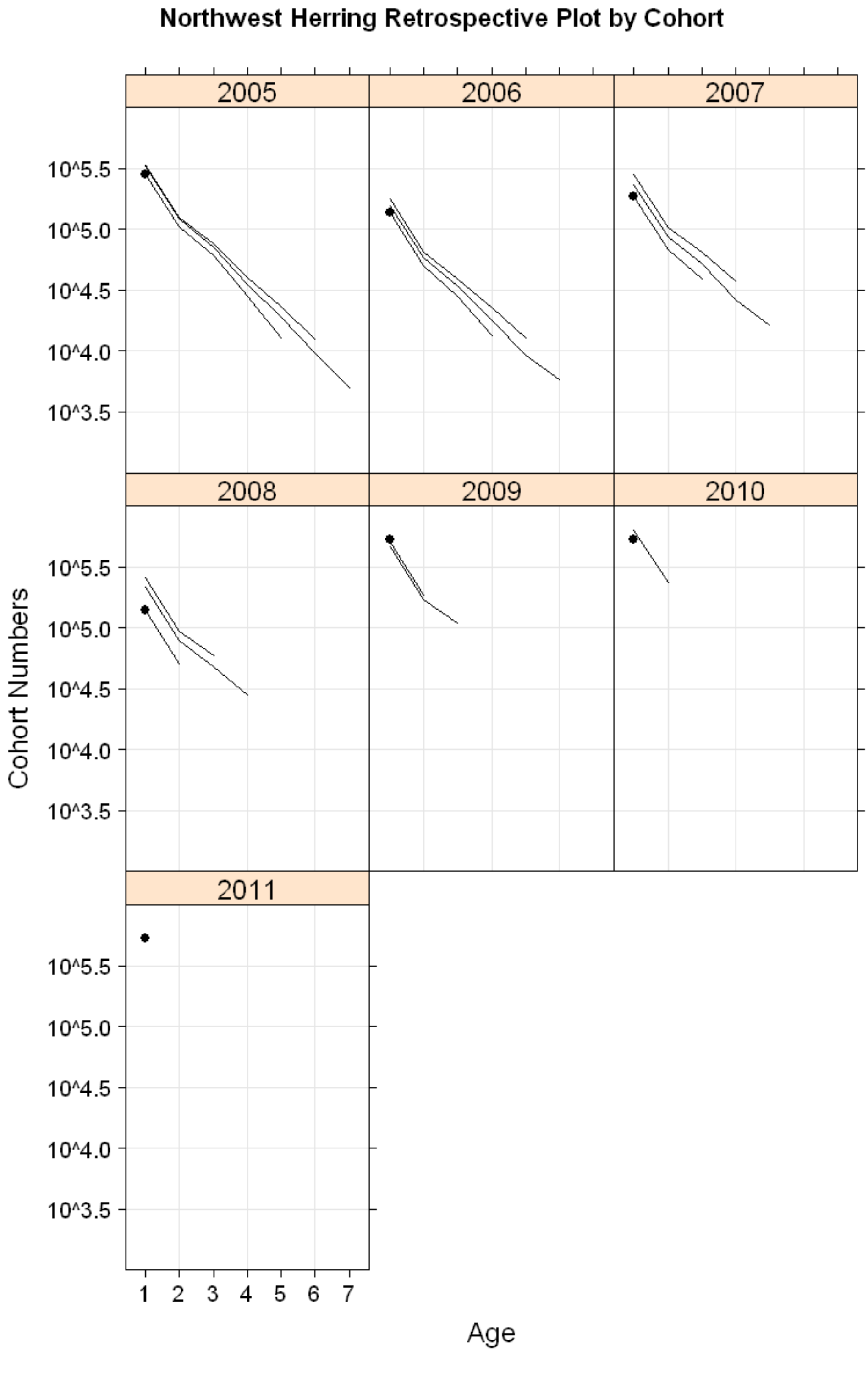


Figure 6.6.1.16. Herring in Divisions VIa(S) and VIIb,c. Retrospective by cohort for the exploratory FLICA assessment.

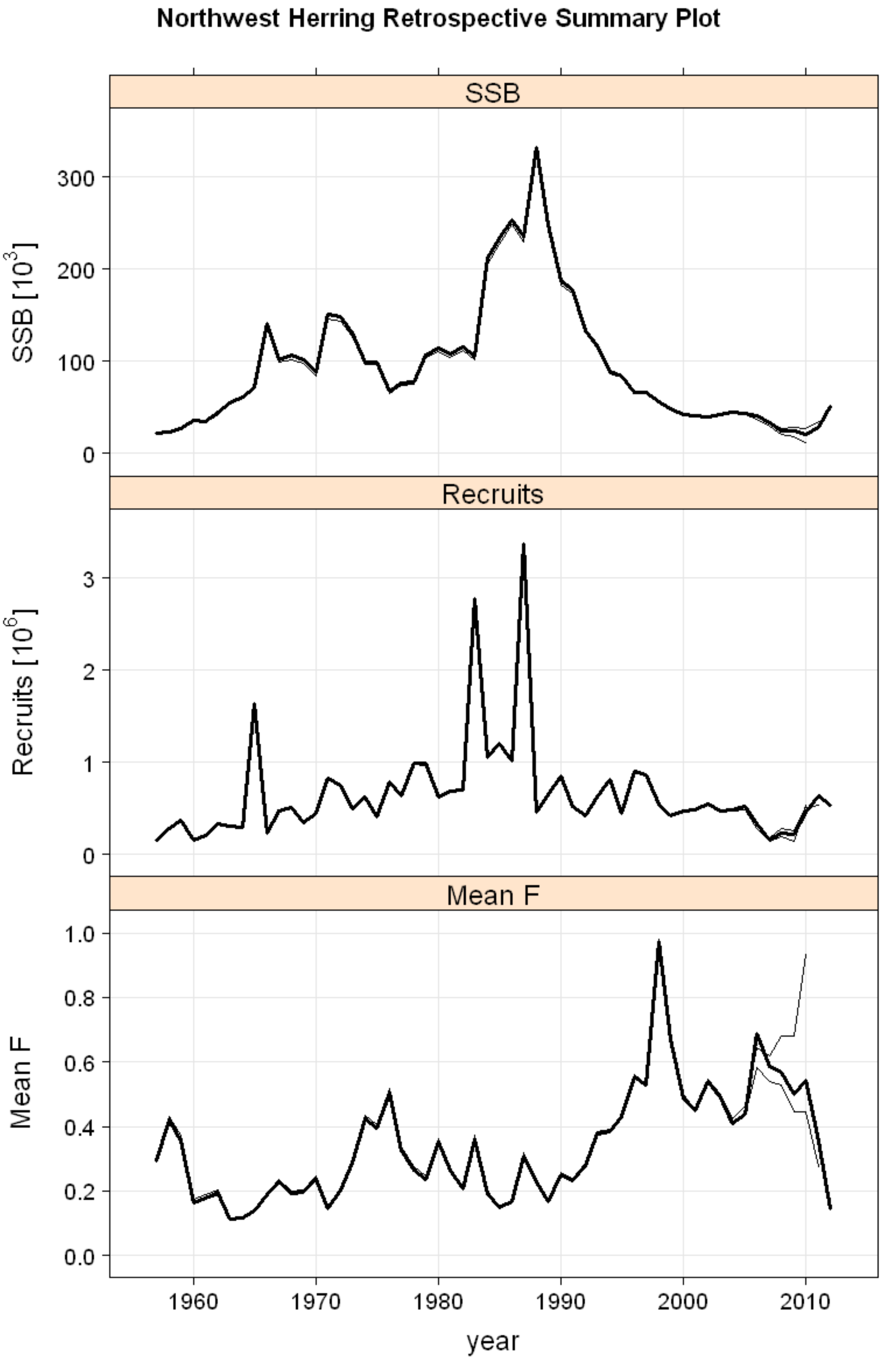


Figure 6.6.1.17 Herring in Divisions VIa(S) and VIIb,c. Analytical Retrospective of the exploratory FLICA assessment.

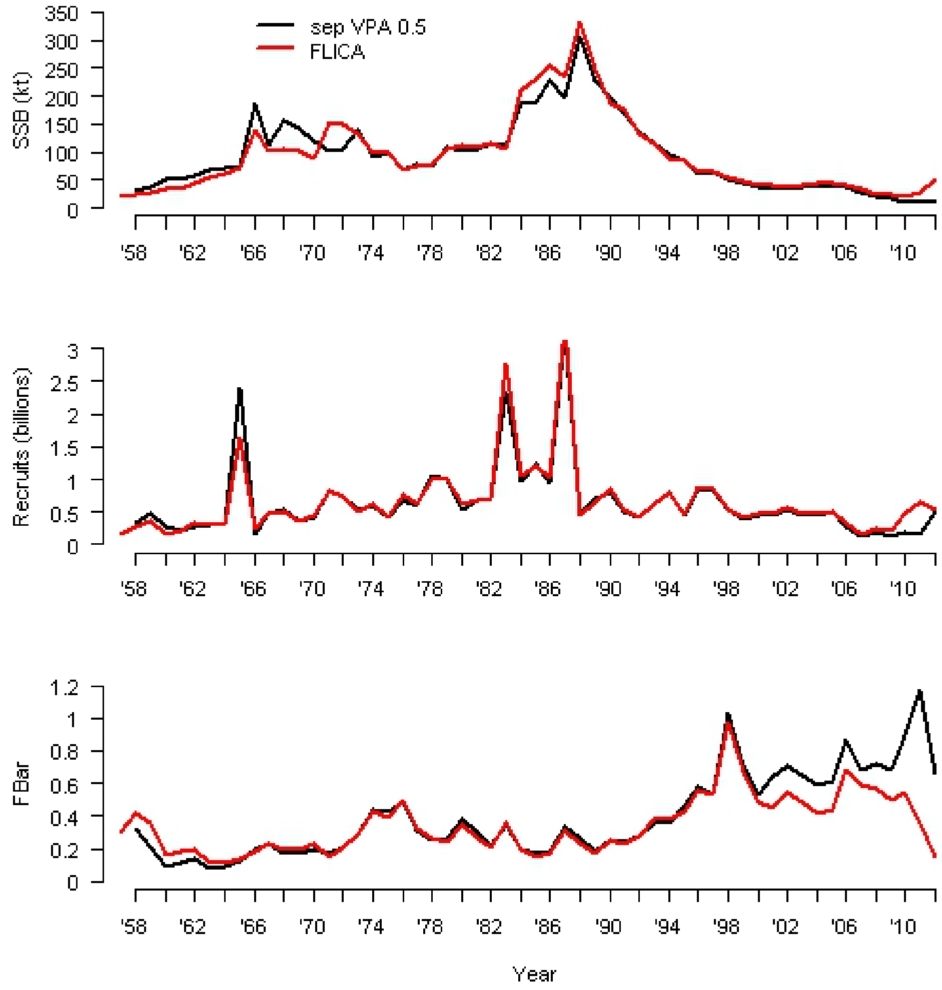


Figure 6.6.1.18 Herring in Divisions VIa(S) and VIIb,c. Comparison between separable VPA with terminal F = 0.5 (black line) and exploratory FLICA assessment (red line). SSB (top), Recruitment (Middle) Mean F 3-6 (bottom).

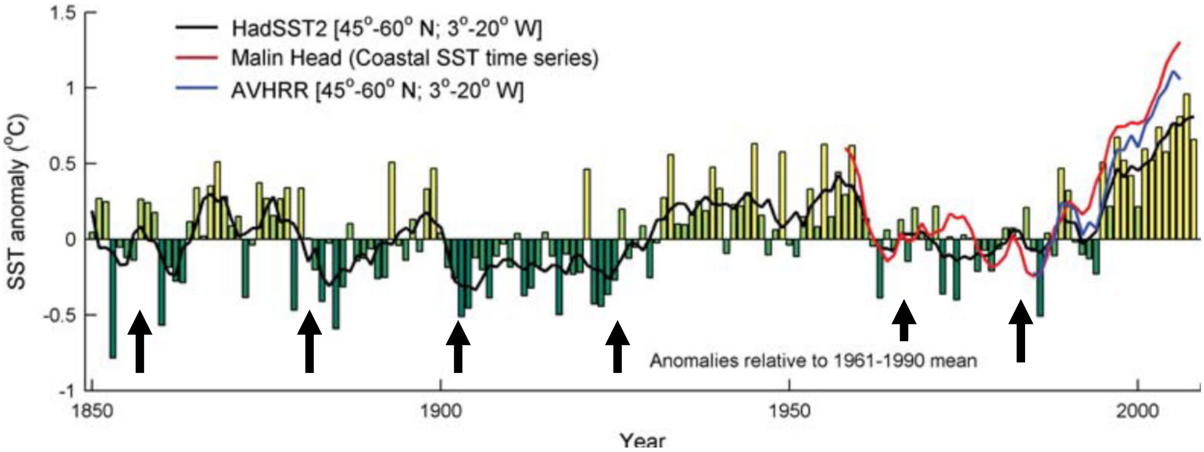


Figure 6.13.1. Herring in Divisions VIa(S) and VIIb,c. Long time series of sea surface temperature (SST) anomalies reproduced from Cannaby and Husrevoglu (2009). Historic instances of high recruitment and/or large fisheries are indicated by arrows.

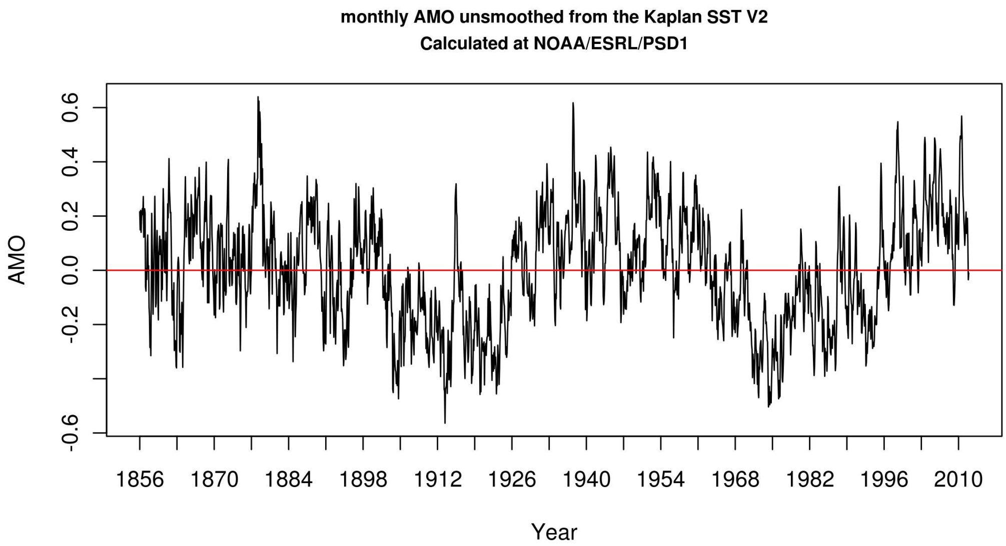


Figure 6.13.2. Herring in Divisions VIa(S) and VIIb,c. Monthly AMO from the Kaplan SST data set.

7 Herring in Division VIIa North (Irish Sea)

The stock was benchmarked in 2012 and a state-space assessment model, SAM, was proposed as the assessment model for the stock. The assessment presented here is an update assessment using the methodology and model configuration from the benchmark (ICES WKPELA 2012).

7.1 The Fishery

7.1.1 Advice and management applicable to 2011 and 2012

In 2012 a TAC of 4 752 t was adopted, but was revised in year to 5 280 t and partitioned as 3 906 t to the UK and 1 374 t to the Republic of Ireland. In 2012 ACOM advised on the basis of MSY approach that landings in 2013 should be no more than 5 100 t. With the in-year revision of the TAC for 2012, STECF updated the short term forecast with the higher TAC constraint. A TAC of 4 993 t was subsequently adopted for 2013, partitioned as 3 693 t to the UK and 1 300 t to the Republic of Ireland.

7.1.2 The fishery in 2012

The catches reported from each country for the period 1987 to 2012 are given in Table 7.1.1, and total catches from 1961 to 2012 in Figure 7.1.1. Reported international landings in 2012 for the Irish Sea amounted to 5 693 t with UK vessels acquiring extra quota through swaps with the Republic of Ireland and banking from 2011 to 2012. The majority of catches in 2012 were taken during the 3rd quarter.

The 2012 VIIa(N) herring fishery started off slowly in late August, with catches taken in the North Channel and north west of the Isle of Man. The majority of the catches were taken on the Douglas Bank prior to the closure in September, with bigger shoals being avoided to ensure quality. A significant proportion of the landings was taken by a pelagic trawler in the 3rd quarter, but similar to recent years, the majority of catches were still taken by a pair of UK pair trawlers. September and October saw activity of the Mourne fishery, limited to boats under 40ft. This was the 7th year of recorded landings for this component of the fishery. In 2012 four vessels recorded landings of ~39 t, taken during a single night in late September.

7.1.3 Regulations and their effects

Closed areas for herring fishing in the Irish Sea along the east coast of Ireland and within 12 nautical miles of the west coast of Britain were maintained throughout the year. The traditional gillnet fishery on the Mourne herring, which has a derogation to fish within the Irish closed box, operated successfully again in 2011. The area to the east of the Isle of Man, encompassing the Douglas Bank spawning ground (described in ICES 2001, ACFM:10), was closed from 21st September to 15th November. Boats from the Republic of Ireland are not permitted to fish east of the Isle of Man. This has contributed to a mismatch in the age structure of catches and the survey.

The arrangement of closed areas in Division VIIa(N) prior to 1999 is discussed in detail in ICES (1996/ACFM:10) with a change to the closed area to the east of the Isle of Man being altered in 1999 (ICES 2001/ACFM:10). The closed areas consist of: all year juvenile closures along part of the east coast of Ireland, and the west coast of Scotland, England and Wales; spawning closures along the east coast of the Isle of Man from 21st September to 15th November, and along the east coast of Ireland all year round. Any alterations to the present closures should be considered carefully.

7.1.4 Changes in fishing technology and fishing patterns

The fishery in area VIIa(N) has not changed in recent years. A pair of UK pair trawlers takes the majority of catches during the 3rd and 4th quarters, but since 2011 a single pelagic trawler take some of the TAC. A small local fishery continues to record landings on the traditional Mourne herring grounds during the 4th quarter. This fishery resumed in 2006 and has seen increasing catches of herring since, peaking at ~171 t in 2009. The fishery has been restricted by the TAC since.

7.2 Biological Composition of the Catch

7.2.1 Catch in numbers

Routine sampling of the main catch component was conducted in 2012, with sampling coverage concentrated on the pair trawlers. There was no biological sampling of the main catch component (pair trawlers) in 2009 due to a failure to acquire samples from the landings. Catches in numbers-at-age are given in Table 7.6.3.1 for the years 1972 to 2012 and a graphical representation is given in Figure 7.2.1. The catch in numbers at length is given in Table 7.2.2 for 1995 to 2012, excluding 2009.

7.2.2 Quality of catch and biological data

27 samples from the main catch component were acquired in 2012, with a further 3 samples taken from the gillnet fishery operating on the Mourne ground. At sea observer data have been collected since 2010 (~10% of fishing trips sampled annually) with no discards observed. Discarding is not thought to be a feature of this fishery. Details of sampling are given in Table 7.2.3.

7.3 Fishery Independent Information

7.3.1 Acoustic surveys AC(VIIaN)

The information on the time-series of acoustic surveys in the Irish Sea is given in Table 7.3.1. The SSB estimates from the survey are calculated using the (annually varying) maturity ogives from the commercial catch data.

The acoustic survey in 2012 was carried out over the period 29 August - 12 September. The survey was affected by adverse weather conditions and transecting was discontinuous (transecting was interrupted for 3-4 days). A survey design of stratified, systematic transects was employed, as in previous years (Figure 7.3.1.A). A significant decrease in 0-gp herring and sprat biomass was observed in 2012, but particularly for sprat. Sprat and 0-group herring were distributed around the periphery of the Irish Sea (Figure 7.3.1B&7.3.2.B). The bulk of 1+ herring targets in 2011 were observed off the east and southwest coast of the Isle of Man (Figure 7.3.2.A). The survey followed the methods described in the ICES WGIPS 2012 report. Sampling intensity was high during the 2012 survey with 33 successful trawls completed. The length frequencies generated from these trawls highlight the spatial heterogeneous nature of herring age groups in the Irish Sea (Figure 7.3.3).

The estimate of herring SSB of 56 759 t for 2012 is an increase from the 2011 estimate, but still a significant reduction from the 2010 estimate (Table 7.3.1, Figure 7.3.5). The biomass estimate of 79 051 t for 1+ ringers was a significant reduction from the 2011 estimate, which was the second highest in the time series. The timing of the survey in 2012 coincided with the spawning adult population already on the spawning grounds (virtually all the abundance of adult fish were to the east and southwest of the Isle of Man compared to recent surveys estimates). An obvious year effect was observed in 2011 for the older ages (Figure 7.3.4). The year effect, evidence of higher abundance of spawning herring, coupled with the survey being severely affected by adverse weather conditions; suggest poor reflection of the age structure and abundance of the herring population in 2011 estimate. The significant decrease in the SSB is in contrast to the increasing trend observed since 2007, considering the low landings levels and the expected associated low exploitation rate.

The age-disaggregated acoustic estimates of the herring abundance, excluding 0-ring fish, are given in Table 7.3.2. The high abundance of 4+ringers observed and relatively low numbers of younger fish are clear from the numbers at age in 2012.

Results of a microstructure analysis of 1-ringer+ fish were updated for the 2011 data (Figure 7.3.6-7). The splitting information for 2012 was not yet available to the working group. Winter hatched fish, of which the majority are thought to be of Celtic Sea origin, are present in the pre-spawning aggregations sampled in the Irish Sea during the acoustic survey. The presence of these winter hatched fish has implications for the estimates of 1-ringer+ biomass and SSB, as well as confounding traditional cohort type assessment methods. However, removal of the winter hatched fish, leaving only fish of autumn spawning origin, does not change the perception of a significant increase in biomass estimates (Figures 7.3.6-7). The benchmark working group (ICES WKPELA 2012) investigated the mixing issue and its impact on the assessment. The benchmark group concluded that the data should be treated as for a mixed stock. Both the fishery and survey operate on this mixture and by using the data without adjustment for winter hatched fish, the assessment is conducted on the mixed stock. The recruitment data (age 1) have the highest proportion of “alien” stock. The benchmark suggested that this is considered in the assessment model configuration and dealt with objectively within the model.

7.3.2 Extended acoustic surveys

A series of additional acoustic surveys has been conducted since 2007 by Northern Ireland, following the annual pelagic acoustic survey (conducted during the beginning of September). The enhanced survey programme was initiated to investigate the temporal and spatial variability in the population estimates from the routine acoustic survey and only concentrates on the spawning grounds surrounding the Isle of Man and the Scottish coastal waters (strata 2 and 5-9, Figure 7.3.1.A). Herring found in this area represents ~85% of the total Irish Sea SSB estimate since 2001 and ~81% of 1-ringer + biomass. The results of the first three years of the survey series were presented by Schön *et al*. (ICES 2012/ACOM:47, WD11).

The surveys were roughly timed every fortnight, except for the last survey. The density distributions from the surveys highlight the temporal and spatial complexity of the herring distributions. Problems with timing of the survey are further exacerbated by the significant interannual variation in the migration patterns, evident from the changes in density distributions. The results confirm the high estimate of abundance observed during the routine annual acoustic survey estimates. The extended surveys were repeated in 2010 and 2011. A detailed analysis of these surveys is being conducted as part of the development of the management plan. The survey series highlighted the need for restratification of the main survey (for example including the high abundance area off the Mull of Galloway that is associated with peaks in a smaller stratum that will have less weight on the overall estimate). Preliminary results of the 2010-11 surveys support the high abundance of herring in the Irish Sea. In 2012 this extended survey series has been reduced to one repeat survey in late September. The 2012 benchmark (ICES WKPELA 2012) also suggested that the survey series could be use to fine tune the main survey used as the tuning fleet in the assessment. This could solve the year effect observed in 2011.

7.3.3 Larvae surveys (NINEL)

Northern Ireland undertook a herring larvae survey (NINEL) over the period 6-9 November 2013. The survey followed the methods and designs of previous surveys in the time-series (see Stock Annex 8). The production estimate of (1.12×10^{13} larvae) for 2012 in the NE Irish Sea was highest in the time series (Table 7.3.3), but with high uncertainty around the estimate. As in previous years herring larvae were found to be most abundant to the southeast and northeast of the Isle of Man and less abundant in the western Irish Sea (Figure 7.3.8).

There was a continued low occurrence of larvae in the area of the traditional Mourne spawning ground, despite signs of the expansion of a spawning component in this area in recent years as evident from the fishery operating here. The low occurrence of larvae caught during the survey may therefore suggest a timing mis-match between larvae emergence and sampling.

7.3.4 Groundfish surveys (NIGFS-WIBTS-Q1; NIGFS-WIBTS-Q4)

Groundfish surveys carried out by Northern Ireland since 1991 in the Irish Sea (NIGFS-WIBTS-Q1; NIGFS-WIBTS-Q4), were used by the 1996 to 1999 HAWG to obtain indices for 0- and 1-ring herring. These indices have performed poorly in the assessment and have not been used since. The time series was updated in 2011 (Figure 7.3.9). An increasing trend is evident for the 1-ring herring index from the spring groundfish survey over the time series. The indices of the groundfish do not take account of mixing between “winter” and “autumn” spawners. The indices are very noisy and analysis at the benchmark suggested their exclusion (ICES WKPELA2012).

7.4 Mean weight, maturity and natural mortality-at-age

Biological sampling in 2012 was used to calculate mean weights-at-age in the catch (Table 7.6.3.2). The mean weights-at-age in the 3rd quarter catches (for the whole time-series 1961 to present) are used as estimates of stock weights at spawning time (Table 7.6.3.3). Mean weights-at-age have shown a general downward trend in the last 22 years (Figure 7.4.1). No biological sampling information was available for 2009 and the weights at age for 2009 were replaced by averaging the weight at age observed in 2008 and 2010. The 2012 benchmark considered the natural mortality estimates used historically in the model to be inappropriate. The final agreed model from the benchmark used the natural mortality estimates from the North Sea (Table 7.6.3.4), which is not ideal and these should be considered as preliminary estimates until specific values could be calculated for the Irish Sea. A variable maturity ogive are used based on the corresponding annual quarter 3 biological sampling from the catch (Table 7.6.3.5).

7.5 Recruitment

An estimate of total abundance of 0-ringers and 1-ringers is provided by the Northern Ireland acoustic survey, with trends also provided by the groundfish surveys. However, there is evidence that a proportion of these are of Celtic Sea origin (Brophy and Danilowicz, 2002). Further, the SAM assessment provides estimates of the recruitment of herring in which information from the catch and from all fishery independent indices is incorporated. The recruitment trends from the assessment are dealt with in section 7.6.

7.6 Assessment

7.6.1 Data exploration and preliminary modelling

2012 data were added to the Northern Irish larvae series (NINEL), the Northern Irish acoustic survey AC(VIIaN) (total biomass, SSB and age-structure indices) and the catch-at-age data derived from the landings. Extensive data analyses and benchmark assessment trials were performed during the 2012 benchmark meeting (ICES WKPELA 2012). Considerations to data input sources are discussed in the benchmark report and changes highlighted in the sections above. The tool for the assessment of Irish Sea herring is FLSAM, an implementation of the state-space assessment model (SAM, www.stockassessment.org), embedded inside the FLR (Kell et. al 2007) library.

Acoustic (AC(VIIaN)) ages 1-8+) and the NINEL larval indices are available for the assessment of Irish Sea herring. The acoustic and larval survey abundance estimates show diverging trends since SSB increase since 2007, but this increase has now also been reflected in the 2012 SSB estimate from the NINEL (Figure 7.3.5).

The SAM model fits the catch well and residuals are relatively small (Figures 7.6.1-17). The residuals in the numbers-at-age in the catch and acoustic survey generally appear to be independent of time, but there are still some patterns in later years. These patterns are somewhat expected and could be explained by annual changes in migration patterns, magnitude and extent of the mixed component and converging trends in the surveys in recent years. The year effect in the 2011 survey is also evident from these plots with consistent negative residuals at older (3+) ages. The validity of the 2011 survey data was explored by the working group last year, but with the additional year's data the influence on the this year effect on the assessment has been reduced.

The acoustic survey fits reasonably well at all ages except for age 1. The model fit is poor for the larval survey, especially in recent years (Figure 6.6.17). Model fit is poor for age 1 in the catch and survey, which is the age with the highest occurrence of fish mixing from different hatching seasons. The modelled acoustic survey catchability parameter and the selectivity of the fishery by pentad are illustrated in Figures 7.6.18-19. The variable in fishery selection reflects both the historic changes in the fishery (e.g., industrial fishery in the 1970s towards a fishery on the spawning stock in recent years) and the interannual changes in the selectivity related to the variable migration patterns and the effect of the spawning closure.

A feature of the assessment model is the estimation of an observation variance parameter for each data set (Figure 7.6.20). Overall, the catch data (ages 2+) are associated with low observation variances, where age 1 (from catch and survey) and the NINEL data are perceived to be the noisiest data series. Figure 7.6.21 shows observation variance vs. uncertainty of the data sources used in the model. Although the majority of the data sources are associated with relatively high observation variances, none of the uncertainty estimates are particularly high. The CVs do not indicate a lack of convergence of the assessment model.

7.6.2 Exploratory assessment

The addition of the 2012 data did not highlight any major issues with the input data that merit further exploration. No exploratory assessments were performed.

7.6.3 Final assessment

The final assessment was carried out by fitting the state-space model (SAM, in the FLR environment) using the settings and data inputs in accordance to the stock annex (as decided at the 2012 benchmark). The input data and model settings are shown in Tables 7.6.3.1-11, the SAM output is presented in Tables 7.6.3.13-21, the stock summary in Table 7.6.3.12 and Figure 7.6.22, model fit and parameter estimates in Table 7.6.3.22, and negative log-likelihood for the model fit in Table 7.6.3.23.

Diagnostics and selectivity parameters for this run are presented in Figure 7.6.1-19. The stock parameters are estimated well by the model, as indicated by the relatively low uncertainty associated with the stock parameter (Figure 7.6.23).

The retrospective pattern shows a very similar perception in SSB, F and recruitment for the years 2011 and 2012 (Figure 7.6.24). The retrospective bias from the model is low, except for F. The retrospective pattern (other than the 2011 assessment) shows consistent underestimation of SSB and overestimation of F.

7.6.4 State of the stock

Trends from the final assessment indicates an increase in SSB and recruitment in recent years, with an associated downward trend in F. Based on the most recent estimates the stock is being harvested sustainably and below F_{MSY}.

7.7 Short term projections

7.7.1 Deterministic short term projections

A deterministic short term forecast was conducted for Irish Sea herring using MFDP (Smith 2000). Population abundances, F at age and input data were taken from the final SAM accepted assessment, 1961-2012 (Table 7.7.1). Geometric mean recruitment of 1-ringers (1996-2010) replaced recruitment for 1-ringers in 2013. The forecast was based on a TAC constraint (2013 quota = 4 993 t) assuming full uptake of the UK quota, and full swapping to the UK, and subsequent uptake of the Irish quota. Fishing mortality, catch weights at age and stock weights were averaged over the past three years. Fishing mortality was not scaled to the last year, as the terminal estimate of F was not considered more informative.

The short term catch option table is given in Table 7.7.2. SSB is expected to be well above B_{pa} in 2013-2015 (and therefore also $B_{trigger}$, if taken as analogous, similar to other stocks), but is predicted to decrease.

7.7.2 Yield per recruit

The benchmark working group (ICES WKPELA 2012) performed a yield per recruit analysis and estimated yield per recruit reference points by means of the plotMSY software (Figure 7.7.1). Fmax and F0.1 have been poorly defined and no appropriate yield per recruit reference points could be defined for this stock.

7.8 Medium term projections

No medium term stock projections of stock size were conducted by the Working Group.

7.9 Precautionary and yield based reference points

The estimation of $\mathbf{B}_{pa}$ (9 500 t) and $\mathbf{B}_{lim}$ (6 000 t) were not revisited by the benchmark working group. There are no precautionary F reference points for this stock. MSY reference points were estimated by means of the plotMSY software (ICES WKPELA 2012). F_{msy} were calculated based on the three common stock recruit relationships; Ricker, Beverton-Holt and Hockeystick. The Beverton and Holt relationship was preferable as there is no evidence of reduced recruitment at high SSB, which is the underlying assumption for a Ricker curve. CVs and AICc suggest that Beverton and Holt is also slightly better model fit. F_{msy} appears to be well estimated and a F_{msy} of 0.26 is proposed as candidate reference point for management.

7.10 Quality of the assessment

The data used within the assessment, the assessment methods and settings were scrutinized during the 2012 benchmark (ICES WKPELA 2012). The benchmark group performed sensitivity tests to test model configurations and optimised the model fit to the data with the least amount of parameters estimated. The Working Group checked for convergence and judged that a good model fit was found. FLSAM will not run if convergence criteria are not achieved.

The stock is very well sampled and catch information is representative of the fishery (with the exception of 2009 when no samples were provided). The current assessment, being a time-series model, can estimate the missing catch numbers in 2009.

The main issues with the stock are stock mixing (at younger ages from fish of different spawning season origin) and the different trends in mortality observed in the survey and the commercial catches. The majority of this variation may arise from the inter-annual variation in herring migration patterns and their effect on the selectivity of both the fishery and acoustic survey, but is also affected by the effect the annual closure of the Douglas Bank spawning grounds has on the fishery patterns. There are some inconsistencies between observed and modelled landings. The magnitude of these differs between years, but is on average +/-12% over the assessment period and mostly falls within the confidence limits of the estimate. The reason behind these need further investigation, but might be due to conflicting mortality signals from the surveys and catches and the use of a constant M throughout the time series.

The data are treated as for a mixed stock. Both the fishery and survey operate on this mixture and by using the data without adjustment for winter hatched fish, the assessment is be conducted on the mixed stock. The noise in the data due to juvenile stock mixing resulted in increased estimates of F, catchability estimates >1 across the younger ages in the survey, or most likely a combination of these. Recruitment estimates from the SAM model appears unusually smooth. Examination of the model output suggests that the model does not fit the age 1 data and putting all the variability in the observation variance (rather than into the variability of the recruitment process). This smoothed fit might be due to a combination of using a random walk on recruitment (i.e., smoothing and the magnitude of neighbouring values influencing the model estimate) and noisy data sources on recruitment. This result warrants further investigation. In the mean time, the recruitment estimates for the stock should be considered as smooth estimates. Currently, the model doesn't have the structure to deal with the emigration of small herring from other stocks.

The Fbar range 4-6 is considered representative of the mortality on the autumn spawning stock in the Irish Sea, excluding most the ages with significant mixed components.

No major validations of the assumption underpinning the assessment model were found. The final assessment model is dominated by information from the catch, with the noise being added to the survey information as age and year effects. SAM down weights the age 1 and survey information in general. The model fit to the catch information needs further investigation, especially if the additional survey information adds more weight or accuracy to the abundance trends from the survey. The uncertainty estimates of the model parameters, however, suggest the model is both appropriate for the available data and that the model describes these data reasonably well. Very little retrospective bias was also present.

The weight given to catch data will make the model particularly sensitive to the structure within the catch data. The year effects in the acoustic survey, as observed in the 2011 acoustic survey (thought to be a poor estimate of spawning stock abundance and structure) is of major concern and should be given further consideration in future.

7.11 Management considerations

Given the historical landings from this stock and the knowledge that fishing pressure is light and mostly confined to one pair of UK vessels it can be assumed that fishing pressure and activity has not varied considerably in recent years. The catches have been close to TAC levels and the main fishing activity has not varied considerably as shown from landing data (Figure 7.1.1).

The assessment for this stock has not been accepted by the WG for more than 20 years; ACFM did, however, produced a short-term forecast for advice in 1999. The current assessment and forecast indicate an increasing trend in SSB and fishing mortalities at or slightly below F_{msy}. The Working Group supports the development of a long-term management plan for this stock. A significant amount of the issues highlighted by the benchmark process and the Working Group could be addressed as part of this process to improve the robustness of the assessment and advice. Such a plan should be developed with stakeholders and forwarded to ICES for evaluation.

7.12 Ecosystem Considerations

No additional information presented (see Stock Annex 8).

Table 7.1.1 Herring in Division VIIa North (Irish Sea). Working Group catch estimates in tonnes by country, 1987-2012. The total catch does not in all cases correspond to the official statistics and cannot be used for management purposes.

Country	1987	1988	1989	1990	1991	1992	1993	1994	1995
Ireland	1 200	2 579	1 430	1 699	80	406	0	0	0
UK	3 290	7 593	3 532	4 613	4 318	4 864	4 408	4 828	5 076
Unallocated	1 333	-	-	-	-	-	-	-	-
Total	5 823	10 172	4 962	6 312	4 398	5 270	4 408	4 828	5 076

Country	1996	1997	1998	1999	2000	2001	2002	2003	2004
Ireland	100	0	0	0	0	862	286	0	749
UK	5 180	6 651	4 905	4 127	2 002	4 599	2 107	2 399	1 782
Unallocated	22	-	-	-	-	-		-	-
Total	5 302	6 651	4 905	4 127	2 002	5 461	2 393	2 399	2 531

Country	2005	2006	2007	2008	2009	2010	2011	2012
Ireland	1 153	581	0	0	0	0	0	18
UK	3 234	3821	4 629	4895	4594	4894	5202	5675
Unallocated	-	-				-		
Total	4 387	4 402	4 629	4895	4594	4894	5202	5693

Table 7.2.2 Herring in Division VIIa North (Irish Sea). Catch at length data 1995-2012. Numbers of fish in thousands. Table amended with 1990-1994 year-classes removed (see Annex 8).

Length (cm)	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009*	2010	2011	2012
14															-			
14.5															-			
15															-			
15.5					10								16		-	93		
16	21	21	17		19	12	9					2			-	107	30	
16.5	55	51	94		53	49	27			13	1	44	33	1	-	487	165	
17	139	127	281	26	97	67	53			25	39	140	69	3	-	764	356	89
17.5	148	200	525	30	82	97	105			84	117	211	286	11	-	1155	851	143
18	300	173	1022	123	145	115	229			102	291	586	852	34	-	1574	1406	301
18.5	280	415	1066	206	135	134	240	36		114	521	726	2088	64	-	1405	841	533
19	310	554	1720	317	234	164	385	18		203	758	895	2979	85	-	866	1029	479
19.5	305	652	1263	277	82	97	439	0	29	269	933	1246	3527	108	-	673	1026	493
20	326	749	1366	427	218	109	523	0	73	368	943	984	3516	100	-	787	1062	298
20.5	404	867	1029	297	242	85	608	18	215	444	923	1443	2852	133	-	888	1502	511
21	468	886	1510	522	449	115	1086	307	272	862	1256	1521	3451	192	-	1470	1874	643
21.5	782	1258	1192	549	362	138	1201	433	290	1007	1380	1621	2929	217	-	1758	1396	1104
22	1509	1530	2607	1354	1261	289	1748	1750	463	1495	1361	2748	3821	271	-	2363	2372	1586
22.5	2541	2190	2482	1099	2305	418	1763	1949	600	2140	1448	3629	3503	229	-	3362	2778	2404
23	4198	2362	3508	2493	4784	607	2670	2490	1158	2089	1035	4358	4196	322	-	4530	4100	3920
23.5	4547	2917	3902	2041	4183	951	2254	1552	1380	2214	1256	2920	3697	264	-	5232	3394	6024
24	4416	3649	4714	3695	4165	1436	3489	1029	1273	2054	1276	3679	3178	259	-	4559	4759	8849
24.5	3391	4077	4138	2769	3397	1783	4098	758	1249	2269	1083	2431	2136	204	-	3616	3729	7777
25	3100	4015	5031	2625	2620	2144	5566	776	1163	1749	1086	3438	1503	148	-	3083	3430	7020
25.5	2358	3668	3971	2797	1817	1791	4785	1335	1211	1206	584	2198	952	114	-	2582	2662	5759
26	2334	2480	3871	3115	1694	1349	3814	1570	1140	823	438	1714	643	78	-	1777	2343	4835
26.5	1807	2177	2455	2641	1547	840	2243	1552	1573	587	203	605	330	42	-	950	1595	2664
27	1622	1949	1711	2992	1475	616	1489	776	1607	510	165	445	147	23	-	460	1083	1716
27.5	990	1267	1131	1747	867	479	644	433	1189	383	60	155	72	10	-	216	472	629
28	834	906	638	1235	276	212	496	162	726	198	45	104	33	12	-	9	248	231
28.5	123	564	440	170	169	58	179	108	569	51	18	9	26	1	-		53	159
29	248	210	280	111	61	42	10	36	163		12	46			-	9		108
29.5	56	79	59	92		12	0	36	129				7		-			54
30	40	32	8	84		6	9		43						-			17
30.5	5	0	5	3					43						-			17
31	1	2							43						-			
31.5															-			
32															-			
32.5															-			
33															-			
33.5															-			

Table 7.2.3 Herring in Division VIIa North (Irish Sea). Sampling intensity of commercial landings in 2011.

Quarter	Country	Landings (t)	No. samples	No. fish measured	No. fish aged
1	Ireland	0	-	-	-
	UK (N. Ireland)	0	0	0	0
	UK (Isle of Man)	*	-	-	-
	UK (Scotland)	0	-	-	-
	UK (England & Wales)	0	-	-	-
2	Ireland	0	-	-	-
	UK (N. Ireland)	0	0	0	0
	UK (Isle of Man)	*	-	-	-
	UK (Scotland)	0	-	-	-
	UK (England & Wales)	0	-	-	-
3	Ireland	0	-	-	-
	UK (N. Ireland)	4760	24	2843	1158
	UK (Isle of Man)	*	-	-	-
	UK (Scotland)	0	-	-	-
	UK (England & Wales)	0	-	-	-
4	Ireland	18	1	274	99
	UK (N. Ireland)	916	4	960	134
	UK (Isle of Man)	*	-	-	-
	UK (Scotland)	0	-	-	-
	UK (England & Wales)	0	-	-	-

*** no information, but catch is likely to be negligible**

Table 7.3.1 Herring in Division VIIa North (Irish Sea). Summary of acoustic survey AC(VIIaN) information for the period 1989 - 2012. Small clupeoids include sprat and 0-ring herring unless otherwise stated. CVs are approximate. Biomass in t. All surveys carried out at 38kHz except December 1996, which was at 120kHz.

Year	Area	Dates	herring biomass (1+years)	CV	herring biomass (SSB)	CV	small clupeoids (biomass)	CV
1989	Douglas Bank	25/09-26/09			18,000	-	-	-
1990	Douglas Bank	26/09-27/09			26,600	-	-	-
1991	W. Irish Sea	26/07- 8/08	12,760	0.23			66,000[1]	0.20
1992	W. Irish Sea + IOM E. coast	20/07-31/07	17,490	0.19			43,200	0.25
1994	Area VIIa(N)	28/08 – 8/09	31,400	0.36	25,133	-	68,600	0.10
	Douglas Bank	22/09-26/09			28,200	-	-	-
1995	Area VIIa(N)	11/09-22/09	38,400	0.29	20,167	-	348,600	0.13
	Douglas Bank	10/10-11/10		-	9,840	-	-	-
	Douglas Bank	23/10-24/10			1,750	0.51	-	-
1996	Area VIIa(N)	2/09-12/09	24,500	0.25	21,426	0.25	-[2]	-
1997	Area VIIa(N)-reduced	8/09-12/09	20,100	0.28	10,702	0.35	46,600	0.20
1998	Area VIIa(N)	8/09-14/09	14,500	0.20	9,157	0.18	228,000	0.11
1999	Area VIIa(N)	6/09-17/09	31,600	0.59	21,040	0.75	272,200	0.10
2000	Area VIIa(N)	11/09-21/09	40,200	0.26	33,144	0.32	234,700	0.11
2001	Area VIIa(N)	10/09-18/09	35,400	0.40	13,647	0.42	299,700	0.08
2002	Area VIIa(N)	9/09-20/09	41,400	0.56	25,102	0.83	413,900	0.09
2003	Area VIIa(N)	7/09-20/09	49,500	0.22	24,390	0.24	265,900	0.10
2004	Area VIIa(N)	6/09-10/09, 15/09-16/09, 28/09-29/09	34,437	0.41	21,593	0.41	281,000	0.07
2005	Area VIIa(N)	29/08 -14/09	36,866	0.37	31,445	0.42	141,900	0.10
2006	Area VIIa(N)	30/08 – 9/09	33,136	0.24	16,332	0.22	143,200	0.09
2007	Area VIIa(N)	29/08 - 13/09	120,878	0.53	51,819	0.42	204,700	0.09
2008	Area VIIa(N)	27/08 – 14/09	106,921	0.22	77,172	0.23	252,300	0.12
2009	Area VIIa(N)	1/09 – 13/09	95,989	0.39	71,180	0.47	175,000	0.08
2010	Area VIIa(N)	28/08 – 11/09	131,849	0.22	99,877	0.22	107,400	0.10
2011	Area VIIa(N)	27/08-10/09 11-12/10	131,527	0.36	49,128	0.22	280,000	0.11
2012	Area VIIa(N)	29/08-12/09	79,051	0.18	56,759	0.22	171,190	0.11

[1] sprat only; [2]Data can be made available for the IoM waters only

Table 7.3.2 Herring in Division VIIa North (Irish Sea). Age-disaggregated acoustic estimates (thousands) of herring abundance from the Northern Ireland surveys in September AC(VIIaN).

AGE (RINGS)	1	2	3	4	5	6	7	8+
1994	66.8	68.3	73.5	11.9	9.3	7.6	3.9	10.1
1995	319.1	82.3	11.9	29.2	4.6	3.5	4.9	6.9
1996	11.3	42.4	67.5	9	26.5	4.2	5.9	5.8
1997	134.1	50	14.8	11	7.8	4.6	0.6	1.9
1998	110.4	27.3	8.1	9.3	6.5	1.8	2.3	0.8
1999	157.8	77.7	34	5.1	10.3	13.5	1.6	6.3
2000	78.5	103.4	105.3	27.5	8.1	5.4	4.9	2.4
2001	387.6	93.4	10.1	17.5	7.7	1.4	0.6	2.2
2002	391	71.9	31.7	24.8	31.3	14.8	2.8	4.5
2003	349.2	220	32	4.7	3.9	4.1	1	0.9
2004	241	115.5	29.6	15.4	2.1	2.3	0.2	0.2
2005	94.3	109.9	97.1	17	8	0.8	0.6	5.8
2006	374.7	96.6	15.6	10.0	0.5	0.4	0.5	0.5
2007	1316.7	251.3	46.6	21.1	20.8	1.2	0.7	0.6
2008	475.7	452.4	114.2	39.1	26.4	17.1	4.3	0.6
2009	371.2	182.6	177.8	92.7	32.5	15.1	13.9	6.9
2010	580.6	561.2	117.7	120.8	34.3	16.8	4.3	6.5
2011	1927.0	330.2	43.9	15.0	21.9	6.3	2.7	2.0
2012	369.1	191.9	161.0	51.4	21.6	19.3	12.1	3.1

Table 7.3.3 Herring in Division VIIa North (Irish Sea). Larval production (10^{11}) indices for the Manx component. Table amended with Douglas Bank time series removed (see Stock Annex 8).

Year	Northeast Irish Sea				
		Isle of Man	NINEL	Northern Ireland	
	Date	Production	Date	Production	CV
1992	20 Nov	128.9	-	-	-
1993	22 Nov	1.1	17 Nov	38.3	0.48
1994	24 Nov	12.5	16 Nov	71.2	0.12
1995	-	-	28 Nov	15.1	0.62
1996	26 Nov	0.3	19 Nov	4.7	0.30
1997	1 Dec	35.9	4 Nov	29.1	0.11
1998	1 Dec	3.5	3 Nov	5.8	1.02
1999	-	-	9 Nov	16.7	0.57
2000	-	-	11 Nov	35.5	0.12
2001	11 Dec	198.6	7 Nov	55.3	0.55
2002	6 Dec	19.8	4 Nov	31.5	0.47
2003	-	-	9 Nov	15.8	0.58
2004	-	-	30 Oct	22.7	0.48
2005	-	-	6 Nov	26.4	0.57
2006	-	-	6 Nov	43.8	0.70
2007	-	-	6 Nov	12.6	0.67
2008	-	-	6 Nov	16.8	0.98
2009	-	-	8 Nov	16.9	0.89
2010	-	-	9 Nov	20.4	0.88
2011	-	-	8 Nov	13.8	0.05
2012	-	-	7 Nov		

TABLE 7.6.3.1 Irish Sea Herring. CATCH IN NUMBER

Units : thousands

age	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972
1	4541	381	4837	1508	846	940	4440	1020	1321	5605	12168	40640
2	11471	12296	9441	18095	27077	15048	40922	30181	42799	31177	66921	46660
3	2629	7340	2341	4346	8180	15635	5598	13459	16908	33630	31940	26950
4	12427	1811	2887	710	987	1999	4633	4079	12681	16465	29405	13180
5	239	5433	2263	532	705	118	1351	816	1321	12611	5070	13750
6	478	191	2263	710	987	353	0	612	2642	1752	3549	6760
7	1195	191	546	0	423	118	0	0	528	2102	1014	2660
8	2151	667	624	177	705	0	0	0	0	1051	1014	1670

age	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
1	42150	43250	33330	34740	30280	15540	11770	5840	5050	5100	1305	1168
2	32740	109550	48240	56160	39040	36950	38270	25760	15790	16030	12162	8424
3	38240	39750	39410	20780	22690	13410	23490	19510	3200	5670	5598	7237
4	11490	24510	10840	15220	6750	6780	4250	8520	2790	2150	2820	3841
5	6920	10650	7870	4580	4520	1740	2200	1980	2300	330	445	2221
6	5070	4990	4210	2810	1460	1340	1050	910	330	1110	484	380
7	2590	5150	2090	2420	910	670	400	360	290	140	255	229
8	2600	1630	1640	1270	1120	350	290	230	240	380	59	479

age	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
1	2429	4491	2225	2607	1156	2313	1999	12145	646	1970	3204	5335
2	10050	15266	12981	21250	6385	12835	9754	6885	14636	7002	21330	17529
3	17336	7462	6146	13343	12039	5726	6743	6744	3008	12165	3391	9761
4	13287	8550	2998	7159	4708	9697	2833	6690	3017	1826	5269	1160
5	7206	4528	4180	4610	1876	3598	5068	3256	2903	2566	1199	3603
6	2651	3198	2777	5084	1255	1661	1493	5122	1606	2104	1154	780
7	667	1464	2328	3232	1559	1042	719	1036	2181	1278	926	961
8	724	877	1671	4213	1956	1615	815	392	848	1991	1452	1364

age	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
1	9551	3069	1810	1221	2713	179	694	3225	8692	5669	20290	8939	NA
2	21387	11879	16929	3743	11473	9021	4694	8833	13980	15253	18291	18974	NA
3	7562	3875	5936	5873	7151	1894	3345	5405	10555	8198	4980	7487	NA
4	7341	4450	1566	2065	13050	1866	2559	2161	3287	6318	1655	2696	NA
5	1641	6674	1477	558	3386	2395	882	623	1422	1325	1062	2082	NA
6	2281	1030	1989	347	936	953	2945	213	415	605	325	1761	NA
7	840	2049	444	251	650	474	872	673	292	262	122	328	NA
8	1432	451	622	147	803	337	605	127	368	246	111	216	NA

age	2010	2011	2012
1	9588	7454	2491
2	17627	17598	9664
3	6679	8984	12247
4	6201	3982	7944
5	3200	3671	3061
6	925	1751	3158
7	370	690	1591
8	185	425	652

TABLE 7.6.3.2 Irish Sea Herring. WEIGHTS AT AGE IN THE CATCH

Units : kg

age	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972
1	0.082	0.067	0.067	0.078	0.065	0.092	0.093	0.091	0.074	0.101	0.108	0.074
2	0.123	0.125	0.131	0.129	0.132	0.140	0.149	0.153	0.152	0.162	0.158	0.155
3	0.178	0.152	0.184	0.156	0.176	0.185	0.180	0.196	0.204	0.206	0.189	0.195
4	0.198	0.177	0.208	0.171	0.192	0.218	0.199	0.231	0.231	0.225	0.214	0.219
5	0.232	0.199	0.228	0.226	0.210	0.258	0.223	0.246	0.254	0.245	0.225	0.232
6	0.226	0.214	0.234	0.240	0.230	0.253	0.243	0.269	0.266	0.251	0.266	0.251
7	0.253	0.275	0.266	0.269	0.272	0.225	0.227	0.234	0.239	0.269	0.241	0.258
8	0.248	0.251	0.258	0.296	0.265	0.264	0.275	0.264	0.270	0.258	0.241	0.278

age	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
1	0.074	0.074	0.074	0.074	0.074	0.074	0.074	0.074	0.074	0.074	0.074	0.076
2	0.155	0.155	0.155	0.155	0.155	0.155	0.155	0.155	0.155	0.155	0.155	0.142
3	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.187
4	0.219	0.219	0.219	0.219	0.219	0.219	0.219	0.219	0.219	0.219	0.219	0.213
5	0.232	0.232	0.232	0.232	0.232	0.232	0.232	0.232	0.232	0.232	0.232	0.221
6	0.251	0.251	0.251	0.251	0.251	0.251	0.251	0.251	0.251	0.251	0.251	0.243
7	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.240
8	0.278	0.278	0.278	0.278	0.278	0.278	0.278	0.278	0.278	0.278	0.278	0.273

age	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
1	0.087	0.068	0.058	0.070	0.081	0.096	0.073	0.062	0.089	0.070	0.075	0.067
2	0.125	0.143	0.130	0.124	0.128	0.140	0.123	0.114	0.127	0.123	0.121	0.116
3	0.157	0.167	0.160	0.160	0.155	0.166	0.155	0.140	0.157	0.153	0.146	0.148
4	0.186	0.188	0.175	0.170	0.174	0.175	0.171	0.155	0.171	0.170	0.164	0.162
5	0.202	0.215	0.194	0.180	0.184	0.187	0.181	0.165	0.182	0.180	0.176	0.177
6	0.209	0.228	0.210	0.198	0.195	0.195	0.190	0.174	0.191	0.189	0.181	0.199
7	0.222	0.239	0.218	0.212	0.205	0.207	0.198	0.181	0.198	0.202	0.193	0.200
8	0.258	0.254	0.229	0.232	0.218	0.218	0.217	0.197	0.212	0.212	0.207	0.214

age	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
1	0.064	0.080	0.069	0.064	0.067	0.085	0.081	0.073	0.067	0.064	0.067	0.071
2	0.118	0.123	0.120	0.120	0.106	0.113	0.116	0.107	0.103	0.105	0.112	0.110
3	0.146	0.148	0.145	0.148	0.139	0.144	0.136	0.130	0.136	0.131	0.135	0.135
4	0.165	0.163	0.167	0.168	0.156	0.167	0.160	0.157	0.156	0.149	0.158	0.153
5	0.176	0.181	0.176	0.188	0.168	0.180	0.167	0.165	0.166	0.164	0.173	0.156
6	0.188	0.177	0.188	0.204	0.185	0.184	0.172	0.187	0.180	0.177	0.183	0.182
7	0.204	0.188	0.190	0.200	0.198	0.191	0.186	0.200	0.191	0.184	0.199	0.196
8	0.216	0.222	0.210	0.213	0.205	0.217	0.199	0.205	0.209	0.211	0.227	0.206

age	2009	2010	2011	2012
1	0.0620	0.053	0.058	0.070
2	0.1080	0.106	0.106	0.120
3	0.1330	0.131	0.134	0.138
4	0.1490	0.145	0.152	0.152
5	0.1545	0.153	0.159	0.164
6	0.1730	0.164	0.175	0.174
7	0.1855	0.175	0.187	0.179
8	0.1890	0.172	0.196	0.191

TABLE 7.6.3.3 Irish Sea Herring. WEIGHTS AT AGE IN THE STOCK

Units : kg

age \ year	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972
1	0.082	0.067	0.067	0.078	0.065	0.092	0.093	0.091	0.074	0.101	0.108	0.074
2	0.123	0.125	0.131	0.129	0.132	0.140	0.149	0.153	0.152	0.162	0.158	0.155
3	0.178	0.152	0.184	0.156	0.176	0.185	0.180	0.196	0.204	0.206	0.189	0.195
4	0.198	0.177	0.208	0.171	0.192	0.218	0.199	0.231	0.231	0.225	0.214	0.219
5	0.232	0.199	0.228	0.226	0.210	0.258	0.223	0.246	0.254	0.245	0.225	0.232
6	0.226	0.214	0.234	0.240	0.230	0.253	0.243	0.269	0.266	0.251	0.266	0.251
7	0.253	0.275	0.266	0.269	0.272	0.225	0.227	0.234	0.239	0.269	0.241	0.258
8	0.248	0.251	0.258	0.296	0.265	0.264	0.275	0.264	0.270	0.258	0.241	0.278

age \ year	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
1	0.074	0.074	0.074	0.074	0.074	0.074	0.074	0.074	0.074	0.074	0.074	0.076
2	0.155	0.155	0.155	0.155	0.155	0.155	0.155	0.155	0.155	0.155	0.155	0.142
3	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.187
4	0.219	0.219	0.219	0.219	0.219	0.219	0.219	0.219	0.219	0.219	0.219	0.213
5	0.232	0.232	0.232	0.232	0.232	0.232	0.232	0.232	0.232	0.232	0.232	0.221
6	0.251	0.251	0.251	0.251	0.251	0.251	0.251	0.251	0.251	0.251	0.251	0.243
7	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.240
8	0.278	0.278	0.278	0.278	0.278	0.278	0.278	0.278	0.278	0.278	0.278	0.273

age \ year	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
1	0.087	0.068	0.058	0.070	0.081	0.077	0.070	0.061	0.088	0.073	0.072	0.067
2	0.125	0.143	0.130	0.124	0.128	0.135	0.121	0.111	0.126	0.126	0.120	0.115
3	0.157	0.167	0.160	0.160	0.155	0.163	0.153	0.136	0.157	0.154	0.147	0.148
4	0.186	0.188	0.175	0.170	0.174	0.175	0.167	0.151	0.171	0.174	0.168	0.162
5	0.202	0.215	0.194	0.180	0.184	0.188	0.180	0.159	0.183	0.181	0.180	0.177
6	0.209	0.229	0.210	0.198	0.195	0.196	0.189	0.171	0.191	0.190	0.185	0.195
7	0.222	0.239	0.218	0.212	0.205	0.207	0.195	0.179	0.198	0.203	0.197	0.199
8	0.258	0.254	0.229	0.232	0.218	0.217	0.214	0.191	0.214	0.214	0.212	0.212

age \ year	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
1	0.063	0.073	0.068	0.063	0.066	0.085	0.081	0.067	0.067	0.064	0.073	0.071
2	0.119	0.121	0.121	0.120	0.105	0.113	0.116	0.114	0.103	0.105	0.114	0.110
3	0.148	0.150	0.145	0.149	0.139	0.144	0.136	0.144	0.136	0.131	0.137	0.135
4	0.167	0.166	0.168	0.171	0.156	0.167	0.160	0.161	0.156	0.149	0.158	0.153
5	0.178	0.179	0.178	0.188	0.167	0.180	0.167	0.170	0.166	0.164	0.174	0.156
6	0.189	0.190	0.189	0.204	0.183	0.184	0.172	0.192	0.180	0.177	0.183	0.182
7	0.206	0.200	0.199	0.205	0.199	0.191	0.186	0.202	0.191	0.184	0.199	0.196
8	0.214	0.230	0.214	0.215	0.205	0.217	0.199	0.214	0.209	0.211	0.227	0.206

age \ year	2009	2010	2011	2012
1	0.0660	0.060	0.057	0.059
2	0.1140	0.118	0.109	0.109
3	0.1350	0.134	0.136	0.131
4	0.1500	0.147	0.155	0.149
5	0.1550	0.153	0.162	0.153
6	0.1740	0.165	0.177	0.162
7	0.1860	0.176	0.188	0.168
8	0.1895	0.173	0.197	0.190

TABLE 7.6.3.4 Irish Sea Herring. NATURAL MORTALITY

Units : NA

year

age	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972
1	0.787	0.787	0.787	0.787	0.787	0.787	0.787	0.787	0.787	0.787	0.787	0.787
2	0.380	0.380	0.380	0.380	0.380	0.380	0.380	0.380	0.380	0.380	0.380	0.380
3	0.353	0.353	0.353	0.353	0.353	0.353	0.353	0.353	0.353	0.353	0.353	0.353
4	0.335	0.335	0.335	0.335	0.335	0.335	0.335	0.335	0.335	0.335	0.335	0.335
5	0.315	0.315	0.315	0.315	0.315	0.315	0.315	0.315	0.315	0.315	0.315	0.315
6	0.311	0.311	0.311	0.311	0.311	0.311	0.311	0.311	0.311	0.311	0.311	0.311
7	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304
8	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304

year

age	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
1	0.787	0.787	0.787	0.787	0.787	0.787	0.787	0.787	0.787	0.787	0.787	0.787
2	0.380	0.380	0.380	0.380	0.380	0.380	0.380	0.380	0.380	0.380	0.380	0.380
3	0.353	0.353	0.353	0.353	0.353	0.353	0.353	0.353	0.353	0.353	0.353	0.353
4	0.335	0.335	0.335	0.335	0.335	0.335	0.335	0.335	0.335	0.335	0.335	0.335
5	0.315	0.315	0.315	0.315	0.315	0.315	0.315	0.315	0.315	0.315	0.315	0.315
6	0.311	0.311	0.311	0.311	0.311	0.311	0.311	0.311	0.311	0.311	0.311	0.311
7	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304
8	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304

year

age	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
1	0.787	0.787	0.787	0.787	0.787	0.787	0.787	0.787	0.787	0.787	0.787	0.787
2	0.380	0.380	0.380	0.380	0.380	0.380	0.380	0.380	0.380	0.380	0.380	0.380
3	0.353	0.353	0.353	0.353	0.353	0.353	0.353	0.353	0.353	0.353	0.353	0.353
4	0.335	0.335	0.335	0.335	0.335	0.335	0.335	0.335	0.335	0.335	0.335	0.335
5	0.315	0.315	0.315	0.315	0.315	0.315	0.315	0.315	0.315	0.315	0.315	0.315
6	0.311	0.311	0.311	0.311	0.311	0.311	0.311	0.311	0.311	0.311	0.311	0.311
7	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304
8	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304

year

age	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
1	0.787	0.787	0.787	0.787	0.787	0.787	0.787	0.787	0.787	0.787	0.787	0.787
2	0.380	0.380	0.380	0.380	0.380	0.380	0.380	0.380	0.380	0.380	0.380	0.380
3	0.353	0.353	0.353	0.353	0.353	0.353	0.353	0.353	0.353	0.353	0.353	0.353
4	0.335	0.335	0.335	0.335	0.335	0.335	0.335	0.335	0.335	0.335	0.335	0.335
5	0.315	0.315	0.315	0.315	0.315	0.315	0.315	0.315	0.315	0.315	0.315	0.315
6	0.311	0.311	0.311	0.311	0.311	0.311	0.311	0.311	0.311	0.311	0.311	0.311
7	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304
8	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304

year

age	2009	2010	2011	2012
1	0.787	0.787	0.787	0.787
2	0.380	0.380	0.380	0.380
3	0.353	0.353	0.353	0.353
4	0.335	0.335	0.335	0.335
5	0.315	0.315	0.315	0.315
6	0.311	0.311	0.311	0.311
7	0.304	0.304	0.304	0.304
8	0.304	0.304	0.304	0.304

TABLE 7.6.3.5 Irish Sea Herring. PROPORTION MATURE

Units : NA

age	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
1	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.02	0.15	0.11	0.12	0.36	0.40
2	0.22	0.24	0.34	0.53	0.61	0.47	0.37	0.88	0.71	0.92	0.87	0.88	0.77	0.99	0.99
3	0.63	0.83	0.88	0.81	0.90	0.91	0.75	0.94	0.92	0.94	0.97	0.90	0.89	0.96	1.00
4	1.00	0.92	0.89	1.00	1.00	1.00	0.83	0.94	0.94	0.96	0.98	1.00	0.97	1.00	0.94
5	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
6	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
7	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
8	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

age	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
1	0.07	0.03	0.04	0.00	0.20	0.19	0.10	0.02	0.00	0.14	0.31	0.00	0.00	0.07	0.06
2	0.96	0.92	0.81	0.84	0.88	0.89	0.80	0.73	0.69	0.62	0.73	0.85	0.90	0.63	0.66
3	0.98	0.96	0.88	0.81	0.95	0.90	0.89	0.88	0.83	0.71	0.66	0.91	0.96	0.93	0.90
4	1.00	1.00	0.91	0.78	0.95	0.94	0.91	0.90	0.93	0.88	0.81	0.87	0.99	0.95	0.95
5	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
6	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
7	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
8	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

age	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
1	0.04	0.28	0.00	0.19	0.10	0.02	0.04	0.30	0.02	0.14	0.15	0.02	0.11	0.114	0.20
2	0.30	0.48	0.46	0.68	0.86	0.60	0.82	0.83	0.84	0.79	0.54	0.92	0.76	1.000	0.97
3	0.74	0.72	0.99	0.99	0.94	0.96	0.95	0.97	0.95	0.99	0.88	0.95	0.95	0.970	0.99
4	0.82	0.81	1.00	0.97	0.99	0.83	1.00	0.99	0.97	1.00	0.97	0.98	0.97	1.000	1.00
5	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.000	1.00
6	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.000	1.00
7	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.000	1.00
8	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.000	1.00

age	2006	2007	2008	2009	2010	2011	2012
1	0.19	0.16	0.16	0.13	0.11	0.08	0.10
2	0.89	0.94	0.84	0.82	0.92	0.90	0.84
3	1.00	0.98	1.00	0.97	1.00	1.00	1.00
4	1.00	1.00	1.00	0.98	0.98	1.00	1.00
5	1.00	1.00	1.00	1.00	0.97	1.00	1.00
6	1.00	1.00	1.00	1.00	1.00	1.00	1.00
7	1.00	1.00	1.00	1.00	1.00	1.00	1.00
8	1.00	1.00	1.00	1.00	1.00	1.00	1.00

TABLE 7.6.3.6 Irish Sea Herring. FRACTION OF HARVEST BEFORE SPAWNING

Units : NA

year

age	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
1	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
2	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
3	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
4	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
5	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
6	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
7	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
8	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9

year

age	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
1	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
2	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
3	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
4	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
5	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
6	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
7	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
8	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9

year

age	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
1	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
2	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
3	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
4	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
5	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
6	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
7	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
8	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9

year

age	2006	2007	2008	2009	2010	2011	2012
1	0.9	0.9	0.9	0.9	0.9	0.9	0.9
2	0.9	0.9	0.9	0.9	0.9	0.9	0.9
3	0.9	0.9	0.9	0.9	0.9	0.9	0.9
4	0.9	0.9	0.9	0.9	0.9	0.9	0.9
5	0.9	0.9	0.9	0.9	0.9	0.9	0.9
6	0.9	0.9	0.9	0.9	0.9	0.9	0.9
7	0.9	0.9	0.9	0.9	0.9	0.9	0.9
8	0.9	0.9	0.9	0.9	0.9	0.9	0.9

TABLE 7.6.3.7 Irish Sea Herring. FRACTION OF NATURAL MORTALITY BEFORE SPAWNING

Units : NA

age	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
1	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
2	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
3	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
4	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
5	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
6	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
7	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
8	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75

age	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
1	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
2	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
3	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
4	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
5	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
6	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
7	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
8	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75

age	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
1	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
2	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
3	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
4	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
5	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
6	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
7	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
8	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75

age	2006	2007	2008	2009	2010	2011	2012
1	0.75	0.75	0.75	0.75	0.75	0.75	0.75
2	0.75	0.75	0.75	0.75	0.75	0.75	0.75
3	0.75	0.75	0.75	0.75	0.75	0.75	0.75
4	0.75	0.75	0.75	0.75	0.75	0.75	0.75
5	0.75	0.75	0.75	0.75	0.75	0.75	0.75
6	0.75	0.75	0.75	0.75	0.75	0.75	0.75
7	0.75	0.75	0.75	0.75	0.75	0.75	0.75
8	0.75	0.75	0.75	0.75	0.75	0.75	0.75

TABLE 7.6.3.8 Irish Sea Herring. SURVEY INDICES

AC(VIIaN) - Configuration

Irish Sea herring (Division VIIa) (run name: ICAMDC20) . Imported from VPA file.

min	max	plusgroup	minyear	maxyear	startf	endf
1.0	8.0	8.0	1994.0	2012.0	0.7	0.8

Index type : number

AC(VIIaN) - Index Values

Units : NA

age \ year	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
1	66830	319116	11340	134146	110438	157756	78524	387559	390982	349216	241014
2	68290	82256	42372	49977	27312	77722	103439	93402	71935	220014	115529
3	73529	11935	67473	14812	8083	34017	105291	10194	31701	31984	29593
4	11860	29246	8954	10985	9266	5108	27543	17489	24804	4735	15398
5	9299	4574	26469	1751	6479	10260	8072	7704	31277	3921	2067
6	7550	3500	4171	4553	1778	13521	5432	1372	14830	4089	2299
7	3867	4887	5911	571	2254	1586	4899	626	2756	977	238
8	10118	6894	5815	1910	780	6289	2359	2263	4461	906	240

age \ year	2005	2006	2007	2008	2009	2010	2011	2012
1	94330	374731	1316673	475675	371230	580602	1927032	369094
2	109938	96623	251276	452364	182643	561245	330180	191900
3	97111	15625	46570	114210	177813	117699	43855	160980
4	17023	9982	21101	39076	92741	120777	14978	51363
5	8029	530	20818	26370	32490	34325	21896	21643
6	810	369	1200	17063	15071	16759	6308	19285
7	607	478	718	4254	13940	4336	2715	12105
8	5804	469	556	599	6871	6453	1959	3128

NINEL - Configuration

FLT04: Combined larvae (Catch: Unknown) (Effort: Unknown)

min	max	plusgroup	minyear	maxyear	startf	endf
NA	NA	NA	1993	2012	NA	NA

Index type : biomass

NINEL - Index Values

Units : NA

age \ year	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
all	38.3	71.2	15.1	4.7	29.1	5.8	16.7	35.5	55.3	31.5	15.8	22.7	26.4	43.8

age \ year	2007	2008	2009	2010	2011	2012
all	12.6	16.8	16.9	20.4	13.8	112.2

TABLE 7.6.3.9 Irish Sea Herring. STOCK OBJECT CONFIGURATION

```
      min       max plusgroup   minyear   maxyear   minfbar   maxfbar
        1         8         8      1961      2012         4         6
```

TABLE 7.6.3.10 Irish Sea Herring. sam CONFIGURATION SETTINGS

```
name           :
desc           :
range          :       min       max plusgroup   minyear   maxyear   minfbar
maxfbar
range          :         1         8         8      1961      2012         4
6
fleets         :     catch AC(VIIaN)     NINEL
fleets         :         0         2         3
plus.group     : TRUE
states         :            age
states         : fleet       1  2  3  4  5  6  7  8
states         :   catch     1  2  3  4  5  6  7  7
states         :   AC(VIIaN) NA NA NA NA NA NA NA NA
states         :   NINEL     NA NA NA NA NA NA NA NA
logN.vars      : 1 2 2 2 2 2 2 2
catchabilities :            age
catchabilities : fleet       1  2  3  4  5  6  7  8
catchabilities :   catch     NA NA NA NA NA NA NA NA
catchabilities :   AC(VIIaN)  1  2  3  4  4  4  4  4
catchabilities :   NINEL     NA NA NA NA NA NA NA NA
power.law.exps :            age
power.law.exps : fleet       1  2  3  4  5  6  7  8
power.law.exps :   catch     NA NA NA NA NA NA NA NA
power.law.exps :   AC(VIIaN) NA NA NA NA NA NA NA NA
power.law.exps :   NINEL     NA NA NA NA NA NA NA NA
f.vars         :            age
f.vars         : fleet       1  2  3  4  5  6  7  8
f.vars         :   catch     1  1  1  1  1  1  1  1
f.vars         :   AC(VIIaN) NA NA NA NA NA NA NA NA
f.vars         :   NINEL     NA NA NA NA NA NA NA NA
obs.vars       :            age
obs.vars       : fleet       1  2  3  4  5  6  7  8
obs.vars       :   catch     1  2  3  3  4  4  4  4
obs.vars       :   AC(VIIaN)  5  6  6  7  7  8  8  8
obs.vars       :   NINEL     NA NA NA NA NA NA NA NA
srr            : 0
cor.F          : FALSE
nohess         : FALSE
timeout        : 3600
sam.binary     :
```

TABLE 7.6.3.11 Irish Sea Herring. FLR, R SOFTWARE VERSIONS

```
FLSAM.version                       0.99-99
FLCore.version                          2.4
R.version      R version 2.13.1 (2011-07-08)
platform                     i386-pc-mingw32
run.date                 2013-03-18 11:41:20
```

TABLE 7.6.3.12 Irish Sea Herring. STOCK SUMMARY

Year	Recruitment Age 1	Low	High	TSB	Low	High	SSB	Low	High	Fbar (Ages 4-6) f	Low f	High f	Landings tonnes	Landings SOP
1961	81146	50845	129503	26108	19860	34323	7969	4945	12842	0.3118	0.1956	0.4972	5710	1.0002
1962	85648	55803	131455	19908	15212	26056	5955	3845	9222	0.3000	0.1935	0.4650	4343	0.9995
1963	127644	88491	184120	21093	16369	27180	5201	3381	7999	0.3138	0.2036	0.4836	3947	0.9992
1964	169566	116712	246357	26849	20678	34863	5194	3513	7679	0.2919	0.1858	0.4585	3593	1.0004
1965	184057	127171	266389	31351	24455	40192	7689	5484	10779	0.3065	0.1964	0.4784	5923	1.0021
1966	269952	180948	402736	47052	35646	62106	9112	6549	12680	0.2739	0.1776	0.4225	5666	1.0003
1967	331042	221119	495610	64861	48922	85993	10853	7980	14761	0.2795	0.1893	0.4127	8721	1.0023
1968	385001	254792	581750	81634	61684	108036	25210	18281	34765	0.2795	0.1960	0.3987	8660	0.9995
1969	386930	265509	563879	93620	73604	119080	31382	23380	42123	0.3169	0.2325	0.4318	14141	1.0004
1970	441529	303867	641558	119731	95327	150381	40741	31033	53488	0.3749	0.2828	0.4971	20622	0.9997
1971	447754	311919	642744	127644	102991	158198	43695	34248	55749	0.4074	0.3105	0.5344	26807	0.9994
1972	431490	302741	614994	107152	87808	130757	38716	30388	49326	0.4551	0.3489	0.5938	27350	0.8928
1973	467428	324280	673766	102334	83668	125165	32080	25409	40503	0.4859	0.3750	0.6296	22600	0.9927
1974	374745	263965	532016	101215	82634	123973	38101	29558	49113	0.5824	0.4484	0.7564	38640	1.0043
1975	332036	234153	470839	79063	65037	96114	28396	22250	36239	0.6334	0.4830	0.8308	24500	0.9747
1976	278452	195297	397012	64667	52848	79128	18941	14368	24970	0.6728	0.5040	0.8981	21250	1.0073
1977	261712	184571	371095	53263	43384	65392	13966	10503	18572	0.6476	0.4828	0.8687	15410	1.0484
1978	217510	152752	309721	47193	38151	58378	12218	9183	16258	0.6021	0.4446	0.8155	11080	1.0819
1979	172992	119004	251472	42277	33853	52798	10995	8072	14977	0.5642	0.4107	0.7750	12338	1.0757
1980	166875	115666	240756	35066	28122	43726	11039	8244	14782	0.5106	0.3663	0.7119	10613	1.0308
1981	178260	121766	260965	32338	25202	41495	10849	8096	14537	0.4115	0.2902	0.5836	4377	1.0999
1982	184795	123678	276113	36461	27667	48050	12232	8832	16940	0.3255	0.2250	0.4708	4855	1.0166
1983	174556	117275	259815	40660	30676	53893	14376	10187	20286	0.2743	0.1865	0.4033	3933	1.0165
1984	163244	111509	238982	43958	34072	56714	16309	11863	22423	0.2660	0.1856	0.3811	4066	1.0392
1985	176840	121071	258298	46958	37416	58932	16102	12418	20879	0.3097	0.2295	0.4180	9187	0.9802
1986	189852	128712	280034	45890	36879	57102	18057	14154	23036	0.3148	0.2342	0.4231	7440	1.0238
1987	194853	128691	295030	40619	32343	51014	15945	12302	20667	0.3230	0.2396	0.4355	5823	0.9632
1988	148449	101646	216804	42404	33991	52899	17785	13573	23303	0.3676	0.2706	0.4993	10172	0.9505
1989	143344	98107	209438	38369	30528	48224	14271	10828	18809	0.3434	0.2522	0.4675	4949	0.9966
1990	126500	87287	183331	36607	29446	45510	13905	10685	18096	0.3424	0.2522	0.4648	6312	0.9872
1991	110857	76250	161171	30394	24667	37450	9539	7336	12402	0.3231	0.2391	0.4366	4398	0.9994
1992	129703	89151	188699	25438	20721	31229	8999	7149	11329	0.3401	0.2557	0.4525	5270	0.9890
1993	100208	69609	144256	28970	23664	35465	8917	7033	11305	0.3350	0.2512	0.4467	4409	0.9869
1994	119491	83611	170770	26213	21551	31882	9965	7923	12533	0.3478	0.2614	0.4629	4828	0.9757
1995	113210	80127	159952	25463	20936	30971	9232	7330	11627	0.3546	0.2672	0.4704	5076	1.0007
1996	101722	71608	144500	23086	19091	27918	7274	5740	9219	0.3747	0.2838	0.4947	5301	0.9999
1997	104820	74131	148214	21343	17644	25819	7037	5537	8943	0.4295	0.3281	0.5621	6651	0.9996
1998	109864	76662	157446	20492	16674	25185	7213	5771	9017	0.4656	0.3520	0.6159	4905	0.9951
1999	84965	58892	122583	19881	16202	24395	7064	5505	9066	0.4236	0.3210	0.5589	4127	1.0001
2000	86336	59726	124802	18303	14915	22459	7418	5819	9455	0.3787	0.2859	0.5016	2002	0.9993
2001	93526	64837	134910	18266	14667	22749	5774	4477	7446	0.4474	0.3412	0.5868	5461	1.0004
2002	95511	65339	139616	18915	14978	23886	5897	4568	7612	0.4435	0.3345	0.5881	2393	0.9984
2003	121662	84929	174281	19776	15554	25143	5540	4316	7110	0.4719	0.3483	0.6394	2399	1.0010
2004	142629	99591	204264	21985	17369	27827	7824	5973	10248	0.4209	0.3107	0.5701	2531	0.9979
2005	168721	117400	242476	25694	20222	32646	9309	7106	12195	0.4218	0.3066	0.5805	4387	1.0062
2006	218819	151239	316596	29231	22838	37414	9782	7496	12766	0.3793	0.2722	0.5286	4402	1.0005
2007	265136	179826	390919	39696	30367	51891	13602	10256	18041	0.2860	0.2019	0.4053	4629	1.0012
2008	249946	168846	369999	44312	34008	57736	16778	12505	22509	0.2739	0.1914	0.3918	4895	1.0008
2009	270222	181310	402736	46630	35487	61271	18010	13289	24409	0.2581	0.1735	0.3840	4594	0.0000
2010	284361	185327	436316	48582	36670	64363	20315	14851	27788	0.2433	0.1626	0.3639	4894	0.9989
2011	258074	156837	424657	48630	35721	66205	21530	15310	30278	0.2418	0.1578	0.3705	5202	1.0014
2012	241832	126238	463274	48291	33273	70087	21541	14529	31937	0.2527	0.1586	0.4027	5693	0.9999

TABLE 7.6.3.13 Irish Sea Herring. ESTIMATED FISHING MORTALITY

Units : f

year

age	1961	1962	1963	1964	1965	1966
1	0.02174438	0.01927204	0.01870995	0.01651312	0.01495514	0.01448705
2	0.44331708	0.52348861	0.48460556	0.44557486	0.40002029	0.34965791
3	0.31307891	0.38792238	0.40299948	0.46526879	0.43820870	0.39194647
4	0.33561185	0.31073961	0.32781692	0.27759280	0.29399280	0.28083162
5	0.24019601	0.27337795	0.28670542	0.23997993	0.22295173	0.17920946
6	0.35965861	0.31584617	0.32680226	0.35804378	0.40260474	0.36171452
7	0.69066526	0.60045955	0.62743826	0.47642260	0.38298862	0.32481483
8	0.69066526	0.60045955	0.62743826	0.47642260	0.38298862	0.32481483

year

age	1967	1968	1969	1970	1971	1972	1973
1	0.01547081	0.01619585	0.01934348	0.02604056	0.03627233	0.0501970	0.06285027
2	0.33641828	0.29147530	0.27898424	0.28739434	0.35243115	0.3443144	0.37293915
3	0.30458655	0.27494066	0.29156276	0.33608203	0.40353986	0.4447024	0.52576023
4	0.30218979	0.32719466	0.35615117	0.41198844	0.44636869	0.4433304	0.46875736
5	0.19349570	0.18407721	0.23135545	0.31742935	0.34767053	0.4202019	0.47257917
6	0.34273422	0.32732556	0.36305534	0.39539896	0.42812931	0.5018570	0.51641736
7	0.34514178	0.37319284	0.41475388	0.52651787	0.55166186	0.6519679	0.76834994
8	0.34514178	0.37319284	0.41475388	0.52651787	0.55166186	0.6519679	0.76834994

year

age	1974	1975	1976	1977	1978	1979	1980
1	0.07493756	0.08201116	0.0852472	0.08145537	0.0733436	0.06401742	0.05284459
2	0.52855945	0.56763311	0.6038799	0.60384967	0.5430575	0.58501371	0.55159014
3	0.64759486	0.69044428	0.7116138	0.71902439	0.6976484	0.64705110	0.60354782
4	0.60795768	0.65024894	0.7088226	0.67801220	0.6481715	0.61550021	0.55094516
5	0.55535929	0.63207956	0.6476272	0.63197844	0.5500369	0.52345720	0.48930953
6	0.58385653	0.61796096	0.6618145	0.63279422	0.6082252	0.55364034	0.49168353
7	0.83609754	0.83545399	0.8481736	0.79561490	0.6395631	0.51634507	0.43410450
8	0.83609754	0.83545399	0.8481736	0.79561490	0.6395631	0.51634507	0.43410450

year

age	1981	1982	1983	1984	1985	1986	1987
1	0.04345628	0.03591501	0.02947243	0.0264685	0.02574023	0.02561185	0.02483503
2	0.36972714	0.27310471	0.20217937	0.1691617	0.19363119	0.22020420	0.21099940
3	0.36323691	0.26965821	0.22038043	0.2172080	0.26392244	0.26289515	0.25120147
4	0.45455789	0.35144572	0.26577638	0.2503488	0.30897343	0.30083300	0.28207000
5	0.35583078	0.25007360	0.22809342	0.2492996	0.29147530	0.30143526	0.32010699
6	0.42413648	0.37487224	0.32893339	0.2982868	0.32870322	0.34208364	0.36688751
7	0.37598351	0.33692329	0.25256163	0.3083869	0.40341479	0.46161688	0.52334729
8	0.37598351	0.33692329	0.25256163	0.3083869	0.40341479	0.46161688	0.52334729

year

age	1988	1989	1990	1991	1992	1993	1994
1	0.02516755	0.02529623	0.02731553	0.02956098	0.03201662	0.03083515	0.0325851
2	0.21634087	0.19229974	0.21998410	0.23330702	0.25095039	0.27634644	0.3243928
3	0.27560131	0.24994860	0.24470546	0.24341195	0.26654825	0.27299549	0.3132668
4	0.32184024	0.28897936	0.27912376	0.26100910	0.28845967	0.27365147	0.2771490
5	0.35911953	0.33500829	0.33581328	0.32049135	0.33712550	0.34372959	0.3648752
6	0.42182700	0.40603334	0.41225631	0.38763930	0.39479841	0.38763930	0.4014750
7	0.62836127	0.59605043	0.57996936	0.51061469	0.44000464	0.44332595	0.4832361
8	0.62836127	0.59605043	0.57996936	0.51061469	0.44000464	0.44332595	0.4832361

year

age	1995	1996	1997	1998	1999	2000
1	0.03569302	0.03862715	0.03910519	0.03536615	0.03194946	0.02864432
2	0.40857083	0.49747499	0.56597238	0.42760304	0.33888312	0.25890347
3	0.33736158	0.35409147	0.38935257	0.37770191	0.33834134	0.29293633
4	0.28820017	0.29858519	0.37901102	0.41651200	0.36853485	0.35632929
5	0.37544248	0.40291889	0.45609234	0.49279599	0.42875055	0.36996014
6	0.40000029	0.42265882	0.45326878	0.48762920	0.47340217	0.40978608
7	0.51055342	0.59878062	0.73698333	0.67297305	0.55110496	0.41433104
8	0.51055342	0.59878062	0.73698333	0.67297305	0.55110496	0.41433104

year

age	2001	2002	2003	2004	2005	2006	2007
1	0.02640505	0.02334669	0.02490218	0.02938708	0.03429691	0.0371534	0.0402639
2	0.32206561	0.28038265	0.21127388	0.21934707	0.26780398	0.2724500	0.2419317
3	0.35081369	0.28007440	0.29039884	0.32090826	0.32403621	0.3101498	0.2393807
4	0.46723637	0.45240386	0.48232361	0.42862194	0.41776341	0.3472189	0.2369515
5	0.41806431	0.39907736	0.41764228	0.41041354	0.41854118	0.3727676	0.2820700
6	0.45703285	0.47898787	0.51580835	0.42355157	0.42923531	0.4179431	0.3391204
7	0.55673829	0.60245036	0.75803934	0.60688862	0.54831244	0.4804366	0.3529602
8	0.55673829	0.60245036	0.75803934	0.60688862	0.54831244	0.4804366	0.3529602

year

age	2008	2009	2010	2011	2012
1	0.04014329	0.0388130	0.03757561	0.03568589	0.03328994

```
2 0.21205704 0.2009297 0.18383806 0.16257758 0.14016990
3 0.20597510 0.1965576 0.18894487 0.18757059 0.18676577
4 0.21491772 0.2125028 0.21140068 0.21912783 0.23591116
5 0.27667825 0.2623699 0.24942425 0.24299850 0.24800658
6 0.32995467 0.2994823 0.26895801 0.26334245 0.27414448
7 0.32595368 0.2768720 0.23459375 0.25869643 0.27712129
8 0.32595368 0.2768720 0.23459375 0.25869643 0.27712129
```

TABLE 7.6.3.14 Irish Sea Herring. ESTIMATED POPULATION ABUNDANCE

Units : NA

age \ year	1961	1962	1963	1964	1965	1966
1	81145.572	85647.901	127643.9466	169566.4221	184056.858	269952.1500
2	42701.956	32208.961	31824.7638	58104.5934	89054.160	69633.4267
3	14971.445	20449.220	10773.0185	11926.2842	25463.466	44846.4629
4	46258.476	8664.591	9408.7934	4705.5597	4397.977	11228.3825
5	1756.538	22674.586	5332.6309	4185.9962	2739.964	1935.2659
6	1368.951	1086.373	11638.8044	2903.0001	2272.873	1557.9093
7	2474.268	652.297	671.4234	5996.9123	1501.170	951.6526
8	4163.453	2300.082	1211.9671	694.0195	2980.660	2291.1290

age \ year	1967	1968	1969	1970	1971	1972
1	331041.8230	385000.5339	386930.357	441529.449	447754.334	431490.166
2	146532.1299	152055.3685	208355.284	170586.879	217075.392	203007.865
3	31382.3214	77419.9672	83700.481	129702.676	95606.874	99210.586
4	21031.9923	16809.5087	48050.124	48678.854	75962.874	45478.729
5	6356.2890	11062.3198	8907.955	27667.120	23860.986	36717.178
6	1198.4688	3686.3792	7888.017	5545.821	14361.410	13291.766
7	803.2773	632.7656	2060.286	4453.297	2864.932	7041.666
8	1768.6998	1388.9454	1077.609	1758.647	2839.264	2717.045

age \ year	1973	1974	1975	1976	1977	1978
1	467427.717	374744.598	332036.440	278451.729	261712.015	217509.977
2	161619.486	237518.311	140224.502	139944.333	102436.667	114806.112
3	106510.622	79618.360	92318.515	50463.218	50919.437	33894.228
4	44891.332	47382.110	28001.126	31445.149	16627.280	16871.819
5	21778.968	22381.724	17444.854	10306.190	10246.587	5895.237
6	17569.153	10403.525	9820.232	6244.773	3816.542	3610.133
7	5785.442	8044.147	4231.027	4000.601	2145.869	1464.399
8	4034.348	3324.917	3558.520	2480.958	2001.596	1221.580

age \ year	1979	1980	1981	1982	1983	1984
1	172991.891	166874.9486	178260.2785	184794.5599	174555.8453	163243.789
2	92874.091	62692.6817	67171.2092	79459.2825	86163.3334	82289.599
3	51225.872	33322.8958	18943.1942	31824.7638	42150.4230	54393.503
4	10913.982	20088.4439	10022.6218	8621.3762	18077.0779	26876.296
5	6186.347	3919.8160	8256.0373	3762.7299	4078.1552	11736.982
6	2558.816	2618.8747	1474.2431	4133.9969	2141.5818	2504.138
7	1330.221	1083.6606	1141.5018	638.6777	2044.2781	1151.246
8	973.989	946.2436	945.2033	1037.4282	734.4339	1799.745

age \ year	1985	1986	1987	1988	1989	1990
1	176839.885	189851.981	194852.862	148449.483	143343.625	126500.305
2	68665.351	80097.506	85647.901	109425.584	55547.845	70969.111
3	60536.393	36938.144	40457.204	49961.101	67104.072	31602.768
4	38292.143	35171.803	18797.892	22426.532	24909.387	41689.309
5	19262.202	20720.939	19242.949	10831.350	10291.772	13209.612
6	7917.256	11837.172	11606.261	10767.633	5228.083	5120.974
7	1582.878	4575.631	6819.899	6277.958	4883.415	2532.089
8	1844.752	1915.243	3446.795	5312.937	4617.922	3812.346

age \ year	1991	1992	1993	1994	1995	1996
1	110857.403	129702.676	100207.669	119491.438	113210.025	101722.114
2	56443.759	40014.613	70827.314	34752.264	66105.022	49761.656
3	40700.677	30976.992	18445.948	44311.521	14704.370	36206.719
4	17655.454	24514.008	16218.373	9358.123	23813.311	6962.543
5	24391.744	10831.350	12904.095	8900.832	4951.768	13373.093
6	6658.836	14437.727	5989.121	6696.900	4517.888	2572.414
7	2310.456	3376.855	7534.140	3183.065	3232.787	2364.921
8	2466.363	1930.241	2612.597	5284.324	4055.381	3362.029

age \ year	1997	1998	1999	2000	2001	2002	2003
1	104820.013	109864.163	84965.4515	86335.833	93526.491	95511.315	121661.7583
2	44311.521	42616.637	61697.5808	30576.897	38101.160	39854.875	39143.9048
3	22203.384	14489.797	21598.9504	36901.224	16720.654	14647.135	18204.0614
4	20490.159	11205.948	6706.9528	11342.364	23956.621	7406.402	6907.0644
5	4009.412	10855.205	5108.1879	3537.587	6542.012	10644.515	3023.5896
6	6768.265	2069.992	4850.3202	2274.692	2055.964	3146.355	5037.1715
7	1259.160	3338.911	966.4214	1989.821	1165.727	1045.238	1334.3506
8	2356.894	1197.510	1710.7720	1021.983	1605.676	1175.090	899.3749

age \ year	2004	2005	2006	2007	2008	2009
1	142628.6959	168720.7061	218818.9599	265136.4823	249945.9566	270222.237

```
  2  59337.6921  61882.9515  69772.8329  99608.2230 124492.4064  97148.887
  3  21095.1830  38522.5861  29027.5309  33090.4500  54230.5673  71825.870
  4   8691.4929   9922.8951  19535.7227  13733.5909  18295.3096  32048.319
  5   2694.3169   3871.8976   3964.7576   9510.9591   8535.5920  10798.905
  6   1304.7934   1275.8910   1612.7563   1962.1577   5698.1680   4677.879
  7   1921.7663    638.6139    611.6132    711.4463   1174.6200   2932.469
  8    619.9259   1072.9853    691.6638    559.5316    695.6175   1059.656
   year
age       2010       2011       2012
  1 284361.046 258073.576 241832.351
  2 122027.292 135266.204 101823.887
  3  49711.919  63640.160  83700.481
  4  40700.677  25848.297  39183.068
  5  18184.048  22606.664  15137.040
  6   5818.513  10135.506  13405.227
  7   2385.824   3180.202   6146.266
  8   1946.718   2360.668   3093.010
```

TABLE 7.6.3.15 Irish Sea Herring. PREDICTED CATCH NUMBERS AT AGE

Units : NA

age \ year	1961	1962	1963	1964	1965	1966
1	1210.1505	1133.4485	1639.6859	1925.0361	24745.5264	17283.1964
2	12903.5791	11097.1101	10328.6824	17629.5191	7706.3504	12389.1950
3	3422.2380	5602.8462	3046.3213	3789.3887	959.7569	2354.3030
4	11314.3827	1983.6225	2255.0784	976.6907	472.4585	273.6445
5	323.7462	4686.7282	1148.8308	770.9704	654.1129	410.2103
6	358.7013	254.9303	2812.1090	757.8383	415.8481	229.4488
7	1082.6424	257.7629	274.1019	229.5406	825.6822	3522.7950
8	1821.7266	908.9136	494.7339	1892.4925	2690.9781	35182.3565

age \ year	1967	1968	1969	1970	1971	1972	1973
1	7003.2528	891.9589	7867.6917	11072.059	14664.428	19797.085	18813.877
2	4700.4334	5136.2062	35767.6810	54263.115	49746.729	42348.996	82495.580
3	964.0952	42565.5279	31486.0541	27067.797	30412.227	37275.815	32594.538
4	4287.5896	17995.1940	14133.0316	23538.673	14015.372	14458.388	18642.701
5	32292.8138	12354.5538	6509.1880	6065.183	10928.398	7122.898	8299.910
6	15803.3939	1587.8084	1572.5440	4346.082	4566.124	6171.764	4013.745
7	4022.1425	2083.2407	1592.7861	1062.054	2956.111	2726.898	4012.702
8	1603.2210	609.4519	629.0244	1052.528	1140.657	1901.446	1658.668

age \ year	1974	1975	1976	1977	1978	1979	1980
1	18195.326	15833.924	14245.6945	10696.8010	7458.7267	5969.2108	5260.4929
2	51420.901	53766.184	39351.9182	40708.8177	34846.2219	22487.1654	17465.6260
3	39588.739	22105.904	22451.2147	14633.9580	20948.0324	12948.4323	4913.1964
4	11583.651	13832.968	7087.3728	6961.5679	4335.4037	7341.3645	3150.1331
5	7126.746	4285.875	4185.7032	2170.1900	2192.1542	1317.8014	2140.3401
6	3952.288	2642.419	1563.0745	1436.0765	948.3466	885.3473	442.7521
7	2109.487	2014.568	1035.6350	606.2606	468.6471	332.6830	311.3912
8	1774.191	1249.277	965.9673	505.7032	343.1371	290.4932	257.8660

age \ year	1981	1982	1983	1984	1985	1986	1987
1	4524.2179	3515.7213	2955.4612	3115.7650	3330.3078	3312.704	2558.919
2	15937.9765	13212.1217	10715.4296	10121.0228	13260.4341	13641.338	17839.672
3	6387.8945	7068.0507	9000.7213	11927.3576	7250.4586	7625.933	10223.252
4	2192.1761	3611.6500	5095.5353	8724.3217	7826.1815	3956.796	5291.251
5	718.8265	717.7203	2236.0809	4209.7140	4662.1873	4559.645	2829.740
6	1121.5198	520.3023	559.3358	1922.4391	2973.6636	3092.577	3219.528
7	158.8738	395.9627	265.5014	457.7073	1475.8952	2427.944	2565.580
8	258.0698	142.2520	415.0546	533.4632	617.7229	1227.015	2171.297

age \ year	1988	1989	1990	1991	1992	1993	1994
1	2483.813	2364.6611	2238.5419	2835.7451	2111.0485	2656.620	2753.423
2	8137.270	11743.9090	9842.9427	7448.8132	14345.6207	8088.107	18676.102
3	12595.313	5821.5976	7463.4272	6155.9846	3742.8401	10133.885	3582.980
4	5352.880	8698.0140	3471.7359	5264.0712	3324.5846	1939.664	5107.320
5	2535.282	3260.7744	5787.7564	2682.5416	3248.7968	2356.706	1342.716
6	1515.166	1502.7169	1857.5060	4088.9357	1670.6867	1922.977	1293.375
7	1919.193	974.9732	806.9163	1048.0641	2352.6085	1064.712	1129.014
8	1814.872	1467.9468	861.4009	599.0709	815.7843	1767.498	1416.296

age \ year	1995	1996	1997	1998	1999	2000	2001
1	2675.7366	2790.0645	2650.0665	1852.4604	1690.1626	1689.9429	1527.3661
2	16488.5256	16221.1301	12498.7010	14906.7588	5850.3689	8819.1432	8180.5118
3	9195.4125	6104.1857	3883.1036	5275.8232	7966.0975	4211.3140	3039.3228
4	1539.8496	5550.5372	3281.4150	1774.7237	2917.6098	7698.4940	2319.0665
5	3844.5045	1274.7304	3669.7910	1544.9858	947.4745	1938.4811	3036.2546
6	770.4309	2144.8824	695.2281	1591.3532	664.2244	655.8617	1041.9195
7	932.6220	576.6757	1434.1534	357.9954	588.1371	435.1671	414.0596
8	1325.8380	1079.4533	514.3788	633.7028	302.0825	599.3885	465.5176

age \ year	2002	2003	2004	2005	2006	2007	2008
1	2075.0697	2863.7579	3946.3643	5536.8997	7263.5212	6826.8592	7279.4457
2	6242.7745	9791.6964	12203.0354	13962.4938	17944.3396	19917.2207	17139.1397
3	3898.3552	4925.2485	9064.9445	6579.5393	5975.4220	8557.6423	7250.2411
4	2276.0118	2605.2919	2912.9454	4916.8335	2478.1064	3024.4665	6630.7288
5	895.1757	786.4192	1148.3599	1068.6164	2020.0550	1782.6031	3465.6310
6	1767.7627	391.4235	386.9517	478.6023	489.2336	1388.1678	1187.4459
7	623.1330	765.4853	235.6388	203.6311	184.0689	284.0783	432.7369
8	419.9938	246.9263	395.9429	230.2878	144.7662	168.2364	353.0960

year

age	2010	2011	2012
1	6276.3256	5493.221	1210.1505
2	16965.0394	11123.108	12903.5791
3	9216.8628	12080.526	3422.2380
4	4348.9512	7041.032	11314.3827
5	4209.5877	2870.610	323.7462
6	2030.4445	2782.235	358.7013
7	629.1691	1291.823	1082.6424
8	467.0424	650.122	1821.7266

TABLE 7.6.3.16 Irish Sea Herring. CATCH AT AGE RESIDUALS

Units : NA

age	1961	1962	1963	1964	1965	1966	1967
1	1.524520	-1.256850	1.247130	-0.281472	0.3693770	-0.567929	-0.7194780
2	-0.482610	0.420707	-0.368543	0.106885	0.1916050	0.747473	-0.0464252
3	-0.847089	0.867561	-0.845994	0.440254	0.0898994	-0.525554	0.7997230
4	0.301305	-0.292461	0.793580	-1.024440	0.9486770	-1.993680	-1.6553800
5	-0.719350	0.350224	1.606870	-0.879365	0.9750720	-0.356005	-0.2773040
6	0.680540	-0.684311	-0.514919	-0.154542	0.0404236	-1.576170	-0.5158210
7	0.234035	-0.710499	1.633360	-0.616094	-0.3745210	0.266763	0.0450788
8	0.393803	-0.733477	0.550191	-0.928184	-1.2125300	0.619843	-1.6007400

age	1968	1969	1970	1971	1972	1973	1974
1	-0.8928370	-0.390932	0.1088110	1.175120	0.8712040	0.9596260	0.6978110
2	-1.5654700	-0.563170	0.8598020	-0.262763	-1.0554400	1.1632700	-0.2619720
3	0.0225051	0.211682	0.5317620	-0.388382	0.0819359	0.6375510	-0.0144855
4	-0.2001990	0.490596	0.7148420	-0.197429	-0.7381890	0.8790090	-0.2131420
5	0.0837643	1.567550	-0.4248100	0.544375	-0.0685065	0.5909330	0.2351410
6	-0.4360370	0.256130	-0.4802320	0.929982	-0.4660920	0.5160270	0.1497230
7	0.5631880	0.657517	-0.1097370	-0.250182	-0.1220820	0.5914390	-0.0219910
8	-0.3400380	1.216690	-0.0884004	0.903578	0.7416270	-0.0413196	-0.1864030

age	1975	1976	1977	1978	1979	1980
1	0.9058270	0.8692740	0.4305550	0.52589300	-0.0252306	-0.0470723
2	0.1784340	-0.0327734	-0.3972470	0.38441400	0.5570890	-0.4136280
3	-0.1985490	0.0339985	-0.2805890	0.36792900	1.3169100	-1.3773900
4	0.3069490	-0.1566650	-0.0849019	-0.06391620	0.4782900	-0.3899980
5	0.1573290	0.1821100	-0.5236600	0.00845766	0.9649970	0.1705130
6	0.1457420	-0.1616830	-0.1641280	0.24134200	0.0650967	-0.6966440
7	0.4345970	-0.3065390	0.2369360	-0.37539700	0.1870440	-0.1686750
8	0.0390049	0.3506790	-0.8722740	-0.39879300	-0.5534350	-0.1701870

age	1981	1982	1983	1984	1985	1986	1987
1	0.1381050	-1.142510	-1.0702500	-0.2870500	0.3447060	-0.4588430	0.021466
2	0.0236114	-0.339620	-0.9866850	-0.0288899	0.5775980	-0.2034850	0.717386
3	-0.3829610	-0.749043	-0.7006280	1.2012800	0.0923746	-0.6930820	0.855551
4	-0.0623908	-0.794818	-0.9079270	1.3513400	0.2841480	-0.8914010	0.971170
5	-1.8452700	-1.132980	-0.0160402	1.2740400	-0.0692161	-0.2060580	1.156760
6	-0.0244664	-0.171417	-0.9162650	0.7616610	0.1723960	-0.2551130	1.082870
7	-0.2997600	-1.043020	-0.3505550	0.8925240	-0.0191856	-0.0996294	0.547332
8	0.9171290	-2.085940	0.3396270	0.7238710	0.8306760	0.7320140	1.571090

age	1988	1989	1990	1991	1992	1993	1994
1	-0.881730	-0.0254679	-0.1304770	1.6769400	-1.3651200	-0.344723	0.1747210
2	-0.994507	0.3643330	-0.0372296	-0.3227930	0.0821627	-0.591355	0.5449100
3	-0.145113	-0.0531859	-0.3261040	0.2930690	-0.7021430	0.586838	-0.1768910
4	-0.412386	0.3492560	-0.6531300	0.7700270	-0.3118730	-0.193981	0.1001190
5	-0.713818	0.2332710	-0.3147630	0.4591840	-0.2667330	0.201658	-0.2683270
6	-0.446528	0.2373590	-0.5177670	0.5339200	-0.0935899	0.213226	-0.2702550
7	-0.492675	0.1575970	-0.2734140	-0.0274423	-0.1795320	0.432780	-0.4698420
8	0.177509	0.2262840	-0.1312500	-1.0052500	0.0918051	0.282224	0.0590176

age	1995	1996	1997	1998	1999	2000	2001
1	0.7955270	1.418670	0.16919800	-0.0267269	-0.374853	0.545706	-2.471580
2	0.2509480	1.133780	-0.20853400	0.5216930	-1.831580	1.078850	0.401089
3	0.1917530	0.687971	-0.00670601	0.3787380	-0.979224	1.700880	-1.519280
4	-0.9099440	0.898117	0.97858300	-0.4019410	-1.110320	1.695370	-0.698282
5	-0.1537830	0.598649	1.41759000	-0.1066700	-1.254890	1.321960	-0.562311
6	0.0292667	0.145832	0.93167500	0.5286700	-1.538970	0.842994	-0.211442
7	0.0710354	0.891487	0.84563800	0.5103270	-2.018260	0.951040	0.320446
8	0.0672505	0.669871	-0.31167700	-0.0441924	-1.707190	0.693147	-0.765734

age	2002	2003	2004	2005	2006	2007	2008
1	-1.2626800	0.136950	0.910287	0.0271809	1.1842600	0.310758	0.317563
2	-1.1693600	-0.422561	0.557495	0.3625500	0.0784845	-0.198975	0.115100
3	-0.4917930	0.298591	0.488890	0.7064790	-0.5853760	-0.429370	-0.263624
4	0.3764640	-0.600621	0.388095	0.8054730	-1.2968200	-0.369318	-0.215247
5	-0.0351409	-0.552121	0.506594	0.5097120	-1.5239700	0.367989	-0.189002
6	1.2097400	-1.442270	0.165858	0.5554890	-0.9694630	0.563864	-0.591999
7	0.7964580	-0.305197	0.508306	0.5973650	-0.9748310	0.340749	-0.371234
8	0.8650940	-1.575970	-0.173474	0.1564430	-0.6295130	0.592338	-1.532060

year

```
age       2010        2011      2012
  1  0.1982480 -0.91170100  1.524520
  2  0.1502410 -0.57666100 -0.482610
  3 -0.0821878  0.04397930 -0.847089
  4 -0.2831600  0.38761900  0.301305
  5 -0.3244920  0.15220400 -0.719350
  6 -0.3509620  0.30026600  0.680540
  7  0.2187600  0.49373100  0.234035
  8 -0.2235730  0.00684417  0.393803
```

TABLE 7.6.3.18 Irish Sea Herring. PREDICTED INDEX AT AGE NINEL

```
Units  :  NA
     year
age       1993     1994     1995     1996     1997   1998     1999   2000
  all 20.06025 22.41925 20.76959 16.36492 15.83132 16.229 15.89302 16.688
     year
age       2001     2002     2003     2004     2005     2006     2007     2008
  all 12.99052 13.26687 12.46369 17.60143 20.94291 22.00721 30.60275 37.74489
     year
age       2009     2010     2011     2012
  all 40.51855 45.70419 48.43584 48.46103
```

TABLE 7.6.3.19 Irish Sea Herring. INDEX AT AGE RESIDUALS NINEL

```
Units  :  NA
     year
age       1993   1994      1995     1996     1997     1998      1999     2000
  all 0.767383 1.3712 -0.378282 -1.48037 0.722344 -1.22094 0.0587716 0.895694
     year
age      2001    2002     2003     2004    2005     2006     2007      2008
  all 1.71885 1.02608 0.281454 0.301854 0.27477 0.816695 -1.05299 -0.960519
     year
age       2009      2010     2011     2012
  all -1.03762 -0.957174 -1.48987 0.996173
```

TABLE 7.6.3.20 Irish Sea Herring. PREDICTED INDEX AT AGE AC(VIIaN)

Units : NA

age	1994	1995	1996	1997	1998	1999
1	190956.322	180502.517	161943.049	166758.177	175343.117	135821.934
2	64828.461	115774.545	81601.261	69009.538	73585.259	113868.551
3	59148.115	19277.039	46896.579	28001.126	18429.354	28293.857
4	12957.629	32702.277	9486.927	26286.217	13976.743	8671.439
5	11714.703	6465.916	17105.238	4928.057	12979.676	6408.369
6	8601.140	5808.978	3251.852	8361.641	2492.222	5902.493
7	3865.321	3846.081	2633.397	1264.030	3516.671	1115.290
8	6416.705	4824.730	3743.701	2366.057	1261.302	1974.242

age	2000	2001	2002	2003	2004	2005
1	138371.863	150196.543	153675.728	195633.8346	228456.2489	269358.9081
2	59940.040	71246.431	76895.297	79514.9235	119826.4830	120547.6031
3	50031.095	21700.053	20044.699	24718.3213	27998.3260	50980.5772
4	14799.520	28770.332	8992.534	8200.0866	10742.7888	12365.4306
5	4638.007	8273.559	13655.396	3824.9857	3427.1353	4894.9043
6	2903.232	2532.773	3812.842	5937.5389	1648.1851	1604.9694
7	2544.400	1339.578	1160.655	1318.5527	2126.9621	738.5066
8	1306.870	1845.102	1304.885	888.7091	686.1114	1240.9097

age	2006	2007	2008	2009	2010	2011
1	348571.9695	421510.5138	397360.8147	430025.591	453023.826	411514.691
2	135387.9987	197758.1305	252685.2697	198809.031	252938.081	284873.357
3	38824.2372	46676.6818	78464.3766	104610.583	72831.221	93302.296
4	25667.9908	19597.9451	26542.4336	46588.080	59219.135	37387.810
5	5187.0997	13319.5745	12001.6570	15348.147	26095.026	32594.538
6	2045.8733	2640.6754	7721.6241	6485.732	8253.478	14438.016
7	744.2225	952.5475	1604.9373	4156.838	3490.883	4570.144
8	841.6380	749.1656	950.4637	1502.146	2848.421	3392.492

age	2012
1	386389.034
2	218098.048
3	122847.619
4	55943.638
5	21746.541
6	18942.058
7	8710.897
8	4383.839

TABLE 7.6.3.21 Irish Sea Herring. INDEX AT AGE RESIDUALS AC(VIIaN)

Units : NA

age	1994	1995	1996	1997	1998	1999	2000
1	-1.115660000	0.605470	-2.825320	-0.231270	-0.491251	0.159051	-0.601996
2	0.095342000	-0.626566	-1.201360	-0.591537	-1.816880	-0.700015	1.000220
3	0.398943000	-0.878847	0.666933	-1.167400	-1.510790	0.337686	1.363910
4	-0.126363000	-0.159434	-0.082527	-1.245510	-0.586783	-0.755496	0.886721
5	-0.329677000	-0.494147	0.623249	-1.477160	-0.991888	0.671873	0.791028
6	-0.158652000	-0.616642	0.302970	-0.739837	-0.410997	1.008820	0.762493
7	0.000528209	0.291520	0.984083	-0.967192	-0.541377	0.428545	0.797371
8	0.554282000	0.434381	0.535977	-0.260610	-0.584953	1.410160	0.718827

age	2001	2002	2003	2004	2005	2006	2007
1	1.007240	0.992265	0.6156780	0.0568092	-1.114890	0.0769273	1.21036000
2	0.496275	-0.122182	1.8656900	-0.0670016	-0.168963	-0.6183040	0.43896100
3	-1.384920	0.840252	0.4723350	0.1015140	1.181230	-1.6684500	-0.00412459
4	-0.710547	1.448400	-0.7839590	0.5139230	0.456329	-1.3482300	0.10548300
5	-0.101817	1.183070	0.0353959	-0.7217970	0.706444	-3.2563000	0.63751900
6	-0.746143	1.653170	-0.4539780	0.4050460	-0.832284	-2.0846400	-0.95995100
7	-0.925920	1.052550	-0.3648960	-2.6656800	-0.238672	-0.5388460	-0.34403600
8	0.248474	1.496130	0.0234478	-1.2784400	1.877630	-0.7117010	-0.36292500

age	2008	2009	2010	2011	2012
1	0.191190	-0.156200	0.263648	1.640560	-0.04864480
2	1.067490	-0.155545	1.461060	0.270495	-0.23449400
3	0.688219	0.972370	0.879866	-1.383930	0.49557900
4	0.552120	0.982831	1.017360	-1.305880	-0.12199100
5	1.123730	1.070560	0.391292	-0.567994	-0.00681449
6	0.965026	1.026220	0.862076	-1.007820	0.02183880
7	1.186410	1.472700	0.263865	-0.633806	0.40048100
8	-0.561928	1.850510	0.995324	-0.668344	-0.41080500

TABLE 7.6.3.23 Irish Sea Herring. FIT PARAMETERS

	name	value	std.dev
1	logFpar	1.083800	0.234650
2	logFpar	1.152200	0.152710
3	logFpar	0.788490	0.154220
4	logFpar	0.784590	0.141630
5	logSdLogFsta	-1.350800	0.163110
6	logSdLogN	-1.397700	0.211960
7	logSdLogN	-1.564100	0.177100
8	logSdLogObs	-0.142230	0.140420
9	logSdLogObs	-1.411200	0.249660
10	logSdLogObs	-1.167000	0.150270
11	logSdLogObs	-0.862980	0.095256
12	logSdLogObs	-0.060723	0.169680
13	logSdLogObs	-0.606000	0.133010
14	logSdLogObs	-0.355950	0.126580
15	logSdLogObs	-0.196480	0.104970
16	logScaleSSB	-6.096900	0.206310
17	logSdSSB	-0.170890	0.162260

TABLE 7.6.3.24 Irish Sea Herring. NEGATIVE LOG-LIKELIHOOD

603.622

Table 7.7.1. Herring in Division VIIa North (Irish Sea). Input data for short-term forecast.

MFDP version 1a

Run: ISHfinal

Time and date: 14:43 18/03/2013

Fbar age range: 4-6

2013

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
1	144514	0.787	0.097	0.9	0.75	0.059	0.036	0.06
2	106480	0.38	0.887	0.9	0.75	0.112	0.162	0.111
3	60526	0.353	1	0.9	0.75	0.134	0.188	0.134
4	48788	0.335	0.993	0.9	0.75	0.15	0.222	0.15
5	22139	0.315	0.99	0.9	0.75	0.156	0.247	0.159
6	8620	0.311	1	0.9	0.75	0.168	0.269	0.171
7	7467	0.304	1	0.9	0.75	0.177	0.257	0.18
8	5167	0.304	1	0.9	0.75	0.187	0.257	0.186

2014

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
1	144514	0.787	0.097	0.9	0.75	0.059	0.036	0.06
2	.	0.38	0.887	0.9	0.75	0.112	0.162	0.111
3	.	0.353	1	0.9	0.75	0.134	0.188	0.134
4	.	0.335	0.993	0.9	0.75	0.15	0.222	0.15
5	.	0.315	0.99	0.9	0.75	0.156	0.247	0.159
6	.	0.311	1	0.9	0.75	0.168	0.269	0.171
7	.	0.304	1	0.9	0.75	0.177	0.257	0.18
8	.	0.304	1	0.9	0.75	0.187	0.257	0.186

2015

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
1	144514	0.787	0.097	0.9	0.75	5.90E-02	3.60E-02	6.00E-02
2	.	0.38	0.887	0.9	0.75	0.112	0.162	0.111
3	.	0.353	1	0.9	0.75	0.134	0.188	0.134
4	.	0.335	0.993	0.9	0.75	0.15	0.222	0.15
5	.	0.315	0.99	0.9	0.75	0.156	0.247	0.159
6	.	0.311	1	0.9	0.75	0.168	0.269	0.171
7	.	0.304	1	0.9	0.75	0.177	0.257	0.18
8	.	0.304	1	0.9	0.75	0.187	0.257	0.186

Input units are thousands and kg - output in tonnes

Table 7.7.2. Herring in Division VIIa North (Irish Sea). Management options table.

Maturity 2010-2012
MFDP version 1a
Run: ISHfinal
Irish Sea Herring
Time and date: 14:43 18/03/2013
Fbar age range: 4-6

2013				
Biomass	SSB	FMult	FBar	Landings
43019	22114	0.8947	0.22	4993

2014					2015	
Biomass	SSB	FMult	FBar	Landings	Biomass	SSB
38341	22864	0	0	0	39230	23588
.	22443	0.1	0.0246	544	38725	22758
.	22031	0.2	0.0492	1078	38230	21961
.	21627	0.3	0.0738	1602	37745	21194
.	21230	0.4	0.0984	2115	37270	20458
.	20841	0.5	0.123	2618	36805	19749
.	20459	0.6	0.1476	3112	36348	19068
.	20085	0.7	0.1721	3596	35901	18414
.	19718	0.8	0.1967	4071	35463	17784
.	19358	0.9	0.2213	4537	35034	17178
.	19005	1	0.2459	4994	34613	16596
.	18658	1.1	0.2705	5442	34201	16036
.	18318	1.2	0.2951	5882	33796	15497
.	17985	1.3	0.3197	6313	33400	14978
.	17658	1.4	0.3443	6736	33012	14479
.	17337	1.5	0.3689	7151	32631	13999
.	17022	1.6	0.3935	7559	32258	13537
.	16713	1.7	0.4181	7958	31893	13092
.	16411	1.8	0.4427	8350	31534	12664
.	16113	1.9	0.4673	8735	31183	12251
.	15822	2	0.4918	9112	30838	11855

Input units are thousands and kg - output in tonnes

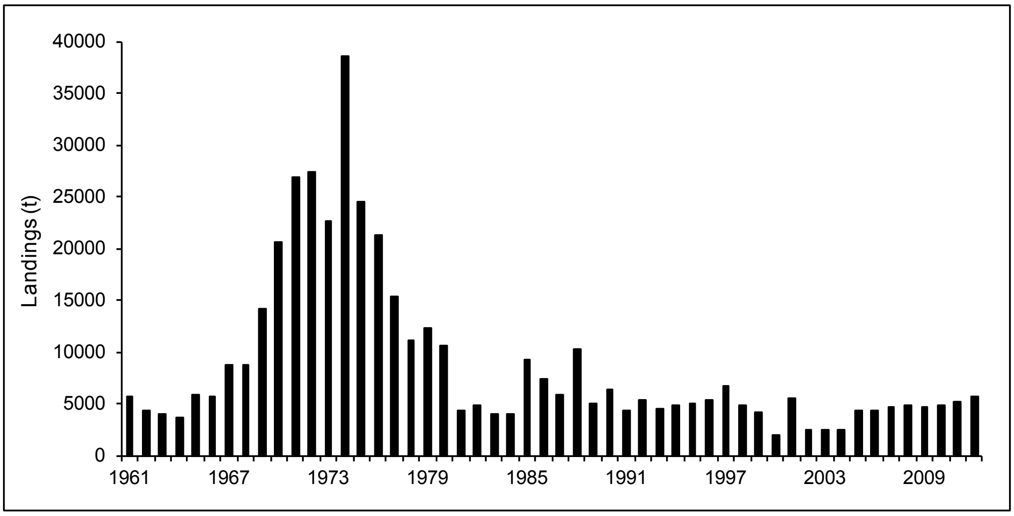


Figure 7.1.1 Herring in Division VIIa North (Irish Sea). Landings of herring from VIIa(N) from 1961 to 2012.

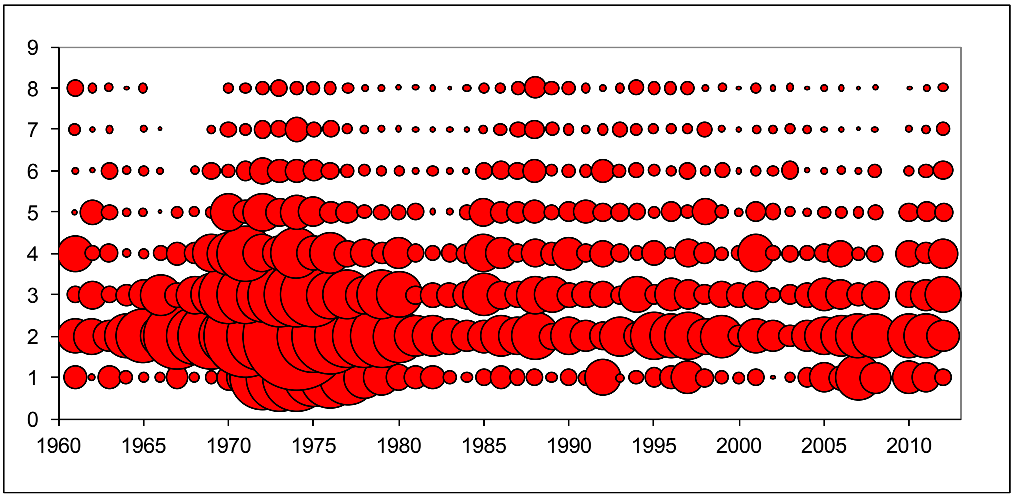


Figure 7.2.1 Herring in Division VIIa North (Irish Sea). Landings (catch-at-age) of herring from VIIa(N) from 1961 to 2012. No 2009 commercial samples.

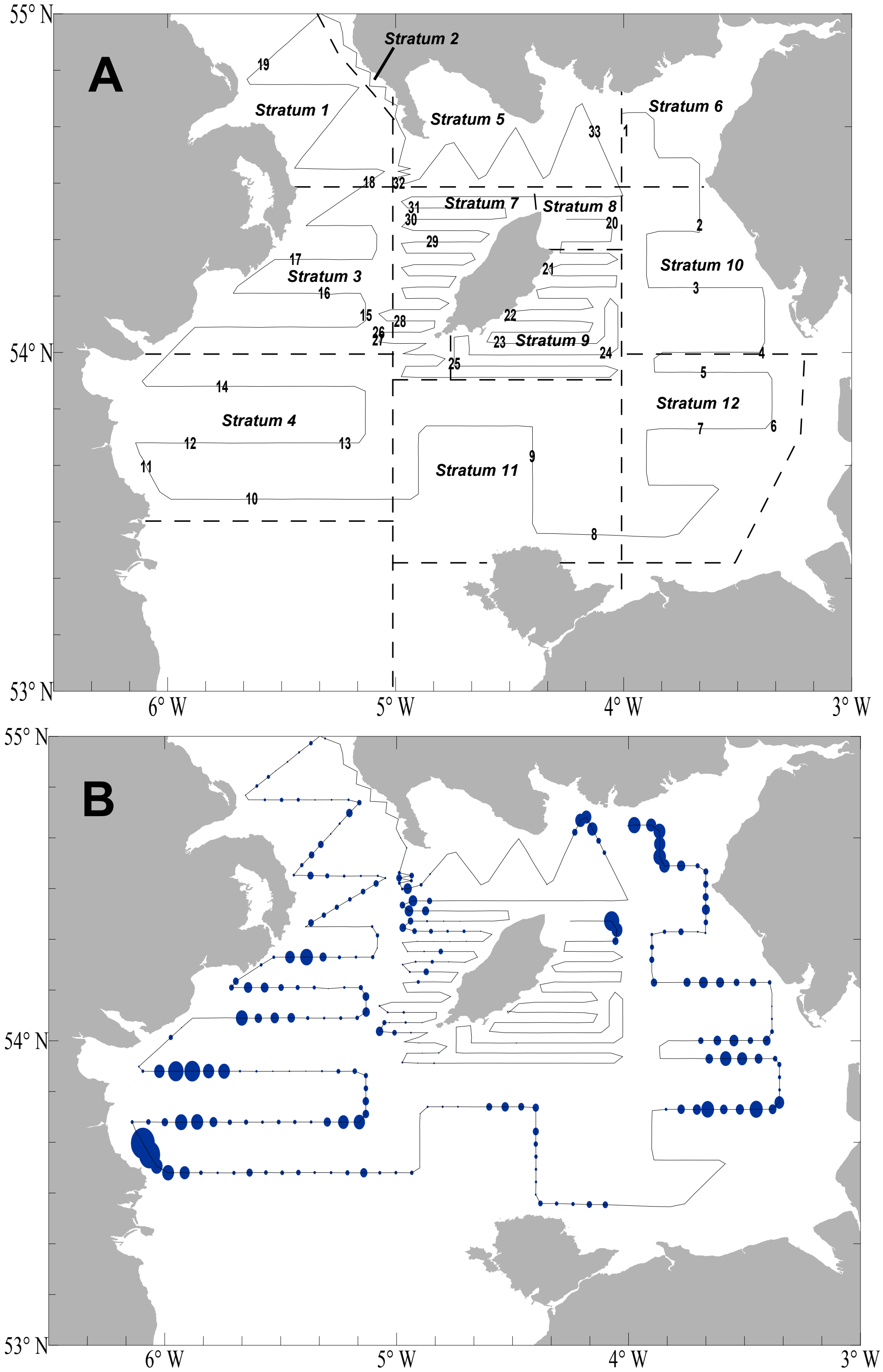


Figure 7.3.1 **Herring in Division VIIa North (Irish Sea). (A) Transects, stratum boundaries and trawl positions for the 2012 acoustic survey; (B) Density distribution of sprats (size of ellipses is proportional to square root of the fish density (t n.mile-2) per 15-minute interval). Maximum density was 590 t n.mile^{-2}. Note: same scaling of ellipse sizes on above figures. The survey is a composite of the main survey and an earlier survey done as part of the extended survey series.**

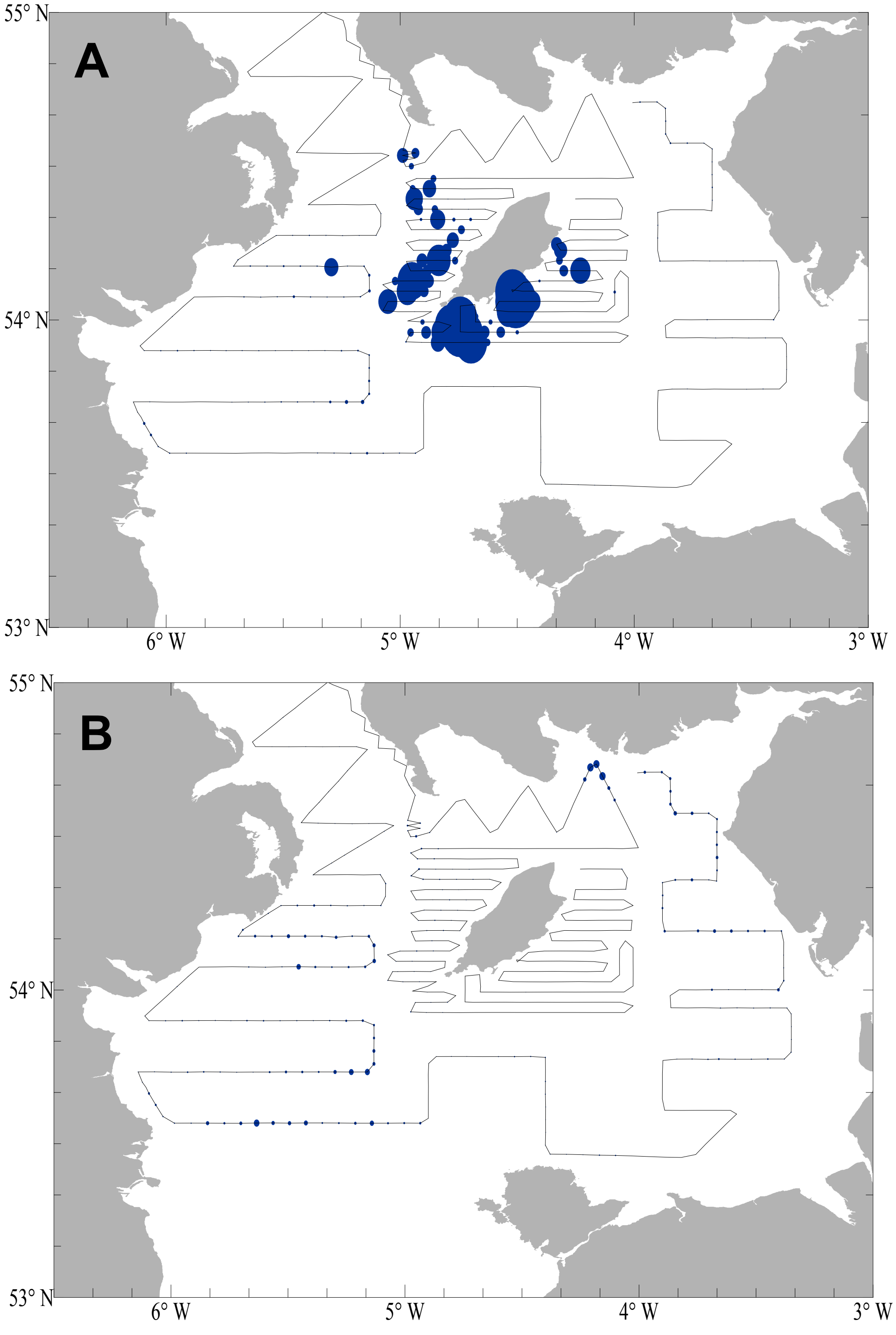


Figure 7.3.2 Herring in Division VIIa North (Irish Sea). (A) Density distribution of 1-ring and older herring (size of ellipses is proportional to square root of the fish density (t n.mile^{-2}) per 15-minute interval). Maximum density was 1 730 t n.mile^{-2}. (B) Density distribution of 0-ring herring. Maximum density was 36 t n.mile^{-2}. Note: same scaling of ellipse sizes on above figures. The survey is a composite of the main survey and an earlier survey done as part of the extended survey series.

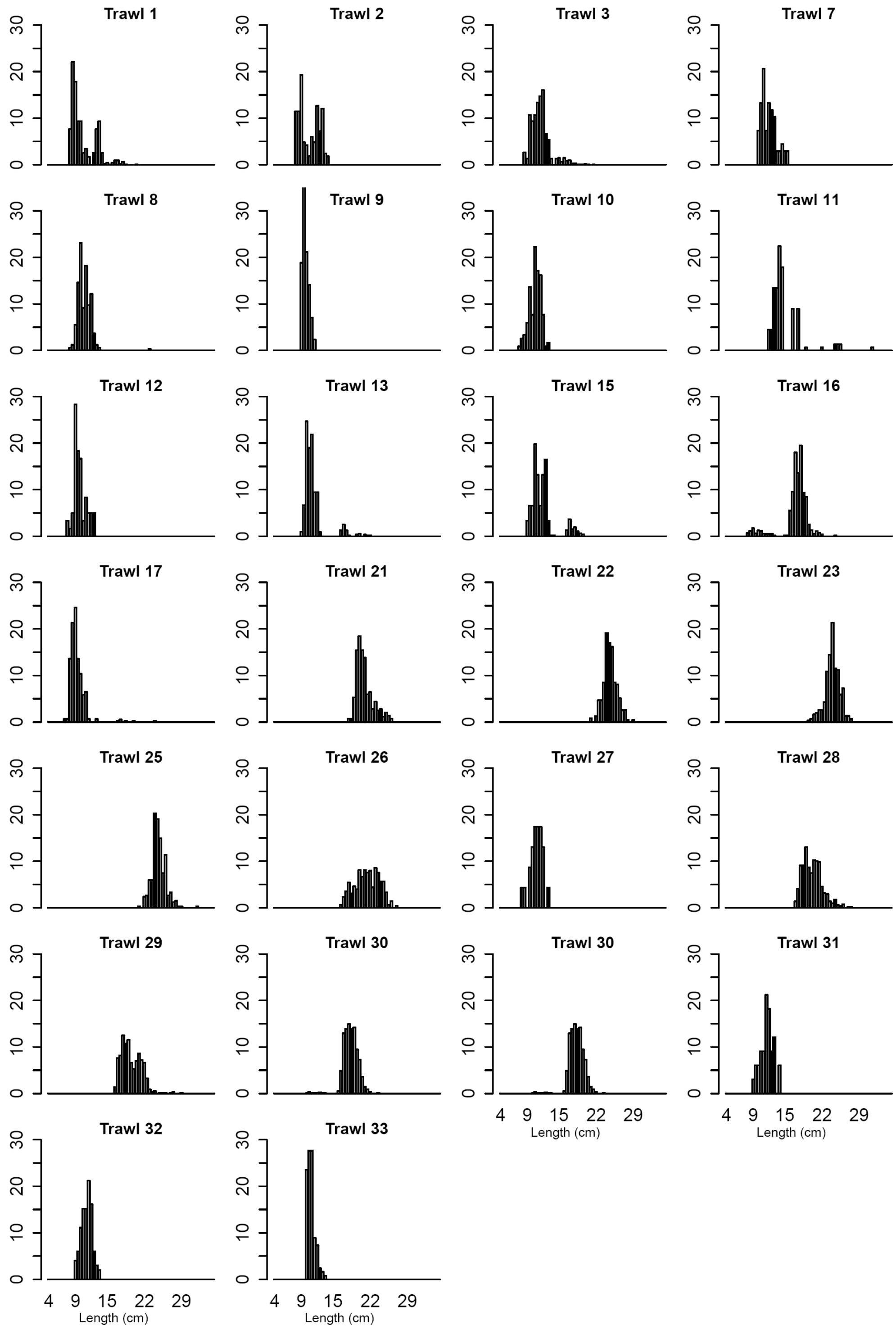


Figure 7.3.3 **Herring in Division VIIa North (Irish Sea). Percentage length compositions of herring in each trawl sample in the September 2012 acoustic survey.**

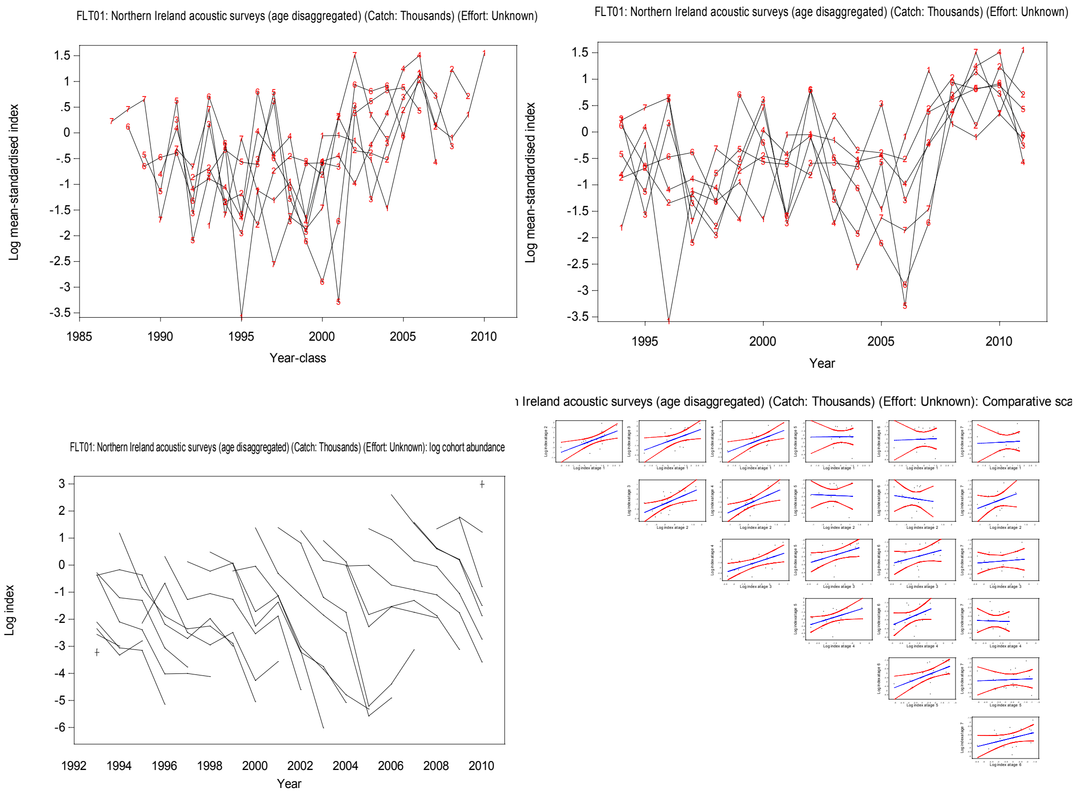


Figure 7.3.4 Herring in Division VIIa North (Irish Sea). Acoustic survey (AC(VIIaN)) log mean-standardised indices by year and age class, scatter plots and catch curves.

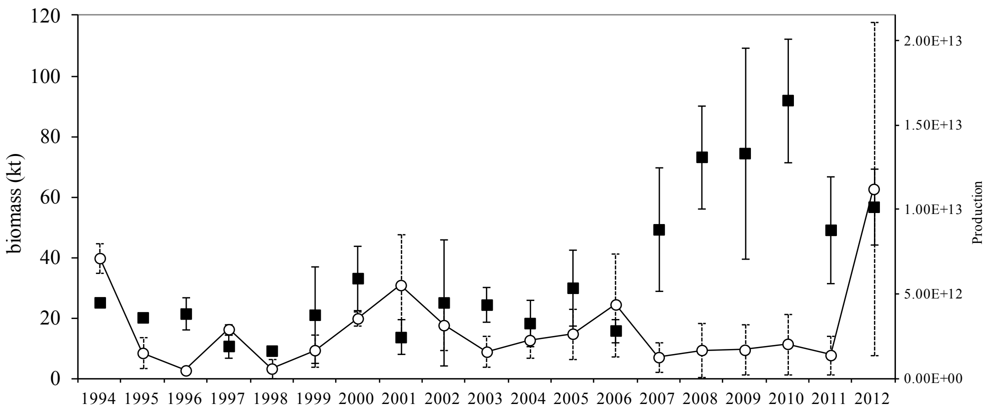


Figure 7.3.5 Herring in Division VIIa North (Irish Sea). Comparison of SSB indices from the acoustic survey estimates of SSB (sold squares) and the larval production estimates (open circles). Vertical bars are ±1 standard errors

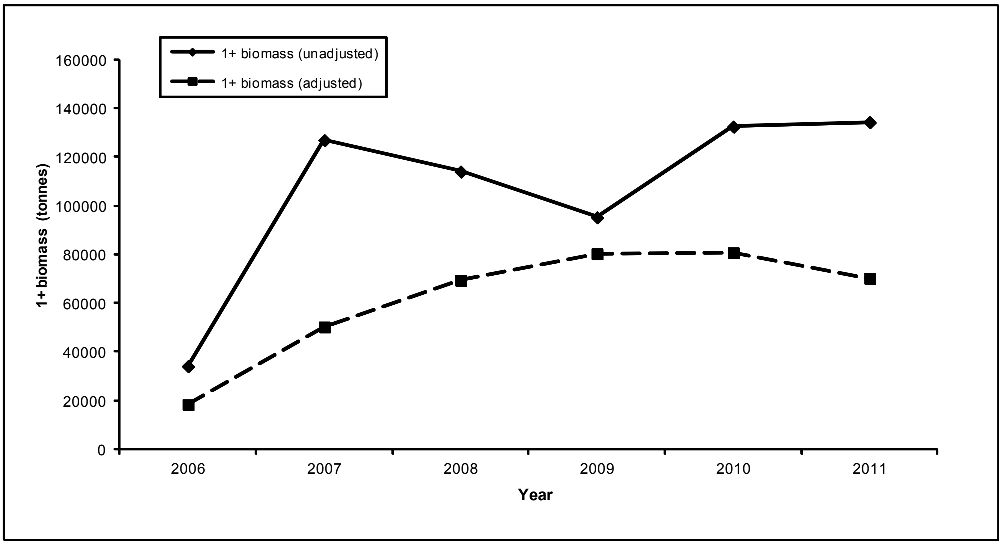


Figure 7.3.6 Herring in Division VIIa North (Irish Sea). Comparison of 1-ringer+ biomass estimates from acoustic survey with adjusted data ("winter spawners removed") and unadjusted data sets.

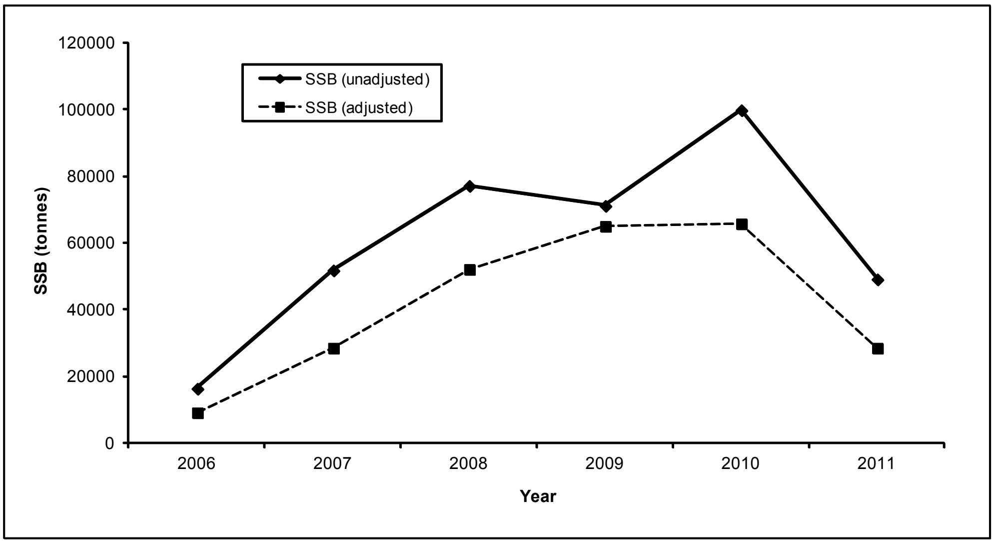


Figure 7.3.7 Herring in Division VIIa North (Irish Sea). Comparison of SSB biomass estimates from acoustic survey with adjusted data ("winter spawners removed") and unadjusted data sets.

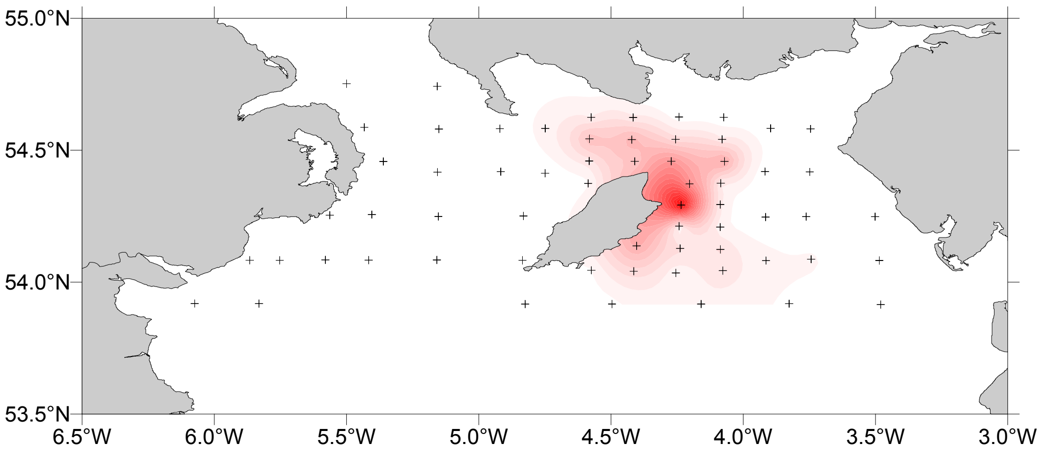


Figure 7.3.8 Herring in Division VIIa North (Irish Sea). Estimates of larval herring abundance in the Northern Irish Sea in 2012. Areas of shading are proportional to larva abundance (maximum = 446.7 ind per m²).

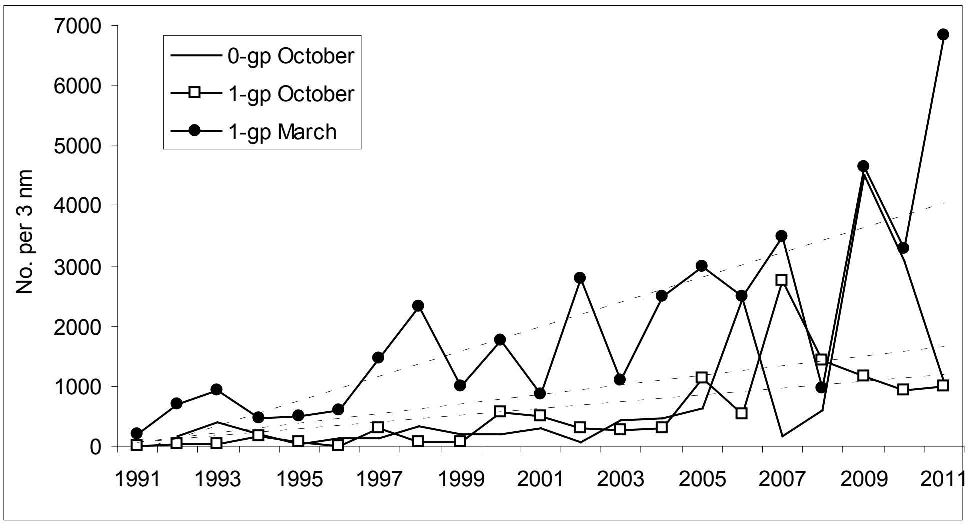


Figure 7.3.9 Herring in Division VIIa North (Irish Sea). Trends in 0-gp and 1-gp herring indices from the Northern Irish March and October groundfish surveys in the northern Irish Sea 1991 - 2011. [Ages are assigned from length frequency].

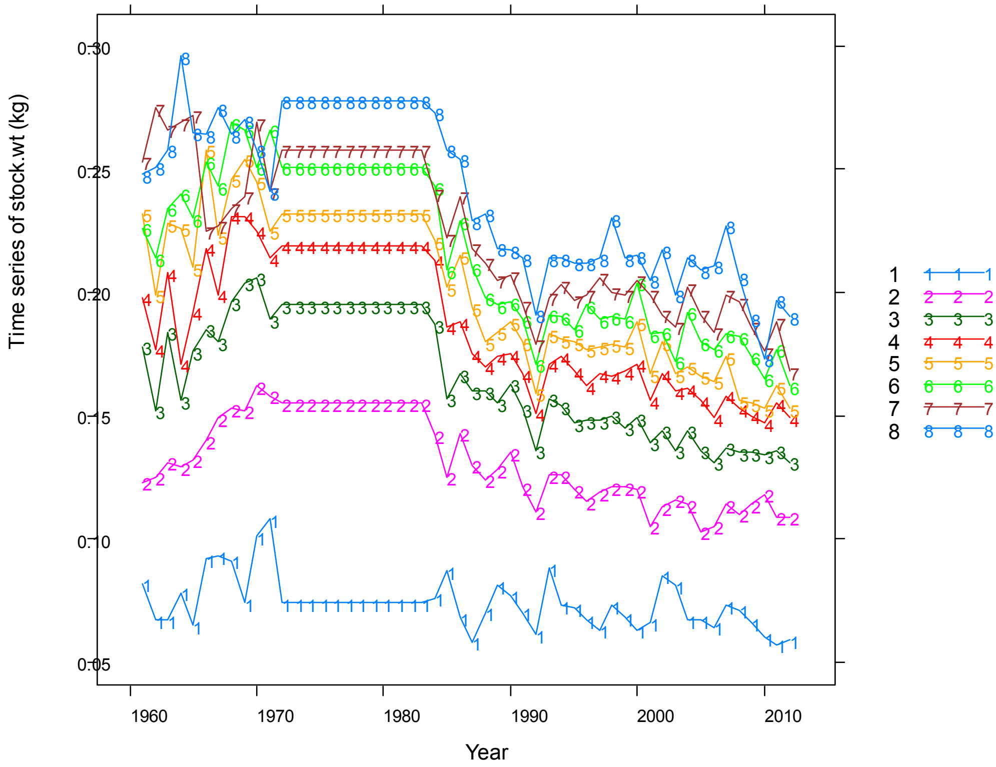


Figure 7.4.1 Herring in Division VIIa North (Irish Sea). Timeseries of catch weights at age.

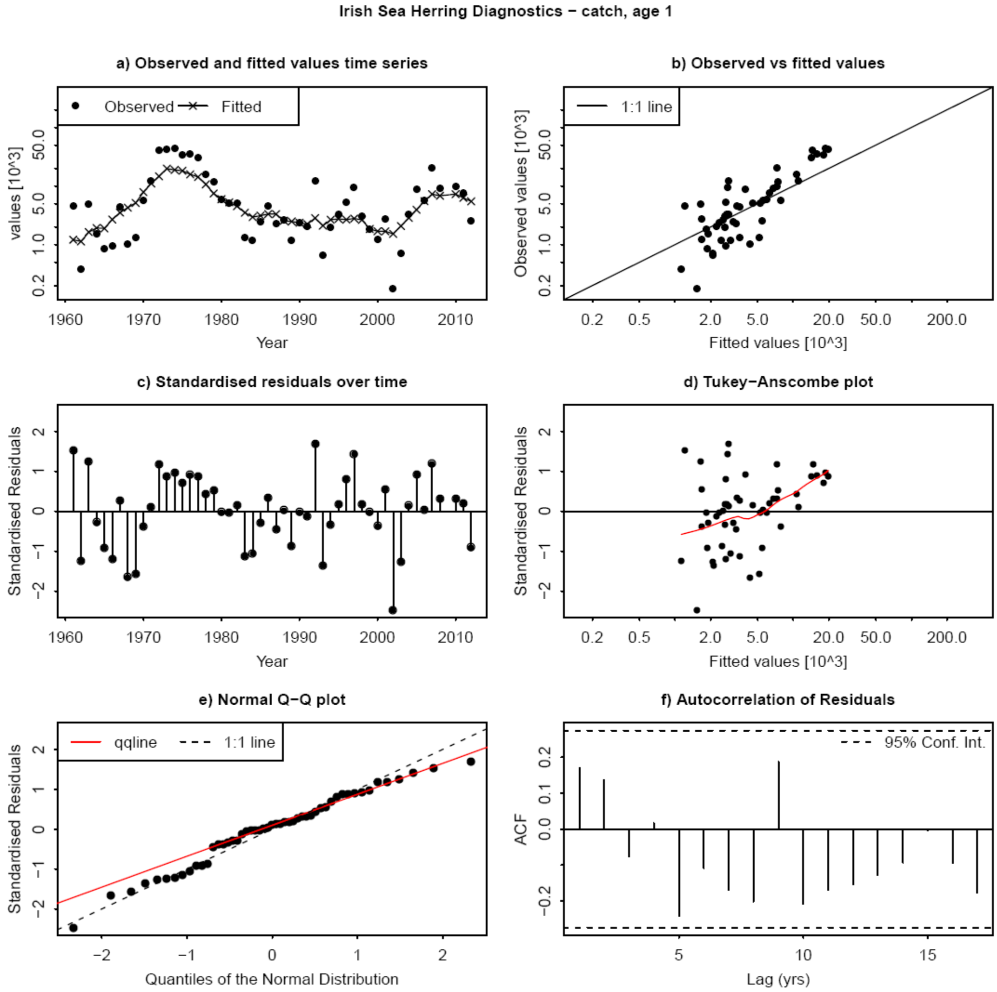


Figure 7.6.1 Herring in Division VIIa North (Irish Sea). FLSAM run output. Diagnostics of model fit to the catch data at age1.

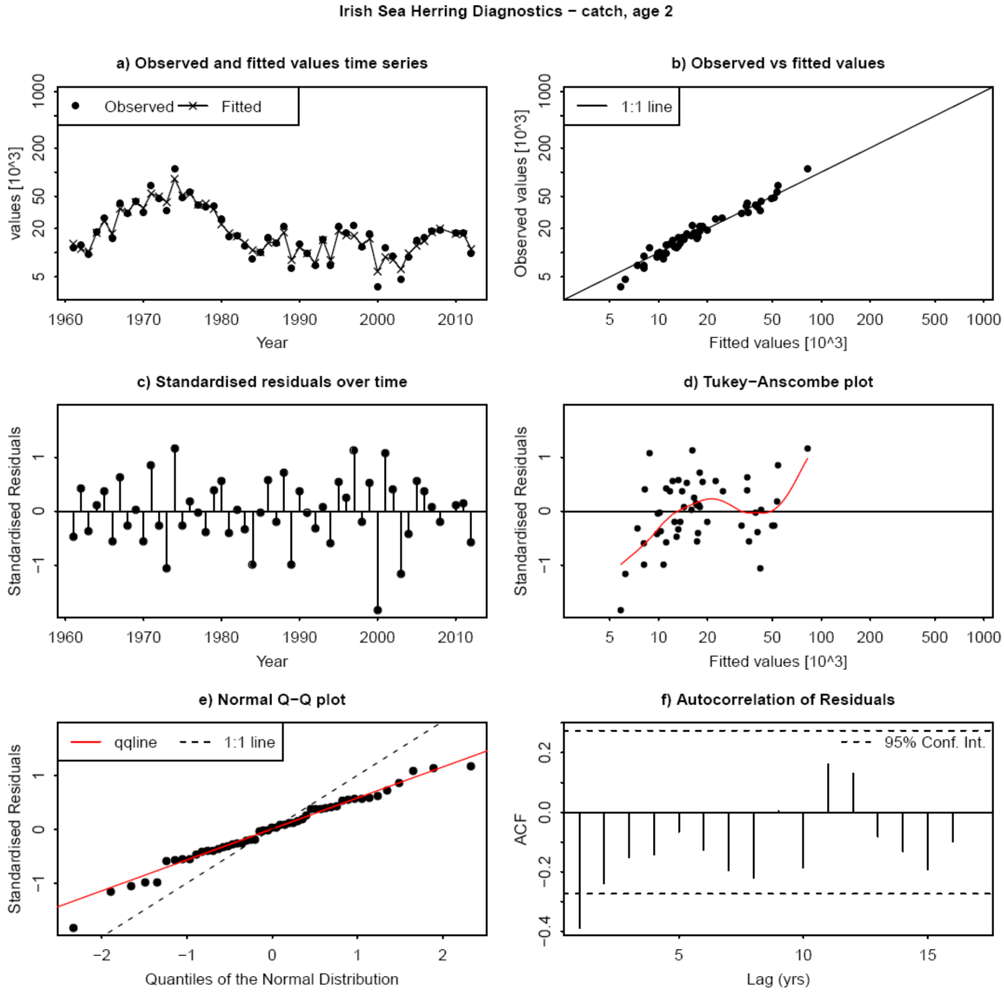


Figure 7.6.2 Herring in Division VIIa North (Irish Sea). FLSAM run output. Diagnostics of model fit to the catch data at age2.

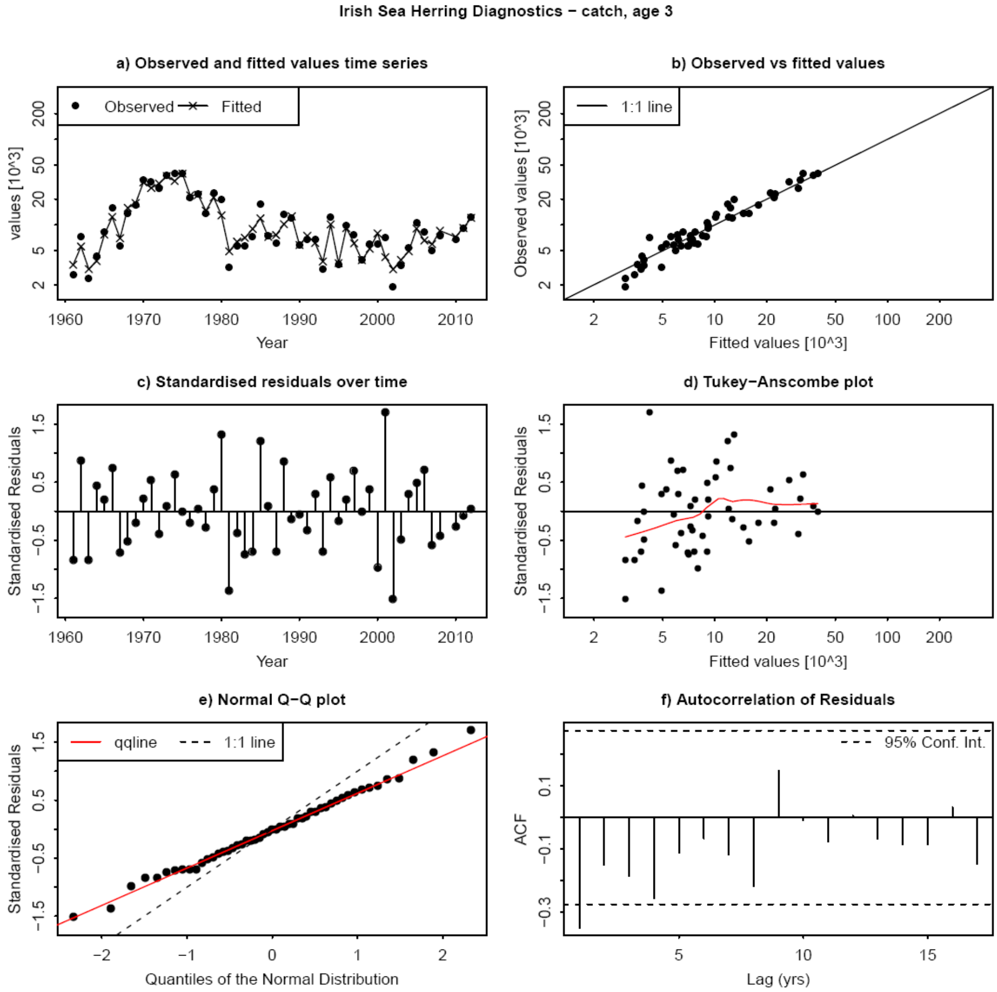


Figure 7.6.3 Herring in Division VIIa North (Irish Sea). FLSAM run output. Diagnostics of model fit to the catch data at age3.

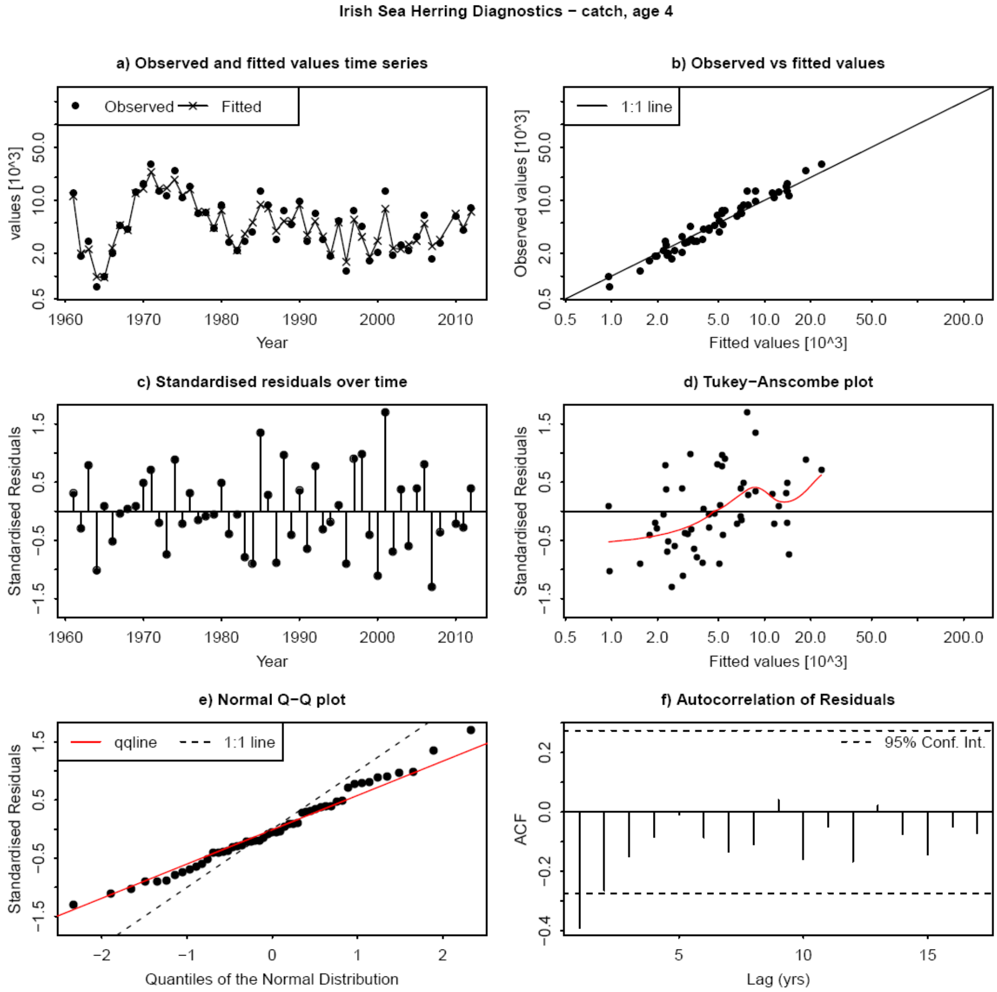


Figure 7.6.4 **Herring in Division VIIa North (Irish Sea). FLSAM run output. Diagnostics of model fit to the catch data at age4.**

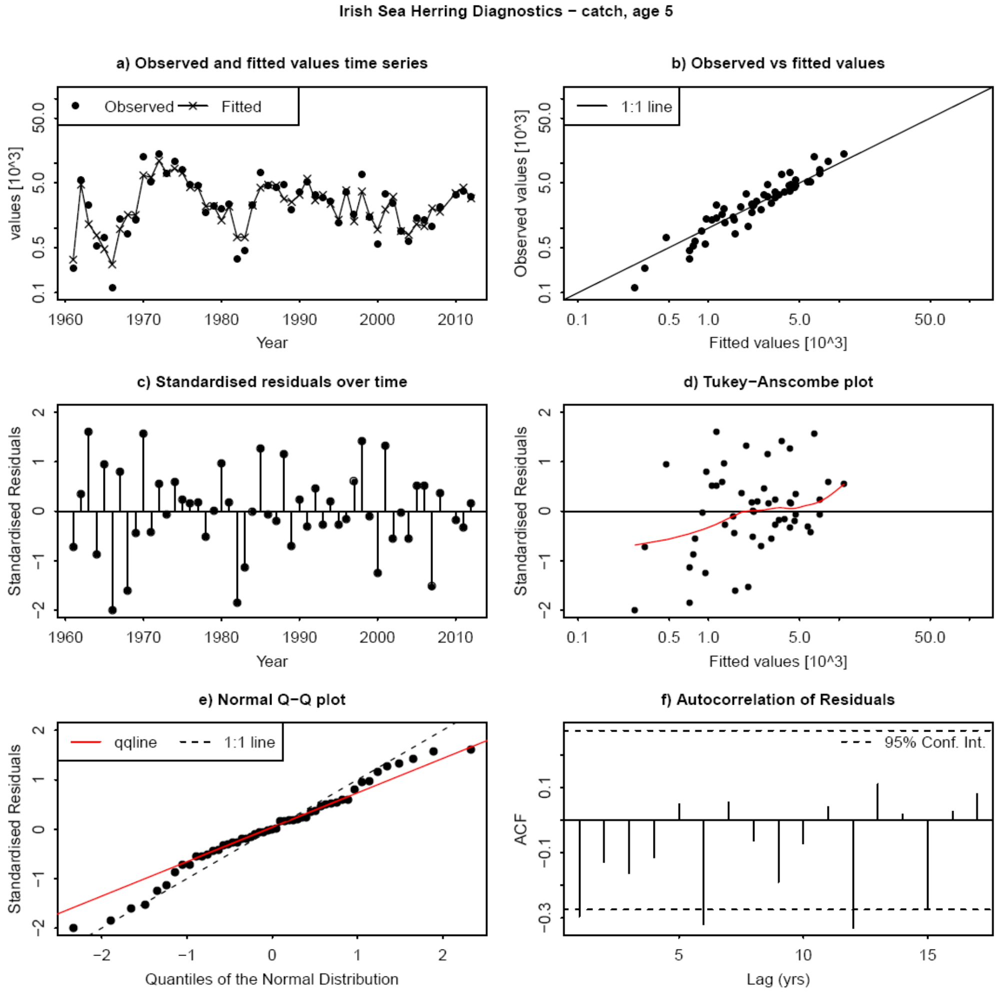


Figure 7.6.5 **Herring in Division VIIa North (Irish Sea). FLSAM run output. Diagnostics of model fit to the catch data at age5.**

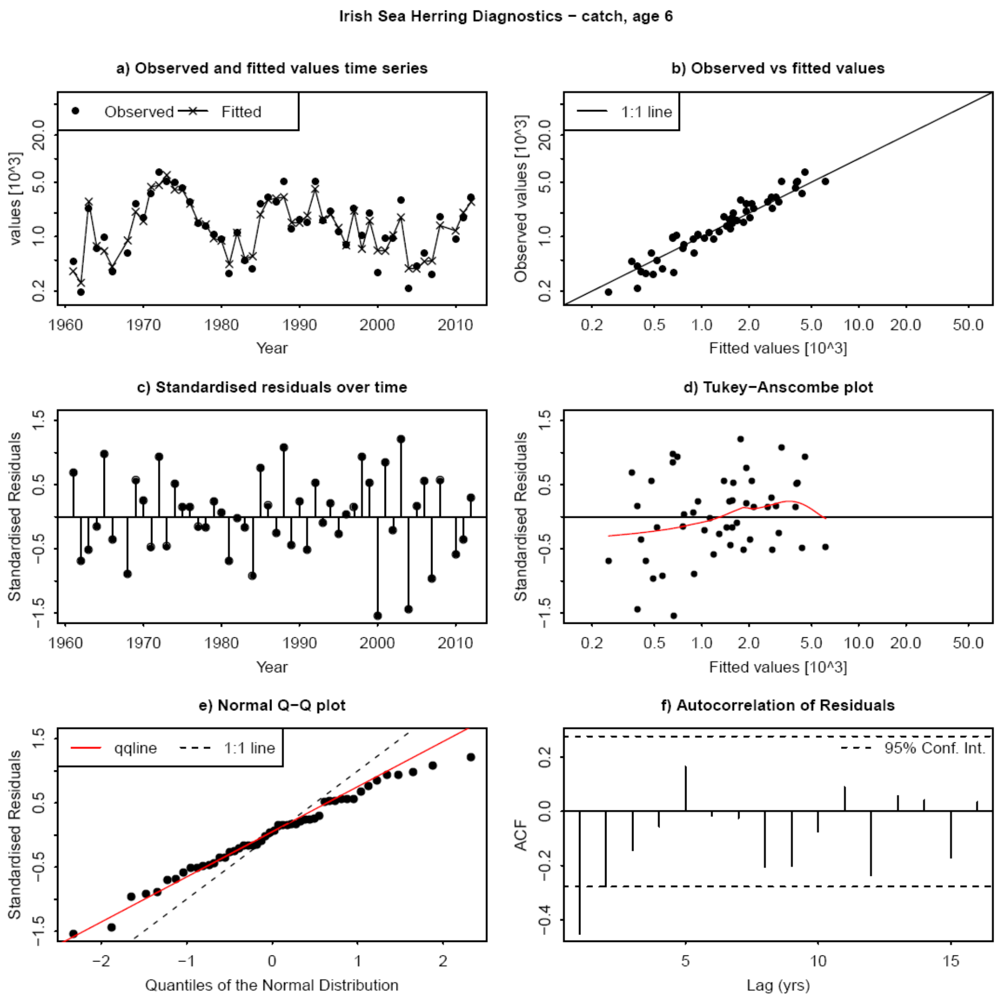


Figure 7.6.6 Herring in Division VIIa North (Irish Sea). FLSAM run output. Diagnostics of model fit to the catch data at age6.

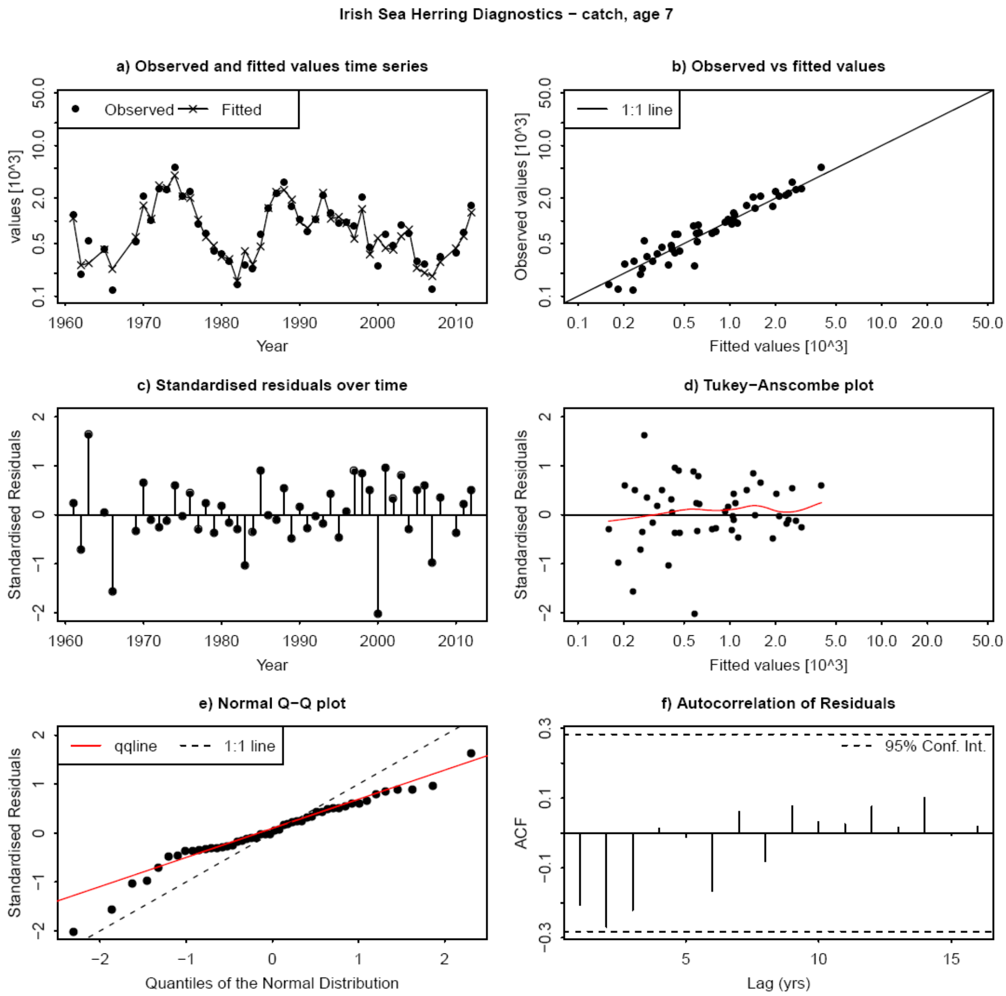


Figure 7.6.7 Herring in Division VIIa North (Irish Sea). FLSAM run output. Diagnostics of model fit to the catch data at age7.

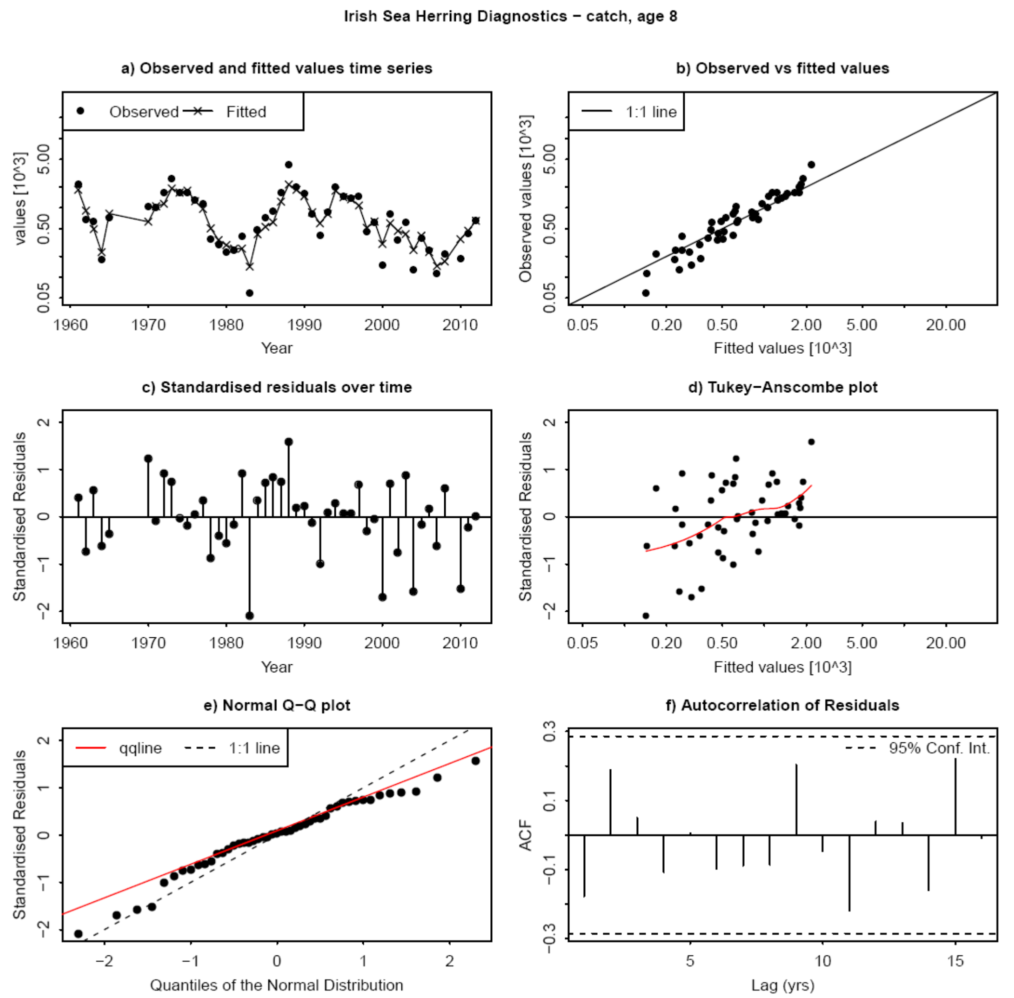


Figure 7.6.8 Herring in Division VIIa North (Irish Sea). FLSAM run output. Diagnostics of model fit to the catch data at age8.

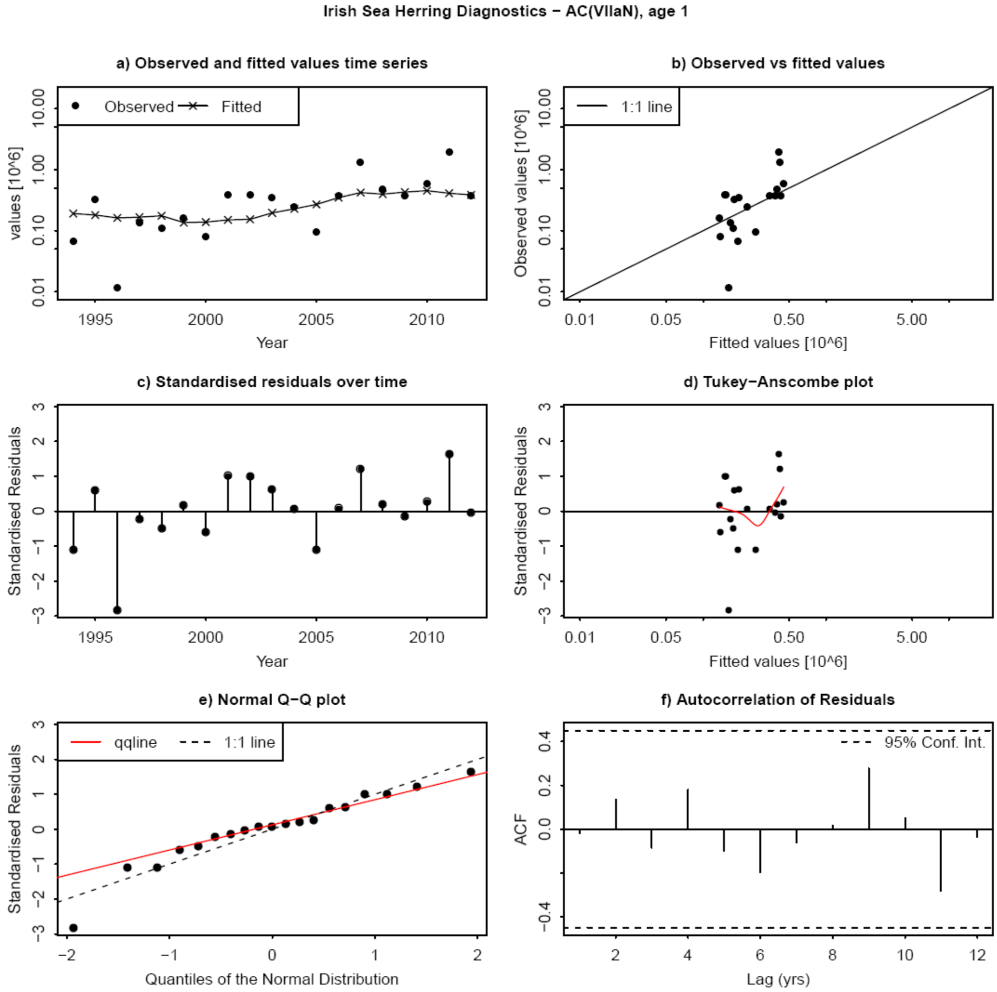


Figure 7.6.9 Herring in Division VIIa North (Irish Sea). FLSAM run output. Diagnostics of model fit to acoustic survey (AC(VIIaN)) data at age1.

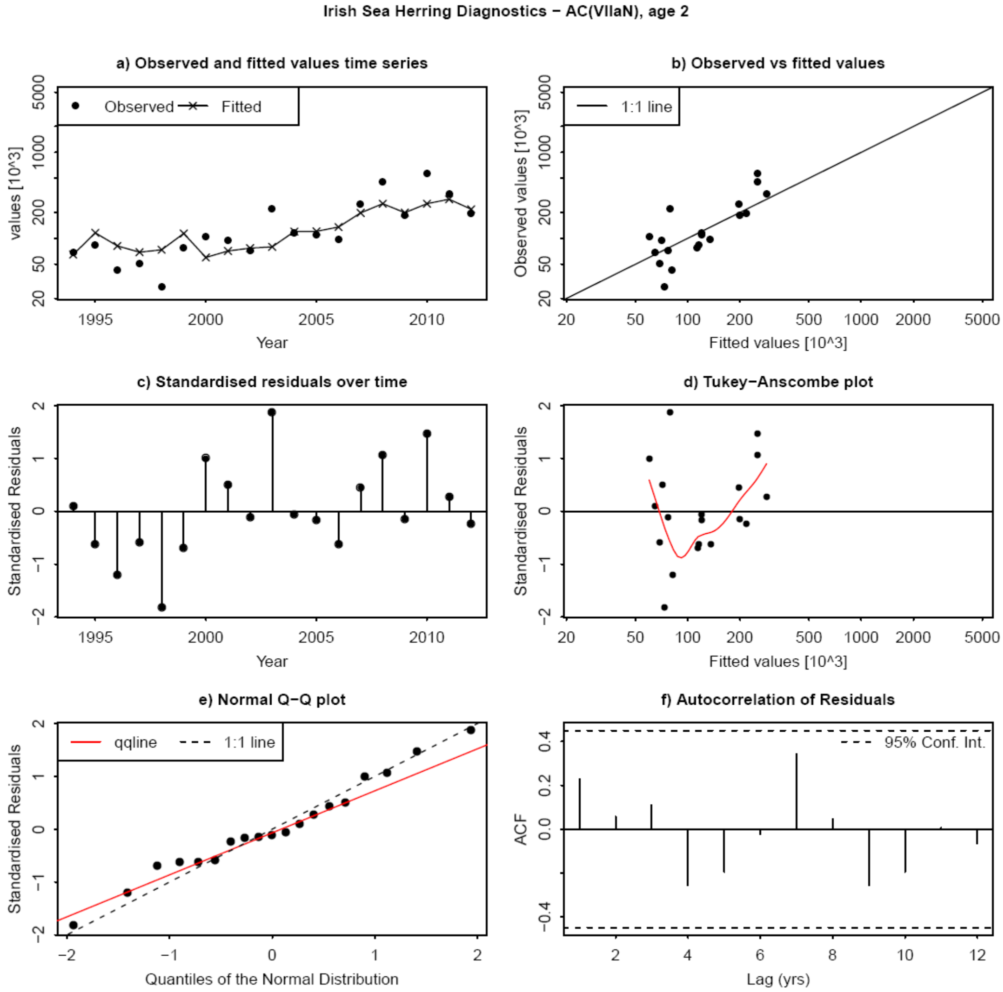


Figure 7.6.10 Herring in Division VIIa North (Irish Sea). FLSAM run output. Diagnostics of model fit to acoustic survey (AC(VIIaN)) data at age2.

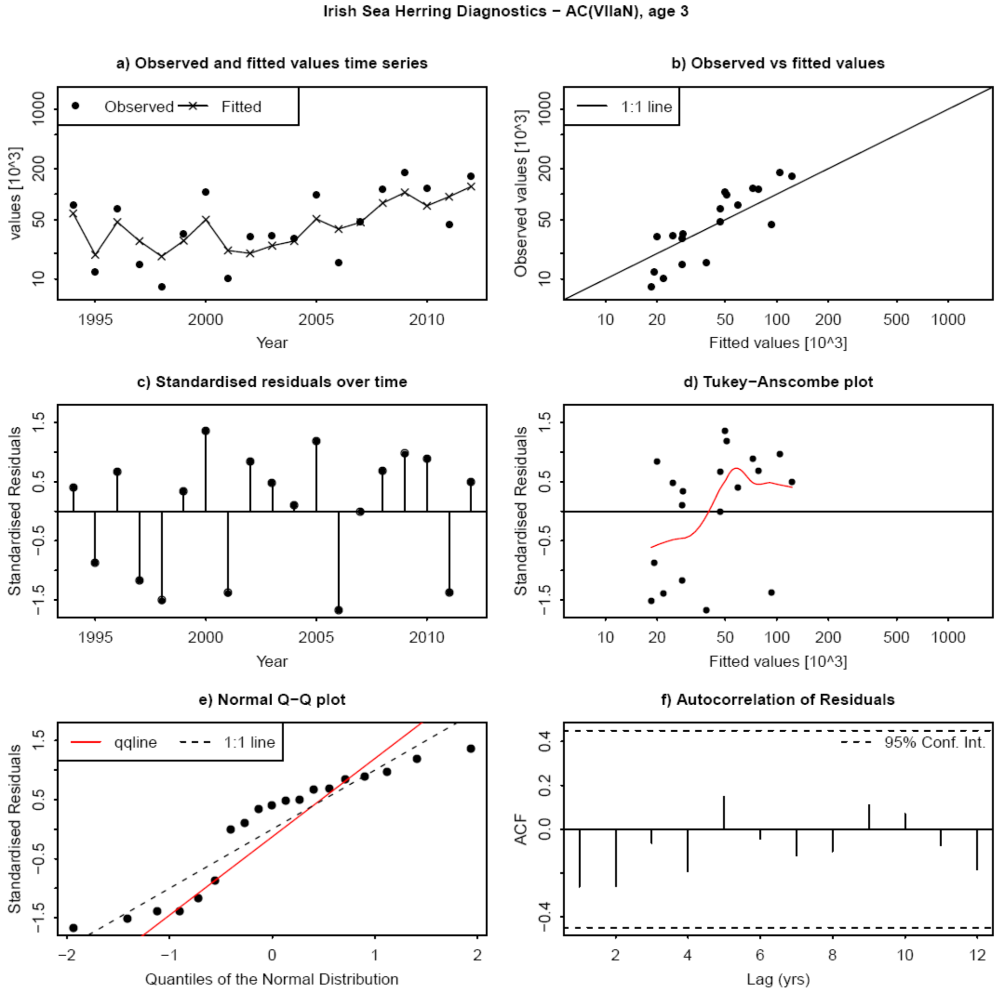


Figure 7.6.11 **Herring in Division VIIa North (Irish Sea). FLSAM run output. Diagnostics of model fit to acoustic survey (AC(VIIaN)) data at age3.**

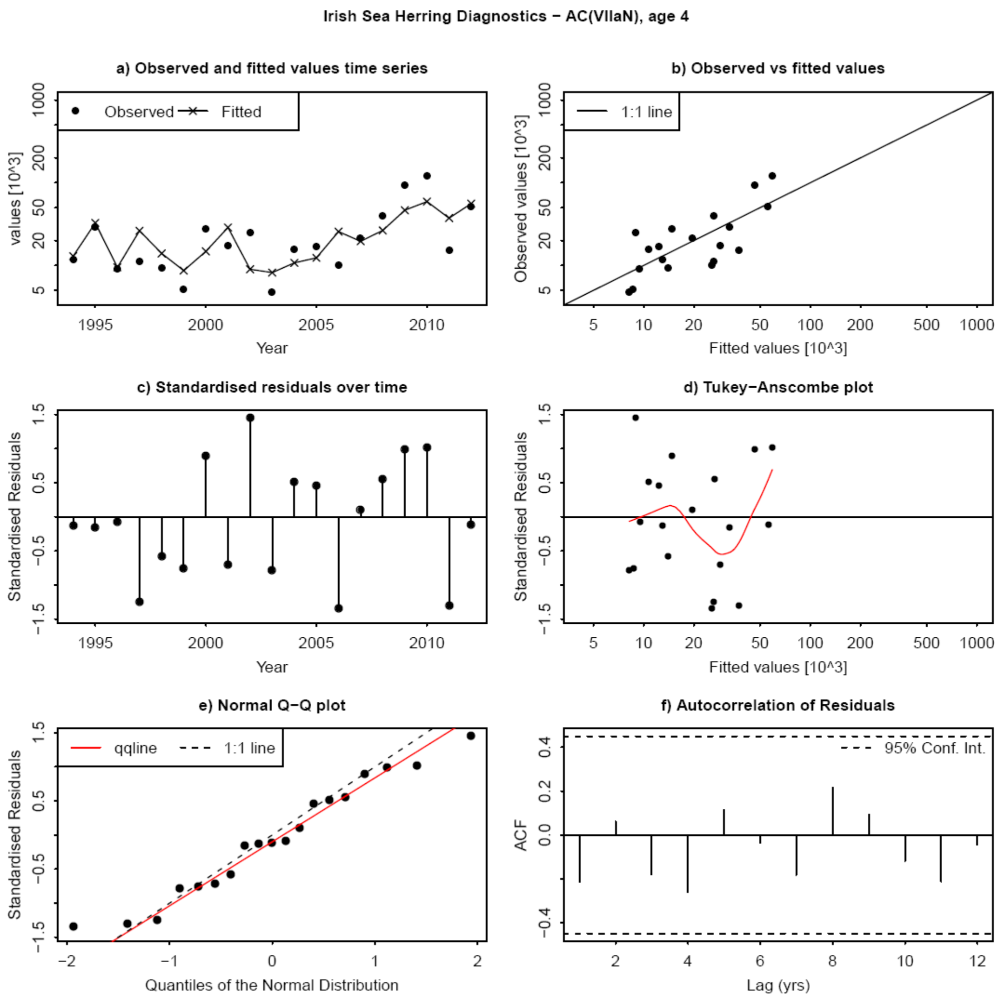


Figure 7.6.12 Herring in Division VIIa North (Irish Sea). FLSAM run output. Diagnostics of model fit to acoustic survey (AC(VIIaN)) data at age4.

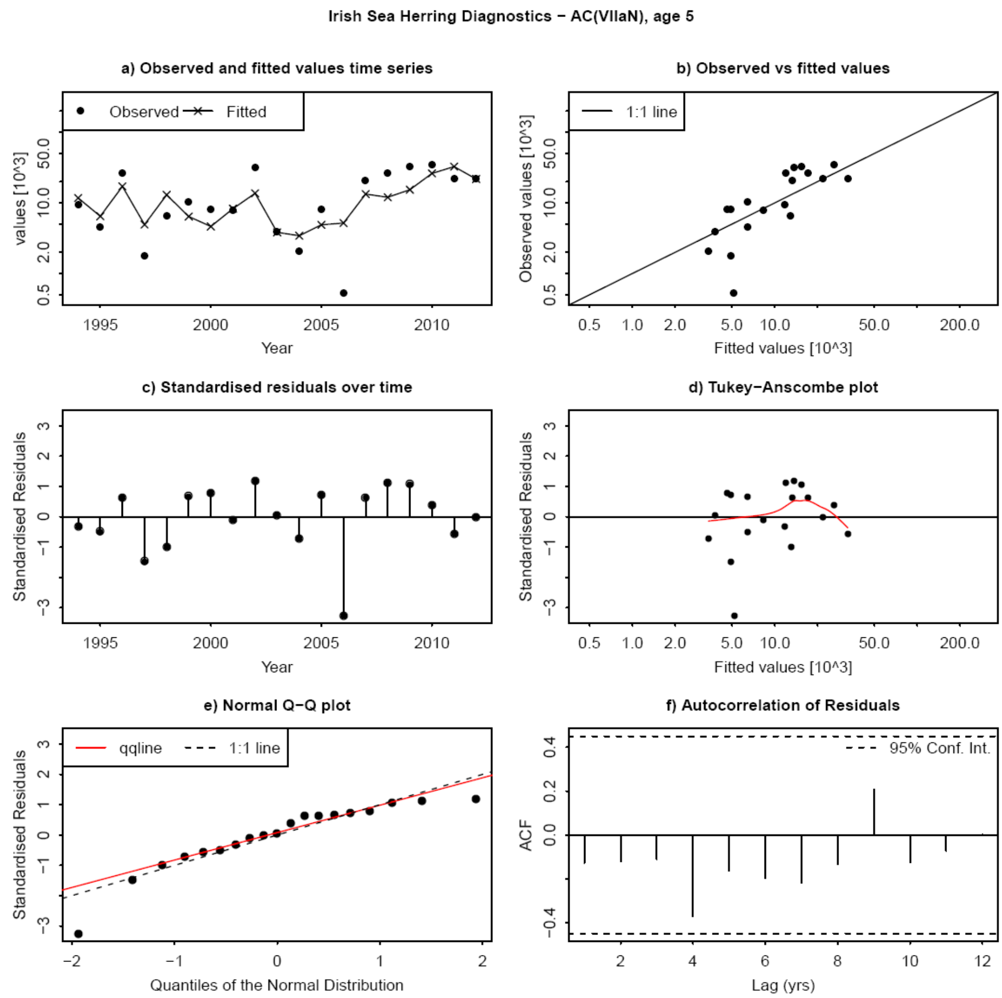


Figure 7.6.13 **Herring in Division VIIa North (Irish Sea). FLSAM run output. Diagnostics of model fit to acoustic survey (AC(VIIaN)) data at age5.**

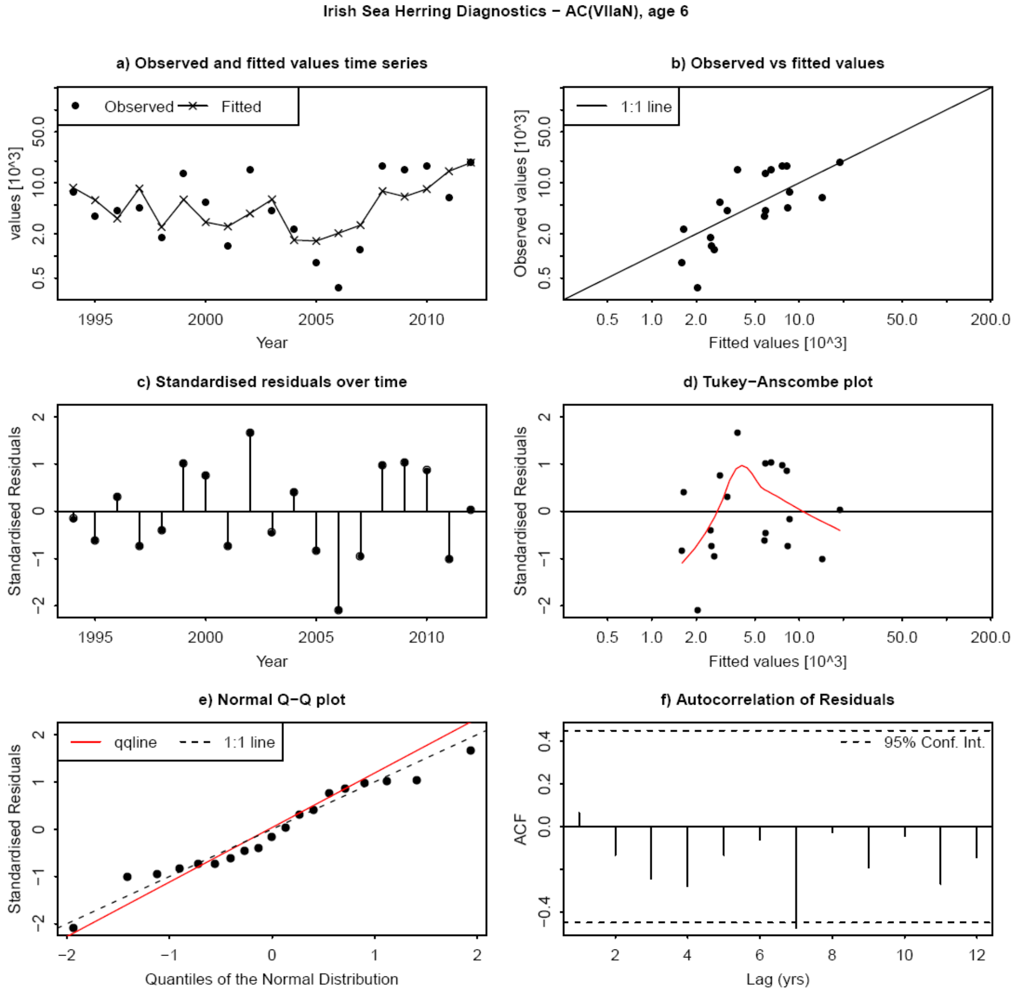


Figure 7.6.14 Herring in Division VIIa North (Irish Sea). FLSAM run output. Diagnostics of model fit to acoustic survey (AC(VIIaN)) data at age6.

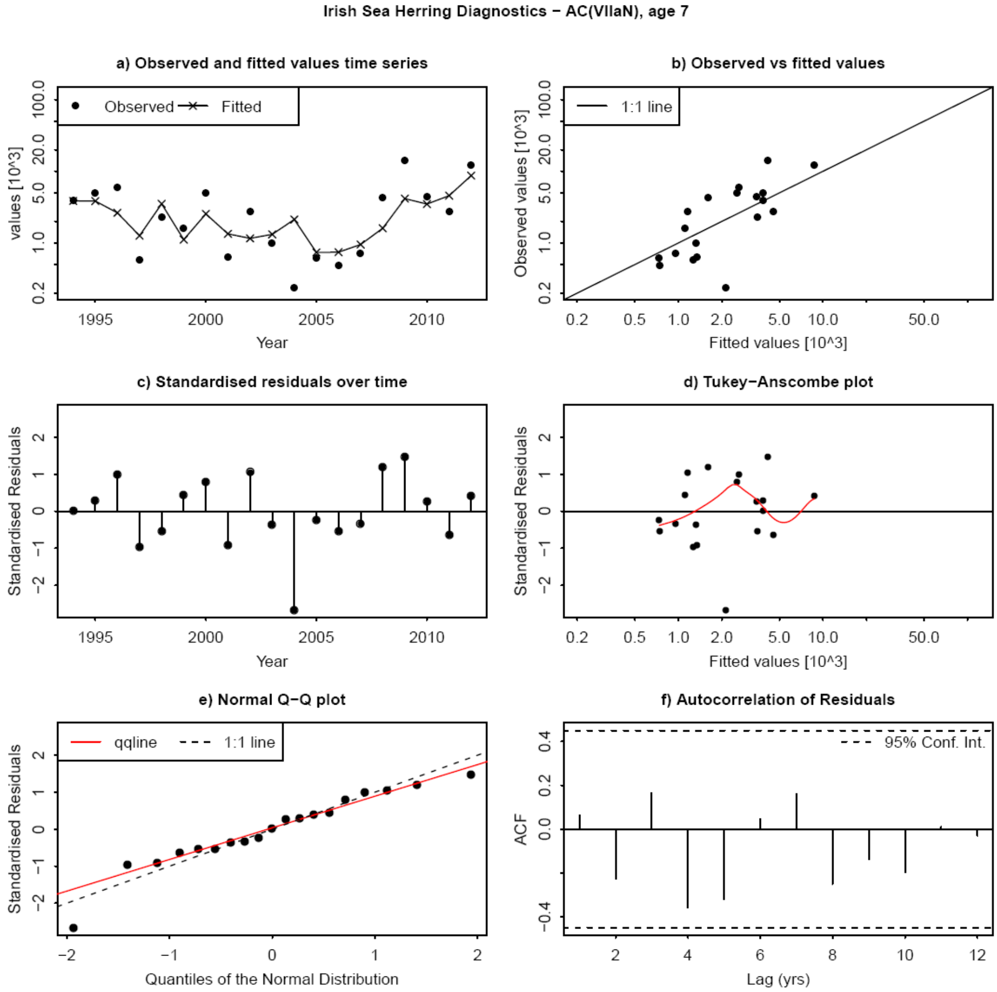


Figure 7.6.15 **Herring in Division VIIa North (Irish Sea). FLSAM run output. Diagnostics of model fit to acoustic survey (AC(VIIaN)) data at age7.**

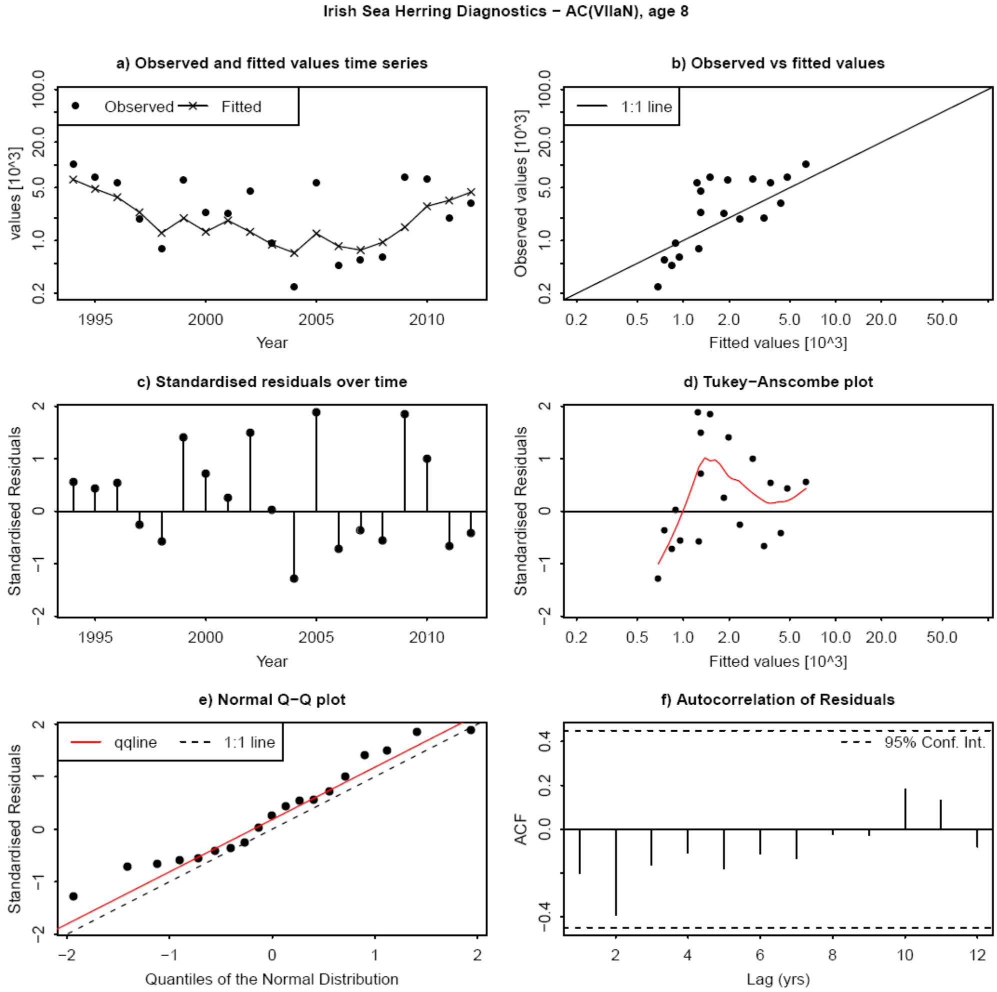


Figure 7.6.16 **Herring in Division VIIa North (Irish Sea). FLSAM run output. Diagnostics of model fit to acoustic survey (AC(VIIaN)) data at age8.**

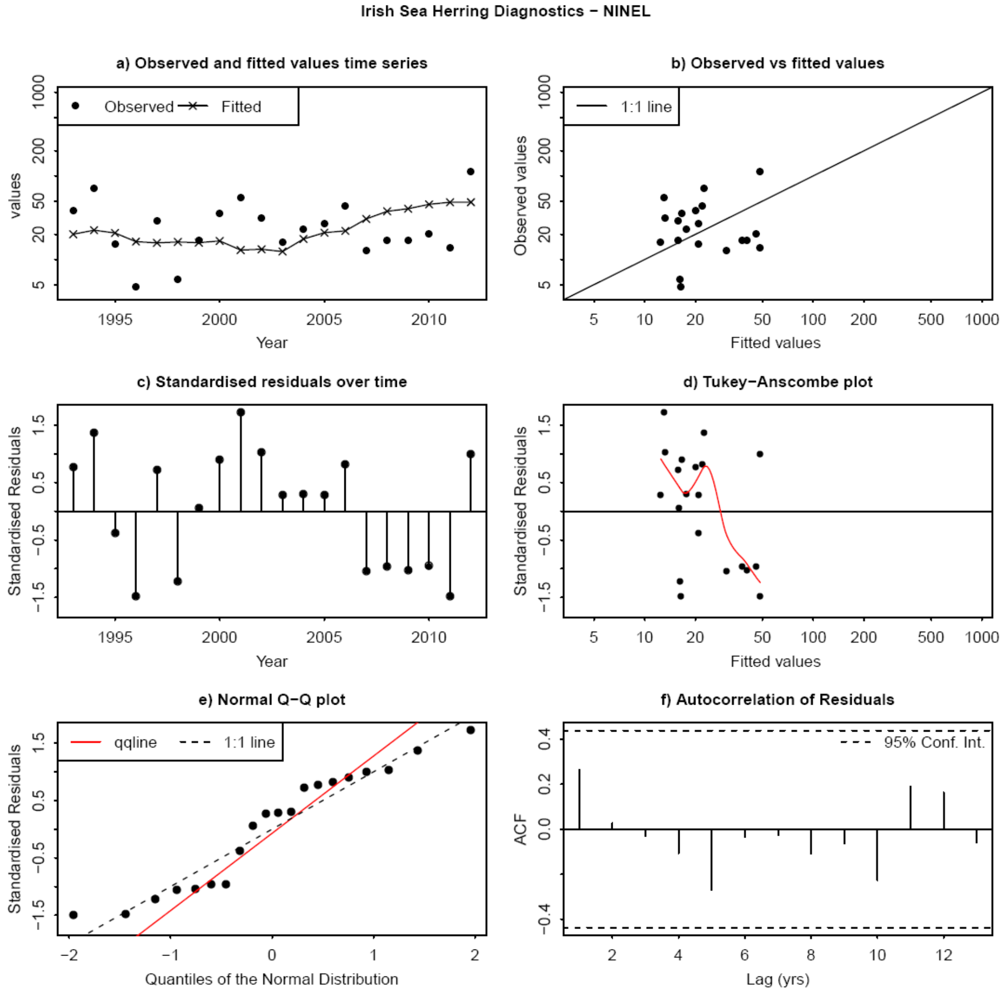


Figure 7.6.17 Herring in Division VIIa North (Irish Sea). FLSAM run output. Diagnostics of model fit to larval survey (NINEL).

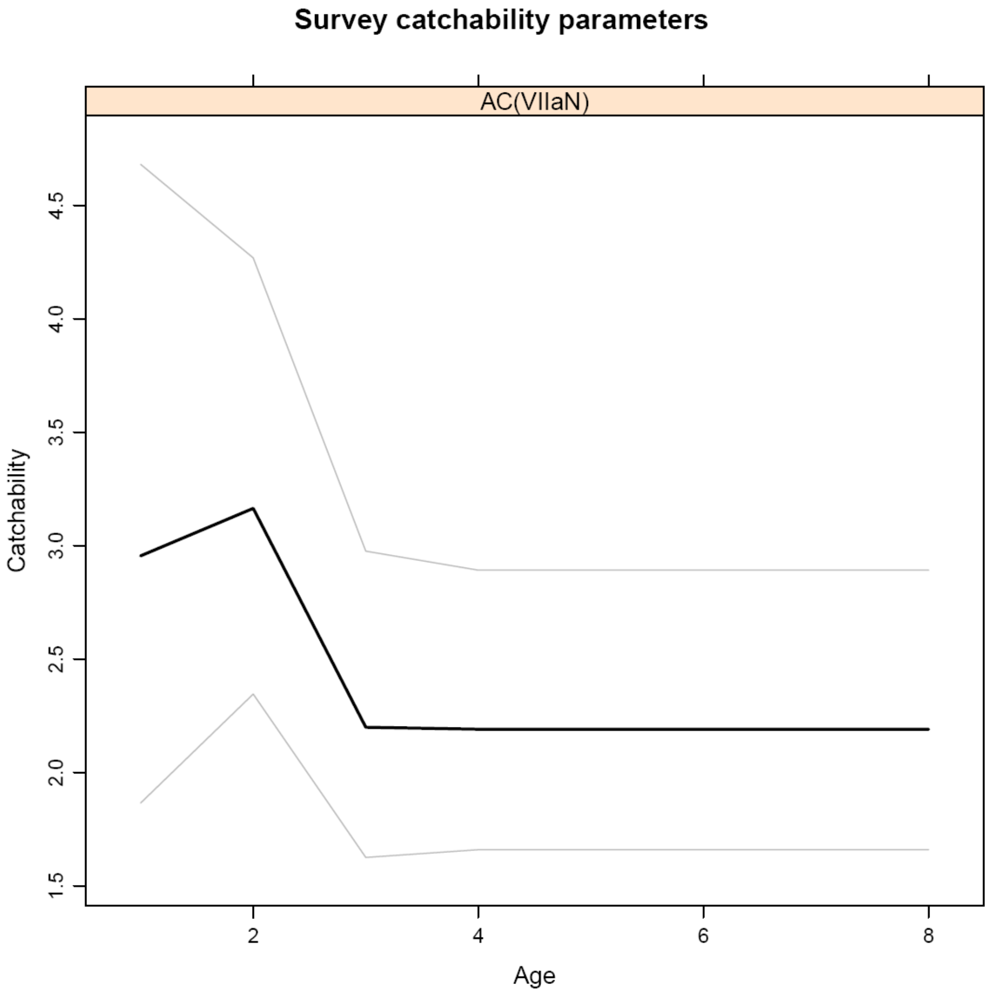


Figure 7.6.18 Herring in Division VIIa North (Irish Sea). FLSAM run output. Survey catchability parameter from the acoustic survey AC(VIIaN).

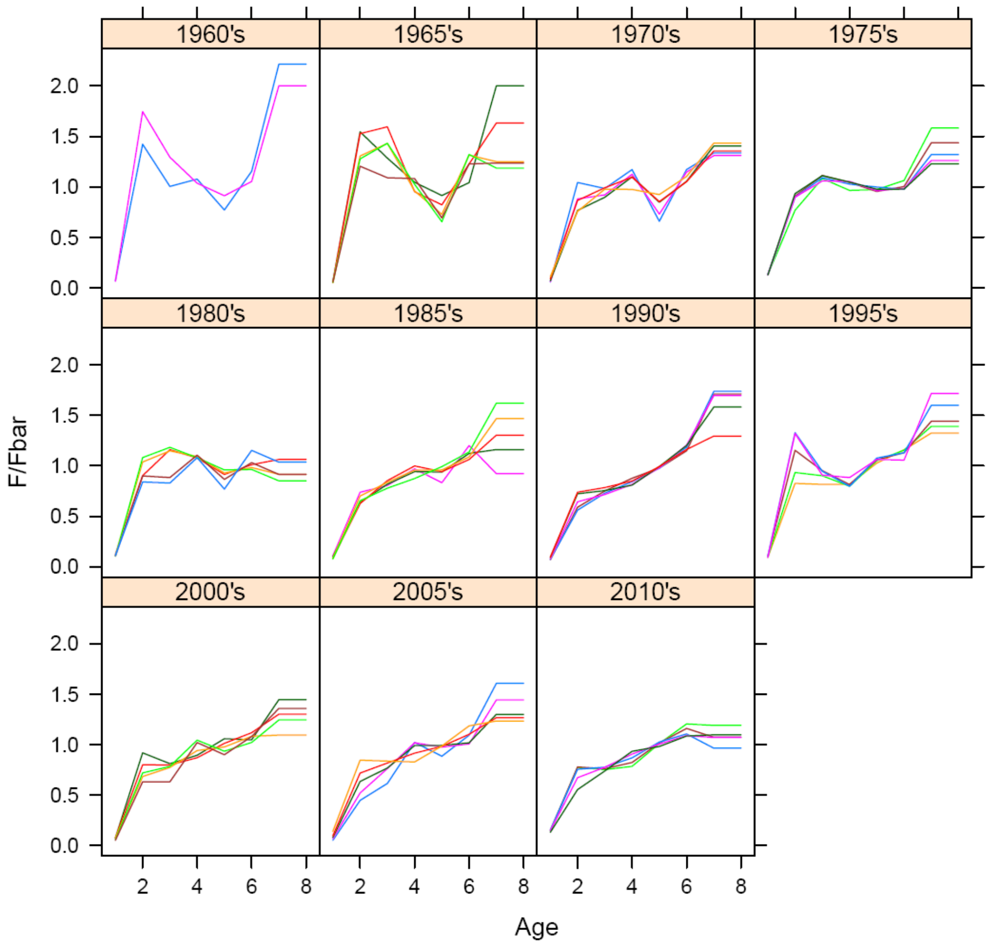


Figure 7.6.19 **Herring in Division VIIa North (Irish Sea). FLSAM run output. Selectivity of the fishery by pentad.**

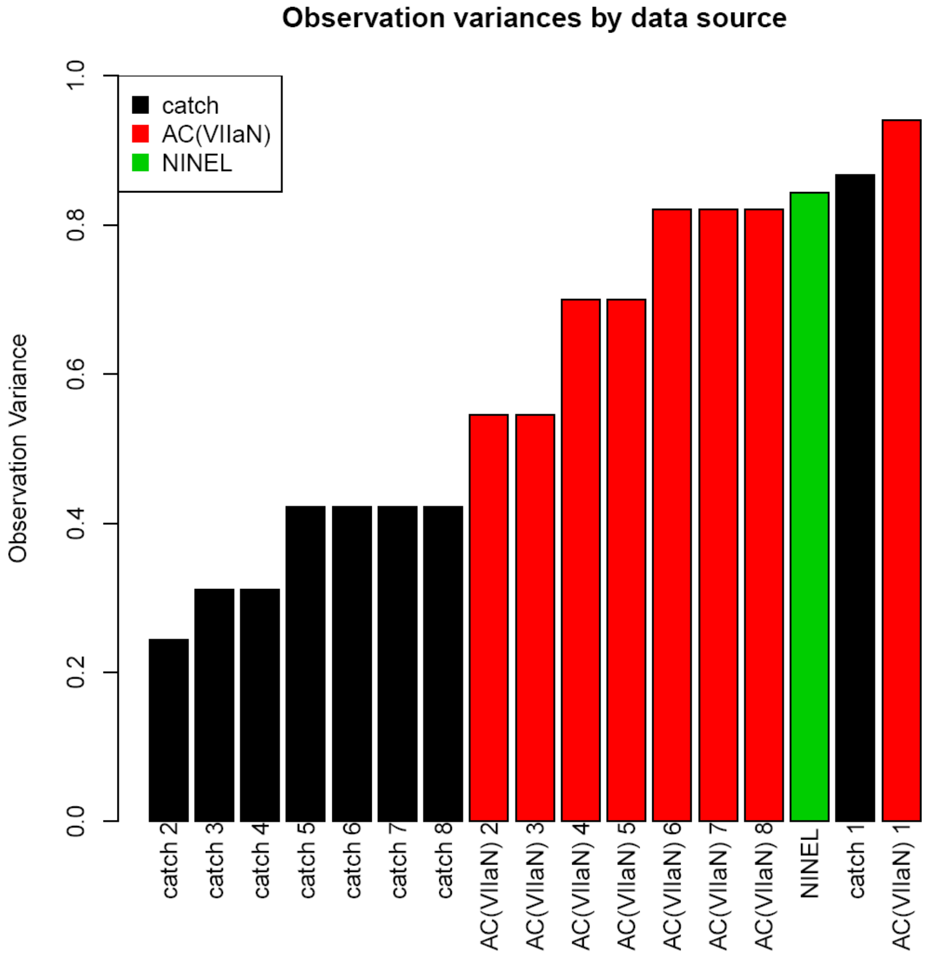


Figure 7.6.20 Herring in Division VIIa North (Irish Sea). Observation variances of all the data sources fitted in the FLSAM assessment model.

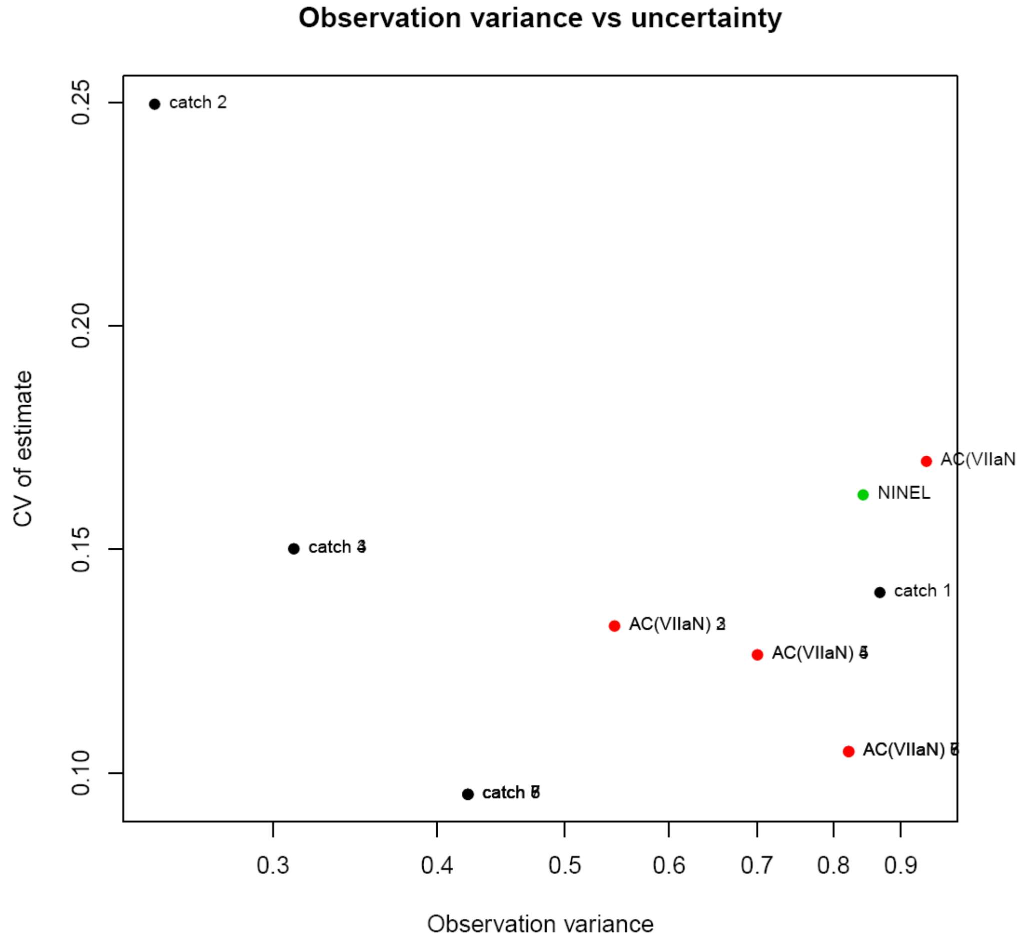


Figure 7.6.21 **Herring in Division VIIa North (Irish Sea). Observation variances vs uncertainty of the data sources fitted in the FLSAM assessment model.**

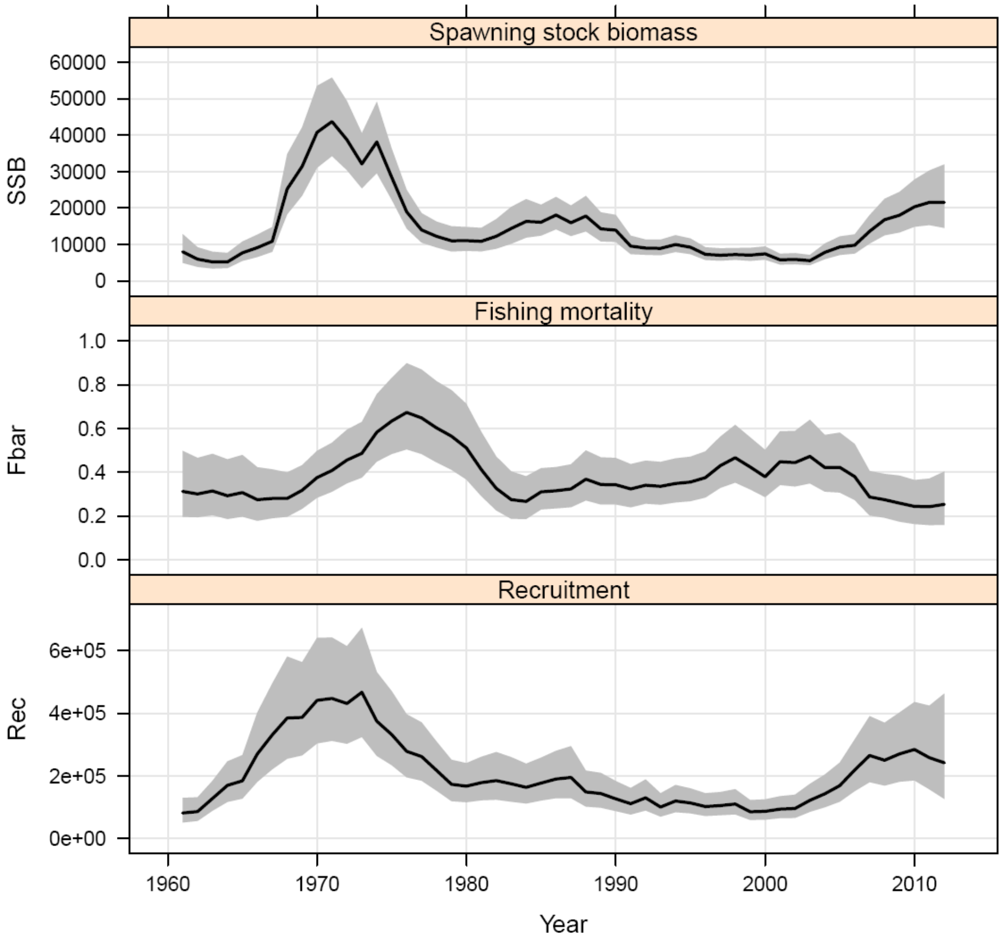


Figure 7.6.22 Herring in Division VIIa North (Irish Sea). Stock trends from the final FLSAM run, with 95% confidence intervals. Summary of estimates of spawning stock at spawning time, recruitment at 1-ring, mean $F_{4\text{-}6}$.

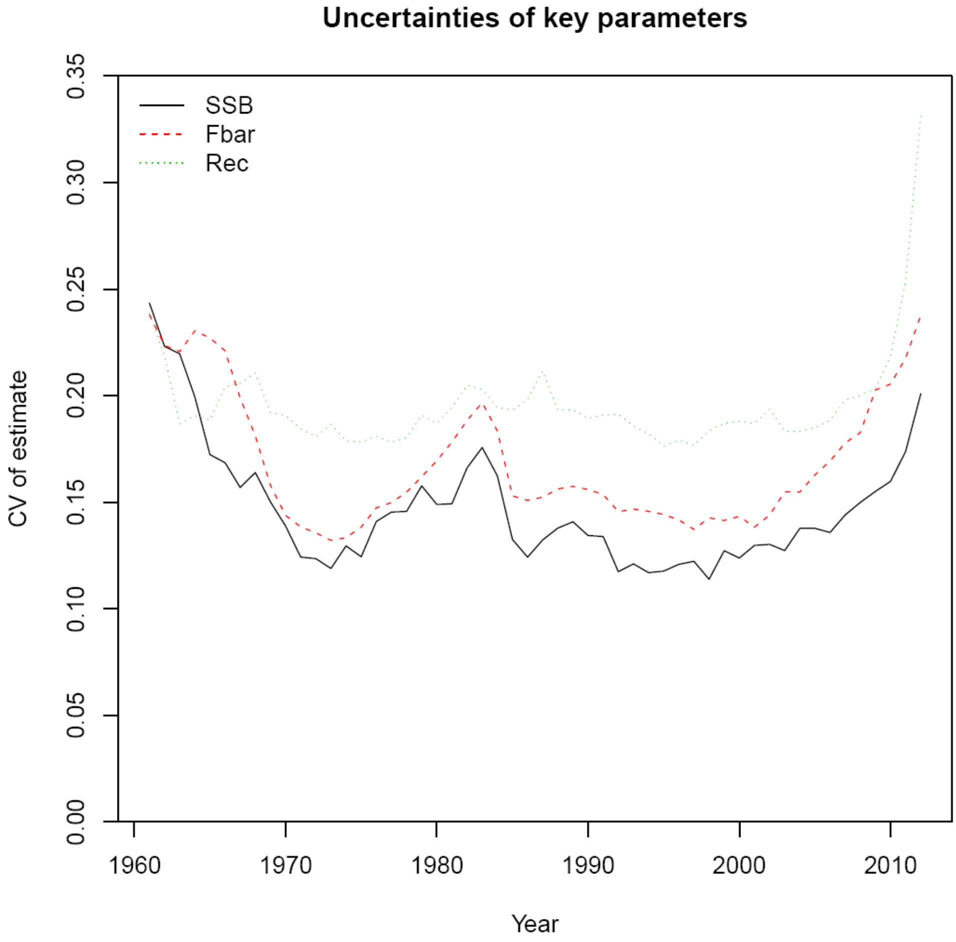


Figure 7.6.23 Herring in Division VIIa North (Irish Sea). Uncertainty of stock parameter estimates from the final FLSAM assessment. Rec = recruitment age 1.

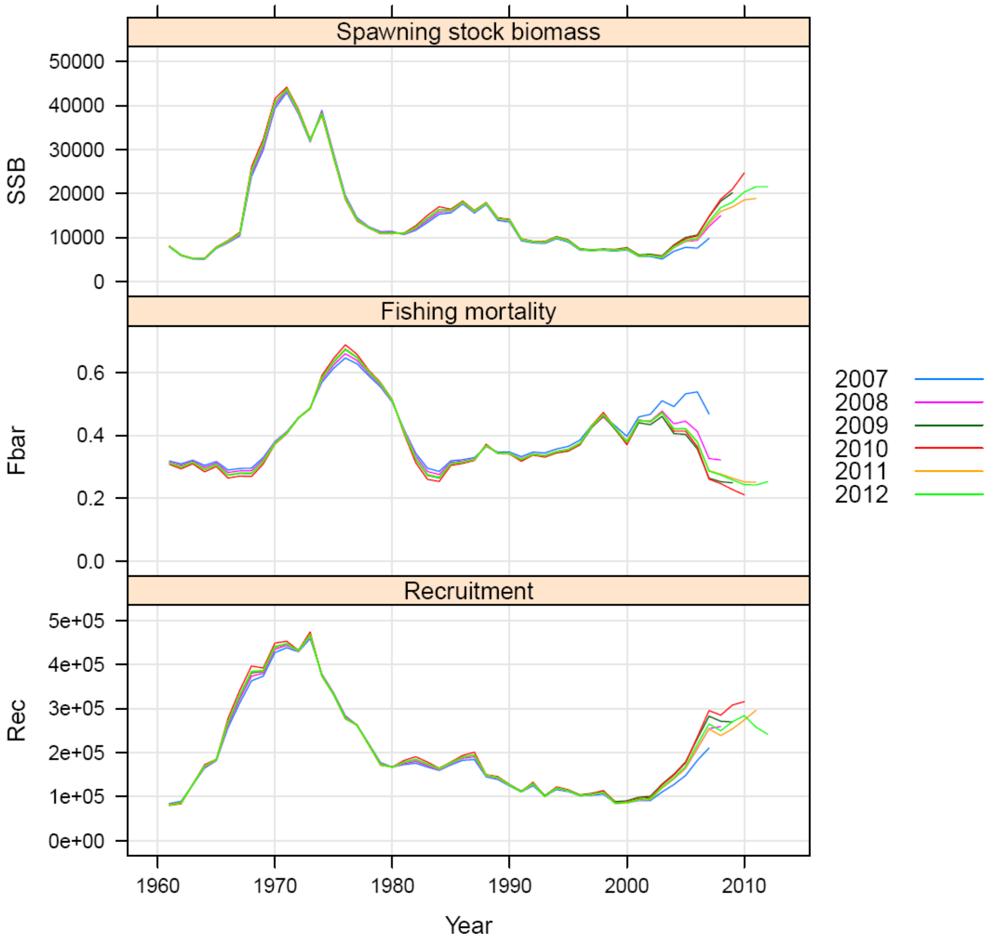


Figure 7.6.24 Herring in Division VIIa North (Irish Sea). Analytical retrospective patterns (2012 to 2007) of SSB, recruitment and mean $F_{4\text{-}6}$ from the final FLSAM assessment.

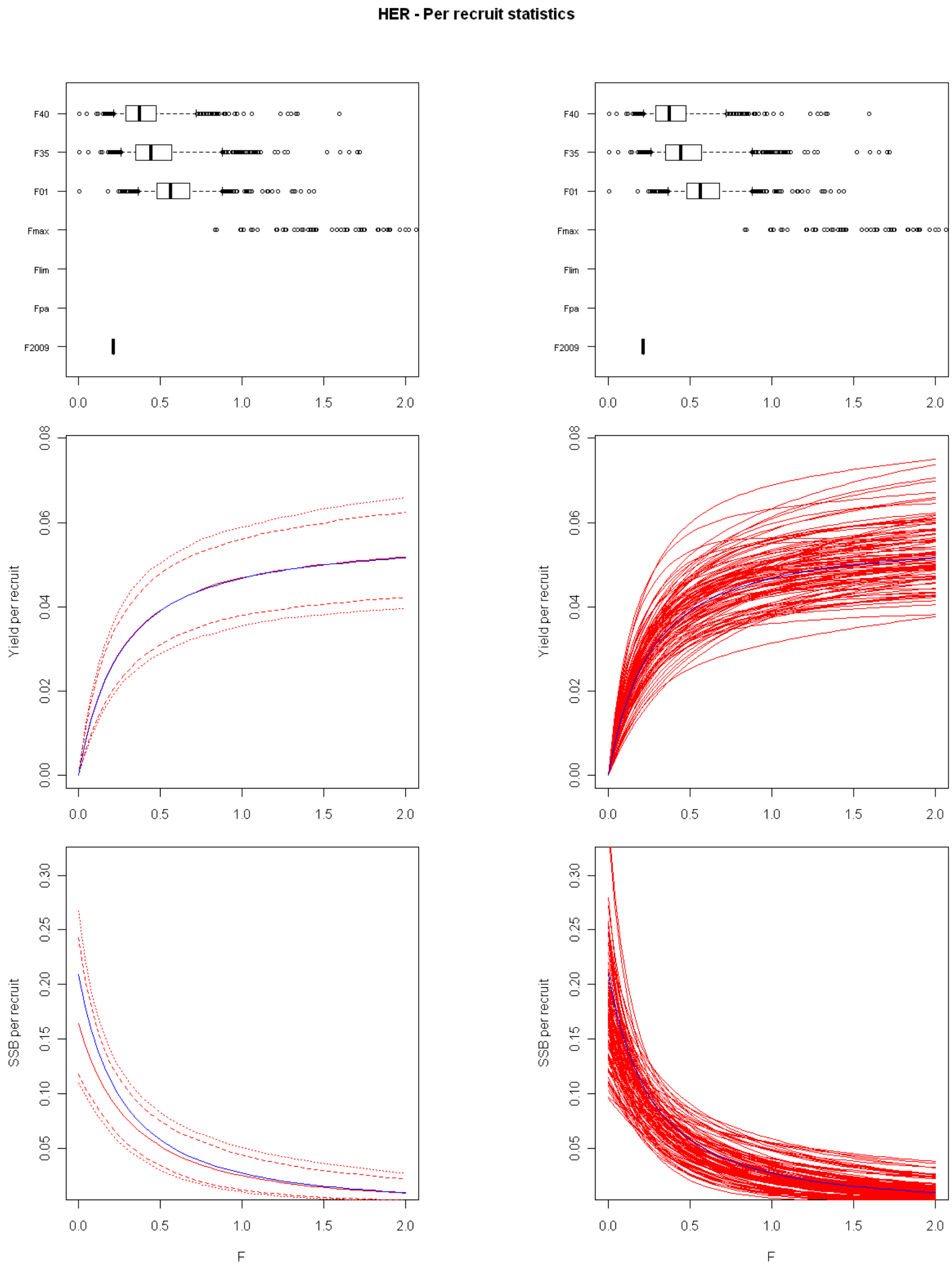


Figure 7.7.1 Herring in Division VIIa North (Irish Sea). F reference points and yield-per-recruit and SSB-per-recruit against mortality.

8 Sprat in the North Sea

8.1 The Fishery

8.1.1 ACOM Advice Applicable to 2012 and 2013

There have never been any explicit management objectives for this stock. The TAC set for 2012 was 161 500 t. The bycatch quota of herring (EU fleet) was set at 17 900 t. Also for 2013, a TAC was set at 161 500 t. The 2013 herring bycatch quota is 14 400 t.

8.1.2 Catches in 2012

Catch statistics for 1996–2012 for sprat in the North Sea by area and country are presented in Table 8.1.1. Catch data prior to 1996 are considered unreliable (see Stock Annex). As in previous years, the small catches of sprat from the fjords of western Norway are not included in the catches for the North Sea, due to uncertainties in stock identity. Total catches for the North Sea in 2012 were 85 656 t (the WG estimate). This is a 36% reduction compared to 2011, and 40% below the average for the time series. The Danish catches represent over 80% of the total catches.

In 2012 the catches were taken in IVb and IVc. The spatial distribution of landings had changed somewhat since 2010-2011, as no catches were taken in IVa, and the proportion taken in IVc was reduced: 91% was taken in IVb and 9% in IVc. Only small catches were landed in the first and second quarter in 2012, while majority of landings were taken in the 4th quarter (Table 8.1.2). Quarterly and annual distribution of catches per rectangle is seen in Figures 8.1.1a-d and Figure 8.1.2. Catch distribution 1997-2012 is shown in Figure 8.1.3.

8.1.3 Regulations and their effects

The Norwegian vessels are not allowed to fish in the Norwegian zone until the quota in the EU-zone has been taken. They are not allowed to fish in the 2nd quarter or July in the EU and the Norwegian zone. There is also a maximum vessel quota of 700 t when fishing in the EU-zone. A herring by-catch of up to 10% in biomass is allowed in Norwegian sprat catches. In the Danish sprat catches, a by-catch of up to 40% in biomass of herring is allowed. Most sprat catches are taken in an industrial fishery where catches are limited by herring by-catch restrictions. By-catches of herring are practically unavoidable except in years with high sprat abundance or low herring recruitment. By-catch is especially considered to be a problem in area IVc.

8.1.4 Changes in fishing technology and fishing patterns

No major changes in fishing technology and fishing patterns for the sprat fisheries in the North Sea have been reported. From about 2000, Norwegian pelagic trawlers were licensed to take part in the sprat fishery in the North Sea. In the first years the catches taken by trawlers were low but in the last years their share of the total Norwegian catches has increased.

8.2 Biological composition of the catch

Only data on by-catch from the Danish fishery were available to the Working Group (Table 8.2.1). The Danish sprat fishery has recently been conducted with a low by-catch of herring. The total amount of herring caught as by-catch in the sprat fishery has mostly been less than 10% except in last year (2012: 14%) and in 2008 (11%).

As there are very few 5+-year olds in the catches, the mean weight of this age group is frequently missing in the historic data. To eliminate the problem with missing data, ages 4 and 5+ were joined in a 4+ group and mean weight at age of this group re-estimated as the weighted average of mean weights of the two groups.

The estimated quarterly landings at age in numbers for the period are presented in Table 8.2.2. In 2012 the one-year old sprat contributed 68% of the total landings, which is above the average contribution (60% since 1996, range: 27-94%). 2-year olds contributed in 2012 with 26% of the total landings, leaving 6% of the contribution to 0- and 3+- year olds.

Mean-weight-at-age (g) in the landings in 2012 were on similar level as in the last five years for age 2-3, and slightly lower for age 1(Table 8.2.3).

Denmark and Norway provided age data of commercial landings in 2012 (Table 8.2.4), and these are the samples used for raising catches in Intercatch. All the quarters were covered. The small fishery in quarter 2 was sampled by only one sample. The sample data were used to raise the landings data from the North Sea. The landings by the Netherlands, Sweden, UK-England, UK-Scotland and Germany were minor and unsampled. The sampling level (no. per 1000 t landed) in 2012 (1.1) was greatly improved compared to 2007-2011 (0.4 samples for 2007-2010, and 0.6 for 2011) because of the newly implemented sampling programme for collecting haul based samples from the Danish sprat fishery. The required sampling level in the EU directive for the collection of fisheries data (Commission Regulation 1639/2001) is 1 sample per 2000 tonnes (also see Stock Annex).

The number of samples, both length and length-age samples, is shown in Table 8.2.5 and Figure 8.2.1. These are the samples used for the assessment.

8.3 Fishery Independent Information

8.3.1 IBTS Q1 (February) and Q3

Sprat of age 1 and 2 were mostly found in the south-east, with the highest concentrations in the most eastern parts of the distribution area (Figure 8.3.1a-c). 3+-ringers were also found in the south-eastern part of the North Sea. Table 8.3.1 gives the time series of IBTS indices by age. The indices from 1997 and 2000-2012 have been updated by ICES since HAWG 2012.

IBTS Q3 survey indices were also used in the assessment.

8.3.2 Acoustic Survey (HERAS)

The sprat in 2012 was mostly found in the eastern and southern parts of the North Sea, with highest abundances in the south-eastern part as well as one rectangle bordering the English Channel (maximum) and one at the eastern coast of UK (Figure 8.3.2). Total abundance in 2012 was estimated by WGIPS (see section 1.4.2) to be 45 466 million individuals and the biomass 409 000 tonnes (Table 8.3.2). This is a decrease of about 12% in terms of biomass when compared to last year, but the fifth highest biomass on record (ICES CM 2012/SSGESST:22). In terms of abundance, it is the fourth highest estimate. In 2006–2008, there was a downward trend in North Sea sprat, whereas in 2009-2012 the biomass level has been fairly high and stable. The majority of the stock consists of mature sprat. The sprat stock is dominated by 1- and 2-year old fish representing 80% of the biomass in 2012 (range observed 80%-99%).

Figure 8.3.3 compare the three survey indices for 1-year-olds, and Figures 8.3.4-7 show external and internal consistency of the survey indices.

8.4 Mean weights-at-age and maturity-at-age

Data on maturity by age, mean weight- and length-at-age during the 2012 summer acoustic survey are presented in the WGIPS report (ICES CM 2012/SSGESST:22). Mean weights-at-age and maturity from the catch data are given in Tables 8.2.3 and 8.6.1.

8.5 Recruitment

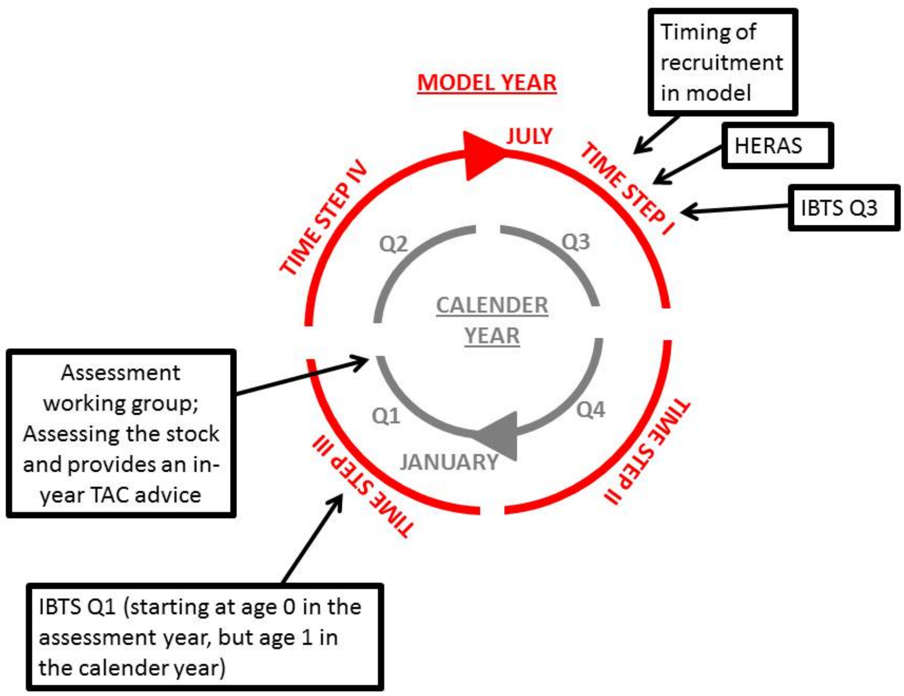
The IBTS (February) 1-group index (Table 8.3.1) is used as a recruitment index for this stock. The incoming 1-group in 2013 (2012 year class) was estimated to be the 12^{th} lowest in the time series, and well below the average of the time series. In 2012 the 1-group was 4^{th} highest of the time series.

8.6 Stock Assessment

The stock assessment was benchmarked in February 2013 (ICES CM 2013/ACOM:XX).

In-year advice is the only possible type of advice for this short-lived species with a fishery dominated by 1- and 2-year-old fish. This, however, requires information about incoming 1-year-old fish. In order to meet this requirement and to come up with a model that logically matches the natural life cycle of sprat, the annual time-step in the model was shifted, relative to the calendar year, to a time-step going from July to June (see text table below). SSB and recruitment was estimated at July 1st. In figures and tables with assessment output and input, the years refer to the shifted model year (July to June) and in each figure and table it is noted whether model year or calendar year apply (when the model year is given the year refers to the year at the beginning of the model year; for example: 2000 refers to the model year 1 July 2000 to 30 June 2001). The following schematic illustrates the shifted model year relative to the calendar year and provides an overview of the timing of surveys etc.

Model year		calendar year	
2000	Season 1	2000	Quarter 3
2000	Season 2	2000	Quarter 4
2000	Season 3	2001	Quarter 1
2000	Season 4	2001	Quarter 2



8.6.1 Input data

8.6.1.1 Catch data

The age distribution of quarterly catches of less than 5000 tonnes was very poorly estimated: less than 5 samples were taken from these catches (from a total of 148 quarters sampled). As these catches are too small to have any major effect on the stock, they were removed from the likelihood estimation to avoid problems caused by the low sampling level.

Biological samples taken by Norway (2005 to present) and Denmark (1991 to present) were re-analysed. Briefly, biological data from both countries were joined in a dataset and yearly and quarterly age-length keys (ALK's) produced using the method of Rindorf and Lewy (2001). When sufficient data were available, separate ALK's were produced for each 4-rectangle area. If the data were insufficient, 16-rectangle areas were used. This level was followed by a quarterly, half-yearly and yearly all North Sea ALK. The ALK was applied to the length samples and the age composition investigated using the same hierarchical method. Age compositions were only used when a minimum of 5 length samples were recorded at a given level, otherwise the next hierarchical level was used. The spatio-temporal distribution of the total international catches were assumed to follow that of the Danish catches (comprising > 90% of the catches in the last decade) and the number caught by year, age group and quarter estimated along with the mean weight at age (Tables 8.2.2-3, Figure 8.6.2).

Information on catch data is provided in Tables 8.1.1-2 and in Figures 8.1.1, 8.1.3 and 8.6.1. Sampling effort is presented in Table 8.2.5 and Figure 8.2.1.

8.6.1.2 Weight at age

The mean weights at age observed in the catch are given in Table 8.2.3 by quarter. It is assumed that the mean weights in the stock are the same as in the catch. The time series of mean weight in the catch and in the stock is shown in Figure 8.6.2.

8.6.1.3 Surveys

Three surveys were included, IBTS Q1 (1974-present), IBTS Q3 (1991-present) and HERAS (Q3) (2001-present). HERAS indices are presented in Table 8.3.2. 0-group (young-of-the-year) sprat is unlikely to be fully recruited by the time of IBTS Q3 and HERAS, and this age group was therefore excluded from runs. Internal consistency in survey data and external consistency between surveys are presented in Figures 8.3.3-7.

8.6.1.4 Natural mortality

Natural mortality was estimated as the average by age and quarter for the period 1991 to 2011 as estimated by the multispecies assessment WG (ICES CM 2011/SSGSUE:10). Proportion mature fish was derived from the 1st quarter IBTS excluding data from Sweden, which had substantially lower proportions mature than the remaining countries. Maturity of age 4+ was set to 1. Natural mortalities and maturities are given in Tables 8.6.1-2.

Natural mortality by quarter and year as estimated in the multispecies model and input data for the multispecies model is given in the WKSPRAT report (Figures 4.4.1-2).

8.6.1.5 Proportion mature

Annual varying maturity ogives were used after 1994 (Table 8.6.1). More details about the maturity staging are given in Section 4.6.3.2 in the WKSPRAT report (ICES CM 2013/48).

8.6.2 Stock assessment model

The assessment was made using SMS (Lewy and Vinther 2004) with quarterly time steps. Three surveys were included, IBTS Q1 ages 1-4+, IBTS Q3 ages 1-3 and HERAS (Q3) ages 1-3. 0-group sprat is unlikely to be fully recruited to the GOV (IBTS) or HERAS in Q3 and this age group was excluded from runs. External consistency IBTS Q1 and IBTS Q3 is shown in Figure 8.3.3.

The model converged and fitted the catches of the main ages caught in the main quarters (the periods with most samples) reasonably well (ages 1-2, seasons 1 and 2, Table 8.6.3). The IBTS Q1 had a low CV as did the HERAS survey, whereas the CV of IBTS Q3 was somewhat higher (Table 8.6.3). There were no obvious patterns in the residuals, apart from a series of strong negative residuals of the youngest age group (1 winter ring) in IBTS Q1 in the years 1974 to 1982 (Figs. 8.6.3-4). This was presumably caused by the lower catchability of this age group to gears different from the GOV, which was used as the primary gear from 1983 onwards. The IBTS Q1 for 1 winter ringers was therefore excluded for the period 1974-1982. Common CVs were estimated for the groups: 0 to 3 ringers in IBTS Q1 and 2 and 3 ringers in HERAS. For all other age groups age specific CVs were estimated.

The final outputs detailing trends in mean F, SSB and recruitment are given in Figures 8.6.5-8. From these figures it is apparent that recent high catch levels have occurred simultaneously with high SSBs and recruitment.

8.7 Reference points

The stock and recruitment relationship generated from the model output data indicates an increasing relationship between the SSB and recruitment, and no breakpoint for a hockey stick relationship could be estimated by the model. B_{lim} was not sensitive to choice of approach (ICES CM 2003/ACFM:15), and ended up between 80 000 and 100 000 t. The following approaches were attempted: Increasing relationships, a "cloud" for data from 1991 onwards (B_{lim} = B_{loss} =82 000 t), and a hockey stick with a predefined breakpoint (where years of very high recruitment preferentially should be above B_{lim} and years of very low recruitment below B_{lim}). The lowest B_{lim} came out of the B_{loss} approach. It was decided that ensuring that years of very good recruitment occurred when the stock was above B_{lim} and years of very low recruitment occurred when the stock was below B_{lim} was an important criteria given the appearance of the relationship. Hence, a B_{lim} of 90 000 t (Fig. 8.7.1) and B_{pa} of 142 000 t was agreed. B_{pa} is defined as the upper 90% confidence interval of B_{lim} and calculated based on a terminal SSB CV of 0.28.

8.8 State of the Stock

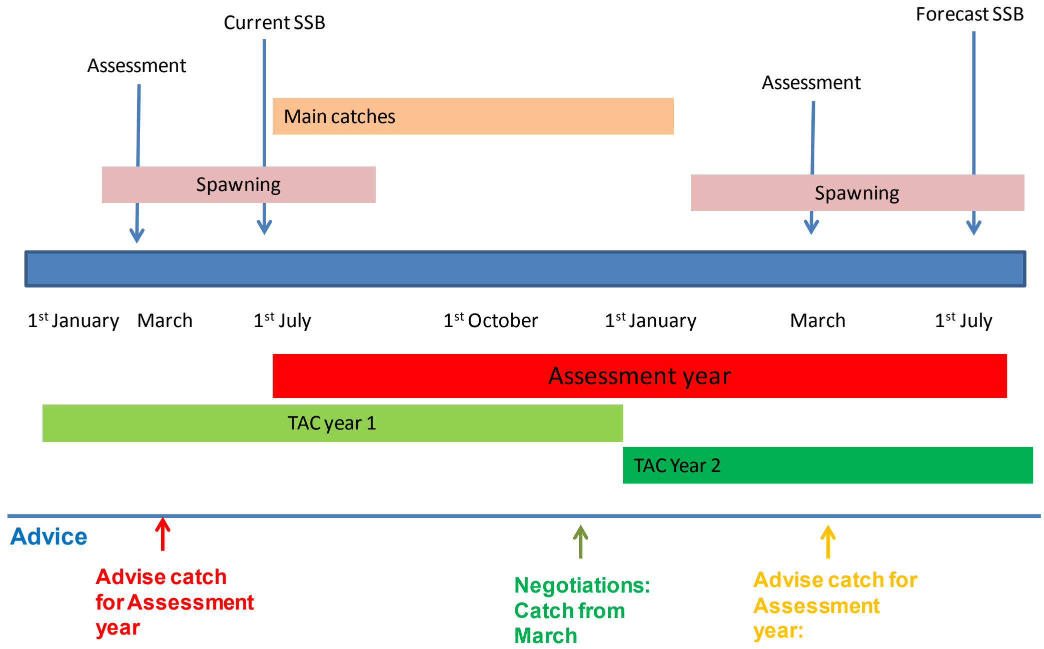
The sprat stock seems to be increasing judged both by surveys individually and by the assessment performed. The stock appears to have been well above Bpa since 2005, with the exception of 2007 where SSB was approximately at Bpa. Since 2009 SSB has remained more or less stable around 300 thousand tonnes and fishing mortality has been relatively low (0.5 – 0.7).

Stock summary from the assessment output can be found in Table 8.6.5 and Figure 8.6.8.

8.9 Short-term projections

MSY escapement strategy is a well practiced approach for short-lived species and is currently applied to capelin and Norway pout stocks. WKSPRAT suggested using the reference points described in the section above and 3 year averages of weight-at-age, proportion mature, and the natural mortality for the incoming year (Table 8.9.1). By the time of the assessment (HAWG is held in March) information on the catches in quarter 1 and 2 (Jan – Jun) will not be available. Instead, the group suggests using a value that corresponds to x % of the catch in quarters 3 and 4, where x is estimated from the catch in quarter 1 and 2 relative to the combined catch of quarter 3 + 4 averaged over the three previous years (in total the catch should not exceed the TAC). Lastly, the lower 25% fractile of the mean recruitment over the last 20 years was used as input in the projection. This differs from the suggestion made at the benchmark (geometric recruitment mean for the entire time-series) and encompasses a more precautionary approach to uncertainty in the projection of recruitment, especially as this is a short-lived species where the recruitment is an important driver of the yield.

Since the catch projections are now based on an assessment year which is from July 1st to June 30th each year rather than the traditional TAC years of January 1st to December 31st the following figure (see below) illustrates the timing of steps in the process in relation to the spawning an fisheries of North Sea sprat.



For the short-term projections a number of assumptions are made for the projection year. Firstly it assumed that 50% of the young sprat (1 winter ring) are mature (input maturity ogive) and contribute the same quality of eggs as older fish. In addition, there is very little to no selection for 0-groups in the fishery. In 2013 the SSB was 78,000t above B_{pa}.

Using the input and assumptions detailed above the projection for an F=0 is an SSB in 2014 of 234 000t (Table 8.9.2, Fig. 8.9.1). From the various options available the $F_{MSY\text{-}escapement}$ = 2.5 resulting in an SSB_{2014}= 142 000t and a catch of 194 000t and an F=M=1.3 results in an SSB_{2014} = 161 000t and a catch of 144 000t.

8.10 Quality of the assessment

The assessment model converged.

The data used within the assessment, the assessment methods and settings were carefully scrutinized during the 2013 benchmark (WKSPRAT: ICES CM 2013/ACOM:48). A complete overview of the choices made during the benchmark can be found in the ICES WKSPRAT 2013 report (ICES CM 2013/ACOM:48) and these are described in the North Sea Sprat Stock Annex (Annex 9). The 2013 assessment was classified as an update assessment and was carried out following these procedures and settings.

The assessment shows high CVs for the catches but lower CVs for surveys. This is likely to be due to low sampling effort in several years in spite of substantial catches taken. The trend over time in CVs of F, SSB and recruitment are in general low (see Table 8.6.3 and Figure 8.6.5). There was some concern in WKSPRAT that the spatial distribution of the biological samples taken from the fishery did not always follow the catch distribution. This represents a problem if there are spatial differences in growth and age composition and may decrease the consistency between years of the cohorts signal in the catches. To remedy the problem, the existing Danish and Norwegian biological samples were used to produce spatially explicit age compositions and weight at age whenever the sampling level allowed. Ideally, this should be coupled with total catches per quarter and statistical rectangle.

8.11 Management Considerations

A management plan needs to be developed.

The ICES approach for MSY-based management of a short-lived species like sprat is an escapement strategy, i.e. to maintain SSB above MSY Bescapement after the fishery has taken place. This does not include an upper limit on F. A management strategy evaluation is needed to evaluate the long-term consequences for the stock of using MSY escapement strategy, a strategy that may suggest using extremely high fishing pressure. Sprat is an important forage fish, thus also multispecies considerations should be made.

The sprat stock in the North Sea is dominated by young fish. The stock size is mostly driven by the recruiting year class. Thus, the fishery in a given year will be dependent on that year's incoming year class.

In the forecast table for North Sea herring, industrial fisheries are allocated a bycatch of approx 14 400 t of juvenile herring in 2013. It is important to continue monitoring bycatch of juvenile herring to ensure compliance with this allocation.

Catches in recent years have been well below the advised and agreed TAC. Management of this stock should consider management advice given for herring in Subarea IV, Division VIId, and Division IIIa.

8.11.1 Stock units

North Sea sprat is considered an independent stock. This is discussed in WKSPRAT 2013 (ICES CM 2013/ACOM:48). In addition, there are several peripheral areas of the North Sea where there may be populations of sprats that behave as separate stocks from the main North Sea stock. Local depletion of sprats in such areas is an issue of ecological concern.

There is a necessity to determine whether the sprat in the North Sea (area IV) constitute a stock or whether they encompass one or both the adjoining populations of sprat (i.e. IIIa or VII (English Channel)). This is vital for establishing the correct assessment/stock units in the area.

8.12 Ecosystem Considerations

Multispecies investigations have demonstrated that sprat is an important prey species in the North Sea ecosystem. Many of the plankton-feeding fish have recruited poorly in recent years (e.g. sandeel, Norway pout). The implications of the environmental change for sprat and the influence of the sprat fishery for other fish species and sea birds are at present unknown.

In the North Sea, the key predators consuming sprats are included in the stock assessment, using SMS estimates of sprat consumption for each predatory fish stock, and estimates for seabirds. Impacts of changes in zooplankton communities and consequent changes in food densities for sprats are not included in the assessment, but it may be useful to explore the possibility of including this, or a similar proxy bottom-up driver, in future assessments.

In the North Sea, the retreat of *C. finmarchicus* and its ecosystem implications is probably the most intensely studied case of bottom up effects on fish stocks. Further details on the linkages between sprat and zooplankton in the North Sea are given in section 1.3.2. For more details, see WKSPRAT 2013 (ICES CM 2013/ACOM:38).

8.13 Changes in the environment

Temperatures in this area have been increasing over the last few decades. It is considered that this may have implications for sprat, although the magnitude or direction of such changes has not been quantified. Further details can be found in Section 1.8.

Table 8.1.1. North Sea sprat. Catches (' 000 t) 1996-2012. See ICES CM 2006/ACFM:20 for earlier catch data. Catch in fjords of western Norway excluded.
(Data provided by Working Group members except where indicated). These figures do not in all cases correspond to the official statistics and cannot be used for management purposes.
The IVb catches for 2000-2007 divided by IVbW and IVE can be found in ICES CM 2008/ACOM:02

Country	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
	Division IVa																
Denmark	0.3			0.7		0.1	1.1		*		*	0.8	*	*			
Norway														*		*	
Sweden						0.1											
UK (Scotland)																0.5	
Total	0.3			0.7		0.2	1.1		*		*	0.8	*	*		0.5	
	Division IVb																
Denmark	76.5	93.1	119.3	160.3	162.9	143.9	126.1	152.9	175.9	204.0	79.5	55.5	51.4	115.6	80.8	90.9	65.7
Norway	52.8	3.1	15.3	13.1	0.9	5.9	*		0.1		0.8	3.7	1.3	4.0	8.0	0.1	6.2
Sweden	0.5		1.7	2.1		1.4				*				0.3	0.6	1.1	1.8
UK(Scotland)				1.4								0.1		2.5	1.1	1.9	0.7
UK(Engl.&Wales)														*			
Germany																3.3	0.5
Netherlands																1.1	2.7
Total	129.8	96.2	136.3	176.9	163.8	151.2	126.1	152.9	176.0	204.1	80.3	59.3	52.7	122.4	90.4	98.4	77.5
	Division IVc																
Denmark	3.9	5.7	11.8	3.3	28.2	13.1	14.8	22.3	16.8	2.0	23.8	20.6	8.1	8.2	48.5	20.0	3.2
Norway		0.1	16.0	5.7	1.8	3.6					9.0	2.9		1.8	3.2	9.9	3.0
Sweden														0.6	0.6	0.2	0.4
UK(Scotland)													0.2			0.4	
UK(Engl.&Wales)	2.6	1.4	0.2	1.6	2.0	2.0	1.6	1.3	1.5	1.6	0.5	0.3	*	*	0.8	0.6	0.5
Germany																*	*
Netherlands				0.2												4.2	1.0
Belgium																*	
Total	6.5	7.2	28.0	10.8	32.0	18.7	16.4	23.6	18.3	3.6	33.4	23.8	8.4	10.6	53.0	35.2	8.0
	Total North Sea																
Denmark	80.7	98.8	131.1	164.3	191.1	157.1	142.0	175.2	192.7	206.0	103.4	76.8	59.6	123.8	129.3	111.0	68.9
Norway	52.8	3.2	31.3	18.8	2.7	9.5	*		0.1		9.8	6.7	1.3	5.8	11.1	10.0	9.1
Sweden	0.5		1.7	2.1		1.5				*				0.9	1.2	1.2	2.2
UK(Scotland)				1.4								0.1	0.2	2.5	1.1	2.8	0.7
UK(Engl.&Wales)	2.6	1.4	0.2	1.6	2.0	2.0	1.6	1.3	1.5	1.6	0.5	0.3	*	*	0.8	0.6	0.5
Germany																3.3	0.5
Netherlands				0.2												5.3	3.7
Total	136.6	103.4	164.3	188.4	195.9	170.2	143.6	176.5	194.3	207.7	113.7	83.8	61.1	133.1	143.5	133.6	85.6

* < 50 t

Table 8.1.2. North Sea sprat. Catches (tonnes) by quarter. Catches in fjords of Western Norway excluded. Data for 1996-1999 in ICES CM 2007/ACFM:11
The IVb catches for 2000-2007 divided by IVbW and IVE can be found in ICES CM 2008/ACOM:02.

Year	Quarter	Area				Total	Year	Quarter	Area				Total
		IVaW	IVaE	IVb	IVc				IVaW	IVaE	IVb	IVc	
2000	1			18 126	28 063	46 189	2007	1			582	247	829
	2			1 722	45	1 767		2			241	3	244
	3			131 306	1 216	132 522		3			16 603		16 603
	4			12 680	2 718	15 398		4	769		41 850	23 531	66 150
	Total			163 834	32 042	195 876		Total	769		59 276	23 781	83 826
2001	1	115		40 903	9 716	50 734	2008	1			2 872	43	2 915
	2			1 071		1 071		2			52	*	52
	3			44 174	481	44 655		3			21 787		21 787
	4	79		65 102	8 538	73 719		4			27 994	8 334	36 329
	Total	194		151 249	18 735	170 177		Total			52 706	8 377	61 083
2002	1	1 136		2 182	2 790	6 108	2009	1			36	1 268	1 304
	2			435	93	528		2			2 526	1	2 527
	3			70 504	647	71 151		3		22	41 513		41 535
	4			52 942	12 911	65 853		4			78 373	9 336	87 709
	Total	1 136		126 063	16 441	143 640		Total		22	122 448	10 604	133 075
2003	1			11 458	7 727	19 185	2010	1			10 976	17 072	28 048
	2			625	26	652		2			3 235	3	3 238
	3			56 207	165	56 372		3			14 220		14 220
	4			84 629	15 651	100 280		4			62 006	35 973	97 979
	Total			152 919	23 570	176 489		Total			90 437	53 048	143 485
2004	1			827	1 831	2 657	2011	1			3747	21039	24 786
	2	7		260	16	283		2			2067	3	2 070
	3			54 161	496	54 657		3			22309	451	22 761
	4			120 685	15 937	136 622		4	8		70256	13759	84 023
	Total	7		175 932	18 280	194 219		Total	8		98 380	35 252	133 640
2005	1			11 538	2 457	13 995	2012	1			81	1649	1 730
	2			2 515	123	2 638		2			2924	0	2 924
	3			107 530		107 530		3			26779	307	27 086
	4			82 474	1 033	83 507		4			47765	6060	53 825
	Total			204 057	3 613	207 670		Total	0	0	77 549	8 016	85 565
2006	1	25	22	13 713	33 534	47 294							
	2			190	8	198							
	3			40 051	8	40 059							
	4	2		26 579	77	26 658							
	Total	27	22	80 533	33 627	114 209							

* < 0.5 t

Table 8.2.1. North Sea sprat. Species composition in the entire Danish sprat fishery in tonnes and percentage of the total catch in the North Sea and Skagerrak / Kattegat. Data is reported for 1998-2012.

	Year	Sprat	Herring	Horse mack.	Whiting	Haddock	Mackerel	Cod	Sandeel	Other	Total
Tonnes	1998	129 315	11 817	573	673	6	220	11	2 174	1 188	145 978
Tonnes	1999	157 003	7 256	413	1 088	62	321	7	4 972	635	171 757
Tonnes	2000	188 463	11 662	3 239	2 107	66	766	4	423	1 911	208 641
Tonnes	2001	136 443	13 953	67	1 700	223	312	4	17 020	1 142	170 862
Tonnes	2002	140 568	16 644	2 078	2 537	27	715	0	4 102	800	167 471
Tonnes	2003	172 456	10 244	718	1 106	15	799	11	5 357	3 509	194 214
Tonnes	2004	179 944	10 144	474	334		4 351	3	3 836	1 821	200 906
Tonnes	2005	201 331	21 035	2 477	545	4	1 009	16	6 859	974	234 250
Tonnes	2006	103 236	8 983	577	343	25	905	4	5 384	576	120 033
Tonnes	2007	74 734	6 596	168	900	6	126	18	6	253	82 807
Tonnes	2008	61 093	7 928	26	380	10	367	0	23	1 735	71 563
Tonnes	2009	112 721	7 222	44	307	3	116	1	1 526	407	122 345
Tonnes	2010	115 246	6 544	36	261	8	20	2	1 371	747	124 235
Tonnes	2011	114 130	10 533	35	234	0	134	1	2 021	385	127 473
Tonnes	2012	91 331	15 338	11	518	7	257	5	93	645	108 205
Percent	1998	88.6	8.1	0.4	0.5	0.0	0.2	0.0	1.5	0.8	100.0
Percent	1999	91.4	4.2	0.2	0.6	0.0	0.2	0.0	2.9	0.4	100.0
Percent	2000	90.3	5.6	1.6	1.0	0.0	0.4	0.0	0.2	0.9	100.0
Percent	2001	79.9	8.2	0.0	1.0	0.1	0.2	0.0	10.0	0.7	100.0
Percent	2002	83.9	9.9	1.2	1.5	0.0	0.4	0.0	2.4	0.5	100.0
Percent	2003	88.8	5.3	0.4	0.6	0.0	0.4	0.0	2.8	1.8	100.0
Percent	2004	89.6	5.0	0.2	0.2	0.0	2.2	0.0	1.9	0.9	100.0
Percent	2005	85.9	9.0	1.1	0.2	0.0	0.4	0.0	2.9	0.4	100.0
Percent	2006	86.0	7.5	0.5	0.3	0.0	0.8	0.0	4.5	0.5	100.0
Percent	2007	90.3	8.0	0.2	1.1	0.0	0.2	0.0	0.0	0.3	100.0
Percent	2008	85.4	11.1	0.0	0.5	0.0	0.5	0.0	0.0	2.4	100.0
Percent	2009	92.1	5.9	0.0	0.3	0.0	0.1	0.0	1.2	0.3	100.0
Percent	2010	92.8	5.3	0.0	0.2	0.0	0.0	0.0	1.1	0.6	100.0
Percent	2011	89.5	8.3	0.0	0.2	0.0	0.1	0.0	1.6	0.3	100.0
Percent	2012	84.4	14.2	0.0	0.5	0.0	0.2	0.0	0.1	0.6	100.0

Table 8.2.2. North Sea sprat. Catch in numbers by age (1000's) by season and year. (Calender year)

Year	Quarter	Age-0	Age-1	Age-2	Age-3	Age-4
1974	Q1	0	6272325	790695.8	65337.9	20350.72
	Q2	0	2218063	155263.3	9815.841	4029.555
	Q3	0	10213374	2393120	129570.2	7975.586
	Q4	13084.26	13048044	956771.4	52690.9	4157.97
1975	Q1	0	696195	12003206	986590	25782
	Q2	0	1018123	2352752	104940	4880
	Q3	0	12918925	10736964	105391	4416
	Q4	250758	14464471	5675423	295597	573
1976	Q1	0	1107469	4640901	3154501	79988
	Q2	0	602808	1252379	892969	25288
	Q3	145908	34455928	1034996	62802	1684
	Q4	2390988	24218227	2268791	119117	10861
1977	Q1	0	958492	6582627	220068	7237
	Q2	0	336631	1911499	63715	1980
	Q3	270260	2418648	7958073	64857	1849
	Q4	714507	3795711	5165711	89508	3399
1978	Q1	0	1997665	1870443	2946432	50032
	Q2	0	944317	558836	753894	12357
	Q3	19318	24762016	283043	41466	2684
	Q4	610307	11474429	1671693	165459	10743
1979	Q1	0	2824973	5296327	1403127	26486
	Q2	0	999681	1569671	338916	6951
	Q3	0	26410475	604986	0	114364
	Q4	107972	10821695	2774083	65919	217
1980	Q1	0	834905	6082389	328697	26923
	Q2	0	176315	1569213	133865	7878
	Q3	0	1553793	13828835	1179699	69428
	Q4	0	1535249	13663793	1165620	68599
1981	Q1	0	677820	3301518	430692	11111
	Q2	0	1239390	565592	50254	11901
	Q3	67791	7418262	1137037	59229	1917
	Q4	0	2372758	3498461	210015	23252
1982	Q1	0	80850	3604533	261247	8880
	Q2	0	5846	236614	21504	749
	Q3	17113	4804566	233451	3497	93
	Q4	216721	4586482	1622144	79138	19452
1983	Q1	0	943231	222085	261541	3379
	Q2	0	93992	21770	35670	362
	Q3	293277	2325072	1196283	182646	5793
	Q4	47818	1288560	622989	97960	3056
1984	Q1	0	137804	214705	7388	0

	Q2	0	68285	57546	1988	0
	Q3	15178	2818749	238816	4770	0
	Q4	32969	2823642	264259	7577	0
1985	Q1	0	397395	600767	10446	1033
	Q2	0	19013	28744	500	49
	Q3	0	543759	822033	14293	1414
	Q4	0	675670	1021452	17760	1757
1986	Q1	0	51567	131324	91756	9075
	Q2	0	10271	26157	18276	1807
	Q3	0	54333	138367	96677	9562
	Q4	0	136735	348218	243300	24063
1987	Q1	0	523038	7571	2938	0
	Q2	0	449629	7721	3504	0
	Q3	0	845988	59876	994	0
	Q4	52643	1866082	257169	1730	0
1988	Q1	0	493180	688667	23432	3157
	Q2	0	72029	111595	3987	781
	Q3	0	1586856	4134647	9609	0
	Q4	0	23940	85397	910	0
1989	Q1	0	1822864	688151	35173	0
	Q2	0	38434	14712	1195	0
	Q3	12416	1349973	3441515	971	0
	Q4	674	48312	75260	53	0
1990	Q1	0	500283	243280	48737	14638
	Q2	0	34285	23249	6770	2271
	Q3	0	2107664	1548789	449802	167844
	Q4	0	1674087	1230181	357271	133316
1991	Q1	0	50269	3312	689	103
	Q2	0	32873	3114	450	69
	Q3	39075	1582926	1968851	33462	844
	Q4	1358716	2738086	585720	12904	370
1992	Q1	0	8192	3674	123	8
	Q2	0	415567	186393	6232	390
	Q3	17469	8903703	1139117	143169	14295
	Q4	178160	1120582	138127	17884	1902
1993	Q1	0	2330690	1439234	194770	8536
	Q2	0	788283	382178	53291	2798
	Q3	0	2861064	4943973	194177	24607
	Q4	2048272	4728377	1288186	35809	2506
1994	Q1	0	2327734	2074998	320669	33962
	Q2	0	2427321	1081474	157150	7661
	Q3	0	29911167	550021	27189	375
	Q4	1891731	5127983	1436318	133383	5555
1995	Q1	0	421834	1895084	608541	16521
	Q2	0	530161	358121	116385	4436
	Q3	208386	19738855	3119870	499613	3712

	Q4	731010	7327987	3289073	669519	13910
1996	Q1	0	5784702	1613377	375365	21893
	Q2	0	356707	106061	25043	1625
	Q3	107253	127719	381423	137974	27334
	Q4	880333	660293	2178394	774114	181774
1997	Q1	0	1530663	515776	60268	7729
	Q2	0	264007	89901	14984	1470
	Q3	44531	1640137	521235	74525	27396
	Q4	107553	3494688	1265240	200795	85539
1998	Q1	0	674134	508613	70038	13829
	Q2	0	83006	58156	6706	1092
	Q3	620081	3588086	1619886	172387	4584
	Q4	1015745	3531232	1518689	410014	0
1999	Q1	0	1038772	2189060	159850	33261
	Q2	0	134048	226782	18915	4103
	Q3	211127	13970676	458334	88243	686
	Q4	85617	1934117	362667	21842	111
2000	Q1	0	2068324	2972728	652986	240495
	Q2	0	55868	110058	37736	21766
	Q3	1671	9463341	1526772	84078	5227
	Q4	2432	722669	421757	38132	2148
2001	Q1	0	756085	2938300	1259571	168402
	Q2	0	10921	35795	12415	1222
	Q3	330710	2999048	731582	61006	0
	Q4	731508	4466857	1535060	134942	0
2002	Q1	0	323605	70070	13307	791
	Q2	0	23206	5025	954	57
	Q3	72234	6240286	393859	40131	3446
	Q4	480139	4192059	902086	193376	10170
2003	Q1	0	1595254	1150283	106446	3660
	Q2	0	67395	38384	3408	121
	Q3	0	3773602	536016	39557	13331
	Q4	411438	7597795	1040850	47583	30233
2004	Q1	0	132197	22821	1347	76
	Q2	0	29872	5157	304	17
	Q3	330650	3616036	790575	46831	3599
	Q4	21362903	4845166	372609	33761	1849
2005	Q1	0	3214471	218695	9249	305
	Q2	0	690733	41135	1703	54
	Q3	0	12371678	222757	34807	1169
	Q4	905687	7636106	193874	15025	595
2006	Q1	0	675765	5164658	136240	5908
	Q2	0	11341	59145	1469	65
	Q3	0	2354139	1164248	196933	3705
	Q4	0	1589716	922747	98174	2439
2007	Q1	0	188409	112126	21465	1057

	Q2	0	12611	7505	1437	71
	Q3	0	791996	370110	83329	3360
	Q4	570769	3607022	1587098	207134	16190
2008	Q1	0	275013	212650	8983	1280
	Q2	0	4661	3355	217	36
	Q3	11226	374967	1350863	273722	23195
	Q4	471069	1457841	1154410	243032	40973
2009	Q1	0	274316	32208	1962	129
	Q2	0	302545	35522	2163	143
	Q3	0	4428777	185438	18651	853
	Q4	221908	7851426	562588	93691	4255
2010	Q1	0	43328	3230747	475426	71299
	Q2	0	6548	342686	39999	8396
	Q3	12808	1429681	433709	7880	1438
	Q4	344087	3395699	3034682	825848	970833
2011	Q1	0	190971	1981930	704501	91150
	Q2	0	90971	174916	55063	6773
	Q3	2669	1410307	959871	206730	28765
	Q4	366915	4094960	2652433	752025	214962
2012	Q1	0	101747	41459	5929	697
	Q2	0	191599	78071	11165	1313
	Q3	16927	2207305	609219	68208	16287
	Q4	111565	3503253	1603395	239132	17808

Table 8.2.3. North Sea sprat. Mean weight at age (kg) by season and year.

(Calendar year)

Year	Quarter	Age-0	Age-1	Age-2	Age-3	Age-4
1974	Q1		0.0060	0.0129	0.0178	0.0250
	Q2		0.0055	0.0113	0.0158	0.0232
	Q3	0.0064	0.0089	0.0134	0.0231	0.0263
	Q4	0.0056	0.0084	0.0136	0.0197	0.0255
1975	Q1		0.0035	0.0071	0.0125	0.0199
	Q2		0.0061	0.0092	0.0112	0.0177
	Q3	0.0064	0.0085	0.0136	0.0179	0.0206
	Q4	0.0059	0.0105	0.0166	0.0210	0.0210
1976	Q1		0.0035	0.0098	0.0148	0.0190
	Q2		0.0054	0.0097	0.0139	0.0197
	Q3	0.0033	0.0068	0.0129	0.0167	0.0182
	Q4	0.0035	0.0083	0.0151	0.0190	0.0185
1977	Q1		0.0037	0.0063	0.0106	0.0174
	Q2		0.0035	0.0063	0.0091	0.0128
	Q3	0.0065	0.0083	0.0124	0.0197	0.0181
	Q4	0.0067	0.0105	0.0143	0.0201	0.0182
1978	Q1		0.0030	0.0083	0.0125	0.0165
	Q2		0.0044	0.0078	0.0113	0.0159
	Q3	0.0049	0.0060	0.0116	0.0184	0.0187
	Q4	0.0047	0.0101	0.0163	0.0201	0.0191
1979	Q1		0.0022	0.0072	0.0105	0.0146
	Q2		0.0037	0.0066	0.0095	0.0134
	Q3	0.0064	0.0056	0.0068	0.0171	0.0078
	Q4	0.0036	0.0100	0.0148	0.0185	0.0100
1980	Q1		0.0022	0.0073	0.0124	0.0163
	Q2		0.0044	0.0078	0.0113	0.0160
	Q3	0.0064	0.0059	0.0078	0.0102	0.0118
	Q4	0.0050	0.0058	0.0078	0.0099	0.0111
1981	Q1		0.0031	0.0076	0.0129	0.0161
	Q2		0.0047	0.0056	0.0081	0.0104
	Q3	0.0069	0.0093	0.0120	0.0143	0.0170
	Q4	0.0050	0.0113	0.0147	0.0192	0.0238
1982	Q1		0.0037	0.0084	0.0155	0.0192
	Q2		0.0049	0.0087	0.0126	0.0178
	Q3	0.0069	0.0073	0.0106	0.0165	0.0200
	Q4	0.0088	0.0112	0.0145	0.0211	0.0239
1983	Q1		0.0030	0.0061	0.0074	0.0159
	Q2		0.0029	0.0052	0.0075	0.0106
	Q3	0.0079	0.0117	0.0155	0.0203	0.0233
	Q4	0.0079	0.0129	0.0171	0.0212	0.0189
1984	Q1		0.0036	0.0101	0.0151	0.0200
	Q2		0.0045	0.0081	0.0117	0.0181

	Q3	0.0070	0.0105	0.0139	0.0182	0.0184
	Q4	0.0057	0.0124	0.0176	0.0156	0.0180
1985	Q1		0.0093	0.0135	0.0197	0.0197
	Q2		0.0093	0.0135	0.0197	0.0197
	Q3	0.0064	0.0093	0.0135	0.0197	0.0197
	Q4	0.0050	0.0093	0.0135	0.0197	0.0197
1986	Q1		0.0073	0.0099	0.0166	0.0166
	Q2		0.0073	0.0099	0.0166	0.0166
	Q3	0.0064	0.0073	0.0099	0.0166	0.0166
	Q4	0.0050	0.0073	0.0099	0.0166	0.0166
1987	Q1		0.0032	0.0065	0.0108	0.0200
	Q2		0.0032	0.0058	0.0083	0.0181
	Q3	0.0064	0.0092	0.0126	0.0144	0.0184
	Q4	0.0058	0.0093	0.0112	0.0146	0.0180
1988	Q1		0.0033	0.0075	0.0122	0.0510
	Q2		0.0042	0.0076	0.0109	0.0154
	Q3	0.0064	0.0119	0.0141	0.0144	0.0184
	Q4	0.0050	0.0110	0.0149	0.0188	0.0180
1989	Q1		0.0049	0.0100	0.0202	0.0200
	Q2		0.0054	0.0096	0.0138	0.0181
	Q3	0.0062	0.0084	0.0097	0.0199	0.0184
	Q4	0.0045	0.0077	0.0104	0.0132	0.0180
1990	Q1		0.0039	0.0097	0.0145	0.0173
	Q2		0.0050	0.0090	0.0129	0.0183
	Q3	0.0064	0.0071	0.0093	0.0123	0.0141
	Q4	0.0050	0.0070	0.0095	0.0120	0.0136
1991	Q1		0.0049	0.0101	0.0137	0.0133
	Q2		0.0051	0.0092	0.0132	0.0186
	Q3	0.0059	0.0145	0.0154	0.0259	0.0174
	Q4	0.0042	0.0146	0.0190	0.0258	0.0173
1992	Q1		0.0042	0.0080	0.0117	0.0167
	Q2		0.0043	0.0077	0.0111	0.0157
	Q3	0.0075	0.0099	0.0123	0.0144	0.0177
	Q4	0.0067	0.0114	0.0146	0.0167	0.0174
1993	Q1		0.0029	0.0083	0.0130	0.0150
	Q2		0.0037	0.0066	0.0094	0.0133
	Q3	0.0064	0.0109	0.0122	0.0125	0.0178
	Q4	0.0063	0.0102	0.0133	0.0166	0.0174
1994	Q1		0.0022	0.0070	0.0102	0.0146
	Q2		0.0027	0.0048	0.0069	0.0097
	Q3	0.0064	0.0063	0.0085	0.0127	0.0133
	Q4	0.0087	0.0103	0.0125	0.0153	0.0137
1995	Q1		0.0021	0.0089	0.0112	0.0160
	Q2		0.0035	0.0063	0.0091	0.0128
	Q3	0.0028	0.0080	0.0110	0.0118	0.0154
	Q4	0.0051	0.0097	0.0129	0.0160	0.0161
1996	Q1		0.0061	0.0103	0.0121	0.0149
	Q2		0.0058	0.0104	0.0149	0.0211

	Q3	0.0076	0.0113	0.0149	0.0195	0.0225
	Q4	0.0078	0.0116	0.0155	0.0170	0.0210
1997	Q1		0.0023	0.0056	0.0102	0.0126
	Q2		0.0028	0.0049	0.0071	0.0101
	Q3	0.0077	0.0115	0.0152	0.0200	0.0230
	Q4	0.0033	0.0114	0.0156	0.0188	0.0220
1998	Q1		0.0050	0.0088	0.0122	0.0158
	Q2		0.0044	0.0080	0.0114	0.0162
	Q3	0.0047	0.0122	0.0153	0.0187	0.0226
	Q4	0.0066	0.0120	0.0151	0.0184	0.0180
1999	Q1		0.0031	0.0049	0.0102	0.0120
	Q2		0.0029	0.0051	0.0074	0.0104
	Q3	0.0059	0.0099	0.0122	0.0130	0.0151
	Q4	0.0037	0.0102	0.0127	0.0150	0.0154
2000	Q1		0.0035	0.0086	0.0109	0.0114
	Q2		0.0042	0.0075	0.0108	0.0153
	Q3	0.0063	0.0119	0.0142	0.0157	0.0143
	Q4	0.0059	0.0120	0.0146	0.0158	0.0144
2001	Q1		0.0044	0.0098	0.0127	0.0148
	Q2		0.0051	0.0091	0.0131	0.0185
	Q3	0.0070	0.0104	0.0138	0.0181	0.0184
	Q4	0.0049	0.0108	0.0133	0.0172	0.0180
2002	Q1		0.0107	0.0203	0.0297	0.0423
	Q2		0.0095	0.0170	0.0245	0.0347
	Q3	0.0072	0.0104	0.0137	0.0148	0.0188
	Q4	0.0064	0.0115	0.0134	0.0143	0.0191
2003	Q1		0.0044	0.0085	0.0104	0.0145
	Q2		0.0045	0.0080	0.0116	0.0164
	Q3	0.0064	0.0127	0.0145	0.0191	0.0193
	Q4	0.0068	0.0109	0.0140	0.0147	0.0152
2004	Q1		0.0094	0.0179	0.0262	0.0374
	Q2		0.0074	0.0132	0.0190	0.0269
	Q3	0.0087	0.0112	0.0137	0.0141	0.0179
	Q4	0.0041	0.0091	0.0121	0.0150	0.0198
2005	Q1		0.0034	0.0068	0.0095	0.0156
	Q2		0.0034	0.0061	0.0087	0.0124
	Q3	0.0064	0.0085	0.0115	0.0117	0.0184
	Q4	0.0065	0.0100	0.0109	0.0117	0.0187
2006	Q1		0.0057	0.0077	0.0097	0.0184
	Q2		0.0043	0.0076	0.0110	0.0155
	Q3	0.0064	0.0104	0.0118	0.0132	0.0184
	Q4	0.0050	0.0090	0.0122	0.0153	0.0173
2007	Q1		0.0084	0.0161	0.0236	0.0336
	Q2		0.0078	0.0140	0.0201	0.0285
	Q3	0.0064	0.0124	0.0136	0.0143	0.0152
	Q4	0.0062	0.0101	0.0127	0.0149	0.0154
2008	Q1		0.0046	0.0074	0.0101	0.0145
	Q2		0.0044	0.0079	0.0113	0.0160

	Q3	0.0066	0.0099	0.0111	0.0127	0.0130
	Q4	0.0053	0.0094	0.0132	0.0143	0.0164
2009	Q1		0.0084	0.0159	0.0234	0.0333
	Q2		0.0071	0.0128	0.0184	0.0260
	Q3	0.0064	0.0091	0.0118	0.0137	0.0188
	Q4	0.0046	0.0095	0.0131	0.0163	0.0192
2010	Q1		0.0044	0.0077	0.0103	0.0133
	Q2		0.0043	0.0076	0.0110	0.0155
	Q3	0.0067	0.0079	0.0094	0.0133	0.0156
	Q4	0.0045	0.0091	0.0111	0.0131	0.0173
2011	Q1		0.0053	0.0077	0.0101	0.0143
	Q2		0.0039	0.0070	0.0101	0.0142
	Q3	0.0051	0.0083	0.0101	0.0132	0.0154
	Q4	0.0054	0.0088	0.0113	0.0140	0.0168
2012	Q1		0.0090	0.0171	0.0251	0.0357
	Q2		0.0076	0.0135	0.0194	0.0275
	Q3	0.0087	0.0086	0.0104	0.0137	0.0170
	Q4	0.0063	0.0087	0.0120	0.0149	0.0195

Table 8.2.4. North Sea sprat. Sampling for biological parameters in 2012. This table only shows age-length samples, and therefore the number of samples differ from Table 8.2.5.

Country	Quarter	Landings ('000 tonnes)	No. samples	No. measured	No. aged
Denmark	1	0.1	2	261	68
	2	2.9	1	99	50
	3	24.3	27	2833	841
	4	41.6	42	5153	1317
	Total	68.9	72	8346	2276
Norway	1	1.1			
	2	0.0			
	3	0.4			
	4	7.7	16	1132	395
	Total	9.1	16	1132	395
All countries	1	1.2	2	261	68
	2	2.9	1	99	50
	3	24.6	27	2833	841
	4	49.3	58	6285	1712
Total North Sea		78.1	88	9478	2671

Table 8.2.5. North Sea sprat. Number of biological samples taken from 1991 and onward. The number of samples differ from Table 8.2.4, since this table shows both length and age-length samples. These are the samples used in the assessment. (Calendar year)

Year	Sampling quarter 1	Sampling quarter 2	Sampling quarter 3	Sampling quarter 4
1991	40	0	5	21
1992	2	4	38	20
1993	48	2	15	40
1994	50	1	21	29
1995	50	2	16	29
1996	50	2	1	20
1997	29	1	2	16
1998	34	1	31	14
1999	32	1	43	8
2000	14	0	21	8
2001	13	0	2	6
2002	2	0	9	32
2003	11	2	11	26
2004	3	1	12	21
2005	10	2	23	40
2006	29	0	10	1
2007	3	0	5	30
2008	9	3	9	6
2009	2	1	13	29
2010	14	1	19	21
2011	9	1	23	51
2012	2	1	33	83

Table 8.3.1. North Sea sprat. Abundance indices by age from IBTS Q1 (Feb) from 1984-2013. Data from 1997 and 2000-2012 was updated in 2012-2013.
* Preliminary

Year	Age					
	1	2	3	4	5+	Total
1984	233.76	329.00	39.61	6.20	0.29	608.86
1985	376.10	195.48	26.76	3.80	0.35	602.49
1986	44.19	73.54	22.01	1.23	0.24	141.21
1987	542.24	66.28	19.14	1.92	0.24	629.82
1988	98.61	884.07	61.80	6.99	0.00	1 051.46
1989	2 314.22	476.29	271.85	5.47	1.65	3 069.48
1990	234.94	451.98	102.16	28.06	2.22	819.37
1991	676.78	93.38	23.33	2.63	0.12	796.24
1992	1 060.78	297.69	43.25	7.23	0.53	1 409.48
1993	1 066.83	568.53	118.42	6.07	0.34	1 760.19
1994	2 428.36	938.16	92.16	3.59	0.50	3 462.77
1995	1 224.89	1 036.40	87.33	2.52	0.76	2 351.90
1996	186.13	383.53	146.84	18.28	0.74	735.53
1997	591.86	411.96	179.54	15.53	2.24	1 201.13
1998	1 171.05	1 456.51	305.91	15.75	3.38	2 952.60
1999	2 534.53	562.10	80.35	4.83	0.45	3 182.25
2000	1 089.53	700.81	48.35	1.86	0.01	1 840.57
2001	883.06	1 057.00	185.47	17.55	0.35	2 143.42
2002	896.13	642.52	69.76	7.97	0.29	1 616.66
2003	1 711.89	337.90	32.83	2.12	0.55	2 085.29
2004	1 593.89	495.70	78.24	3.50	1.54	2 172.87
2005	3 058.99	269.37	36.47	0.88	0.00	3 365.71
2006	426.00	1 174.01	93.97	5.08	0.00	1 699.05
2007	1 053.60	1 341.36	275.19	11.18	0.01	2 681.34
2008	1 428.00	766.99	96.68	6.84	0.02	2 298.52
2009	3 140.02	451.26	25.53	1.59	1.18	3 619.58
2010	2 101.87	1 735.99	156.14	24.36	1.12	4 019.48
2011	675.62	899.09	701.35	97.27	109.02	2 482.35
2012	2 451.72	1 983.95	447.12	30.82	7.46	4 921.07
2013*	705.61	1 299.36	458.69	53.08	7.73	2 524.47

Table 8.3.2. North Sea sprat. Time-series of sprat abundance and biomass (ICES areas IVa-c) as obtained from summer North Sea acoustic survey. The surveyed area has increased over the years. Only figures from 2004 and onwards are broadly comparable. In 2003, information on sprat abundance is available from one nation only.

Abundance (million)						Biomass (1000 tonnes)				
Year/Age	0	1	2	3+	sum	0	1	2	3+	sum
2000	0	11,569	6,407	180	18,156	0	100	92	3	196
2001	0	12,639	1,812	110	14,561	0	97	24	2	122
2002	0	15,769	3,687	207	19,664	0	167	55	4	226
2003*	0	25,294	3,983	338	29,615	0	198	61	6	266
2004*	17,401	28,940	5,312	367	52,019	19	267	73	6	366
2005*	0	69,798	2,526	350	72,674	0	475	33	6	513
2006*	0	21,862	19,916	760	42,537	0	159	265	12	436
2007	0	37,250	5,513	1,869	44,631	0	258	66	29	353
2008	0	17,165	7,410	549	25,125	0	161	101	9	271
2009	0	47,520	16,488	1,183	65,191	0	346	189	21	556
2010	1,991	19,492	13,743	798	36,023	22	163	177	14	376
2011	0	26,536	13,660	2,430	42,625	0	212	188	44	444
2012	7,807	21,912	12,541	3,205	45,466	27	177	150	55	409

***re-calculated using FishFrame**

Table 8.6.1. North Sea sprat. Maturity at age input (years and age refer to the model year)

Year	Age0	Age1	Age2	Age3+
1974	0	0.41134	0.85845	0.94476
1975	0	0.41134	0.85845	0.94476
1976	0	0.41134	0.85845	0.94476
1977	0	0.41134	0.85845	0.94476
1978	0	0.41134	0.85845	0.94476
1979	0	0.41134	0.85845	0.94476
1980	0	0.41134	0.85845	0.94476
1981	0	0.41134	0.85845	0.94476
1982	0	0.41134	0.85845	0.94476
1983	0	0.41134	0.85845	0.94476
1984	0	0.41134	0.85845	0.94476
1985	0	0.41134	0.85845	0.94476
1986	0	0.41134	0.85845	0.94476
1987	0	0.41134	0.85845	0.94476
1988	0	0.41134	0.85845	0.94476
1989	0	0.41134	0.85845	0.94476
1990	0	0.41134	0.85845	0.94476
1991	0	0.41134	0.85845	0.94476
1992	0	0.41134	0.85845	0.94476
1993	0	0.41134	0.85845	0.94476
1994	0	0.41134	0.85845	0.94476
1995	0	0.092549	0.768707	0.874724
1996	0	0.419683	0.739067	0.924385
1997	0	0.661775	0.851568	0.937538
1998	0	0.55938	0.912602	0.979343
1999	0	0.350288	0.880373	0.974545
2000	0	0.427791	0.911569	0.959348
2001	0	0.364679	0.871836	1
2002	0	0.195968	0.730718	0.774047
2003	0	0.519543	0.883941	0.977179
2004	0	0.166232	0.647305	0.842359
2005	0	0.48079	1	1
2006	0	0.283235	0.854179	0.942823
2007	0	0.248309	0.78757	0.896822
2008	0	0.615987	0.922063	0.985663
2009	0	0.52327	0.917751	0.98815
2010	0	0.376405	0.844943	0.948755
2011	0	0.617188	0.978968	1
2012	0	0.501045	0.948946	1

Table 8.6.2. North Sea sprat. Natural mortality input (years refer to the model year)

Year	Season	Age 0	Age 1	Age 2	Age 3
1974	S1	0.2563	0.4352	0.4139	0.2122
	S2	0.3576	0.1955	0.1515	0.1196
	S3	0.3117	0.2896	0.2722	0.2722
	S4	0.4924	0.3614	0.2441	0.2441
1975	S1	0.3391	0.7355	0.618	0.227
	S2	0.4433	0.2668	0.1863	0.1708
	S3	0.3607	0.346	0.322	0.322
	S4	0.4844	0.3806	0.2602	0.2602
1976	S1	0.3811	0.4863	0.3882	0.2117
	S2	0.5113	0.2671	0.1944	0.1746
	S3	0.3617	0.3345	0.3182	0.3182
	S4	0.5257	0.3908	0.2557	0.2557
1977	S1	0.3536	0.5051	0.4044	0.2489
	S2	0.5184	0.256	0.1991	0.1795
	S3	0.4265	0.4006	0.3822	0.3822
	S4	0.5294	0.4066	0.2749	0.2749
1978	S1	0.3643	0.4796	0.3798	0.212
	S2	0.458	0.2353	0.1806	0.1644
	S3	0.3552	0.3373	0.3264	0.3264
	S4	0.4653	0.3539	0.2524	0.2524
1979	S1	0.3384	0.4537	0.3717	0.1902
	S2	0.4975	0.2233	0.169	0.154
	S3	0.4256	0.3973	0.3796	0.3796
	S4	0.5859	0.437	0.3	0.3
1980	S1	0.4097	0.5496	0.4447	0.2372
	S2	0.6261	0.3198	0.2768	0.2168
	S3	0.4717	0.4453	0.4125	0.4125
	S4	0.5781	0.4293	0.2743	0.2743
1981	S1	0.3632	0.5036	0.3967	0.1764
	S2	0.5864	0.289	0.2315	0.1571
	S3	0.3506	0.3132	0.2894	0.2894
	S4	0.5118	0.357	0.194	0.194
1982	S1	0.2956	0.5157	0.4047	0.1737
	S2	0.5197	0.3066	0.1925	0.165
	S3	0.3225	0.3018	0.2666	0.2666
	S4	0.5154	0.3515	0.1703	0.1703
1983	S1	0.247	0.52	0.3894	0.1381
	S2	0.484	0.2515	0.1472	0.1294
	S3	0.3179	0.2895	0.2611	0.2611
	S4	0.4837	0.3406	0.1665	0.1665
1984	S1	0.2972	0.5445	0.4345	0.1691
	S2	0.5705	0.3327	0.1975	0.1801

	S3	0.3232	0.3117	0.2893	0.2893
	S4	0.4695	0.3278	0.197	0.197
1985	S1	0.2891	0.4899	0.4133	0.1537
	S2	0.564	0.2781	0.2391	0.1497
	S3	0.3821	0.3526	0.3198	0.3198
	S4	0.5258	0.3621	0.2185	0.2185
1986	S1	0.4069	0.4545	0.3642	0.161
	S2	0.755	0.4161	0.3751	0.1562
	S3	0.3765	0.3594	0.3382	0.3382
	S4	0.5113	0.3612	0.2096	0.2096
1987	S1	0.3697	0.5407	0.4497	0.1969
	S2	0.8415	0.5418	0.2222	0.1994
	S3	0.3833	0.3668	0.3437	0.3437
	S4	0.5187	0.3703	0.206	0.206
1988	S1	0.3985	0.5314	0.4421	0.1691
	S2	0.8348	0.4813	0.1796	0.1613
	S3	0.461	0.4445	0.4145	0.4145
	S4	0.5854	0.4262	0.2591	0.2591
1989	S1	0.4933	0.6002	0.4954	0.2198
	S2	0.7957	0.4272	0.2436	0.219
	S3	0.4389	0.4265	0.3989	0.3989
	S4	0.561	0.4112	0.2442	0.2442
1990	S1	0.3665	0.5797	0.4856	0.1869
	S2	0.6574	0.3869	0.1959	0.1737
	S3	0.376	0.3629	0.3379	0.3379
	S4	0.5166	0.3669	0.2261	0.2261
1991	S1	0.3016	0.5519	0.4561	0.1702
	S2	0.5958	0.368	0.3254	0.1649
	S3	0.3354	0.3185	0.2896	0.2896
	S4	0.4931	0.3447	0.1975	0.1975
1992	S1	0.3129	0.521	0.4235	0.1523
	S2	0.6013	0.3533	0.3021	0.1442
	S3	0.3273	0.3162	0.2901	0.2901
	S4	0.4789	0.3331	0.2	0.2
1993	S1	0.3195	0.4998	0.4097	0.1567
	S2	0.5757	0.3345	0.2922	0.154
	S3	0.3339	0.3152	0.2836	0.2836
	S4	0.4729	0.332	0.1813	0.1813
1994	S1	0.3049	0.4519	0.3588	0.1392
	S2	0.5247	0.2986	0.1468	0.1338
	S3	0.2918	0.2796	0.2475	0.2475
	S4	0.4554	0.3107	0.1756	0.1756
1995	S1	0.3218	0.496	0.3824	0.1442
	S2	0.6082	0.35	0.2883	0.1494
	S3	0.3114	0.296	0.267	0.267
	S4	0.4787	0.3323	0.1663	0.1663

1996	S1	0.2429	0.4703	0.3845	0.1345
	S2	0.5042	0.3238	0.1499	0.1342
	S3	0.2491	0.2321	0.198	0.198
	S4	0.4193	0.2757	0.1282	0.1282
1997	S1	0.2845	0.5075	0.3818	0.1291
	S2	0.5895	0.3441	0.1511	0.1354
	S3	0.272	0.2627	0.2297	0.2297
	S4	0.4383	0.2952	0.1411	0.1411
1998	S1	0.3328	0.5163	0.3913	0.1232
	S2	0.61	0.3389	0.1466	0.1228
	S3	0.3256	0.3115	0.266	0.266
	S4	0.4808	0.3399	0.1548	0.1548
1999	S1	0.3715	0.4606	0.3603	0.1105
	S2	0.6355	0.3203	0.1186	0.1037
	S3	0.2867	0.2746	0.2433	0.2433
	S4	0.449	0.3052	0.1516	0.1516
2000	S1	0.3694	0.5041	0.3982	0.1385
	S2	0.6492	0.3438	0.1581	0.1384
	S3	0.3323	0.3233	0.2904	0.2904
	S4	0.4919	0.3448	0.1937	0.1937
2001	S1	0.3755	0.4655	0.3768	0.1452
	S2	0.6405	0.345	0.2894	0.1432
	S3	0.2912	0.2809	0.2511	0.2511
	S4	0.4382	0.2985	0.1589	0.1589
2002	S1	0.3072	0.5344	0.4098	0.1557
	S2	0.5773	0.3673	0.2952	0.1523
	S3	0.2714	0.2611	0.2236	0.2236
	S4	0.4848	0.3241	0.1651	0.1651
2003	S1	0.3248	0.5661	0.4364	0.1374
	S2	0.603	0.3563	0.2861	0.1355
	S3	0.2779	0.2666	0.2272	0.2272
	S4	0.4841	0.3248	0.1487	0.1487
2004	S1	0.2973	0.5756	0.4419	0.1311
	S2	0.5336	0.3301	0.2697	0.1203
	S3	0.2587	0.2471	0.2162	0.2162
	S4	0.4396	0.2994	0.1453	0.1453
2005	S1	0.2426	0.5654	0.4546	0.1087
	S2	0.5528	0.3537	0.2985	0.1009
	S3	0.2513	0.237	0.2062	0.2062
	S4	0.45	0.2972	0.136	0.136
2006	S1	0.2712	0.5773	0.4552	0.1155
	S2	0.5701	0.3709	0.3133	0.1177
	S3	0.2682	0.2543	0.2184	0.2184
	S4	0.4602	0.3063	0.1466	0.1466
2007	S1	0.3239	0.545	0.4352	0.1081
	S2	0.6146	0.3483	0.3004	0.1093

	S3	0.2862	0.2749	0.2398	0.2398
	S4	0.4552	0.3076	0.1632	0.1632
2008	S1	0.287	0.5855	0.4601	0.1213
	S2	0.563	0.3687	0.3147	0.1203
	S3	0.2721	0.2613	0.2299	0.2299
	S4	0.4371	0.3043	0.1649	0.1649
2009	S1	0.2546	0.5372	0.4492	0.119
	S2	0.5747	0.3711	0.3251	0.1162
	S3	0.2568	0.2447	0.2082	0.2082
	S4	0.4146	0.2752	0.1482	0.1482
2010	S1	0.2779	0.5664	0.4431	0.1291
	S2	0.6307	0.4016	0.3318	0.1343
	S3	0.2717	0.2603	0.226	0.226
	S4	0.4356	0.2957	0.1588	0.1588
2011	S1	0.2732	0.563	0.4508	0.1231
	S2	0.5895	0.3805	0.3239	0.1236
	S3	0.2669	0.2554	0.2214	0.2214
	S4	0.4291	0.2917	0.1573	0.1573
2012	S1	0.2732	0.563	0.4508	0.1231
	S2	0.5895	0.3805	0.3239	0.1236
	S3	0.2669	0.2554	0.2214	0.2214
	S4	0.4291	0.2917	0.1573	0.1573

Table 8.6.3. North Sea sprat. Assessment diagnostics.

```
objective function (negative log likelihood):  338.029
Number of parameters: 125
Maximum gradient: 5.97714e-006
Akaike information criterion (AIC):   926.057
Number of observations used in the likelihood:
                            Catch    CPUE     S/R Stomach     Sum
                             624     244      39       0     907
objective function weight:
                          Catch  CPUE   S/R
                          1.00  1.00  0.10

unweighted objective function contributions (total):
                Catch    CPUE    S/R    Stom.  Penalty     Sum
              357.9   -20.1     2.6     0.0 0.00e+000   340.4

unweighted objective function contributions (per observation):
                Catch   CPUE     S/R   Stomachs
               0.57   -0.08    0.07    0.00

contribution by fleet:
----------------------
IBTS Q1                     total: -14.962   mean:  -0.101
IBTS Q3                     total:  12.487   mean:   0.189
Acoustic                    total: -17.656   mean:  -0.589

F, season effect:
-----------------
age: 0
    1974-1995:   0.018 0.076 0.547 0.250
    1996-2012:   0.032 0.404 0.749 0.250
age: 1
    1974-1995:   0.737 0.814 0.611 0.250
    1996-2012:   1.610 4.135 0.958 0.250
age: 2
    1974-1995:   0.490 0.935 0.449 0.250
    1996-2012:   1.646 9.074 0.803 0.250
age: 3
    1974-1995:   0.396 1.152 0.590 0.250
    1996-2012:   2.200 13.336 1.041 0.250

F, age effect:
--------------
                0      1      2      3
1974-1995:  0.024  0.205  0.698  0.698
1996-2012:  0.006  0.046  0.081  0.081


Exploitation pattern (scaled to mean F=1)
-----------------------------------------
                        0      1      2      3
1974-1995 season 1:  0.000  0.153  0.346  0.279
          season 2:  0.002  0.169  0.660  0.813
          season 3:  0.013  0.127  0.317  0.417
          season 4:  0.006  0.052  0.177  0.177

1996-2012 season 1:  0.000  0.117  0.209  0.279
          season 2:  0.004  0.300  1.152  1.693
          season 3:  0.007  0.070  0.102  0.132
          season 4:  0.002  0.018  0.032  0.032


sqrt(catch variance) ~ CV:
--------------------------

              season
--------------------------------------
age        1       2       3       4

 0       1.428   1.530   1.161   1.087
 1       0.977   0.780   1.319   0.673
 2       1.214   1.251   1.579   1.212
 3       1.214   1.251   1.579   1.212
```

Survey catchability:

--------------------	age 0	age 1	age 2	age 3
IBTS Q1	0.163	0.665	1.202	1.202
IBTS Q3		1.028	1.922	1.922
Acoustic		0.672	1.494	2.073

sqrt(Survey variance) ~ CV:

---------------------------	age 0	age 1	age 2	age 3
IBTS Q1	0.55	0.55	0.55	0.55
IBTS Q3		0.69	0.51	1.12
Acoustic		0.30	0.37	0.37

Recruit-SSB		alfa	beta	recruit s2	recruit s
Sprat	Hockey stick -break.:	2235.041	9.000e+004	0.421	0.649

Table 8.6.4. North Sea Sprat. Assessment output: Stock numbers (millions). Age 0 at start of 2nd half-year, age 1+ at start of 1st half-year

Year/Age	Age 0	Age 1	Age 2	Age 3
1974	800163	138097	6984	298
1975	1580949	70165	23376	562
1976	746716	120881	5400	491
1977	891133	51811	15525	332
1978	1147437	58144	5079	468
1979	609804	88186	6459	164
1980	603646	38470	9353	218
1981	232114	32475	3092	228
1982	145221	15678	3777	139
1983	181981	10950	2320	387
1984	76302	14680	1154	84
1985	41448	5788	1886	84
1986	332780	2829	642	72
1987	258072	19136	339	41
1988	836174	14139	2515	62
1989	283986	39701	1944	525
1990	334022	13935	5942	600
1991	712130	21267	880	67
1992	670669	51684	3284	112
1993	942614	48871	7724	329
1994	482666	68218	4226	139
1995	259029	39188	11061	412
1996	529606	18734	4375	444
1997	513416	48613	3697	779
1998	659610	42091	8616	674
1999	614271	47374	4887	510
2000	443939	45858	8953	902
2001	337385	30212	6896	1096
2002	429036	25030	3388	231
2003	417572	33214	2636	123
2004	934706	31592	4408	199
2005	360885	78928	2854	92
2006	450281	31004	12189	283
2007	399243	36850	4410	1064
2008	801860	30528	4280	215
2009	560161	66868	4743	509
2010	608658	48741	12526	837
2011	536288	48735	8151	1939
2012	302301	44749	8232	1405
2013		25296	8333	1797

Table 8.6.5. North Sea Sprat. Assessment output: Estimated recruitment, total stock biomass (TBS), spawning stock biomass (SSB), landings weight (Yield) and average fishing mortality.

Year	Recruits (million)	TSB (tonnes)	SSB (tonnes)	Yield (tonnes)	Mean F ages 1-2
1974	295931	3205740	590355	379883	0.977
1975	637949	4989920	518830	607849	1.513
1976	314845	3170490	515133	701782	1.151
1977	373635	3042240	363312	335306	1.522
1978	471681	3595690	277897	489316	1.577
1979	251840	2481750	399520	484624	1.511
1980	270293	2186080	246161	483279	1.557
1981	98879	964612	157392	201840	1.344
1982	58064	560152	100752	127212	0.866
1983	69990	579348	71625	67486	1.658
1984	31021	345743	68242	68416	1.059
1985	16872	184419	42942	39458	1.446
1986	152040	1001400	18513	20659	1.075
1987	117848	927252	75470	42156	0.432
1988	389712	2637800	80360	86481	0.208
1989	137621	1267090	176813	63698	0.072
1990	145641	1135810	124670	89571	2.319
1991	292181	2062040	89576	84649	0.616
1992	277499	2274420	229060	153649	0.735
1993	390060	3023320	269314	234265	1.863
1994	193592	1902680	301043	398697	0.938
1995	107915	1184690	144308	416538	1.393
1996	201867	1514640	118159	83634	0.607
1997	206679	1812790	342415	90316	0.626
1998	276951	2259760	321635	161433	1.225
1999	264031	2176410	211862	220736	0.598
2000	192360	1764060	293278	179540	0.758
2001	145915	1305030	192745	110442	1.535
2002	174733	1383240	78083	144265	1.413
2003	173091	1435690	187017	131255	0.952
2004	373211	2716580	85722	229197	1.699
2005	139759	1639510	380236	257645	0.771
2006	178795	1573090	213021	70750	0.825
2007	166239	1462920	141970	78730	1.270
2008	320758	2372150	222621	65598	0.634
2009	219981	2070910	379008	175282	0.459
2010	246921	2180220	310601	161814	0.496
2011	214250	1612320	355114	111200	0.536
2012	120725	1547070	294419	107070	0.365
2013			217169		
arith. mean	223369	1885874	230159	203993	1.041
geo. mean	186862				

Table 8.9.1. North Sea Sprat. Input to forecast.

Age	Age 0	Age 1	Age 2	Age 3
Stock numbers(2013) (millions)	184780	25296	8333	1797
Exploitation pattern Q1	0.000	0.046	0.082	0.109
Exploitation pattern Q2	0.001	0.117	0.450	0.662
Exploitation pattern Q3	0.003	0.027	0.040	0.052
Exploitation pattern Q4	0.000	0.000	0.000	0.000
Weight in the stock Q1 (gram)	6.749	8.639	10.967	14.870
Weight in the catch Q1 (gram)	6.75	8.64	10.97	14.87
Weight in the catch Q2 (gram)	5.56	8.96	12.15	15.62
Weight in the catch Q3 (gram)	7.05	12.93	18.71	25.16
Weight in the catch Q4 (gram)	6.37	11.10	15.94	21.14
Proportion mature(2013)	0.00	0.50	0.92	0.98
Proportion mature(2014)	0.00	0.43	0.88	0.96
Natural mortality Q1	0.27	0.56	0.45	0.13
Natural mortality Q2	0.60	0.39	0.33	0.13
Natural mortality Q3	0.27	0.26	0.22	0.22
Natural mortality Q4	0.43	0.29	0.16	0.16

Table 8.9.2. Sprat North Sea. Short-term predictions options table.

Basis: $F_{(2012)}$=0.38; Yield(2012)=107 000t; Recruitment(2012)=121 billion; Recruitment(2013)= 25% lower fractile boundary of the long term mean recruitment (GM 1992-2012) = 166 billion; SSB(2013)=220 000t.

F multiplier	Basis	F(2013)	Landings(2013)	SSB(2014)	%SSB change*	%Catch change**
0	F=0	0.00	0	234	6 %	-100 %
1.5	$F_{(2012)}$*1.5	0.57	85	188	-14 %	-20 %
2	$F_{(2012)}$*2	0.76	104	179	-18 %	-3 %
2.65	$F_{(2012)}$*2.65	1.01	124	170	-23 %	16 %
3	$F_{(2012)}$*3	1.14	134	165	-25 %	25 %
3.42	$F_{(2012)}$*3.42	1.30	144	161	-27 %	34 %
4	$F_{(2012)}$*4	1.52	156	156	-29 %	46 %
4.5	$F_{(2012)}$*4.5	1.72	165	152	-31 %	54 %
5.15	$F_{(2012)}$*5.15	1.96	176	148	-32 %	65 %
6.433	MSY	2.45	194	142	-35 %	81 %

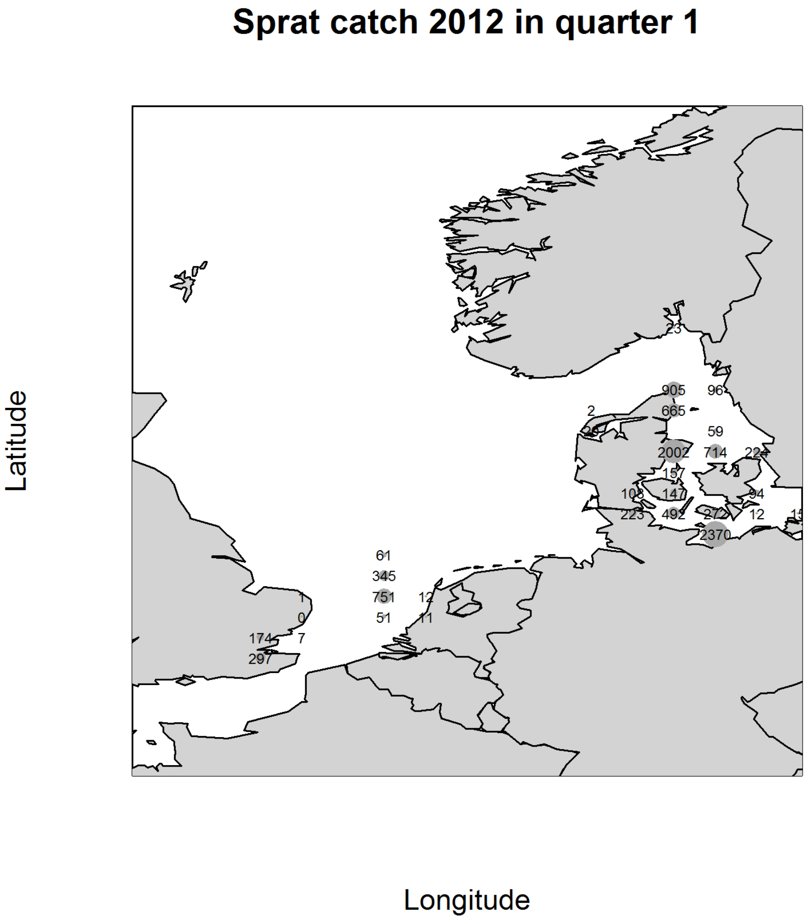


Figure 8.1.1a. North Sea sprat and IIIa sprat. Sprat catches in the North Sea and Div. IIIa (in tonnes) in the first quarter of 2012 by statistical rectangle.

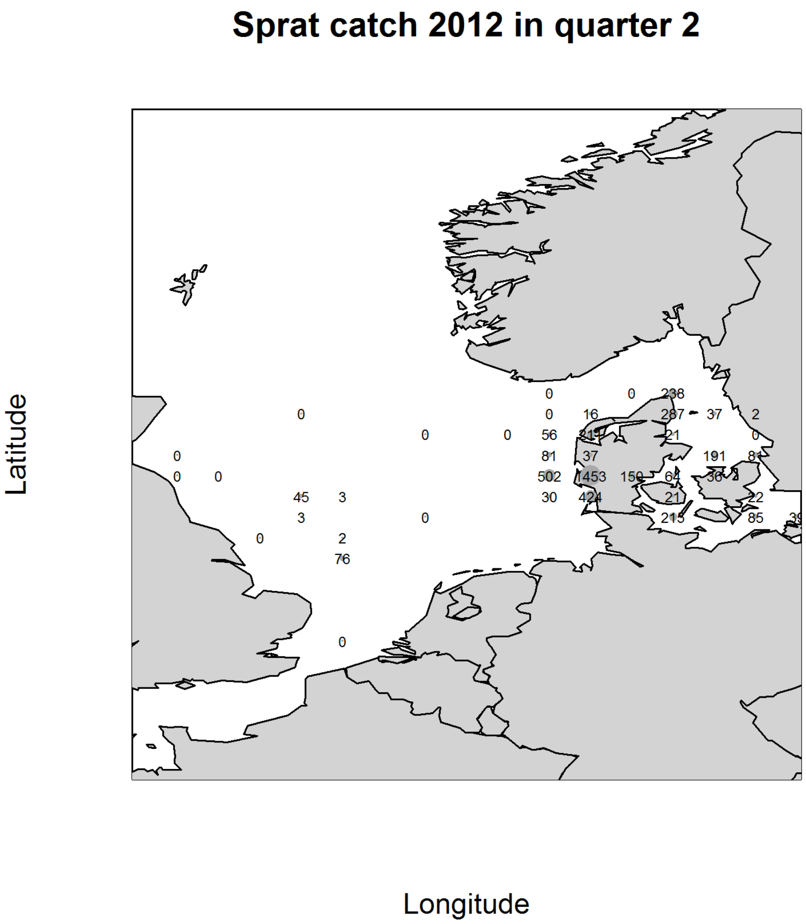


Figure 8.1.1b. North Sea sprat and IIIa sprat. Sprat catches in the North Sea and Div. IIIa (in tonnes) in the second quarter of 2012 by statistical rectangle.

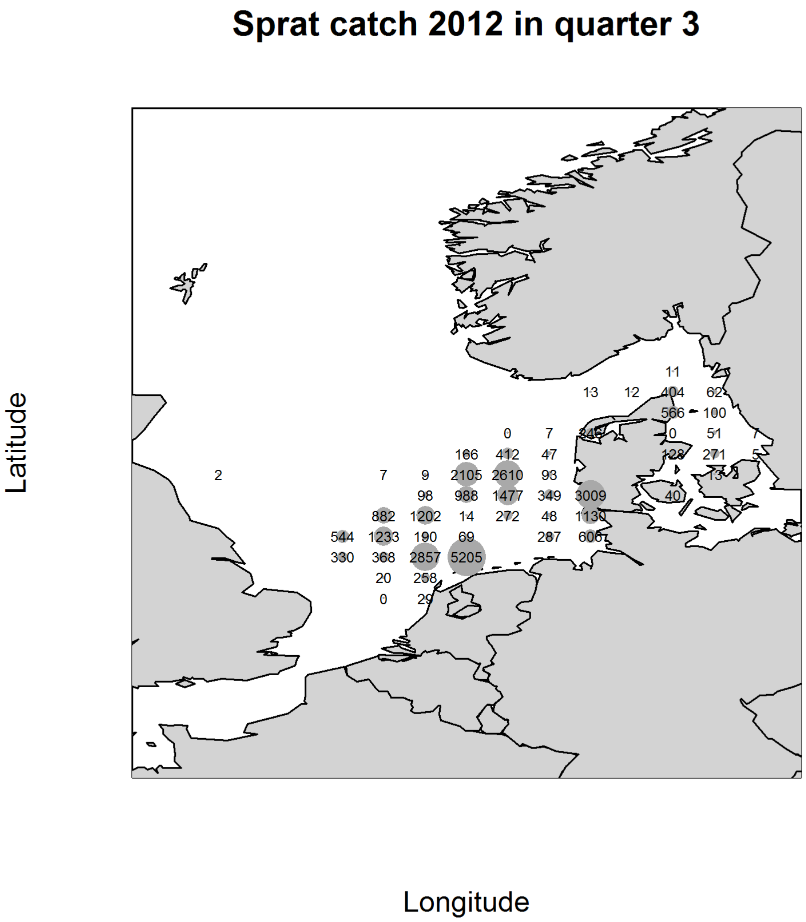


Figure 8.1.1c. North Sea sprat and IIIa sprat. Sprat catches in the North Sea and Div. IIIa (in tonnes) in the third quarter of 2012 by statistical rectangle.

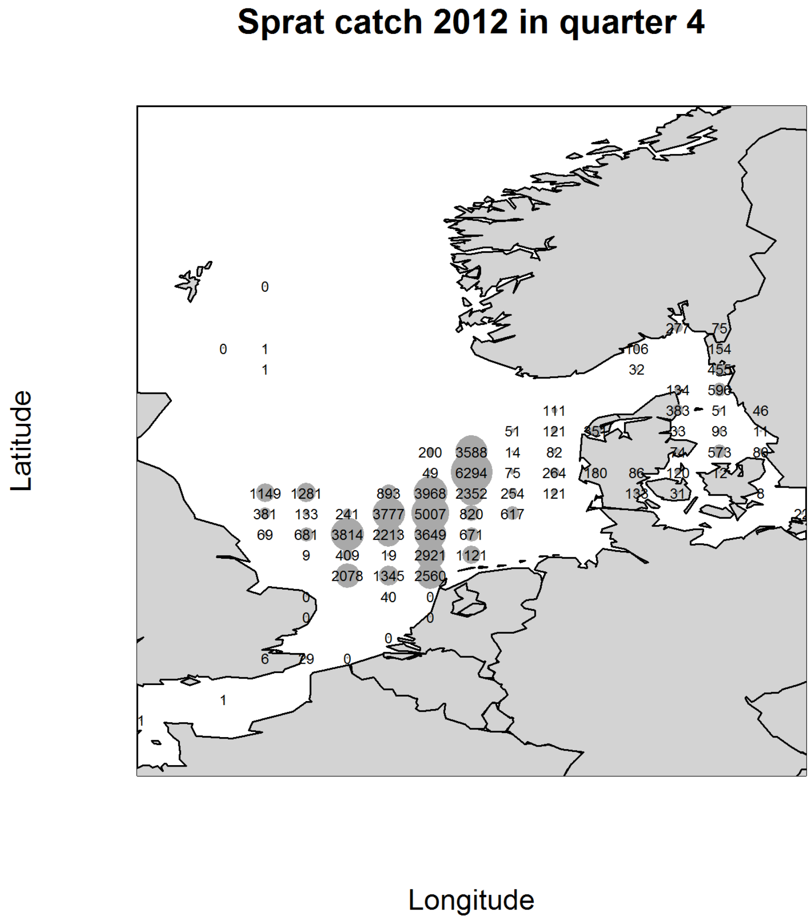


Figure 8.1.1d. North Sea sprat and IIIa sprat. Sprat catches in the North Sea and Div. IIIa (in tonnes) in the fourth quarter of 2012 by statistical rectangle.

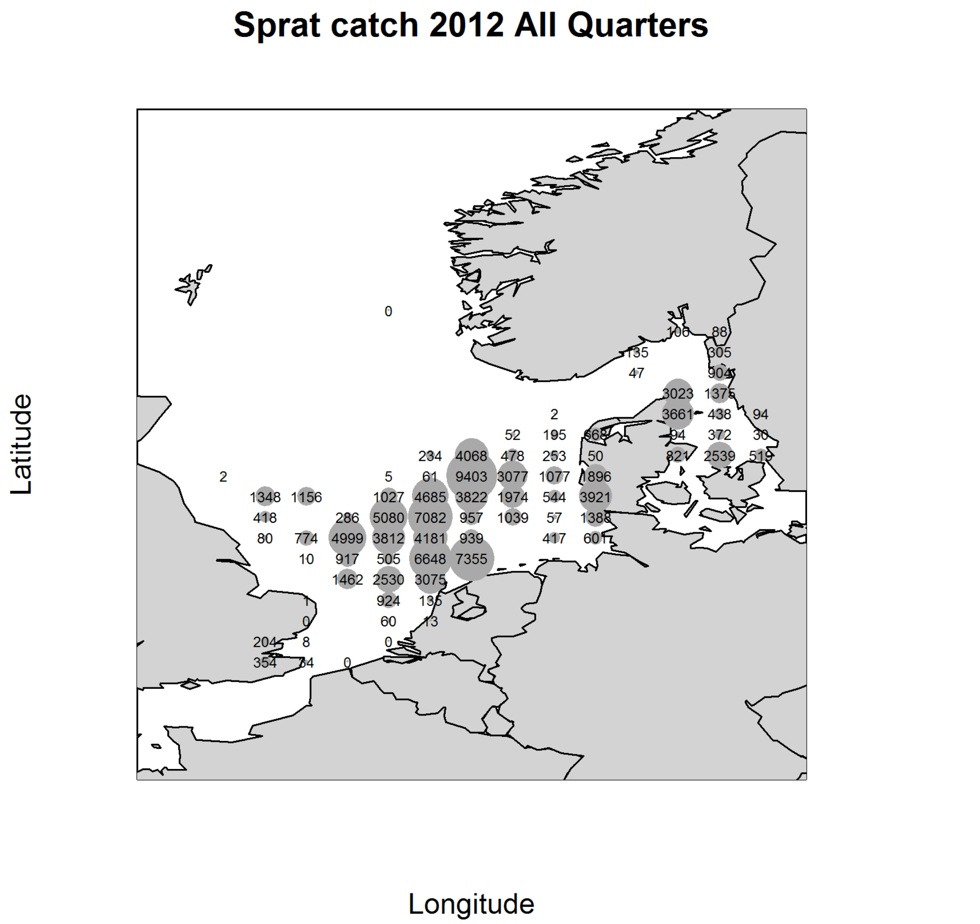


Figure 8.1.2 North Sea sprat and IIIa sprat. Sprat catches in the North Sea and Div. IIIa (in tonnes) in 2012 by statistical rectangle.

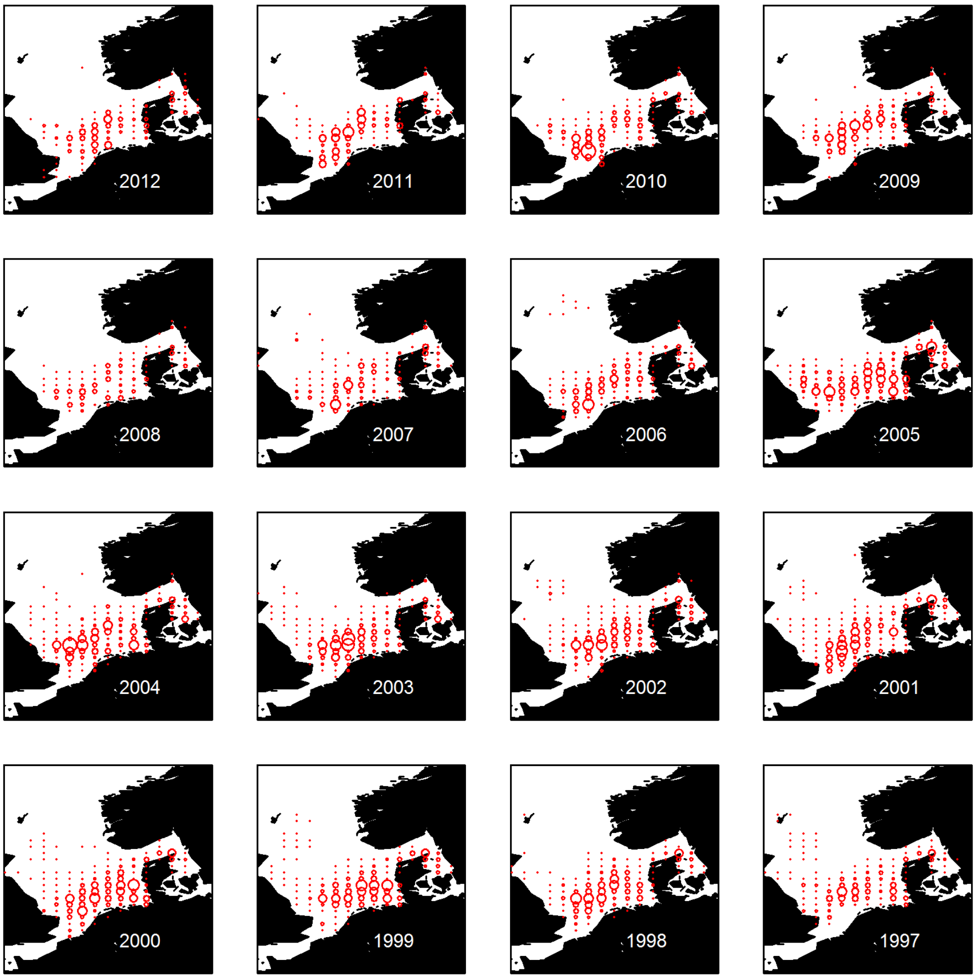


Figure 8.1.3. North Sea sprat and IIIa sprat. Sprat catches in the North Sea and Div. IIIa (in tonnes) for each year 1997-2012 by statistical rectangle.

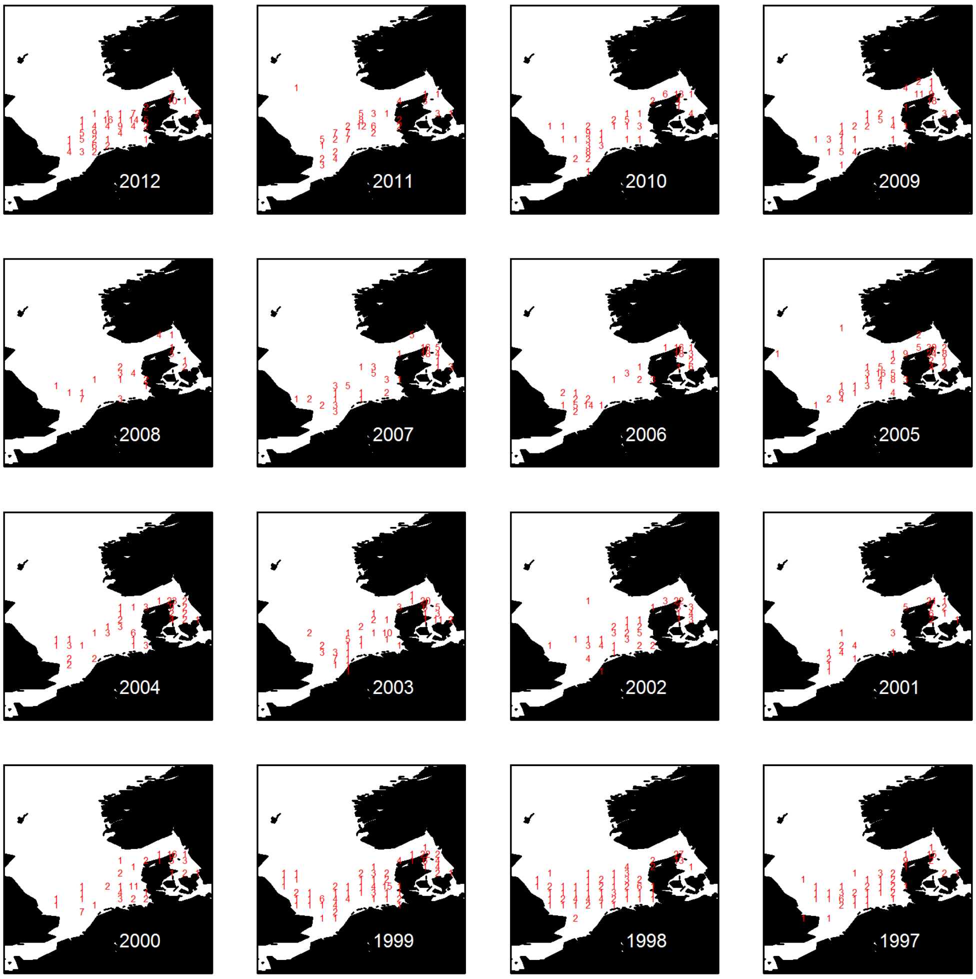


Figure 8.2.1. North Sea sprat and IIIa sprat. Number of samples taken in the North Sea and Div. IIIa for each year 1997-2012 by statistical rectangle.

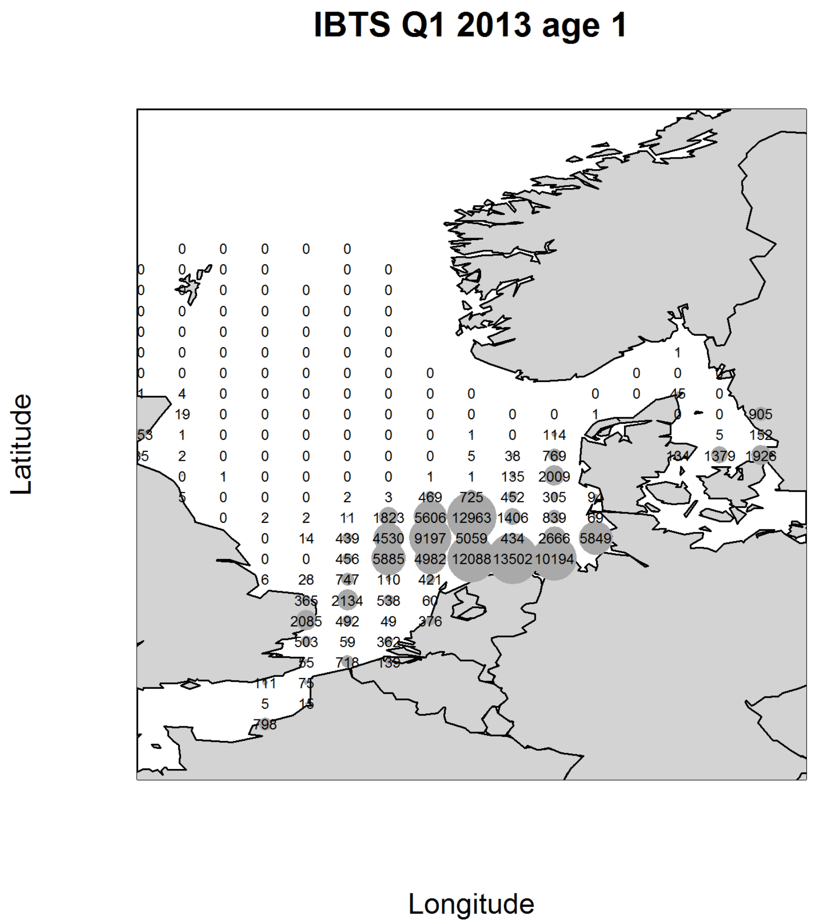


Figure 8.3.1a. North Sea sprat and IIIa sprat. Distribution of 1-ringers in the IBTS (February) 2012 in the North Sea and Division IIIa (Mean number per hour per rectangle).

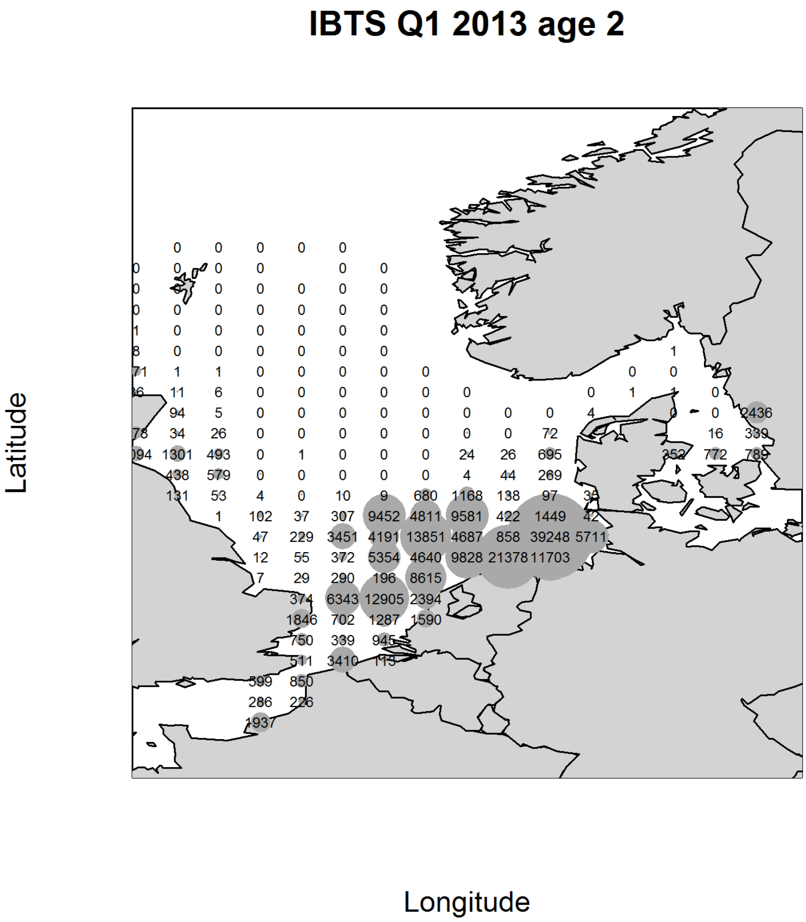


Figure 8.3.1b. North Sea sprat and IIIa sprat. Distribution of 2-ringers in the IBTS (February) 2012 in the North Sea and Division IIIa (Mean number per hour per rectangle).

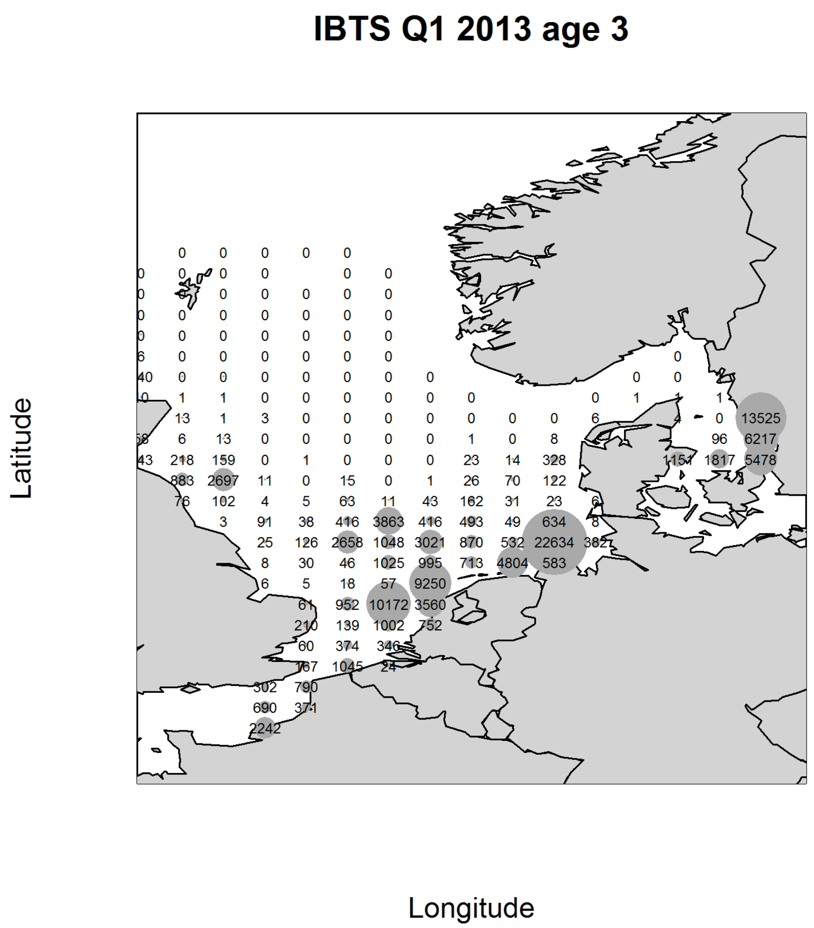


Figure 8.3.1c. North Sea sprat and IIIa sprat. Distribution of 3-ringers in the IBTS (February) 2012 in the North Sea and Division IIIa (Mean number per hour per rectangle).

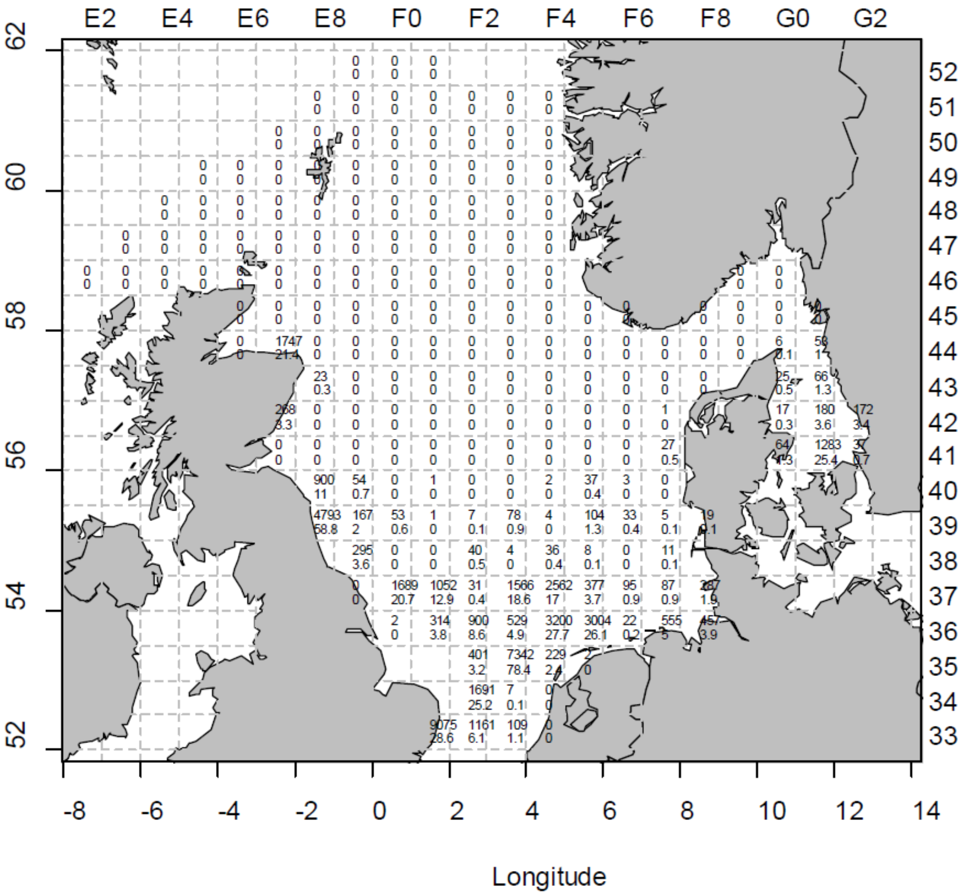


Figure 8.3.2. North Sea Sprat and IIIa sprat. Abundance (upper figure in each rectangle, in millions) and biomass (lower figure, in 1000 t) per statistical rectangle as obtained by the herring acoustic survey (HERAS) 2012. Blank rectangles were not covered.

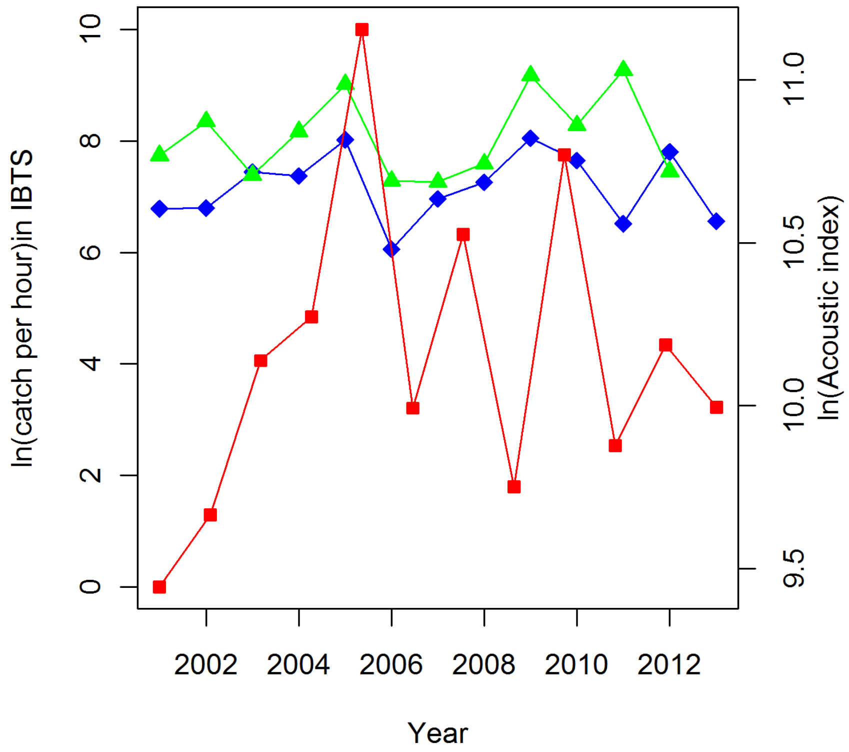


Figure 8.3.3. North Sea sprat. Mean catch rate of 1-year olds in quarters 1 (blue diamonds) and 3 (green triangles) and in HERAS (red squares).

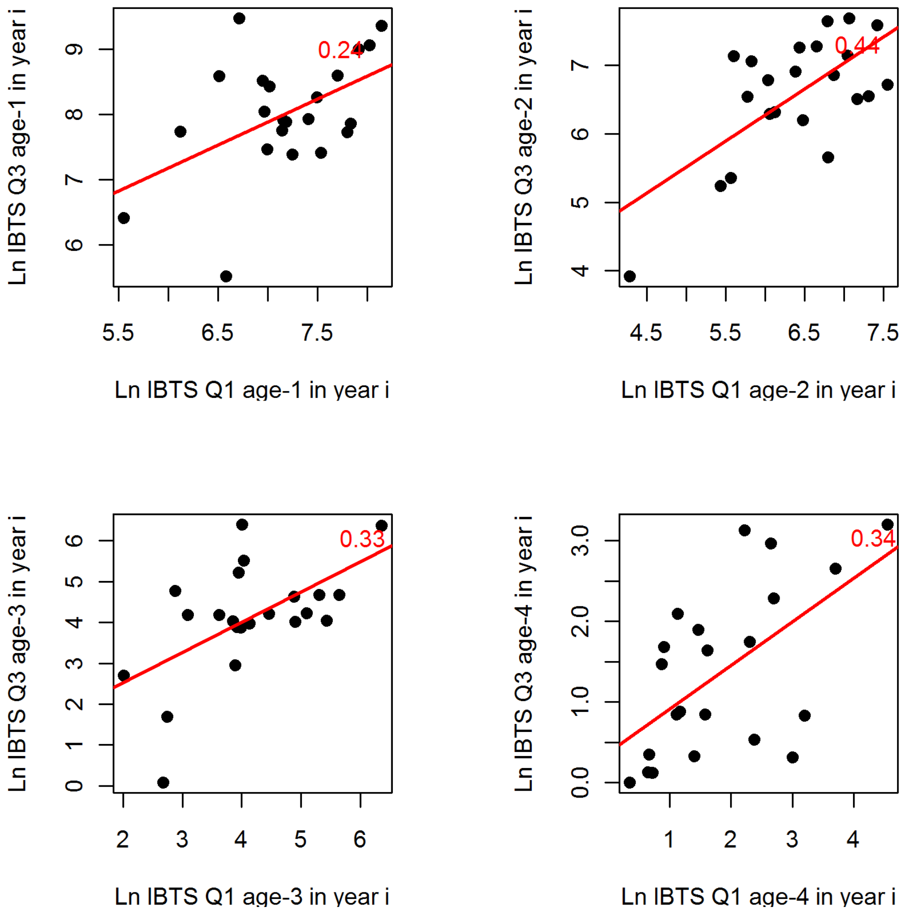


Figure 8.3.4. North Sea sprat. External consistency between the IBTS Q1 and Q3 surveys. Red number inside the graphs are R2. (Quarter (Q) and age refer to the calendar year)

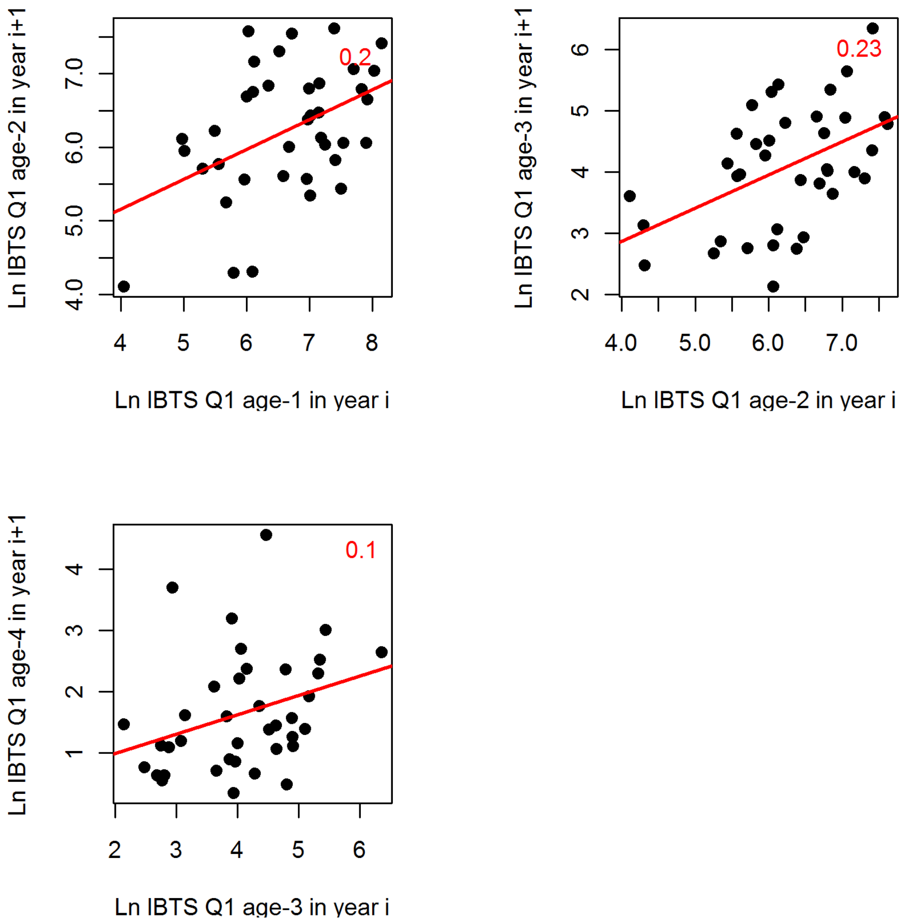


Figure 8.3.5. North Sea sprat. Internal consistency in the IBTS Q1 survey. Red number inside the graphs are R2. (Quarter (Q) and age refer to the calendar year)

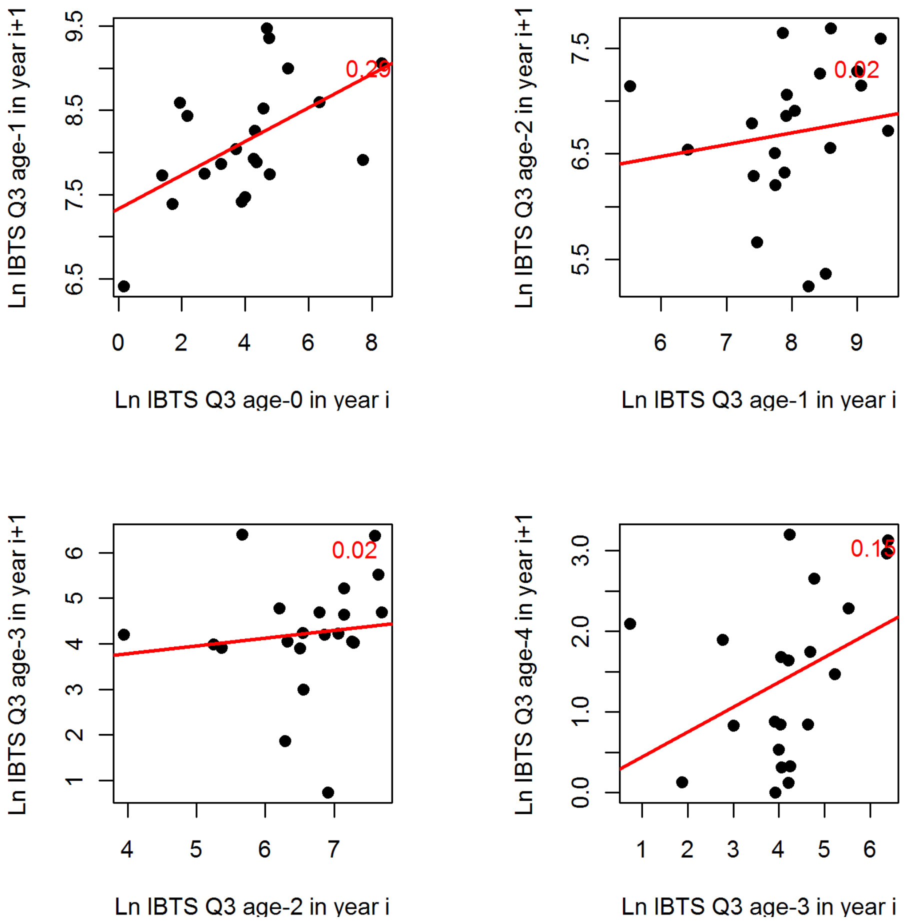


Figure 8.3.6. North Sea sprat. Internal consistency in the IBTS Q3 survey. Red number inside the graphs are R2. (Quarter (Q) and age refer to the calendar year)

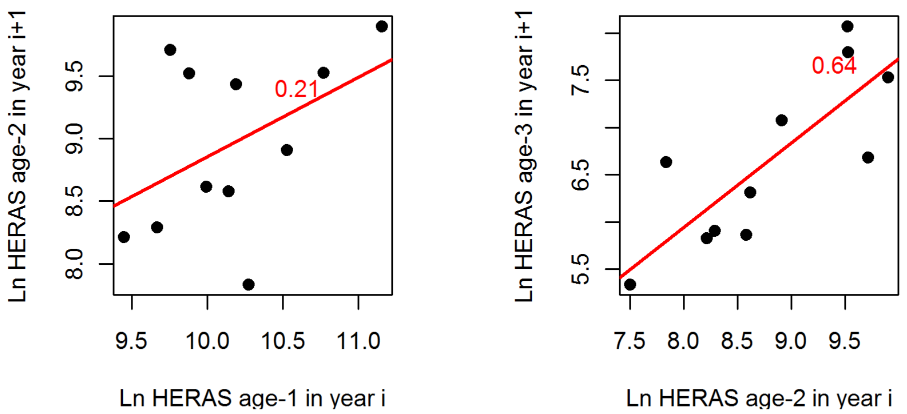


Figure 8.3.7. North Sea sprat. Internal consistency in the HERAS (acoustic) survey. Red number inside the graphs are R2. (Quarter (Q) and age refer to the calendar year)

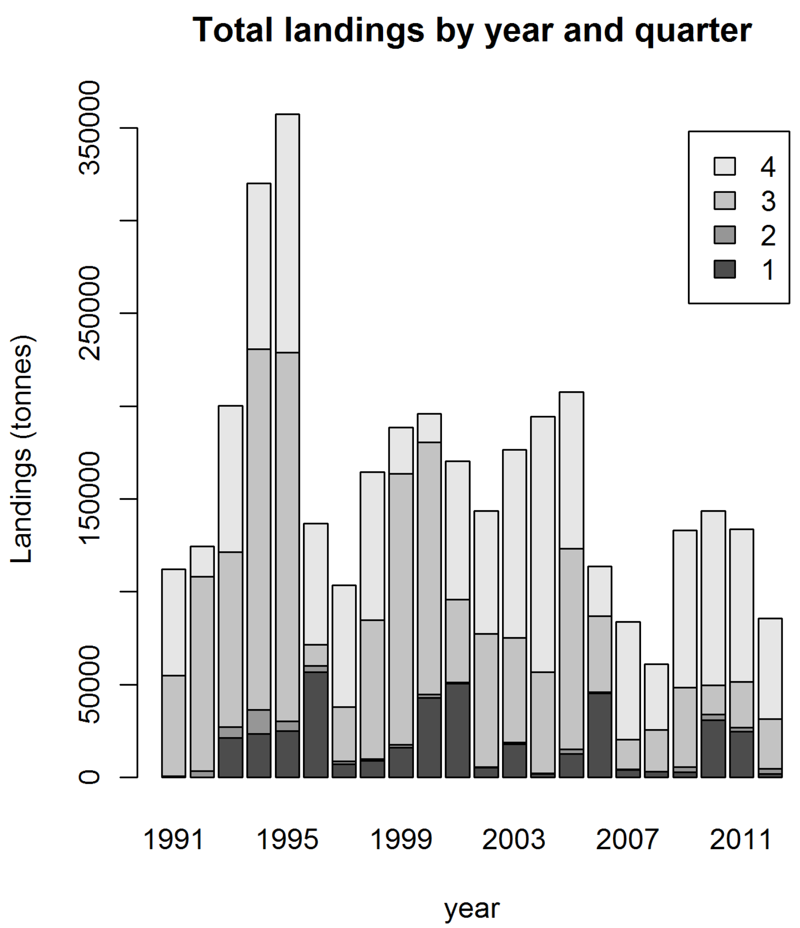


Figure 8.6.1. North Sea sprat. Quarterly distribution of Danish catches (Calendar year).

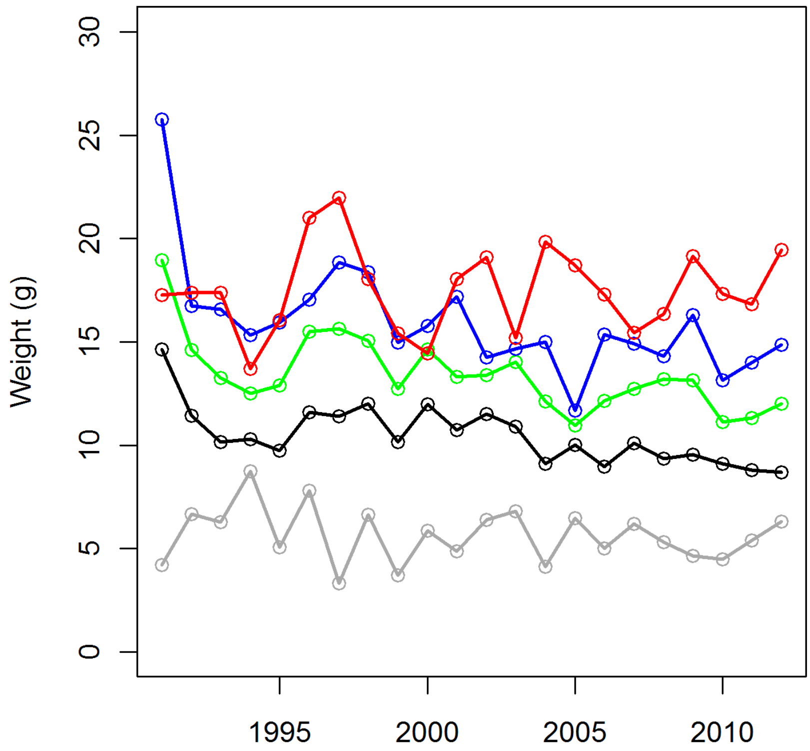


Figure 8.6.2. North Sea sprat. Mean weight at age in quarter 4.

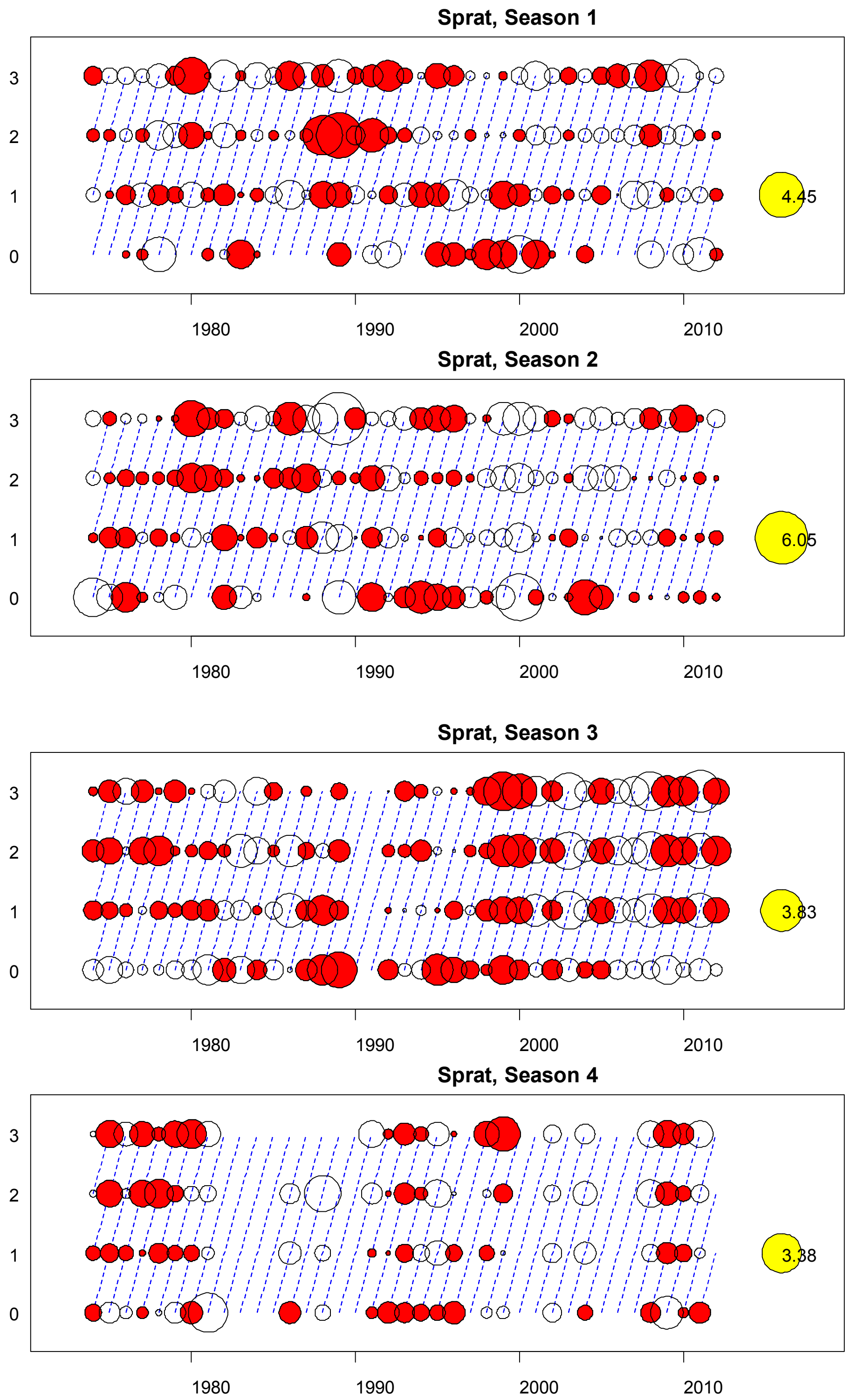


Figure 8.6.3. North Sea sprat. Catch residuals by age.

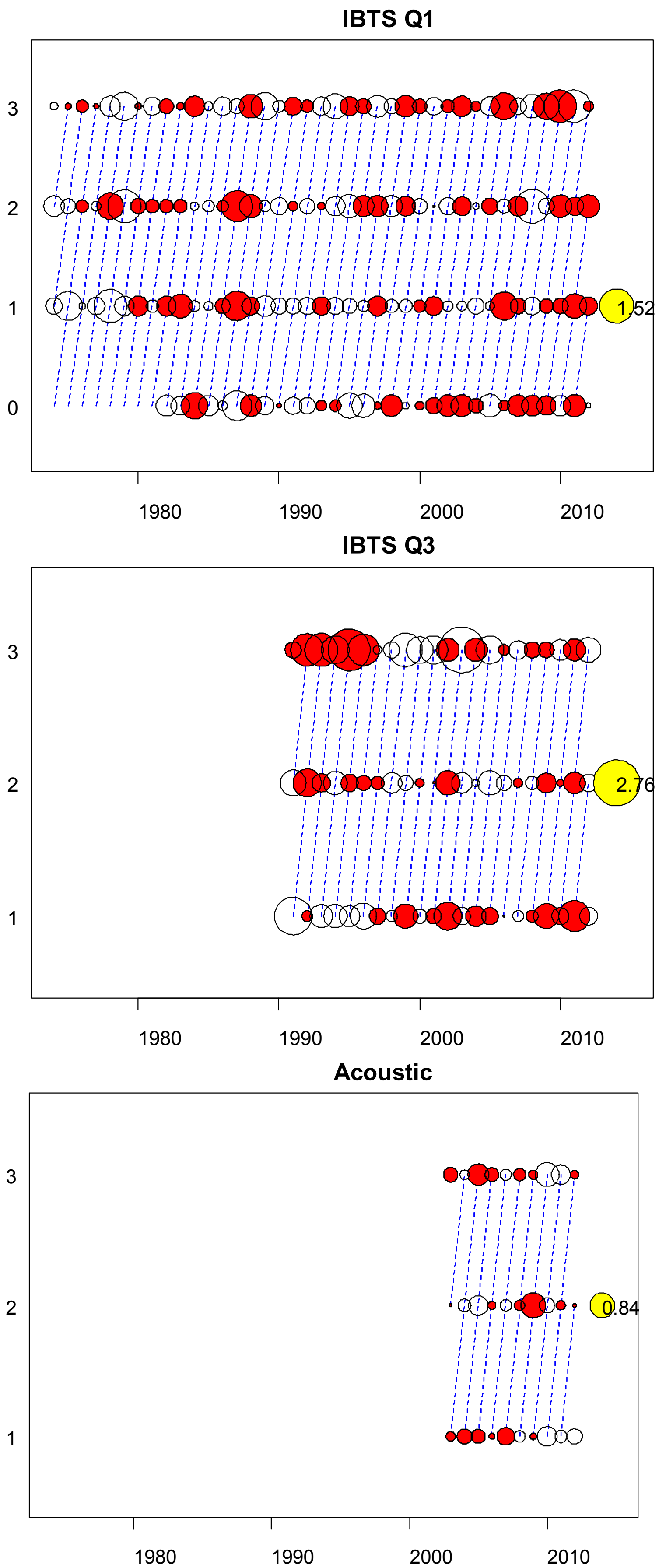


Figure 8.6.4. North Sea sprat. Survey residuals by age.

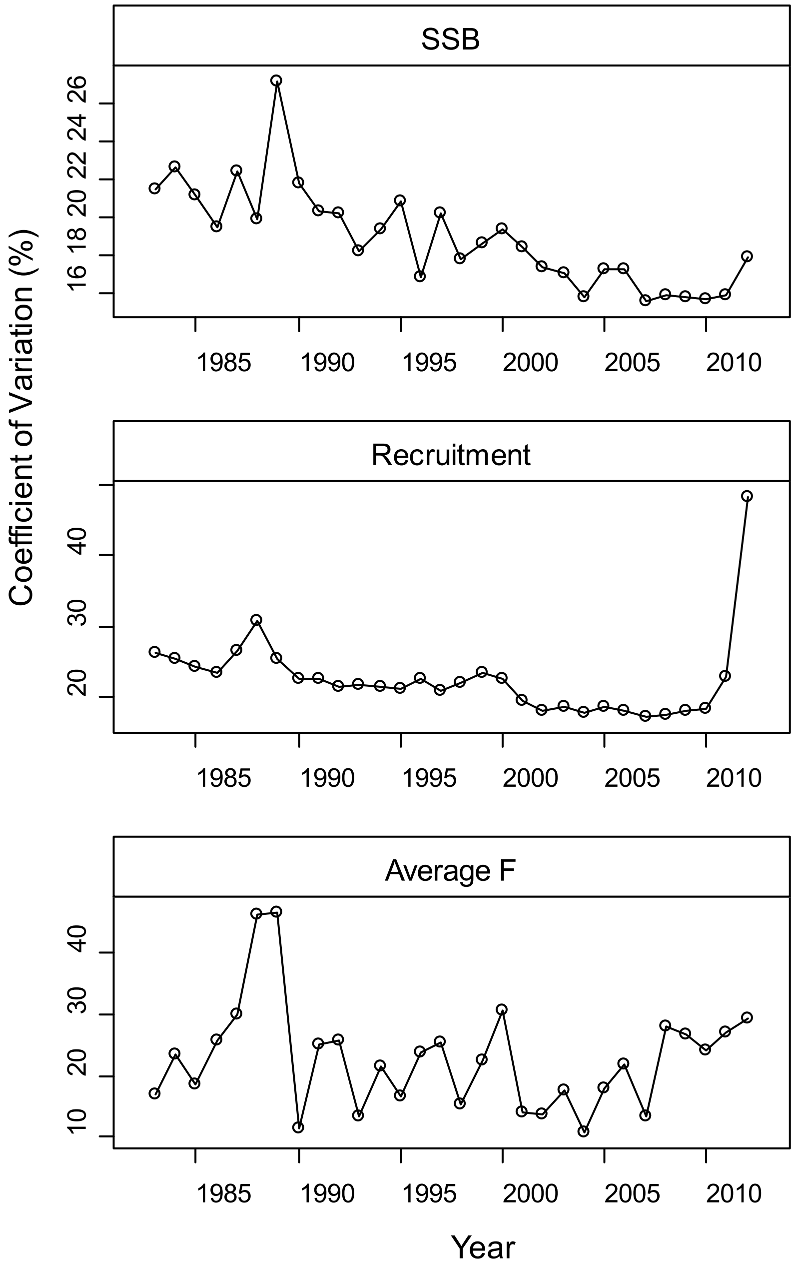


Figure 8.6.5. North Sea sprat. Coefficients of variance.

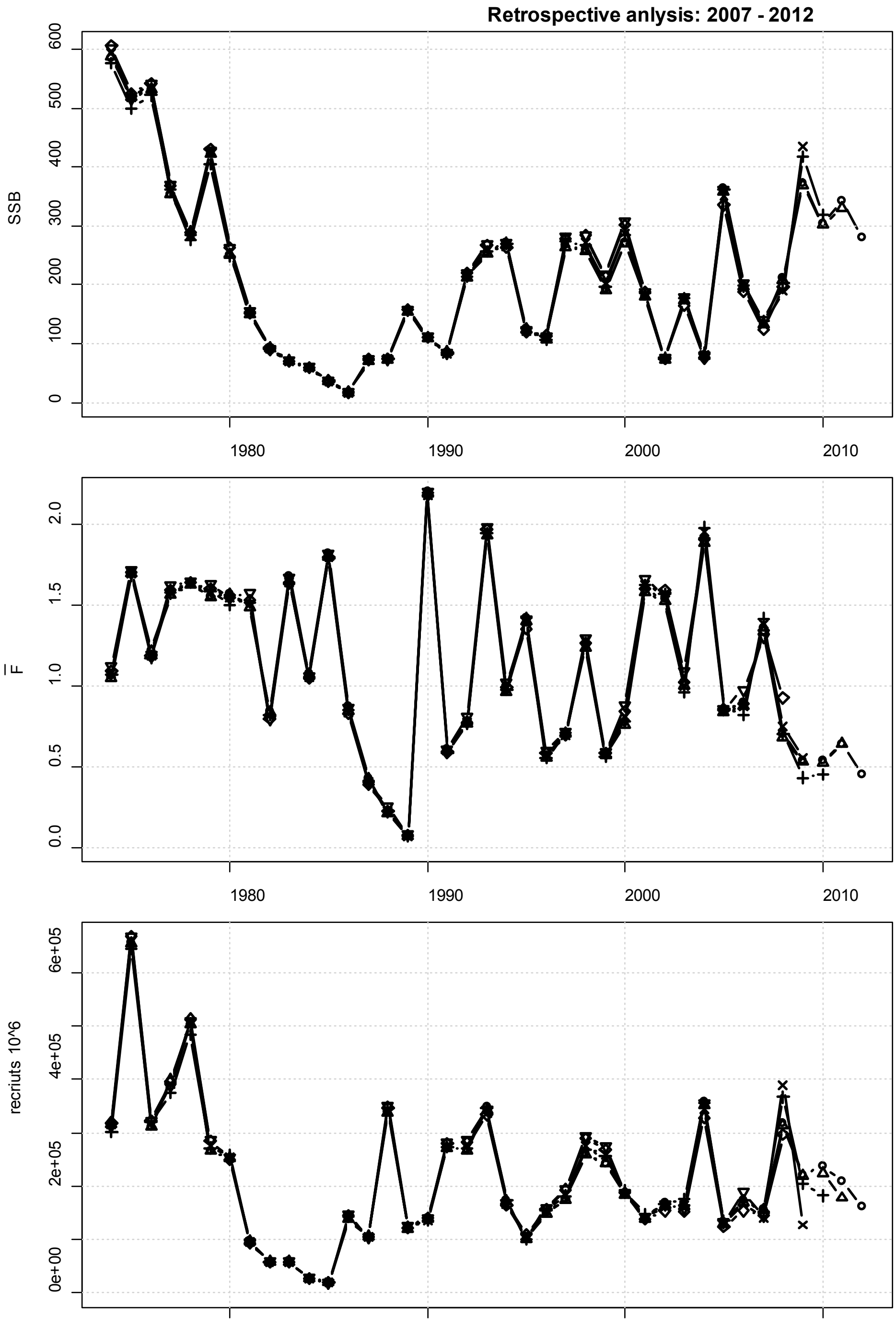


Figure 8.6.6. North Sea sprat. Retrospective analysis.

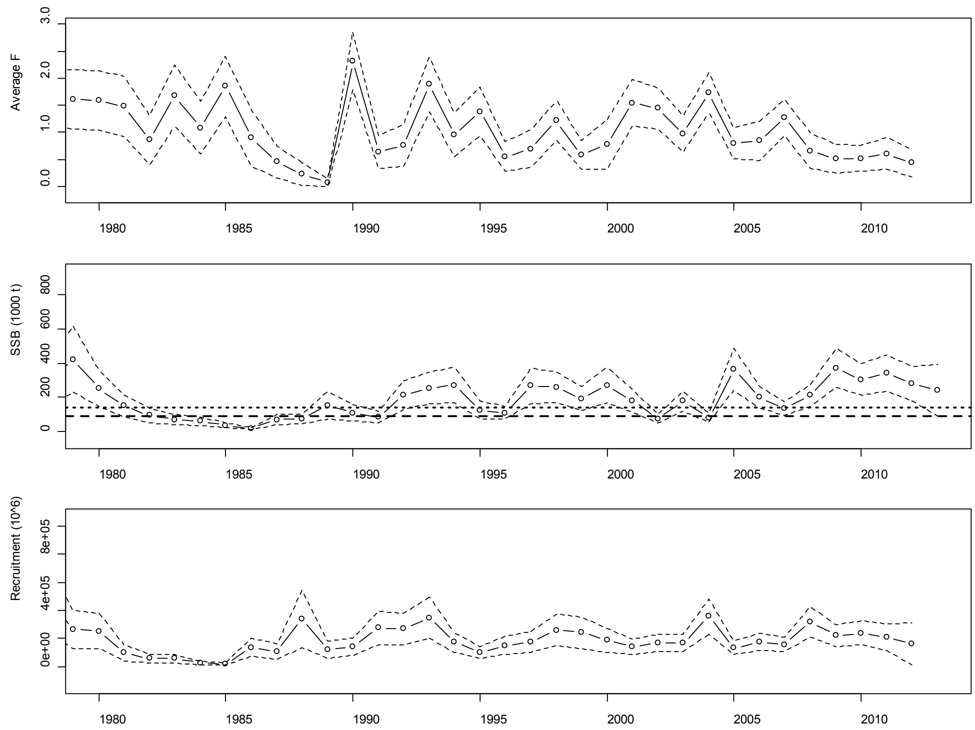


Figure 8.6.7. North Sea sprat. Temporal development in Mean F, SSB and recruitment. Hatched lines are 95% confidence intervals.

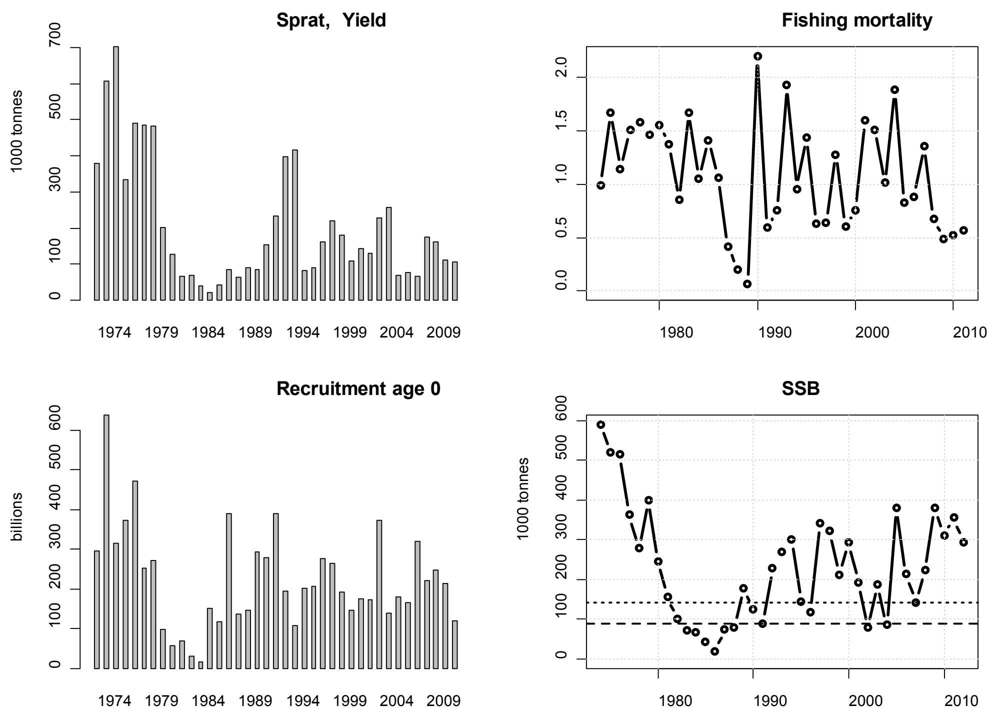


Figure 8.6.8. North Sea sprat. Assessment summary.

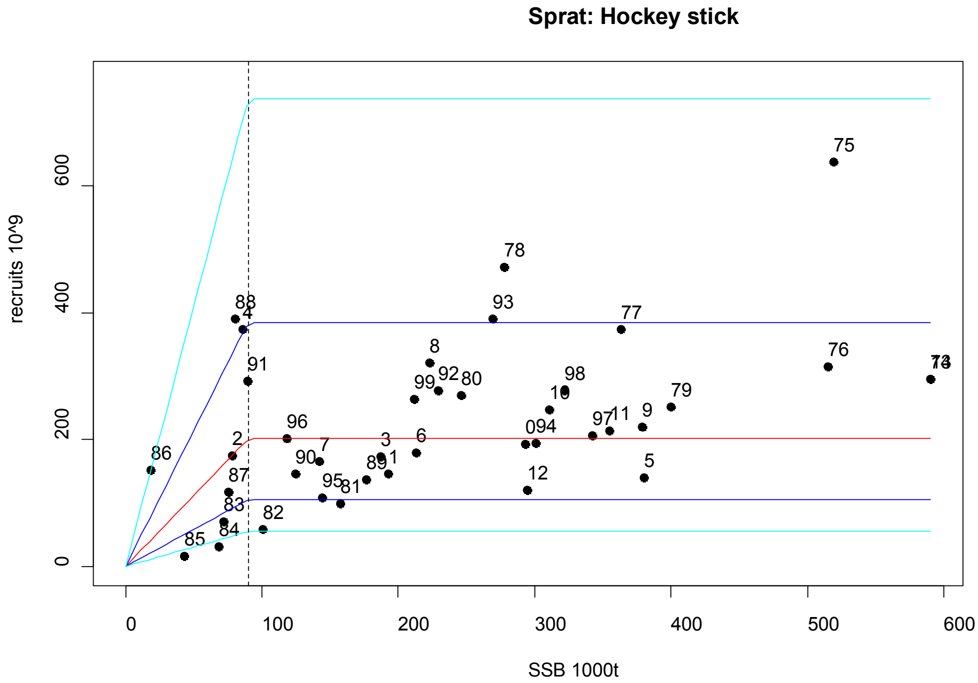


Figure 8.7.1. North Sea sprat. Stock-recruitment relationship.

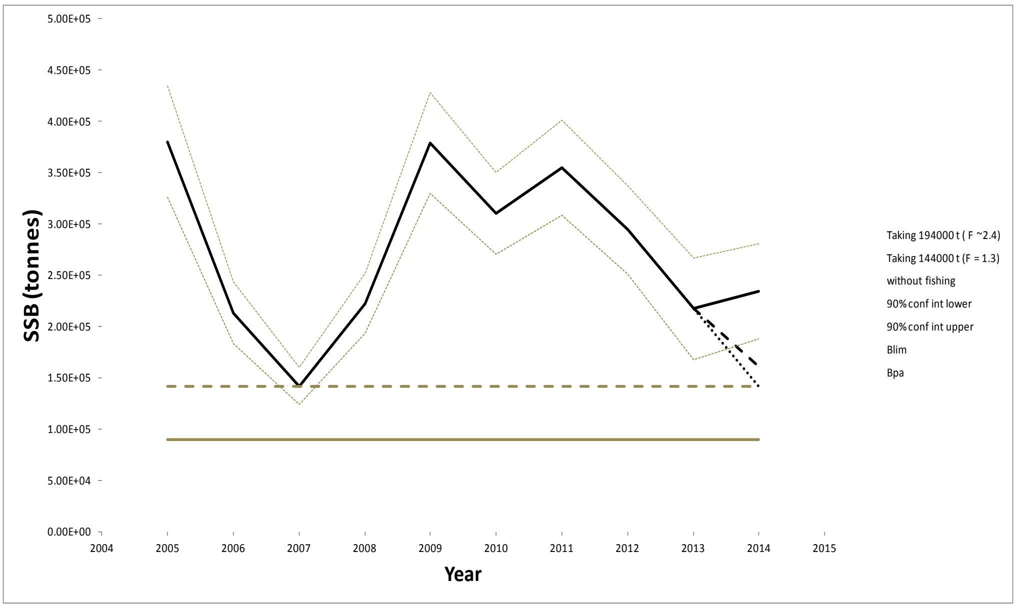


Figure 8.9.1 Sprat in the North Sea. Short-term projection of SSB for modelled years. Fs in the 2013/14 taken as 0, 1.3 and 2.4.

9 Sprat in Division IIIa

9.1 The Fishery

9.1.1 ICES advice applicable for 2012 and 2013

In 2012, the TAC for sprat was set at 52 000 t and the by-catch of herring in the industrial and sprat fishery limited to 6 659 t. The advice in 2012 (for 2013) was for a reduction in TAC by 20%. For 2013, the TAC for sprat is set at 41 600 t.

Sprat is mainly being fished together with juvenile herring. The sprat fishery has been controlled by a herring by-catch TAC as well as by-catch percentage limits (Norway and Denmark: respectively max 10% and 50% by-catch of herring in weight), the latter being the most regulative.

9.1.2 Landings

The total landings in 2012 (10 417 t) were similar to the landings in 2011 (Table 9.1.1). The table presents the landings from 1996 onwards. The data prior to 1996 can be found in the HAWG report from 2006 (ICES 2006/ACFM:20). In the few years prior to 1996 the official and ICES catches differed considerably and there is no clear documentation as to why.

There were sprat landings in all quarters (Table 9.1.2, see Figures 8.1.1–8.1.2). In 2012 the proportion of total landings from the 3rd and 4th quarters (76%) was approximately the same as in 2011 (73%). In the Norwegian fishery sprat were, as before, taken in the 1st and 4th quarter, all as part of the fishery for canning production.

9.1.3 Fleets

Fleets from Denmark, Norway and Sweden carry out the sprat fishery in Division IIIa.

The Danish sprat fishery consists of trawlers using 16 mm mesh size codend and all landings are used for fishmeal and oil production. In Sweden there is a fishery with pelagic trawl targeting sprat for reduction and a late fall purse seine fishery for sprat to be used in human consumption. The Norwegian sprat fishery in Division IIIa is a coastal / fjord purse seine fishery for human consumption.

9.1.4 Regulations and their effects

Sprat cannot be fished without by-catches of herring except in years with high sprat abundance or low herring recruitment. Management of this stock should consider management advice given for herring in Subarea IV, Division VIId, and Division IIIa.

Most sprat catches are taken in a small-meshed industrial fishery where catches are limited by herring by-catch restrictions.

9.1.5 Changes in fishing technology and fishing patterns

No changes in fishing technology and fishing patterns for the sprat fisheries in IIIa have been reported for 2012.

9.2 Biological Composition of the Catch

9.2.1 Catches in number and weight-at-age

During the 2013 benchmark (see WKSPRAT report: ICES CM 2013/ACOM:48), mean weights and catch-in-numbers by quarter were recalculated. The numbers in the Tables differ from previous years along with a change from a 5+ group to 4+. In 2011 the 1- and 2-year-olds dominated the landings (in numbers) by contributing approximately 72% of the total landings in numbers with 3-year olds about 20% (Table 9.2.1). In 2012 the 1- and 2-year- contributed approximately 79% of the total landings in numbers.

Mean weight-at-age (g) in the catches are presented by quarter in Table 9.2.2. Mean-weight-at-age for all ages is in the same order as the previous years. Mean weights-at-age for 1996-2003 are presented in ICES CM 2005/ACFM:16. Landings in 2011, for which no samples were collected, were raised using a combination of Danish and Norwegian samples, without any differentiation in types of fleets. In 2012, Denmark provided biological samples from all quarters and Sweden from the 1st and 4th quarters. Details on the sampling for biological data per country, area and quarter are shown in Table 9.2.3.

9.3 Fishery-independent information

Three surveys cover this stock: International Bottom Trawl Survey (IBTS) in the first and third quarters of the year and the herring acoustic survey (HERAS) cover the same area during June-July. For more details, see ICES WKSPRAT (2013). The survey indices available are the IBTS in the Skagerrak/Kattegat from 1983 onwards (from this year, all nations used GOV trawl), and an acoustic abundance index by age from HERAS from 2006 onwards.

One problem with the surveys in IIIa (highlighted by ICES WKSPRAT (2013)) was that they mainly cover the central parts of Skagerrak/Kattegat, whereas all the Norwegian and some of the Swedish catches are taken in coastal areas not covered adequately by the surveys. Also, most of the sprat is concentrated in a very small part of the survey area, meaning that only a few trawl hauls / transects give survey information about sprat, making the survey indices less precise.

9.3.1 ICES co-ordinated Herring Acoustic survey (HERAS)

Acoustic estimates of sprat have been available from HERAS in Division IIIa since 1996 (see Table 9.3.1). At the time of the surveys in 2012, sprat were once again only found in Kattegat. The 2012 abundance was estimated to be 1 902 million individuals, an increase compared to 1 574 million individuals in 2011. The biomass was estimated to be 37 596 tonnes, an increase of about 27%. Most sprat were 3+ group, and all of them were mature.

9.3.2 IBTS (1st and 3rd Quarter)

The IBTS (February) sprat indices for 1984-2012 are presented in Table 9.3.2. The preliminary total IBTS index for 2013 decreased again, this time by approximately 32%. The abundance index for the 1-group was above the recent averages for the period 2010-12 with the highest value occurring in the 3-year-olds. This value was marginally lower than the average for the period 2005 to 2012.

9.3.3 Survey consistency

The estimation of average catch at age in the IBTS was explored in ICES CM 2013/ACOM:XX, but also see section 8.6.1. These data were compared with the HERAS data for internal and external consistency. Based on these analyses the survey index was estimated from a stratified mean (see ICES CM 2013/ACOM:XX).

9.4 Mean weight-at-age and length-at-maturity

Data on maturity by age, mean weight- and length-at-age during the 2012 HERAS are presented in Table 4.1.1.7 in the WGIPS report (ICES CM 2012/SSGESST:22). The 2009 results on age and maturity distribution were considered questionable by HAWG 2012, and therefore revised by WGIPS 2011 (ICES CM 2011/SSGESST:02).

9.5 Recruitment

For this stock, the IBTS index for 1-group sprat in the first quarter is the only available recruitment index (Table 9.3.2). The 1-group index for 2013 at 16% of the total index, was higher than for 2012 and 2011 (7 and 2% respectively) but was still in the lowest 25% recorded for the period 1984 to the present. However, in 2009 the age 1 index contributed a much higher proportion of the total index (85 %). The procedure for the survey did not differ from previous years. However, the index does not fully reflect the strong and weak cohorts seen in the catch. This has also been expressed in a previous working group report (ICES 1998/ACFM:14) and in the benchmark (ICES CM 2013/ACOM:XX), and may be linked to difficulties in age determination and/or methodological issues related to the way the indices are estimated (see WKSPRAT Section 3.1.7). This was also shown by the WKSHORT (ICES CM 2009/ACOM:34) for sprat in the North Sea.

9.6 Stock Assessment

9.6.1 Data exploration

In 2012 (ICES CM 2012/ACOM: 06), the IBTS and the catch data series were explored in order to find out whether they could provide some information about the exploitation level of the sprat stock. This was further explored at the sprat benchmark (ICES CM 2013/ACOM:XX) and here (Figure. 9.6.1).

9.6.2 Stock Assessment

Several attempts were made to produce a quarterly or annual SMS stock assessment for sprat in IIIa. However, the lack of consistency between the surveys meant that though CVs of catches in the main fishing season was at 0.91 (0.77 when considering only the years from 1997 onwards), survey CVs remained very high (>1.10 for all three surveys). In all models, the CV of the SSB in the terminal year remained above 50%. Substantial residual patterns were seen in all the assessments. Accordingly, it was decided not to attempt to use an analytical assessment for advice.

9.6.3 State of the Stock

No assessment of the sprat stock in Division IIIa has been presented since the mid-1980ies. Various methods have been explored without success (ICES CM 2007/ACFM:11).

9.7 Short term projections

WKSPRAT proposed using the IBTS Q1 age 1 as an indicator of the incoming year class and IBTSQ1 age 2, IBTSQ3 age 1 the previous year and HERAS age 1 the previous year as indicators of age 2. These should provide in year advice for IIIa based on the ICES data limited stock approach (Category 3/4 DLS: ICES CM 2012/ACOM 68). Together, this provides an index of the sprat which will be age 1 and 2 in the beginning of July. These two age groups make up 77% of the catch biomass on average.

Method

WKSPRAT identified the useful survey indices for IIIa sprat as:

IBTS Q1 Age 1

IBTS Q1 Age 2

IBTS Q3 Age 1

HERAS Age 1

As there were several indices of approximately equal quality, it was necessary to combine these into a single index. This was performed separately for the two cohorts (the cohorts with 1 and 2 winter rings in quarter 1). The cohort with one winter ring in the last available IBTS Q1 had only one survey index available whereas the cohort with 2 winter rings in the last available IBTS Q1 had three survey indices. To combine these three, all survey indices were expressed in relative deviation from the mean:

$$I = \frac{S_y - \sum_{i=1}^{N} S_i/N}{\sum_{i=1}^{N} S_i/N}$$

Where I is the index of a given age in a given survey, S is the survey catch per unit effort (or total number in the case of acoustic estimates), i are the different survey years and N is the number of years in which the survey is available. Indices of 2 winter ring sprat in quarter 1 were produced as:

$$\bar{I} = \frac{\sum_{j=1}^{M} I_j}{M}$$

Where subscript j denotes the survey (IBTS Q1 age 2 in the given year, IBTS Q3 age 1 in the previous year and HERAS age 1 in the previous year) and M is the number of surveys available (1 to 3 depending on year). A combined index for the two cohorts making up the majority of the catch was the produced as a weighted average of the cohort specific indices. Weights used were the average proportion of the weight of the catch which consisted of the particular age group over the past 3 years. With this method, the weights assigned to the two indices were 0.49 for the 1 winter ring index and 0.52 for the 2 winter ring index. The resulting anomaly index was multiplied by a precautionary buffer of 20% into a catch multiplier CM for the 2014 of:

$$CM_y = \frac{(1 + \bar{I}_y)}{(1 + (\bar{I}_{y-1} + \bar{I}_{y-2} + \bar{I}_{y-3} + \bar{I}_{y-4})/4)} * (1 - 0.2)$$

Where y indicates year.

If the index $\bar{I}$ exceeds 0.2 or falls below -0.2, it is replaced by an uncertainty cap of 0.2 and -0.2, respectively, so the minimum and maximum values of *CM* are 0.64 and 0.96. After 2014, the uncertainty cap has already been applied and the *CM* for 2015-2016 will be

$$CM = (1 + \bar{I})$$

The catch multiplier is used to estimate next year's TAC as

$$TAC_y = CM(C_{y-1}+C_{y-2}+C_{y-3})/3$$

Results

The anomalies in the survey indices are seen in Fig. 9.7.1 and the total index in Fig. 9.7.2. Further, the proportion of all commercial catches (in biomass) consisting of fish with more than 2 winter rings is given in Fig. 9.7.3. Applying the rule stated in the methods, the catch multiplier is estimated at 0.64. As the average catch over the last three years is 10 605 t, the TAC using this method will be 6 787 t which is well below the historical minimum catch of 8 700 t.

9.8 Reference Points

No precautionary reference points are defined for this stock.

9.9 Quality of the Assessment

The stock was benchmarked and peer-reviewed in February 2013 (ICES CM 2013/ACOM:XX).

No analytical assessment applies to this stock.

9.10 Management Considerations

Sprat is a short-lived species with large inter-annual fluctuations in stock biomass. The natural inter-annual variability in stock abundance, mainly driven by recruitment variability, is high and does not appear to be strongly influenced by the observed levels of fishing effort.

The sprat is mainly fished together with herring. The human consumption fishery only takes a minor proportion of the total catch. Within the current management regime, where there is a by-catch ceiling limitation of herring as well as by-catch percentage limits, the sprat fishery is controlled by these factors. In recent years the sprat fisheries have not been limited by the sprat quota, since this quota has not been taken.

9.11 Ecosystem Considerations

No information of the ecosystem and the accompanying considerations are known at present. In the adjacent North Sea, multispecies investigations have demonstrated that sprat is one of the important prey species in the North Sea ecosystem, for both fish and seabirds (ICES CM 2011/SSGSUE:10). It is considered that there are fewer predator populations in IIIa than in the North Sea. For an analytical assessment it is not possible to include annual estimates of sprat consumption by predators as done for the North Sea stock, but it would be possible to estimate average predation consumption.

A major source of uncertainty with IIIa sprats is the extent to which these fish derive from migrations of fish from the North Sea stock into IIIa.

9.12 Changes in the environment

Temperatures in the Skagerrak area have increased over the last few years (Johannesen *et al*. 2011). In the North Sea a shift in species composition and biomass of zooplankton have been observed (Llope *et al*. 2012). There are no indications of systematic changes in growth or age at maturity in sprat in the North Sea or in Division IIIa.

Table 9.1.1 Division IIIa sprat. Landings in ('000 t) 1996-2012.
(Data provided by Working Group members). These figures do not in all cases correspond to the official statistics and cannot be used for management purposes.

	Skagerrak				Kattegat			Div. IIIa total
	Denmark	Sweden	Norway	Total	Denmark	Sweden	**Total**	
1996	7.0	3.5	1.0	11.5	3.4	3.1	6.5	18.0
1997	7.0	3.1	0.4	10.5	4.6	0.7	5.3	15.8
1998	3.9	5.2	1.0	10.1	7.3	1.0	8.3	18.4
1999	6.8	6.4	0.2	13.4	10.4	2.9	13.3	26.7
2000	5.1	4.3	0.9	10.3	7.7	2.1	9.8	20.1
2001	5.2	4.5	1.4	11.2	14.9	3.0	18.0	29.1
2002	3.5	2.8	*	6.3	9.9	1.4	11.4	17.7
2003	2.3	2.4	0.8	5.6	7.9	3.1	10.9	16.5
2004	6.2	4.5	1.1	11.8	8.2	2.0	10.2	22.0
2005	12.1	5.7	0.7	18.5	19.8	2.1	21.8	40.3
2006	1.2	2.8	0.3	4.3	6.6	1.6	8.2	12.5
2007	1.4	2.8	1.6	5.9	8.5	1.3	9.8	15.7
2008	0.3	1.5	0.9	2.6	5.6	0.9	6.5	9.1
2009	1.1	1.4	0.7	3.2	5.8	0.2	6.0	9.2
2010	3.4	1.2	0.9	5.4	5.0	0.2	5.3	10.7
2011	3.5	1.8	0.7	6.0	4.5	0.3	4.8	10.7
2012	1.7	1.3	0.5	3.5	6.7	0.2	6.9	10.4

* < 50 t

Table 9.1.2. Division IIIa sprat. Landings of sprat ('000 t) by quarter by countries, 2000-2012. Data for 1996-1999 in ICES CM 2007/ACFM:11
(Data provided by the Working Group members)

	Quarter	Denmark	Norway	Sweden	Total
2001	1	2.53	0.00	2.63	5.17
	2	6.55	0.00	0.11	6.67
	3	10.16	0.00	0.06	10.22
	4	0.90	1.40	4.75	7.05
	Total	20.15	1.40	7.56	29.11
2002	1	3.80	0.00	1.42	5.22
	2	2.06	0.00	0.37	2.43
	3	5.90	0.00	0.07	5.97
	4	1.68	0.00	2.41	4.09
	Total	13.45		4.26	17.70
2003	1	3.54	0.10	1.67	5.30
	2	0.59	0.00	0.80	1.40
	3	1.00	0.00	0.72	1.72
	4	5.04	0.80	2.31	8.13
	Total	10.18	0.80	5.50	16.54
2004	1	3.11	0.00	1.35	4.46
	2	0.64	0.00	0.87	1.51
	3	3.70	0.00	0.44	4.14
	4	6.94	1.10	3.83	11.88
	Total	14.39	1.10	6.49	21.98
2005	1	6.47	0.00	1.68	8.15
	2	4.65	0.00	0.07	4.72
	3	18.61	0.71	0.81	20.13
	4	2.13	0.00	5.17	7.30
	Total	31.86	0.71	7.73	40.30
2006	1	5.43	0.17	2.68	8.28
	2	0.17	0.00	0.16	0.32
	3	1.34	0.00	0.10	1.44
	4	0.88	0.13	1.46	2.46
	Total	7.82	0.30	4.39	12.51
2007	1	2.26	0.45	0.38	3.09
	2	0.70	0.00	0.59	1.29
	3	5.15	*	0.21	5.36
	4	1.79	1.16	2.98	5.92
	Total	9.90	1.60	4.16	15.66
2008	1	2.25	0.20	0.64	3.09
	2	0.67	0.00	0.35	1.02
	3	0.45	0.00	0.19	0.64
	4	2.46	0.70	1.21	4.37
	Total	5.83	0.90	2.39	9.12
2009	1	2.20	0.40	0.40	3.00
	2	0.30	0.00		0.30
	3	3.20	0.00	0.10	3.30
	4	1.20	0.24	1.20	2.64
	Total	6.90	0.64	1.70	9.24
2010	1	1.45	0.05	0.02	1.51
	2	0.64	0.00	0.01	0.65
	3	3.38	0.00	0.03	3.41
	4	2.93	0.86	1.35	5.14
	Total	8.39	0.91	1.40	10.71
2011	1	3.20	0.09	0.02	3.31
	2	0.60	0.00	0.02	0.62
	3	2.30	*	0.01	2.31
	4	1.90	0.61	1.99	4.50
	Total	8.00	0.71	2.03	10.74
2012	1	4.44	0.02	0.23	4.69
	2	0.82	0.00	0.09	0.91
	3	1.63	0.00	0.00	1.63
	4	1.54	0.46	1.19	3.19
	Total	8.43	0.48	1.50	10.42

* < 50 t

Table 9.2.1 **Division IIIa sprat**. Landed numbers (millions) of sprat by age groups in 2004-2012 (based on Danish and Norwegian sampling). The landed numbers in 1996-2003 can be found in the ICES CM 2007/ACFM:11.

	Quarter	Age					Total
		0	1	2	3	4+	
2004	1	0.0	705.4	38.0	30.1	27.7	801.1
	2	0.0	162.2	9.0	10.5	7.5	189.2
	3	0.0	446.5	24.0	9.9	4.5	484.8
	4	2027.5	187.2	15.4	4.5	0.6	2235.2
	Total	2027.5	1501.3	86.4	54.9	40.2	3710.3
2005	1	0.0	2212.5	114.0	20.7	8.0	2355.2
	2	0.0	1180.6	39.0	1.8	1.7	1223.1
	3	43.4	1806.8	147.7	13.4	15.0	2026.2
	4	19.1	234.8	11.0	2.8	0.7	268.5
	Total	62.5	5434.7	311.7	38.8	25.4	5873.1
2006	1	0.0	365.0	430.0	108.1	37.6	940.7
	2	0.0	16.8	14.0	2.3	0.7	33.8
	3	0.0	10.0	95.9	14.7	6.7	127.3
	4	5.2	15.1	50.7	12.9	0.0	83.9
	Total	5.2	406.9	590.7	138.1	44.9	1185.8
2007	1	0.0	62.1	18.7	40.1	3.5	124.4
	2	0.0	4.8	1.6	4.5	0.4	11.3
	3	0.0	797.1	65.6	23.9	3.5	890.0
	4	26.3	257.0	17.6	9.1	1.9	311.9
	Total	26.3	1121.0	103.5	77.6	9.3	1337.6
2008	1	0.0	12.5	128.9	27.7	59.3	228.4
	2	0.0	4.5	46.8	10.1	21.5	83.0
	3	100.1	24.8	5.8	0.8	1.5	132.8
	4	602.2	212.7	52.5	4.5	10.5	882.3
	Total	702.3	254.6	234.0	43.1	92.7	1326.6
2009	1	0.0	700.4	52.0	35.4	10.7	798.5
	2	0.0	91.3	8.2	7.3	2.8	109.6
	3	0.0	277.8	13.9	10.5	5.1	307.3
	4	0.1	111.7	5.4	5.8	2.3	125.3
	Total	0.1	1181.3	79.4	58.9	21.0	1340.7
2010	1	0.0	157.1	125.7	47.2	17.8	347.9
	2	0.0	108.8	87.0	32.7	12.3	240.8
	3	1.3	108.7	188.1	59.9	44.2	402.1
	4	2.0	8.2	20.9	15.8	17.1	64.0
	Total	3.2	382.8	421.8	155.6	91.5	1054.8
2011	1	0.0	163.5	32.1	2.4	9.5	207.6
	2	0.0	43.0	8.4	0.6	2.5	54.6
	3	0.0	371.0	106.2	3.6	1.6	482.4
	4	0.0	178.9	72.3	2.1	16.0	269.2
	Total	0.0	756.4	219.0	8.7	29.7	1013.8
2012	1	0.0	68.9	333.6	113.8	39.5	555.9
	2	0.0	24.0	101.6	32.9	9.4	168.0
	3	0.0	113.9	81.8	10.5	19.3	225.6
	4	0.1	183.9	132.0	17.0	31.2	364.2
	Total	0.1	390.8	649.0	174.2	99.4	1313.6

Table 9.2.2. **Division IIIa sprat.** Quarterly mean weight-at-age (g) in the andings for the years 2004-2012 (from Danish, Swedish, and Norwegian samples). The equivalent data for 1996-2003 can be found in ICES CM 2007 /ACFM: 11.

Year		Age				
	Quarter	0	1	2	3	4+
2004	1	0.0	4.9	11.5	13.4	14.0
	2	0.0	5.1	9.5	12.6	14.6
	3	5.7	11.5	14.2	15.5	16.7
	4	3.9	11.8	15.5	16.0	17.7
Weighted mean		3.9	7.8	12.8	13.8	14.5
2005	1	0.0	2.9	11.1	12.7	14.6
	2	0.0	4.5	9.7	12.1	13.7
	3	7.7	11.2	13.6	14.4	23.1
	4	7.5	13.2	15.9	17.4	19.2
Weighted mean		7.7	6.4	12.3	13.6	19.7
2006	1	0.0	5.2	10.9	14.3	15.1
	2	0.0	5.3	9.9	13.2	15.3
	3	5.7	12.0	16.7	19.6	20.4
	4	6.0	15.7	17.4	19.9	18.9
Weighted mean		6.0	5.7	12.4	15.4	15.9
2007	1	0.0	3.6	9.3	12.9	13.3
	2	0.0	5.2	9.8	13.0	15.1
	3	5.7	11.9	13.1	15.0	15.2
	4	8.7	12.5	15.4	19.7	15.9
Weighted mean		8.7	11.5	12.7	14.4	14.6
2008	1	0.0	5.9	11.7	15.4	18.4
	2	0.0	6.3	11.7	15.6	18.1
	3	3.6	5.1	11.2	12.2	14.5
	4	3.5	7.1	9.6	10.8	11.8
Weighted mean		3.5	6.8	11.2	14.9	17.6
2009	1	0.0	3.8	7.8	8.2	9.9
	2	0.0	4.1	7.6	10.1	11.8
	3	5.7	11.7	13.7	13.9	13.2
	4	5.8	11.8	14.6	15.8	15.1
Weighted mean		5.8	6.4	9.3	10.2	11.5
2010	1	0.0	5.1	10.1	13.3	15.9
	2	0.0	5.3	9.9	13.2	15.3
	3	6.5	10.3	11.3	13.0	14.8
	4	6.6	11.9	13.9	16.0	18.4
Weighted mean		6.5	9.8	11.7	14.3	16.7
2011	1	0.0	6.6	13.2	17.4	20.8
	2	0.0	6.8	12.7	16.8	19.6
	3	5.7	9.4	10.7	12.8	15.7
	4	5.7	13.0	16.0	13.1	19.1
Weighted mean		5.7	7.9	14.4	16.7	20.6
2012	1	0.0	3.5	9.4	11.8	16.4
	2	0.0	4.7	8.8	11.7	13.6
	3	5.5	10.0	14.3	16.4	18.8
	4	5.2	10.5	14.1	15.9	17.5
Weighted mean		5.4	5.3	11.6	12.3	16.0

Table 9.2.3 **Division IIIa sprat.** Sampling commercial landings for biological samples in 2012.

Country	Quarter	Landings (tonnes)	No. samples	No. meas.	No. aged	Samples per 1000 t
Denmark	1	4 442	18	1 822	547	4
	2	821	3	156	48	4
	3	1 631	6	178	0	4
	4	1 540	3	185	49	2
	Total	8 434	30	2 341	644	4
Norway	1	23				
	2	-				
	3	-				
	4	458				
	Total	481				
Sweden	1	226	1	300	297	4
	2	88				
	3	-				
	4	1 188	11	550	548	9
	Total	1 502	12	850	548	8
Denmark		8 434	30	2 341	644	4
Norway		481				
Sweden		1 502	12	850	548	8
	Total	10 417	42	3 191	1 192	4

Table 9.3.1. **Division IIIa sprat**. HERAS indices of sprat per age group 2000-2012.
* These figures should be uploadedfrom FishFrame

	Abundance (million)					Biomass (1000 t)				
	Age									
Year	0	1	2	3+	Sum	0	1	2	3+	Sum
2000										2.0
2001										8.0
2002										10.0
2003	*	*	*	*	983.0	*	*	*	*	13.0
2004	*	*	*	*	1 090.0	*	*	*	*	15.0
2005	*	*	*	*	5 060.0	*	*	*	*	59.8
2006	86.0	61.3	1 451.9	653.0	2 252.2	0.3	0.6	21.2	11.5	33.6
2007	0.0	5 611.9	323.9	382.9	6 318.7	0.0	47.9	3.8	6.5	58.2
2008	0.0	23.0	457.8	291.2	772.0	0.0	0.2	6.3	5.8	12.3
2009	0.0	169.5	432.4	1 631.9	2 233.8	0.0	1.8	6.5	28.3	36.6
2010	0.0	836.1	343.8	376.3	1 556.2	0.0	7.3	4.9	6.4	18.6
2011	0.0	45.4	546.9	981.9	1 574.2	0.0	0.5	9.1	17.8	27.5
2012	0.3	123.9	290.1	1 488.0	1 902.3	0.0	1.2	5.0	31.4	37.6

Table 9.3.2. **Division IIIa sprat**. IBTS (February) indices of sprat per age group 1984-2013.

Year	No Rect	No hauls	Age Group					
			1	2	3	4	5+	Total
1984	15	38	5 675.45	868.88	205.10	79.08	63.57	6 892.08
1985	14	38	2 157.76	2 347.02	392.78	139.74	51.24	5 088.54
1986	15	38	628.64	1 979.24	2 034.98	144.19	37.53	4 824.58
1987	16	38	2 735.92	2 845.93	3 003.22	2 582.24	156.64	11 323.95
1988	13	38	914.47	5 262.55	1 485.07	2 088.05	453.13	10 203.26
1989	14	38	413.94	911.28	988.95	554.53	135.79	3 004.48
1990	15	38	481.02	223.89	64.93	61.11	45.69	876.65
1991	14	38	492.50	726.82	698.11	128.36	375.44	2 421.23
1992	16	38	5 993.64	598.71	263.97	202.90	76.04	7 135.25
1993	16	38	1 589.92	4 168.61	907.43	199.32	239.64	7 104.92
1994	16	38	1 788.86	715.84	1 050.87	312.65	70.11	3 938.32
1995	17	38	2 204.07	1 769.53	35.19	44.96	4.23	4 057.98
1996	15	38	199.30	5 515.42	692.78	111.98	173.75	6 693.23
1997	16	41	232.65	391.23	1 239.13	139.14	134.51	2 136.67
1998	15	39	72.25	1 585.22	619.76	1 617.71	521.52	4 416.46
1999	16	42	4 534.96	355.24	249.86	44.25	313.52	5 497.83
2000	16	41	292.32	737.80	59.69	51.79	23.21	1 164.80
2001	16	42	6 539.48	1 144.34	676.71	92.37	45.87	8 498.77
2002	16	42	1 180.52	1 035.71	89.96	58.85	12.93	2 377.96
2003	17	46	462.64	1 247.49	1 172.13	382.29	123.17	3 387.72
2004	16	41	402.87	49.00	156.62	86.57	27.48	722.54
2005	17	50	3 314.17	1 563.16	470.84	837.09	538.37	6 723.63
2006	17	45	1 323.59	11 855.76	1 753.92	299.05	159.23	15 391.55
2007	18	46	774.11	306.63	250.81	42.08	13.74	1 387.37
2008	17	46	150.85	982.68	132.54	228.48	107.70	1 602.26
2009	17	46	2 686.72	124.46	259.15	29.60	37.43	3 137.36
2010	17	44	218.66	618.49	151.69	354.14	157.65	1 500.62
2011	17	43	135.55	2 887.27	1 472.91	721.10	839.95	6 056.77
2012	17	46	209.49	1 531.55	651.53	346.72	128.08	2 867.37
2013*	17	46	301.26	237.34	596.45	484.86	319.28	1 939.18

* Preliminary

Table 9.3.3. **Division IIIa sprat.** IBTS Q3 indices of sprat per age group 1991-2012.
* No survey

Year	Age Group						
	0	1	2	3	4	5+	Total
1991	36.70	493.72	319.35	19.42	113.08	12.08	994.34
1992	7.52	1 731.96	383.25	178.80	60.99	24.38	2 386.90
1993	0.67	309.01	1 719.96	260.70	50.68	6.10	2 347.11
1994	103.31	9 945.22	95.21	73.75	7.06	0.10	10 224.65
1995	0.00	13 295.42	648.80	90.34	90.73	18.04	14 143.33
1996	0.00	130.75	1 582.10	271.89	62.76	56.22	2 103.72
1997	534.19	437.18	31.67	63.33	6.64	4.77	1 077.79
1998	39.71	62.82	90.15	30.15	53.02	4.78	280.63
1999	2.61	8 082.65	282.95	85.84	66.95	56.13	8 577.11
2000	*	*	*	*	*	*	*
2001	0.27	8 501.66	657.70	434.57	19.85	4.50	9 618.55
2002	0.00	3 568.48	763.63	135.47	71.97	6.96	4 546.51
2003	1 133.30	444.80	1 200.60	495.57	98.30	33.36	3 405.92
2004	191.03	7 388.17	645.61	706.08	167.96	54.27	9 153.11
2005	169.27	12 817.78	1 357.63	183.51	68.87	23.95	14 620.99
2006	0.65	848.87	4 640.51	1 841.23	184.42	115.64	7 631.31
2007	49.05	10 899.96	474.27	666.30	175.11	12.98	12 277.67
2008	480.49	809.37	2 779.77	463.18	663.33	129.31	5 325.46
2009	85.17	3 258.75	370.34	337.84	102.80	57.85	4 212.74
2010	14.49	2 335.44	890.51	500.90	268.70	167.77	4 177.81
2011	1.43	1 413.12	1 159.32	484.34	177.13	131.55	3 366.88
2012	10.41	832.37	3 324.18	2 217.86	657.44	281.26	7 323.52

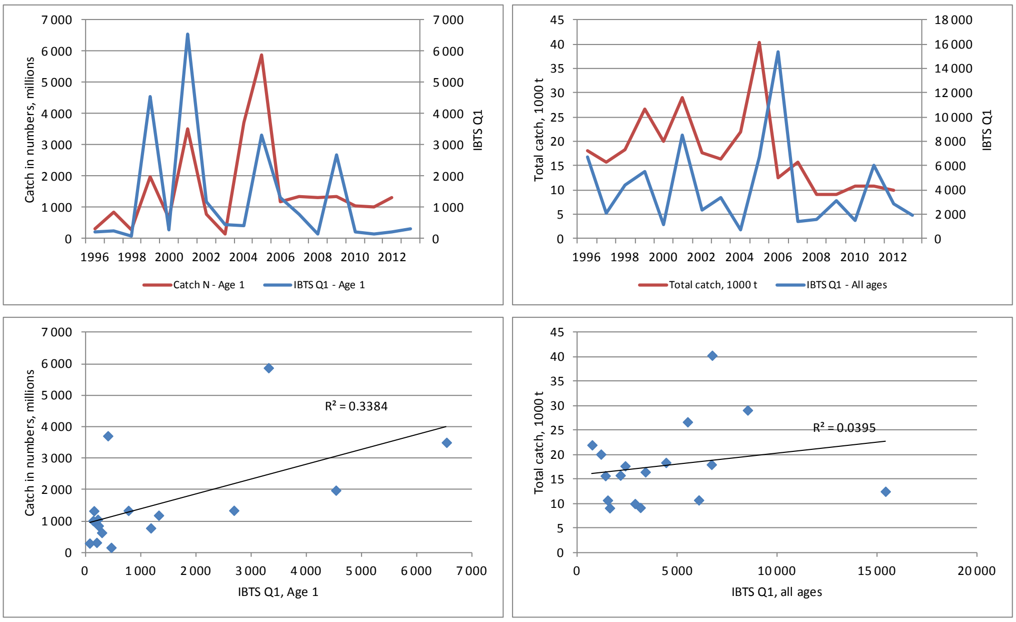


Figure 9.6.1. Division IIIa sprat. Data exploration of the IBTS and landings time series. Annual landings (in numbers) of 1-year-olds and the IBTS index of one-year-olds in 1st quarter and their regression ($R^2 = 0.3384$), left side plots. Total annual landings (in 1000 t) and the IBTS index of all age classes in 1st quarter and their regression ($R^2 = 0.0395$), right side plots.

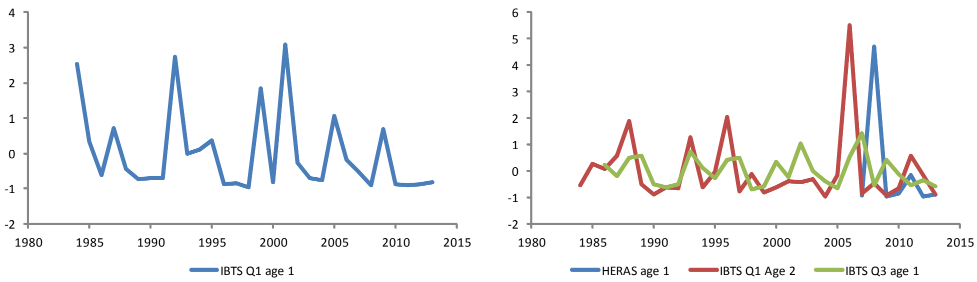


Figure 9.7.1. Division IIIa sprat. Survey index anomalies for surveys used for 1 (top) and 2 (bottom) winter ringers.

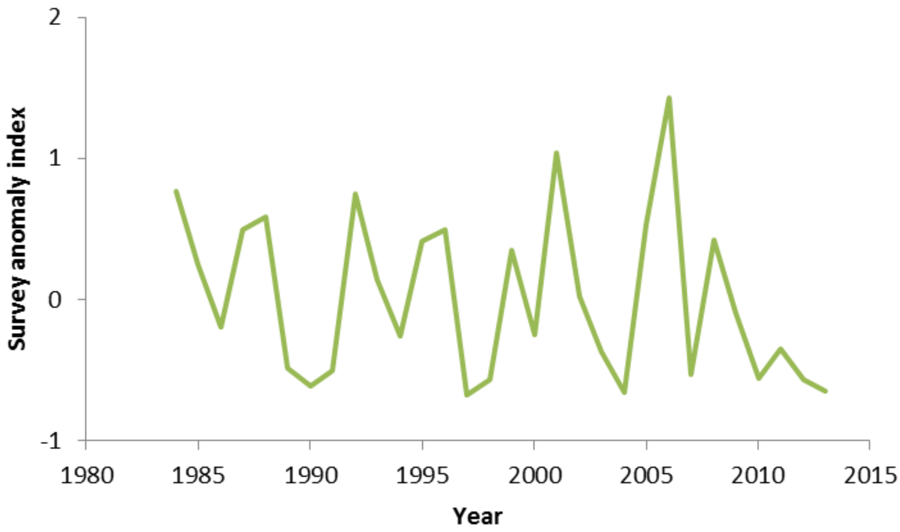


Figure 9.7.2. Division IIIa sprat. Survey index anomalies for total index.

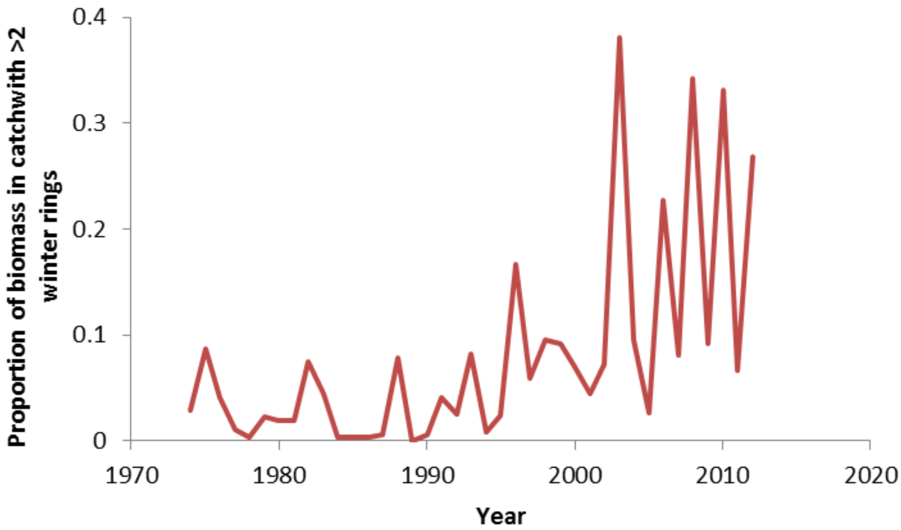


Figure 9.7.3. Division IIIa sprat. The proportion of all commercial catches (in biomass) consisting of fish with more than 2 winter rings

10 Sprat in the Celtic Seas (Subareas VI and VII)

Most sprat fisheries in the Celtic Seas area are sporadic and occur in different places at different times. Separate fisheries have taken place in the Minch, and the Firth of Clyde (VIaN); in Donegal Bay (VIaS); Galway Bay and in the Shannon Estuary (VIIb); in various bays in VIIj; in VIIaS; in the Irish Sea and in the English Channel (VIIde). A map of these areas is provided in Figure 10.1.

The stock structure of sprat populations in this eco-region is not clear. In 2013, HAWG presents all available data on these sprat populations, in a single chapter. However HAWG does not necessarily advocate that VI and VII constitutes a management unit for sprat, and further work is required to solve the problem.

10.1 The Fishery

10.1.1 ICES advice applicable for 2011 and 2012

ICES analysed data for sprat in the Celtic Sea and West of Scotland for the first time in 2011. Currently there is no TAC for sprat in this area, and it is not clear whether there should be one or several management units. ICES stated that there is insufficient information to evaluate the status of sprat in this area. Therefore, based on precautionary consideration, ICES advised that catches should not be allowed to increase in 2013. The TAC for the English Channel (VIId, e) is the only one in place for sprat in this area.

10.1.2 Landings

The total sprat landings, by ICES subdivision (where available) are provided in Tables 10.1.1. – Table 10.1.7 and in Figures 10.2.1-10.2.8).

Division VIa (West of Scotland and Northwest of Ireland)

Landings have been dominated by UK-Scotland and Ireland (Table 10.1.1). The Scottish fisheries have taken place in both the Minch and in the Firth of Clyde. The Irish fishery has always been in Donegal Bay. Despite the wide separation of these areas, the trends in landings between the two countries are similar, though the UK data have always been higher. Irish data may be underestimated, due to difficulties in quantifying the landings from vessels of less than 10 m length.

The Scottish fishery is mainly for human consumption and is typically a winter fishery taking place in November and December. Occasionally the fishing continues into January. Landings were high in the early part of the time series peaking with average annual landings of ~ 7000t in the period 1972 to 1978. Landings were low for a period after this until a second peak in the period 1995 to 2000 where landings averaged just below 5000t annually. In 2006 to 2009 the fishery was virtually absent but has slowly picked up again since 2010. In 2012 landings reached 1689 tonnes which is the largest amount landed since 2004.

Division VIIa (Irish Sea)

The main historic fishery was by Irish boats, in the 1970s, in the western Irish Sea (Table 10.1.2a). This was an industrial fishery and landings were high throughout the 1970s, peaking at over 8 000 t in 1978. The fishery came to an end in 1979, due to the closure of the fish meal factory in the area. It is not known what proportion of the catch was made up of juvenile herring, though the fishing grounds were in the known herring nursery areas. In the late 1990s and early 2000s , UK vessels landed up to 500 t per year. In recent years a trial fishery for sprat was carried out by the vessels that fish herring in the area. This was carried out to investigate the feasibility of a clean commercially viable sprat fishery. The results of the trials were inconclusive and plans to conduct further experiments are under discussion. Irish Landings from 1950-1994 may be from VIIaN or VIIaS. Recent Irish landings are mainly from VIIaS, mainly Waterford Harbour (Table 10.1.2).

Divisions VIIbc (West of Ireland)

Sporadic fisheries have taken place, mainly in Galway Bay and the Mouth of the Shannon. The highest recorded landing was in 1980 and 1981 during the winter of 1980/1981, when over 5 000 t were landed by Irish boats (Figure 10.2.4). This fishery took place in Galway Bay in the winter of 1980/1981 (Department of Fisheries and Forestry (1982). Since the early 1990s landings fluctuated from very low levels to no more than 700 t per year. Irish data may be underestimated, due to difficulties in quantifying the landings from vessels of less than 10 m length.

Divisions VIIg-k (Celtic Sea)

Sprat landings in the Celtic Sea from 1985 onwards are WG estimates. In the Celtic Sea, Ireland has dominated landings. Patterns of Irish landings in Divisions VIIg and VIIj are similar, though the VIIj landings have been higher. Landings for VIIg and VIIj were aggregated in this report. Landings have increased from low levels in the early 1990s, with catches fluctuating between 0 t in 1993 and just under 4 200 t in 2005 (Table 10.1.6). Irish data may be underestimated, due to difficulties in quantifying the landings from vessels of less than 10 m length.

Divisions VIIde (English Channel)

Total landings from the international sprat fishery are available since 1950 (see Fig.). Sprat landings prior to 1985 in VIId,e were extracted from FishBase, from 1985 onwards they are WG estimates. Since 1985 sprat catch has been taken mainly by UK, England and Wales. According to official catch statistics large catches were taken by Danish trawlers in the late 70s and 80s from the English Channel. However, the identity of the catches was not confirmed by the Danish data managers raising the question of whether those reported catches were the result of species misreporting (i.e. herring misreported as sprat). Therefore, ICES cannot verify the quality of catch data prior to 1988.

The fishery starts in August and runs into the following year into February and sometimes March. Most of the catch is taken in VIIe, where 88% on average of landed sprat are caught.

The UK has a history of taking the quota, but sprat is found by sonar search and sometimes the shoals are found too far offshore for sensible economic exploitation. Skippers then go back to other trawling activity. This offshore/ near shore shift may be related to environmental changes such as temperature and/ or salinity.

10.1.3 Fleets

Most sprat in the Celtic Seas ecoregions are caught by small pelagic vessels that also target herring, mainly Irish, English and Scottish vessels. In Ireland, many polyvalent vessels target sprat on an opportunistic basis. At other times these boats target demersals and tuna, as well as pelagics. Targeted fishing takes place when there are known sprat abundances. However the availability of herring quota is a confounding factor in the timing of a sprat-targeted fishery around Ireland.

Sprat may also be caught in mixed shoals with herring. The level of discarding is unknown.

In the English Channel the primary gear used for sprat is midwater trawl. Within that gear type three vessels under 15m actively target sprat and are responsible for the majority of landings (since 2003 they took on average 94% of the total landings). Sprat is also caught by driftnet, fixed nets, lines and pots. Most of the landings are sold for human consumption.

In Ireland, larger sprats are sold for human consumption whilst smaller ones for fish meal. Other countries mainly land catches for industrial purposes.

10.1.4 Regulations and their effects

There is a TAC for sprat for VIId,e, English Channel. No other TACs or quotas for sprat exist in this eco-region. Most sprat catches are taken in small-mesh fisheries for either human consumption or reduction to fish meal and oil. It is not clear whether by-catches of herring in sprat fisheries in Irish and Scottish waters are subtracted from quota.

10.1.5 Changes in fishing technology and fishing patterns

There is insufficient information available.

10.2 Biological Composition of the Catch

10.2.1 Catches in number and weight-at-age

There is no information on catches in number or weight in the catch for sprat in this ecoregion.

10.2.2 Biological sampling from the Scottish Fishery (VIa)

Between 1985 and 2002 the fishery was relatively well sampled and length and age data exists for this period with some gaps. Unfortunately the data is not available electronically at the present time.

Sampling of sprat in VIa came to an end in 2003 and no information on biological composition of catches exists in the period 2003 – 2011. Sampling was resumed in 2012 where 8 landings were sampled and it is anticipated that this sampling will continue in the future.

10.3 Fishery-independent information

Celtic Sea Acoustic Survey

The Irish Celtic Sea Herring Acoustic Survey has been used to calculate sprat biomass. Biomass estimates for Celtic Sea Sprat for the period November 1991 to October 2012 are shown in Figure 10.3.1 and Table 10.3.1. However, the survey results prior to 1997 are not comparable with the latter surveys because different survey designs were applied.

Since 2004 the survey has taken place each October in the Celtic Sea. Due to the lack of reliable 36 kHz data in 2010, no sprat abundance is available for this year.

It can be seen that there are large inter-annual variations in sprat abundance. Large sprat schools were notably missing in 2006, and so no biomass could be calculated. The utility of this survey as an index of sprat abundance should be considered carefully (Fallon *et al*. 2012). Sprat is the second most abundant species observed from survey data. Sprat biomass over the time series (2004-2012) is highly variable, more so than could be accounted for by 'normal' inter survey variability (Figure 10.3.1**)**. This is in part due to the behaviour of sprats in the Celtic Sea which are often seen in the highest numbers after the survey has ended in November/December and again in spring during spawning. The survey is placed to coincide with peak herring abundance and is temporally mismatched with what would be considered sprat peak abundance.

Scottish Acoustic Surveys

A Clyde herring and sprat acoustic survey was carried out in June/July 1985-1990 and then discontinued (Figure 10.3.2 for coverage). Biomass estimates from all years as well as lengths and ages from some years are available from this survey but not presented here.

In 2012 this survey was reinstated as an October/November survey and results from the first survey are being processed at the moment. Age and length distribution from this survey are in Figure 10.3.3.

Scottish IBTS surveys

The Scottish West Coast IBTS has been carried out in Q1 since 1981 to the present and in Q4 from 1991 onwards (Figure 10.3.2). Although the survey is a ground fish bottom trawl survey it does catch sprat throughout the survey area. The survey provides numbers at length per haul and aggregated age-length keys on a sub area basis. In the period 1981 to 2012 a total of 1434 hauls were completed and approximately half of these caught sprat.

Northern Ireland Groundfish Survey

The Agri-Food and Biosciences Institute of Northern Ireland (AFBINI) groundfish survey of ICES Division VIIaN are carried out in March and October at standard stations between 53° 20′N and 54° 45′N (see Annex 8 for more detail on the survey). Sprat is routinely caught in the groundfish surveys however, data were not available at the time of submission of this report.

AFBI Acoustic Survey

The Agri-Food and Biosciences Institute of Northern Ireland (AFBINI) carries out an annual acoustic survey in the Irish Sea each September (see Annex 8 for a description of the survey). While targeting herring, a sprat biomass is also calculated. The annual calculated biomass from 1998-2012 is shown in Figure 10.4. and Table 10.3.2. The biomass is estimated to have peaked in 2002 with 405 000 t and it has declined since then to just under 95 000t in 2010. Estimates in 2012 of 238 000 t suggest a substantial increase. Further work is required to investigate the utility of this survey for measuring sprat biomass in this area.

FSP Acoustic Survey off the western English Channel

A second acoustic survey was carried out in October 2012 covering the Lyme bay area where the main sprat population was thought to be concentrated during the onset of the fishing season (September-October). See description of the survey in the Stock Annex (Figure 10.3.5).

The estimated sprat biomasses were similar in both years. In 2012, both estimates (2011, and 2012) were re-computed using a new more robust Target Strength (TS) published for herring (Saunders *et al*., 2012), which has brought down the estimates but still shows a healthy population. The revised 2011 sprat biomass estimate is 33,861 tonnes and the estimate for 2012 is 27,971 tonnes.

Biological data

Trawl catches suggested that most (73.1% by number) of the sprat were mature (spent), with 26.9% immature, and that the sex ratio slightly favoured females (59: 41). Four age classes were identified: 0, 1, 2 and 3, contributing 1.5%, 8.9%, 70.1% and 19.4 % to the population by number, respectively. Low numbers of the 0 and 1 age groups may be the result of gear selectivity. The observed low numbers of sprat age 4 and older could be the result of exploitation as the fishery targets the larger fish for human consumption. However, just three of the trawl hauls contained good samples of sprat, so it is equally possible that the age 4+ sprat were under-sampled because of their different geographic distribution or behavior.

IBTS Q1 in the Eastern English Channel

Starting in 2006, the French in quarter 1 started to carry out additional tows in the Eastern English Channel as part of the standard IBTS survey. This proved successful and starting in 2007 the RV 'Thalassa' carried out 8 GOV trawls and 20 MIK stations.

During the IBTSWG in 2009, Roundfish Area 10 (Fig. 10.3.6) was created to cover these new stations fished by France and the Netherlands.

Data are stored in DATRAS database and available for the period 2007 to 2012.

10.4 Mean weight-at-age and length-at-maturity

No data on mean weight at age or maturity at age in the catch are available.

10.5 Recruitment

The various ground fish surveys may provide an index of sprat recruitment in this ecoregion. However further work is required.

10.6 Stock Assessment

An analytical assessment was carried out for sprat in the English Channel.

10.6.1 Data exploration

A data exploration for English Channel sprat was carried out in 2013 at the benchmark workshop WKSPRAT. An lpue time-series for English Channel sprat based on mid-water trawlers data was constructed (Figure 10.5.1). The lpue was based on data from three >15m vessels that target sprat in the area. The index included searching time and time at sea with zero returns which was appropriate given sprat shoaling behavior. Vessels considered for lpue calculations have been making use of standard sonar technology to locate the fish throughout the period of analysis and no other major technical advances need to be factored out. Concerns were expressed about using lpue as an index of abundance for sprat. However, the lpue series presented is the best data set available to assess sprat trends in the area.

The lpue time-series was fitted by means of a surplus production dynamic model of the Schaefer form. Observation error was assumed to be predominant, i.e. the error occurs in the relationship between the biomass and the index of abundance. For this form of estimator, the quantity minimized to estimate values for the parameters r, K and initial biomass (B_{1988}) is:

$$SS = \sum_{y=1988}^{2012} \left[lnI_y - \ln\left(\hat{q}_I \hat{B}_y\right)\right]^2 + \sum_{y=2011}^{2012} \left[lnS_y - \ln\left(\hat{q}_2 . \hat{B}_y\right)\right]^2$$

Where I_y corresponds to the lpue index for year y and B_y is the stock biomass in year y. The catchabilities q_1 and q_2 corresponding to the surveys were estimated analytically. The survey biomass estimate was incorporated into the sum of squares by adding a second term with weight = 1. The model was coded on AD Model Builder.

The biomass dynamics was modelled as:

$$B_{y+1} = B_y + rB_y \left(1 - {}^{B_y}\!/_{K}\right) - C_y$$

Where r is the intrinsic growth rate, K is the average unexploited equilibrium biomass (carrying capacity) and C_y is the catch in year y.

Model fit to the data

The model was fitted to the lpue data and to the 2011and 2012 survey estimate. A number of runs were carried out at the benchmark to explore the model performance. The following model configuration performed best:

Acoustic survey relative, 5 parameters were estimated, K, initial B, r and two catchabilities (q_{lpue} and q_{survey}) and,

A penalty term on variation of q to avoid large departure from q = 1 (survey as absolute);

A sensitivity test to considering the International landings 1950-2012 was also carried out.

Results

A preliminary run where the model had no constrains, was scaled by the landings, resulting in low biomass well below the acoustic estimates. The results from the acoustic survey are based on a conservative target strength. Further, both surveys used consistent methodology and provide similar estimates for the survey area close to 30 thousand tonnes. Based on this understanding a penalty term was introduced in the objective function to prevent the survey catchability to depart largely from a value of 1. This resulted in a predicted biomass consistent with the survey estimates and the landings (Figs. 5.6.8-9). Parameter estimates with associated CVs for this run are shown below.

parameter	Estimate	CV
r	0.32	0.42
K	38680.00	0.35
Binit	10900.00	0.52
survey q	1.24	

Table. Parameter estimates for the surplus production model configured with a penalty in catchability q to departure from 1.

The results from the sensitivity test are illustrated on Figure 10.6.1. The model was run assuming the initial biomass equal to carrying capacity (*K*) which was estimated at 90 thousand tonnes. This shows *K* would have had to be much larger than estimated using recent landings data to be able to sustain the large catches reported in the 70s and 80s. The current biomass is estimated at about 50% of K.

The model fit to the lpue data and to the acoustic survey are shown in Figure 10.6.2. This reveals a noisy series and a model fit suggesting an increasing trend in lpue. The estimated biomass trend relative to the landings is shown in Figure 10.6.3.

Conclusions from the Biomass dynamic model

A number of exploratory runs were carried out at the sprat benchmark Workshop. The model seems to require some auxiliary information in order to find a sensible solution. Attempts to fix the intrinsic growth rate r or the survey catchability q2 resulted in high uncertainty in the remaining parameters. A model where a penalty term was introduced to constrain departure from 1 of the survey catchability q performed best. This model configuration resulted in a reasonable fit to the lpue trend and scaled the biomass to a level consistent with the acoustic estimates.

Estimated MSY for VIId-e English Channel sprat based on parameters K and r tabled above is 3094 tonnes.

10.7 State of the Stock

The exploitation ratio of < 17% estimated for recent years suggests that sprat in the western Channel area is lightly exploited.

10.8 Short term projections

No projections are presented for this stock.

10.9 Reference Points

No precautionary reference points are defined for sprat populations in this region due to uncertainty in stock definition.

10.10 Quality of the Assessment

NA

10.11 Management Considerations

Sprat is a short-lived species with large inter-annual fluctuations in stock biomass. The natural inter-annual variability in stock abundance, mainly driven by recruitment variability, is high and does not appear to be strongly influenced by the observed levels of fishing effort.

Sprat in VIIde

The sprat has mainly been fished together with herring. The human consumption fishery only takes a minor proportion of the total catch. Within the current management regime, where there is a by-catch ceiling limitation of herring as well as by-catch percentage limits, the sprat fishery is controlled by these factors. Most management areas in this ecoregion do not have a quota for sprat. However, there is a quota in VIId e, English Channel, which was restrictive in recent years.

Sprat annual landings from VIId-e over the past 20 years have been 2243 tonnes on average, with a maximum of just 4435 tonnes (in 2012). The 2012 annual landings of 4435 t constitute only 16% of the acoustic estimate of sprat biomass for the survey area in 2012. The surplus production model taking into account seasonal landings estimated exploitation fraction between 11 and 18% for recent years. This level of exploitation is well below similar low-trophic species such as sardine in ICES areas VIII and IX that support a catch of ~30% of spawning-stock biomass (ICES WGANSA 2011) and the Bay of Biscay anchovy for which a 30% constant proportion management strategy was tested by simulation (ICES WGANSA 2011).

The stable or increasing trend in commercial lpue suggests that the fishery is not having a detrimental impact on English Channel sprat.

CATCH ADVICE

Catch advice was based on category 3 (WKLIFE 2012) according to the data and analysis that were available. This category includes stocks for which survey indices (or other indicators of stock size such as reliable fishery-dependent indices are available that provide reliable indications of trends in stock metrics such as mortality, recruitment and biomass. Those are a time-series of lpue (1988- 2012) and two acoustic surveys (2011 and 2012) performed in the area where the fishery takes place in the vicinity of Lyme Bay.

A Depletion-Corrected Average Catch (DCAC) procedure was implemented but based on the data available it was not considered appropriate.

Data and computations

Catch and lpue data and, predicted lpue based on the surplus production model for 2008 – 2012 were used. The period chosen was based on common practice.

	Catch	lpue	pred lpue
2008		1029.26	938.008
2009		773.19	896.942
2010	4404.294	1526.95	898.397
2011	3136	1047.41	827.981
2012	4434	1988.61	835.466
C(2010-2012)	3991.431		
Unc Cap +	4789.718		
Unc cap -	3193.145		
lpue(2011-12)		1518.01	831.7235
lpue(2008-10)		1109.8	911.1157

Catch advice in 2014 is computed according to the following equation:

$$C_{y+1} = C_{y-1}\left(\frac{\sum_{i=y-x}^{y-1} I_i/x}{\sum_{i=y-z}^{y-x-1} I_i/(z-x)}\right)$$

Where I is the survey index, x is the number of years in the survey average, and $z > x$. For example, $x = 2$ would be a two year survey average, and $x = 2$ $z = 5$, which is analogous to the five steps in the ICES MSY transition from 2010 to 2015 (ICES Introduction 1.2);

An Uncertainty Cap and the Precautionary buffer were also applied. The results are shown on the table below:

Catch adjustment	*lpue*	*pred lpue*
Corrected Catch y+1	5459.572	3643.629
Uncertainty Cap	4790	3643
Precautionary Buffer	3832	2914.4

The catch advice was based on the observed lpue as the surplus production model is exploratory and not an accepted assessment at present.

10.12 Ecosystem Considerations

In the North Sea Multispecies investigations have demonstrated that sprat is one of the important prey species in the North Sea ecosystem, for both fish and seabirds. At present, there are no data available on the total amount of sprat taken by seabirds in this area.

The Celtic Sea is a feeding ground for several species of large baleen whales (O'Donnell *et al*, 2004-2009). These whales feed primarily on sprat and herring from September to February.

Table 10.1.1 Sprat in the Celtic Seas. Landings of sprat, 1985-2012 VIa. Irish data may be underestimated, due to difficulties in quantifying the landings from vessels of less than 10 m length.

Country	Denmark	roe Islands	Ireland	Norway	Vales+N.Irl.	(- Scotland	Total
1985	0	0	51	557	0	2946	3554
1986	0	0	348	0	2	520	870
1987	269	0	0	0	0	582	851
1988	364	0	150	0	0	3864	4378
1989	0	0	147	0	0	1146	1293
1990	0	0	800	0	0	813	1613
1991	0	0	151	0	0	1526	1677
1992	28	0	360	0	0	1555	1943
1993	22	0	2350	0	0	2230	4602
1994	0	0	39	0	0	1491	1530
1995	241	0	0	0	0	4124	4365
1996	0	0	269	0	0	2350	2619
1997	0	0	1596	0	0	5313	6909
1998	40	0	94	0	0	3467	3601
1999	0	0	2533	0	310	8161	11004
2000	0	0	3447	0	0	4238	7685
2001	0	0	4	0	98	1294	1396
2002	0	0	1333	0	0	2657	3990
2003	887	0	1060	0	0	2593	4540
2004	0	0	97	0	0	1416	1513
2005	0	252	1134	0	13	0	1399
2006	0	0	601	0	0	0	601
2007	0	0	333	0	0	14	347
2008	0	0	892	0	0	0	892
2009	0	0	104	0	0	70	174
2010	0	0	332	0	0	537	869
2011	0	0	464	0	248	507	1219
2012	0	0	113	0	0	1688	1801

Table 10.1.2 Sprat in the Celtic Seas. Irish Landings of sprat, 1995-2012 from VIIaS . Irish data may be underestimated, due to difficulties in quantifying the landings from vessels of less than 10 m length. 2012 landings are preliminary.

Country	Ireland
1985	0
1986	0
1987	0
1988	0
1989	0
1990	0
1991	0
1992	0
1993	0
1994	0
1995	0
1996	0
1997	0
1998	7
1999	25
2000	123
2001	7
2002	0
2003	3103
2004	408
2005	361
2006	114
2007	0
2008	102
2009	0
2010	422
2011	1518
2012	6894
Total	13084

Table 10.1.3. Sprat in the Celtic Seas. Landings of sprat, 1985-2012 VIIbc. Irish data may be underestimated, due to difficulties in quantifying the landings from vessels of less than 10 m length. 2012 landings are preliminary.

Country	Ireland
1985	0
1986	0
1987	0
1988	0
1989	0
1990	0
1991	0
1992	0
1993	0
1994	0
1995	0
1996	0
1997	0
1998	7
1999	25
2000	123
2001	7
2002	0
2003	3103
2004	408
2005	361
2006	114
2007	0
2008	102
2009	0
2010	422
2011	1518
2012	6894
Total	13084

Table 10.1.4 Sprat in the Celtic Seas. Landings of sprat, 1995-2012 VIIde.

Country	Denmark	France	letherlands	Vales+N.Irl.	K - Scotland	Total
1985	0	14	0	3771	0	3785
1986	15	0	0	1163	0	1178
1987	250	23	0	2441	0	2714
1988	2529	2	1	2944	0	5476
1989	2092	10	0	1520	0	3622
1990	608	79	0	1562	0	2249
1991	0	0	0	2567	0	2567
1992	5389	35	0	1791	0	7215
1993	0	3	0	1798	0	1801
1994	3572	1	0	3176	40	6789
1995	2084	0	0	1516	0	3600
1996	0	2	0	1789	0	1791
1997	1245	1	0	1621	0	2867
1998	3741	0	0	1973	0	5714
1999	3064	0	1	3558	0	6623
2000	0	1	1	1693	0	1695
2001	0	0	0	1349	0	1349
2002	0	0	0	1196	0	1196
2003	0	2	72	1368	0	1442
2004	0	6	0	836	0	842
2005	0	0	0	1635	0	1635
2006	0	7	0	1969	0	1976
2007	0	0	0	2706	0	2706
2008	0	0	0	3367	0	3367
2009	0	2	0	2773	0	2775
2010	0	0	0	4404	0	4404
2011	0	0	0	3136	0	3136
2012	0	0	0	4435	0	4435

Table 10.1.5 Sprat in the Celtic Seas. Landings of sprat, 1985-2012 VIIf.

Country	Netherland	UK - Eng+V	Total
1985	273	0	273
1986	0	0	0
1987	0	0	0
1988	0	0	0
1989	0	0	0
1990	0	0	0
1991	0	1	1
1992	0	0	0
1993	0	0	0
1994	0	2	2
1995	0	0	0
1996	0	0	0
1997	0	0	0
1998	0	51	51
1999	0	0	0
2000	0	0	0
2001	0	0	0
2002	0	0	0
2003	0	0	0
2004	0	0	0
2005	0	0	0
2006	0	0	0
2007	0	2	2
2008	0	0	0
2009	0	1	1
2010	0	7	7
2011	**0**	**0**	0
2012	**0**	**0**	0

Table 10.1.6 Sprat in the Celtic Seas. Landings of sprat, 1985-2012 VIIg-k. Irish data may be underestimated due to difficulties in quantifying the landings from vessels of less than 10 m length and the Irish 2012 landings are preliminary.

Country	Denmark	France	Ireland	letherlands	Spain	Vales+N.Irl.	Total
1985	0	0	3245	0	0	0	3245
1986	538	0	3032	0	0	2	3572
1987	0	1	2089	0	0	0	2090
1988	0	0	703	1	0	0	704
1989	0	0	1016	0	0	0	1016
1990	0	0	125	0	0	0	125
1991	0	0	14	0	0	0	14
1992	0	0	98	0	0	0	98
1993	0	0	0	0	0	0	0
1994	0	0	48	0	0	0	48
1995	250	0	649	0	0	0	899
1996	0	0	3924	0	0	0	3924
1997	0	0	461	0	0	6	467
1998	0	0	1146	0	0	0	1146
1999	0	0	3263	0	0	0	3263
2000	0	0	1764	0	0	0	1764
2001	0	0	306	0	0	0	306
2002	0	0	385	0	0	0	385
2003	0	0	747	0	0	0	747
2004	0	0	3523	0	0	0	3523
2005	0	0	4173	0	0	0	4173
2006	0	0	768	0	0	0	768
2007	0	0	3380	0	1	0	3381
2008	0	0	1358	0	0	0	1358
2009	0	0	3431	0	0	0	3431
2010	0	0	2436	0	0	0	2436
2011	0	0	1767	0	0	12	1779
2012	0	0	2632	0	0	0	2632

Table 10.1.7 Sprat in the Celtic Seas. Landings of sprat, 1985-2012 Total Landings, Division VI, VII. Irish data may be underestimated, due to difficulties in quantifying the landings from vessels of less than 10 m length and the Irish 2012 landings are preliminary.

Country	Denmark	Faeroe Isla	France	Ireland	Isle of Man	Netherland	Norway	Spain	UK - Engla	UK - Scotl.	Un.Sov.Soc.	Total
1985	0	0	14	3964	0	273	557	0	3791	2946	0	11545
1986	553	0	0	4532	1	0	0	0	1173	520	0	6779
1987	519	0	24	2230	0	0	0	0	2441	582	0	5796
1988	2893	0	2	853	0	2	0	0	2948	3870	0	10568
1989	2092	0	10	1163	0	0	0	0	1521	1146	0	5932
1990	608	0	79	1325	0	0	0	0	1562	813	0	4387
1991	0	0	0	205	0	0	0	0	2571	1526	0	4302
1992	5417	0	35	508	0	0	0	0	1791	1555	0	9306
1993	22	0	3	2353	0	0	0	0	1798	2230	0	6406
1994	3572	0	1	232	0	0	0	0	3178	1531	0	8514
1995	2575	0	0	799	0	0	0	0	1546	4124	0	9044
1996	0	0	2	4214	0	0	0	0	1789	2350	0	8355
1997	1245	0	1	2085	0	0	0	0	1629	5313	0	10273
1998	3781	0	0	1578	0	0	0	0	2027	3467	0	10853
1999	3064	0	0	5826	0	1	0	0	4014	8161	0	21066
2000	0	0	1	6032	0	1	0	0	2064	4238	0	12336
2001	0	0	0	455	0	0	0	0	1716	1297	0	3468
2002	0	0	0	1729	0	0	0	0	1502	2657	0	5888
2003	887	0	2	4948	0	72	0	0	1960	2593	0	10462
2004	0	0	6	4096	0	0	0	0	970	1416	0	6488
2005	0	252	0	5928	0	0	0	0	2239	0	0	8419
2006	0	0	7	1523	0	0	0	0	2532	0	0	4062
2007	0	0	0	3745	0	0	0	1	2708	14	0	6468
2008	0	0	0	2353	0	0	0	0	3369	0	0	5722
2009	0	0	2	3773	0	0	0	0	2774	70	0	6619
2010	0	0	0	3189	0	0	0	0	4411	537	0	8138
2011	0	0	0	3753	0	0	0	0	3396	507	0	7656
2012	0	0	0	9662	0	0	0	0	4435	1689	0	15786

Table 10.3.1. Sprat in the Celtic Seas. Sprat biomass by year in the Celtic Sea (Source: MI Celtic Sea Herring Acoustic Survey)

Year	Biomass(t)
Nov/Dec-91	36880
Jan-92	15420
Jan-92	5150
Nov-92	27320
Jan-93	18420
Nov-93	95870
Jan-94	8035
Nov-95	75440
2002	20600
2003	1395
2004	14675
2005	29019
2008	5493
2009	16229
2011	31593
2012	35100

Table 10.3.2. Sprat in the Celtic Seas. Annual sprat biomass in ICES sub-division VIIa (Source: AFBINI annual herring acoustic survey).

Year	Sprat & 0-gp herring Biomass (t)	CV	% sprat	Sprat Biomass (t)
1994	68,600	0.1	95	65,200
1995	348,600	0.13	n/a	n/a
1996	n/a	n/a	n/a	n/a
1997	45,600	0.2	n/a	n/a
1998	228,000	0.11	97	221,300
1999	272,200	0.1	98	265,400
2000	234,700	0.11	94	221,400
2001	299,700	0.08	99	295,100
2002	413,900	0.09	98	405,100
2003	265,900	0.1	95	253,800
2004	281,000	0.07	96	270,200
2005	141,900	0.1	96	136,100
2006	143,200	0.09	87	125,000
2007	204,700	0.09	91	187,200
2008	252,300	0.12	83	209,800
2009	175,200	0.08	78	136,200
2010	107,400	0.1	87	93,700
2011	280,000	0.11	85	238,400
2012	171,200	0.11	0.95	162,600

Note. 1997 Survey: North Channel not fully surveyed;
IOM west and east coast strata expanded;
n/s = not surveyed
1996 survey: faulty transducer in strata b, f and g

Figure 10.1. Sprat in the Celtic Seas. Map showing areas mentioned in the text.

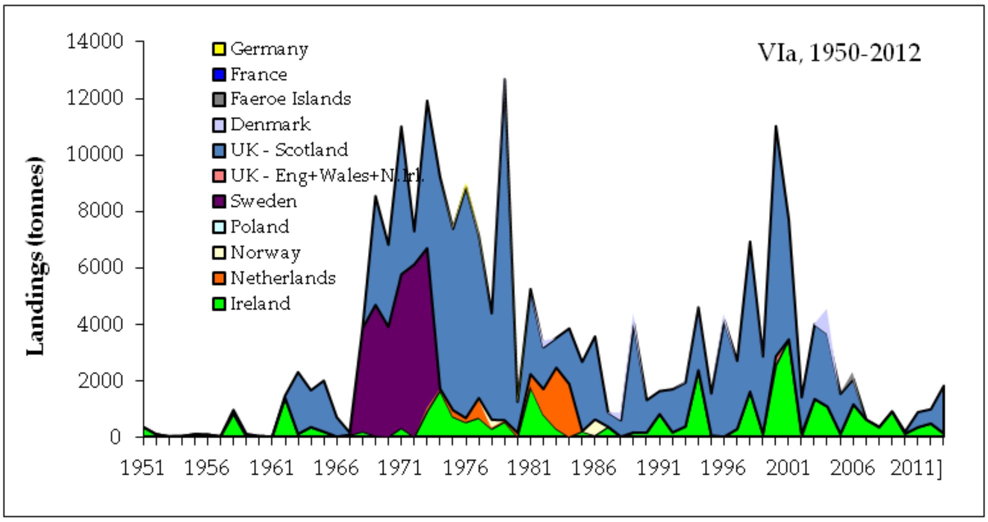


Figure 10.2.1. Sprat in the Celtic Seas. Landings of sprat 1950-2012 ICES Sub-division VIa.

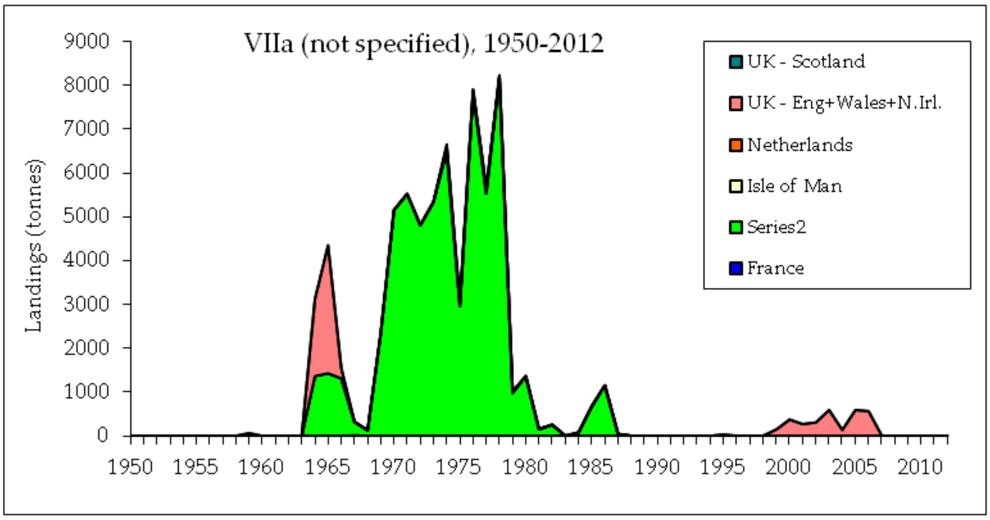


Figure 10.2.2. Sprat in the Celtic Seas. Landings of sprat 1950-2011 ICES Sub-division VIIaN. Note: Southern Irish landings from 1973-1995 may be from VIIaN or VIIaS.

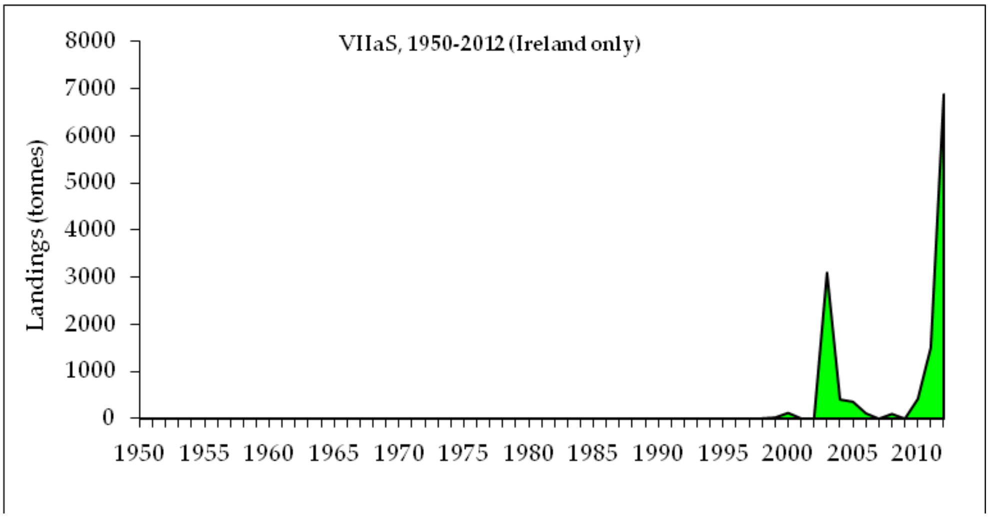


Figure 10.2.3. Sprat in the Celtic Seas. Landings of sprat 1950-2012 ICES Sub-division VIIaS.

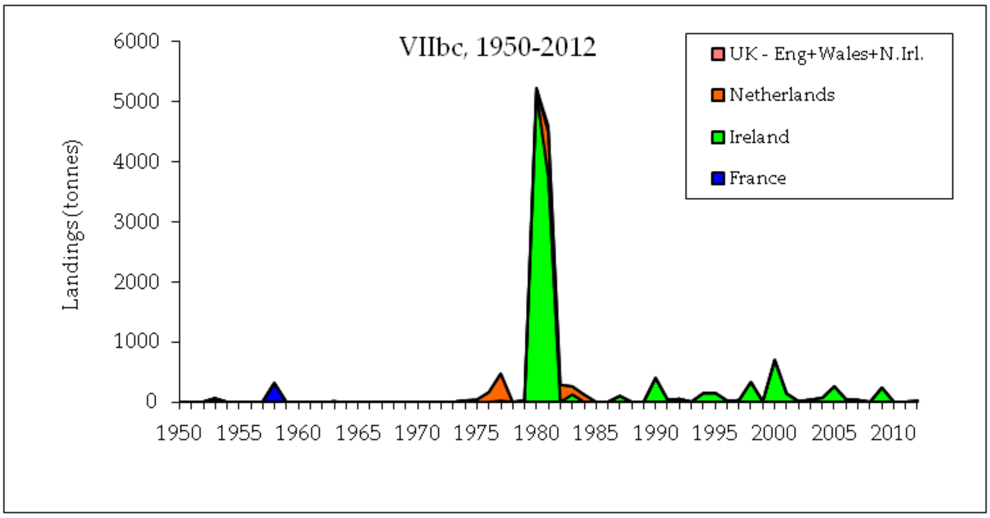


Figure 10.2.4. Sprat in the Celtic Seas Landings of sprat 1950-2012 ICES Sub-divisions VIIbc.

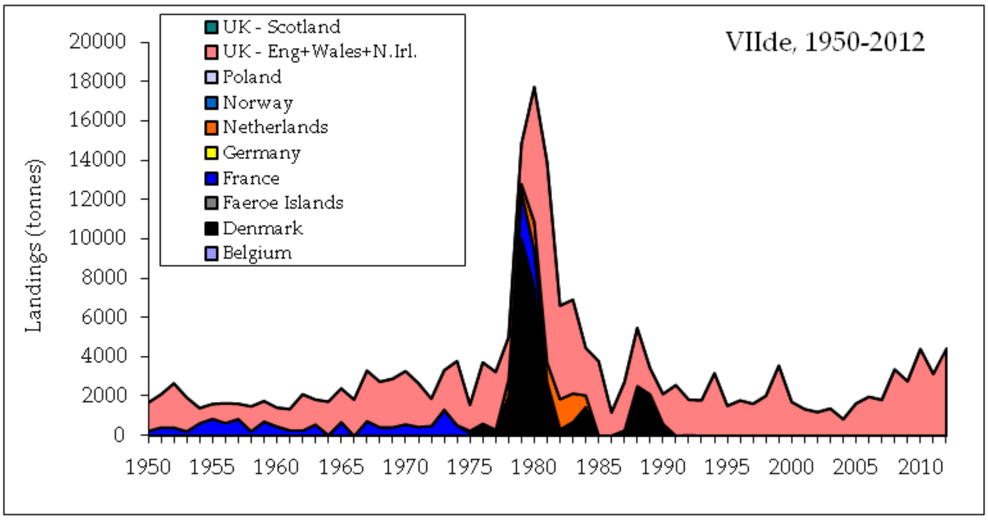


Figure 10.2.5. Sprat in the Celtic Seas. Landings of sprat 1950-2012 ICES Sub-divisions VIIde.

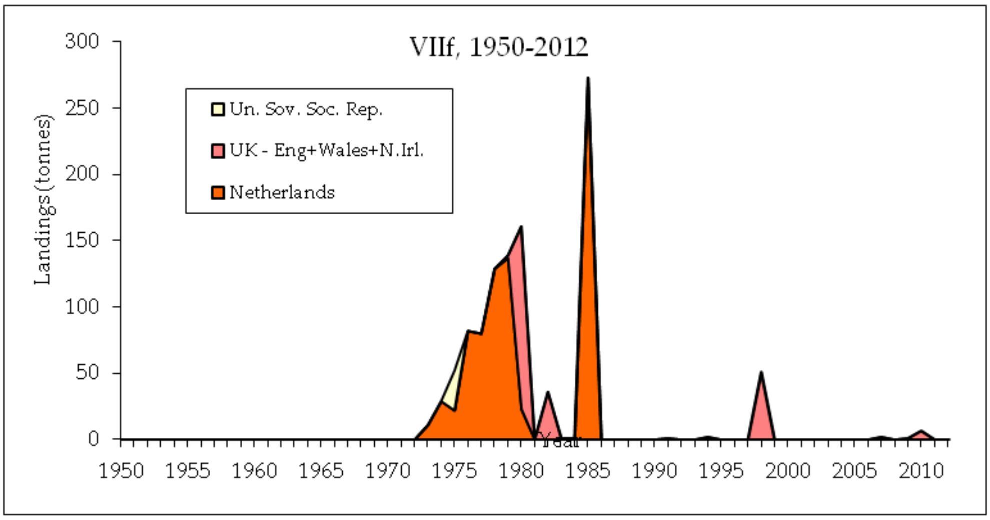


Figure 10.2.6. Sprat in the Celtic Seas. Landings of sprat 1950-2012 ICES Sub-division VIIf.

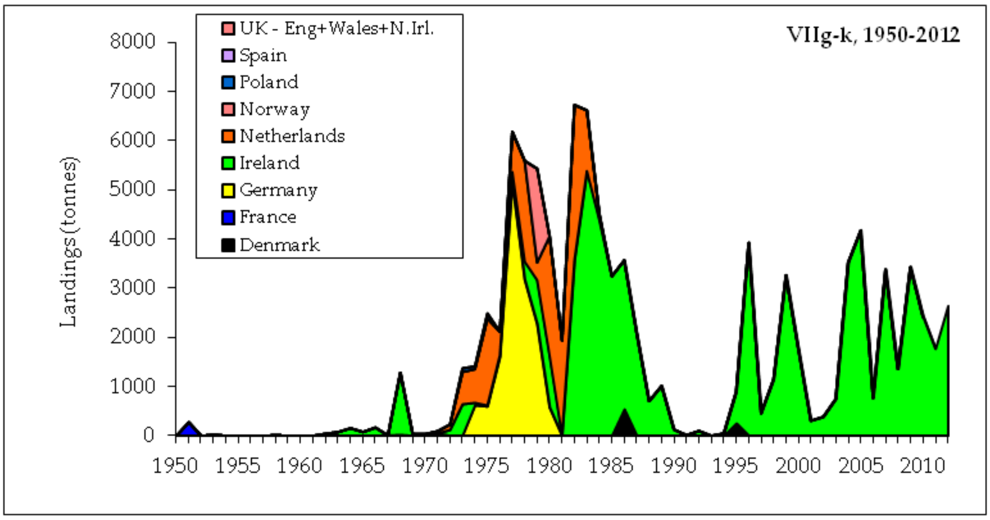


Figure 10.2.7. Sprat in the Celtic Seas Landings of sprat 1950-2012 ICES Sub-divisions VIIg-k.

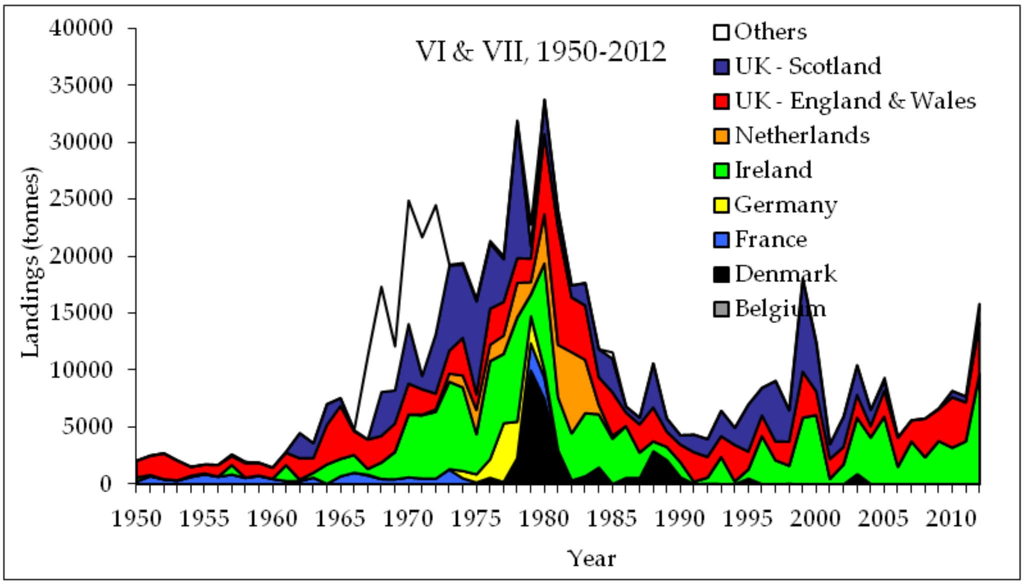


Figure 10.2.8. Sprat in the Celtic Seas Landings of sprat 1950-2012 ICES Divisions VI and VII (Celtic Seas Ecoregion).

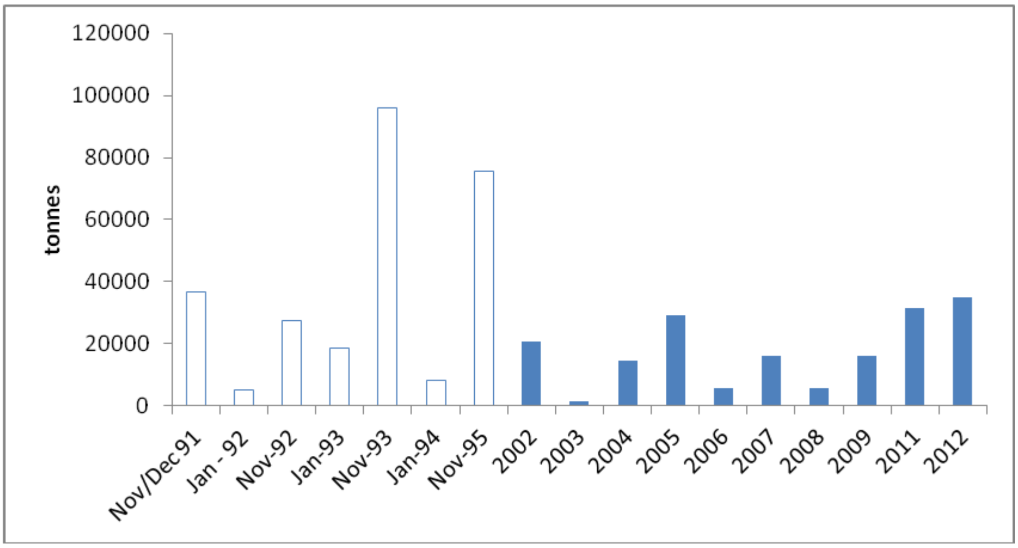


Figure 10.3.1. Sprat in the Celtic Seas. Annual sprat biomass in the Celtic Sea. (Source: MI Celtic Sea Herring Acoustic Survey). Solid bars correspond to the period where the surveys are considered consistent.

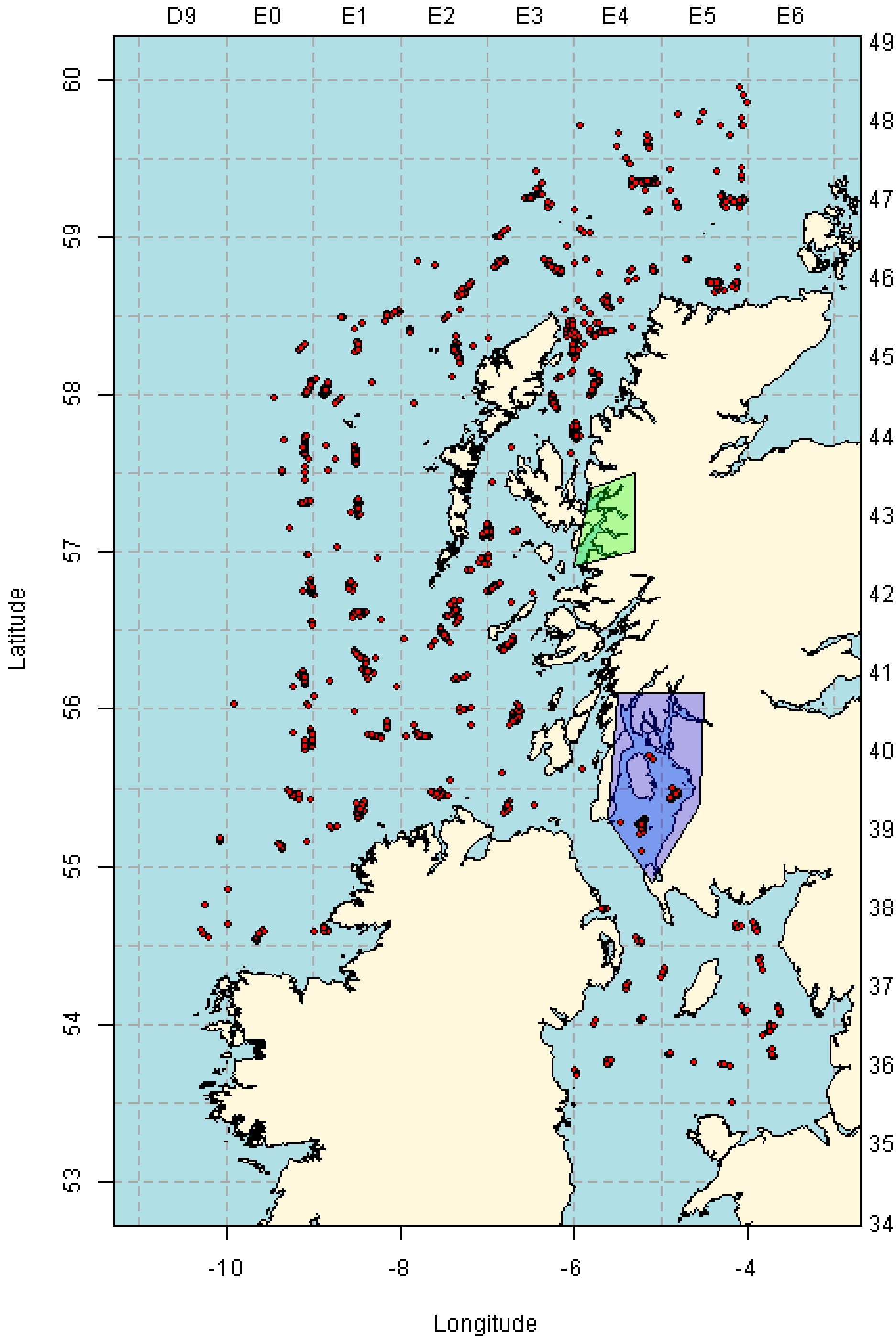


Figure 10.3.2: Extent of Scottish surveys that may provide information about sprat in VIa. In purple is the extent of the Clyde Herring and Sprat Acoustic Surveys carried out in July between 1985 and 1989 and again in October 2012. In green is the extent of the Sea Lochs Surveys carried out annually in Q1 and Q4 between 2001 and 2005. Red markers indicate all hauls from the Q1 and Q4 Scottish West Coast IBTS between 1985 and 2012.

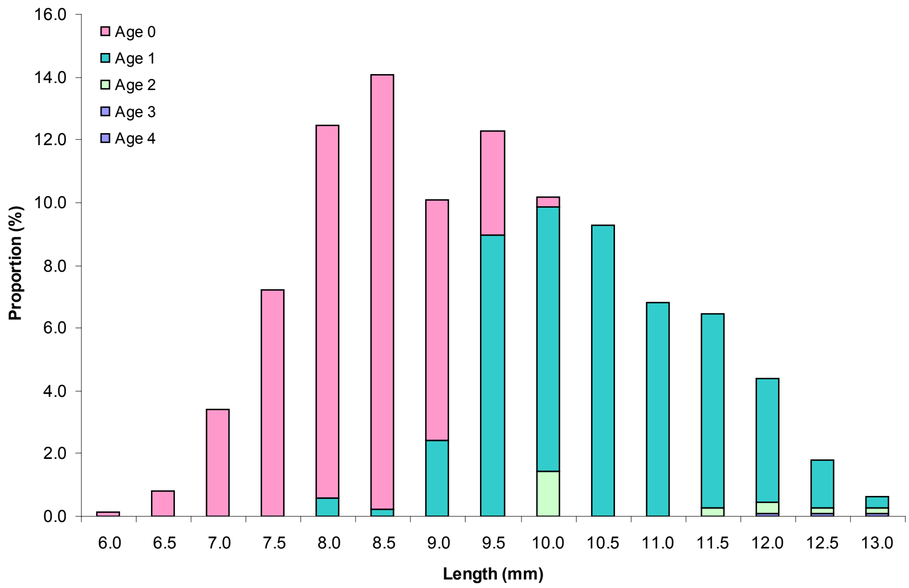


Figure 10.3.3. Length and age of sprat caught in the October 2012 Clyde Herring and Sprat Acoustic Survey. Data from six hauls were combined giving equal weight to the age and length distribution in each haul. 1442 sprat were measured and 182 were aged.

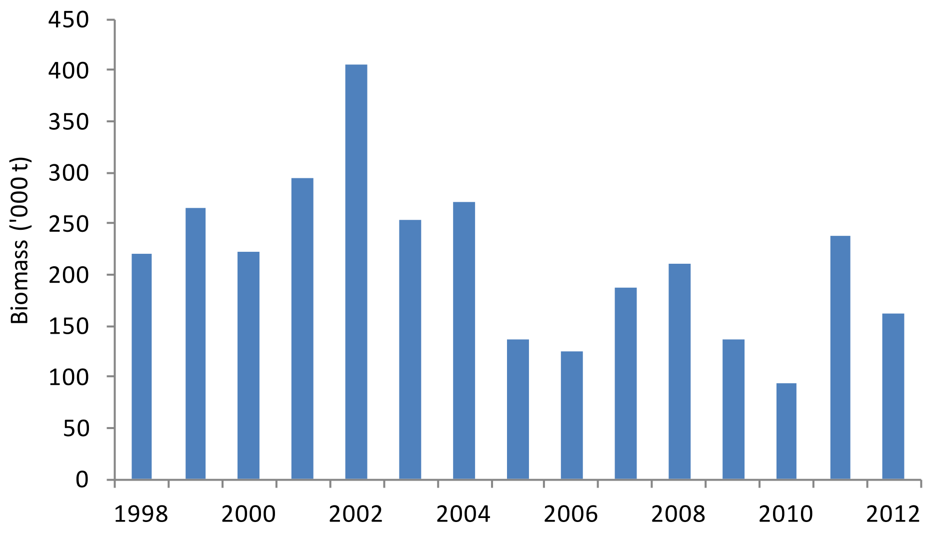


Figure 10.3.4. Sprat in the Celtic Seas. Annual sprat biomass in ICES sub-division VIIaN (Source: AFBINI annual herring acoustic survey).

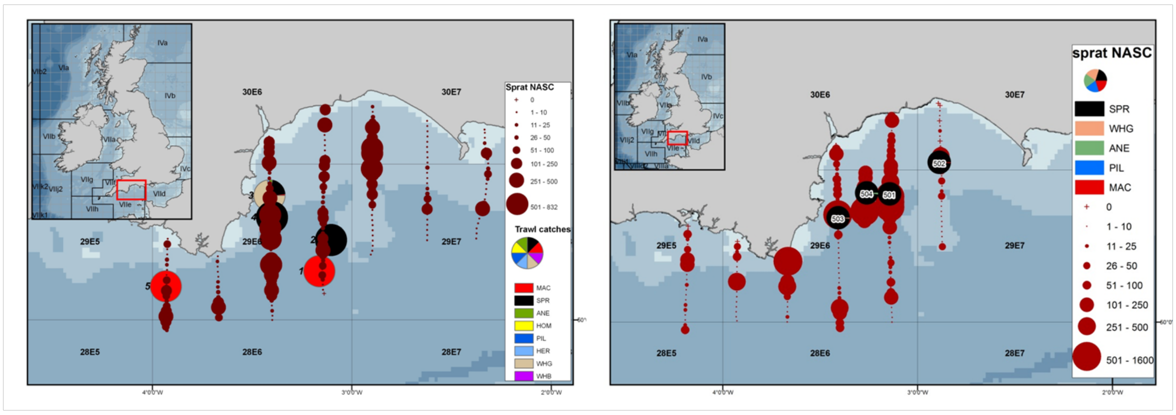


Figure 10.3.5. Sprat in VIIde. Acoustic surveys in 2011 (left) and 2012 (right). Along-transect acoustic densities attributed to sprat (NASC) per nautical mile are shown in maroon. The position and the catch composition of the five 2011 trawls (italics emboldened) and of the four 2012 trawls are also displayed. Boundaries of the ICES rectangles are indicated in grey (numbers emboldened within each rectangle). Three-letter species codes in legend: SPR sprat; MAC mackerel; WHG whiting; ANE anchovy; HER herring; HOM horse mackerel; PIL pilchard (sardine); WHB blue whiting.

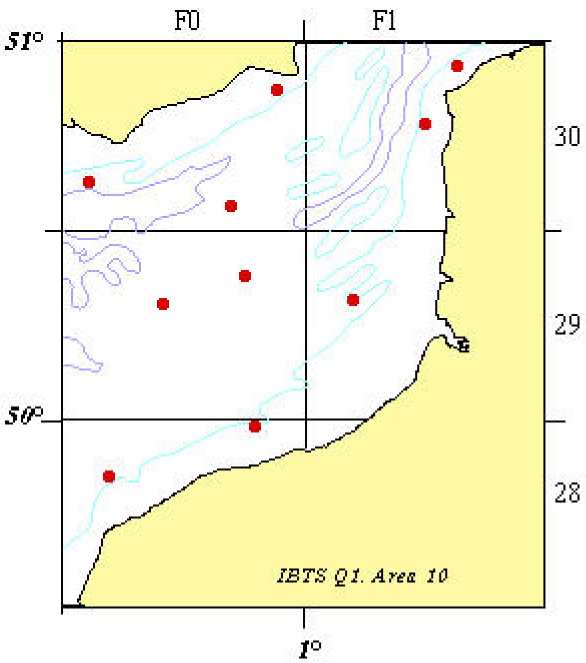


Figure 10.3.6: sampling area 10 in the Eastern Channel. (Hauls position for IBTS 11 sampled by France)

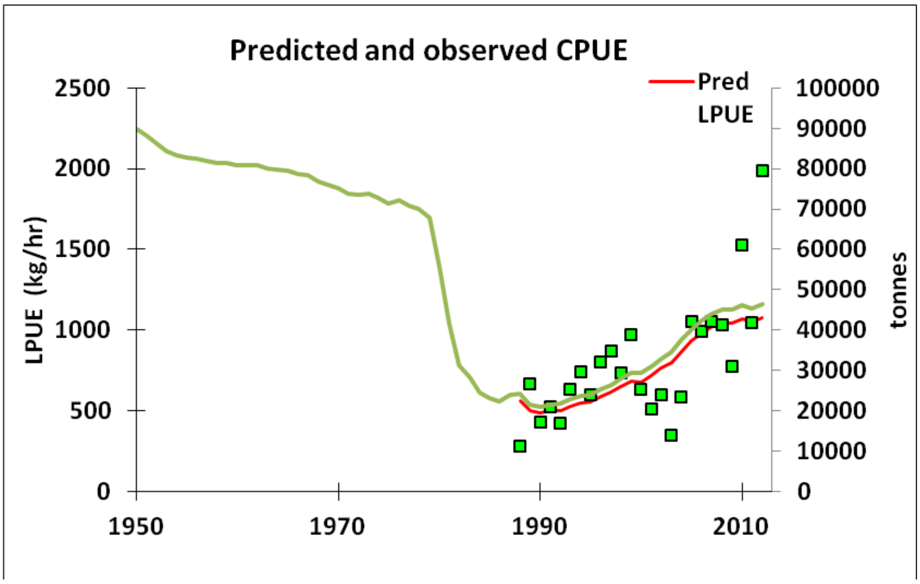


Figure 10.6.1. Surplus production model. Sensitivity test to fitting the official landings from 1950 to 2010. Predicted and observed lpue and model estimate of biomass (right hand y-axis) in tones.

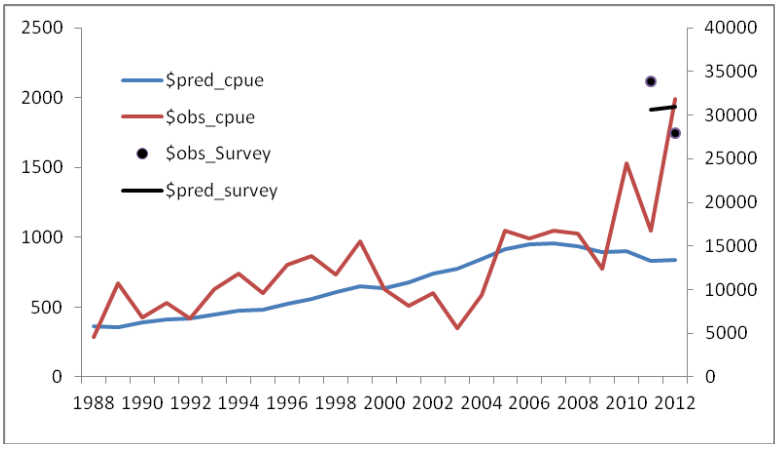


Figure 10.6.2. Surplus production model (constrain in q) fit to the three vessels lpue data and the acoustic survey.

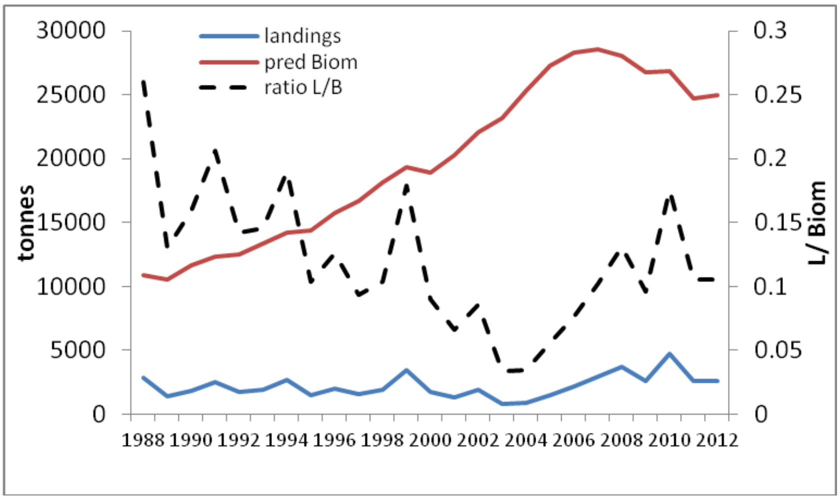


Figure 10.6.3. Surplus production model (q constrained): estimated total biomass, landings and exploitation ratio.

11 Sandeel in IV (HAWG Feb. 2013)

For assessment purposes, the European continental shelf has since 1995 been divided into four regions: Division IIIa (Skagerrak), Division IV (the North Sea excl Shetland Islands), Division Vb2 (Shetland Islands), and Division VIa (west of Scotland). Only the stock in Division IV and part of IIIa is assessed in this report.

Before 1995 two independent sandeel assessments were made: One for the northern North Sea and one for the southern North Sea. In 1995, it was decided to amalgamate the two stocks into a single stock unit The Shetland sandeel stock was assessed separately. ICES assessments used these stock definitions from 1995 to 2009.

Larval drift models and studies on growth differences have indicated that the assumption of a single stock unit is invalid and that the total stock is divided in several sub-populations. Based on this information ICES (ICES CM 2009\ACOM:51) suggested that the North Sea should be divided into seven sandeel assessment areas as indicated in Figure 4.1.1. On this basis the benchmark assessment (ICES 2010, (WKSAN 2010)) decided to make area specific assessments from 2010 onwards.

In 2010 the SMS-effort model was used for the first time to estimate fishing mortalities and stock numbers at age by half year, using data from 1983 to 2010. This model assumes that fishing mortality is proportional to fishing effort.

Further information on the stock areas and assessment model can be found in the Stock Annex and in the benchmark report (WGSAN, 2010).

11.1 General

11.1.1 Ecosystem aspects

Sandeels in the North Sea can be divided into a number of reproductively isolated sub-populations (see the Stock Annex). A decline in the sandeel population in recent years concurrent with a marked change in distribution has increased the concern about local depletion, of which there has been some evidence (ICES WGNSSK 2006b, ICES AGSAN 2008b).

Local depletion of sandeel aggregations at a distance less than 100 km from seabird colonies may affect some species of birds, especially black-legged kittiwake and sandwich tern, whereas the more mobile marine mammals and fish are likely to be less vulnerable to local sandeel depletion.

The stock annex contains a comprehensive description of ecosystem aspects.

11.1.2 Fisheries

General information about the sandeel fishery can be found in the Stock Annex.

The size distribution of the Danish fleet has changed through time, with a clear tendency towards fewer and larger vessels (ICES WGNSSK 2006b). In 2009 only 84 Danish vessels participated in the North Sea sandeel fishery, compared to more than 200 vessels in 2004 and the number of active vessels has decreased even further since.

The same tendency was seen for the Norwegian vessels fishing sandeels until 2005. In 2006 only 6 Norwegian vessels were allowed to participate in an experimental sandeel fishery in the Norwegian EEZ compared to 53 in 2002. However, the number of Norwegian fishing vessels participating in the sandeel fishery has increased to 42 in 2008. From 2002 to 2008 also the average GRT per trip in the Norwegian fleet increased from 269 to 507 t. Norwegian EEZ was closed in 2009, and in 2010 an experimental fishery started 23 April in a small area. The quota was 20 000 t, and half of the vessels could fish from 23 April to 30 April, and the other half could fish between 28 April and 5 May. The objective of the experiment was to measure the abundance of sandeel with acoustic before and after the fishery and examine the effect of the fishery on the biomass. Based on the acoustic survey an additional quota on 30 000 t was given. This fishery started 15 May and closed 23 June. In accordance to the Norwegian management plan (sec 4.1.4), only subareas 1b, 2b, and 3b were open for fishery in 2010 (Fig. 4.1.5). In 2011, the preliminary quota in the Norwegian EEZ was 60 000 t, which was increased with 30 000 t based on the acoustic survey results. Only subareas 1a, 2a and 3a were open for fishery. In 2012 the quota was 40 000 t, and only subareas 1b, 2b and 3b were open. The fishing season was from 23 April to 23 June. In addition, an exploratory fishery was carried out in subarea 5a from 15 May with a quota of 2 000 t.

The rapid changes of the structure of the fleet that have occurred in recent years may introduce more uncertainty in the assessment, as the fishing pattern and efficiency of the "new" fleet may differ from the previous fleet and the participation of fewer vessels has limited the spatial coverage of the fishery.

The sandeel fishery in 2012 was opened 1st of April and ended in areas 1-3 in May when the quota was taken. As in the most recent years the main fishery in area 1 took place in the in the Dogger Bank area and grounds north east of Dogger Bank. The overall fishing activity was very low due a historically small quota.

11.1.3 ICES Advice

ICES advised that, the fishery in 2012 should be allowed only if analysis of data from the in-year monitoring program indicated that the stock would be above B_{pa} by 2013.

Subsequently, based on results from the in-year monitoring programme ICES recommended that the catches in area 1 should not exceed 23 000. Catches in area 2, 3 and 4 should not exceed 5 000 t per area. ICES noted that the management of sandeel fisheries should try to prevent depletion of local aggregations, particularly in areas where predators congregate.

ICES recommended that future management should take into account the spatial structure of sandeels.

11.1.4 Management

TAC

EU waters of IIa, IIIa and IV.

In December 2011 a provisional TAC of 200.000 tons and quotas regarding sandeel in EU waters of IIa, IIIa and IV for 2012 was decided by the Council and later published in Council Regulation (EU) No 44/2012 of 17 January 2012. According to the special condition attached to this TAC it should all be fished in management area 1. However based on the new ICES advice from March 2012 EU decided to reduce the overall TAC for sandeel in EU waters of IIa, IIIa and IV to 38.420 tons (Commission implementing Regulation (EU) No 368/2012 of 27 April 2012), of which 23.000 tons in ICES management area 1, 5.000 tons in ICES management areas 2, 3 and 4 and 420 tons in the Kattegat (management area 6). On top of this an amount of 22.803 tons sandeel was added to the EU 2012 quota for quantities withheld in the year 2011 (Commission implementing Regulation (EU) No 319/2012 of 13 April 2012). The total TAC for sandeel in all EU waters of IIa, IIIa and IV in 2012 amounted to 61.223 tons of which 2.300 in management area 1 was given to Norway.

Norwegian waters of IIa and IV.

Based on a recommendation from the Norwegian Institute for Marine research a total TAC of 20.000 tons for 2013 (open between April 23 – June 23) was established to be fished in two specific areas in Norwegian waters of IV. This TAC may be changed on May 15 2013 after having conducted acoustic surveys in April/May

Norwegian sandeel management plan

An Area Based Sandeel Management Plan for the Norwegian EZZ was fully implemented in 2011, but was also used in 2010. Based on historical fishing patterns and local stock developments 6 areas are defined, each consisting of "a" and "b" subareas (Figure 4.1.5). The main objective of the Plan is to rebuild the spawning stocks in all 6 areas and thereby enhance the total recruitment and catch potential. Acoustic surveys and catch information (if available) are used to estimate the abundance, age structure and geographical distribution of the sandeel population. If the analyses show that the spawning stock is large and widely distributed within an area (Figure 4.1.6), one of the adjacent subareas can be open for fishery. The subsequent year, if the state of the spawning stock still is strong, the other subarea will be open. Prior to the fishing season, which is restricted to 23 April – 23 June, a preliminary TAC is given and within the open subareas the fleet can operate freely. The acoustic surveys carried out in the current year will be used to validate previous biomass estimates and to estimate the recruitment strength of the 1-year old sandeels. Based on this updated survey information, the TAC within the current year can be increased and new areas (subareas) can be open.

Closed periods

From 2005 to 2007 the fishery in the Norwegian EEZ opened April 1 and closed again June 23. In 2008 the ordinary fishery was stopped 2 June, and only a restricted fishery with 5 vessels continued. No fishery was allowed in 2009. From 2010 the fishing season is 23 April – 23 June in the Norwegian EEZ.

Since 2005 Danish vessels have not been allowed to fish sandeels before 31st of March. In 2012 sandeel fishery in the EU zone was opened on the 1st of April and ended in the beginning of May when the quota was taken .

Closed areas

The Norwegian EEZ closed for an ordinary fishery in 2006 based on the results of a three week RTM fishery. In 2007, no ordinary fishery was allowed north of 57°30′N and in the ICES rectangles 42F4 and 42F5 after the RTM fishery ended. In 2008, the ordinary fishery was closed except in ICES rectangles 42F4 and 44F4, and for 5 vessels only, the ICES rectangles 44F3, 45F3, 44F2 and 45F2 were open. The Norwegian EEZ was closed to fishery in 2009. In accordance with the Norwegian sandeel management plan, only the Norwegian management subareas 1b, 2b and 3b were open in 2010 and 2012, and only the subareas 1a, 2a and 3a were open in 2011. In 2012, an exploratory fishery was carried out in subarea 5a from 15 May with a quota of 2 000 t.

In the light of studies linking low sandeel availability to poor breeding success of kittiwake, there has been a moratorium on sandeel fisheries on Firth of Forth area along the U.K. coast since 2000, except for a limited fishery in May and June for stock monitoring purposes.

11.1.5 Catch

Landing and trends in landings

Landings statistics for Division IV are given by country in Table 4.1.1. Landing statistics and effort by assessment area are given in Tables 4.1.2 to 4.1.7. Figure 4.1.1 shows the areas for which catches are tabulated.

The sandeel fishery developed during the 1970s, and landings peaked in 1997 and 1998 with more than 1 million tons. Since 1983 the total landings have fluctuated between 1.2 million tons (1997) and 101 000 tons (2012) with an overall average at 659 000 tons (Figure 4.1.2). There was a significant decrease in landings in 2003. The average landings of the period 1983 to 2002 was 835 000 tons whereas the average landings of the period 2003 to 2012 was 306 000 tons. Total landings in 2012 were 101 000 t.

Spatial distribution of landings

Yearly landings for the period 2001–2012 distributed by ICES rectangle are shown in Figure 4.1.2. Dogger Bank remains the main fishing area, with one rectangle (39F1) contributing the highest landings of all rectangles in 6 out of the last 10 years. The fishery in the Norwegian EEZ has varied over time, primarily as a result of changes in regulations.

Figure 4.1.3 shows the landings by area. There are large differences in the regional patterns of the landings. Areas 1 and 3 have always been the most important with regard to sandeel landings. On average, together these two areas have contributed 85% of the total sandeel landings in the period 1983 to 2012. However, there has been a significant shift in the relative contribution of the two areas over the period. Up to 2002 area 1 and 3 contributed 47 and 36% respectively whereas their contributions were 67 and 22% in the period 2003 to 2012. In Area-3, landings in the Norwegian EEZ have declined since 2006 partly due to national regulation of the fishery.

The third most important area for the sandeel fishery is area 2. In the period 2003 to 2012 landings from this area contributed 10% of the total landings on average. The contribution of area 2 over the entire period is 9% on average.

Area 4 has contributed about 5% of the total landings since 1994 but there have been a few outstanding years with particular high landings (1994, 1996 and 2003 contributing 19, 17 and 20% of the total landings respectively). In the periods 1994 to 2002 and 2003 to 2012 the average contributions from area 4 was 8 and <1% respectively.

Several banks in the Norwegian EEZ have not provided landings for the last 8-12 years due to very low abundance of sandeels. For several years after 2001 almost all landings from the Norwegian EEZ came from the Vestbank area (Figure 4.1.5). However, due to a strong recruitment in 2006 some of the southerly banks in Norwegian EEZ were repopulated, but Inner Shoal East and Outer Shoal were commercially depleted in 2007, and the stock at English Klondyke, which was closed after the RTM fishery in 2007, was commercially depleted in 2008. In 2009, high densities of sandeel in the Norwegian EEZ were restricted to the Vestbank area and in a small area at Inner Shoal West (Figure 4.1.6). In 2010, the about 19 000 t were landed from small areas at Vestbanken during the experimental fishery, and 30 000 t were landed from 1b, 2b and 3b. In 2011, about 89 000 t were landed from 1a, 2a and 3a, and in 2012 about 40 000 t were landed from 1b, 2b and 3b, and less than 500 t from 5a in an exploratory fishery.

Estimation of effort

Individual Norwegian logbook records were included in the dataset used to estimate effort in 2012, since there was no country-effect. However, it was also decided not to update 2011 since the estimated country-effect was based on very few overlapping catches, hence, raising doubts about validity of the country-effect.

Measuring days fished

In the Norwegian data, days fished refer to the actual days fished whereas in the Danish data, days fished refer to the number of days from the first day of fishing to landing of the catch. To ensure comparability of the two sets, one day was added to each Norwegian logbook record before estimating CPUE.

Effect of vessel size on CPUE

In order to avoid bias in effort introduced by changes in the average size of fishing vessels over time, the CPUEs are used to estimate a vessel standardization coefficient, *b*. The parameter *b* was estimated using the model

$$\ln(\hat{CPUE}_{w,r,y,V}) = a_{w,r,y} + b_y \ln\left(\frac{V}{V^*}\right)$$

where indices *sq*, *w* and *y* denote square, week (Julian day of midpoint of trip/7, rounded to the nearest integer) and year, respectively, *V* is vessel size, *V** is 200 GRT, $\hat{CPUE}_{w,r,y,V}$ is median CPUE in the given rectangle, week and year for a vessel size of *V* and *a* and *b* are estimated using general linear models with normal error distribution. The effect of country on *b* was estimated and found not to be significant (*b* of Denmark=0.478 (std=0.030) and Norway=0.665 (std=0.100), P=0.0739). The estimated common value of *b* was 0.495 (std=0.040) which is close to the average from 2000-2010 (0.434).

Effect of country on CPUE

There was a significant (P=0.0099) difference in *a* between countries as Danish ln(CPUE) was on average 0.586 less than Norwegian ln(CPUE), corresponding to Norwegian average CPUE being 178% of Danish CPUE. This difference was estimated from CPUEs in ICES statistical rectangle 39F1, as there was no spatio-temporal overlap between Norwegian and Danish logbooks in other places. In spite of the limited data available, a correction factor significantly different from zero was estimated and used to standardise Norwegian effort to Danish levels in 2011 (i.e. one Norwegian fishing day corrected for vessel size counted as 1.78 Standardised Fishing Days), although it was not applied in the assessment. In 2012, the difference was not statistically significant and no standardization for country effects was performed. As more data is added in the coming years, this issue should be revisited.

11.2 Sandeel in Area-1

11.2.1 Catch data

Total catch weight by year for area 1 is given in Tables 4.1.2-4.1.4. Catch numbers at age by half-year is given in Table 4.2.1.

In 2011 the proportion of 2-group in the catch was almost 90%. The same year-class were exploited in 2012 as 3-group, where it constituted ~80% of the catch (Figure 4.2.1). Such a high proportion of older fish has never been observed previously,

11.2.2 Weight at age

The methods applied to compile age-length-weight keys and mean weights at age in the catches and in the stock are described in the Stock Annex.

The mean weights at age observed in the catch are given in Table 4.2.2 by half year. It is assumed that the mean weights in the sea are the same as in the catch. The time series of mean weight in the catch and in the stock is shown in Figure 4.2.2. From 2004 there is an increasing trend in mean weights for all age groups except for age group 1. A number of issues still need to be addressed in this regard. Firstly, the method used to record fishing days differs between the two countries. Secondly, it should be investigated to what extent the Danish and Norwegian CPUEs are comparable both in absolute levels and in the difference between vessel sizes.

11.2.3 Maturity

Maturity estimates from 2005 onwards are obtained from the Danish dredge survey in December as described in the stock annex.

For 1983 to 2004 the means of the period 2005-2010 are applied (Table 4.2.3)

11.2.4 Natural mortality

As described in the Stock Annex values of natural mortality are obtained from a multispecies model where predation mortality is estimated (ICES, 2008).

Text table: Values for natural mortality by age and half year used in the assessments.

Age	First half year	Second half year
0		0.96
1	0.46	0.58
2	0.44	0.42
3	0.31	0.37
4+	0.28	0.36

11.2.5 Effort and research vessel data

Trends in overall effort and CPUE

The Tables 4.1.5-4.1.7 and Figure 4.2.3 show the trends in the international effort over years measured as number of fishing days standardised to a 200 GRT vessel. The standardisation includes just the effect of vessel size, and does not take changes in efficiency into account. Total international standardized effort peaked in 2001 (10500 days), and declined thereafter to 1776 days in 2007. In the period from 2007 to 2011 effort has been fluctuating around a mean of 5000 days before reaching an all time low of 1746 in 2012 The average CPUE in the period 1994 to 2002 was 60 tons/day. In

2003 CPUE declined to the all time lowest at 21 tons/day. Since 2004 the CPUE has increased and reached the all time highest (101 tons/day) in 2010 followed by lower, but still above average values in 2011 and 2012 (87 and 80 tons/day).

Tuning series used in the assessments

No commercial tuning series are used in the present assessment.

In 2010, for the first time, a time series of stratified catch rates (Table 4.2.4) from a dredge survey was used to calibrate the assessment.

The internal consistency, i.e. the ability of the survey to follow cohorts, was evaluated by plotting catch rates of an age group in a given year versus the catch rates of the next age group in the following year. The internal consistency plot (Figure 4.2.4) shows a modest consistency between age 0 and age 1 which has deteriorated in recent years.

Details about the dredge survey and the consistency analysis are given in the Stock Annex and the benchmark report (WKSAN, 2010).

11.2.6 Notes regarding the dredge survey

The Danish dredge survey was carried out as planned and all fixed positions were covered without notable problems related to weather or other potentially obstructive factors.

In addition to the primary Danish dredge survey in Nov/Dec 2012, a parallel supplementary dredge survey was carried as a collaboration initiative between DTU-Aqua and the Danish Fishermens´s Association (EFF-project). The purpose of the supplementary survey was to validate reproducibility of survey results and test for effects of wind speed, time of day etc. The primary survey covered all the fixed survey positions in accordance with the survey protocol. The secondary survey ship fished new positions all over the North Sea as well as 20 out of the 32 fixed positions in Area 1, and sampling procedure was identical between survey ships. However, the collaboration project was cancelled and collected data withdrawn on January 28. Hence, only data from the primary Danish dredge survey has been included in the assessment.

11.2.7 Data analysis

Based on the results from the Benchmark assessment (WKSAN, 2010) the SMS-effort model was used to estimate fishing mortalities and stock numbers at age by half year, using data from 1983 to 2012. In the SMS model it is assumed that fishing mortality is proportional to fishing effort. For details about the SMS model and model settings, see the Stock Annex.

The diagnostics output from SMS are shown in Table 4.2.6. The seasonal effect on the relation between effort and F ("F, Season effect" in the table) is as expected rather constant over the three year ranges used, showing a stable relationship between effort and F for the full assessment period. The "age catchability" ("F, age effect" in the table) shows a change in the fishery pattern where the fishery was mainly targeting the age 2+ sandeel in the beginning of the period, to a fishery mainly targeting age 1 and age 2 in the most recent years.

The CV of the dredge survey (Table 4.2.6) is medium (0.49) for age 0 and high (1.16) for age 1, indicating a reasonable consistency between the results from the dredge survey and the overall model results. The residual plot (Figure 4.2.5) shows no clear bias for this relatively short time series. The 2011 survey estimate of the 2010 year class is considerably higher than the estimate from all data sources.

The model CV of catch at age is low (0.301) for age 1 and age 2 in the first half of the year and high for the remaining ages and season combinations. The residual plots for catch at age (Figure 4.2.6) confirm that the fit is generally poor except for age 1 and 2 in the first half year. There is a cluster of negative residuals (observed catch is less than model catch) for age 4+ in 2005-2011, but for age 1 – age 3 there is no obvious bias in first half year catches in most recent years.

The CV of the fitted Stock recruitment relationship (table 4.2.6) is high (0.78) which is also indicated by the stock recruitment plot (Figure 4.2.7). The estimated recruitment in 2012 is about average for the period 2002-2012.

The retrospective analysis (Figure 4.2.8) shows very consistent assessment results from one year to the next. This is probably due to the assumed relationship between effort and F, which is rather insensitive to removal of a few years. However, it should be noted that the very short time series (2004-2012) of the dredge survey is actually too short to make a proper retrospective analysis.

Uncertainties of the estimated SSB, F and recruitment (Figure 4.2.9) are in general small, which gives relatively narrow 95% confidence limits (Figure 4.2.10). The confidence limits of SSB show that SSB has been above B_{lim} between 2007 and 2012 with a high probability, but just above B_{lim} in 2013. The confidence limits of recruitment in 2012 are wider than of the previous two (poor) recruitments.

The plot of standardised fishing effort and estimated F (Figure 4.2.11) show a clear relation between effort and F as specified by the model. As the model assumes a different efficiency and catchability for the three periods 1983-1988, 1989-1998 and 1999-2012, the relation between effort and F varies between these periods. It is clearly seen that an effort unit in 1983 gives a smaller F than one in the most recent years. This is due to technical creeping, i.e. a standard 200 GT vessel has become more efficient over time.

11.2.8 Final assessment

The output from the assessment is presented in Tables 4.2.7 (fishing mortality at age by half year), 4.2.8 (fishing mortality at age by year), 4.2.9 (stock numbers at age) and 4.2.10 (Stock summary).

11.2.9 Historic Stock Trends

The stock summary (Figure 4.2.13 and Table 4.2.10) shows that SSB have been at or below B_{lim} from 2000 to 2002 and again in 2004 and 2006. Between 2007 and 2012, SSB has been above B_{pa}, but is expected to be below B_{pa} (just above B_{lim}) in 2013. $F_{(1-2)}$ is estimated to have been below the long time average since 2005.

11.2.10 Recruitment estimates

Recruitment estimates are given in the summary table (Table 4.2.10). 2010 and 2011 provided two consecutive years of historically poor recruitment, which has never previously been observed. The second lowest value of biennial recruitment was around twice the current and was recorded in the years 1986 and 1987, following the strongest year class on record (1985). For comparison, the 2009 year class was the 3rd largest on record. Hence, the recruitment success could potentially be depressed by the large biomass of older fish. However, it is equally possible that other effects are the cause. The recruitment estimate for 2012 indicates a recruitment just above the long term mean, however, confidence intervals around the estimate were large (Figure 4.2.10).

11.2.11 Short-term forecasts

Input

Input to the short term forecast is given in Table 4.2.11. Stock numbers in the TAC year are taken from the assessment for age 1 and older. Recruitment in the second half year of 2013 is the geometric mean of the recruitment 1983-2011 (191 billion at age 0). The exploitation pattern and Fsq is taken from the assessment values in 2012. As the SMS-model assumes a fixed exploitation pattern since 1999, the choice of years is not critical. However no fishery took place in the second half-year of 2012 and this also assumed to be the case in 2013. Mean weight at age in the catch and in the sea is the average value for the years 2010-2012. The maturity estimate in 2012 is obtained from the dredge survey in December 2012. For 2014 the long term average proportion mature is applied. Natural mortality is the fixed M applied in the assessment.

The Stock annex gives more details about the forecast methodology.

Output

The short term forecast shows that a TAC of 225 000 t in 2013 is consistent with a SSB at B $MSY_{trigger}$ at 215 000 tons. Such at TAC corresponds to an F of 0.599 of 406% compared to 2012 (table 4.2.11 and 4.2.15).

11.2.12 Biological reference points

B_{lim} is set at 160 000 tons and B_{pa} at 215 000 tons. B $MSY_{trigger}$ is set at B_{pa}.

Further information about biological reference points for sandeels in IV can be found in the Stock Annex.

11.2.13 Quality of the assessment

The quality of the present assessment is considered much improved compared to the combined assessment for whole North Sea previously presented by ICES. This is mainly due to the fact that the present division of stock assessment areas better reflects the spatial stock structure and dynamic of sandeel. Addition of fishery independent data from the dredge survey has also improved the quality of the assessment. Application of the new statistical assessment model SMS-effort has removed the retrospective bias in F and SSB for the most recent years. This is probably due to the robust model assumption of fishing mortality being proportional to fishing effort. This assumption in combination with the available data, give rather narrow confidence limits for the model estimates of F, SSB and recruitment.

The model uses effort as basis for the calculation of F. The total international effort is derived from Danish and Norwegian (in 2011 and 2012) CPUE and total international landings. Danish catches are by far the weightiest in the area, but effort by the individual countries would improve the quality of the assessment.

11.2.14 Status of the Stock

Recruitment in 2009 was estimated to be twice the long term mean but recruitment in both 2010 and 2011 was less than 10% of the recruitment in 2009. In 2012 recruitment was estimated to be near the long term mean once again. SSB has been above B_{pa} from 2007 to 2012, but is expected to fall below B_{pa} to just above B_{lim} in 2013.

11.2.15 Management Considerations

A management plan needs to be developed. The ICES approach for MSY based management of a short-lived species as sandeel is the so-called escapement strategy, i.e. to maintain SSB above MSY $B_{trigger}$ after the fishery has taken place. The assessment indicates that an Fat 0.599 in order to catch the TAC that is consistent with the present MSY $B_{trigger}$ at B_{pa} (215 000 tonnes). Taking the historical F and stock development into account an F value above 0.6 is probably not recommendable. The rather high F in 2013 and the rather low TAC is due to the an average recruitment in 2012, but very low stock sizes of the 2010 and 2011 year-classes. As effort is assumed proportional to F, the management plan should include an upper effort limit defined on the basis of the effort applied in the most recent years.

11.3 Sandeel in Area-2

11.3.1 Catch data

Total catch weight by year for area 2 is given in Tables 4.1.2-4.1.4. Catch numbers at age by half-year is given in Table 4.3.1.

In 2010 the proportion of 1-group in the catch was more than 80% (Figure 4.3.1) followed by a proportion of 2-group in 2011 of 68% and 40% 3-group in 2012. The proportion of 1-groups in 2011 was low (11%), but lower values have been recorded in 17% of the years since 1983. In 2012, the proportion of 1-groups was slightly higher than in 2011, but catches were still dominated by older fish with a clear peak in 3-groups.

11.3.2 Weight at age

The methods applied to compile age-length-weight keys and mean weights at age in the catches and in the stock are described in the Stock Annex.

The mean weights at age observed in the catch are given in Table 4.3.2 by half year. It is assumed that the mean weights in the sea are the same as in the catch. The time series of mean weight in the catch and in the stock is shown in Figure 4.3.2. Since 2000 there has been a general decrease in 1st half-year mean weights for all ages, although with temporary increases in mean weight in 2006 and 2007 and again in 2012.

11.3.3 Maturity

The dredge survey does not cover Area-2. Therefore means of the maturity estimates from Area-1 in the period 2005-2010 are used for the entire time series in Area-2.

The Danish dredge survey is described in the stock annex.

11.3.4 Natural mortality

As described in the Stock Annex, values of natural mortality are obtained from a multispecies model where predation mortality is estimated (ICES, 2008).

Text table: Values for natural mortality by age and half year used in the assessments.

Age	First half year	Second half year
0		0.96
1	0.46	0.58
2	0.44	0.42
3	0.31	0.37
4+	0.28	0.36

11.3.5 Effort and research vessel data

Trends in overall effort and CPUE

Tables 4.1.5-4.1.7 and Figure 4.3.3 show the trends in the international effort over years measured as number of fishing days standardised to a 200 GRT vessel. The standardisation includes just the effect of vessel size, and does not take changes in efficiency into account.

Total international standardized effort has shown a clear drop from 13240 days in 1985 136 days in 2007. In 2012 the effort was low. The CPUE increased from 1983 (36 tons/day) to 1994 (57 tons/day). Since 2004 the CPUE has increased and reached the all time highest (59 tons/day) in 2010 followed by a decline to 40 tons/day in 2011 and just below 30 tons/day in 2012.

Tuning series used in the assessments

No commercial tuning series are used in the present assessment.

A dredge survey in area 2 was initiated in 2010 such that the time series is too short for assessment purposes. However, as there is a strong correlation between recruitments in Area-1 and Area-2 (Figure 4.3.4) the catch rate indices of age group 0 from Area-1 (Table 4.2.4) was used to calibrate the assessment of Area-2.

Details about the dredge survey and the consistency analysis are given in the Stock Annex and the benchmark report (WKSAN, 2010).

11.3.6 Data analysis

The diagnostics output from SMS-effort are shown in Table 4.3.5. The seasonal effect on the relation between effort and F (“F, Season effect” in the table) is as expected rather constant over the two year ranges used, showing a stable relationship between effort and F for the full assessment period. The “age catchability” (“F, age effect” in the table) and the “Exploitation pattern” show that the exploitation in the second half of the year is highest for the most recent period 1999-2011.

The CV of the dredge survey (Table 4.3.5) is low (0.30) for age 0 indicating a high consistency between the results from the dredge survey and the overall model results. The residual plot (Figure 4.3.5) shows no bias for this relatively short time series.

The model CV of catch at age 1 and 2 is medium (0.421) in the first half of the year and high for the remaining ages and season combinations. The residual plots for catch at age (Figure 4.3.6) confirm that the fit is generally poor except for age 1 and 2 in the first half year. There are clusters of positive and negative residuals for age 1 in the first half-year.

The CV of the fitted Stock recruitment relationship (Table 4.3.5) is high (0.98) which is also indicated by the stock recruitment plot (Figure 4.3.7).

The retrospective analysis (Figure 4.3.8) shows a reasonable consistent assessment results from one year to the next. This is probably due to the assumed relationship between effort and F, which is rather insensitive to removal of a few years. However, it should be noted that the very short time series (2004-2012) of the dredge survey is actually too short to make a proper retrospective analysis.

Uncertainties of the estimated SSB, F and recruitment (Figure 4.3.9) are in general high, which gives wide confidence limits (Figure 4.3.10).

The plot of standardised fishing effort and estimated F (Figure 4.3.11) shows a clear relation between effort and F as specified by the model. As the model assumes a different efficiency and catchability for the two periods 1983-1998, 1998-2012, the relation between effort and F varies between these periods. It is seen that an effort unit prior to 1998 gives a smaller F than one in the most recent years. This indicates technical creep, i.e. a standard 200 GT vessel has become more efficient over time.

11.3.7 Final assessment

The output from the assessment is presented in Tables 4.3.6 (fishing mortality at age by half year), 4.3.7 (fishing mortality at age by year), 4.3.8 (stock numbers at age) and 4.3.9 (Stock summary).

11.3.8 Historic Stock Trends

The stock summary (Figure 4.3.13 and Table 4.3.9) show that recruitment has been highly variable but without a clear trend for the whole time series. SSB has decreased considerably from 1999 to 2002 where SSB was below B_{lim}. From 2004 SSB has increased and SSB was above B_{pa} in 2011 but fell just below B_{pa} in 2012, and approached B_{lim} in the beginning of 2013. $F_{(1-2)}$ is estimated to have been below the long time average since 2005.

11.3.9 Recruitment estimates

The recruitment estimate of 2011 indicated recruitment at 17 billion. The 2010 year-class was also poor, and the biennial average has only been below that in the most recent years once in the time series (following the strong 1996 year-class). Recruitment estimate of 2012 indicate recruitment at 50 billion, which is about average for the period 2000-2012.

11.3.10 Short-term forecasts

Input

Input to the short term forecast is given in Table 4.3.10. Stock numbers for age 1 and older in the TAC year are taken from the assessment. Recruitment in the second half year of 2012 is the geometric mean of the recruitment 1983-2012 (41 billion at age 0). The exploitation pattern and Fsq is taken from the assessment values in 2012. As the SMS-model assumes a fixed exploitation pattern since 1999, the choice of year is not critical for. Mean weight at age in the catch and in the sea is the average value for the years 2009-2012. Proportion mature in 2013 is obtained from the dredge survey December 2012. For 2014 the long term average proportion mature is applied. Natural mortality is the fixed M applied in the assessment.

The Stock annex gives more details about the forecast methodology.

Short-term forecast

The assessment forecast (Table 4.3.11) suggests a TAC of 17 000 t. It should be noted that the confidence intervals around the SSB estimate were large (Figure 4.3.10).

11.3.11 Biological reference points

B_{lim} is set at 70 000 tons and B_{pa} at 100 000 tons. B $MSY_{trigger}$ is set at B_{pa}.

Further information about biological reference points can be found in the Stock Annex.

11.3.12 Quality of the assessment

The quality of the present assessment is considered much improved compared to the combined assessment for whole North Sea previously presented by ICES. This is mainly due to the fact that the present division of stock assessment areas better reflects the actual spatial stock structure and dynamic of sandeel. Addition of fishery independent data from the dredge survey has also improved the quality of the assessment although it would be preferable to have area specific survey data. Application of the new statistical assessment model SMS-effort has removed the retrospective bias in F and SSB for the most recent years. This is probably due to the robust model assumption of fishing mortality being proportional to fishing effort. This assumption in combination with the available data, give reasonable confidence limits for the model estimates of F, SSB and recruitment.

There is only three years (2010 to 2012) of fishery independent data available from the dredge survey in December covering the main fishing banks in area 2. The present use of data from the dredge survey in area 1 improves the quality of the assessment, but the newly established survey will be continued.

The model uses effort as basis for the calculation of F. The total international effort is derived from Danish CPUE and total international landings. Danish catches are by far the weightiest in the area, but effort by the individual countries would improve the quality of the assessment.

11.3.13 Status of the Stock

In spite of a low value of F (around 0.1) since 2007 and the strong 2009 year class, SSB in 2013 was below B_{pa}. This is the result of two subsequent extremely small year-classes (2010 and 2011).

11.3.14 Management Considerations

A management plan needs to be developed. The ICES approach for MSY based management of a short-lived species as sandeel is the so-called escapement strategy, i.e. to maintain SSB above MSY $B_{trigger}$ after the fishery has taken place. Taking the historical F and stock development into account an F value above 0.4-0.5 is probably not recommendable. Such F ceiling can be expressed as an effort ceiling for management usage as effort is assumed proportional to F.

11.4 Sandeel in Area-3

11.4.1 Catch data

Total catch weight by year for area 3 is given in Tables 4.1.2-4.1.4. Catch numbers at age by half-year is given in Table 4.4.1.

In 2011 the proportion of 2-group in the catch was around 70% (Figure 4.4.1). The same year-class were exploited in 2012 as 3-group, where it constituted ~60% of the catch (Figure 4.2.1). This proportion differed between the Norwegian EEZ and the remainder of area 3 as virtually all fish caught in the Norwegian EEZ were 3-group. The proportion of 0-groups in the catch has been very low since 2004.

11.4.2 Weight at age

The mean weights at age observed in the catch are given in Table 4.4.2 by half year. It is assumed that the mean weights in the sea are the same as in the catch. The time series of mean weight in the catch and in the stock is shown in Figure 4.4.2. The mean weights of age 4 have been very variable over the full time series.

11.4.3 Maturity

Maturity estimates from 2005 onwards are obtained from the Danish dredge survey as described in the stock annex.

For 1983 to 2004 the means of the period 2005-2011 are applied (Table 4.4.3).

11.4.4 Natural mortality

As described in the Stock Annex values of natural mortality are obtained from a multispecies model where predation mortality is estimated (ICES, 2008).

Text table: Values for natural mortality by age and half year used in the assessments.

Age	First half year	Second half year
0		0.96
1	0.46	0.58
2	0.44	0.42
3	0.31	0.37
4+	0.28	0.36

11.4.5 Effort and research vessel data

Trends in overall effort and CPUE

Tables 4.1.5-4.1.7 and Figure 4.4.3 show the trends in the international effort over years measured as number of fishing days standardised to a 200 GRT vessel. The standardisation includes just the effect of vessel size, and does not take changes in efficiency into account. Total international standardized effort peeked in 1998 (12176 days), and declined thereafter to less than 2000 days since 2005. CPUE has fluctuated without a clear trend over the full time series, with minimum CPUE in 2003.

In 2012 a decision was made to use Norwegian effort-data in (since there was no country-effect), but it was also decided not to update 2011.

Tuning series used in the assessments

No commercial tuning series are used in the present assessment.

In 2010, for the first time, a time series of stratified catch rates (Table 4.1.8) from the dredge survey was used to calibrate the assessment. This survey covers only the southern part of area 3.

The internal consistency, i.e. the ability of the survey to follow cohorts, was evaluated by plotting catch rates of an age group in a given year versus the catch rates of the next age group in the following year. The internal consistency plot (Figure 4.4.4) shows high consistency for both age 0 and age 1.

Details about the dredge survey and the consistency analysis are given in the Stock Annex and the benchmark report (WKSAN, 2010).

11.4.6 Explorative analysis using the Norwegian Acoustic Survey in assessment

The Norwegian Acoustic survey in NEZ has been conducted in April-May in five years (2007-2011) allowing a preliminary analysis of the potential use of this survey in the assessment in area 3. The survey design is stratified systematic with parallel or zig-zag transects. The starting position in each stratum is random. By using multifrequency acoustic, the sandeel schools are identified and the average nautical area scattering coefficient (NASC) classified as sandeel is calculated by stratum (Figure 4.1.5). Age, length and weight information is collected with pelagic and demersal trawls, dredges and for some surveys grabs. In addition, data from the commercial fishery has been included to estimate age-length keys and the weight-length function.

The number of sandeel in each length group within the surveyed area (A) is then computed as:

$$N_i = f_i \frac{NASC \cdot A}{\sigma}$$

where:

$$f_i = \frac{n_i L_i^2}{\sum_{i=1}^{m} n_i L_i^2}$$ **is the "acoustic contribution" from the length group L_i to the total energy.**

The target strength (TS) for 38 kHz is defined by: $TS = 20\log L - 93dB$

Where the conversion $\sigma = 4\pi 10^{TS/10}$ is used for estimating the backscattering cross section from the mean TS. From the age-length-key the number by age by stratum is calculated, and summed for all strata except Vikingbanken and Klondyke (Figure 4.1.5) which have had a very variable sampling effort between years. The acoustic estimate in number of individuals by age and survey is presented in Table 4.4.5.

The CV was generally low in the explorative assessment that included the acoustic index, indicating a good fit of the acoustic survey (Table 4.4.8). In the explorative run catchability was estimated separately for each age-class, which resulted in a catchability more than twice as high for age 2 compared to age 1 and age 4 (Table 4.4.8). Unless there is a good reason to expect this sort of age-specific catchability, it may be preferred to apply equal catchability among age-groups. The resulting explorative forecast resulted in a TAC of 90 000 t (12 000 more than in the valid assessment). Estimated recruitment and SSB over time is largely the same as in the valid assessment (Figure 4.4.18).

11.4.7 Data Analysis

The diagnostics output from SMS-effort model are shown in Table 4.4.12. The seasonal effect on the relation between effort and F ("F, Season effect" in the table) is quite different over the three year ranges used. One effort unit applied in the first half year in the period 1989-1998 produces more than twice the fishing mortality in the second half year (ratio between 1.235 and 0.500), presumably because of the higher catchability of fish in the first half of the year where the majority are present in the water column. The "age catchability" ("F, age effect" in the table) shows a change in the fishery: where the fishery was mainly targeting the age 2+ sandeel in the beginning of the period, it was mainly targeting age 1 and age 2 in the most recent years.

The CV of the dredge survey (Table 4.4.9) is medium (0.54) for age 0 and higher (0.82) for age 1, showing an overall medium consistency between the results from the dredge survey and the overall model results. This might be due to the southerly survey coverage of the stock area. The problem for age 1 seems to be increasing over time as indicated by the suite of high positive residuals from 2008-2011 (figure 4.4.8). The residual plot for age 0 (Figure 4.4.9) shows no clear bias for this relatively short time series.

The model CV of catch at age is high (0.50) for age 1 and age 2 in the first half of the year. For the older ages and for all ages in the second half year, the CVs are very high. The residual plots for catch at age (Figure 4.4.11) confirm that the fits is generally very poor except for age 1 and 2 in the first half year. There is a cluster of negative residuals (observed catch is less than model catch) for age 4+ in most recent years, but for age 1 – age 3 there is no obvious bias in first half year catches in most recent years.

The CV of the fitted Stock recruitment relationship (Table 4.4.10) is high (0.99) which is also indicated by the stock recruitment plot (Figure 4.4.12). The very high recruitment in 1996 is a clear outlier. The estimated recruitments in 2010 and 2011 are the lowest observed whereas that in 2012 is just above average of the last decade.

The retrospective analysis (Figure 4.4.13) shows very consistent assessment results from one year to the next. This is probably due to the assumed relationship between effort and F, which is rather insensitive to removal of a few years. However, it should be noted that the very short time series (2004-2012) of the dredge survey is actually too short to make a proper retrospective analysis.

Uncertainties of the estimated SSB, F and recruitment (Figure 4.4.14) are in general large, which gives wide confidence limits (Figure 4.4.15) on output variables.

The plot of standardised fishing effort and estimated F (Figure 4.4.16) show a clear relation between effort and F as specified by the model. As the model assumes a different catchability at age for the three periods 1983-1988, 1989-1998 and 1999-2012, and as the seasonal distribution of the fishery is variable from one year to the next, the relation between effort and F varies between these periods. There is a shift in the ratio between effort and F over the full time series. In the year range 1989-1998 F is in general lower than effort on the plot, while the opposite is the case for the remaining periods. This is probably due to fact that F presented on the graph is the mean F(age1-age2) while a substantial part of the effort in 1989-1998 has been use to target the 0-group sandeel in the second half year.

11.4.8 Final assessment

The output from the assessment is presented in Tables 4.4.11 (fishing mortality at age by half year), 4.4.12 (fishing mortality at age by year), 4.4.13 (stock numbers at age) and 4.4.14 (Stock summary).

11.4.9 Historic Stock Trends

The stock summary (Figure 4.4.17 and Table 4.4.17) shows that SSB have been at or below B_{lim} from 2001 to 2007 after which it has increased for two years and the decreased again. SSB in 2012 was estimated to be below B_{pa}, and below B_{lim} in 2013. $F_{(1-2)}$ is estimated to have been below the long time average since 2005. Recruitment seems to have been at a lower level since the very high recruitment in 1996.

11.4.10 Recruitment estimates

Based on the dredge survey December 2012 the recruitment is estimated to 126 billion which is the highest recruitment on record in the dredge survey giving the second highest estimated recruitment in the assessment since 1996(Table 4.4.14). This recruitment lies between the arithmetic and geometric long term mean in the area. It should be noted that the high recruitment estimate is largely due to very high catch rates on a single survey position located in the most western part of Area 3.

11.4.11 Short-term forecasts

Input

Input to the short term forecast is given in Table 4.4.15. Stock numbers in the TAC year are taken from the assessment for age 1 and older. Recruitment in the second half year is the geometric mean of the recruitment 1983-2011 (87 billion at age 0). The exploitation pattern and Fsq is taken from the assessment values in 2012. As the SMS-model assumes a fixed exploitation pattern since 1999, the choice of year is not critical for. Mean weight at age in the catch and in the sea is the average value for the years 2009-2011. Proportion mature in 2013 is given in table 4.4.3. For 2014 the long term average proportion mature is applied. Natural mortality is the fixed M applied in the assessment. The exploitation pattern for the 2nd half year was set to 0 because: (i) even in years where catches was roughly the same as the adviced for 2013, catches in 2nd half was minute. (ii) the few catches taken in 2nd half year is usually taken in the very beginning of the period and does therefore not represent the 2nd half year well anyway.

The Stock annex gives more details about the forecast methodology.

Output

The assessment indicates a TAC of 78 000 t (corresponding to F = 0.266).

11.4.12 Biological reference points

B_{lim} is set at 100 000 t and B_{pa} is estimated to 195 000 tons. B $MSY_{trigger}$ is set at B_{pa}. Further information about biological reference points can be found in the Stock Annex.

11.4.13 Quality of the assessment

In the assessments for the combined "North Sea sandeel stock" previously done by ICES, catches of sandeel in the Northern North Sea (mainly area 3 sandeel) have decreased far more than sandeel from the Southern North Sea (mainly area 1 sandeel). This heterogeneity is one of reason for the present assessments by area. While the quality (based on confidence limits of SSB and F) of the area 1 assessment is high the quality of the area 3 assessment is low. This is partly due to quality of input to the assessment. Norwegian effort data with the right resolution are only available for 2011 and 2012, and the relationship between Norwegian and Danish CPUEs cannot be estimated from data from area 3 alone due to the differences in regulations and the resulting lack of spatial overlap between the two fleets.

The dredge survey covers mainly the southern part of area 3. A northerly extension of the survey area will increase the quality of the survey results for assessment purpose. Both the dredge survey and the commercial catches show pronounced differences in age composition between the NEZ and the EU part of area 3 (Figures 4.4.18 and 4.4.19), and the extremely low recruitment in 2010 and 2011 seems to be derived primarily from the western part of area 3 .

Application of the new statistical assessment model SMS-effort resulted in no retrospective bias in F and SSB for the most recent years, in contrast to the assessment for the combined North Sea stock. This is probably due to the robust model assumption of fishing mortality being proportional to fishing effort. However, the difference in regulation (NEZ has been closed in some years and partially open in other) conflicts with the assumption of cohort models such as SMS.

In 2012, extremely high survey catch rates on a single position in the south-west corner of Area 3 caused the historically high 0-group survey index. This position is the only position in ICES statistical rectangle 42F3 and is therefore given a high weight in the index. There are reasons to be concerned when the survey index reflects a single position rather than the area as a whole.

11.4.14 Status of the Stock

The stock has increased from the record low SSB in 2004 at half of B_{lim} to above B_{pa} in 2010 and 2011. In 2012 SSB decreased again and is expected just below B_{lim} in 2013. Recruitment was at the long term mean in 2008 and 2009 and has been historically low in 2010 and 2011. In 2012 recruitment increased again to a level between the geometric and arithmetic long term mean. F has been below the long term mean since 2004, however highly variable between years.

11.4.15 Management Considerations

A management plan needs to be developed for area 3 sandeel. Area 3 comprises both Norwegian and EU EEZ and currently there is no agreement between the parties on management of the stock. The EU fishery has previously been part of the Real Time Monitoring system, while the Norwegian EEZ is managed based on a system of closed areas in combination with acoustic monitoring of the geographical distribution and size of the stock. Both approaches might be applicable in the future. Even though the new assessment for area 3 sandeel is considered uncertain, it is considered adequate as the basis for TAC advice.

The Danish dredge survey covers only the most southern part of area 3 in the North Sea. The Skagerrak area was covered for the first time in 2011, but the results will not be included in the dredge index until a longer time series exists. Extension of the area covered by the dredge survey index will probably decrease the assessment uncertainty. The Sandeel Benchmark group (WKSAN 2010) concluded that the dredge survey estimates of the incoming year class appear less robust for area 3. In 2012, extremely high survey catch rates on a single position in the south-west corner of Area 3 caused the historically high 0-group survey index. There are reasons to be concerned when the survey index reflects an outlying position rather than the area as a whole.

11.5 Sandeel in Area-4

11.5.1 Catch data

Total catch weight by year for area 4 is given in Tables 4.1.2-4.1.4.

Catch numbers at age by half-year is given in Table 4.5.1.

11.5.2 Weight at age

The methods applied to compile age-length-weight keys and mean weights at age in the catches and in the stock are described in the Stock Annex.

The mean weights at age observed in the catch are given in Table 4.5.2 by half year. It is assumed that the mean weights in the sea are the same as in the catch. The time series of mean weight in the catch and in the stock is shown in Figure 4.5.1. The mean weights of age 4 have been very variable over the full time series.

11.5.3 Effort and research vessel data

Trends in overall effort and CPUE

Tables 4.1.5-4.1.7 and Figure 4.5.2 show the trends in the international effort over years measured as number of fishing days standardised to a 200 GRT vessel. The standardisation includes just the effect of vessel size, and does not take changes in efficiency into account. The figure also shows the development in CPUE. In recent years, very low catches have been taken in the area and the uncertainty in the estimated mean CPUE has therefore increased as has the estimates of mean weight and catch at age.

Abundance indices

The Scottish sandeel survey of area 4, off the north east UK coast, was established in 1999. Dredge hauls encompassing the major Firth of Forth banks were taken at 8 stations in 1999 – 2003 and 2008-10; 3 stations on the Wee Bankie, 3 on Marr Bank and 2 on Berwick bank. Since 2008, the Turbot bank has also been surveyed with 2 stations in 2008 and 3 stations from 2009. The survey is undertaken in November-December to coincide with the Danish sampling (see the Stock Annex for more details).

The CPUE from the survey areas is presented in Table 4.5.3. As only sandeels ≥ 8.5 cm TL are fully selected by the gear and 0-group are typically below this length, age 1 catches are higher than age 0 for a given year class. Nevertheless, high catch rate at age 0 gave rise to high catches at age 1 and catch rates of age 1 and 2 were significantly correlated ($P < 0.05$, Figure 4.5.3). Based on the 3 years of data the temporal changes in 0-group abundance around Turbot Bank appeared to follow that in the Firth of Forth.

The 2011 year class was lower than the 2009 year class but slightly higher than that in 2008 (Table 4.5.3). High 0-group CPUE at one station on Berwick bank had a positive bias on the Firth of Forth estimate as exclusion of this station reduced 0-group CPUE from 119 to 33 sandeels per hour. Overall, the 2011 and 2012 year-class were weak and close to the lowest observed in all years surveyed, and lowest summed over two consecutive years.

To produce an analytical assessment for area 4, information on older age groups is needed. The low and variable catchability of older age classes in the dredge renders the assessments completely dependent on information on age distributions from the fishery. Past analyses have shown that stable estimates of catch per unit effort and mean weights at age could be achieved with less than 100 samples (see Real Time Monitoring advice 2010, ICES advice report section 6.3.3.1). Based on past average sandeel tons per haul (commercially around 55 t) and the fact that it would be preferable to sample no more than one every three hauls in order to reduce correlation, a monitoring catch obtaining a minimum of 30 samples would be of the order of 5 000 t. The low sandeel abundance in 2012 will likely mean that less than 55 tons may be obtained per haul and, hence, more than 30 samples could be obtained from 5 000 t of monitoring catch. This monitoring TAC should be taken as similar to previous year's fishery as possible and should over time result in an analytical assessment for area 4.

11.6 Sandeel in Area-5

11.6.1 Catch data

Total catch weight by year for area 5 is given in Tables 4.1.2-4.1.4.

11.7 Sandeel in Area-6

11.7.1 Catch data

Total catch weight by year for area 6 is given in Tables 4.1.2-4.1.4.

11.8 Sandeel in Area-7

11.8.1 Catch data

Total catch weight by year for area 7 is given in Tables 4.1.2-4.1.4

Table 4.1.1. SANDEEL in ICES div IV and IIIa. Landings ('000 t), 1955-2011. (Data provided by Working Group Members)

Year	Denmark	Germany	Faroes	Ireland	Netherlands	Norway	Sweden	UK	Lithuania	Total
1955	37.6	+	-	-	-	-	-	-	-	37.6
1956	81.9	5.3	-	-	+	1.5	-	-	-	88.7
1957	73.3	25.5	-	-	3.7	3.2	-	-	-	105.7
1958	74.4	20.2	-	-	1.5	4.8	-	-	-	100.9
1959	77.1	17.4	-	-	5.1	8.0	-	-	-	107.6
1960	100.8	7.7	-	-	+	12.1	-	-	-	120.6
1961	73.6	4.5	-	-	+	5.1	-	-	-	83.2
1962	97.4	1.4	-	-	-	10.5	-	-	-	109.3
1963	134.4	16.4	-	-	-	11.5	-	-	-	162.3
1964	104.7	12.9	-	-	-	10.4	-	-	-	128.0
1965	123.6	2.1	-	-	-	4.9	-	-	-	130.6
1966	138.5	4.4	-	-	-	0.2	-	-	-	143.1
1967	187.4	0.3	-	-	-	1.0	-	-	-	188.7
1968	193.6	+	-	-	-	0.1	-	-	-	193.7
1969	112.8	+	-	-	-	-	-	0.5	-	113.3
1970	187.8	+	-	-	-	+	-	3.6	-	191.4
1971	371.6	0.1	-	-	-	2.1	-	8.3	-	382.1
1972	329.0	+	-	-	-	18.6	8.8	2.1	-	358.5
1973	282.9	-	1.4	-	-	17.2	1.1	4.2	-	306.8
1974	432.0	-	6.4	-	-	78.6	0.2	15.5	-	532.7
1975	372.0	-	4.9	-	-	54.0	0.2	13.6	-	444.7
1976	446.1	-	-	-	-	44.2	0.1	18.7	-	509.1
1977	680.4	-	11.4	-	-	78.7	6.1	25.5	-	802.1
1978	669.2	-	12.1	-	-	93.5	2.3	32.5	-	809.7
1979	483.1	-	13.2	-	-	101.4	-	13.4	-	611.1
1980	581.6	-	7.2	-	-	144.8	-	34.3	-	767.9
1981	523.8	-	4.9	-	-	52.6	-	46.7	-	628.1
1982	528.4	-	4.9	-	-	46.5	0.4	52.2	-	632.4
1983	515.2	-	2.0	-	-	12.2	0.2	37.0	-	566.8
1984	618.9	-	11.3	-	-	28.3	-	32.6	-	691.1
1985	601.7	-	3.9	-	-	13.1	-	17.2	-	635.9
1986	832.7	-	1.2	-	-	82.1	-	12.0	-	928.0
1987	609.2	-	18.6	-	-	193.4	-	7.2	-	828.4
1988	708.8	-	15.5	-	-	185.1	-	5.8	-	915.3
1989	841.6	-	16.6	-	-	186.8	-	11.5	-	1056.3
1990	512.1	-	2.2	-	0.3	88.9	-	3.9	-	607.5
1991	726.5	-	11.2	-	-	128.8	-	1.2	-	867.7
1992	803.7	-	9.1	-	-	89.3	0.6	4.9	-	907.6
1993	533.4	-	0.3	-	-	95.5	-	1.5	-	630.8
1994	688.6	-	10.3	-	-	165.8	-	5.9	-	870.7
1995	672.6	-	-	-	-	263.4	-	6.7	-	942.8
1996	649.5	-	5.0	-	-	160.7	-	9.7	-	824.8
1997	831.8	-	11.2	-	-	350.1	-	24.6	-	1217.8
1998	628.2	-	11.0	-	+	343.3	8.6	23.8	-	1014.8
1999	511.3	-	13.2	0.4	+	187.6	23.2	11.5	-	747.1

2000	557.3	-	-	-	+	119.0	28.6	10.8	-	715.7
2001	650.0	-	-	-	-	183.0	50.0	1.3	-	884.3
2002	659.5	-	-	-	-	176.0	19.2	4.9	-	859.6
2003	282.8	-	-	-	-	29.6	21.8	0.5	-	334.7
2004	288.8	2.7	-	-	-	48.5	33.3	+	-	373.3
2005	158.9	-	-	-	-	17.3	0.5	-	-	176.6
2006	255.4	3.2	-	-	-	5.6	27.9	-	-	292.8
2007	166.9	1.0	2.0	-	-	51.1	7.9	1.0	-	229.9
2008	246.9	4.4	2.4	-	-	81.6	12.5	-	-	347.8
2009	293.0	12.2	2.5	-	1.8	27.4	12.4	3.6	2.0	352.9
2010	285.9	13.0	-	-	-	78.0	32.7	4.0	0.6	414.2
2011	278.5	9.8	-	-	-	109.0	32.7	6.1	1.7	437.8
2012	51.4	1.7	-	-	-	42.5	5.7	-	-	101.3

+ = less than half unit.

- = no information or no catch.

Table 4.1.2. Total catch (tonnes) by area as estimated by ICES

Year	Area 1	Area 2	Area 3	Area 4	Area 5	Area 6	Area 7	All
1983	377558	80482	105974	2796	0	0	0	566810
1984	491950	66352	123639	2570	6587	0	0	691098
1985	436214	99428	59090	38123	3004	0	0	635858
1986	389081	94604	420304	12706	11277	0	0	927973
1987	360867	53761	403897	8179	1713	0	0	828417
1988	401551	121394	391050	1335	0	0	0	915330
1989	445586	109691	492395	4384	3353	909	0	1056318
1990	283259	100960	219103	3314	374	499	0	607508
1991	346621	107663	368324	41372	3697	17	0	867694
1992	564285	69848	195733	68905	4554	4277	0	907600
1993	136538	59820	296118	133136	666	4490	0	630768
1994	209631	50648	444084	159789	2765	3748	0	870666
1995	410687	60143	266720	52759	150637	1830	0	942776
1996	324561	80205	250252	162338	6176	1263	0	824796
1997	431871	102730	608164	59353	11279	2373	2068	1217839
1998	371060	68950	507269	58460	2984	936	5182	1014841
1999	456162	34205	242315	14251	149	0	0	747083
2000	378960	55212	267253	13904	339	0	0	715667
2001	548664	61673	265245	6837	1774	67	0	884260
2002	607709	36035	212704	1963	10	1184	0	859604
2003	184734	68963	75244	5273	54	450	0	334718
2004	210029	72582	88933	1188	0	570	0	373302
2005	104510	41740	29847	280	0	262	0	176640
2006	238343	35399	18870	29	0	161	0	292802
2007	109369	5911	114572	0	4	0	0	229855
2008	238493	13069	95072	1201	0	0	0	347836
2009	308725	10181	34015	0	0	0	0	352922
2010	301433	31760	80887	104	0	0	0	414183
2011	312378	29916	94714	272	0	481	0	437761
2012	44713	8048	45734	2551	0	210	0	101256
arith. mean	334185	61046	227251	28579	7047	791	242	659139

Table 4.1.3. Total catch (tonnes) by area, first half year as estimated by ICES

Year	Area 1	Area 2	Area 3	Area 4	Area 5	Area 6	Area 7	All
1983	313567	65008	64173	2796	0	0	0	445544
1984	412200	47036	93138	2570	6587	0	0	561531
1985	365080	73442	33030	37901	3004	0	0	512457
1986	353390	71597	245682	12527	7940	0	0	691135
1987	305160	34380	399843	7857	1713	0	0	748953
1988	371971	105426	314622	1254	0	0	0	793273
1989	432962	100439	447387	4382	2037	897	0	988104
1990	257861	96519	138394	2926	0	485	0	496185
1991	267842	69370	290017	17140	3697	17	0	648083
1992	520040	56893	163533	67068	4554	4270	0	816357
1993	119220	43201	209146	123143	252	4393	0	499354
1994	190869	23473	388488	148007	2763	3222	0	756821
1995	372896	25371	242186	52665	150632	1829	0	845578
1996	289986	58639	102168	45209	1827	1168	0	498997
1997	349671	52649	514991	48410	9021	2194	1654	978590
1998	353605	42984	382308	56934	2881	935	4525	844172
1999	419485	24509	109949	13544	149	0	0	567637
2000	336746	38793	258133	13904	323	0	0	647899
2001	374869	35257	91012	6715	1774	67	0	509694
2002	603401	21188	211833	1963	10	1184	0	839579
2003	157817	57142	34354	4974	54	450	0	254792
2004	194154	54047	69126	1166	0	569	0	319061
2005	101390	32270	28738	280	0	262	0	162941
2006	234007	22058	15813	0	0	160	0	272038
2007	109363	5910	114572	0	4	0	0	229849
2008	235100	9755	94745	1201	0	0	0	340801
2009	290948	9817	22575	0	0	0	0	323340
2010	297507	22605	78181	104	0	0	0	398398
2011	309466	28343	94708	272	0	481	0	433270
2012	44713	8048	44595	2551	0	210	0	100117
arith. mean	299510	44539	176581	22582	6641	760	206	550818

Table 4.1.4. Total catch (tonnes) by area, second half year as estimated by ICES

Year	Area 1	Area 2	Area 3	Area 4	Area 5	Area 6	Area 7	All
1983	63991	15474	41801	0	0	0	0	121266
1984	79750	19317	30501	0	0	0	0	129567
1985	71133	25986	26060	222	0	0	0	123401
1986	35691	23007	174623	179	3337	0	0	236838
1987	55707	19382	4053	322	0	0	0	79464
1988	29580	15968	76428	81	0	0	0	122057
1989	12624	9251	45008	2	1316	12	0	68214
1990	25397	4440	80709	388	374	14	0	111323
1991	78779	38293	78307	24232	0	0	0	219611
1992	44245	12954	32200	1837	0	6	0	91243
1993	17317	16619	86972	9993	414	97	0	131414
1994	18762	27175	55596	11783	3	526	0	113845
1995	37791	34773	24534	94	5	1	0	97198
1996	34575	21566	148084	117129	4349	95	0	325799
1997	82201	50082	93173	10943	2258	179	414	239249
1998	17455	25966	124961	1526	102	1	657	170669
1999	36677	9696	132366	706	0	0	0	179446
2000	42213	16419	9120	0	16	0	0	67768
2001	173795	26416	174233	122	0	0	0	374566
2002	4308	14846	871	0	0	0	0	20025
2003	26917	11821	40890	299	0	0	0	79926
2004	15876	18535	19807	22	0	2	0	54241
2005	3120	9470	1109	0	0	0	0	13699
2006	4336	13341	3057	29	0	0	0	20764
2007	6	0	0	0	0	0	0	6
2008	3394	3314	328	0	0	0	0	7035
2009	17778	364	11440	0	0	0	0	29582
2010	3925	9154	2705	0	0	0	0	15785
2011	2912	1573	6	0	0	0	0	4491
2012	0	0	1139	0	0	0	0	1139
arith. mean	34675	16507	50669	5997	406	31	36	108321

Table 4.1.5. Effort (days fishing for a standard 200 GT vessel) as estimated by ICES

Year	Area 1	Area 2	Area 3	Area 4	All
1983	8944	2257	3391	64	14656
1984	10129	1947	3579	48	15703
1985	10173	3240	2136	652	16200
1986	7435	1968	7516	283	17203
1987	5406	1143	5333	176	12058
1988	7522	2908	9384	41	19855
1989	8564	2843	11889	56	23351
1990	7856	3032	7081	51	18020
1991	6393	2213	8209	343	17158
1992	9065	1619	5011	570	16265
1993	3667	1711	8121	1327	14826
1994	3423	895	7628	1597	13543
1995	6013	1205	4977	423	12618
1996	6130	1761	6394	1453	15738
1997	5567	2245	10988	646	19447
1998	6729	1862	12176	623	21390
1999	9175	964	7121	213	17472
2000	7173	1330	5749	150	14403
2001	11091	1617	6286	96	19090
2002	8181	1203	4279	22	13684
2003	7582	2495	3356	100	13533
2004	7097	2432	3191	38	12758
2005	2926	1119	909	16	4970
2006	4315	1015	567	0	5896
2007	1777	136	2074	0	3987
2008	2974	311	1837	8	5130
2009	4181	233	660	0	5074
2010	2992	540	2142	1	5674
2011	3495	761	1826	16	6098
2012	626	260	786	74	1746
arith. mean	6220	1576	5153	303	13251

Table 4.1.6. Effort (days fishing for a standard 200 GT vessel) first half year as estimated by ICES

Year	Area 1	Area 2	Area 3	Area 4	All
1983	6914	1838	2400	64	11217
1984	7848	1154	2564	48	11615
1985	8135	2373	1259	648	12416
1986	6653	1352	4714	280	13000
1987	4254	630	5201	161	10246
1988	6684	2472	7071	39	16266
1989	8175	2584	10283	56	21098
1990	7226	2927	4841	46	15040
1991	4863	1348	6558	112	12882
1992	8000	1317	4245	308	13871
1993	3194	1232	5407	1154	10987
1994	3056	408	6585	1417	11467
1995	5362	572	4467	422	10822
1996	5445	1148	2816	469	9877
1997	4127	898	8371	509	13905
1998	6205	957	7934	587	15683
1999	8033	685	3220	213	12150
2000	6217	819	5517	150	12704
2001	8091	953	2501	92	11638
2002	8000	583	4215	22	12820
2003	6555	1920	1801	85	10361
2004	6642	1702	2395	36	10774
2005	2880	827	876	16	4599
2006	4185	625	500	0	5310
2007	1777	136	2074	0	3987
2008	2894	213	1817	8	4933
2009	3965	226	484	0	4675
2010	2883	352	2063	1	5300
2011	3419	680	681	16	4796
2012	626	260	764	74	1723
arith. mean	5410	1106	3787	234	10539

Table 4.1.7. Effort (days fishing for a standard 200 GT vessel) second half year as estimated by ICES

Year	Area 1	Area 2	Area 3	Area 4	All
1983	2029	419	991	0	3439
1984	2280	793	1015	0	4088
1985	2038	867	877	3	3784
1986	782	616	2802	3	4203
1987	1152	513	132	16	1812
1988	838	436	2313	2	3589
1989	388	260	1606	0	2254
1990	630	105	2240	5	2980
1991	1529	865	1651	231	4276
1992	1064	302	766	262	2394
1993	473	479	2714	172	3839
1994	367	487	1043	179	2076
1995	651	634	510	1	1797
1996	685	614	3578	984	5860
1997	1441	1347	2617	138	5542
1998	524	905	4242	36	5707
1999	1141	279	3901	0	5321
2000	956	511	232	0	1699
2001	3000	664	3785	4	7452
2002	181	619	64	0	864
2003	1027	575	1554	15	3172
2004	456	730	797	2	1984
2005	46	292	34	0	371
2006	129	390	67	0	587
2007	0	0	0	0	0
2008	79	98	20	0	197
2009	216	6	176	0	399
2010	108	188	78	0	374
2011	36	82	0	0	118
2012	0	0	23	0	23
arith. mean	808	469	1327	68	2673

Table 4.2.1. Area-1 Sandeel. Catch at age numbers (millions) by half year

Year/Age	Age 0, 2nd half	Age 1, 1st half	Age 1, 2nd half	Age 2, 1st half	Age 2, 2nd half	Age 3, 1st half	Age 3, 2nd half	Age 4+, 1st half	Age 4+, 2nd half
1983	9012	2254	237	26355	2634	709	480	291	2
1984	0	44054	8817	1641	90	9256	539	308	41
1985	6877	5867	1109	29368	1904	1878	1294	208	172
1986	173	45239	3875	7522	213	1624	170	30	13
1987	159	4499	1656	23174	3455	1178	102	168	26
1988	683	1908	66	8090	168	14127	1342	2183	44
1989	194	62021	913	6238	85	1382	15	4607	52
1990	1397	15548	1331	12325	426	1824	63	551	19
1991	8672	16388	6836	6837	206	1002	66	345	0
1992	1451	50586	3022	8649	295	873	121	542	26
1993	1958	2055	439	5623	312	1464	178	440	52
1994	0	24171	1885	2841	137	1283	56	970	100
1995	22	37430	3776	6355	1002	747	117	293	28
1996	5097	12531	1271	14658	1232	4965	239	954	76
1997	0	38993	8912	2388	176	3641	168	726	56
1998	251	9627	465	28301	1228	2143	124	1470	70
1999	1135	45248	2880	5481	231	10130	805	613	162
2000	8399	32806	2773	3242	148	467	54	681	78
2001	59325	56332	2993	8182	414	1050	41	828	69
2002	16	83678	490	10574	89	1177	13	214	3
2003	2575	3729	412	11456	4351	852	113	210	24
2004	608	30373	2613	677	100	2224	229	453	48
2005	53	9902	326	3337	139	143	5	222	11
2006	42	32935	656	2447	64	750	28	142	12
2007	0	10429	1	4666	0	311	0	171	0
2008	8	27196	267	4057	61	1213	23	217	5
2009	1075	19242	2471	14088	313	1546	14	393	4
2010	11	40643	541	2158	18	957	1	110	0
2011	5	1745	39	32327	325	1101	14	232	1
2012	0	372	0	407	0	3266	0	124	0
arith. mean	3640	25593	2036	9782	661	2443	214	623	40

Table 4.2.2. Area-1 Sandeel. Individual mean weight(g) at age in the catch and in the sea

Year/Age	Age 0, 2nd half	Age 1, 1st half	Age 1, 2nd half	Age 2, 1st half	Age 2, 2nd half	Age 3, 1st half	Age 3, 2nd half	Age 4+, 1st half	Age 4+, 2nd half
1983	2.4	5.5	7.8	10.0	10.8	13.9	14.2	17.0	17.7
1984	3.4	5.5	7.5	10.1	11.6	13.8	14.2	17.0	17.7
1985	2.4	5.5	7.7	10.0	11.4	13.9	14.6	17.9	19.3
1986	2.8	5.5	7.6	10.0	11.2	13.8	14.1	16.3	18.8
1987	1.3	5.8	9.0	11.0	10.8	15.6	21.4	18.1	19.8
1988	3.0	4.0	13.2	12.5	15.5	15.5	17.1	18.7	19.6
1989	5.0	4.0	10.1	12.5	14.4	15.5	17.0	18.0	19.0
1990	2.3	4.1	10.8	12.5	14.8	15.8	18.1	19.9	21.5
1991	2.7	8.1	7.5	16.4	13.6	17.1	12.1	17.7	44.0
1992	5.3	7.4	9.5	13.7	16.6	17.6	20.0	23.0	22.6
1993	4.1	7.2	7.1	11.1	9.5	14.0	12.9	20.0	17.6
1994	3.5	5.4	7.7	8.4	11.7	12.5	14.6	19.9	18.6
1995	2.4	7.6	6.8	11.3	9.9	14.0	14.0	19.0	18.7
1996	3.1	5.5	4.8	8.2	7.6	11.7	9.5	17.7	15.3
1997	3.2	7.3	8.5	8.2	14.4	9.9	15.5	14.4	16.2
1998	2.8	6.3	6.1	8.8	9.3	11.4	11.6	13.3	14.8
1999	2.8	5.3	6.1	7.5	9.2	10.2	11.5	12.2	14.7
2000	2.6	6.2	5.7	8.4	8.6	10.5	10.7	12.4	13.7
2001	2.5	4.5	3.8	8.5	9.0	11.3	12.3	15.9	17.8
2002	2.9	6.0	6.4	7.4	9.7	9.8	12.1	13.7	15.5
2003	2.1	3.5	2.5	6.8	3.3	8.3	7.5	10.4	7.0
2004	3.4	5.0	4.3	7.8	5.9	8.6	6.0	10.0	8.1
2005	2.4	6.5	5.2	8.9	7.8	10.4	9.8	11.5	12.5
2006	2.3	5.9	5.1	9.7	7.7	11.7	9.6	13.0	12.3
2007	2.3	5.5	5.1	9.4	7.7	13.5	9.6	14.7	12.2
2008	3.7	6.3	8.1	10.8	12.3	13.3	15.4	15.8	19.6
2009	2.4	6.1	5.1	9.4	7.8	12.0	9.7	13.1	12.4
2010	3.2	6.3	6.8	12.3	10.3	13.8	12.9	17.1	16.4
2011	2.5	5.1	5.2	8.7	7.8	13.2	9.8	15.4	12.5
2012	3.5	6.4	7.5	9.5	11.3	11.2	14.2	14.5	18.1
arith. mean	3.0	5.8	7.0	10.0	10.4	12.8	13.1	15.9	17.1

Table 4.2.3. Sandeel in Area-1. Proportion mature.

Year/Age	Age 1	Age 2	Age 3	Age 4
1983-2004	0.02	0.83	1.00	1.00
2005	0.06	0.98	1.00	1.00
2006	0.01	0.90	1.00	1.00
2007	0.01	0.94	1.00	1.00
2008	0.02	0.97	1.00	1.00
2009	0.00	0.61	1.00	1.00
2010	0.01	0.56	1.00	1.00
2011	0.00	0.58	1.00	1.00
2012	0.03	0.77	0.98	1.00
2013	0.01	0.85	1.00	1.00

Table 4.2.4. Sandeel in Area-1. Dredge survey CPUE (number / hour)

		Age		
Area	Year	0	1	2
1	2004	931	171	7
	2005	2266	53	10
	2006	1481	236	7
	2007	3443	95	29
	2008	429	345	31
	2009	3733	92	34
	2010	424	1959	142
	2011	652	872	581
	2012	2067	215	25

Table 4.2.5. Area-1 Sandeel. SMS settings and statistics.

objective function (negative log likelihood): 32.8626
Number of parameters: 55
Maximum gradient: 8.9394e-005
Akaike information criterion (AIC): 175.725
Number of observations used in the likelihood:

Catch	CPUE	S/R	Stomach	Sum
300	18	27	0	345

objective function weight:

Catch	CPUE	S/R
1.00	1.00	0.01

unweighted objective function contributions (total):

Catch	CPUE	S/R	Stom.	Penalty	Sum
28.8	4.0	6.9	0.0	0.00e+000	39.7

unweighted objective function contributions (per observation):

Catch	CPUE	S/R	Stomachs
0.10	0.22	0.23	0.00

contribution by fleet:

Dredge survey 2004-2012 total: 3.984 mean: 0.221

F, season effect:
----
age: 0
1983-1988: 0.000 1.000
1989-1998: 0.000 1.000
1999-2012: 0.000 1.000
age: 1 - 4
1983-1988: 0.501 0.500
1989-1998: 0.469 0.500
1999-2012: 0.405 0.500

F, age effect:

	0	1	2	3	4
1983-1988:	0.026	0.279	1.206	1.990	1.990
1989-1998:	0.053	0.829	1.300	1.431	1.431
1999-2012:	0.055	1.641	2.183	1.535	1.535

Exploitation pattern (scaled to mean F=1)

		0	1	2	3	4
1983-1988	season 1:	0.000	0.290	1.257	2.074	2.074
	season 2:	0.016	0.085	0.368	0.607	0.607
1989-1998	season 1:	0.000	0.741	1.162	1.279	1.279
	season 2:	0.005	0.038	0.059	0.065	0.065
1999-2012	season 1:	0.000	0.730	0.971	0.683	0.683
	season 2:	0.009	0.128	0.170	0.120	0.120

Table 4.2.6 (continued). Area-1 Sandeel. SMS settings and statistics
sqrt(catch variance) ~ CV:
----

	season	
age	1	2
0		1.061
1	0.301	0.701
2	0.301	0.701
3	0.687	1.285
4	0.687	1.285

Survey catchability:

--------------------	age 0	age 1
Dredge survey 2004-2012	2.264	1.779

sqrt(Survey variance) ~ CV:

---------------------------	age 0	age 1
Dredge survey 2004-2012	0.49	1.16

Recruit-SSB		alfa	beta	recruit s2	s
Area-1	Hockey stick -break.:	1440.507	1.600e+005	0.615	0.784

Table 4.2.7. Area-1 Sandeel. Fishing mortality at age

Year/Age	Age 0, 2nd half	Age 1, 1st half	Age 1, 2nd half	Age 2, 1st half	Age 2, 2nd half	Age 3, 1st half	Age 3, 2nd half	Age 4+, 1st half	Age 4+, 2nd half
1983	0.009	0.158	0.046	0.683	0.200	1.128	0.330	1.128	0.330
1984	0.010	0.179	0.052	0.776	0.225	1.280	0.371	1.280	0.371
1985	0.009	0.186	0.046	0.804	0.201	1.327	0.332	1.327	0.332
1986	0.003	0.152	0.018	0.657	0.077	1.085	0.127	1.085	0.127
1987	0.005	0.097	0.026	0.420	0.114	0.694	0.187	0.694	0.187
1988	0.004	0.153	0.019	0.660	0.083	1.090	0.136	1.090	0.136
1989	0.003	0.519	0.026	0.814	0.041	0.896	0.045	0.896	0.045
1990	0.005	0.459	0.043	0.720	0.067	0.792	0.074	0.792	0.074
1991	0.013	0.309	0.104	0.484	0.162	0.533	0.179	0.533	0.179
1992	0.009	0.508	0.072	0.797	0.113	0.877	0.124	0.877	0.124
1993	0.004	0.203	0.032	0.318	0.050	0.350	0.055	0.350	0.055
1994	0.003	0.194	0.025	0.304	0.039	0.335	0.043	0.335	0.043
1995	0.006	0.340	0.044	0.534	0.069	0.588	0.076	0.588	0.076
1996	0.006	0.346	0.046	0.542	0.073	0.597	0.080	0.597	0.080
1997	0.013	0.262	0.098	0.411	0.153	0.452	0.169	0.452	0.169
1998	0.005	0.394	0.036	0.618	0.056	0.680	0.061	0.680	0.061
1999	0.010	0.819	0.144	1.090	0.191	0.766	0.134	0.766	0.134
2000	0.008	0.647	0.123	0.862	0.164	0.606	0.115	0.606	0.115
2001	0.026	0.836	0.383	1.112	0.509	0.782	0.358	0.782	0.358
2002	0.002	0.857	0.024	1.141	0.032	0.802	0.022	0.802	0.022
2003	0.007	0.581	0.112	0.773	0.150	0.543	0.105	0.543	0.105
2004	0.004	0.710	0.060	0.945	0.080	0.664	0.056	0.664	0.056
2005	0.000	0.311	0.006	0.413	0.008	0.291	0.006	0.291	0.006
2006	0.001	0.454	0.017	0.605	0.023	0.425	0.016	0.425	0.016
2007	0.000	0.193	0.000	0.257	0.000	0.180	0.000	0.180	0.000
2008	0.001	0.314	0.011	0.418	0.014	0.294	0.010	0.294	0.010
2009	0.002	0.432	0.030	0.574	0.040	0.404	0.028	0.404	0.028
2010	0.001	0.297	0.014	0.395	0.019	0.278	0.013	0.278	0.013
2011	0.001	0.382	0.010	0.508	0.014	0.357	0.010	0.357	0.010
2012	0.000	0.068	0.000	0.090	0.000	0.064	0.000	0.064	0.000
arith. mean	0.006	0.379	0.056	0.624	0.099	0.639	0.109	0.639	0.109

Table 4.2.8. Area-1 : Annual Fishing mortality (F) at age

Year/Age	Age 0	Age 1	Age 2	Age 3	Age 4	Avg. 1-2
1983	0.009	0.238	0.970	1.586	1.586	0.604
1984	0.010	0.270	1.097	1.792	1.793	0.683
1985	0.009	0.274	1.110	1.810	1.809	0.692
1986	0.003	0.208	0.839	1.359	1.357	0.524
1987	0.005	0.145	0.592	0.969	0.969	0.368
1988	0.004	0.210	0.847	1.373	1.371	0.529
1989	0.003	0.675	0.990	1.074	1.072	0.832
1990	0.005	0.614	0.903	0.982	0.980	0.758
1991	0.013	0.474	0.706	0.777	0.777	0.590
1992	0.009	0.698	1.029	1.122	1.121	0.864
1993	0.004	0.284	0.420	0.458	0.458	0.352
1994	0.003	0.267	0.395	0.430	0.429	0.331
1995	0.006	0.467	0.689	0.751	0.750	0.578
1996	0.006	0.476	0.702	0.765	0.763	0.589
1997	0.013	0.411	0.612	0.674	0.675	0.512
1998	0.005	0.527	0.776	0.843	0.842	0.651
1999	0.010	1.136	1.430	1.006	1.005	1.283
2000	0.008	0.910	1.146	0.805	0.805	1.028
2001	0.026	1.351	1.719	1.219	1.220	1.535
2002	0.002	1.083	1.353	0.948	0.946	1.218
2003	0.007	0.820	1.032	0.725	0.724	0.926
2004	0.004	0.936	1.172	0.821	0.819	1.054
2005	0.000	0.400	0.498	0.346	0.345	0.449
2006	0.001	0.588	0.734	0.511	0.510	0.661
2007	0.000	0.246	0.307	0.213	0.212	0.277
2008	0.001	0.408	0.509	0.354	0.353	0.459
2009	0.002	0.570	0.712	0.497	0.496	0.641
2010	0.001	0.389	0.485	0.338	0.337	0.437
2011	0.001	0.492	0.614	0.427	0.426	0.553
2012	0.000	0.087	0.109	0.075	0.075	0.098
arith. mean	0.006	0.522	0.817	0.835	0.834	0.669

Table 4.2.9. Area-1 : Stock numbers (millions). Age 0 at start of 2nd half-year, age 1+ at start of 1st half-year

Year/Age	Age 0	Age 1	Age 2	Age 3	Age 4
1983	602486	16801	54894	2615	274
1984	147000	228677	4842	9605	342
1985	957303	55734	64151	754	968
1986	150338	363337	15619	9940	170
1987	72948	57370	108380	3171	1525
1988	365047	27793	17925	26890	999
1989	175015	139270	8274	3608	4151
1990	243967	66786	28532	1489	1567
1991	326782	92901	14296	5499	665
1992	75106	123464	21740	3169	1539
1993	316001	28492	24432	3704	888
1994	463747	120496	7963	7153	1563
1995	109805	176998	34216	2390	3049
1996	699089	41806	42587	7922	1451
1997	105526	266081	9983	9743	2428
1998	178080	39900	65636	2403	3341
1999	237244	67874	9179	14162	1420
2000	399318	89972	9158	1078	3218
2001	549783	151648	14718	1390	1091
2002	29034	205207	15852	1231	409
2003	217960	11099	30046	2076	368
2004	95590	82832	1961	5054	651
2005	233050	36454	13554	298	1413
2006	127247	89197	9388	3763	666
2007	276914	48666	19670	2120	1452
2008	110348	106028	14184	6439	1536
2009	687532	42222	27077	3894	3004
2010	36157	262720	9404	6197	2309
2011	26236	13831	68054	2631	3258
2012	210933	10039	3303	17090	2114
2013		80765	3315	1277	9171

Table 4.2.10. Area-1 : Estimated recruitment, total stock biomass (TBS), spawning stock biomass (SSB), landings weight (Yield) and average fishing mortality.

Year	Recruits (million)	TSB (tonnes)	SSB (tonnes)	Yield (tonnes)	Mean F ages 1-2
1983	602486	681403	497144	349232	0.604
1984	147000	1446740	203620	467609	0.683
1985	957303	974484	564799	424114	0.692
1986	150338	2298820	310271	382735	0.524
1987	72948	1602040	1073280	357671	0.368
1988	365047	772564	624134	398271	0.529
1989	175015	796975	227983	445695	0.832
1990	243967	685399	356375	283040	0.758
1991	326782	1094250	315199	347096	0.590
1992	75106	1301130	356380	564298	0.864
1993	316001	547638	299495	124082	0.352
1994	463747	843051	189224	209538	0.331
1995	109805	1825020	439279	410513	0.578
1996	699089	697562	413201	298702	0.589
1997	105526	2148000	238310	431808	0.512
1998	178080	900726	556191	371117	0.651
1999	237244	592612	226405	427691	1.283
2000	399318	686254	126441	284521	1.028
2001	549783	840106	150147	513068	1.535
2002	29034	1358570	139953	596049	1.218
2003	217960	263365	190716	121863	0.926
2004	95590	476245	71012	195274	1.054
2005	233050	375532	151417	100835	0.449
2006	127247	665921	140201	231448	0.661
2007	276914	505488	226964	108600	0.277
2008	110348	928440	272326	237447	0.459
2009	687532	598077	240522	291247	0.641
2010	36157	1891420	206943	300954	0.437
2011	26236	748306	428674	311542	0.553
2012	210933	317199	244155	44594	0.098
2013			186297*		
arith. Mean**	274186	962111	311841	321022	0.669
geo. mean	190942				

***Using weights from 2012**

****Period 1983-2012**

Table 4.2.11. Sandeel in Area-1. Input values for preliminary short term forecast

Age	Age 0	Age 1	Age 2	Age 3	Age 4
Stock numbers(2013)	190942	80765	3315	1277	9171
Exploitation pattern 1st half		0.068	0.090	0.064	0.064
Exploitation pattern 2nd half	0.000	0.000	0.000	0.000	0.000
Weight in the stock 1st half		5.92	10.17	12.76	15.66
Weight in the catch 1st half		5.92	10.17	12.76	15.66
weight in the catch 2nd half	3.06	6.51	9.81	12.30	15.66
Proportion mature(2013)	0.00	0.01	0.85	1.00	1.00
Proportion mature(2014)	0.00	0.02	0.83	1.00	1.00
Natural mortality 1st half		0.46	0.44	0.31	0.28
Natural mortality 2nd half	0.96	0.58	0.42	0.37	0.36

Table 4.2.12. Sandeel in Area-1. Forecast for 2013 for various levels of F.

Basis: Fsq=F(2012)=0.078; Yield(2012)=45; Recruitment(2012)=211; Recruitment(2013)= geometric mean (GM 83-11) = 191 billion;SSB(2013)=193						
F multiplier	Basis	F(2013)	Landings(2013)	SSB(2014)	%SSB change*	%TAC change**
0	F=0	0	0	353	83%	-100%
0.25	Fsq*0.25	0.02	9	348	80%	-79%
0.5	Fsq*0.5	0.04	18	342	77%	-59%
0.75	Fsq*0.75	0.059	27	336	74%	-39%
1	Fsq*1	0.079	36	331	71%	-19%
1.25	Fsq*1.25	0.099	45	325	68%	1%
1.5	Fsq*1.5	0.119	53	320	66%	20%
1.75	Fsq*1.75	0.139	62	315	63%	39%
2	Fsq*2	0.158	70	310	60%	57%
7.554	MSY	0.599	225	215	11%	404%

***SSB in 2014 relative to SSB in 2013**

**** TAC in 2013relative to landings in 2012**

Table 4.3.1. Area-2 Sandeel. Catch at age numbers (millions) by half year

Year/Age	Age 0, 2nd half	Age 1, 1st half	Age 1, 2nd half	Age 2, 1st half	Age 2, 2nd half	Age 3, 1st half	Age 3, 2nd half	Age 4+, 1st half	Age 4+, 2nd half
1983	2237	444	61	5479	602	147	109	61	0
1984	0	5041	2127	200	22	1036	130	35	10
1985	2600	1187	414	5867	707	381	487	45	65
1986	210	9208	2391	1484	133	308	100	6	7
1987	55	508	576	2610	1202	133	35	19	9
1988	155	550	15	2313	92	3986	783	616	26
1989	127	14306	669	1400	63	342	11	1016	39
1990	351	5749	206	4667	63	691	9	209	3
1991	4208	4562	3327	1650	100	251	32	87	0
1992	458	5408	869	1137	85	122	35	76	8
1993	153	736	220	1250	531	693	185	212	43
1994	0	1849	2243	296	342	172	192	78	85
1995	0	1131	430	1009	1623	103	190	65	146
1996	90	700	538	1273	443	1555	344	280	68
1997	2	6004	6789	227	116	270	82	177	47
1998	0	32	3	2370	1459	252	115	348	161
1999	292	243	98	101	37	874	299	247	77
2000	0	1064	619	351	186	338	129	813	173
2001	2242	259	356	1157	620	147	81	473	257
2002	3	2449	1329	120	189	109	34	58	29
2003	244	136	27	3460	624	387	84	149	24
2004	0	5054	1330	409	209	626	293	120	54
2005	3	1786	459	1425	339	154	34	305	93
2006	2	1796	1014	383	119	157	56	47	23
2007	0	298	0	198	0	35	0	6	0
2008	0	985	208	148	79	66	48	9	7
2009	17	410	106	680	2	22	0	1	0
2010	1	2488	1601	143	43	374	34	60	5
2011	0	308	19	1778	90	435	17	94	3
2012	0	160	0	146	0	269	0	39	0
arith. mean	448	2495	935	1458	337	481	132	192	49

Table 4.3.2. Area-2 Sandeel. Individual mean weight(g) at age in the catch and in the sea

Year/Age	Age 0, 2nd half	Age 1, 1st half	Age 1, 2nd half	Age 2, 1st half	Age 2, 2nd half	Age 3, 1st half	Age 3, 2nd half	Age 4+, 1st half	Age 4+, 2nd half
1983	2.5	5.5	8.5	10.0	11.1	13.9	14.3	17.0	17.7
1984	4.0	5.5	7.6	10.3	12.3	13.8	14.2	17.0	17.7
1985	2.4	5.5	7.5	10.0	10.9	14.2	14.2	19.9	18.8
1986	2.9	5.5	7.9	10.2	12.1	14.1	14.1	16.3	18.8
1987	1.3	5.8	9.0	11.0	10.8	15.6	21.4	18.1	19.8
1988	3.0	4.1	13.2	12.5	14.6	15.5	17.0	18.7	19.3
1989	5.0	4.1	10.1	12.5	14.3	15.6	17.0	18.0	19.0
1990	2.6	4.0	11.0	12.5	15.7	15.6	19.4	19.5	23.0
1991	2.7	8.0	7.5	16.3	13.6	17.4	12.1	18.5	44.0
1992	5.3	7.1	9.5	12.8	16.6	17.9	20.0	25.5	22.6
1993	6.2	8.4	12.6	15.9	16.0	17.7	18.4	21.9	23.3
1994	3.8	7.7	8.3	14.7	11.9	19.1	14.8	20.3	18.1
1995	7.2	8.0	11.3	13.2	14.2	16.4	18.8	19.4	22.6
1996	7.9	11.4	12.2	14.3	15.3	17.0	17.5	20.9	21.7
1997	3.1	7.3	6.9	11.5	12.6	13.3	13.6	14.6	14.7
1998	4.0	9.1	6.4	13.6	14.4	16.0	17.2	18.2	18.6
1999	4.2	11.3	9.3	13.9	13.2	16.3	16.5	18.7	20.1
2000	4.0	10.4	11.8	13.8	13.7	16.2	18.4	18.6	20.2
2001	3.8	10.8	8.5	14.0	12.1	17.7	15.2	21.6	18.5
2002	2.9	6.9	8.3	11.5	13.3	14.4	15.4	17.6	17.7
2003	6.2	9.1	9.6	10.6	10.1	14.1	13.9	18.5	16.3
2004	3.6	7.6	8.1	11.5	11.4	13.4	14.3	15.4	17.4
2005	3.5	7.2	7.8	9.3	11.1	11.4	13.9	13.5	16.9
2006	3.0	8.5	10.8	10.5	11.6	12.6	13.1	14.1	14.0
2007	2.3	8.8	5.1	13.3	7.3	15.7	9.1	18.6	11.1
2008	3.6	7.0	7.9	12.5	11.3	12.8	14.1	13.5	17.1
2009	1.4	7.0	3.1	9.8	4.5	15.0	5.6	13.9	6.8
2010	2.4	6.4	5.3	11.0	7.5	11.7	9.4	13.3	11.4
2011	4.3	8.0	8.7	10.9	12.1	11.9	15.1	13.2	18.4
2012	4.6	9.5	9.2	13.2	12.8	14.7	16.0	16.2	19.5
arith. mean	3.8	7.5	8.8	12.2	12.3	15.0	15.1	17.7	18.8

Table 4.3.3. Area-2 Sandeel. Proportion mature at age

Year/Age	Age 1	Age 2	Age 3	Age 4
1983-2013	0.02	0.83	1	1

Table 4.3.5. Area-2 Sandeel. SMS settings and statistics.

```
objective function (negative log likelihood):  88.9064
Number of parameters: 48
Maximum gradient: 3.65547e-005
Akaike information criterion (AIC):   273.813
Number of observations used in the likelihood:
                 Catch    CPUE    S/R Stomach     Sum
                  300       9     27      0    336

objective function weight:
               Catch  CPUE   S/R
               1.00  1.00  0.01

unweighted objective function contributions (total):
          Catch    CPUE    S/R    Stom.  Penalty      Sum
         97.0    -8.2    13.2    0.0 0.00e+000   101.9


unweighted objective function contributions (per observation):
          Catch   CPUE     S/R   Stomachs
         0.32   -0.92    0.44    0.00


contribution by fleet:
----------------------
Dredge survey 2004-2012      total:  -8.239    mean:  -0.915

F, season effect:
-----------------
age: 0
   1983-1998:   0.000 1.000
   1999-2012:   0.000 1.000
age: 1 - 4
   1983-1998:   0.552 0.500
   1999-2012:   0.352 0.500

F, age effect:
--------------
            0      1      2      3      4
1983-1998:  0.019  0.260  0.630  0.563  0.563
1999-2012:  0.003  0.688  1.421  1.118  1.118


Exploitation pattern (scaled to mean F=1)
-----------------------------------------
                  0      1      2      3      4
1983-1998 season 1:  0.000  0.484  1.173  1.047  1.047
        season 2:  0.014  0.100  0.243  0.216  0.216
```

1999-2012 season 1: 0.000 0.413 0.854 0.672 0.672
season 2: 0.002 0.239 0.494 0.389 0.389

Table 4.3.5 (continued). Area-2 Sandeel. SMS settings and statistics

sqrt(catch variance) ~ CV:

	season	
age	1	2
0		2.133
1	0.421	0.890
2	0.421	0.890
3	1.145	1.123
4	1.145	1.123

Survey catchability:

	age 0
Dredge survey 2004-2012	8.826

sqrt(Survey variance) ~ CV:

	age 0
Dredge survey 2004-2012	0.30

Recruit-SSB		alfa	beta	recruit s2	s
Area-2	Hockey stick -break.:	671.811	7.000e+004	0.976	0.988

Table 4.3.6. Area-2 Sandeel. Fishing mortality at age

Year/Age	Age 0, 2nd half	Age 1, 1st half	Age 1, 2nd half	Age 2, 1st half	Age 2, 2nd half	Age 3, 1st half	Age 3, 2nd half	Age 4+, 1st half	Age 4+, 2nd half
1983	0.005	0.159	0.033	0.385	0.080	0.344	0.071	0.344	0.071
1984	0.009	0.102	0.064	0.248	0.155	0.222	0.138	0.222	0.138
1985	0.010	0.215	0.071	0.522	0.173	0.466	0.154	0.466	0.154
1986	0.007	0.124	0.051	0.301	0.124	0.269	0.111	0.269	0.111
1987	0.006	0.058	0.043	0.141	0.104	0.126	0.093	0.126	0.093
1988	0.005	0.229	0.037	0.555	0.089	0.495	0.079	0.495	0.079
1989	0.003	0.242	0.022	0.586	0.053	0.523	0.048	0.523	0.048
1990	0.001	0.273	0.009	0.662	0.022	0.591	0.019	0.591	0.019
1991	0.011	0.126	0.073	0.306	0.178	0.273	0.159	0.273	0.159
1992	0.004	0.123	0.026	0.298	0.062	0.266	0.055	0.266	0.055
1993	0.006	0.115	0.041	0.279	0.098	0.249	0.088	0.249	0.088
1994	0.006	0.038	0.041	0.092	0.100	0.082	0.089	0.082	0.089
1995	0.008	0.053	0.054	0.129	0.130	0.116	0.116	0.116	0.116
1996	0.007	0.107	0.052	0.260	0.126	0.232	0.112	0.232	0.112
1997	0.016	0.084	0.114	0.203	0.276	0.181	0.247	0.181	0.247
1998	0.011	0.089	0.077	0.217	0.186	0.193	0.166	0.193	0.166
1999	0.001	0.101	0.059	0.210	0.121	0.165	0.095	0.165	0.095
2000	0.001	0.122	0.110	0.251	0.227	0.198	0.178	0.198	0.178
2001	0.001	0.143	0.141	0.295	0.292	0.232	0.230	0.232	0.230
2002	0.001	0.091	0.137	0.188	0.283	0.148	0.222	0.148	0.222
2003	0.001	0.247	0.105	0.510	0.217	0.402	0.171	0.402	0.171
2004	0.002	0.264	0.161	0.546	0.332	0.429	0.261	0.429	0.261
2005	0.001	0.129	0.065	0.268	0.134	0.211	0.106	0.211	0.106
2006	0.001	0.098	0.087	0.203	0.180	0.160	0.142	0.160	0.142
2007	0.000	0.021	0.000	0.044	0.000	0.035	0.000	0.035	0.000
2008	0.000	0.034	0.022	0.069	0.045	0.055	0.036	0.055	0.036
2009	0.000	0.036	0.001	0.074	0.003	0.058	0.002	0.058	0.002
2010	0.000	0.053	0.041	0.110	0.084	0.087	0.066	0.087	0.066
2011	0.000	0.107	0.014	0.222	0.029	0.174	0.023	0.174	0.023
2012	0.000	0.041	0.000	0.085	0.000	0.067	0.000	0.067	0.000
arith. mean	0.004	0.121	0.058	0.275	0.130	0.235	0.109	0.235	0.109

Table 4.3.7. Area-2 : Annual Fishing mortality (F) at age

Year/Age	Age 0	Age 1	Age 2	Age 3	Age 4	Avg. 1-2
1983	0.005	0.229	0.523	0.464	0.464	0.376
1984	0.009	0.181	0.420	0.379	0.380	0.301
1985	0.010	0.331	0.759	0.678	0.678	0.545
1986	0.007	0.199	0.459	0.411	0.412	0.329
1987	0.006	0.108	0.252	0.228	0.229	0.180
1988	0.005	0.321	0.729	0.647	0.646	0.525
1989	0.003	0.325	0.736	0.651	0.650	0.531
1990	0.001	0.355	0.799	0.705	0.703	0.577
1991	0.011	0.219	0.507	0.456	0.457	0.363
1992	0.004	0.178	0.406	0.360	0.360	0.292
1993	0.006	0.179	0.412	0.368	0.368	0.296
1994	0.006	0.081	0.190	0.173	0.174	0.135
1995	0.008	0.110	0.258	0.235	0.236	0.184
1996	0.007	0.178	0.411	0.369	0.370	0.295
1997	0.016	0.196	0.462	0.423	0.426	0.329
1998	0.011	0.174	0.407	0.369	0.370	0.290
1999	0.001	0.176	0.347	0.276	0.276	0.261
2000	0.001	0.241	0.481	0.385	0.387	0.361
2001	0.001	0.293	0.585	0.469	0.472	0.439
2002	0.001	0.223	0.448	0.363	0.366	0.335
2003	0.001	0.397	0.781	0.617	0.618	0.589
2004	0.002	0.463	0.916	0.728	0.730	0.689
2005	0.001	0.217	0.427	0.338	0.339	0.322
2006	0.001	0.194	0.387	0.309	0.311	0.290
2007	0.000	0.028	0.053	0.041	0.041	0.040
2008	0.000	0.060	0.119	0.095	0.095	0.090
2009	0.000	0.047	0.092	0.071	0.071	0.069
2010	0.000	0.100	0.198	0.158	0.159	0.149
2011	0.000	0.149	0.289	0.225	0.225	0.219
2012	0.000	0.053	0.103	0.079	0.079	0.078
arith. mean	0.004	0.200	0.432	0.369	0.370	0.316

Table 4.3.8. Area-2 : Stock numbers (millions). Age 0 at start of 2nd half-year, age 1+ at start of 1st half-year

Year/Age	Age 0	Age 1	Age 2	Age 3	Age 4
1983	129796	4265	12010	767	53
1984	36791	49464	1245	3194	275
1985	240324	13958	14806	352	1230
1986	38893	91080	3704	3127	445
1987	18796	14782	27010	1024	1244
1988	118797	7153	4721	8938	943
1989	65930	45247	1939	1050	2830
1990	85695	25164	12288	433	1144
1991	99343	32770	6709	2624	447
1992	32826	37639	9490	1751	1017
1993	129134	12523	11468	2802	1032
1994	61516	49156	3788	3327	1402
1995	21057	23415	16050	1323	2043
1996	203660	8001	7436	5239	1386
1997	3086	77400	2412	2139	2399
1998	13222	1163	22447	632	1531
1999	40463	5007	348	6353	787
2000	10437	15484	1508	106	2801
2001	106166	3992	4343	396	1051
2002	6541	40595	1062	1022	475
2003	63432	2501	11428	281	531
2004	25561	24263	622	2337	238
2005	48597	9772	5607	109	656
2006	30105	18596	2844	1588	293
2007	72165	11517	5459	820	709
2008	19079	27631	3984	2210	762
2009	111425	7304	9239	1503	1390
2010	11861	42663	2487	3620	1407
2011	15505	4540	13729	867	2211
2012	54118	5936	1421	4521	1318
2013		20721	2013	552	2791

Table 4.3.9. Area-2 : Estimated recruitment, total stock biomass (TBS), spawning stock biomass (SSB), landings weight (Yield) and average fishing mortality.

Year	Recruits (million)	TSB (tonnes)	SSB (tonnes)	Yield (tonnes)	Mean F ages 1-2
1983	129796	154914	111401	74481	0.376
1984	36791	334055	64774	63046	0.301
1985	240324	254133	153640	96645	0.545
1986	38893	592894	92871	93146	0.329
1987	18796	421379	286846	53284	0.180
1988	118797	244589	205942	120382	0.525
1989	65930	279004	91293	109703	0.531
1990	85695	284502	158738	100917	0.577
1991	99343	425995	150144	107795	0.363
1992	32826	444668	163266	69825	0.292
1993	129134	360720	225964	59652	0.296
1994	61516	527000	145641	50656	0.135
1995	21057	461409	240903	60138	0.184
1996	203660	315162	207975	80012	0.295
1997	3086	656868	97674	102726	0.329
1998	13222	354747	292317	68953	0.290
1999	40463	179589	123314	32108	0.261
2000	10437	235711	74209	52228	0.361
2001	106166	133539	80997	56934	0.439
2002	6541	315054	38865	35494	0.335
2003	63432	158215	115140	55924	0.589
2004	25561	225655	44684	71413	0.689
2005	48597	132824	54817	41420	0.322
2006	30105	212898	52175	35351	0.290
2007	72165	199781	88332	5911	0.040
2008	19079	282940	83839	13064	0.090
2009	111425	183426	118187	10240	0.069
2010	11861	360086	89110	31747	0.149
2011	15505	227419	166020	29900	0.219
2012	54118	163071	104613	8048	0.078
2013			79269*		
arith. Mean**	63811	304075	129128	59705	0.316
geo. mean	40770				

***Using weights from 2012**

****Period 1983-2011**

Table 4.3.10. Sandeel in Area-2. Input values for preliminary short term forecast

Age	Age 0	Age 1	Age 2	Age 3	Age 4
Stock numbers(2013)	40770	20721	2013	552	2791
Exploitation pattern 1st half		0.041	0.085	0.067	0.067
Exploitation pattern 2nd half	0.000	0.000	0.000	0.000	0.000
Weight in the stock 1st half		7.96	11.74	12.79	14.25
Weight in the catch 1st half		7.95	11.72	12.77	14.23
weight in the catch 2nd half	3.74	7.74	10.83	13.49	16.45
Proportion mature(2013)	0.00	0.02	0.83	1.00	1.00
Proportion mature(2014)	0.00	0.02	0.83	1.00	1.00
Natural mortality 1st half		0.46	0.44	0.31	0.28
Natural mortality 2nd half	0.96	0.58	0.42	0.37	0.36

Table 4.3.11 Sandeel in Area-2. Short term forecast.

Basis: Fsq=F(2012)=0.063; Yield(2012)=8; Recruitment(2012)=54
Recruitment(2013)= geometric mean (GM 83-11) = 41 billion;SSB(2013)=70

F multiplier	Basis	F(2013)	Landings(2013)	SSB(2014)	%SSB change*	%TAC change**
0	F=0	0	0	110	57%	-100%
0.25	Fsq*0.25	0.016	2	108	55%	-70%
0.5	Fsq*0.5	0.032	5	107	53%	-40%
0.75	Fsq*0.75	0.048	7	106	51%	-10%
1	Fsq*1	0.063	10	104	50%	19%
1.25	Fsq*1.25	0.079	12	103	48%	48%
1.5	Fsq*1.5	0.095	14	102	46%	76%
1.75	Fsq*1.75	0.111	16	100	44%	104%
2	Fsq*2	0.127	19	99	42%	132%
1.845	MSY	0.117	17	100	43%	115%

*SSB in 2014 relative to SSB in 2013
**TAC in 2013 relative to landings in 2012

Table 4.4.1. Area-3 Sandeel. Catch at age numbers (millions) by half year

Year/Age	Age 0, 2nd half	Age 1, 1st half	Age 1, 2nd half	Age 2, 1st half	Age 2, 2nd half	Age 3, 1st half	Age 3, 2nd half	Age 4+, 1st half	Age 4+, 2nd half
1983	8788	6876	335	1722	376	114	26	17	0
1984	0	11628	1800	1454	173	502	65	16	0
1985	826	812	232	1164	496	300	199	138	25
1986	9564	33702	9744	3681	649	291	10	0	1
1987	20	34149	253	14264	53	463	1	203	0
1988	13754	7165	1337	18861	366	1021	224	29	21
1989	2659	56641	3176	2245	216	3367	0	33	0
1990	13612	12174	1951	3676	409	544	61	165	18
1991	18977	32228	1338	1885	43	708	12	248	4
1992	5550	14005	124	5593	11	668	3	419	1
1993	23259	19369	1427	865	243	336	89	1651	16
1994	0	45466	2566	7918	1250	1015	165	426	24
1995	2873	28112	1055	2393	182	338	26	176	32
1996	34618	4672	8917	2860	115	411	36	360	266
1997	3214	89081	11945	4255	213	900	14	222	10
1998	31377	4292	1071	30566	845	2762	226	315	34
1999	12349	5453	2551	1584	163	2045	558	445	233
2000	1	25715	779	3617	7	584	3	633	15
2001	25320	8079	6724	1205	14	193	4	197	12
2002	0	22844	107	3706	5	719	2	183	0
2003	9231	1183	127	911	97	144	3	87	3
2004	1832	7975	1341	663	31	127	14	171	2
2005	1	3091	51	252	47	33	5	22	9
2006	0	2078	177	84	41	36	27	6	26
2007	0	14895	0	630	0	87	0	19	0
2008	0	7531	9	2201	3	469	0	77	0
2009	65	3251	1773	185	138	28	26	2	1
2010	0	6773	472	734	13	942	10	162	1
2011	0	1534	0	5313	1	828	0	24	0
2012	0	165	5	292	51	1231	5	388	10
arith. mean	7263	17031	2046	4159	208	707	60	228	25

Table 4.4.2. Area-3 Sandeel. Individual mean weight(g) at age in the catch and in the sea

Year/Age	Age 0, 2nd half	Age 1, 1st half	Age 1, 2nd half	Age 2, 1st half	Age 2, 2nd half	Age 3, 1st half	Age 3, 2nd half	Age 4+, 1st half	Age 4+, 2nd half
1983	3.0	5.6	13.2	12.6	26.5	26.5	31.8	39.6	17.7
1984	4.1	5.6	13.0	12.9	27.8	17.2	34.7	22.9	17.7
1985	2.9	5.6	12.6	12.4	26.3	26.7	32.8	43.0	46.4
1986	3.0	5.6	13.1	13.0	27.5	26.7	14.1	16.3	18.8
1987	2.9	5.6	12.9	13.0	13.4	27.1	21.4	43.7	19.8
1988	3.0	5.6	13.2	13.1	27.4	26.6	27.6	34.2	40.1
1989	5.0	6.2	8.9	14.0	16.0	16.3	17.0	18.0	19.0
1990	3.0	5.6	13.1	13.0	27.0	27.1	35.0	43.8	42.5
1991	3.4	7.4	9.4	14.3	14.8	22.3	15.7	30.6	44.0
1992	5.5	5.5	12.1	10.9	18.6	18.5	20.0	29.8	22.6
1993	3.0	6.2	7.8	15.6	16.2	16.6	21.0	23.2	22.1
1994	3.5	5.7	9.1	12.8	20.8	19.9	34.3	20.6	27.0
1995	4.7	5.8	7.9	10.3	9.8	14.3	13.1	16.4	15.6
1996	2.6	8.0	5.3	13.4	15.2	25.7	17.3	37.3	26.2
1997	2.9	5.1	6.8	9.3	9.8	13.7	14.2	18.2	14.4
1998	3.2	5.0	7.0	10.1	15.0	13.7	17.1	20.2	20.7
1999	6.4	7.4	11.7	10.1	15.7	14.1	17.0	25.9	24.8
2000	4.2	6.8	10.1	10.3	17.6	15.3	21.4	20.3	23.8
2001	4.8	6.3	7.1	13.1	13.9	17.2	14.2	22.0	20.6
2002	4.8	6.6	11.6	12.0	20.3	12.1	24.6	19.0	27.3
2003	3.5	5.2	5.0	14.3	14.5	19.8	22.4	26.1	29.8
2004	5.1	6.3	7.2	8.6	12.3	12.9	16.0	13.1	11.1
2005	2.8	7.6	6.7	15.8	11.8	18.9	14.3	21.8	15.8
2006	3.5	6.8	8.4	12.6	14.6	16.3	17.8	24.8	19.7
2007	4.7	6.8	11.3	14.6	19.8	21.6	24.0	14.7	26.7
2008	3.4	6.6	8.3	14.7	14.5	22.0	17.6	25.5	19.5
2009	7.6	5.9	5.3	9.4	11.3	20.0	18.8	11.2	10.9
2010	2.2	6.2	5.2	17.1	9.1	20.6	11.0	24.1	12.2
2011	4.1	7.4	9.8	12.5	17.1	19.4	20.7	36.3	23.0
2012	3.7	7.3	9.1	13.9	15.5	22.5	19.2	30.1	21.6
arith. mean	3.9	6.2	9.4	12.7	17.3	19.7	20.9	25.8	23.4

Table 4.4.3. Area-3 Sandeel. Proportion mature at age

Year/Age	Age 1	Age 2	Age 3	Age 4
1983-2004	0.05	0.77	1.00	1.00
2005	0.12	0.96	1.00	1.00
2006	0.08	0.78	1.00	1.00
2007	0.02	0.80	1.00	1.00
2008	0.03	0.69	1.00	1.00
2009	0.01	0.48	1.00	1.00
2010	0.04	0.92	1.00	1.00
2011	0.00	0.82	1.00	1.00
2012	0.01	0.70	1.00	1.00
2013	0.04	0.88	1.00	1.00

Table 4.4.4. Area-3 Sandeel. Dredge survey CPUE (number / hour)

		Age		
Area	Year	0	1	2
3	2004	83	20	7
	2005	376	48	2
	2006	903	60	1
	2007	426	212	12
	2008	1094	334	129
	2009	553	1087	111
	2010	40	405	81
	2011	41	60	1257
	2012	1022	10	6

Table 4.4.5. Norwegian acoustic survey. Estimated number of sandeels (billions).

	Age			
Year	1	2	3	4+
2007	160.73	39.24	9.98	3.37
2008	33.03	41.53	2.08	0.46
2009	126.60	42.98	8.68	1.18
2010	165.84	96.75	15.82	9.74
2011	4.10	86.96	9.87	3.68
2012	2.87	2.74	37.97	5.57

Table 4.4.6. Sandeel in Area-3. Explorative short term forecast: Assessment run with both NO acoustic survey index and DK dredge index

Basis: Fsq=F(2012)=0.187; Yield(2012)=46; Recruitment(2012)=122; Recruitment(2013)= geometric mean (GM 83-11) = 85 billion;SSB(2013)=92						
F multiplier	Basis	F(2013)	Landings(2013)	SSB(2014)	%SSB change*	%TAC change**
0	F=0	0	0	257	160%	-100%
0.25	Fsq*0.25	0.046	15	247	149%	-67%
0.5	Fsq*0.5	0.092	30	236	139%	-35%
0.75	Fsq*0.75	0.137	44	227	129%	-4%
1	Fsq*1	0.183	57	217	120%	25%
1.25	Fsq*1.25	0.229	70	208	111%	54%
1.5	Fsq*1.5	0.275	83	200	102%	81%
1.75	Fsq*1.75	0.321	94	192	94%	107%
2	Fsq*2	0.366	106	184	86%	131%
1.651	MSY	0.303	90	195	97%	96%

***SSB in 2014 relative to SSB in 2013**

**** TAC in 2013 relative to landings in 2012**

Table 4.4.7. Area-3 Sandeel. SMS settings and statistics. Explorative assessment: Assessment run with both NO acoustic survey index and DK dredge index

objective function (negative log likelihood): 129.18

Number of parameters: 60

Maximum gradient: 6.38276e-005

Akaike information criterion (AIC): 378.359

Number of observations used in the likelihood:

Catch	CPUE	S/R	Stomach	Sum
300	42	29	0	371

objective function weight:

Catch	CPUE	S/R
1.00	1.00	0.01

unweighted objective function contributions (total):

Catch	CPUE	S/R	Stom.	Penalty	Sum
134.6	-5.6	16.3	0.0	0.00e+000	145.3

unweighted objective function contributions (per observation):

Catch	CPUE	S/R	Stomachs
0.45	-0.13	0.54	0.00

contribution by fleet:

Dredge survey 2004-2011 total: -0.748 mean: -0.042

Acoustic total: -4.833 mean: -0.201

F, season effect:

----

age: 0

1983-1988: 0.000 1.000

1989-1998: 0.000 1.000

1999-2012: 0.000 1.000

age: 1 - 4

1983-1988: 0.905 0.500

1989-1998: 1.241 0.500

1999-2012: 0.732 0.500

F, age effect:

	0	1	2	3	4
1983-1988:	0.082	0.539	1.108	1.942	1.942
1989-1998:	0.277	0.401	0.324	0.269	0.269
1999-2012:	0.053	1.720	1.540	0.935	0.935

Exploitation pattern (scaled to mean F=1)

--

		0	1	2	3	4
1983-1988	**season 1:**	**0.000**	**0.534**	**1.098**	**1.925**	**1.925**
	season 2:	**0.037**	**0.120**	**0.247**	**0.433**	**0.433**
1989-1998	**season 1:**	**0.000**	**1.040**	**0.842**	**0.698**	**0.698**
	season 2:	**0.090**	**0.065**	**0.053**	**0.044**	**0.044**
1999-2012	**season 1:**	**0.000**	**0.568**	**0.509**	**0.309**	**0.309**
	season 2:	**0.030**	**0.487**	**0.436**	**0.265**	**0.265**

Table 4.4.8. (continued). Area-3 Sandeel. SMS settings and statistics. Explorative assessment: Assessment run with both NO acoustic survey index and DK dredge index

sqrt(catch variance) ~ CV:

----

	season	
age	**1**	**2**
0		**1.846**
1	**0.551**	**1.163**
2	**0.551**	**1.163**
3	**0.958**	**1.544**
4	**0.958**	**1.544**

Survey catchability:

--------------------	age 0	age 1	age 2	age 3	age 4
Dredge survey 2004-2011	**1.791**	**1.791**			
Acoustic		**0.379**	**1.062**	**0.737**	**0.375**

sqrt(Survey variance) ~ CV:

--------------------------	age 0	age 1	age 2	age 3	age 4
Dredge survey 2004-2011	**0.36**	**0.94**			
Acoustic		**0.34**	**0.34**	**0.73**	**0.73**

Recruit-SSB		**alfa**	**beta**	**recruit s2**	**recruit s**
Area-3	**Hockey stick -break.:**	**1015.333**	**1.000e+005**	**1.132**	**1.064**

Table 4.4.9. Area-3 Sandeel. SMS settings and statistics.

objective function (negative log likelihood): 130.169
Number of parameters: 54
Maximum gradient: 9.27684e-005
Akaike information criterion (AIC): 368.338
Number of observations used in the likelihood:

Catch	CPUE	S/R	Stomach	Sum
300	18	29	0	347

objective function weight:

Catch	CPUE	S/R
1.00	1.00	0.01

unweighted objective function contributions (total):

Catch	CPUE	S/R	Stom.	Penalty	Sum
128.3	1.8	14.3	0.0	0.00e+000	144.3

unweighted objective function contributions (per observation):

Catch	CPUE	S/R	Stomachs
0.43	0.10	0.48	0.00

contribution by fleet:

Dredge survey 2004-2012 total: 1.773 mean: 0.098

F, season effect:
----
age: 0
1983-1988: 0.000 1.000
1989-1998: 0.000 1.000
1999-2012: 0.000 1.000
age: 1 - 4
1983-1988: 0.898 0.500
1989-1998: 1.233 0.500
1999-2012: 0.720 0.500

F, age effect:

	0	1	2	3	4
1983-1988:	0.082	0.541	1.103	1.972	1.972
1989-1998:	0.278	0.398	0.326	0.267	0.267
1999-2012:	0.049	1.704	1.466	0.930	0.930

Exploitation pattern (scaled to mean F=1)

		0	1	2	3	4
1983-1988	season 1:	0.000	0.536	1.094	1.955	1.955
	season 2:	0.037	0.122	0.248	0.444	0.444
1989-1998	season 1:	0.000	1.035	0.846	0.694	0.694
	season 2:	0.091	0.065	0.054	0.044	0.044
1999-2012	season 1:	0.000	0.575	0.495	0.314	0.314
	season 2:	0.029	0.500	0.430	0.273	0.273

Table 4.4.10(continued). Area-3 Sandeel. SMS settings and statistics.

sqrt(catch variance) ~ CV:

	season	
age	1	2
0		1.891
1	0.504	1.123
2	0.504	1.123
3	0.958	1.553
4	0.958	1.553

Survey catchability:

	age 0	age 1
Dredge survey 2004-2012	1.880	1.880

sqrt(Survey variance) ~ CV:

	age 0	age 1
Dredge survey 2004-2012	0.54	0.82

Recruit-SSB		alfa	beta	recruit s2	s
Area-3	Hockey stick -break.:	1027.043	1.000e+005	0.986	0.993

Table 4.4.11. Area-3 Sandeel. Fishing mortality at age

Year/Age	Age 0, 2nd half	Age 1, 1st half	Age 1, 2nd half	Age 2, 1st half	Age 2, 2nd half	Age 3, 1st half	Age 3, 2nd half	Age 4+, 1st half	Age 4+, 2nd half
1983	0.015	0.218	0.050	0.446	0.101	0.797	0.181	0.797	0.181
1984	0.016	0.235	0.052	0.479	0.107	0.856	0.190	0.856	0.190
1985	0.014	0.117	0.046	0.240	0.094	0.428	0.167	0.428	0.167
1986	0.045	0.445	0.147	0.909	0.300	1.624	0.537	1.624	0.537
1987	0.002	0.493	0.007	1.006	0.014	1.798	0.025	1.798	0.025
1988	0.037	0.671	0.122	1.369	0.250	2.446	0.446	2.446	0.446
1989	0.088	0.996	0.063	0.815	0.052	0.668	0.042	0.668	0.042
1990	0.123	0.468	0.088	0.383	0.072	0.314	0.059	0.314	0.059
1991	0.090	0.635	0.065	0.520	0.053	0.426	0.043	0.426	0.043
1992	0.042	0.411	0.030	0.336	0.025	0.275	0.020	0.275	0.020
1993	0.149	0.523	0.107	0.428	0.087	0.351	0.071	0.351	0.071
1994	0.057	0.637	0.041	0.521	0.033	0.427	0.027	0.427	0.027
1995	0.028	0.432	0.020	0.353	0.016	0.290	0.013	0.290	0.013
1996	0.196	0.272	0.140	0.223	0.115	0.183	0.094	0.183	0.094
1997	0.143	0.810	0.103	0.662	0.084	0.543	0.069	0.543	0.069
1998	0.232	0.768	0.166	0.628	0.136	0.515	0.112	0.515	0.112
1999	0.036	0.720	0.626	0.619	0.539	0.393	0.342	0.393	0.342
2000	0.002	1.281	0.036	1.102	0.031	0.699	0.020	0.699	0.020
2001	0.036	0.549	0.622	0.472	0.535	0.299	0.340	0.299	0.340
2002	0.001	1.001	0.017	0.861	0.015	0.546	0.009	0.546	0.009
2003	0.013	0.354	0.221	0.304	0.190	0.193	0.121	0.193	0.121
2004	0.008	0.571	0.132	0.491	0.113	0.312	0.072	0.312	0.072
2005	0.000	0.210	0.006	0.181	0.005	0.115	0.003	0.115	0.003
2006	0.001	0.121	0.011	0.104	0.010	0.066	0.006	0.066	0.006
2007	0.000	0.499	0.000	0.429	0.000	0.272	0.000	0.272	0.000
2008	0.000	0.438	0.001	0.377	0.001	0.239	0.001	0.239	0.001
2009	0.002	0.115	0.031	0.099	0.027	0.063	0.017	0.063	0.017
2010	0.001	0.482	0.013	0.414	0.011	0.263	0.007	0.263	0.007
2011	0.000	0.442	0.000	0.380	0.000	0.241	0.000	0.241	0.000
2012	0.000	0.185	0.004	0.159	0.003	0.101	0.002	0.101	0.002
arith. mean	0.046	0.503	0.099	0.510	0.101	0.525	0.101	0.525	0.101

Table 4.4.12. Area-3 : Annual Fishing mortality (F) at age

Year/Age	Age 0	Age 1	Age 2	Age 3	Age 4	Avg. 1-2
1983	0.015	0.318	0.612	1.081	1.080	0.465
1984	0.016	0.340	0.655	1.157	1.156	0.498
1985	0.014	0.186	0.361	0.646	0.646	0.274
1986	0.045	0.680	1.313	2.321	2.322	0.997
1987	0.002	0.627	1.187	2.050	2.046	0.907
1988	0.037	0.938	1.793	3.126	3.124	1.366
1989	0.088	1.281	0.999	0.813	0.811	1.140
1990	0.123	0.661	0.514	0.419	0.419	0.588
1991	0.090	0.849	0.659	0.536	0.535	0.754
1992	0.042	0.544	0.420	0.341	0.340	0.482
1993	0.149	0.745	0.579	0.473	0.472	0.662
1994	0.057	0.831	0.645	0.523	0.522	0.738
1995	0.028	0.562	0.434	0.352	0.351	0.498
1996	0.196	0.458	0.358	0.295	0.296	0.408
1997	0.143	1.091	0.850	0.693	0.692	0.971
1998	0.232	1.092	0.853	0.697	0.697	0.973
1999	0.036	1.404	1.168	0.754	0.757	1.286
2000	0.002	1.592	1.308	0.829	0.827	1.450
2001	0.036	1.185	0.989	0.642	0.645	1.087
2002	0.001	1.248	1.022	0.645	0.643	1.135
2003	0.013	0.624	0.515	0.330	0.331	0.569
2004	0.008	0.824	0.675	0.428	0.428	0.750
2005	0.000	0.273	0.221	0.138	0.138	0.247
2006	0.001	0.164	0.133	0.083	0.083	0.148
2007	0.000	0.628	0.510	0.320	0.319	0.569
2008	0.000	0.555	0.450	0.282	0.281	0.502
2009	0.002	0.171	0.140	0.088	0.088	0.155
2010	0.001	0.618	0.502	0.315	0.314	0.560
2011	0.000	0.559	0.453	0.284	0.283	0.506
2012	0.000	0.239	0.193	0.121	0.121	0.216
arith. mean	0.046	0.710	0.684	0.693	0.692	0.697

Table 4.4.13. Area-3 : Stock numbers (millions). Age 0 at start of 2nd half-year, age 1+ at start of 1st half-year

Year/Age	Age 0	Age 1	Age 2	Age 3	Age 4
1983	93541	22530	6337	180	11
1984	43127	35280	6092	1552	36
1985	301553	16253	9359	1435	283
1986	366512	113862	4879	2838	483
1987	81847	134193	22256	616	195
1988	299345	31272	28770	3394	67
1989	101591	110431	5002	2412	97
1990	214895	35623	13534	890	626
1991	89705	72792	7221	3635	538
1992	233340	31378	12774	1724	1329
1993	218037	85676	7137	3770	1171
1994	175473	71958	16131	1805	1657
1995	129582	63460	12911	3921	1135
1996	905879	48250	14271	3774	1909
1997	59564	285171	11286	4309	2213
1998	94269	19763	40468	2264	1817
1999	113488	28617	2745	7978	1126
2000	82514	41906	2634	365	2223
2001	85574	31528	3969	359	661
2002	17216	31607	3457	614	280
2003	40604	6585	4036	609	263
2004	19495	15349	1310	1042	327
2005	31358	7408	2686	303	477
2006	91037	12003	2110	944	360
2007	57220	34835	3717	797	621
2008	92742	21909	7478	1024	557
2009	132851	35508	4989	2168	639
2010	16382	50777	10851	1863	1326
2011	4274	6268	10947	3001	1254
2012	125675	1636	1424	3167	1714
2013		48109	479	512	2263

Table 4.4.14. Area-3 : Estimated recruitment, total stock biomass (TBS), spawning stock biomass (SSB), landings weight (Yield) and average fishing mortality.

Year	Recruits (million)	TSB (tonnes)	SSB (tonnes)	Yield (tonnes)	Mean F ages 1-2
1983	93541	212036	72970	105946	0.465
1984	43127	304532	98069	123635	0.498
1985	301553	258453	144725	59083	0.274
1986	366512	789330	164671	420341	0.997
1987	81847	1072080	286371	403908	0.907
1988	299345	644289	390381	391081	1.366
1989	101591	793415	129003	481893	1.140
1990	214895	428586	197463	219183	0.588
1991	89705	741923	204302	368105	0.754
1992	233340	384771	187543	195700	0.482
1993	218037	730704	202089	263954	0.662
1994	175473	685146	249410	444119	0.738
1995	129582	573875	195920	218922	0.498
1996	905879	742988	334269	247397	0.408
1997	59564	1661140	252688	604159	0.971
1998	94269	575202	387225	499333	0.973
1999	113488	381145	173351	223160	1.286
2000	82514	363349	85968	242732	1.450
2001	85574	272477	70652	245290	1.087
2002	17216	263591	55015	209302	1.135
2003	40604	110666	65058	58942	0.569
2004	19495	125491	31198	79234	0.750
2005	31358	114967	63722	29677	0.247
2006	91037	131977	51576	18863	0.148
2007	57220	318873	74514	113232	0.569
2008	92742	291354	116971	94491	0.502
2009	132851	306035	75172	33350	0.155
2010	16382	571174	253618	80576	0.560
2011	4274	286872	231559	94750	0.506
2012	125675	154438	136655	45732	0.216
2013			87742*		
arith. Mean**	143956	476363	163544	220536	0.697
geo. mean	87284				

***Using weights from 2012**

****Period 1983-2012**

Table 4.4.15. Sandeel in Area-3. Input values for preliminary short term forecast

Age	Age 0	Age 1	Age 2	Age 3	Age 4
Stock numbers(2013)	87284	48109	479	512	2263
Exploitation pattern 1st half		0.185	0.159	0.101	0.101
Exploitation pattern 2nd half	0.000	0.004	0.003	0.002	0.002
Weight in the stock 1st half		6.97	14.50	20.80	30.16
Weight in the catch 1st half		6.97	14.50	20.80	30.16
weight in the catch 2nd half	3.31	8.01	13.88	16.98	18.93
Proportion mature(2013)	0.00	0.04	0.88	1.00	1.00
Proportion mature(2014)	0.00	0.05	0.77	1.00	1.00
Natural mortality 1st half		0.46	0.44	0.31	0.28
Natural mortality 2nd half	0.96	0.58	0.42	0.37	0.36

Table 4.4.16. Sandeel in Area-3. Short term forecast.

Basis: Fsq=F(2012)=0.174; Yield(2012)=46; Recruitment(2012)=126; Recruitment(2013)= geometric mean (GM 83-11) = 87 billion;SSB(2013)=98						
F multiplier	Basis	F(2013)	Landings(2013)	SSB(2014)	%SSB change*	%TAC change**
0	F=0	0	0	249	153%	-100%
0.25	Fsq*0.25	0.044	14	239	143%	-69%
0.5	Fsq*0.5	0.088	28	230	134%	-39%
0.75	Fsq*0.75	0.132	41	221	124%	-10%
1	Fsq*1	0.175	54	212	115%	18%
1.25	Fsq*1.25	0.219	66	204	107%	44%
1.5	Fsq*1.5	0.263	78	196	99%	70%
1.75	Fsq*1.75	0.307	89	188	91%	94%
2	Fsq*2	0.351	100	180	83%	118%
1.516	MSY	0.266	78	195	98%	71%

***SSB in 2014 relative to SSB in 2013**

**** TAC in 2013 relative to landings in 2012**

Table 4.5.1. Area-4 Sandeel. Catch numbers (millions) by half-year

Year/Age	Age 0, 2nd half	Age 1, 1st half	Age 1, 2nd half	Age 2, 1st half	Age 2, 2nd half	Age 3, 1st half	Age 3, 2nd half	Age 4+, 1st half	Age 4+, 2nd half
1994	0	1079	258	1532	63	5177	259	2106	160
1995	4	2699	4	1232	1	531	0	30	0
1996	2769	685	2734	2371	3705	445	244	122	1177
1997	0	2924	1390	295	36	1710	44	419	10
1998	0	2148	60	3748	96	234	6	129	3
1999	0	1492	88	1150	47	1560	47	255	12
2000	0	6530	0	376	0	322	0	296	0
2001	10	2044	65	4952	20	600	1	377	0
2002	0	323	0	772	0	490	0	97	0
2003	180	4319	175	1001	12	2719	6	1252	2
2004	0	924	4	221	1	46	0	82	0
2005	0	47	0	138	0	30	0	17	0
2006	0	8	2	0	0	0	0	0	0
2007	0	2	0	0	0	0	0	0	0
2008	0	205	0	18	0	4	0	1	0
2009	0	0	0	0	0	0	0	0	0
2010	0	48	0	1	0	1	0	0	0
2011	0	4	0	25	0	2	0	0	0
2012	0	0	0	0	0	0	0	0	0

Table 4.5.2. Area-4 Sandeel. Individual mean weight(g) at age in the catch and in the sea

Year/Age	Age 0, 2nd half	Age 1, 1st half	Age 1, 2nd half	Age 2, 1st half	Age 2, 2nd half	Age 3, 1st half	Age 3, 2nd half	Age 4+, 1st half	Age 4+, 2nd half
1994	4.0	11.2	11.1	11.4	14.6	15.1	18.5	21.1	23.5
1995	7.3	8.8	11.9	16.4	13.7	19.9	16.7	16.2	20.5
1996	7.6	5.2	9.0	12.7	16.0	18.4	21.9	22.8	27.1
1997	4.0	6.8	6.9	7.6	10.7	11.4	15.4	18.4	15.1
1998	3.6	6.2	6.2	10.6	10.8	13.9	14.1	14.8	18.9
1999	4.0	6.2	6.9	11.0	12.1	16.3	18.3	20.4	21.0
2000	4.0	4.2	9.1	8.7	16.0	14.2	18.6	18.7	24.9
2001	3.5	3.5	3.8	6.1	6.8	9.2	10.7	14.5	14.8
2002	4.0	3.7	9.1	5.9	16.0	9.4	18.6	17.8	24.9
2003	3.4	5.1	5.2	7.4	5.8	9.1	7.3	12.2	9.4
2004	4.0	4.2	3.3	7.8	5.7	9.7	8.1	14.4	10.3
2005	4.0	4.2	9.1	6.1	16.0	8.6	18.6	11.0	24.9
2006	4.1	6.2	10.3	10.1	12.6	12.4	14.4	14.8	15.9
2007	4.0	5.7	9.1	9.6	16.0	12.0	18.6	13.1	24.9
2008	4.0	5.7	9.1	9.7	16.0	12.0	18.6	13.7	24.9
2009	4.0	5.9	9.1	10.8	16.0	15.6	18.6	19.8	24.9
2010	4.0	5.1	9.1	9.3	16.0	13.4	18.6	17.1	24.9
2011	4.0	4.9	9.1	8.9	16.0	12.8	18.6	16.2	24.9
2012	3.9	4.0	9.0	8.2	16.2	9.6	18.9	12.2	25.6

Table 4.5.3 Area-4 sandeel: Average dredge survey CPUE by age for a) area 4 and b) Firth of Forth

a) Area 4				b) Firth of Forth		
Year	Age 0	Age 1	Age 2	Age 0	Age 1	Age 2
1999				615	494	301
2000				586	3170	258
2001				48	2656	1561
2002				243	404	916
2003				580		
2008	52	24	18	68	24	24
2009	832	87	38	1023	174	56
2010	147	1032	67	186	1244	78
2011	89	165	407	119	220	534
2012	85	135	23	122	178	30

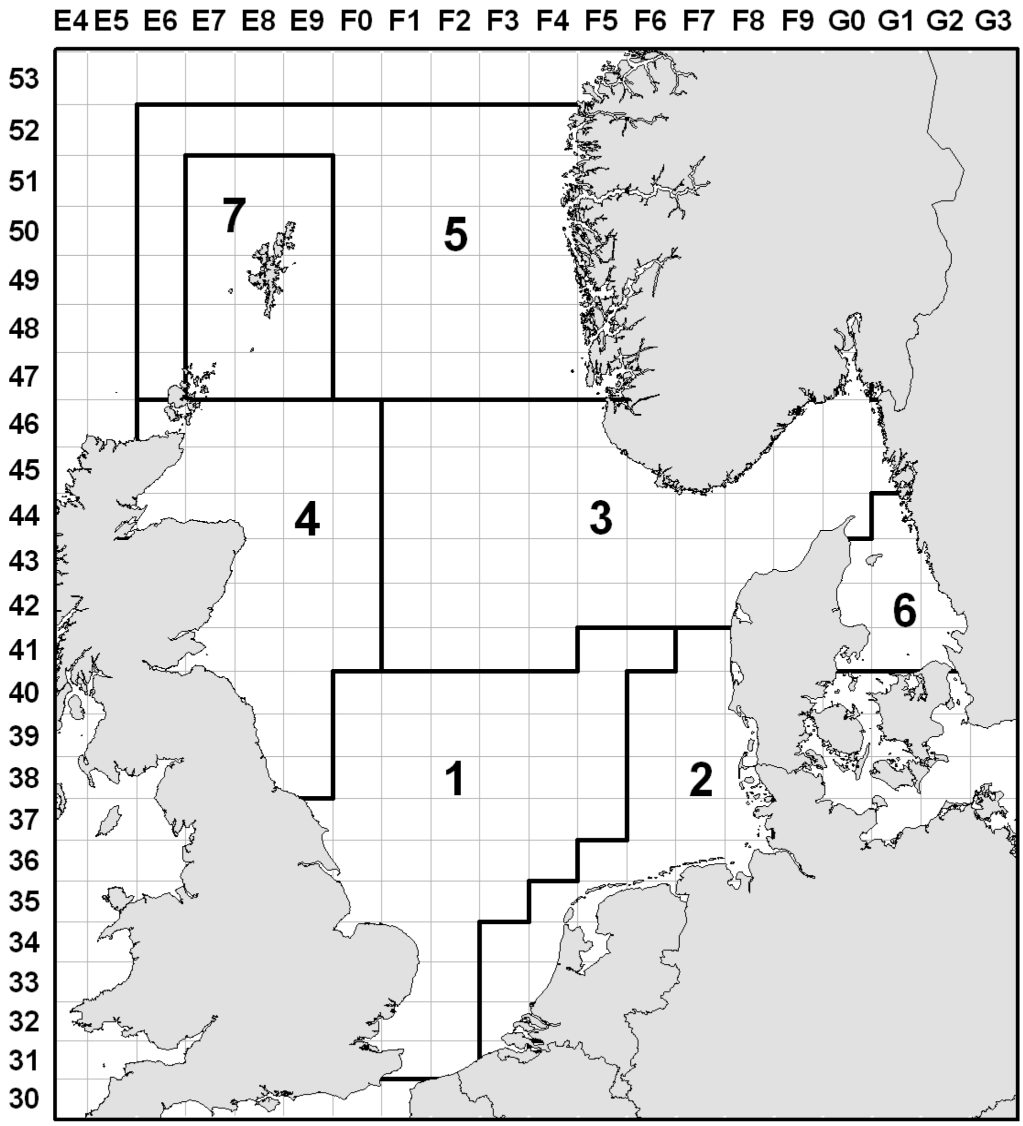


Figure. 4.1.1. Sandeel management areas

Figure 4.1.2. Sandeel in IV. Landings by ICES rectangles 2001-2012.

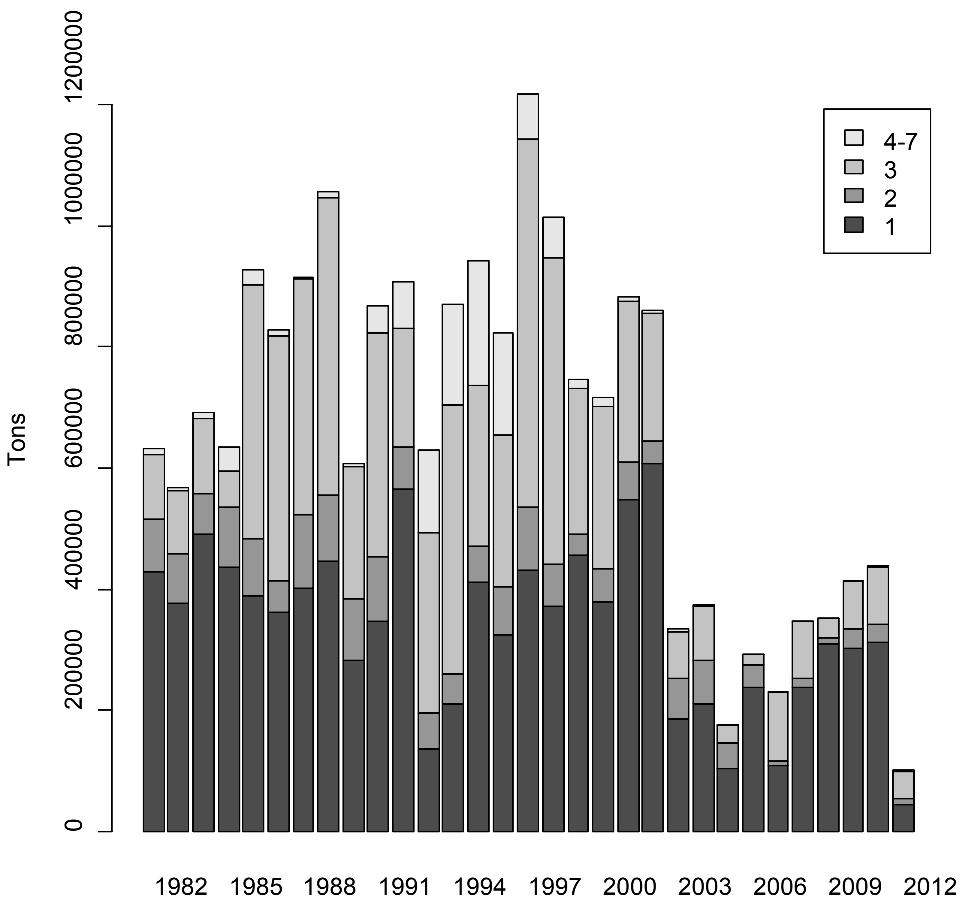


Figure 4.1.3. Sandeel in IV. Total annual landings by area.

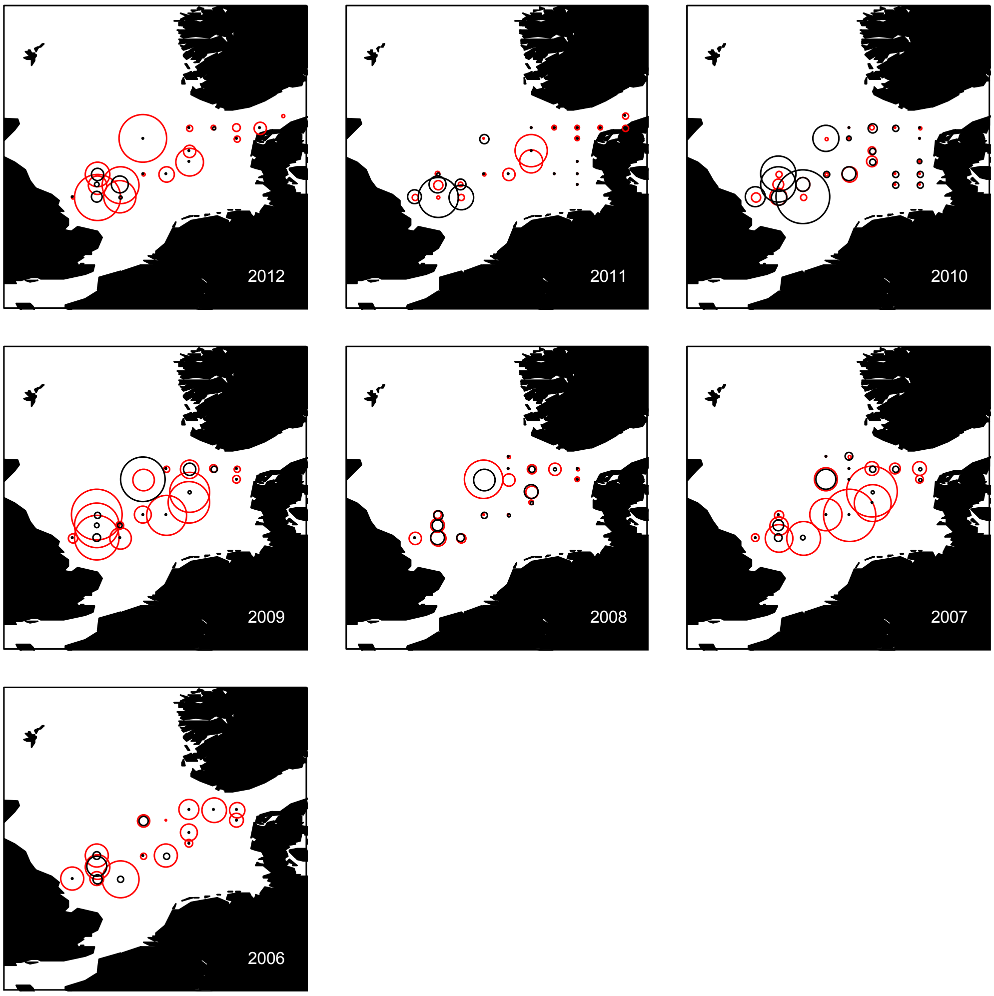


Figure 4.1.4. Danish survey-indices by year and ICES-square. Red circles: 0-group, black circles: 1-group.

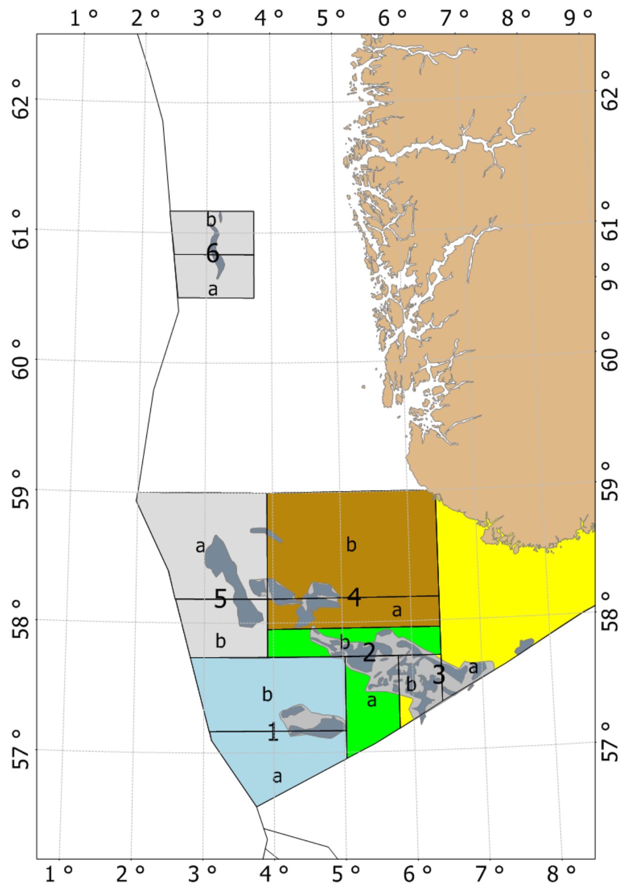


Figure 4.1.5. The Norwegian sandeel management areas. There are 6 main areas each consisting of "a" and "b" subareas.

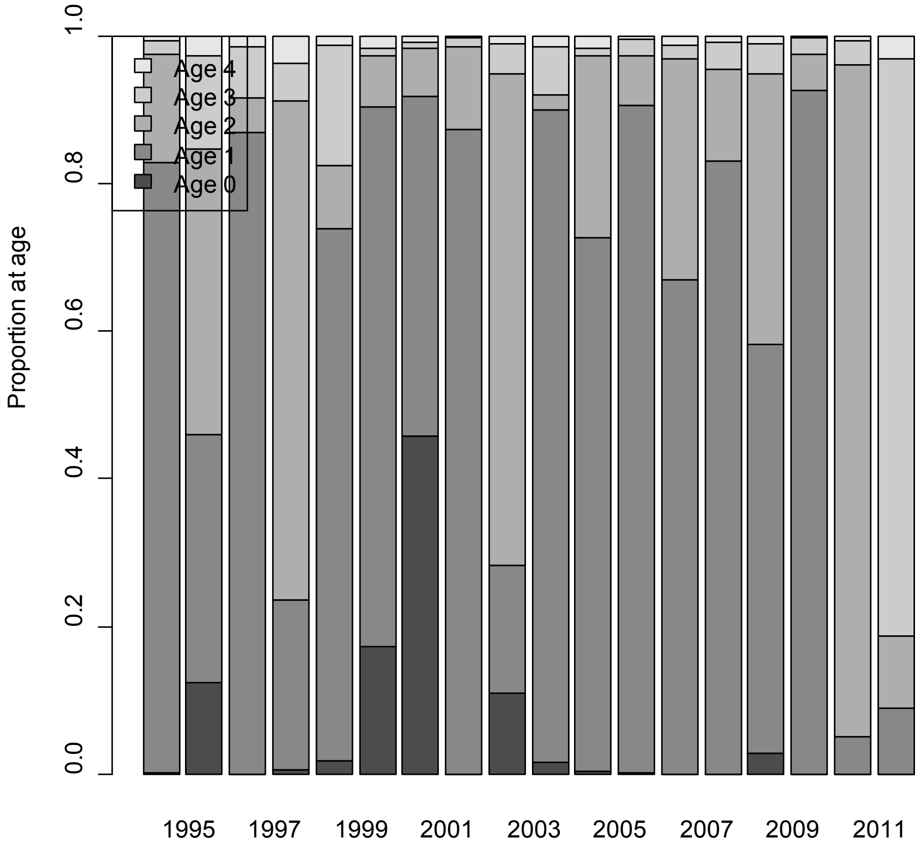


Figure 4.2.1 . Sandeel in Area-1. Catch numbers, Proportion at age.

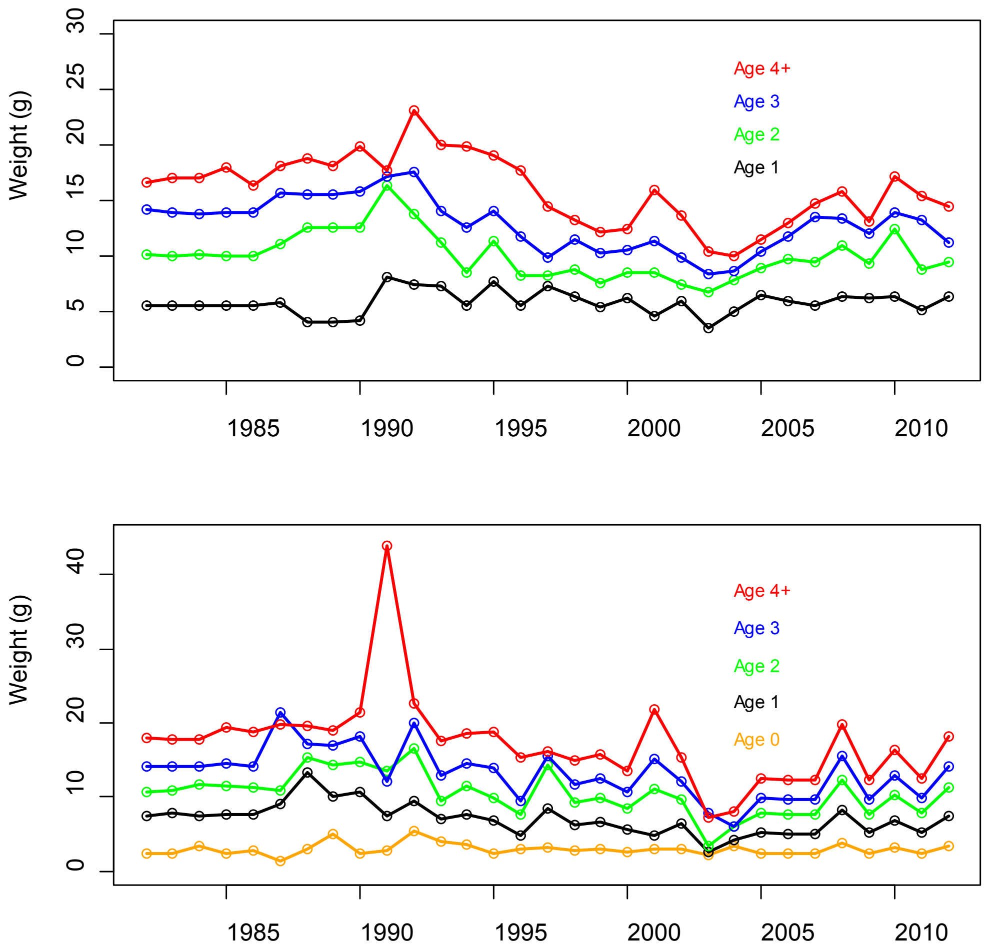


Figure 4.2.2. Sandeel in Area-1. Individual mean weights (g) at age in 1st (upper) and 2nd (lower) half-year. Mean weight in 2007 2nd half-year was missing, instead values from 2006 was borrowed.

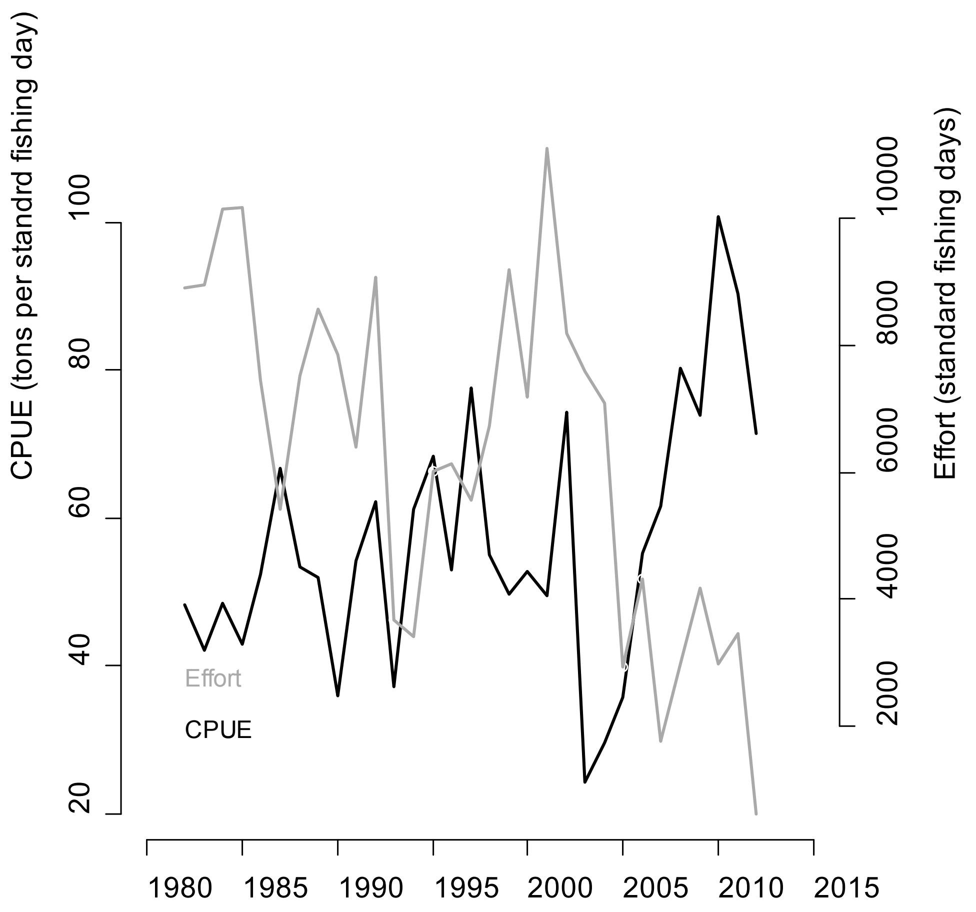


Figure 4.2.3. Sandeel in Area-1. Effort (days fishing for a standard 200 GT vessel) and CPUE (tons per standard fishing day)

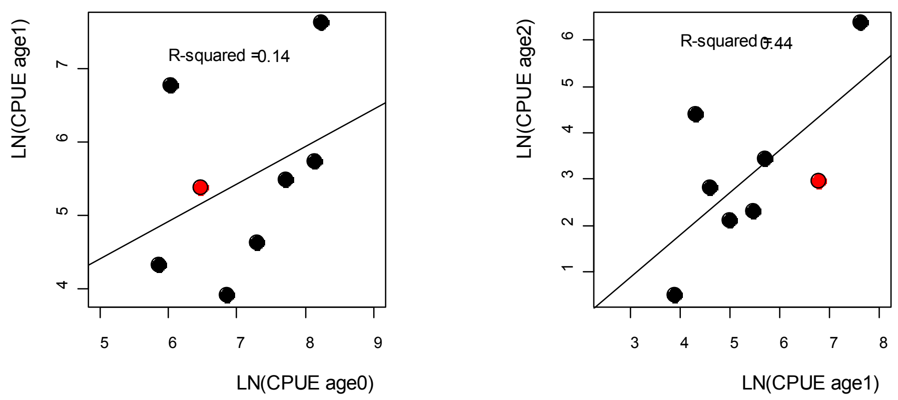


Figure 4.2.4. Sandeel in Area-1. Internal consistence by age of the Danish dredge survey. Red dot indicates most recent data point.

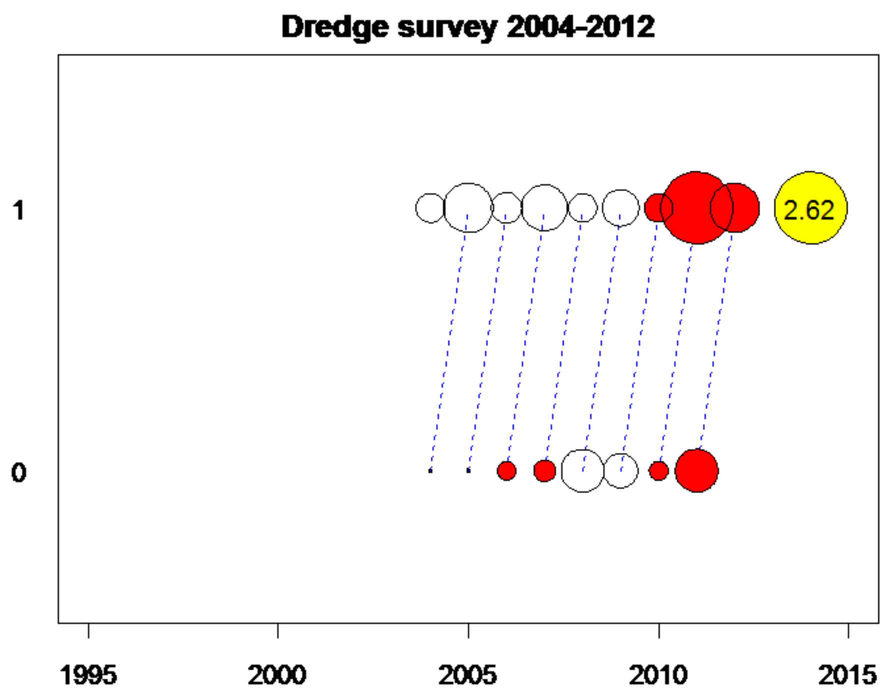


Figure 4.2.5. Sandeel in Area-1. Dredge survey residuals (log(observed CPUE) - log(expected CPUE). 'Red' dots show a positive residual.

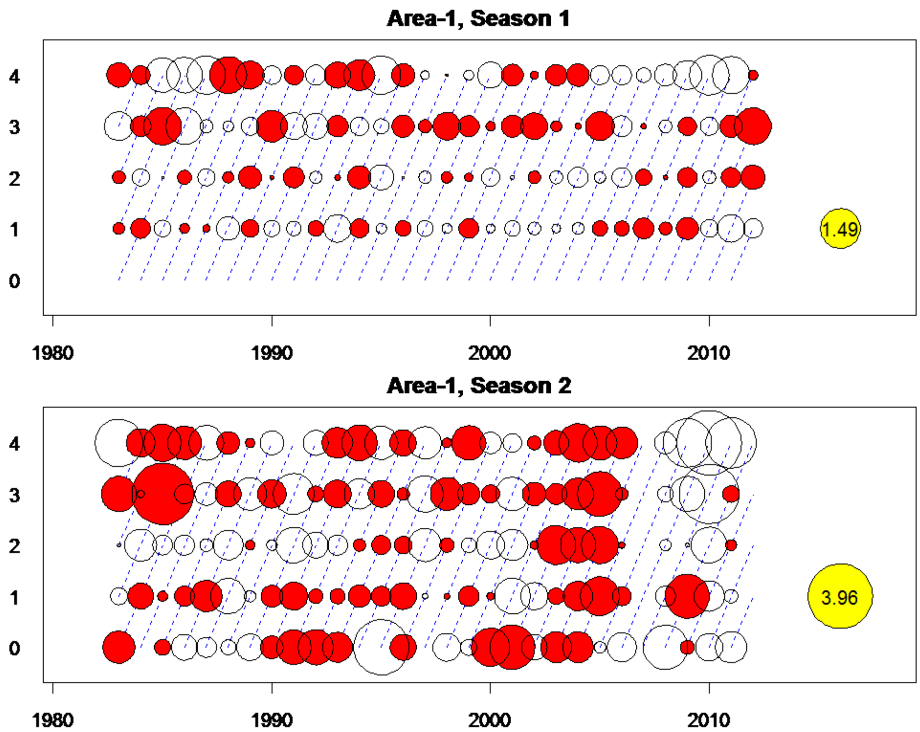


Figure 4.2.6. Sandeel in Area 1. Catch at age residual (log(observed catch) - log(expected catch). 'Red' dots show a positive residual.

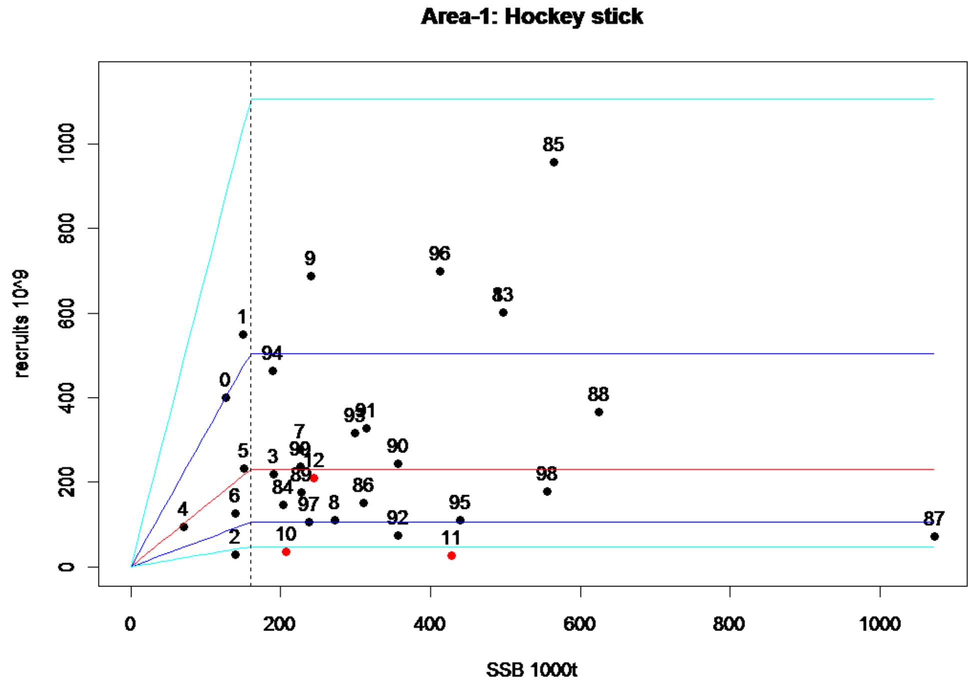


Figure 4.2.7. Sandeel in Area 1. Estimated stock recruitment relation. The 2011 recruitment is highly uncertain and has not been used for the estimation. Red line = median of the expected recruitment, Dark blue lines = one standard deviation, Light blue lines = 2 standard deviations. The area within the light blue lines can be seen as the 95% confidence interval of recruitment.

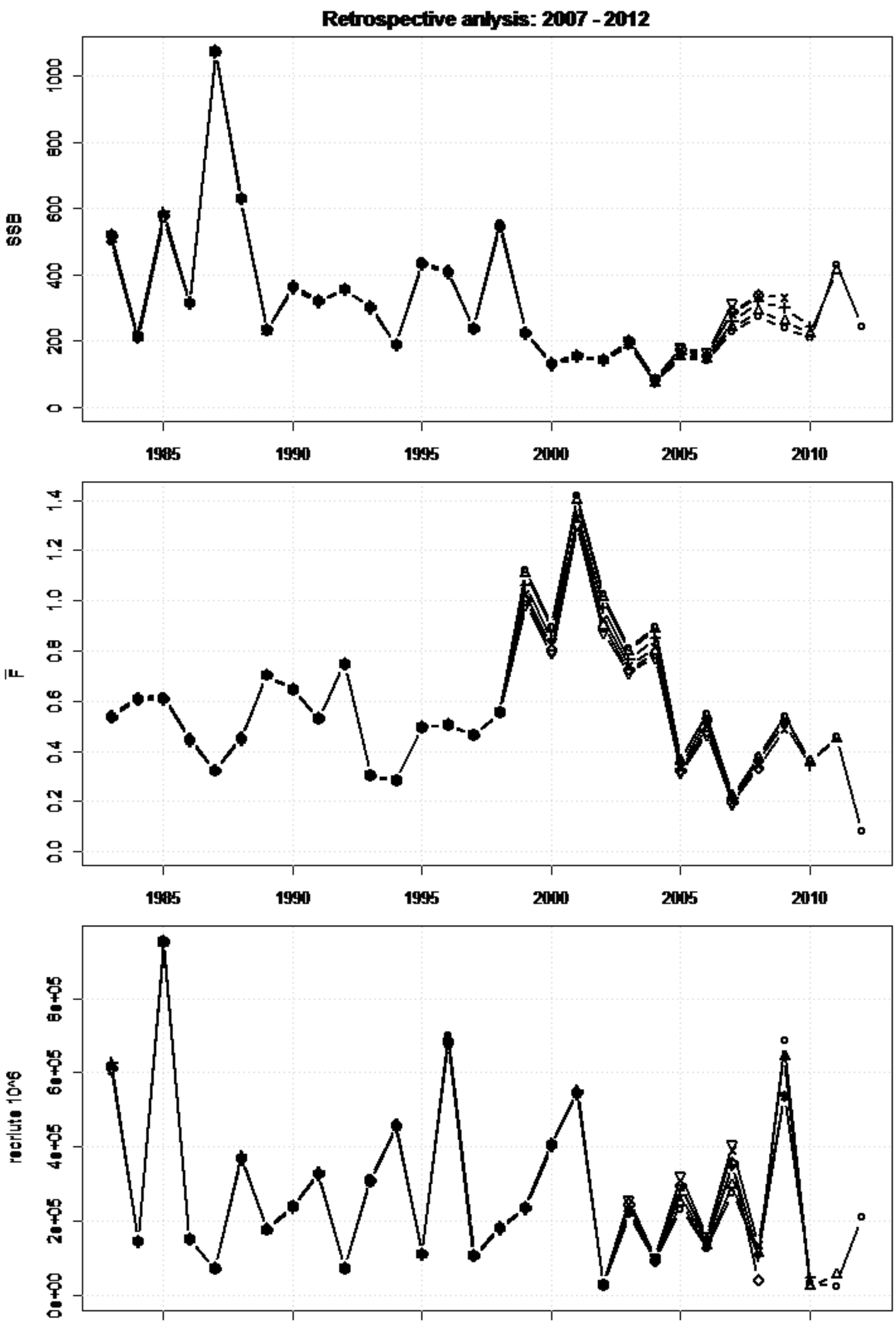


Figure 4.2.8. Sandeel in Area-1. Sandeel retrospective plot.

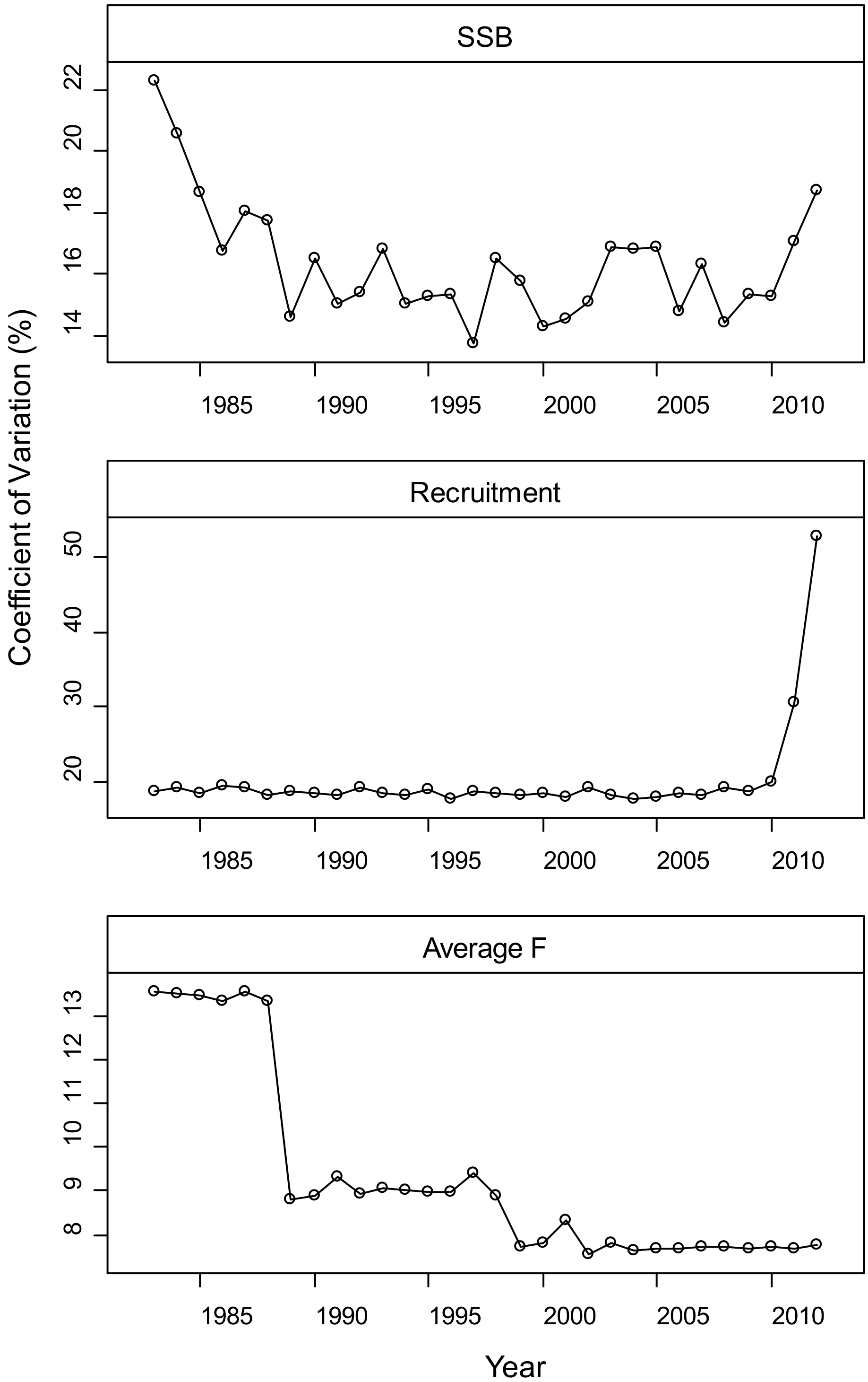


Figure 4.2.9 . Sandeel in Area-1. Uncertainties of model output estimated from parameter uncertainties derived from the Hessian matrix and the delta method.

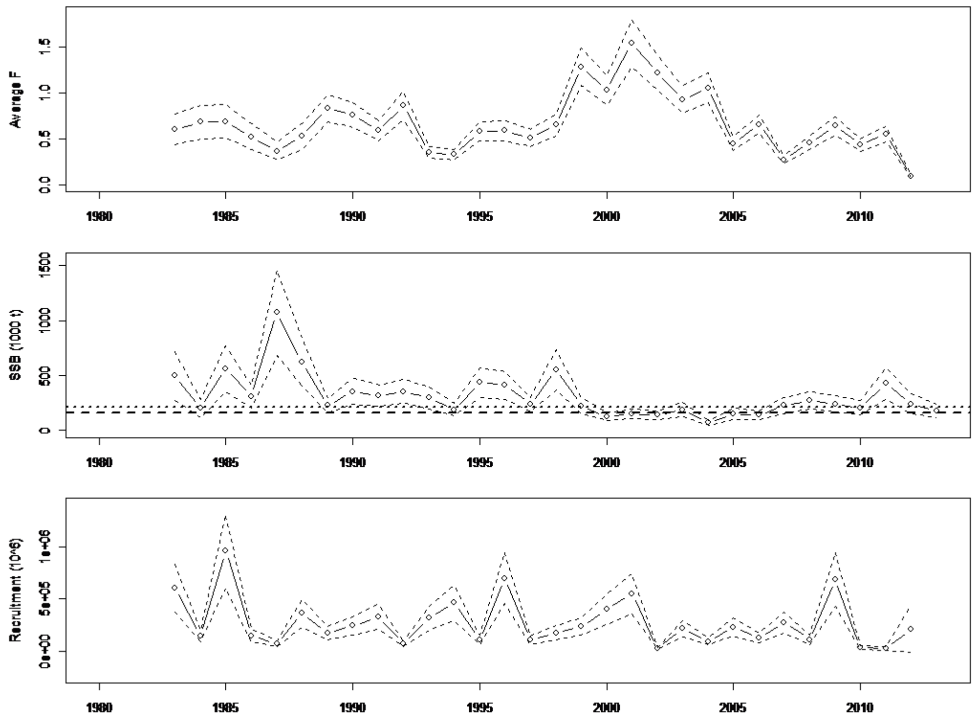


Figure 4.2.10 . Sandeel in Area-1. Model output with mean values and plus/minus 2 * standard deviation.

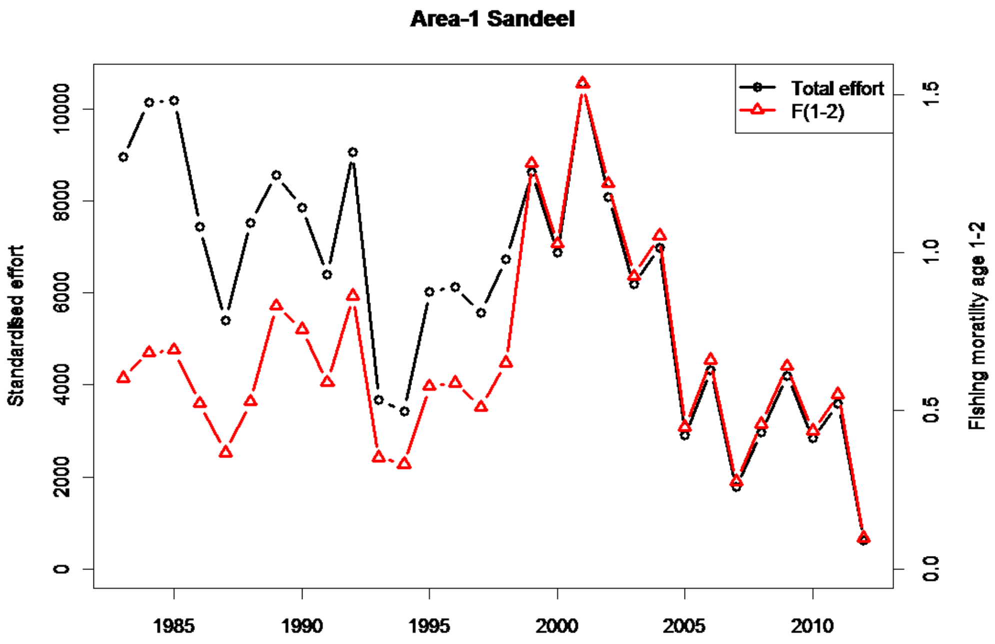


Figure 4.2.11 . Sandeel in Area-1. Total effort (days fishing for a standard 200 GT vessel) and estimated average Fishing mortality.

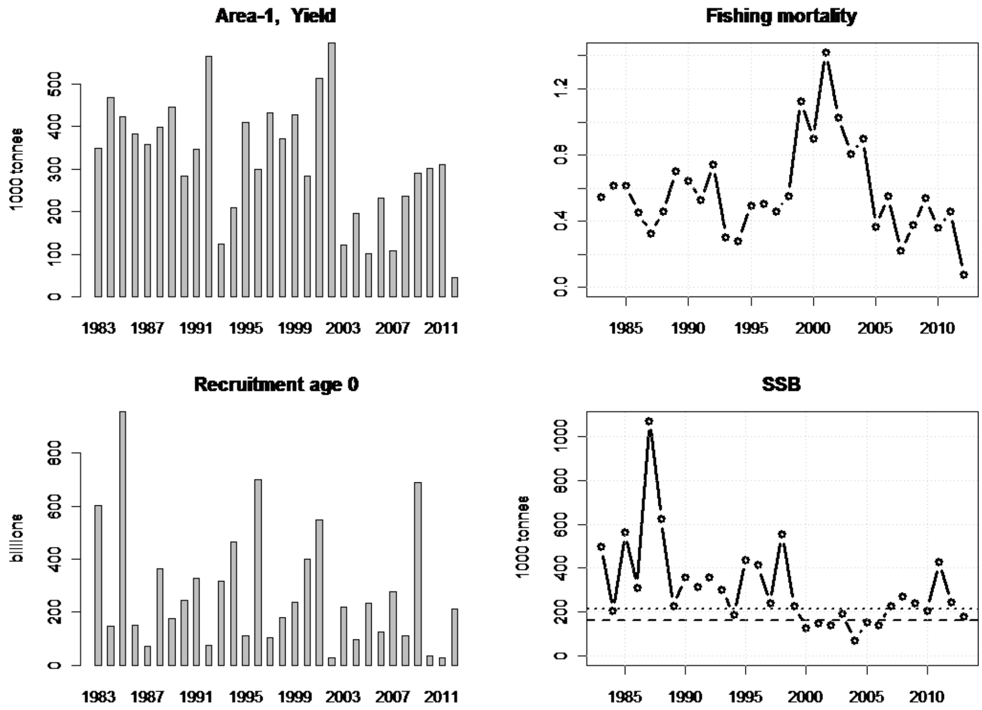


Figure 4.2.12. Sandeel in Area-1. Stock summary.

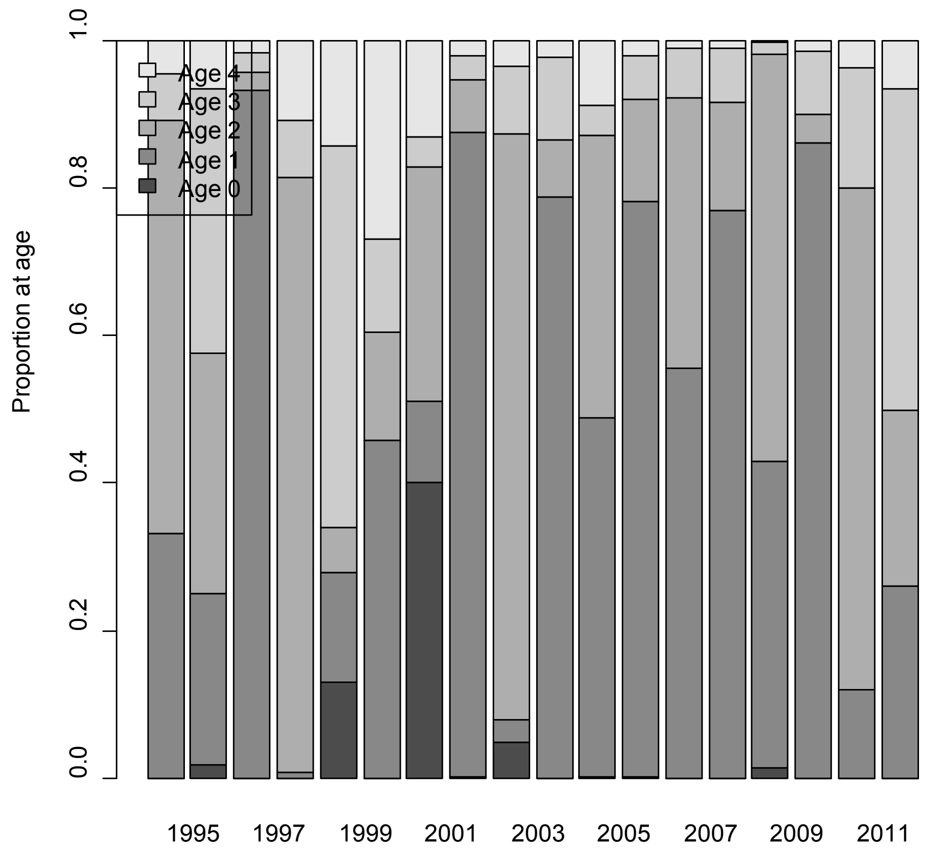
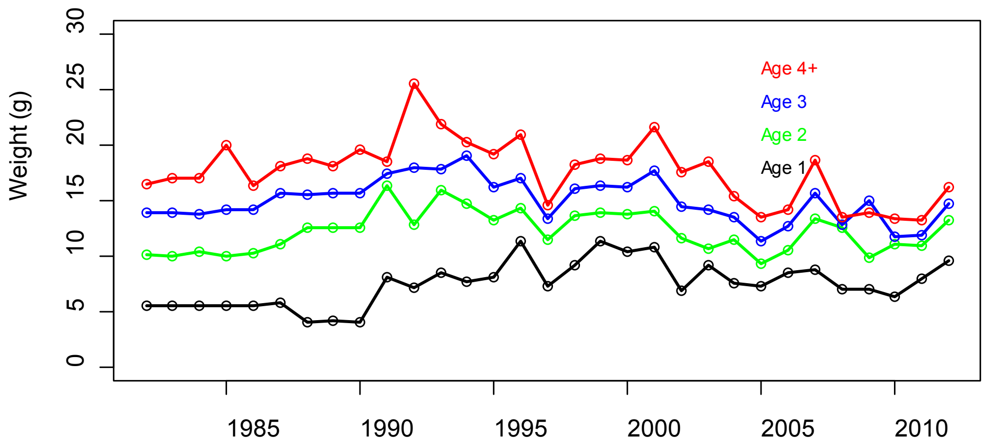


Figure 4.3.1. Sandeel in Area-2. Catch numbers; proportion at age.



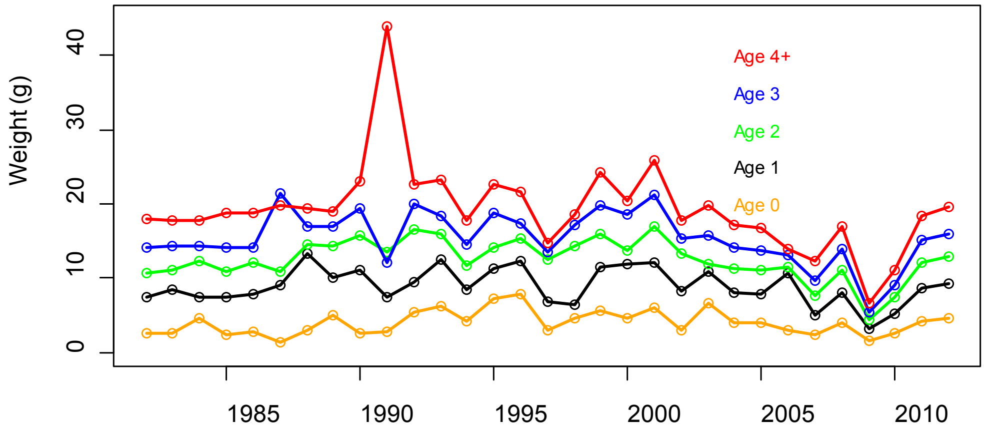


Figure 4.3.2 Sandeel in Area-2. Individual mean weights (g) at age in 1st (upper) and 2nd (lower) half-year.

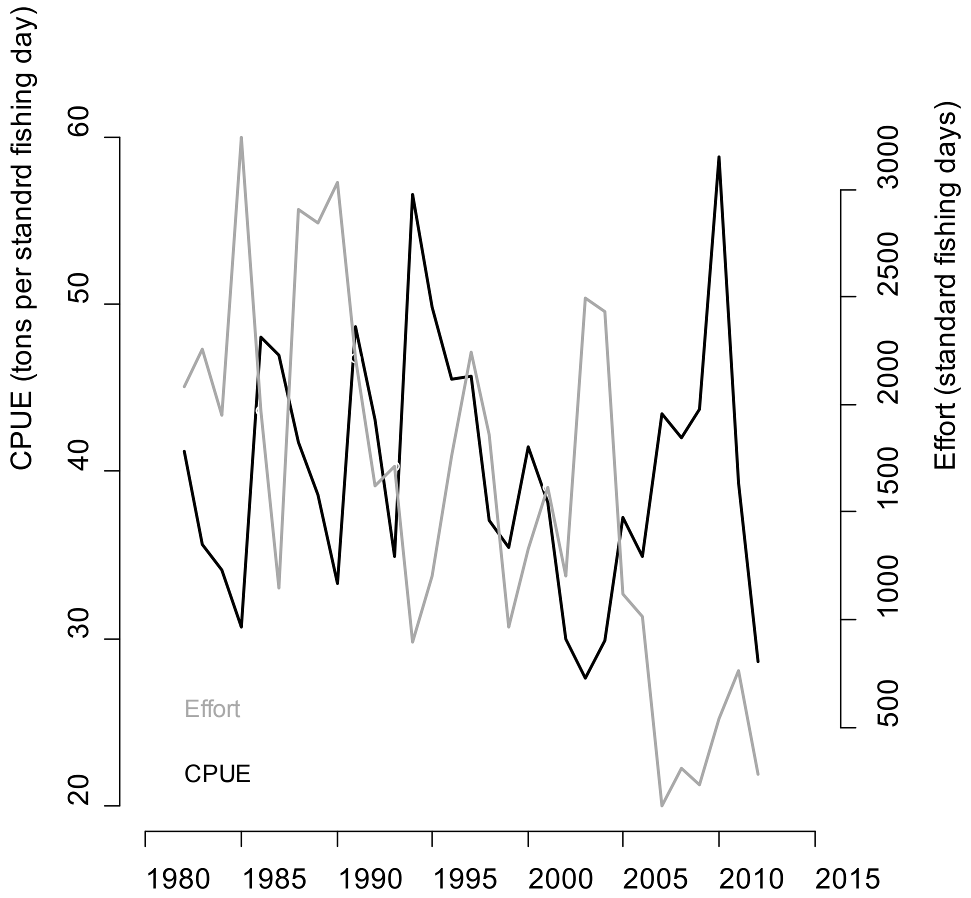


Figure 4.3.3. Sandeel in Area-2. Effort (days fishing for a standard 200 GT vessel) and CPUE (tons per standard fishing day)

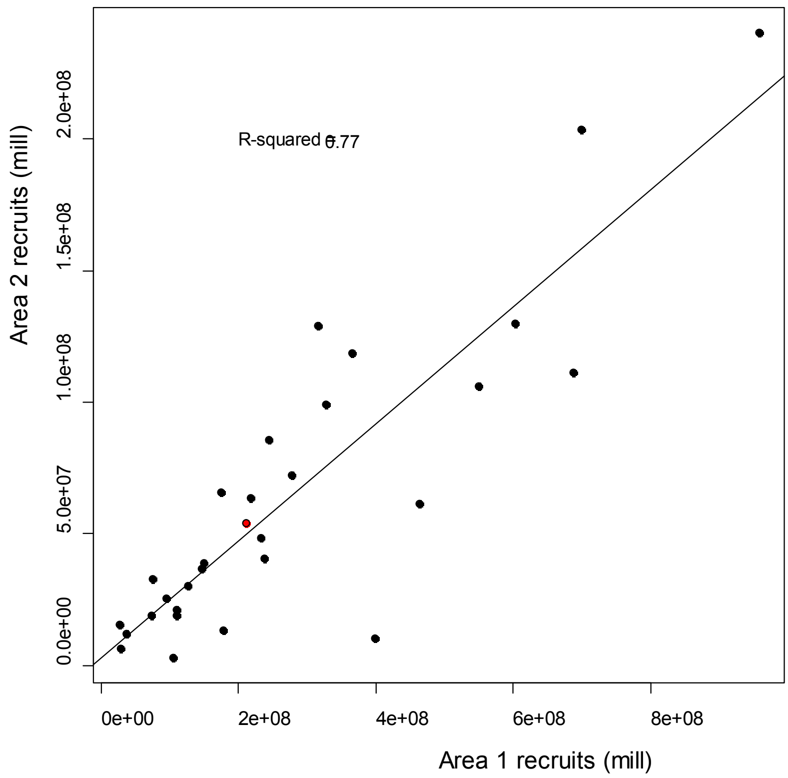


Figure 4.3.4. Sandeel in Area-2. Consistency of recruitments in Area-1 and Area-2

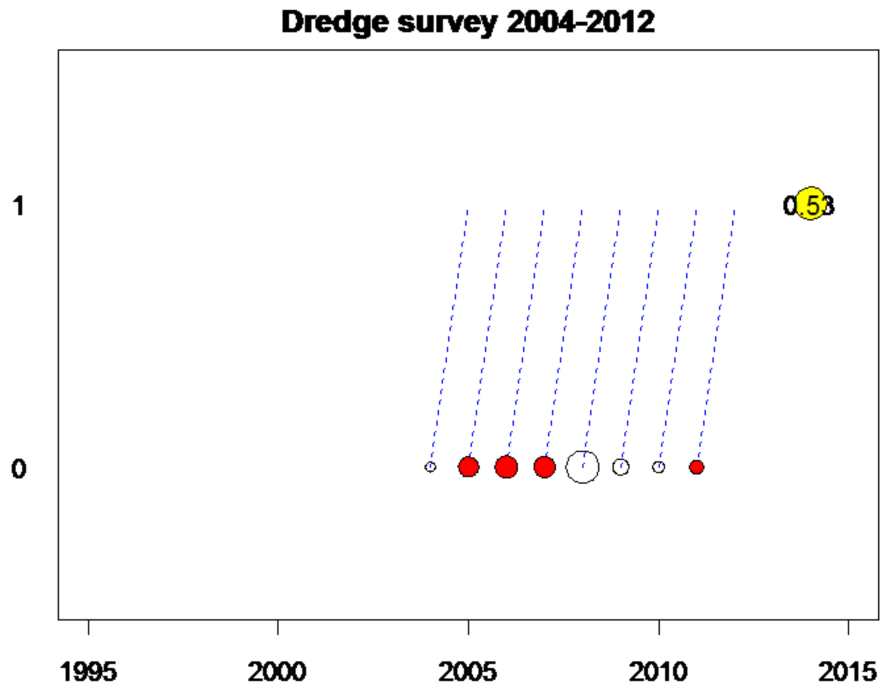


Figure 4.3.5. Sandeel in Area-2. Dredge survey residuals (log(observed CPUE) – log(expected CPUE). Red dots show a positive residual.

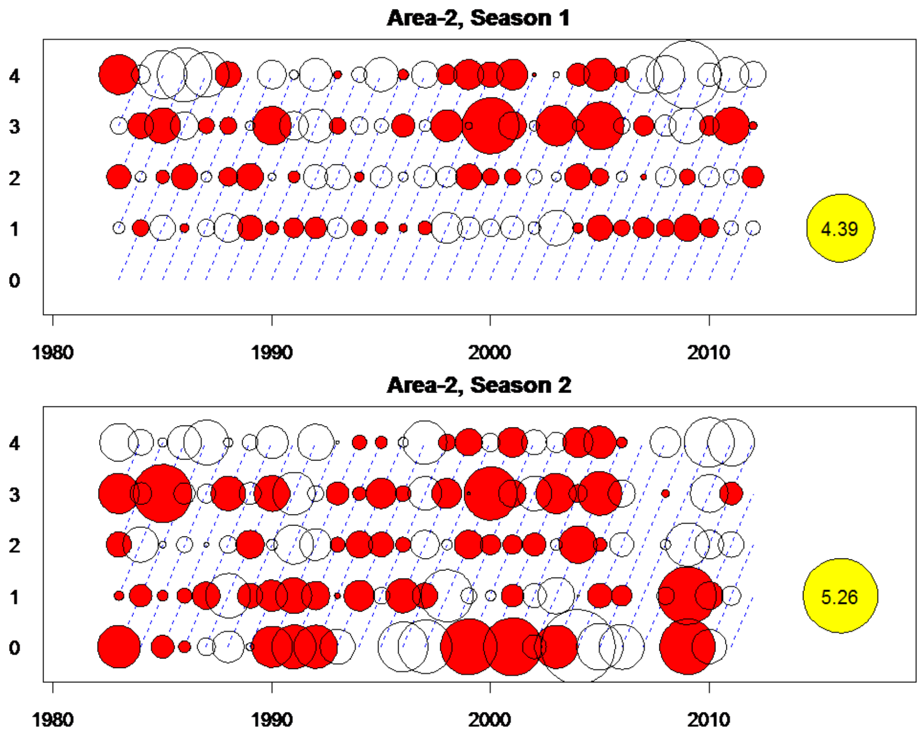


Figure 4.3.6. Sandeel in Area-2. Catch at age residuals (log(observed CPUE) – log(expected CPUE). Red dots show a positive residual.

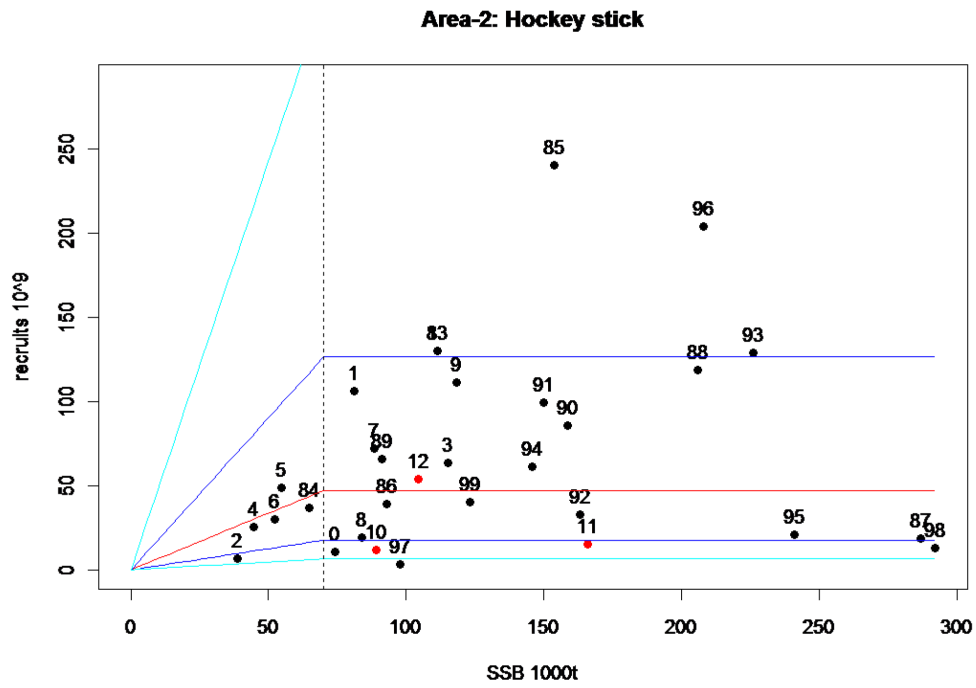


Figure 4.3.7. Sandeel in Area-2. Estimated stock recruitment relation. The 2011 recruitment is highly uncertain and was not used for the estimation. Red line = median of the expected recruitment, Dark blue lines = one standard deviation, Light blue lines = 2 standard deviations. The area within the light blue lines can be seen as the 95% confidence interval of recruitment.

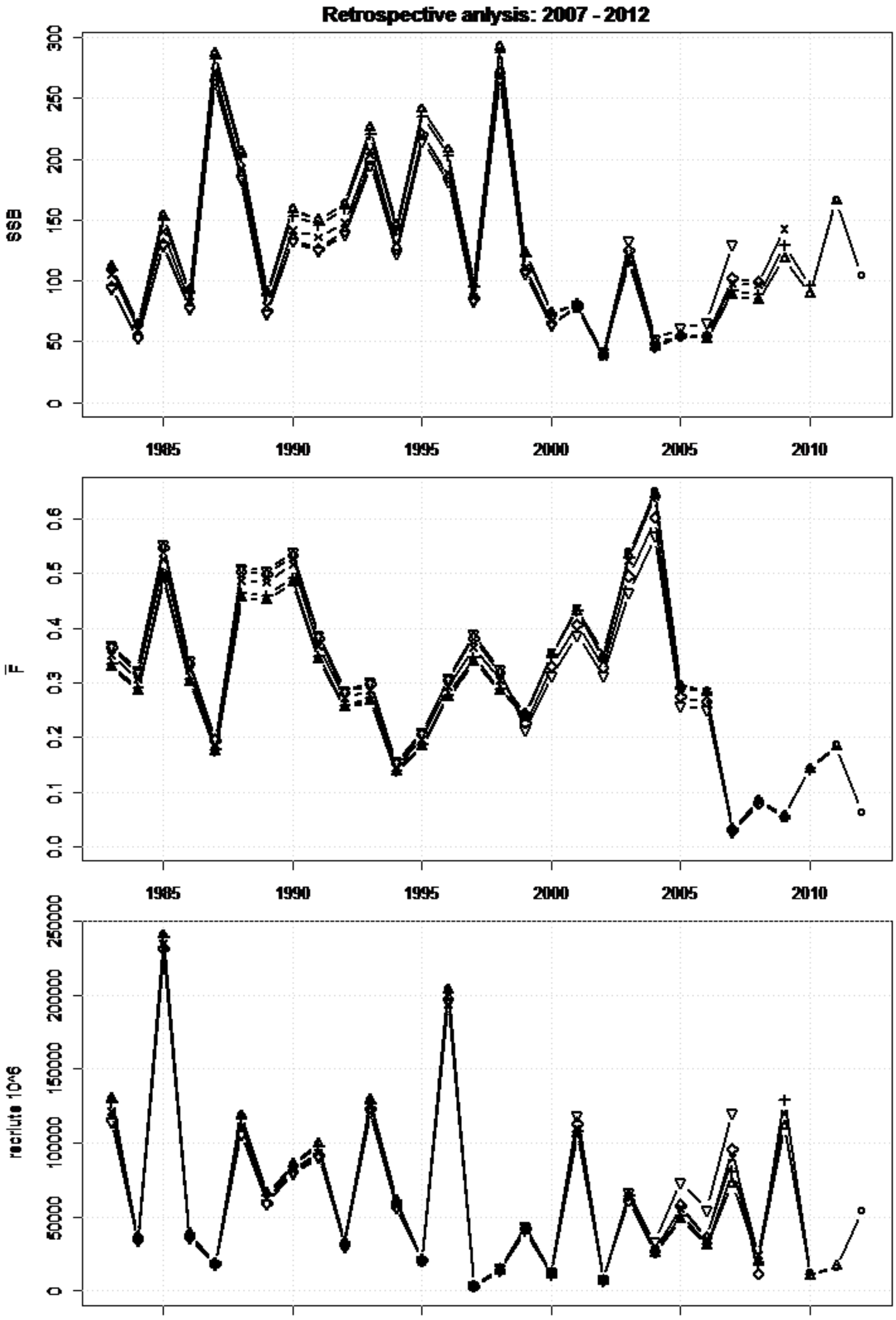


Figure 4.3.8.Sandeel in Area-2. Sandeel retrospective plot..

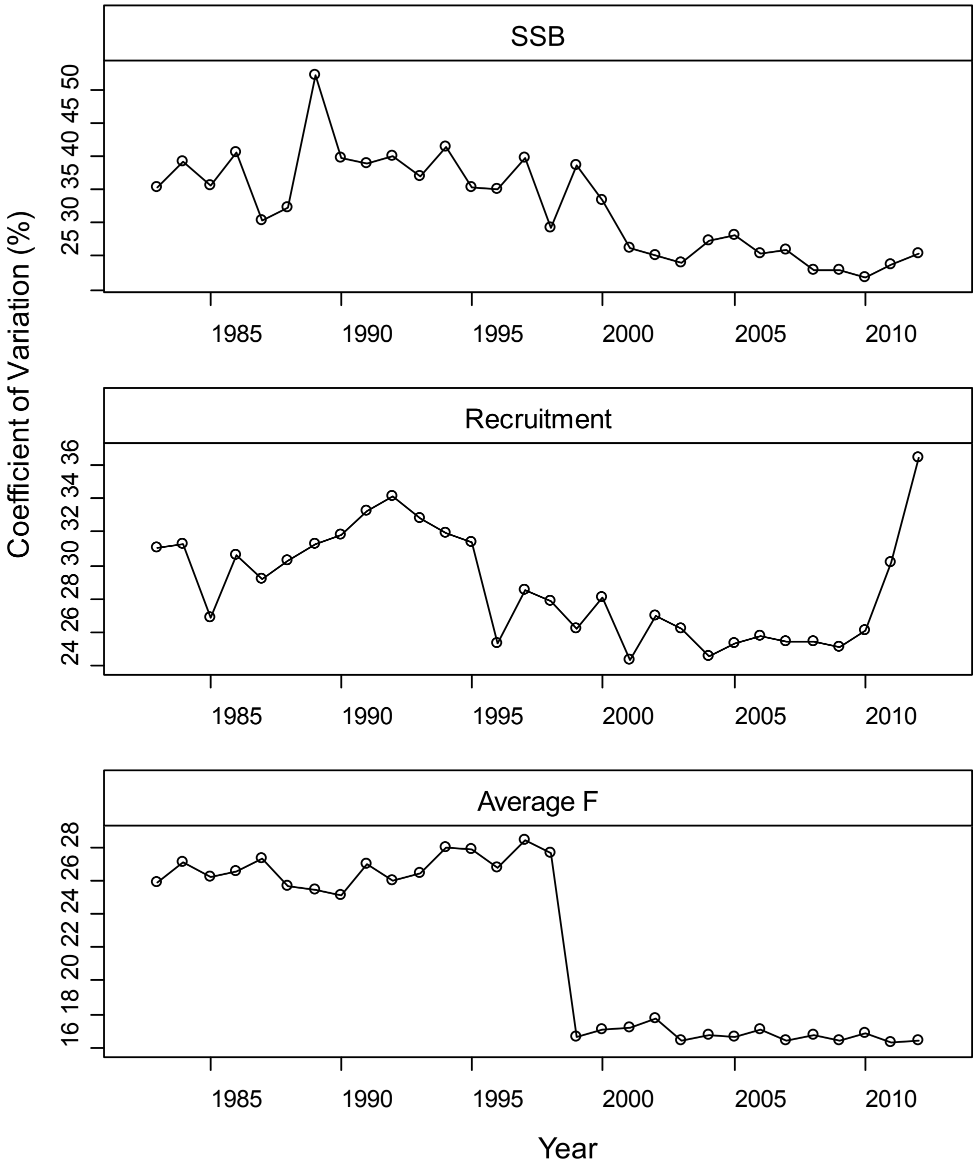


Figure 4.3.9. Sandeel in Area-2. Uncertainties of model output estimated from parameter uncertainties derived from the Hessian matrix and the delta method.

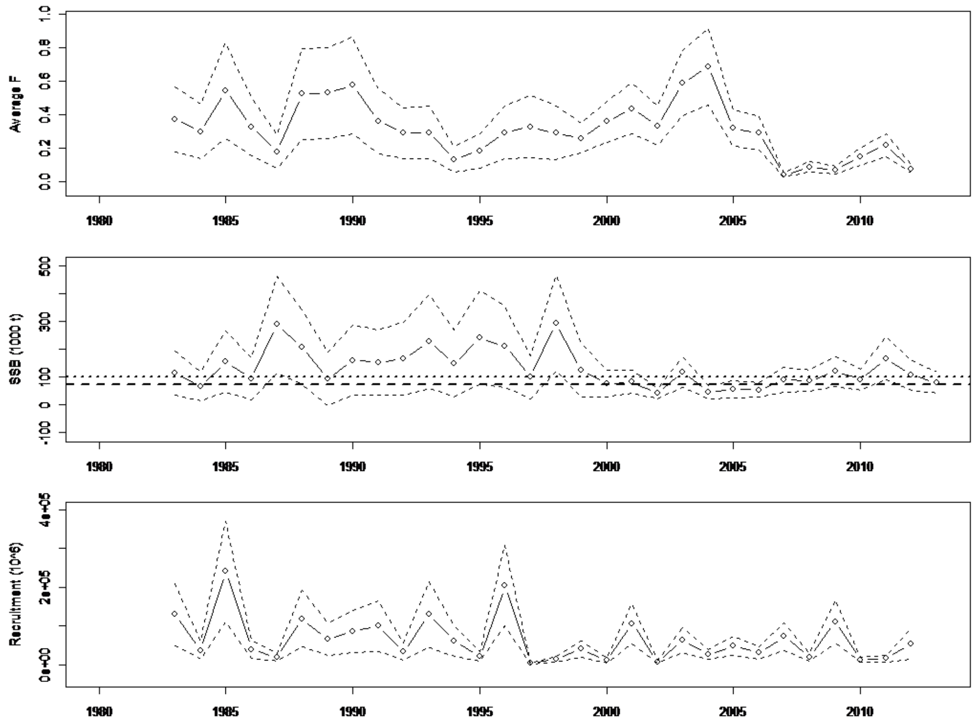


Figure 4.3.10. Sandeel in Area-2. Model output with mean values and plus/minus 2*standard deviation (95% confidence interval).

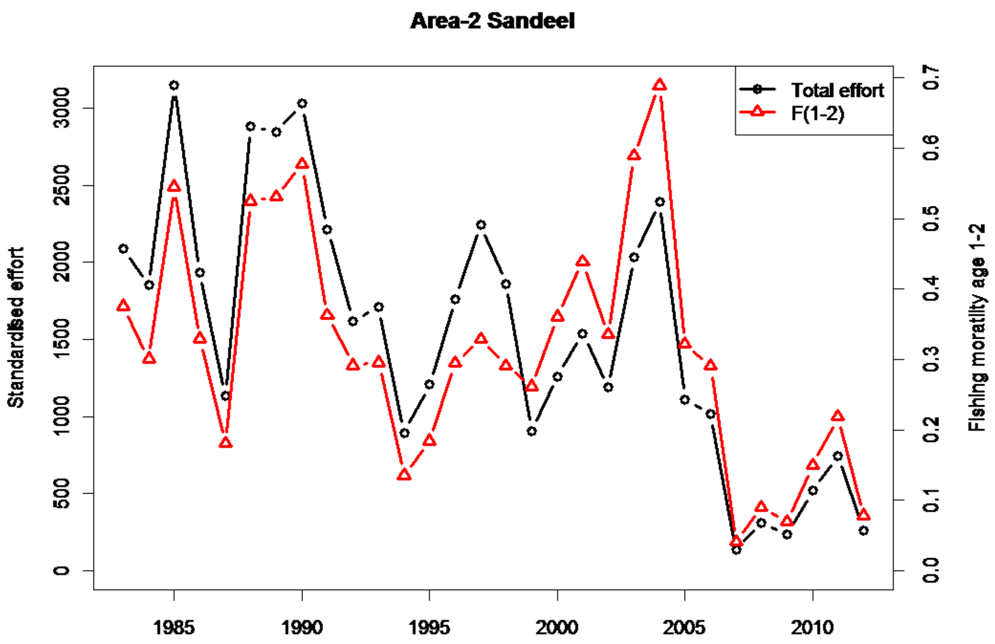


Figure 4.3.11. Sandeel in Area-2. Total effort (days fishing for a standard 200GT vessel) and estimated average Fishing mortality.

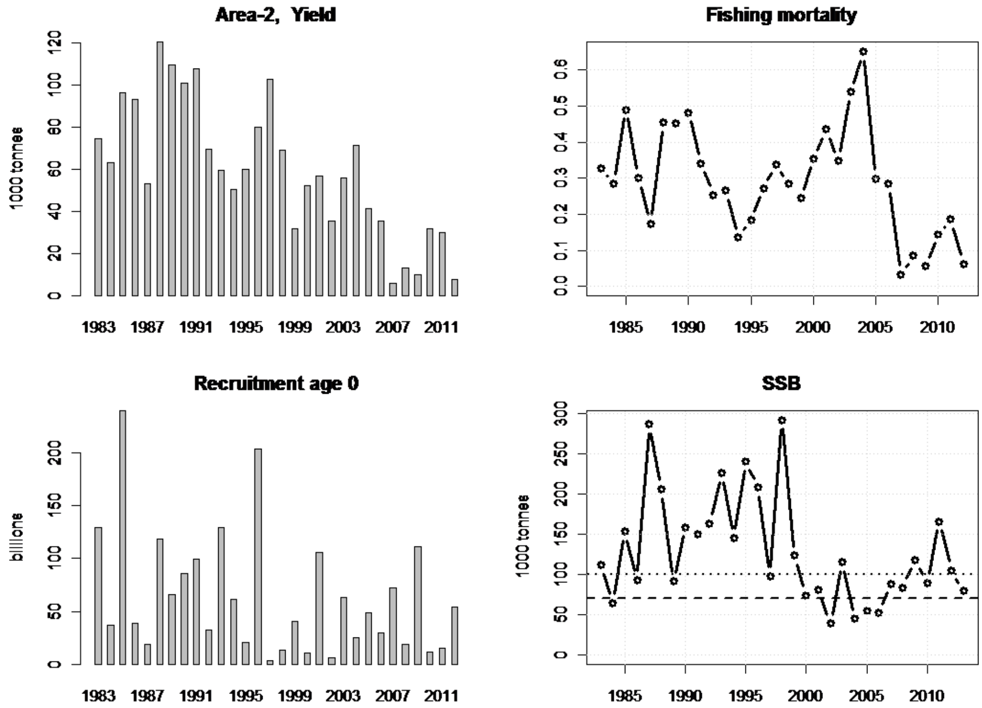


Figure 4.3.12.Sandeel in Area-2. Stock summary.

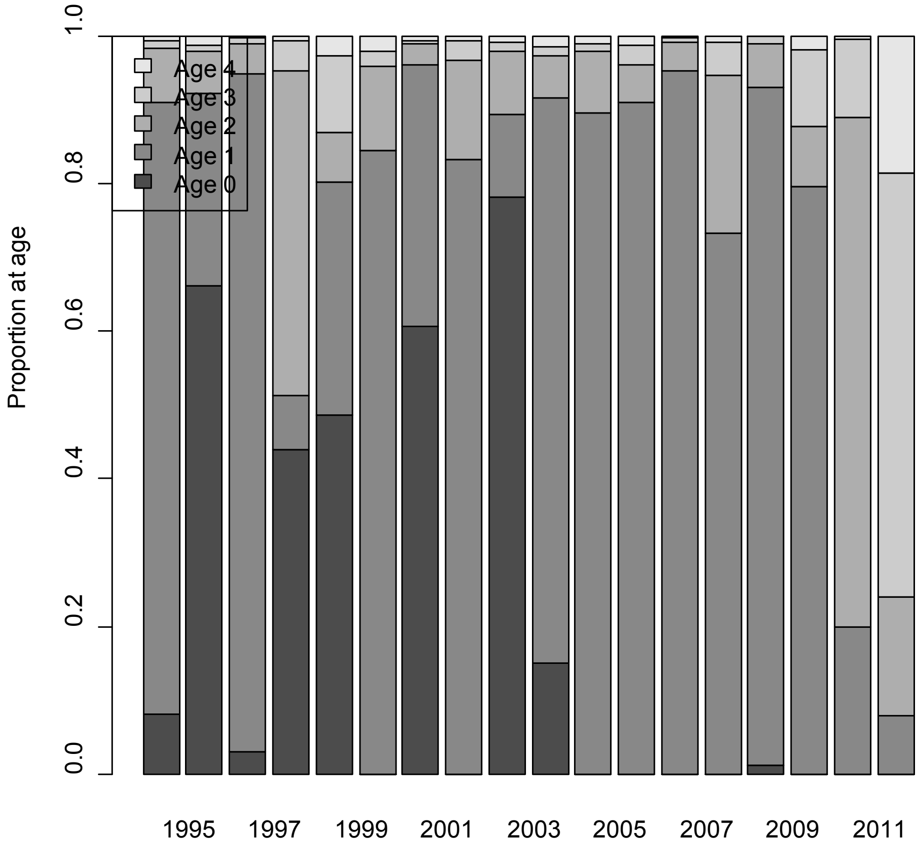
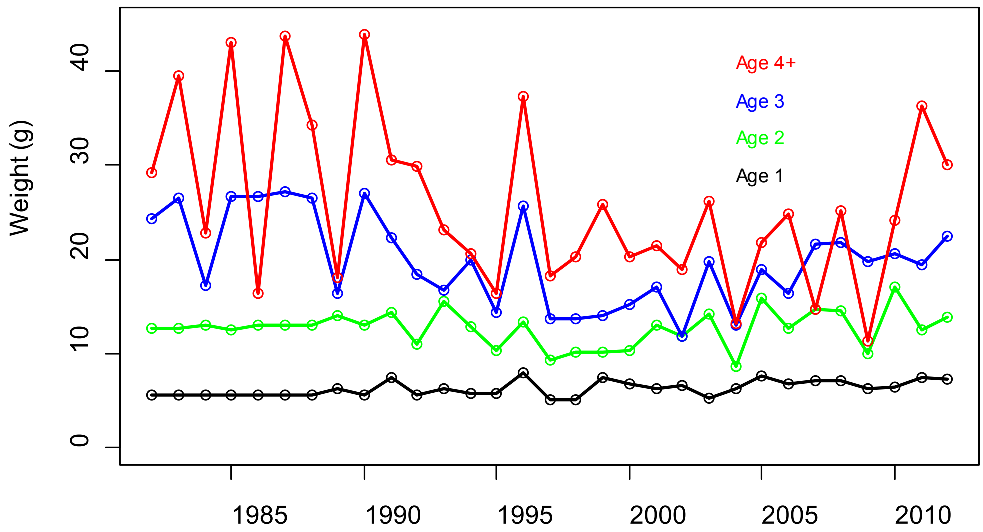


Figure 4.4.1. Sandeel in Area-3. Catch numbers; proportion at age.



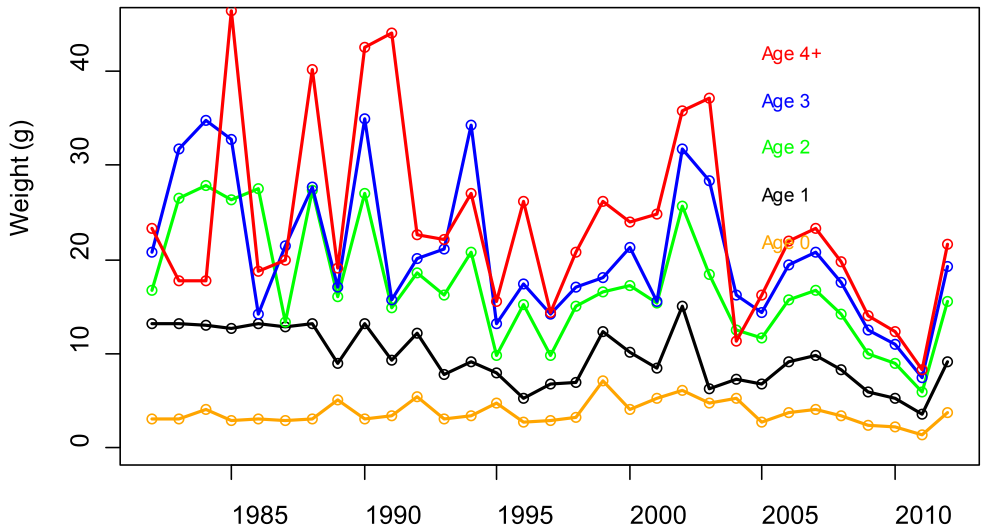


Figure 4.4.2. Sandeel in Area-3. Individual mean weights (g) at age in 1st (upper) and 2nd (lower) half-year.

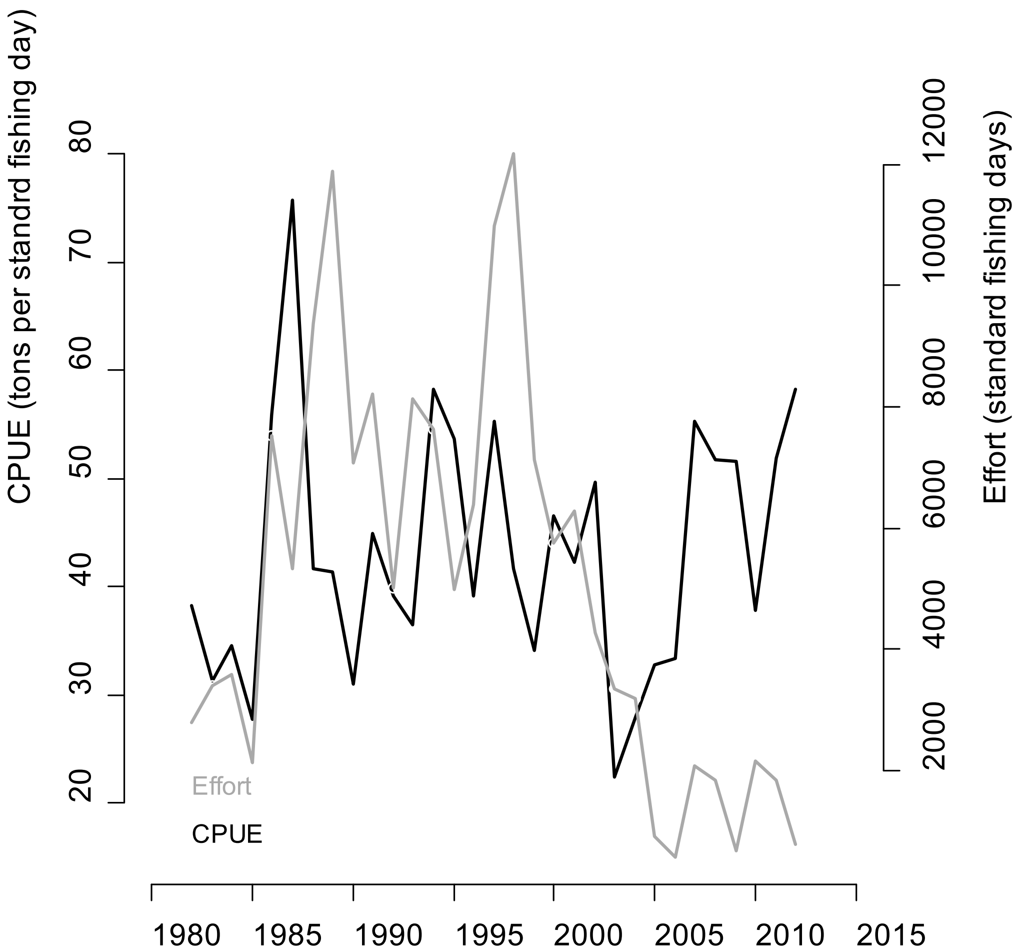


Figure 4.4.3. Sandeel in Area-3. Effort (days fishing for a standard 200 GT vessel) and CPUE (tons per standard fishing day).

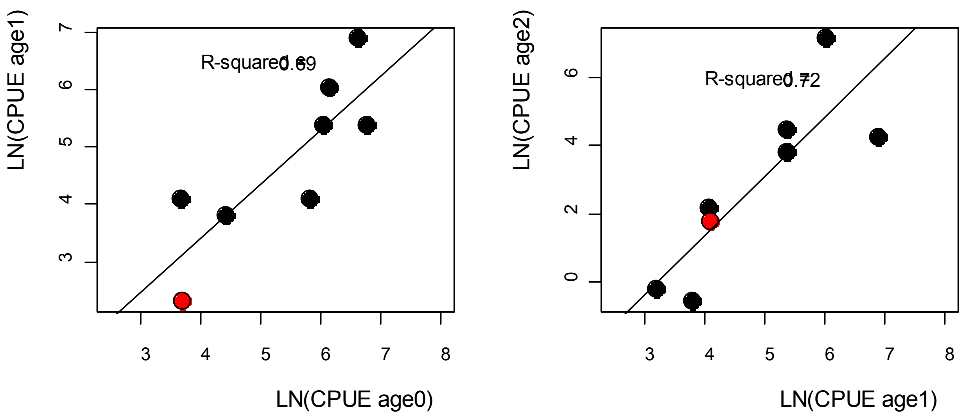


Figure 4.4.4. Sandeel in Area 3. Internal consistency by age of the Danish dredge survey. Red dot indicates most recent data point.

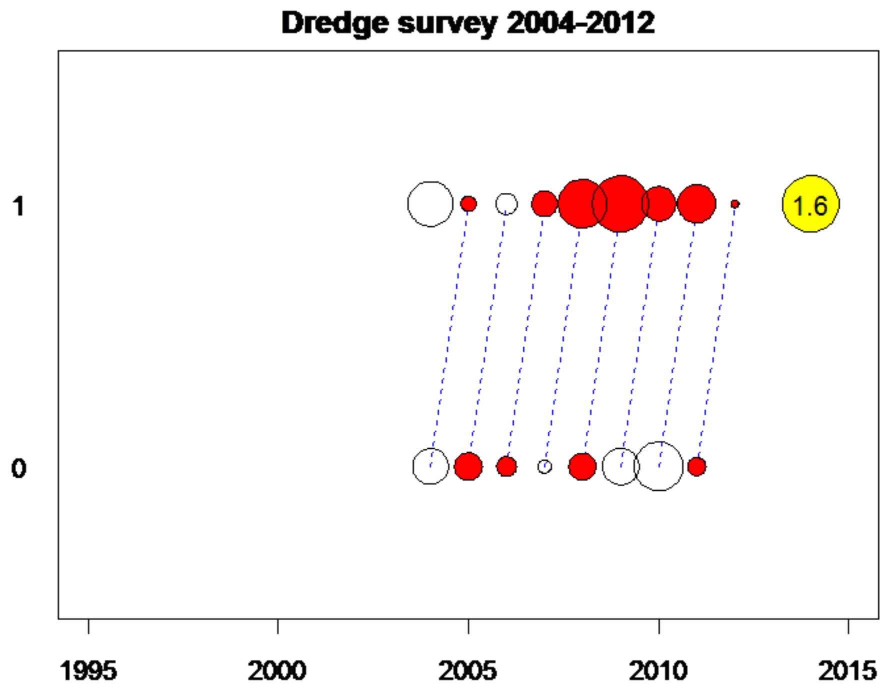


Figure 4.4.9. Sandeel in Area-3. Dredge survey residuals (log(observed CPUE) – log(expected CPUE). Red dots show a positive residual.

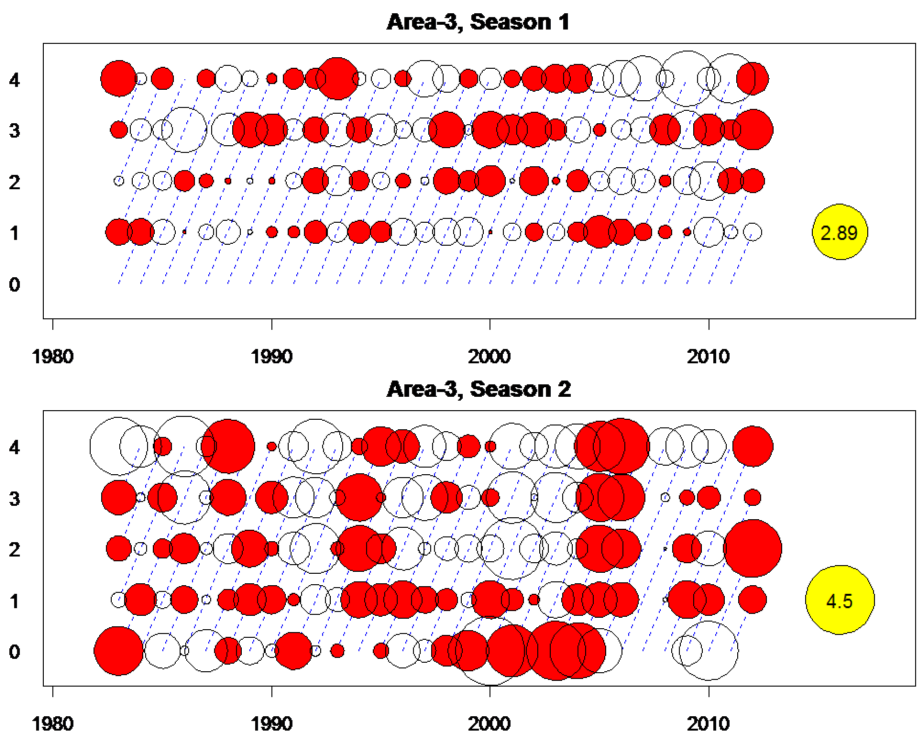


Figure 4.4.10.Sandeel in Area-3. Catch at age residuals (log(observed CPUE) – log(expected CPUE). Red dots show a positive residual.

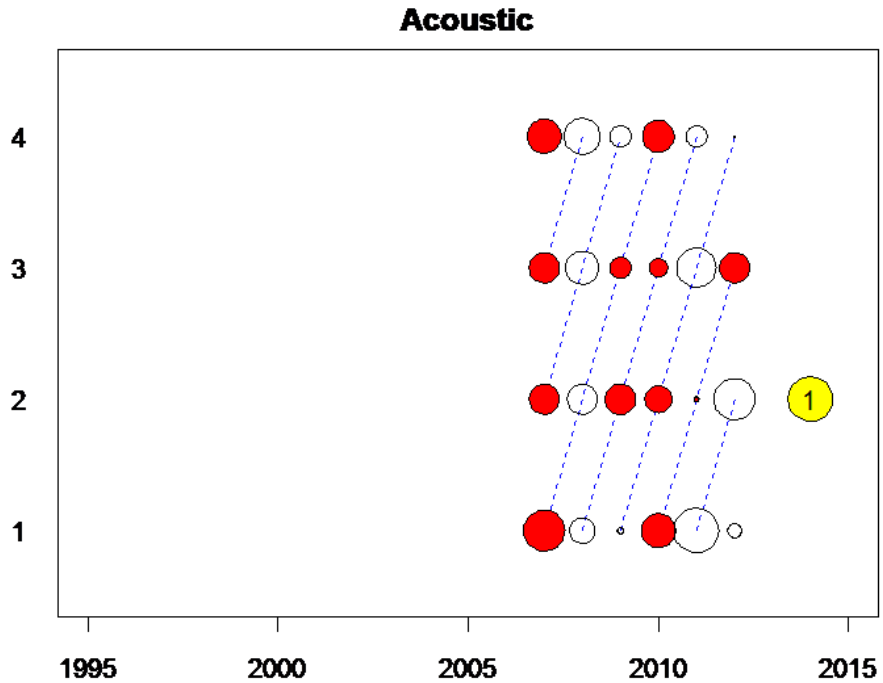


Figure 4.4.11. Sandeel in Area-3. Explorative assessment: Assessment run with both NO acoustic survey index and DK dredge index. Dredge survey residuals (log(observed CPUE) – log(expected CPUE). Red dots show a positive residual.

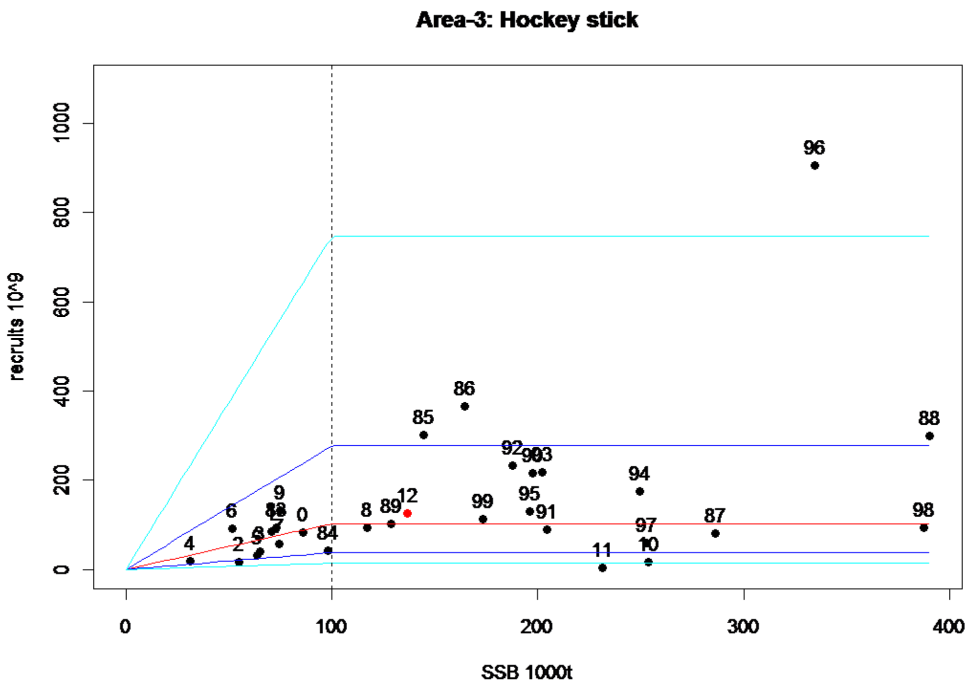


Figure 4.4.12. Sandeel in Area-3. Estimated stock-recruitment relation. The 2011 recruitment is highly uncertain and was not used in the estimation. Red line = median of the expected recruitment, Dark blue lines = one standard deviation, Light blue lines = 2 standard deviations. The area within the light blue lines can be seen as the 95% confidence interval of recruitment.

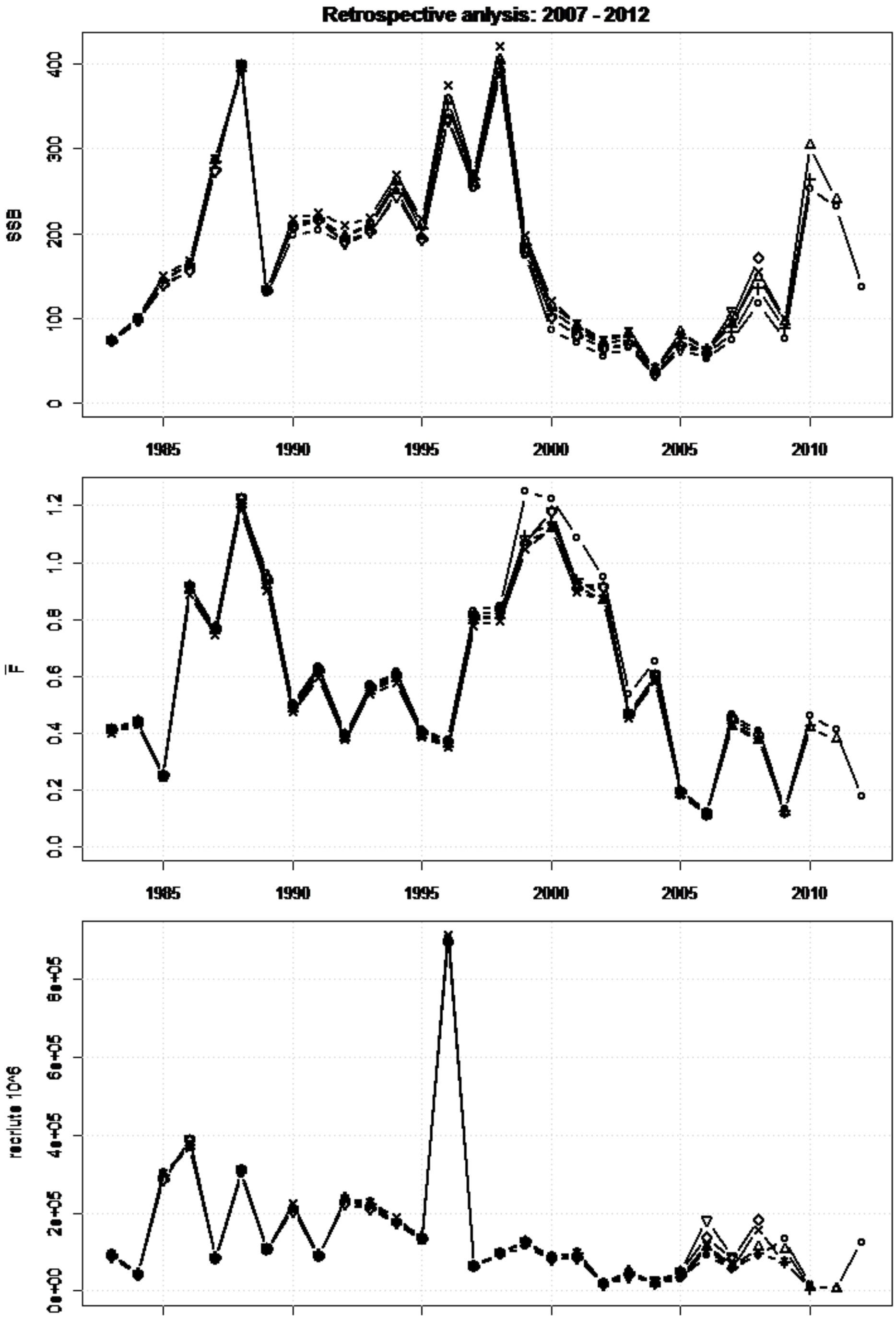


Figure 4.4.13. Sandeel in Area-3. Sandeel retrospective plot.

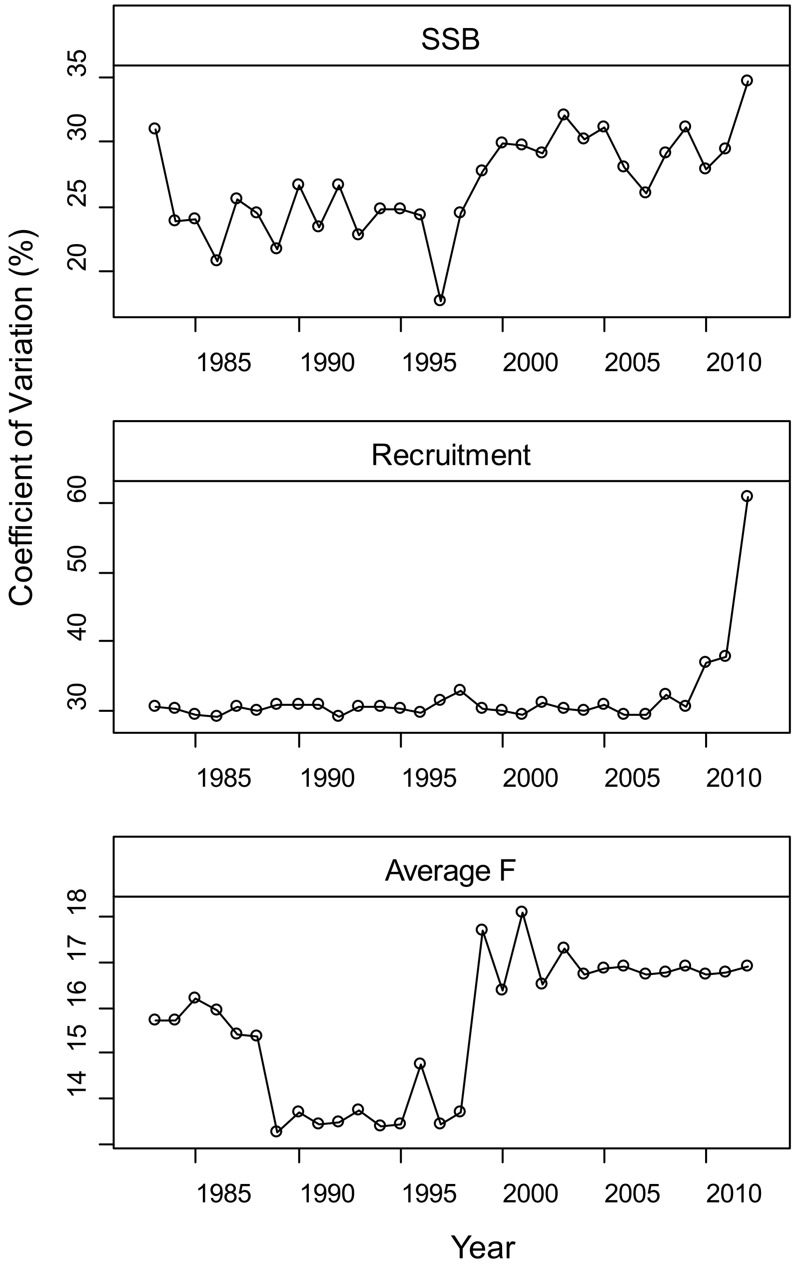


Figure 4.4.14. Sandeel in Area-3. Uncertainties of model output estimated from parameter uncertainties derived from the Hessian matrix and the delta method.

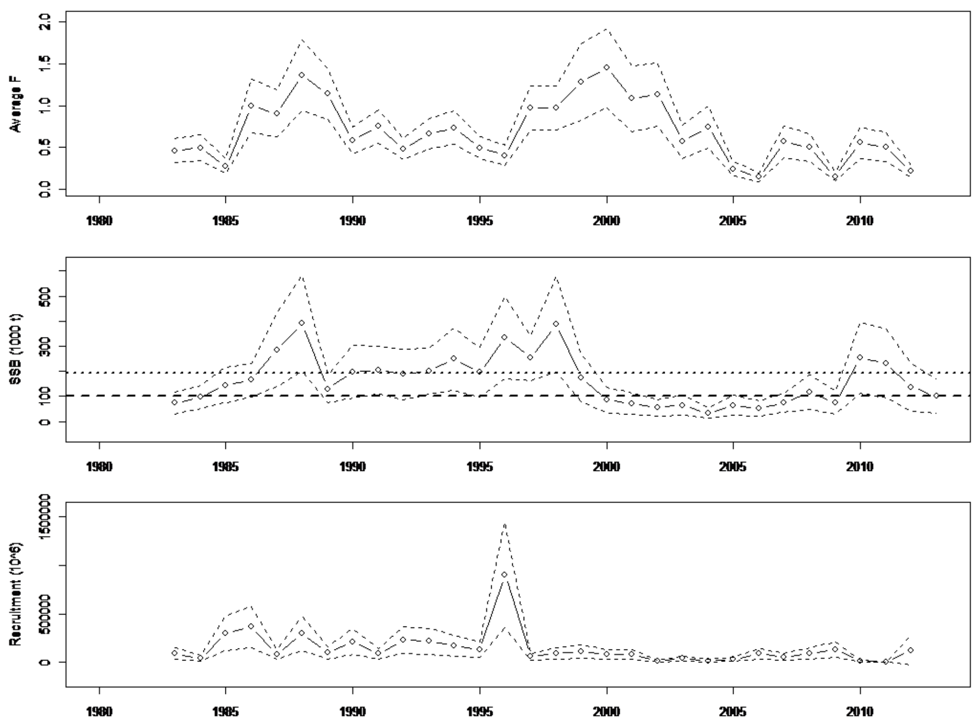


Figure 4.4.15. Sandeel in Area-3. Model output with mean values and plus/minus 2*standard deviation.

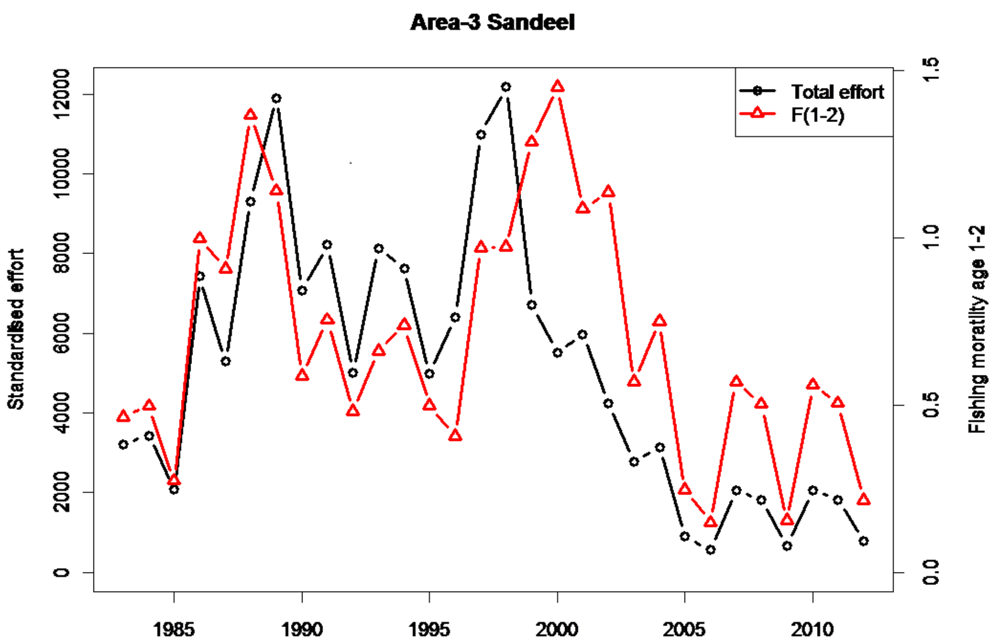


Figure 4.4.16. Sandeel in Area-3. Total effort (days fishing for a standard 200GT vessel) and estimated average Fishing mortality.

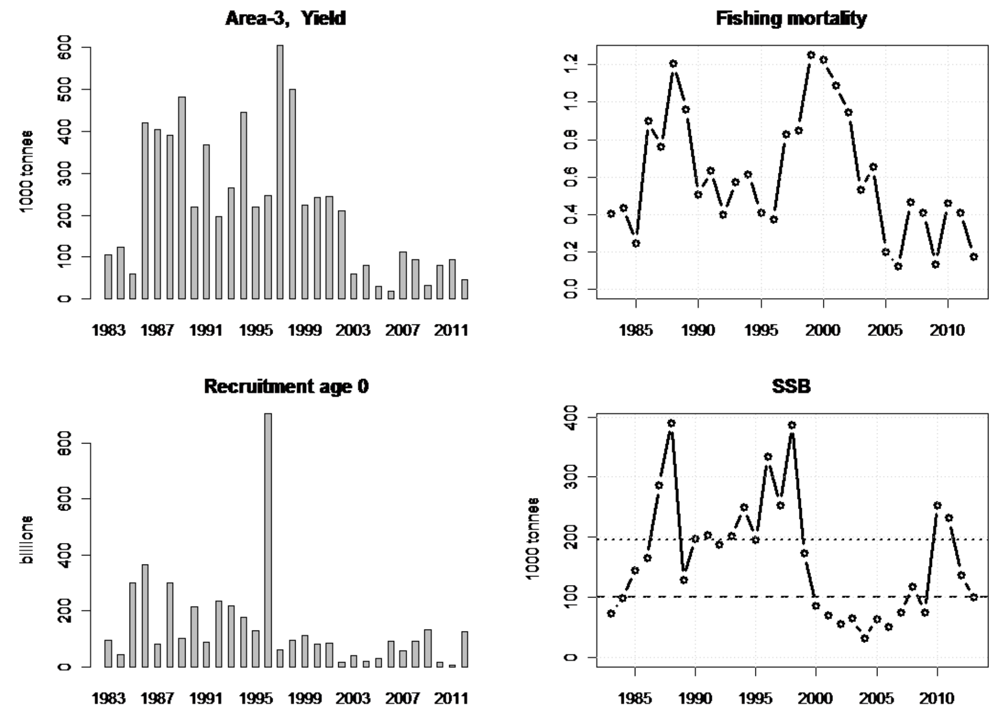


Figure 4.4.17. Sandeel in Area-3. Stock summary.

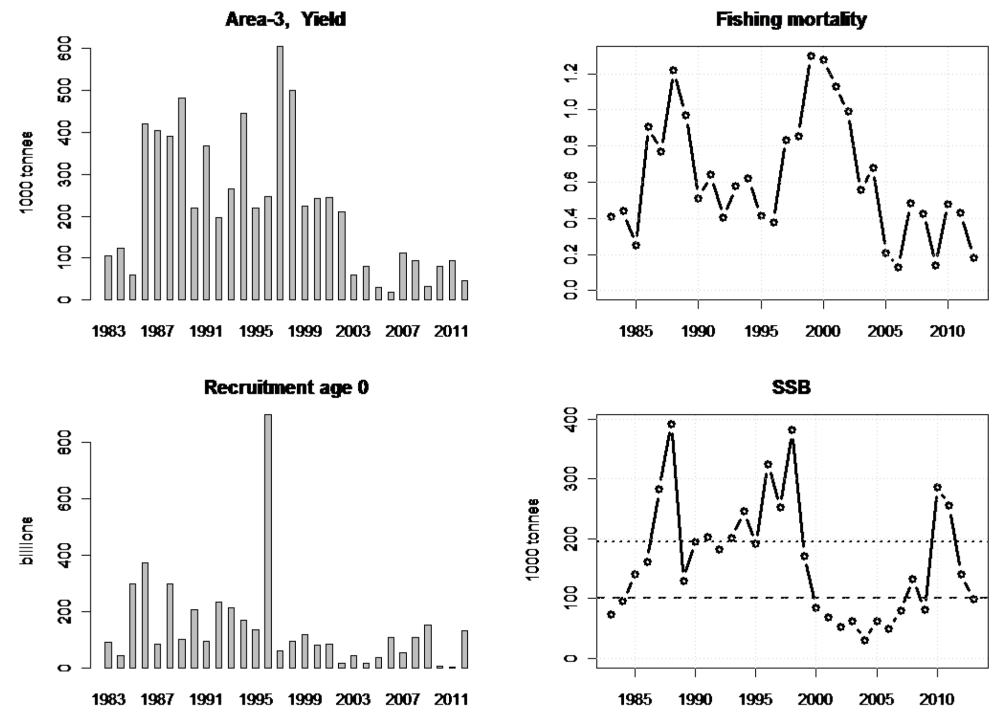
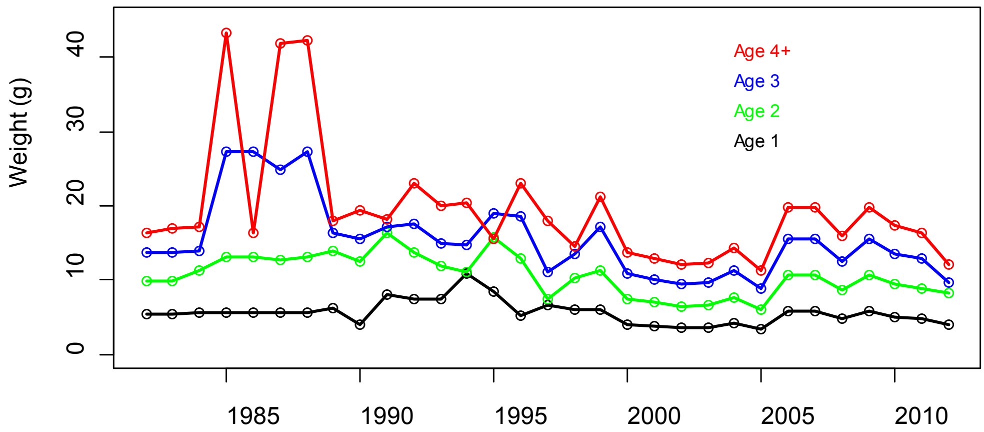


Figure 4.4.18. Sandeel in Area-3. Explorative assessment: Assessment run with both NO acoustic survey index and DK dredge index. Stock summary.



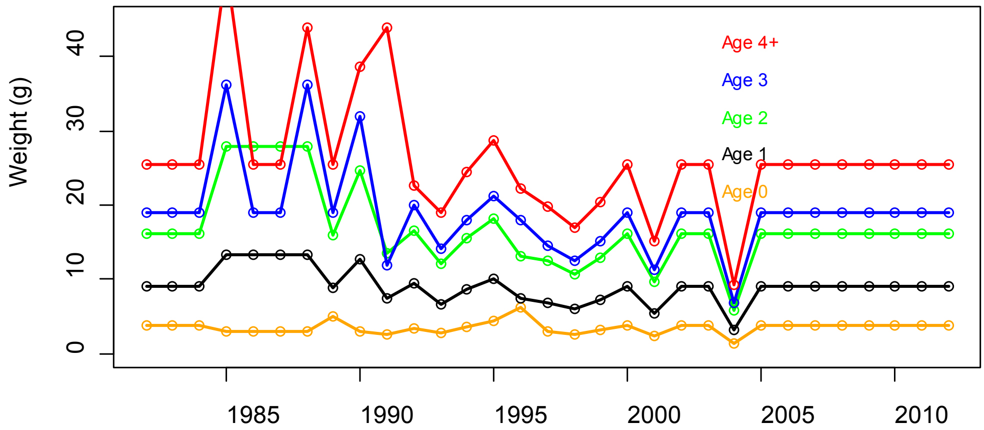


Figure 4.5.1 Sandeel in Area-4. Individual mean weights (g) at age in 1st (upper) and 2nd (lower) half-year.

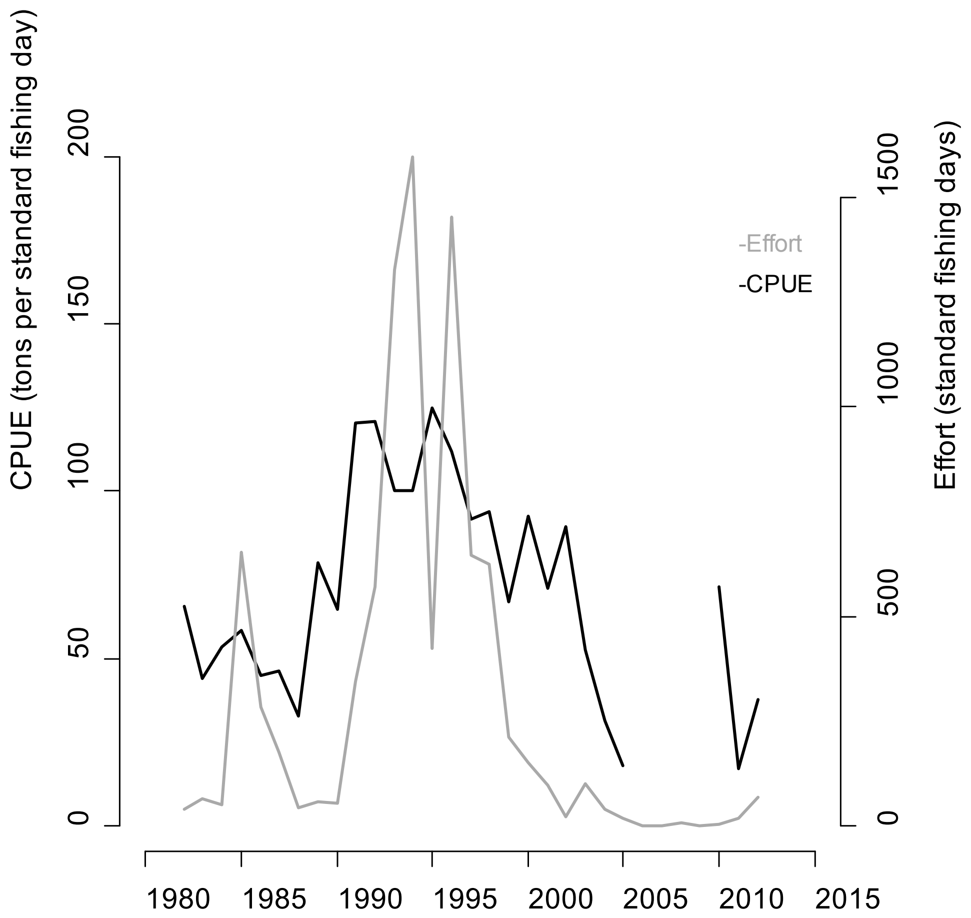


Figure 4.5.2.Sandeel in Area-4. Effort (days fishing for a standard 200GT vessel) and CPUE(tons per standard fishing day).

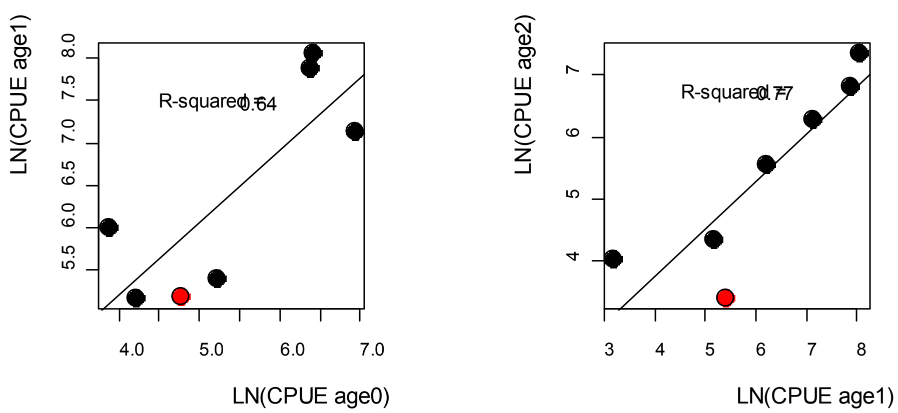


Figure 4.5.3. Internal consistency plot. Average dredge CPUE of consecutive ages from the same year-class for Firth of Forth samples. Red dot indicates most recent data point.

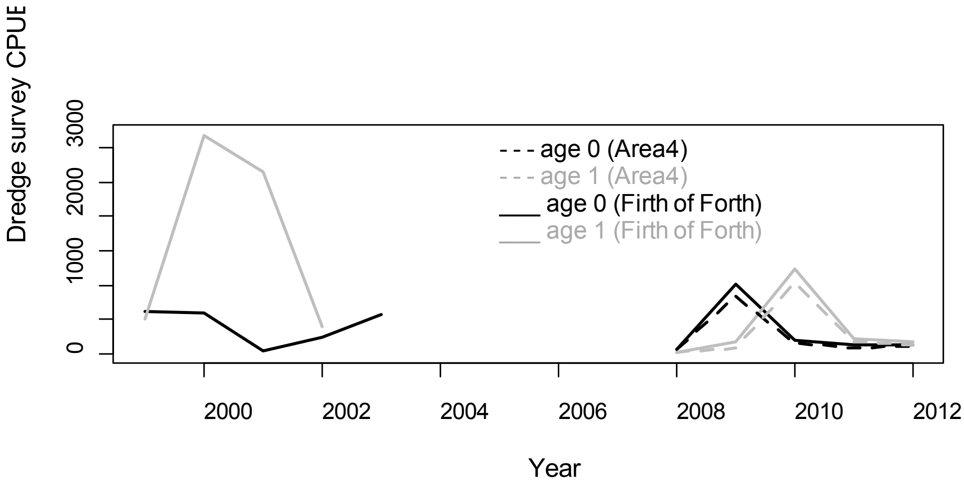


Figure 4.5.3. Dredge survey CPUE for Area 4 and Firth of Forth.

12 Stocks with limited data

Three herring stocks have very little data associated with them and have been poorly described in recent reports. These are Clyde herring, part of Division VIaN (Section 5.11 in ICES 2005a), herring in VII ,f and herring in the Bay of Biscay (Sub-area VIII). In this section only the times series of landings are maintained.

Clyde herring

In 2011 under the provisions of the TAC and Quota Regulations (57/2011), the European Commission delegated the function of setting the TAC for certain stocks which are only fished by one Member State, to that Member State. This provision currently applies to herring in the Firth of Clyde with TAC setting responsibility delegated to Scotland. The stock is as such not an ICES stock with limited data, but it has been decided to continue to display the updated historical landings table for reasons of continuity. Since 1998 the agreed TAC for Clyde herring has never been reached. The landings for 2012 were 303 tonnes which was again well below the TAC of 720 tonnes (Table 12.1).

Division VIIe,f

Figure 12.1 shows time series of landings over the period 1974-2012 in VIIe and VIIf. Data taken from the FISHSTAT database, were adjusted, where possible, with data supplied by working group members and from ICES official catch statistics.

Since 1999, landings in Division VIIe are stable and have fluctuated between 5 and 800 t except in 2005 and 2008 where they reached more than 1000 t

In VIIf, it can be seen that there was a pulse of landings in the late 1970s.

Since then landings have fluctuated between 50 and 200 t in recent years, without any obvious trend (Table 12.2).

Subarea VIII (Bay of Biscay)

In the Bay of Biscay, French landings peaked at 1 700 t in 1976, declining gradually to very low levels by the late 1980s. More recently there was a sudden peak pulse of Dutch landings of 8 000 t in 2002, declining to low levels since (Figure 12.2, Table 12.3). Data before 2005 were taken from the FISHSTAT database, and data from Spain updated. Data for later years were adjusted, where possible, with data supplied by working group members and from ICES official catch statistics.

Table 12.1 Herring from the Firth of Clyde. Catch in tonnes by country, 1957–2012. Spring and autumn-spawners combined.

Year	**1957**	**1958**	**1959**	**1960**	**1961**	**1962**	**1963**	**1964**	**1965**	**1966**	**1967**	**1968**	**1969**	**1970**
All Catches														
Total	5 915	4 926	10 530	15 680	10 848	3 989	7 073	14 509	15 096	9 807	7 929	9 433	10 594	7 763

Year	**1971**	**1972**	**1973**	**1974**	**1975**	**1976**	**1977**	**1978**	**1979**	**1980**	**1981**	**1982**	**1983**	**1984**
All Catches														
Total	4 088	4 226	4 715	4 061	3 664	4 139	4 847	3 862	1 951	2 081	2 135	4 021	4 361	5 770

Year	**1985**	**1986**	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**
Scotland	3 001	3 395	2 895	1 568	2 135	2 184	713	929	852	608	392	598	371	779
Other UK	22	-	-	-	-	-	-	-	1	-	194	127	475	310
Unallocated[1]	433	576	278	110	208	75	18	-	-	-	-	-	-	-
Discards	1 344[3]	679[3]	439[4]	245[4]	-[2]	-[2]	-[2]	-[2]	-[2]	-[2]	-[2]	-	-	-
Agreed TAC	3 000	3 100	3 500	3 200	3 200	2 600	2 900	2 300	1 000	1 000	1 000	1 000	1 000	1 000
Total	4 800	4 650	3 612	1 923	2 343	2 259	731	929	853	608	586	725	846	1089

Year	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**
Scotland	16	1	78	46	88	-	-	+	163	54	266	-	90	119
Other UK	240	0	392	335	240	-	318	512	458	622	488	301	111	184
Unallocated[1]	-	-	-	-	-	-	-	-	-	-	-	-	-	
Discards	-	-	-	-	-	-	-	-	-	-	-	-	-	
Agreed TAC	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	800	800	800	720	720	720
Total	256	1	480	381	328	0	318	512	621	676	754	301	201	303

[1]Calculated from estimates of weight per box and in some years estimated by-catch in the sprat fishery

[2]Reported to be at a low level, assumed to be zero, for 1989-1995.

[3]Based on sampling.

[4]Estimated assuming the same discarding rate as in 1986

Table 12.2. Stocks with limited data. Landings of herring in Divisions VIIe and VIIf. Source: ICES FISHSTAT and National Database from 2005 to 2012.

Division	Country	2005	2006	2007	2008	2009	2010	2011	2012(1)
VIIe	UK (Eng,Wal,NI,Scot,Guer	66	189	106	78	130	185	218	162
VIIe	Denmark	-	-	.	.	-	0	-	-
VIIe	France	516	516	502	499	489	493	486	278
VIIe	Germany, Fed. Rep. of	.	.	.	.	-	0	-	-
VIIe	Netherlands	440	-	-	433	-	2	6	-
	Total	1 022	705	608	1 010	619	678	710	440

Division	Country	2005	2006	2007	2008	2009	2010	2011	2012(1)
VIIf	UK (Eng, Wal, Scot, NI)	198	76	115	29	8	23	78	113
VIIf	Belgium	-	-	-	-	-	0	-	-
VIIf	France	-	-	.	.	-	0	26	-
VIIf	Netherlands	-	-	-	-	-	0	-	-
VIIf	Poland	-	.	.	.	-	0	-	-
	Total	198	76	115	29	8	23	104	113

(1) Preliminary data

Table 12.3. Stocks with limited data. Landings of herring in Sub-area VIII.

Country	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012(1)
France	81	43	15	14	6	12	12	34	50	82	22
Netherlands	7733	1511	1426	28	12	24	24	68	502	222	-
Portugal	-	-	-	-	-	.	.	-	-	-	-
Spain	266	197	0	50	214	120	131	55	38	54	2
UK	0	0	0	0	0	0	0	-	-	-	-
	8080	1751	1411	92	232	156	167	157	590	358	24

(1) Preliminary data

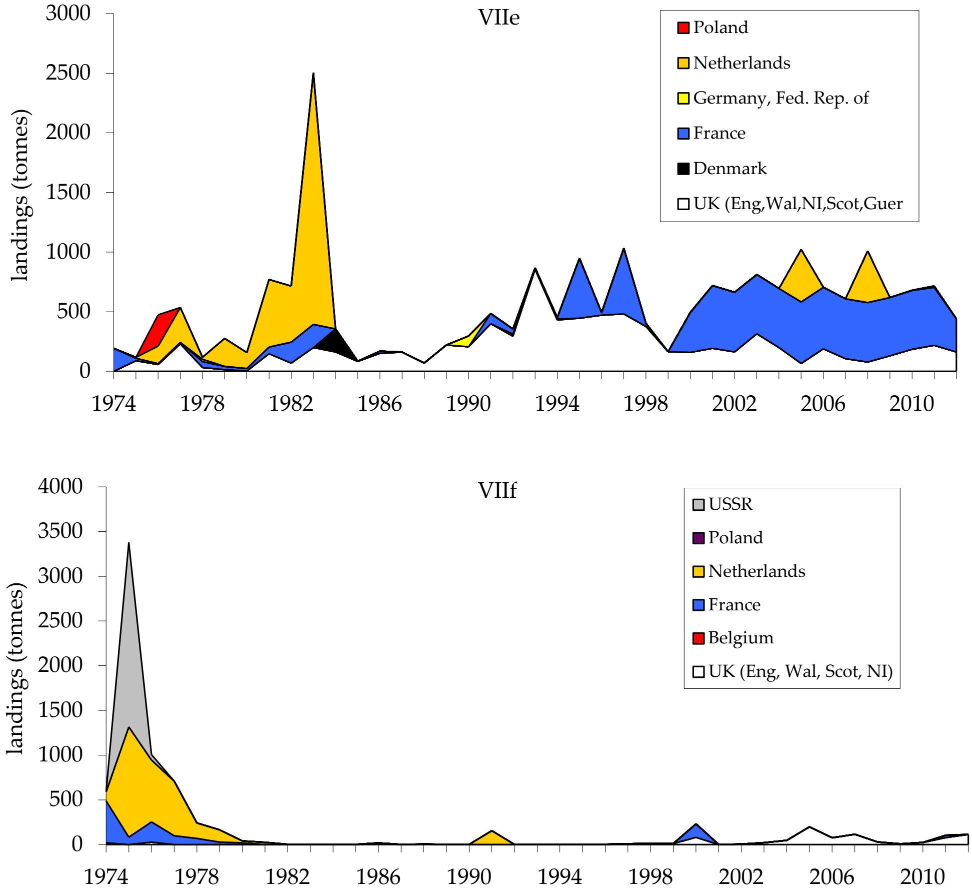


Figure 11.1. Stocks with limited data. Landings over time of herring in Divisions VIIe and VIIf.

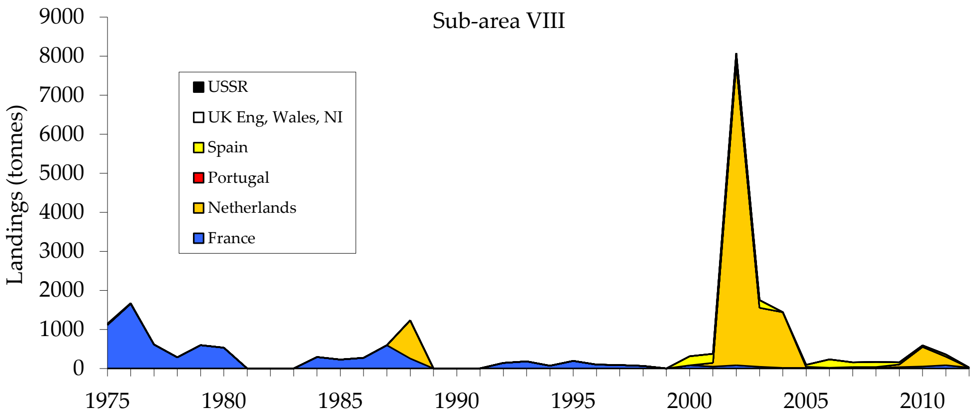


Figure 11.2. Stocks with limited data. Landings over time of herring in Sub-area VIII.

13 References

Beare, D.J., Reid, D.G., Petitgas, P. (2002). Spatio-temporal patterns in herring (Clupea harengus L.) school abundance and size in the northwest North Sea: modelling space–time dependencies to allow examination of the impact of local school abundance on school size. ICES Journal of Marine Science 59: 469-479.

Bierman, S. M., Dickey-Collas, M., van Damme, C. J. G., van Overzee, H. M. J., Pennock-Vos, M. G., Tribuhl, S. V., and Clausen, L. A. W. 2010. Between-year variability in the mixing of North Sea herring spawning components leads to pronounced variation in the composition of the catch. – ICES Journal of Marine Science, 67: 885–896.

Breslin J.J. (1998) The location and extent of the main Herring (Clupea harengus) spawning grounds around the Irish coast. Masters Thesis: University College Dublin

Brunel, T., & Dickey-Collas, M. 2010. Effects of temperature and population density on Atlantic herring von Bertalanffy growth parameters: a macro-ecological analysis. Marine Ecology Progress Series, 405: 15-28.

Burd, A.C. 1985. Recent changes in the central and southern North Sea herring stocks. Can. J. Fish Aquatic Sci., 42: 192-206.

Cannaby, H. and Husrevoglu, Y. S. 2009 The influence of low-frequency variability and long-term trends in North Atlantic sea surface temperature on Irish waters. ICES Journal of Marine Science. 66, 1480-1489.

Cardinale, M, Möllmann, C., Bartolino, V. Casini, M., Kornilovs, G., Raid, T., Margonsky, Grzyb, A., P. Raitaniemi, L., Gröhsler, T. and Flinkman, J. 2009. Effect of environmental variability and spawner characteristics on the recruitment of Baltic herring *Clupea harengus* populations. Marine Ecology Progress Series (MEPS), Vol. 388: 221-234

Clarke, M., and Egan, F. 2012. Evaluation of the Proposed Long-term Management Plan for Celtic Sea Herring. ICES CM 2012/ACOM:75.

Corten, A. 1986. On the causes of the recruitment failure of herring in the central and northern North Sea in the years 1972–1978. Journal du Conseil International pour l'Exploration de la Mer, 42: 281–294.

Cushing, D. H. 1955. On the autumn-spawned herring races of the North Sea. Journal du Conseil Permanent International pour l'Exploration de la Mer, 21: 44–60.

Cushing, D.H., 1968. The Downs stock of herring during the period 1955-1966. J. Cons. Perm. Int. Explor. Mer, 32 :262-269.

Cushing, D.H., 1992. A short history of the Downs stock of herring. ICES J. Mar. Sci., 49: 437-443.

Darby, C.D., Flatman, S., 1994. Virtual population analysis: version 3.1 (Windows/DOS) user guide. MAFF Information Technology Series No.1. Directorate of Fisheries Research: Lowestoft.

De Groot, S.J. 1996. ICES journal of Marine Science 53: 1051-1053. The physical impact of marine aggregate extraction in the North Sea.

Dickey-Collas M. Engelhard G.H. & Möllmann C 2010b. Herring. In: Rijnsdorp, AD, Peck, MA, Engelhard, GH, Möllmann, C Pinnegar (Eds). Resolving climate impacts on fish stocks. ICES Cooperative Research Report 301. pp 121-134

Dickey-Collas, M 2010c. North Sea Herring. In: Petitgas, P. (Ed.). Life cycle spatial patterns of small pelagic fish in the Northeast Atlantic. ICES Cooperative Research Report 306: 7-18.

Dickey-Collas, M, Nash, RDM., Brunel, T, Damme, CJG van, Marshall, CT, Payne, MR, Corten, A, Geffen, AJ, Peck, MA, Hatfield, EMC, Hintzen, NT, Enberg, K, Kell, LT, & Simmonds EJ

2010a. Lessons learned from stock collapse and recovery of North Sea her-ring: a review. ICES Journal of Marine Science, 67: 1875–1886.

Dickey-Collas, Mark, Pastoors, Martin A., van Keeken, Olvin A. (2007). Precisely wrong or vaguely right: simulations of the inclusion of noisy discard data and trends in fishing effort on the stock assessment of North Sea plaice. ICES Journal of Marine Science, 64: 1641-1649.

Edwards, J.I., Armstrong, F., Magurran, A.E., Pitcher, T.J. (1984). Herring, mackerel and sprat target strength experiments with behavioural observations. ICES CM /B:34.

Fassler, SMM, Payne, MR, Brunel, T, Dickey-Collas, M (2011). Does larval mortality influence population dynamics? An analysis of North Sea herring time series. Fisheries Oceanography

Fauchald, P. 2010. Predator–prey reversal: A possible mechanism for ecosystem hysteresis in the North Sea? Ecology, 91(8), 2010, pp. 2191–2197

Grainger, R. J. 1978 A study of herring stocks west of Ireland and their oceanographic conditions. Unpublished PhD. Thesis. Galway: National University of Ireland. 262 pp.

Grainger, R. J. 1980. Irish west coast herring fluctuations and their relation to oceanographic conditions. ICES Marine Science Symposium on the Biological Basis of Pelagic Stock Management No 29., pp. 19.

Gröhsler, T., Müller, H. 2004. Updated Information on Maturity Ogives for Western Baltic Herring. Working document to the Herring Assessment Working Group for the Area South of 62°N (HAWG), 9-18 March 2004, ICES, Copenhagen, pp. 12.

Gröhsler, T., Oeberst, R., Schaber, M. 2013. Implementation of the Stock Separation Function (SF) within GERAS in 2005-2011. Working document No. 01 of the Report of the Benchmark Workshop on Pelagic Stocks (WKPELA), 4-8, February, 2013, Copenhagen, Denmark. 9 pp.

Hammond, P.S. & Harris, R.N. (2006) Grey seal diet composition and prey consumption off western Scotland and Shetland. Final Report to Scottish Executive, Environment and Rural Affairs Department and Scottish Natural Heritage.

Harden Jones, F. R. 1968. Fish Migration. Edward Arnold Ltd, London. 325 pp.

Heath, M.,(1993) A evaluation and reviewof the ICES herring larval surveys in the North sea and adjacent waters. BULLETIN OF MARINE SCIENCE, 53(2): 795-817,]993

Heath, M., Scott, B., & Bryant, A. D. 1997. Modelling the growth of herring from four different stocks in the North Sea. Journal of Sea Research, 38: 413–436.

Helmond, A.T.M. van & H.M.J. van Overzee (2009). Discard sampling of the Dutch pelagic freezer fishery in 2003-2007. CVO Report 09.001, 60 pp.

Helmond, A.T.M. van & H.M.J. van Overzee (2010). Discard sampling of the Dutch pelagic freezer fishery in 2008-2009. CVO Report 10.008, 63 pp

ICES 1992. Report of Working Group on the Assessment of Pelagic Stocks in the Baltic. ICES CM 1992/Assess:13.

ICES 1996. Report of the Herring Assessment Working Group for the Area South of 62°N. ICES CM 1996/ACFM:10.

ICES 1997. Report of the Study Group on Multispecies Model Implementation in the Baltic. ICES CM 1997/J:2.

ICES 1997. Report of the Herring Assessment Working Group for the Area south of 62ºN. ICES CM 1997/ACFM:08. 560pp.

ICES 1998. Report of the Herring Assessment Working Group for the Area south of 62ºN. ICES CM 1998/ACFM:14.

ICES 1998. Report of the Study Group on the Precautionary Approach to Fisheries Management. Feb 1998. ICES CM 1998/ACFM:10.

ICES 2000. Report of the Herring Assessment Working Group for the Area South of 62°N. ICES CM 2000/ACFM:12.

ICES 2001. Report of Herring Assessment WG for the Area South of 62º N. CM 2001/ACFM:12.

ICES 2003. Report of the Study Group on Precautionary Reference Points for Advice on Fishery Management. ICES CM 2003/ACFM:15.

ICES 2005. Herring Assessment Working Group for the Area South of 62ºN (HAWG). ICES CM 2005/ACFM:16.

ICES 2006. Herring Assessment Working Group for the Area South of 62ºN (HAWG). ICES CM 2006/ACFM:20.

ICES 2006. Report of Working Group for Regional Ecosystem Description (WGRED). ICES CM 2006/ACE:03.

ICES 2007. Report of the Herring Assessment Working Group for the Area south of 62ºN. ICES CM 2007/ACFM:11.

ICES 2007. Report of the Workshop on Limit and Target Reference Points. ICES CM 2007/ACFM:05.

ICES 2008. Report of the Herring Assessment Working Group for the Area south of 62ºN. ICES CM 2008/ACOM:02.

ICES 2008. Report of the Workshop on Herring Management Plans (WKHMP). ICES CM 2008/ACOM:27.

ICES 2009. Report of the Benchmark Workshop on Short-lived Species (WKSHORT). ICES CM/ACOM:34

ICES 2009. Report of the Herring Assessment Working Group for the area South of 62° N. ICES CM 2009 /ACOM:03.

ICES 2010. Report of the Herring Assessment Working Group for the Area South of 62n (HAWG), 15 - 23 March 2010, ICES Headquarters, Copenhagen, Denmark. ICES CM 2010/ACOM:06. 688 pp.

ICES WGSAM 2011. Report of the Working Group on Multispecies Assessment Methods (WGSAM). 10–14 October 2011, Woods Hole, USA. ICES CM 2011/SSGSUE:10. 235 p.

ICES 2011. ICES status report on climate change in the North Atlantic. ICES Coop. Res. Rep. No. 310, pp 262.

ICES 2011. Report of the Herring Assessment Working Group for the area South of 62 deg N (HAWG) - 16 - 24 March 2011 - ICES Headquarters, Copenhagen. CM 2011/ACOM: 06

ICES 2011. Report of the Working Group for International Pelagic Surveys (WGIPS). ICES CM 2010/SSGESST:02.

ICES. 2012. Report of the Working Group of International Pelagic Surveys (WGIPS), 3-7 December 2012, ICES Headquarters, Copenhagen, Denmark. ICES CM 2012/SSGESST:22. 317 pp.

ICES 2012. WKPELA Benchmark Workshop on Pelagic Stocks. ICES CM 2012/ACOM:xx

ICES 2012.WGIPS REPORT 2012. Steering Group on Ecosystem Surveys Science and Technology. ICES CM 2012/SSGESST:21. Ref. SCICOM, WGISUR, ACOM, WGWIDE & HAWG

ICES 2012. Report of the Workshop for Revision of the North Sea Herring Long Term Management Plan (WKHELP). ICES ACOM: 72. 111pp.

ICES 2012. Report of the International Bottom Trawl Survey Working Group (IBTSWG), 27-30 March 2012, Lorient, France. ICES CM 2012/SSGESST:03. 323 pp.

ICES 2012. Report of the Working Group of International Pelagic Surveys (WGIPS). 3-7 December 2012 ICES Headquarters, Copenhagen, Denmark. ICES CM 2012/SSGESST:22. 343 p.

ICES 2012. Report of the Herring Assessment Working Group for the area South of 62 deg N (HAWG) - 13 - 21 March 2012 - ICES Headquarters, Copenhagen. CM 2012/ACOM: 06

ICES 2013. Report of the Workshop to consider reference points for all stocks (WKFMSYREF), 23-25 January 2013, Copenhagen. ICES CM 2013/ACOM:37.

ICES 2013. Report of the Benchmark Workshop on sprat (WKSPRAT). ICES CM 2013/ACOM:xx.

ICES 2013. Report of the Benchmark Workshop on Pelagic Stocks (WKPELA), 4-8, February 2013, Copenhagen, Denmark. ICES CM 2013/ACOM:46.

Lewy, P., Vinther, M. 2004. A stochastic age-length-structured multispecies model applied to North Sea stocks. ICES CM 2004/FF:20

Iles, I.D., Sinclair, M. 1982. Atlantic herring–stock discreteness and abundance. Science, 215: 627-633.

Johannessen, T., Dahl, E., Falkenhaug, T., and Naustvoll, L. J. 2011. Concurrent recruitment failure in gadoids and changes in the plankton community of the Norwegian Skagerrak coast after 2002. ICES Journal of Marine Science, doi:10.1093/icesjms/fsr194

Kell, L. T., Dickey-Collas, M., Hintzen, N. T., Nash, R. D. M., Pilling, G. M., and Roel, B. A. 2009. Lumpers or splitters? Evaluating recovery and management plans for metapopulations of herring. – ICES Journal of Marine Science, 66: 1776–1783.

Kell, L. T., Mosqueira, I., Grosjean, P., Fromentin, J-M., Garcia, D., Hillary, R., Jardim, E., Mardle, S., Pastoors, M. A., Poos, J. J., Scott, F., and Scott, R. D. 2007. FLR: an open-source framework for the evaluation and development of management strategies. – ICES Journal of Marine Science, 64.

Kube, S., Postel, L., Honnef, C. and Augustin, C.B. 2007. *Mnemiopsis leidyi* in the Baltic Sea – distribution and overwintering between autumn 2006 and spring 2007. Aquatic Invasions, Vol. 2, Issue 2: 137-145.

Lewy, P., and Vinther, M. 2004. A stochastic age–length-structured multispecies model applied to North Sea stocks. ICES Document CM 2004/FF: 20. 33 pp.

Llope, M., Licandro, P., Chan, K.-S. and Stenseth, N. C. (2012), Spatial variability of the plankton trophic interaction in the North Sea: a new feature after the early 1970s. Global Change Biology, 18: 106–117.

Løland, A., Aldrin, M., Ona, E., Hjellvik, V., Holst, J.C. (2007). Estimating and decomposing total uncertainty for survey-based abundance estimates of Norwegian spring-spawning herring. ICES Journal of Marine Science 64: 1302-1312.

Lynch, D. (2011). Long term changes in the biology of Celtic Sea Herring . MSc. Thesis, Trinity College Dublin.

Matei, D., Baehr, J., Jungclaus, J. H., Haak, H., Müller, W. a, and Marotzke, J. 2012. Multiyear prediction of monthly mean Atlantic Meridional Overturning Circulation at 26.5°N. Science (New York, N.Y.), 335: 76–9.

McPherson, A., Stephenson, R. L., O'Reilly, P. T., Jones, M. W., and Taggart, C. T. 2001. Genetic diversity of coastal Northwest Atlantic herring populations: implications for management. Journal of Fish Biology, 59A: 356–370.

Mesnil, B., and Rochet, M-J., 2010. A continuous hockey stick stock–recruit model for estimating MSY reference points. ICES J. Mar. Sci. 67: 1780–1784.

Muiño, R., Carrera, P., Petitgas, P., Beare, D.J., Georgakarakos, S., Haralambous, J., Iglesias, M., Liorzou, B., Massé, J., Reid, D.G., 2003. Consistency in the correlation of school parameters across years and stocks. ICES Journal of Marine Science 60: 164–175.

Nash, R. and Dickey-Collas, M. 2005. The influence of life history dynamics and environment on the determination of year class strength in North Sea herring (Clupea harengus L.). Fisheries Oceanography, 14: 279–291.

Nash, RDM, Dickey-Collas, M & Kell, LT (2009). Stock and recruitment in North Sea herring (Clupea harengus); compensation and depensation in the population dynamics. Fish Res 95: 88-97.

Needle, C.L. 2003. Survey-based assessments with SURBA. Working Document to the ICES Working Group on Methods of Fish Stock Assessment, Copenhagen, 29 January - 5 February..

Needle, C.L. 2004. Absolute abundance estimates and other developments in SURBA. Working Document to the ICES Working Group on Methods of Fish Stock Assessment, Lisbon, 11–18 February.

Needle, C.L. 2004. Data simulation and testing of XSA, SURBA and TSA. WD to WGNSSK

Nolan, G., and Lyons, K, (2006). Ocean Climate variability on the western Irish shelf, an emerging time series. ICES CM/C:28

Oeberst, R. Klenz, B., Gröhsler, T. Dickey-Collas, M., Nash, R.M., Zimmermann, C. 2009. When is the year class strength determined in Western Baltic herring? ICES Journal of Marine Science**,** 66**:** 1667-1672.

O'Donnell, C, Mullins., E., Saunders, R, Lyons, K., Blaszkowski, M., Sullivan., M., Hoare, D. and Bunn, R. 2009. Northwest Herring Acoustic Survey Cruise Report 2009 FSS Survey Series:2009/03.

O'Donnell, C., Doonan, I., Johnston, G., Lynch, D, Dransfeld, L. and Wall, D. (2005) Celtic Sea Herring Acoustic Survey cruise report 2011. FSS Survey series: 2005/03. Marine Institute publication.

O'Donnell, C., Griffin, K., Clarke, M., Lynch, D, Ulgren, J., Goddijn, L., Wall, D. and Mackey, M. (2004) Celtic Sea Herring Acoustic Survey cruise report 2004. FSS Survey series: 2004/03. Marine Institute publication.

O'Donnell, C., Lynch, D., Lyons, K, Riogain P. and Volkenandt, M. (2011) Celtic Sea Herring Acoustic Survey cruise report 2011. FSS Survey series: 2011/03. Marine Institute publication.

O'Donnell, C., Saunders, R., Lynch, D., Lyons, and Wall, D. (2008) Celtic Sea Herring Acoustic Survey cruise report 2011. FSS Survey series: 2008/03. Marine Institute publication.

Olsen EM, Ottersen G, Llope M, Chan K-S, Beaugrand G, Stenseth NC. 2011. Spawning stock and recruitment in North Sea cod shaped by food and climate. Proc. R. Soc. B. 278: 504-510.

Ona, E. (2003). An expanded target-strength relationship for herring. ICES Journal of Marine Science 60: 493-499.

Overzee, H.M.J. van & A.T.M. van Helmond (2011). Discard sampling of the Dutch pelagic freezer fishery in 2010. CVO Report 11.010, 49 pp.

Patterson, K. R.; D. S. Beveridge 1994: Report of the Herring Larvae Surveys in 1992/1993. Counc. Meet. Pap., H 25, 15 pp.

Patterson, K. R.; D. S. Beveridge 1995a: Report of the Herring Larvae Surveys in the North Sea and Adjacent Waters in 1993/1994. Counc. Meet. Pap., H 22, 17 pp.

Patterson, K. R.; D. S. Beveridge 1995b: Report of the Herring Larvae Surveys in the North Sea and Adjacent Waters in 1994/1995. Counc. Meet. Pap., H 21, 11 pp.

Patterson, K. R.; D. S. Beveridge 1996: Report of the Herring Larvae Surveys in the North Sea in 1995/1996. Counc. Meet. Pap., H 9, 10 pp.

Patterson, K. R.; Schnack, D.; Robb, A. P., 1997: Report of the Herring Larvae Surveys in the North Sea in 1996/1997. Counc. Meet. Pap., Y 14, 15 pp.

Patterson, K.R. 1998a. A programme for calculating total international catch-at-age and weight-at-age. WD to HAWG 1998.

Patterson, K.R. 1998b. Integrated Catch at Age Analysis Version 1.4. Scottish Fisheries Research Report. No. 38.

Payne MR, Clausen LW, Mosegaard H. Finding the signal in the noise: objective data-selection criteria improve the assessment of western Baltic spring-spawning herring. ICES Journal of Marine Science. 2009 ;66(8):1673-1680. Available at : http://icesjms.oxfordjournals.org/cgi/doi/10.1093/icesjms/fsp185.

Payne MR. 2010 Mind the gaps: a state-space model for analysing the dynamics of North Sea herring spawning components. ICES Journal of Marine Science. 2010;67(9):1939-1947. http://icesjms.oxfordjournals.org/cgi/doi/10.1093/icesjms/fsq036

Payne, M. R., Hatfield, E. M. C., Dickey-Collas, M., Falkenhaug, T., Gallego, A., Gröger, J., Licandro, P., Llope, M., Munk, P., Röckmann, C., Schmidt, J. O., and Nash, R. D. M. 2009. Recruitment in a changing environment: the 2000s North Sea herring recruitment failure. - ICES Journal of Marine Science, 66: 272-277.

Payne, MR. 2011. Taylor diagrams can aid in the Interpretation of Fisheries Models. Submitted, Canadian Journal of Fisheries and Aquatic Science

Payne M.R., Ross S.D., Clausen L.W., Munk P., Mosegaard H., and Nash R.D.M. ``Recruitment decline in North Sea herring is accompanied by reduced larval growth rates.'' Under revision for Marine Ecology Progress Series.

Petitgas, P., and Lévénez, J. J. (1996). Spatial organisation in pelagic fish: echogram stucture, spatio-temporal condition and biomass in senegalese waters. ICES Journal Marine Science, 53(2): 147–154.

Petitgas, P., Huret, M., Léger, F., Peck, M. A., Dickey-Collas, M., and Rijnsdorp, A. D. 2009. Patterns and schedules in hindcasted environments and fish life cycles. ICES CM 2009/E:25. 12 pp

Podolska, M., Horbowy, J., and Wyszynski, M. 2006. Discrimination of Baltic herring populations with respect to *Anisakis simplex* larvae infection. Journal of Fish Biology (2006) 68, 1241-1256. Available online at http://www.blackwell-synergy.com

Postuma, K.H. and Zijlstra, J.J., 1974. Larval abundance in relation to stock size, spawning potential and recruitment in North Sea herring. In: Blaxter, J.H.S. (ed.), The Early Life History of Fish. Springer-Verlag, Berlin, pp. 113-128.

Reid, P.C., Edwards, M., Beaugrand, G., Skogen, M., Stevens, D. 2003. Periodic changes in the zooplankton of the North Sea during the twentieth century linked to oceanic inflow. Fish. Ocean. 12: 260-269.

Rindorf, A. and Lewy, P. (2001). Analyses of length and age distributions using continuation-ratio logits. Can. J. Fish. Aquat. Sci. 58, 1141-1152.

Röckmann, C., Dickey-Collas, M., Payne, M. R., and van Hal, R. Realized habitats of early-stage North Sea herring: looking for signals of environmental change. ICES Journal of Marine Science, doi:10.1093/icesjms/fsq171.

Roel B.A., De Oliveira J. 2005. A two-stage biomass model given additional variance in the recruitment index. Working Document/ HAWG WG 2005.

Saunders, R., O'Donnell, C., Lynch, D., Campbell, A., Lyons, K. and Wall, D. (2009) Celtic Sea Herring Acoustic Survey cruise report 2009. FSS Survey series: 2009/03. Marine Institute publication.

Secor, D. H., Kerr, L. A., and Cadrin, S. X. 2009. Connectivity effects on productivity, stability, and persistence in a herring metapopulation model. ICES Journal of Marine Science, 66: 1726–1732.

Shepherd, J.G. 1991. Simple Methods for Short Term Forecasting of Catch and Biomass. ICES J. Mar. Sci., 48: 67–78.

Shepherd, J.G. 1999. Extended survivors analysis: an improved method for the analysis of catch at age data and abundance indices. ICES J. Mar. Sci., 56: 584-591.

Shin, Y. J., and Rochet, M-J. 1998. A model for the phenotypic plasticity of North Sea herring growth in relation to trophic conditions. Aquatic Living Resources, 11: 315–324.

Simmonds, E. J. 2009. Evaluation of the quality of the North Sea herring assessment. ICES Journal of Marine Science, 66: 1814–1822.

Simmonds, E.J. 2003. Weighting of acoustic and trawl survey indices for the assessment of North Sea herring. *ICES Journal of Marine Science*, **60**:463-471.

Simmonds, E.J., MacLennan, D.N. (2005). Fisheries acoustics: theory and practice, 2nd edition. Blackwell Publishing, Oxford.

Simmonds, J. and Keltz, S., 2007. Management implications and options for a stock with unstable or uncertain dynamics: West of Scotland herring. ICES J. Mar. Sci., 64: 679–685.

Skagen, 2010. HCS program for simulating harvest rules: Outline of program and instructions for users. Revision February- March 2010. Unpublished Report. Bergen: Institute of Marine Research. 24 pp.

Speirs D.C., Guirey E.J., Gurney W.S.C., Heath M.R. 2010. A length-structured partial ecosystem model for cod in the North Sea. Fisheries Research 106: 474–494.

STECF 2012. 41st Plenary Meeting Report of the Scientific, Technical and Economic Committee for Fisheries (Plen-12-03). EUR 25579 EN, JRC 76701, 115 pp.

Taylor, K. E. (2001), Summarizing multiple aspects of model performance in a single diagram, J. Geophys. Res., 106, 7183–7192, doi:10.1029/2000JD900719.

Tjelmeland, S., and Lindstrøm, U. 2005. An ecosystem element added to the assessment of Norwegian spring-spawning herring: implementing predation by minke whales. ICES Journal of Marine Science, 62: 285–294.

Torstensen, E., Eltink,A.T.G.W., Casini, M., McCurdy, W. J. And Clausen, L.W. 2004. Report of the Workshop on age estimation on sprat. Institut of Marine Research, Fl□devigen, Arendal, Norway, 14-17 December 2004.

Ulrich-Rescan, C., Andersen, B.S. 2006. Description of the activity of the Danish herring fleets in IIIa. Working Document-1\HAWG WG 2006.

Van Deurs, M., Worsøe, L.A.C. 2006. Catches of Spring- and Autumn spawners in Division IIIa distributed by fleet, sub region, and length group. Working Document-2/ HAWG 2006.

14 Working documents

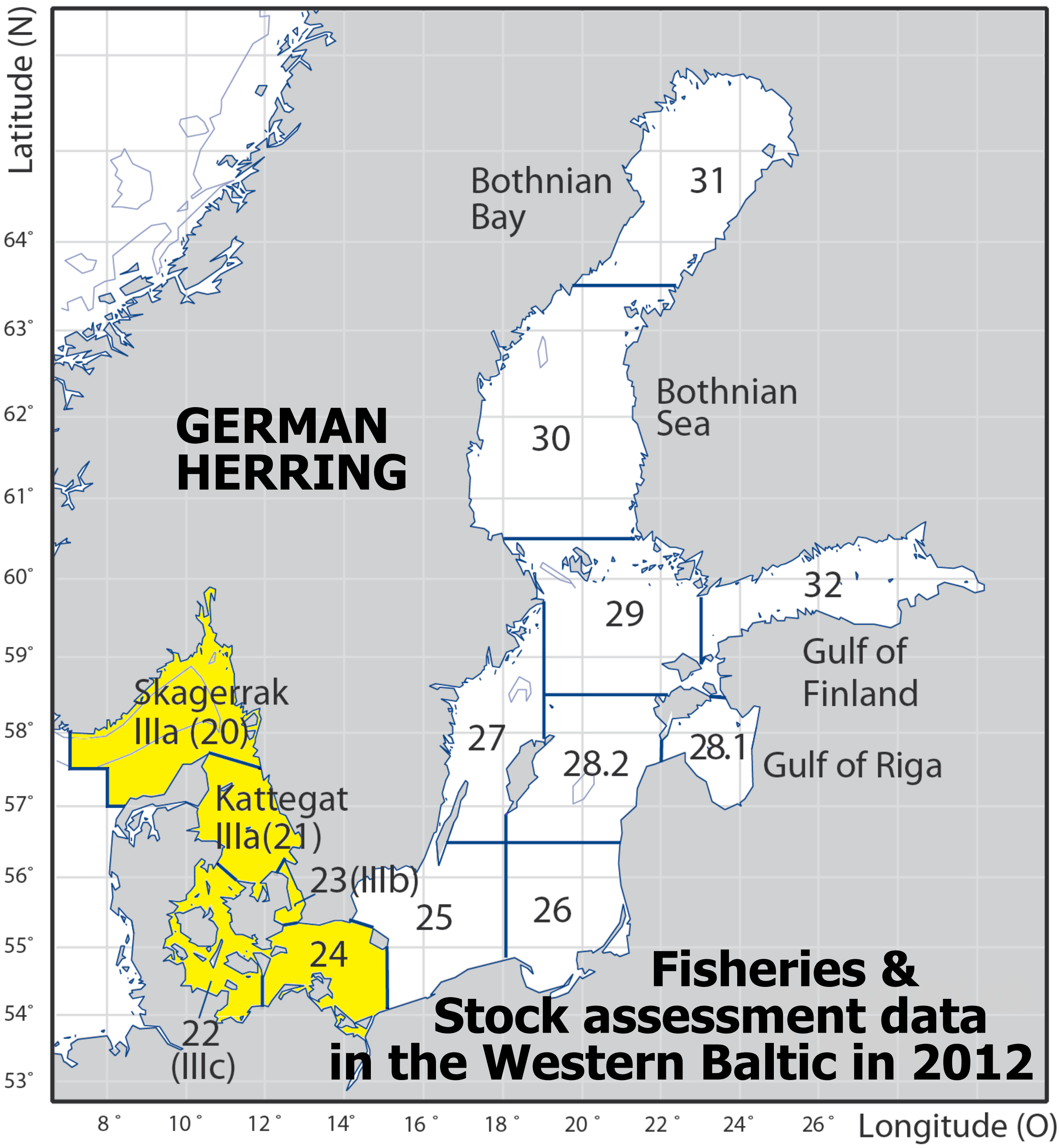
WD1: Tomas Gröhsler. Herring fisheries & stock assessment data in the Western Baltic in 2012

WD2: Rainer Oeberst, Tomas Gröhsler, Matthias Schaber, Niklas Larson. Applicability of the Separation Function (SF) in 2011 and 2012

WD3: Marta Moyano, Franziska Bils, Marc Hufnagl, Myron A. Peck. New information on prey fields and nutritional condition of overwintering herring larvae in the North Sea: Collaboration opportunities

WD4: Mark Payne. ICES HAWG Environmental Brieng Sheet - Working Group on Operational Oceanographic Products for Fisheries and the Environment (WGOOFE)

WD5: A.T.M. van Helmond & H.M.J. van Overzee. IMARES, Wageningen UR - Estimates of discarded herring by Dutch pelagic freezer trawler fishery in 2003-2012



Section | Page

compiled by Tomas Gröhsler, TI-OF, Germany

1 German herring fisheries in 2012

1.1 Fisheries

In 2012 the total German herring landings from the Western Baltic Sea in Subdivisions (SD) 22 and 24 amounted to 11,170 t, 36 % more than in 2011 (8,187 t). The fishing activities in one of the main fishing areas, the Greifswald Bay (SD 24) could already start in January due to mild winter conditions. As in last year's the German fishery was forced to stop their activities at the beginning of May due to quota restrictions.
As in previous years some herring was caught in the Skagerrak/Kattegat area (Division IIIa):

Year	Landings (t)
2005	751
2006	556
2007	454
2008	352 + 1,214 misreported from area SD 23
2009	887
2010	146
2011	54
2012	629

The landings (t by quarter and Sub-Division including information about the fraction of landings in foreign ports (**given as minus values**)) are shown in the table below:

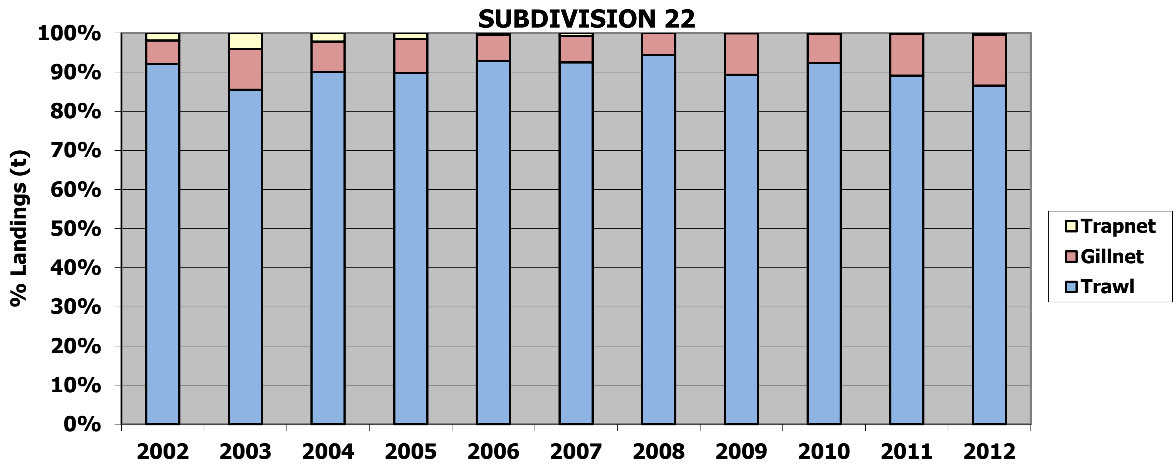
Quarter	Skag./Katteg. (t)	Subdiv. 22 (t)	Subdiv. 24 (t)	TOTAL (t)	TOTAL (%)
I		472.035	8,528.307 -21.450	**9,000.342** **-21.450**	**76.3** **-0.2**
II		340.643	1,140.261 -111.046	**1,480.904** **-111.046**	**12.6** **-0.9**
III	443.738	1.285	0.090	**445.113**	**3.8**
IV	185.564	28.538	659.074	**873.176**	**7.4**
TOTAL	**629.302** **0.000**	**842.501** **0.000**	**10,327.732** **-132.496**	**11,799.535** **-132.496**	**100.0** **-1.1**

Source: Federal Centre for Agriculture and Food (BLE). Since 2008 the obligation to report via logbooks changed to vessels >8 m (until 2007 for vessels >10 m)

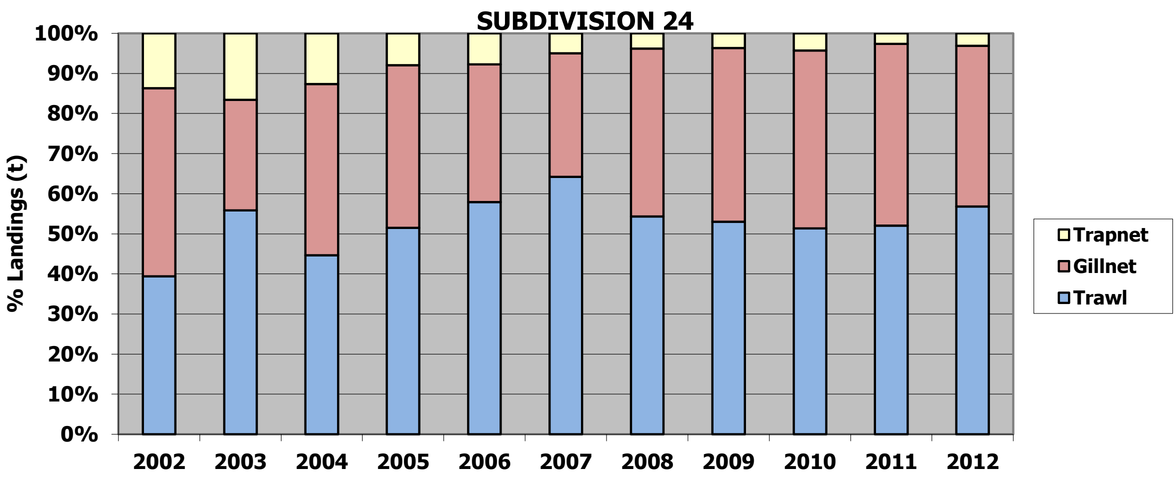
Landings = Total landings
-Landings = Fraction landed abroad

Just as in former years the main fishing season was during the first and second quarter. About 88 % of the herring was caught between January and May (2010-2011: 92%). As in last years, the main fishing area was located in Subdivision 24 (2012: 88 %, 2008 - 2011: 85 %). The overall fishing pattern during the last years was rather stable in the Baltic area of Subdivisions 22 and 24. Until 2000, the dominant part of herring was caught in the passive fishery by gillnets and trapnets around the Island of Rügen. Since 2001, the activities in the trawl fishery have increased. They reached the highest contribution in 2007 of 67 %. Since then the overall contribution of landings by trawl decreased to a rather stable level of 58-61 % (2008: 61 %; 2009: 59 %, 2010: 58 %, 2011: 58 %, 2012: 61 %). The trawl fishery was mostly carried out in Sub-Division 24 (2012: 81 %, 2011: 77 %, 2010: 76 %). The change in fishing pattern since 2001 was caused by the perspective of a new fish processing factory on the Island of Rügen, which finally started the production in autumn 2003. This factory intends to process 50,000 t fish annually. The figure below shows the share of the different gear types in the German herring fishery for the years 2002-2012 in Subdivisions 22 and 24.

SD 22 (t)	Trawl	Gillnet	Trapnet	Total	SD 22 (%)	Trawl	Gillnet	Trapnet
2002	3,871.716	253.710	78.838	4,204.264	2002	92.1%	6.0%	1.9%
2003	3,147.054	382.678	150.007	3,679.739	2003	85.5%	10.4%	4.1%
2004	2,282.844	196.963	55.674	2,535.481	2004	90.0%	7.8%	2.2%
2005	1,700.627	162.795	29.312	1,892.734	2005	89.9%	8.6%	1.5%
2006	2,977.731	215.366	14.372	3,207.469	2006	92.8%	6.7%	0.4%
2007	1,922.914	139.321	16.395	2,078.630	2007	92.5%	6.7%	0.8%
2008	2,086.175	124.471	0.000	2,210.646	2008	94.4%	5.6%	0.0%
2009	1,436.082	171.106	0.910	1,608.098	2009	89.3%	10.6%	0.1%
2010	1,565.826	125.609	3.381	1,694.816	2010	92.4%	7.4%	0.2%
2011	1,040.724	124.015	3.073	1,167.812	2011	89.1%	10.6%	0.3%
2012	729.236	109.950	3.315	842.501	2012	86.6%	13.1%	0.4%



SD 24 (t)	Trawl	Gillnet	Trapnet	Total	SD 24 (%)	Trawl	Gillnet	Trapnet
2002	7,155.192	8,529.682	2,480.824	18,165.698	2002	39.4%	47.0%	13.7%
2003	8,425.517	4,162.634	2,508.141	15,096.292	2003	55.8%	27.6%	16.6%
2004	6,912.896	6,599.784	1,960.868	15,473.548	2004	44.7%	42.7%	12.7%
2005	9,863.481	7,761.212	1,522.218	19,146.911	2005	51.5%	40.5%	8.0%
2006	11,393.038	6,744.164	1,525.095	19,662.297	2006	57.9%	34.3%	7.8%
2007	14,449.006	6,937.814	1,117.411	22,504.231	2007	64.2%	30.8%	5.0%
2008	11,196.706	8,636.140	789.005	20,621.851	2008	54.3%	41.9%	3.8%
2009	7,617.179	6,232.206	523.088	14,372.473	2009	53.0%	43.4%	3.6%
2010	5,415.716	4,679.209	448.801	10,543.726	2010	51.4%	44.4%	4.3%
2011	3,654.547	3,177.875	186.600	7,019.022	2011	52.1%	45.3%	2.7%
2012	5,865.995	4,142.744	318.993	10,327.732	2012	56.8%	40.1%	3.1%



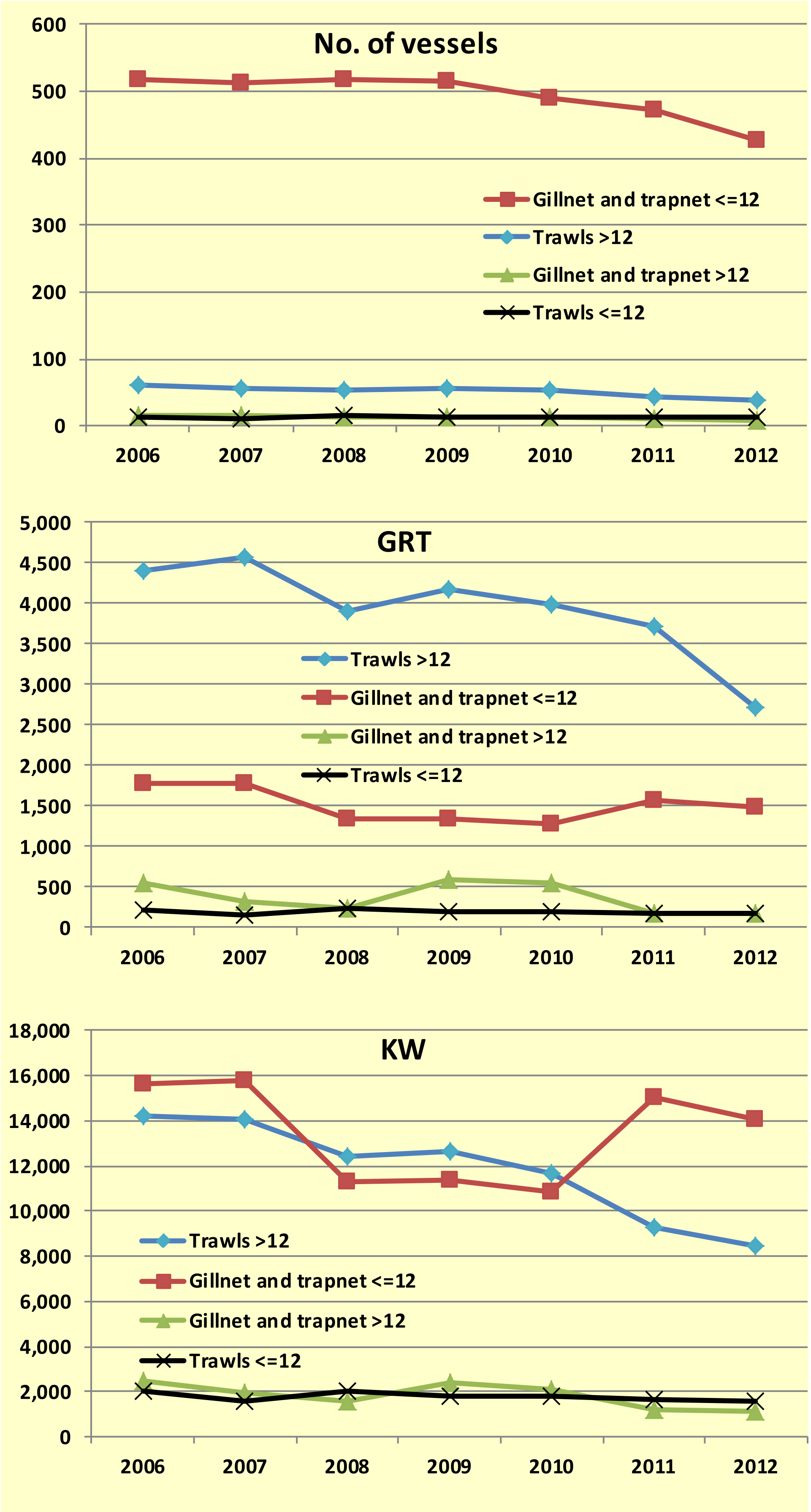
1.2 Fishing fleet

The German fishing fleet in the Baltic Sea consists of two parts where all catches for herring are taken in a directed fishery:

- coastal fleet with undecked vessels (rowing/motor boats <=10 m, engine power <=100 HP)
- cutter fleet with decked vessels and total lengths between 12 m and 30 m.

In the years from 2006 until 2012 the following types of fishing vessels carried out the herring fishery in the Baltic (only referring to vessels, which are contributing to the overall total landings per year with more than 20 %):

	Type of gear	Vessel length (m)	No. of vessels	GRT	kW
2006	Fixed gears (gillnet and trapnet)	<=12	517	1,782	15,673
		>12	16	545	2,482
	Trawls	<=12	13	220	2,055
		>12	62	4,404	14,227
	TOTAL		**608**	**6,947**	**34,437**
2007	Fixed gears (gillnet and trapnet)	<=12	514	1,785	15,799
		>12	15	314	1992
	Trawls	<=12	10	161	1606
		>12	57	4,582	14,106
	TOTAL		**596**	**6,842**	**33,503**
2008	Fixed gears (gillnet and trapnet)	<=12	518	1,350	11,319
		>12	14	234	1,560
	Trawls	<=12	16	232	2,041
		>12	54	3,912	12,465
	TOTAL		**602**	**5,728**	**27,385**
2009	Fixed gears (gillnet and trapnet)	<=12	515	1,344	11,382
		>12	14	602	2,443
	Trawls	<=12	13	205	1,849
		>12	56	4,172	12,623
	TOTAL		**598**	**6,323**	**28,297**
2010	Fixed gears (gillnet and trapnet)	<=12	491	1,280	10,884
		>12	13	551	2,121
	Trawls	<=12	14	193	1,830
		>12	53	3,988	11,708
	TOTAL		**571**	**6,012**	**26,543**
2011	Fixed gears (gillnet and trapnet)	<=12	473	1,566	15,020
		>12	10	185	1,215
	Trawls	<=12	12	171	1,666
		>12	43	3,710	9,325
	TOTAL		**538**	**5,632**	**27,226**
2012	Fixed gears (gillnet and trapnet)	<=12	426	1,485	14,105
		>12	9	184	1,125
	Trawls	<=12	12	170	1,573
		>12	38	2,712	8,480
	TOTAL		**485**	**4,551**	**25,283**


No. of vessels
Gillnet and trapnet <=12
Trawls >12
Gillnet and trapnet >12
Trawls <=12
600
500
400
300
200
100
0
2006
2007
2008
2009
2010
2011
2012
GRT
Trawls >12
Gillnet and trapnet <=12
Gillnet and trapnet >12
Trawls <=12
5,000
4,500
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
2006
2007
2008
2009
2010
2011
2012
KW
Trawls >12
Gillnet and trapnet <=12
Gillnet and trapnet >12
Trawls <=12
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
2006
2007
2008
2009
2010
2011
2012

1.3 Species composition of landings

The catch composition from gillnet and trapnet consists of nearly 100 % of herring.

The results from the species composition of German trawl catches, which were sampled in **Subdivision 22** of quarter 1 in 2012, are given below:

SD 22/Quarter I		Weight (kg)					Weight (%)			
	Sample No.	Herring	Sprat	Cod	Other	Total	Herring	Sprat	Cod	Other
January										
	Mean									
February										
	Mean									
March	1	71	18	0	0	88	80	20	0	0
	Mean	71	18	0	0	88	80	20	0	0
Q I	Mean	71	18	0	0	88	80	20	0	0

The results from the species composition of German trawl catches, which were sampled in **Subdivision 24** of quarter 1, 2 and 4 in 2012, are given below:

SD 24/Quarter I		Weight (kg)					Weight (%)			
	Sample No.	Herring	Sprat	Cod	Other	Total	Herring	Sprat	Cod	Other
January	1	37.2	1.3	0.0	0.0	38.6	96.5	3.5	0.0	0.0
	2	59.2	0.0	0.0	0.0	59.2	100.0	0.0	0.0	0.0
	3	51.4	0.0	0.0	0.0	51.4	100.0	0.0	0.0	0.0
	Mean	48.2	0.7	0.0	0.0	49.7	98.8	1.2	0.0	0.0
February	4	48.8	0.0	0.0	0.0	48.8	100.0	0.0	0.0	0.0
	5	60.5	0.3	0.0	0.0	60.9	99.5	0.5	0.0	0.0
	Mean	54.7	0.2	0.0	0.0	54.8	99.7	0.3	0.0	0.0
March	6	51.0	0.0	0.0	0.0	51.0	100.0	0.0	0.0	0.0
	7	49.7	0.0	0.0	0.0	49.7	100.0	0.0	0.0	0.0
	8	58.3	0.0	0.0	0.0	58.3	100.0	0.0	0.0	0.0
	Mean	53.0	0.0	0.0	0.0	53.0	100.0	0.0	0.0	0.0
Q I	Mean	52.0	0.3	0.0	0.0	52.5	99.5	0.5	0.0	0.0

SD 24/Quarter II		Weight (kg)					Weight (%)			
	Sample No.	Herring	Sprat	Cod	Other	Total	Herring	Sprat	Cod	Other
April	1	50.9	0.1	0.0	0.0	51.0	99.7	0.3	0.0	0.0
	Mean	50.9	0.1	0.0	0.0	51.0	99.7	0.3	0.0	0.0
May										
	Mean									
June										
	Mean									
Q II	Mean	50.9	0.1	0.0	0.0	51.0	99.7	0.3	0.0	0.0

SD 24/Quarter IV		Weight (kg)					Weight (%)			
	Sample No.	Herring	Sprat	Cod	Other	Total	Herring	Sprat	Cod	Other
Octob.	1	68.1	0.6	0.0	0.0	68.7	99.1	0.9	0.0	0.0
	Mean	68.1	0.6	0.0	0.0	68.7	99.1	0.9	0.0	0.0
Novemb.	2	57.1	0.0	0.0	0.0	57.1	100.0	0.0	0.0	0.0
	3	67.2	0.0	0.0	0.0	67.2	100.0	0.0	0.0	0.0
	Mean	62.2	0.0	0.0	0.0	62.2	100.0	0.0	0.0	0.0
Decemb.	4	64.0	0.0	0.0	0.0	64.0	100.0	0.0	0.0	0.0
	Mean	64.0	0.0	0.0	0.0	64.0	100.0	0.0	0.0	0.0
Q IV	Mean	64.8	0.2	0.0	0.0	65.0	99.7	0.3	0.0	0.0

The officially reported total trawl landings of herring in Subdivision 22 and 24 (see 2.1) in combination with the detected mean species composition in the samples (see above) results in the following differences:

Subdiv.	Quarter	Trawl landings (t)	Mean Contribution of Herring (%)	Total Herring corrected (t)	Difference (t)
22	**I**	417	80.0	333	-83
24	**I**	4,765	99.5	4,741	-24
	II	494	99.7	493	-1
	IV	607	99.7	605	-2

The officially reported trawl landings in Subdivision 22 and 24 (see 2.1) and the referring assessment input data (see 2.2 and 2.3) were as in the last years not corrected since the results, which indicate a higher contribution of herring in Subdivision 22 (one sample!), would only result in overall small changes of the official statistics (total trawl landings in Subdivision 22 and 24 of 6,955 t – 110 t -> 2 % difference).

2 Stock assessment data in 2012

2.1 Landings (tons) and sampling effort

Quarter	SKAGERRAK (DIVISION IIIa/SD 20)				KATTEGAT (DIVISION IIIa/SD21)			
	Landings (tons)	No. samples	No. measured	No. aged	Landings (tons)	No. samples	No. measured	No. aged
Q 1	no landings	-	-	-	no landings	-	-	-
Q 2	no landings	-	-	-	no landings	-	-	-
Q 3	443.738	0	0	0	no landings	-	-	-
Q 4	185.564	0	0	0	no landings	-	-	-
Total	629.302	0	0	0	0.000	0	0	0
Q 1	no landings	-	-	-	no landings	-	-	-
Q 2	no landings	-	-	-	no landings	-	-	-
Q 3	no landings	-	-	-	no landings	-	-	-
Q 4	no landings	-	-	-	no landings	-	-	-
Total	0.000	0	0	0	0.000	0	0	0
Q 1	no landings	-	-	-	no landings	-	-	-
Q 2	no landings	-	-	-	no landings	-	-	-
Q 3	no landings	-	-	-	no landings	-	-	-
Q 4	no landings	-	-	-	no landings	-	-	-
Total	0.000	0	0	0	0.000	0	0	0
Q 1	**0.000**	**0**	**0**	**0**	**0.000**	**0**	**0**	**0**
Q 2	**0.000**	**0**	**0**	**0**	**0.000**	**0**	**0**	**0**
Q 3	**443.738**	**0**	**0**	**0**	**0.000**	**0**	**0**	**0**
Q 4	**185.564**	**0**	**0**	**0**	**0.000**	**0**	**0**	**0**
Total	**629.302**	**0**	**0**	**0**	**0.000**	**0**	**0**	**0**

Quarter	SUBDIVISION 22				SUBDIVISION 24			
	Landings (tons)	No. samples	No. measured	No. aged	Landings (tons)	No. samples	No. measured	No. aged
Q 1	416.622	1	670	96	4,764.549	8	3,469	1,015
Q 2	305.723	0	0	0	494.168	1	566	125
Q 3	no landings	-	-	-	no landings	-	-	-
Q 4	6.891	0	0	0	607.278	4	1,916	467
Total	729.236	1	670	96	5,865.995	13	5,951	1,607
Q 1	55.103	2	589	120	3,591.208	10	3,306	612
Q 2	33.474	2	760	121	499.650	5	1,683	294
Q 3	0.995	0	0	0	0.090	0	0	0
Q 4	20.378	0	0	0	51.796	2	591	122
Total	109.950	4	1,349	241	4,142.744	17	5,580	1,028
Q 1	0.310	0	0	0	172.550	0	0	0
Q 2	1.446	0	0	0	146.443	2	1,123	239
Q 3	0.290	0	0	0	no landings	-	-	-
Q 4	1.269	1	516	85	no landings	-	-	-
Total	3.315	1	516	85	318.993	2	1,123	239
Q 1	**472.035**	**3**	**1,259**	**216**	**8,528.307**	**18**	**6,775**	**1,627**
Q 2	**340.643**	**2**	**760**	**121**	**1,140.261**	**8**	**3,372**	**658**
Q 3	**1.285**	**0**	**0**	**0**	**0.090**	**0**	**0**	**0**
Q 4	**28.538**	**1**	**516**	**85**	**659.074**	**6**	**2,507**	**589**
Total	**842.501**	**6**	**2,535**	**422**	**10,327.732**	**32**	**12,654**	**2,874**

Gear	Quarter	TOTAL (DIV. IIIa & SUBDIV. 22+24)			
		Landings (tons)	No. samples	No. measured	No. aged
TRAWL	Q 1	5,181.171	9	4,139	1,111
	Q 2	799.891	1	566	125
	Q 3	443.738	0	0	0
	Q 4	799.733	4	1,916	467
	Total	7,224.533	14	6,621	1,703
GILLNET	Q 1	3,646.311	12	3,895	732
	Q 2	533.124	7	2,443	415
	Q 3	1.085	0	0	0
	Q 4	72.174	2	591	122
	Total	4,252.694	21	6,929	1,269
TRAPNET	Q 1	172.860	0	0	0
	Q 2	147.889	2	1,123	239
	Q 3	0.290	0	0	0
	Q 4	1.269	1	516	85
	Total	322.308	3	1,639	324
TOTAL	Q 1	9,000.342	21	8,034	1,843
	Q 2	1,480.904	10	4,132	779
	Q 3	445.113	0	0	0
	Q 4	873.176	7	3,023	674
	Total	11,799.535	38	15,189	3,296

2.2 Catch in numbers (millions)

		SUBDIVISION 20				SUBDIVISION 22				SUBDIVISION 24				SUBDIVISIONS 22+24			
	W-rings	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
TRAWL	0								0.000				0.005				0.005
	1					0.006	0.018		0.003	1.766	0.029		0.226	1.771	0.047		0.229
	2					0.038	0.339		0.008	1.716	0.548		0.696	1.754	0.886		0.704
	3					1.089	1.014		0.014	9.637	1.639		1.223	10.726	2.653		1.237
	4					1.739	1.162		0.009	12.356	1.878		0.832	14.095	3.040		0.841
	5					0.710	0.347		0.009	7.406	0.561		0.753	8.116	0.908		0.761
	6					0.254	0.239		0.004	2.980	0.386		0.391	3.234	0.626		0.396
	7					0.072	0.220		0.003	1.853	0.355		0.246	1.925	0.575		0.248
	8+					0.045	0.061		0.002	2.011	0.099		0.165	2.056	0.160		0.166
	Sum					3.953	3.400		0.051	39.725	5.496		4.537	43.678	8.895		4.588
	W-rings	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
GILLNET	0																
	1																
	2																
	3					0.003	0.000	0.000	0.021	0.289	0.053	0.000	0.054	0.293	0.053	0.000	0.075
	4					0.027	0.026	0.001	0.013	1.470	0.259	0.000	0.033	1.497	0.285	0.001	0.046
	5					0.033	0.084	0.003	0.015	6.918	0.685	0.000	0.038	6.952	0.769	0.003	0.054
	6					0.042	0.042	0.001	0.023	3.894	0.539	0.000	0.058	3.936	0.581	0.001	0.080
	7					0.087	0.030	0.001	0.015	2.984	0.458	0.000	0.039	3.071	0.487	0.001	0.055
	8+					0.080	0.024	0.001	0.010	3.106	0.789	0.000	0.025	3.185	0.813	0.001	0.035
	Sum					0.273	0.206	0.006	0.097	18.662	2.783	0.000	0.248	18.934	2.988	0.007	0.345
	W-rings	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
TRAPNET	0																
	1					0.000	0.000	0.002	0.0079	0.002	0.001			0.002	0.001	0.002	0.0079
	2					0.000	0.000	0.002	0.0081	0.046	0.039			0.046	0.040	0.002	0.0081
	3					0.001	0.004	0.000	0.0022	0.522	0.443			0.523	0.447	0.000	0.0022
	4					0.001	0.006	0.000	0.0003	0.683	0.579			0.684	0.585	0.000	0.0003
	5					0.001	0.002	0.000	0.0001	0.293	0.249			0.294	0.251	0.000	0.0001
	6					0.000	0.001	0.000	0.0001	0.151	0.128			0.151	0.129	0.000	0.0001
	7					0.000	0.001			0.068	0.058			0.068	0.058		
	8+					0.000	0.000			0.055	0.047			0.055	0.047		
	Sum					0.003	0.015	0.004	0.0187	1.820	1.544			1.823	1.560	0.004	0.0187
	W-rings	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
TOTAL	0								0.000				0.005				0.005
	1					0.006	0.018	0.002	0.010	1.767	0.031		0.226	1.773	0.049	0.002	0.237
	2					0.038	0.339	0.002	0.016	1.763	0.587		0.696	1.801	0.926	0.002	0.712
	3					1.093	1.019	0.001	0.037	10.448	2.134	0.000	1.277	11.542	3.153	0.001	1.314
	4					1.767	1.193	0.001	0.023	14.508	2.717	0.000	0.865	16.275	3.910	0.001	0.888
	5					0.744	0.434	0.003	0.024	14.618	1.495	0.000	0.791	15.362	1.929	0.003	0.815
	6					0.296	0.282	0.001	0.027	7.025	1.053	0.000	0.449	7.321	1.335	0.001	0.476
	7					0.159	0.250	0.001	0.018	4.905	0.871	0.000	0.285	5.064	1.121	0.001	0.303
	8+					0.125	0.085	0.001	0.012	5.172	0.935	0.000	0.190	5.296	1.021	0.001	0.202
	Sum					4.228	3.621	0.010	0.168	60.206	9.822	0.000	4.784	64.434	13.443	0.011	4.952

REPLACEMENT OF MISSING SAMPLES:

SUBDIVISION 22					SUBDIVISION 24				
Missing		Replacement by			Missing		Replacement by		
Gear	Quart.	Area	Gear	Quart.	Gear	Quart.	Area	Gear	Quart.
Trawl	2	24	Trawl	2	Gillent	3	24	Gillnet	4
Trawl	4	24	Trawl	4	Trapnet	1	24	Trapnet	2
Gillent	3	22	Gillnet	2					
Gillnet	4	24	Gillnet	4					
Trapnet	1	24	Trapnet	2					
Trapnet	2	24	Trapnet	2					
Trapnet	3	22	Trapnet	4					

2.3 Mean weight (grammes) in the catch

		SUBDIVISION 20				SUBDIVISION 22				SUBDIVISION 24				SUBDIVISIONS 22+24			
	W-rings	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
TRAWL	0								23.4				23.4				23.4
	1					29.0	19.7		44.1	14.4	19.7		44.1	14.4	19.7		44.1
	2					56.6	49.1		82.3	41.9	49.1		82.3	42.2	49.1		82.3
	3					85.6	75.0		124.2	92.8	75.0		124.2	92.1	75.0		124.2
	4					104.8	89.6		147.2	113.4	89.6		147.2	112.3	89.6		147.2
	5					121.9	117.3		164.5	152.3	117.3		164.5	149.7	117.3		164.5
	6					126.5	115.0		175.3	172.6	115.0		175.3	169.0	115.0		175.3
	7					174.5	135.1		189.6	184.3	135.1		189.6	183.9	135.1		189.6
	8+					171.3	172.6		161.6	193.0	172.6		161.6	192.5	172.6		161.6
	Sum					105.4	89.9		133.9	119.9	89.9		133.8	118.6	89.9		133.8
	W-rings	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
GILLNET	0																
	1																
	2																
	3					141.2	121.8	121.8	186.6	146.2	151.2	186.6	186.6	146.2	151.0	181.5	186.6
	4					154.4	144.1	144.1	195.0	164.3	157.5	195.0	195.0	164.2	156.3	147.7	195.0
	5					181.4	155.1	155.1	209.7	183.3	169.9	209.7	209.7	183.3	168.3	156.5	209.7
	6					200.7	167.7	167.7	215.5	196.5	180.5	215.5	215.5	196.5	179.6	171.2	215.5
	7					210.7	171.8	171.8	228.7	203.0	186.9	228.7	228.7	203.2	185.9	175.9	228.7
	8+					221.3	189.2	189.2	229.3	215.2	192.2	229.3	229.3	215.4	192.1	191.6	229.3
	Sum					202.2	162.6	162.6	209.1	192.4	179.6	209.1	209.1	192.6	178.4	165.6	209.1
	W-rings	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
TRAPNET	0																
	1					18.9	18.9	55.2	55.2	18.9	18.9			18.9	18.9	55.2	55.2
	2					53.4	53.4	69.1	69.1	53.4	53.4			53.4	53.4	69.1	69.1
	3					74.7	74.7	97.1	97.1	74.7	74.7			74.7	74.7	97.1	97.1
	4					87.6	87.6	114.1	114.1	87.6	87.6			87.6	87.6	114.1	114.1
	5					118.1	118.1	137.6	137.6	118.1	118.1			118.1	118.1	137.6	137.6
	6					117.7	117.7	125.0	125.0	117.7	117.7			117.7	117.7	125.0	125.0
	7					151.5	151.5			151.5	151.5			151.5	151.5		
	8+					156.1	156.1			156.1	156.1			156.1	156.1		
	Sum					94.8	94.8	67.9	67.9	94.8	94.8			94.8	94.8	67.9	67.9
	W-rings	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
TOTAL	0								23.4				23.4				23.4
	1					29.0	19.7	55.2	52.5	14.4	19.6		44.1	14.4	19.6	55.2	44.5
	2					56.6	49.1	69.1	75.6	42.2	49.4		82.3	42.5	49.3	69.1	82.1
	3					85.8	75.1	97.5	158.1	93.4	76.9	186.6	126.8	92.7	76.3	111.5	127.7
	4					105.5	90.8	141.4	174.1	117.3	95.7	195.0	149.1	116.0	94.2	144.8	149.7
	5					124.5	124.7	154.9	193.1	166.3	141.6	209.7	166.7	164.3	137.8	156.3	167.5
	6					137.1	122.8	167.1	208.7	184.7	148.8	215.5	180.5	182.7	143.3	170.7	182.1
	7					194.3	139.5	171.8	222.8	195.2	163.4	228.7	195.0	195.2	158.0	175.9	196.6
	8+					203.2	177.1	189.2	218.6	205.9	188.3	229.3	170.6	205.9	187.4	191.6	173.4
	Sum					111.6	94.1	123.7	170.2	141.7	116.1	209.1	137.8	139.7	110.2	127.1	138.9

REPLACEMENT OF MISSING SAMPLES:

SUBDIVISION 22					SUBDIVISION 24				
Missing		Replacement by			Missing		Replacement by		
Gear	Quart.	Area	Gear	Quart.	Gear	Quart.	Area	Gear	Quart.
Trawl	2	24	Trawl	2	Gillent	3	24	Gillnet	4
Trawl	4	24	Trawl	4	Trapnet	1	24	Trapnet	2
Gillent	3	22	Gillnet	2					
Gillnet	4	24	Gillnet	4					
Trapnet	1	24	Trapnet	2					
Trapnet	2	24	Trapnet	2					
Trapnet	3	22	Trapnet	4					

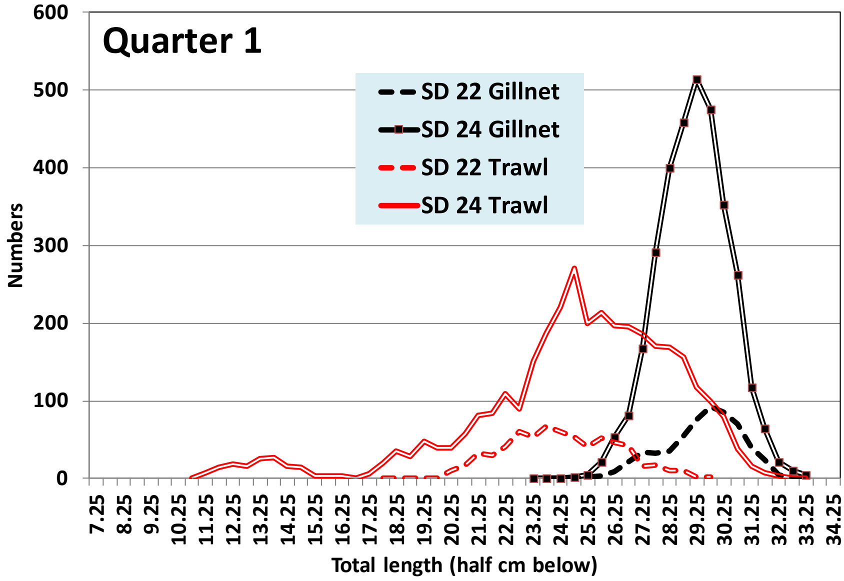
2.4 Mean length (cm) in the catch

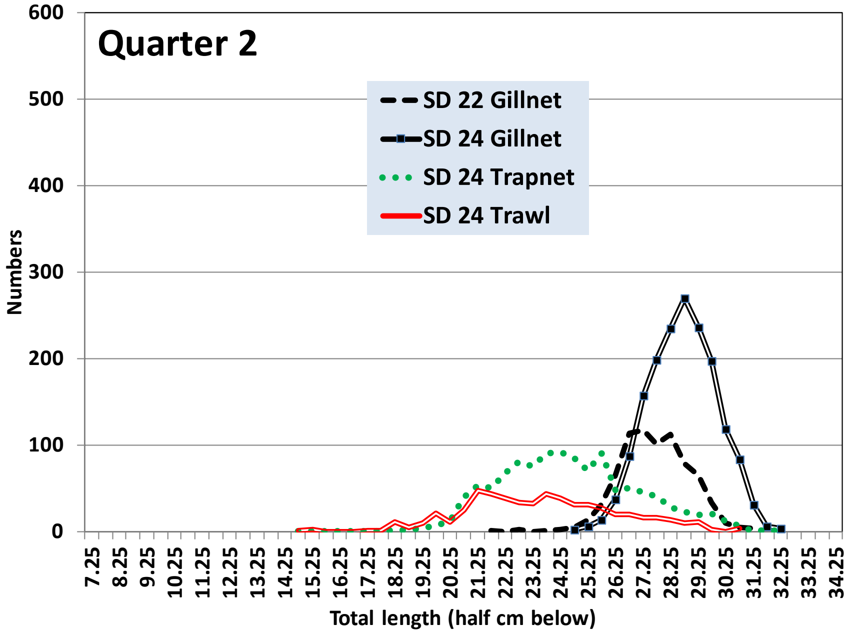
		SUBDIVISION 20				SUBDIVISION 22				SUBDIVISION 24				SUBDIVISIONS 22+24			
	W-rings	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
TRAWL	0								15.5				15.5				15.5
	1					17.8	15.1		18.9	13.4	15.1		18.9	13.4	15.1		18.9
	2					20.3	19.7		22.7	19.0	19.7		22.7	19.0	19.7		22.7
	3					22.9	22.4		25.3	23.5	22.4		25.3	23.4	22.4		25.3
	4					24.3	23.8		26.7	24.9	23.8		26.7	24.8	23.8		26.7
	5					25.5	25.9		27.7	27.2	25.9		27.7	27.0	25.9		27.7
	6					25.7	25.5		28.2	28.2	25.5		28.2	28.0	25.5		28.2
	7					28.4	27.2		29.0	28.9	27.2		29.0	28.9	27.2		29.0
	8+					28.3	29.2		27.5	29.3	29.2		27.5	29.3	29.2		27.5
	Sum					24.3	23.6		25.7	24.9	23.6		25.7	24.8	23.6		25.7
	W-rings	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
GILLNET	0																
	1																
	2																
	3					26.3	24.8	24.8	27.9	26.3	26.8	27.9	27.9	26.3	26.8	27.6	27.9
	4					27.1	26.5	26.5	28.4	27.5	27.3	28.4	28.4	27.4	27.2	26.6	28.4
	5					28.4	27.2	27.2	29.4	28.6	28.0	29.4	29.4	28.6	27.9	27.3	29.4
	6					29.3	28.0	28.0	29.8	29.4	28.7	29.8	29.8	29.4	28.7	28.1	29.8
	7					29.9	28.2	28.2	30.6	29.8	29.2	30.6	30.6	29.8	29.1	28.4	30.6
	8+					30.4	29.3	29.3	30.7	30.5	29.5	30.7	30.7	30.5	29.5	29.4	30.7
	Sum					29.4	27.7	27.7	29.4	29.1	28.7	29.4	29.4	29.1	28.6	27.8	29.4
	W-rings	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
TRAPNET	0																
	1					14.8	14.8	20.2	20.2	14.8	14.8			14.8	14.8	20.2	20.2
	2					20.4	20.4	21.7	21.7	20.4	20.4			20.4	20.4	21.7	21.7
	3					22.9	22.9	24.1	24.1	22.9	22.9			22.9	22.9	24.1	24.1
	4					24.1	24.1	25.2	25.2	24.1	24.1			24.1	24.1	25.2	25.2
	5					26.6	26.6	27.1	27.1	26.6	26.6			26.6	26.6	27.1	27.1
	6					26.5	26.5	27.3	27.3	26.5	26.5			26.5	26.5	27.3	27.3
	7					29.0	29.0			29.0	29.0			29.0	29.0		
	8+					29.4	29.4			29.4	29.4			29.4	29.4		
	Sum					24.6	24.6	21.5	21.5	24.6	24.6			24.6	24.6	21.5	21.5
	W-rings	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
TOTAL	0								15.5				15.5				15.5
	1					17.7	15.1	20.2	19.9	13.4	15.1		18.9	13.4	15.1	20.2	19.0
	2					20.3	19.7	21.7	22.2	19.0	19.7		22.7	19.0	19.7	21.7	22.7
	3					22.9	22.4	24.1	26.7	23.5	22.6	27.9	25.4	23.4	22.6	24.7	25.5
	4					24.4	23.8	26.4	27.7	25.1	24.2	28.4	26.7	25.0	24.1	26.5	26.8
	5					25.6	26.2	27.2	28.8	27.8	27.0	29.4	27.7	27.7	26.8	27.3	27.8
	6					26.2	25.9	28.0	29.5	28.8	27.3	29.8	28.4	28.7	27.0	28.1	28.5
	7					29.2	27.3	28.2	30.4	29.4	28.3	30.6	29.2	29.4	28.1	28.4	29.3
	8+					29.7	29.3	29.3	30.2	30.0	29.5	30.7	27.9	30.0	29.4	29.4	28.1
	Sum					24.6	23.8	25.1	27.4	26.2	25.2	29.4	25.9	26.1	24.8	25.3	26.0

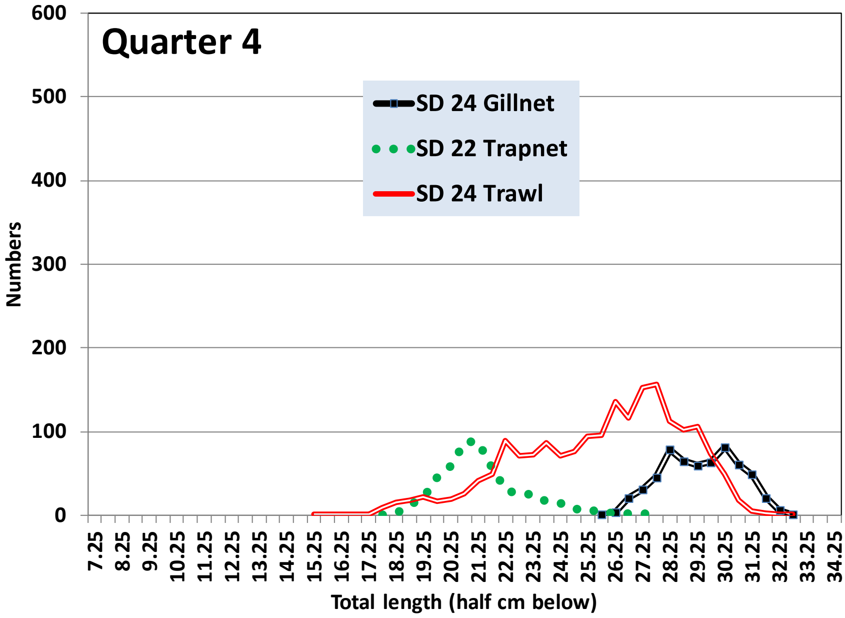
REPLACEMENT OF MISSING SAMPLES:

SUBDIVISION 22					SUBDIVISION 24				
Missing		Replacement by			Missing		Replacement by		
Gear	Quart.	Area	Gear	Quart.	Gear	Quart.	Area	Gear	Quart.
Trawl	2	24	Trawl	2	Gillent	3	24	Gillnet	4
Trawl	4	24	Trawl	4	Trapnet	1	24	Trapnet	2
Gillent	3	22	Gillnet	2					
Gillnet	4	24	Gillnet	4					
Trapnet	1	24	Trapnet	2					
Trapnet	2	24	Trapnet	2					
Trapnet	3	22	Trapnet	4					

2.5 Sampled length distributions by Subdivision, quarter and type of gear







Applicability of the Separation Function (SF) in 2011 and 2012

by

Rainer Oeberst[1], Tomas Gröhsler[1], Matthias Schaber[2], Niklas Larson[3]

[1]Thünen Institute of Baltic Sea Fisheries (TI-OF), Rostock, Germany
[2]Thünen Institute of Sea Fisheries (TI-SF), Hamburg, Germany
[3]University of Agricultural Sciences, Department of Aquatic Resources, Institute of Marine Research, Lysekil, Sweden

Abstract

Length-at-age data of herring sampled during the German Autumn Acoustic Survey (GERAS) in SD 21 and 23, German 'Baltic Acoustic Spring Survey (BASS)' in SD 28 and Swedish 'Baltic International Autumn Acoustic Survey (BIAS)' in SD 27 and 28 were used to estimate the parameters of the Bertalanffy growth function (BGF) for Western Baltic Spring Spawning herring (WBSSH) and Central Baltic herring (CBH) in 2011 and 2012. The BGF parameters of 2011 and 2012 were almost similar compared to the ones estimated for the period 2005 – 2010. As expected, almost all herring captured in SD 21 and 23 (GERAS) were assigned to WBSSH ($TL>=SF_{2005-2010}$), whereas in most cases herring captured during German BASS in SD 28 and during Swedish BIAS in SD 27 and 28 were assigned to CBH ($TL<SF_{2005-2010}$). The results clearly support the applicability of the $SF_{2005-2010}$ for the years 2011 and 2012.

Introduction

Atlantic herring (*Clupea harengus* L.) constitute an important fraction of catches in the European commercial fisheries. The management of herring stocks includes the definition of either management- or distribution area, respectively. Due to the migratory behavior of older herring characterized by extended migrations between feeding and spawning areas, the static stock boundaries used for management can hereby lead to problems in the assessment.

In the Baltic Sea, several herring stocks are surveyed and managed separately. The distribution area of the most westerly located Western Baltic Spring Spawning herring (WBSSH) stock covers the Skagerrak/Kattegat (ICES Division IIIa) and ICES Subdivisions (SDs) 22-24. The main spawning area of WBSSH is considered to be the Greifswalder Bodden at Rügen Island (ICES CM 1998/H:1). Herring caught in Division IIIa also comprises a stock component of the North Sea Autumn Spawning herring (NSASH) distributed in adjacent North Sea areas. The separation of NSASH and WBSSH in Division IIIa within the assessment process is presently based on vertebrae counts and otolith microstructure analysis (ICES CM 2012/ACOM:06).

The areas of the southern and central Baltic Sea (SDs 25-29, 32 excluding the Gulf of Riga) are inhabited by the Central Baltic herring (CBH) stock. Stock separation for assessment purposes so far has been based on ICES Subdivisions with herring originating from SDs 22-24 being by definition allocated to WBSSH and specimens from SDs 25-32 to CBH

Gröhsler et al. (2012) developed a separation function (SF) to assign individuals to one of the both Baltic herring stocks. The SF is based on the different growth function of both herring stocks and involves the parameters length, month of capture and age of individuals. The method was used to quantify the mixing of both herring stocks during the acoustic surveys BASS and BIAS in parts of the Baltic Sea and during the commercial fishery in SD 22, 24 and 25.

The aim of this study was to estimate the parameters of BGF of WBSSH and CBH based on baseline samples from GERAS in SD 21 & 23 (WBSSH) and German BASS in SD 28 & Swedish BIAS in SD

27 and 28 (CBH). The results in 2011 and 2012 were compared with the ones estimated for 2005 – 2010 in order to check the applicability of the $SF_{2005\text{-}2010}$.

Material and Methods

Length-at-age data of herring captured during the German BASS in SD 28 in 2011 and 2012 as well as data of Swedish BIAS in SD 27 and 28 were used to estimate annual parameters of BGF for CBH. The BGF parameters for WBSSH were estimated based on length-at-age data of GERAS in SD 21 and SD 23.

Individual herring were allocated to a defined 0.5 cm length class by adding half of the length class to the measured total length TL (e.g. TL 20.5 cm = length class 20.75 cm). Age (winter rings, AWR) was converted to age in months, AM (with a "theoretical birthday" of January 1st), by the following equation

$$A_M = A_{WR} \times 12 + T \qquad (1)$$

with T representing survey / sampling month (the German acoustic surveys were conducted in May (T = 5, BASS) and October (T = 10, GERAS)).

Individual age and length data from the baseline samples were used to derive growth parameters for both WBSS and CB herring using the von Bertalanffy growth equation

$$L_{S,A_M} = L_{\infty,S} \times \left(1 - e^{\left(-k_S \times \left(\frac{A_M}{12} - t_{0,S}\right)\right)}\right) \qquad (2)$$

with L_{S,A_M} = length of an individual of the corresponding stock S at age A_M, $L_{\infty,S}$ = mean maximum length, k_S = growth parameter and $t_{0,S}$ = theoretical age at length zero of the corresponding stock.

Statistical analyses were conducted with the statistical software program Statgraphics (Statgraphics Centurion, Version XV, StatPoint, Inc.).

Results

Germany only covered parts of SD 28 during the BASS in 2011 and 2012. Therefore, the numbers of herring length-at-age data for estimating the parameters of BGF of CBH were low with N = 278 and N = 155 in 2011 and 2012, respectively. Length-at-age data of 892 and 908 herring were available from Swedish BIAS in 2011 and 2012, respectively. In total 838 and 878 herring were available from German GERAS in SD 21 and 23 to estimate the parameters of BGF of WBSSH in 2011 and 2012, respectively.
The parameters L_∞ and k of the BGF of WBSSH were close to the estimates of 2005 and 2006 (Table 1) and the mean length-at-age of these years was close to the estimates of the BGF 2005 – 2010 (Fig. 1 & 2). The GERAS length-at-age data in SD 21 and SD 23 in 2011 and 2012 were always larger than the estimate of SF (2005 – 2010) with only one exception. The parameters of BGF of CBH in 2011 and 2012 were close to the estimates of 2008 and 2010 and close to the mean BGF based on 2005 - 2010 (Table 2, Fig. 3 & 4).
The parameters of L_∞ and k for WBSSH and CBH of the years 2011 and 2012 were in correspondence to the parameters estimated for 2005-2010 (Fig. 5). The data also clearly showed the differences between the relation of L_∞ and k of WBSSH and CBH.

Conclusion

The estimates of BGF based on baseline samples of WBSSH and CBH in 2011 and 2012 clearly support the applicability of SF based on 2005 to 2010.

References

*Gröhsler, T., Oeberst, R., Schaber, M. Casini, M., Chervonstev, V., Wyszyński, M. (2012). Mixing of Western Baltic Spring Spawning and Central Baltic Herring (*Clupea harengus*) Stocks – Implications and consequences for stock assessment. Working document for the ICES

- "Herring Assessment Working Group for the Area South of 62° N (HAWG)", 13.-22.03.2012, Copenhagen (WD 06).
- "Baltic International Fish Survey Working Group (WGBIFS)", 26.-**30**.03.2012, Kaliningrad, Russia.
- "Baltic Fisheries Assessment Working Group (WGBFAS)", 12.-19.04.2012, Copenhagen (WD 4)

In: Report of the Baltic International Fish Survey Working Group (WGBIFS). ICES CM 2012 /SSGESST: 02, Annex 9: 376-398,
Report of the Baltic Fisheries Assessment Working Group (WGBFAS). ICES CM 2012/ACOM:10, Annex 16: 749-772.
* this WD has been prepared as a manuscript and was submitted to the ICES Journal of Marine Science (Current status: accepted/resubmit after revision).

ICES 1998. Report of the Study Group on the Stock Structure of the Baltic Spring-spawning Herring. ICES C.M. H:1, Ref. B

ICES 2012. Report of the Herring Assessment Working Group for the Area South of 62°N. ICES CM 2012/ACOM:06.

Tables

Table 1: Parameters of the von Bertalanffy growth function (BGF) of Western Baltic Spring Spawning Herring (WBSSH, *Clupea harengus*) by year and total period. L_∞ - mean maximum length (cm), k – growth parameter, t_0 – theoretical age at length zero, N – number of sampled herring, r^2 – coefficient of determination, SE – standard error.

Year	L∞	k	t0	N	r²	SE
2005	31.16	0.36	-0.733	1 299	0.86	2.02
2006	31.81	0.365	-0.547	1 401	0.92	1.9
2007	29.92	0.525	-0.201	1 151	0.89	1.99
2008	29.84	0.539	-0.194	1 048	0.88	2.27
2009	29.34	0.552	-0.133	956	0.87	2.11
2010	30.82	0.482	-0.157	1 025	0.92	2.12
Total	30.57	0.453	-0.337	6 680	0.89	2.12
2011	32.01	0.375	-1.067	838	0.88	1.89
2012	31.33	0.402	-0.859	879	0.90	2.01

Table 2. Parameters of the von Bertalanffy growth function of Central Baltic Herring (CBH, *Clupea harengus*) by year and total period. L_∞ - mean maximum length (cm), k – growth parameter, t_0 – theoretical age at length zero, N – number of sampled herring, r^2 – coefficient of determination, SE – standard error.

Year	L∞	k	t0	N	r²	SE
2005	25.16	0.153	-2.821	1 053	0.66	1.63
2006	23.21	0.186	-2.435	1 317	0.66	1.86
2007	19.64	0.377	-1.097	1 790	0.78	1.75
2008	20.22	0.418	-0.826	1 683	0.8	1.68
2009	21.37	0.331	-0.977	1 580	0.75	1.63
2010	22.28	0.244	-1.701	1 136	0.69	1.69

Total	21.56	0.269	-1.585	8 559	0.74	1.75
2011	21.37	0.265	-1.304	1047	0.89	1.38
2012	20.65	0.364	-0.918	1146	0.86	1.58

Figures

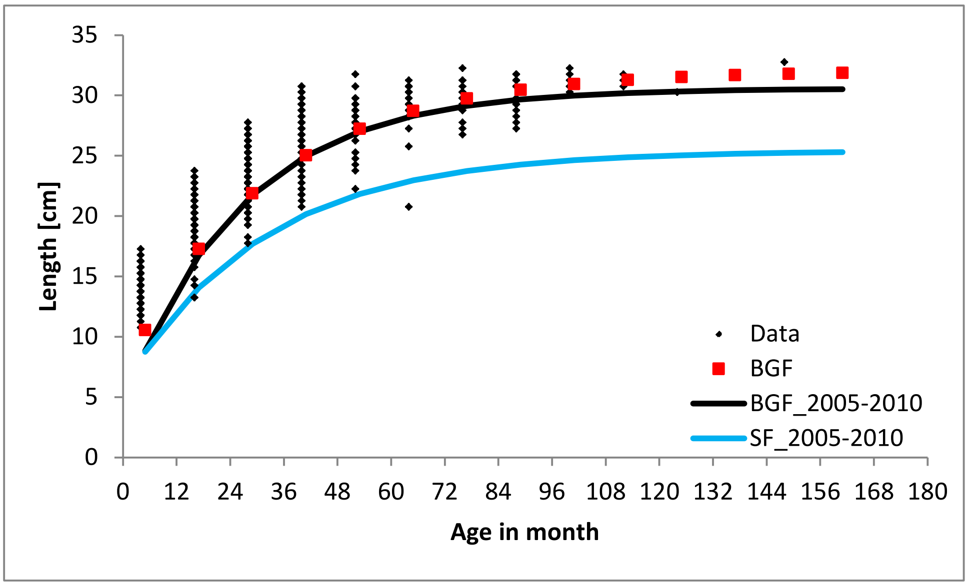


Figure 1: Length-at-age (in months) data of herring captured during GERAS in SD 21 & 23 in 2011 (black dots), BGF based on 2011 data (black line), mean length-at-age based on the BGF of WBSSH 2005 – 2010 (red dots) and estimates of $SF_{2005-2010}$ (blue line).

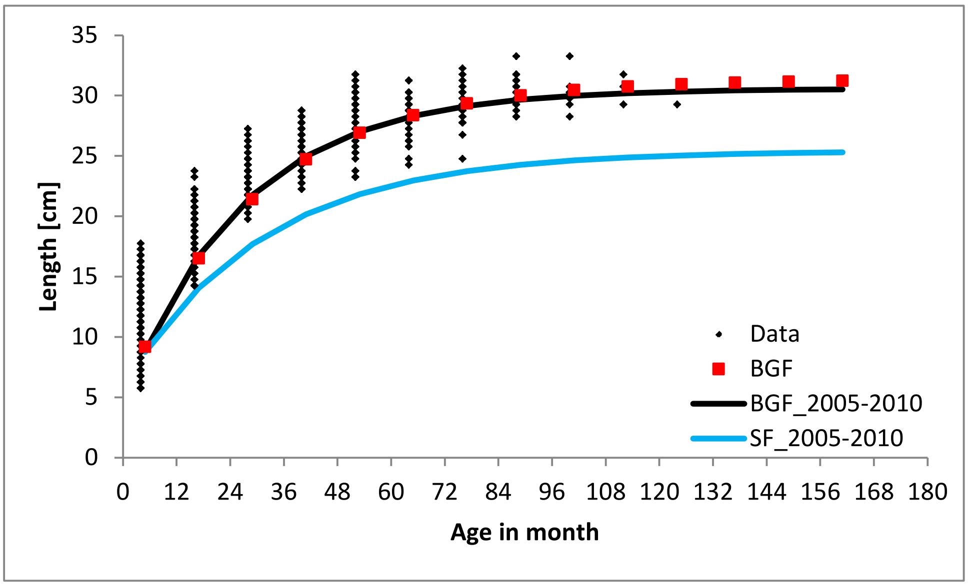


Figure 2: Length-at-age (in months) data of herring captured during GERAS in SD 21 & 23 in 2012 (black dots), BGF based on 2012 data (black line), mean length-at-age based on the BGF of WBSSH 2005 – 2010 (red dots) and estimates of $SF_{2005-2010}$ (blue line).

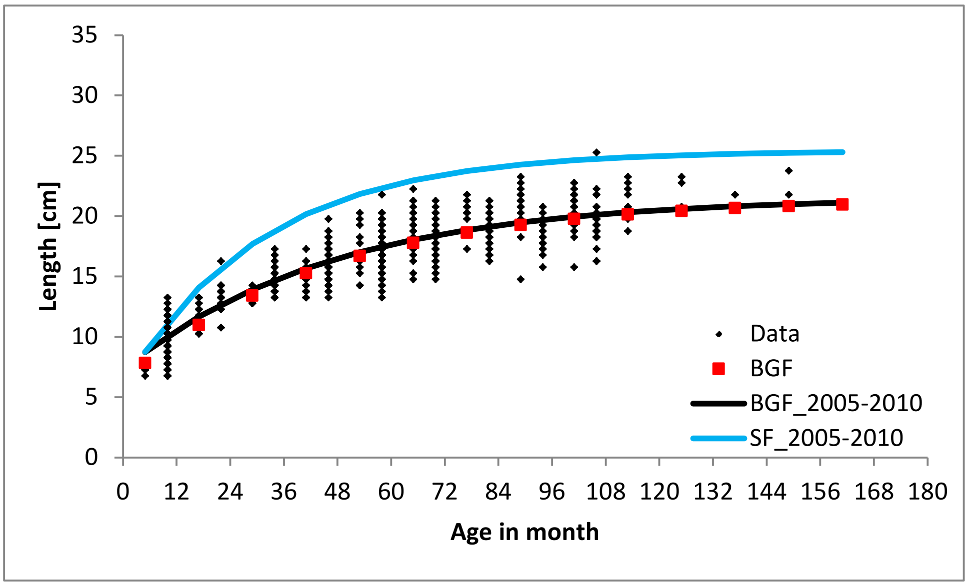


Figure 3: Length-at-age(in months) data of herring captured during German BASS in SD 28 in 2011 (black dots), BGF based on 2011 data (black line), mean length-at-age based on the BGF of WBSSH 2005 – 2010 (red dots) and estimates of $SF_{2005-2010}$ (blue line).

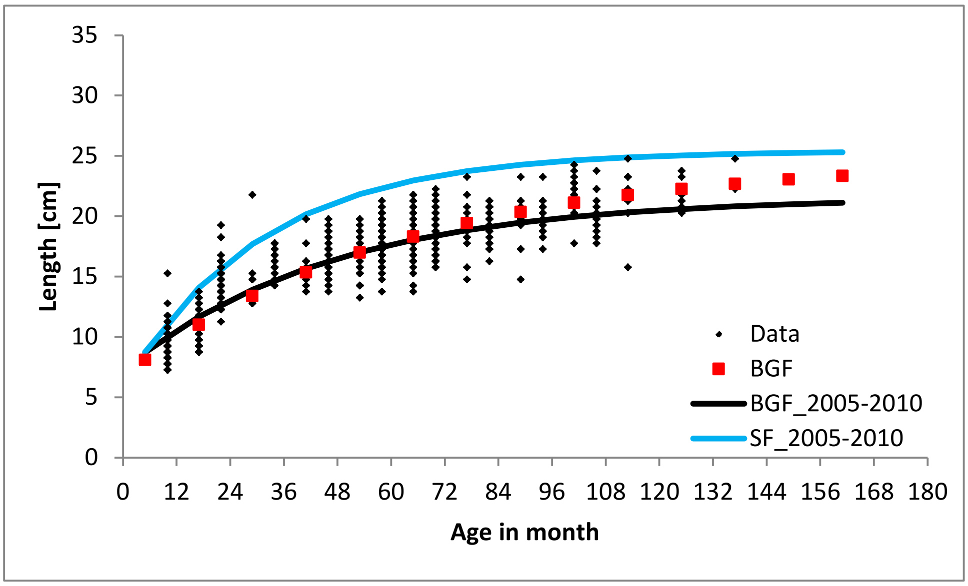


Figure 4: Length-at-age (in months) data of herring captured during German BASS in SD 28 in 2012 (black dots), BGF based on 2012 data (black line), mean length-at-age-based on the BGF of WBSSH 2005 – 2010 (red dots) and estimates of $SF_{2005-2010}$ (blue line).

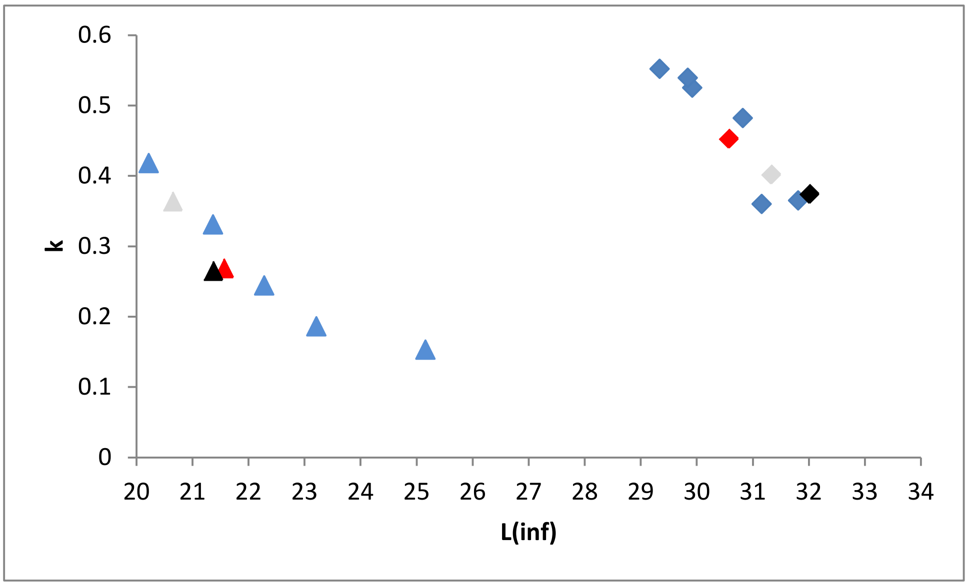


Figure 5 Relation between the parameters of the BGF L(inf) and k for WBBSH (◆) and CBH (▲). The mean estimates based on 2005 – 2010 are marked red, whereas the estimates for 2011 an2012 are marked black and grey, respectively.

New information on prey fields and nutritional condition of overwintering herring larvae in the North Sea: Collaboration opportunities

Marta Moyano, Franziska Bils, Marc Hufnagl, Myron A. Peck

Institute of Hydrobiology and Fisheries Science, University of Hamburg

The poor recruitment of herring in the last decade has been related to the impact of environmental factors on overwintering survival of larvae (Payne et al. 2009). Increased temperatures, changes in the planktonic community and/or in the local hydrodynamics (less retention in nursery areas) have been pointed out as potential causes for increased larval mortality (Dickey-Collas et al., 2010; Fässler et al. 2011). Nevertheless, the processes and causal factors affecting the recruitment strength of the different North Sea stocks are still unknown (Corten, 2013).

We are proposing new field sampling, physiological-based laboratory measurements, and biophysical modelling simulations to help disentangle the factors affecting feeding, condition and survival of overwintering North Sea herring larvae. This winter (2012-2013), the University of Hamburg (IHF), working in cooperation with IMARES (Cindy van Damme), IMR (Richard Nash) and AFBINI (Steven Beggs), started to collect field samples on in situ concentrations of protists and microzooplankton and to identify those items in larval gut contents and to assess larval nutritional condition (RNA/DNA), Samples were collected from the Irish Sea and North Sea Buchan and Downs stocks. The southern North Sea meszooplankton community will also be analyzed. These samples were taken within the frame of the International Herring Larval Survey (IHLS) and the International Bottom-Trawl Survey (IBTS). With these data we expect to shed some light on how prey concentrations may interact with other abiotic factors (temperatures) to affect overwinter survival of larvae and to identify common characteristics of survivors.

In addition to field sampling, we have conducted laboratory experiments testing the effects of prey (mesozooplankton) x temperature combinations on larval growth physiology, survival and biochemical condition. We hope to conduct similar experiments using protists and/or other microzooplankton. Downs herring larvae have been used in these experiments. This laboratory work is critical for parameterizing a biophysical individual-based model (IBM) for herring larvae (Hufnagl & Peck, 2011). The model contains physiologically-based (mechanistic) subroutines for foraging (energy gain) and metabolism (energy loss) and can simulate feeding and growth of larvae within size-structured prey fields. The ultimate goal is to better simulate feeding conditions experienced by larvae in the field (by improving biogeochemical, lower trophic level (LTL) models) and to utilize a coupled LTL-IBM to simulate larval herring drift, feeding and survival and to challenge those model estimates with available time series data on herring (pre- and post winter). That work is linked to activities within WGIPEM (Integrated, Physical-biological and Ecosystem Modelling).

With our participation in the HAWG 2013 meeting we are willing to disseminate our research to the different HAWG members, and hope to establish collaboration with other members. The IHLS and IBTS cruises offer a great opportunity to collect samples from the complete North Sea basin. We therefore propose to take advantage of these cruises for further analyzing recruitment failure hypotheses, which would afterwards support assessment advice.

References:

Corten, A. (2013). Recruitment depressions in North Sea herring. *ICES Journal of Marine Science*, *70*(1), 1–15.

Dickey-Collas, M., Bolle, L., Van Beek, J., & Erftemeijer, P. (2009). Variability in transport of fish eggs and larvae. II. Effects of hydrodynamics on the transport of Downs herring larvae. *Marine Ecology Progress Series*, *390*, 183–194.

Fässler, S. M. M., Payne, M. R., Brunel, T., & Dickey-Collas, M. (2011). Does larval mortality influence population dynamics? An analysis of North Sea herring (Clupea harengus) time series. *Fisheries Oceanography*, *20*(6), 530–543.

Hufnagl, M., & Peck, M. a. (2011). Physiological individual-based modelling of larval Atlantic herring (*Clupea harengus*) foraging and growth: insights on climate-driven life-history scheduling. *ICES Journal of Marine Science*, *68*(6), 1170–1188.

Payne, M. R., Hatfield, E. M. C., Dickey-Collas, M., Falkenhaug, T., Gallego, A., Gröger, J., Licandro, P., et al. (2009). Recruitment in a changing environment: the 2000s North Sea herring recruitment failure. *ICES Journal of Marine Science*, *66*(2), 272–277.

ICES HAWG Environmental Briefing Sheet

Working Group on Operational Oceanographic Products
for Fisheries and the Environment (WGOOFE)

March 13, 2013

1 Regional Environment

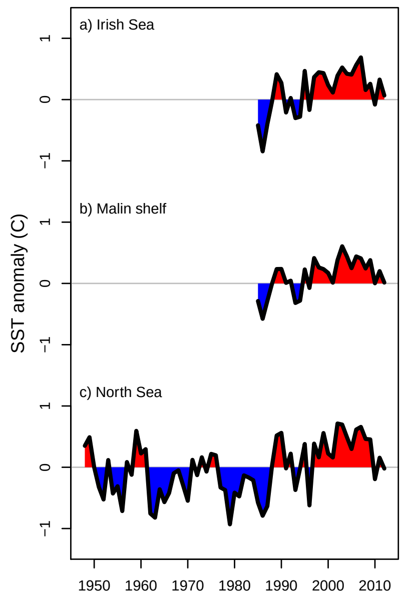


Figure 1: *Anomalies in annually-averaged sea-surface temperatures (SST) for a) the Irish Sea b) the Malin Shelf and c) the North Sea. Anomalies are relative to the arithmetic mean over the period 1985-2000.*

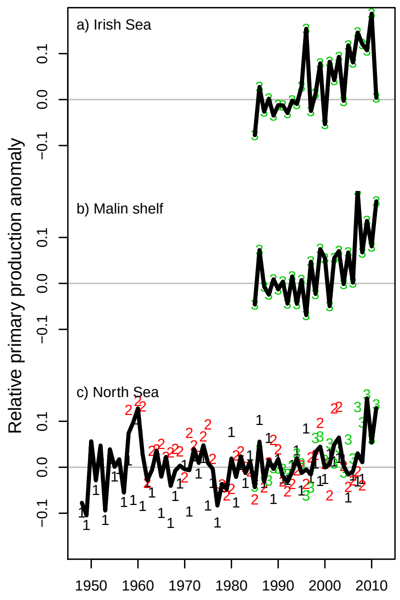


Figure 2: *Relative anomalies in annually-averaged primary productivity for a) the Irish Sea b) the Malin Shelf and c) the North Sea. Points are labelled by data source: 1: ECOSMO 2: ERSEM 3: NORWECOM*

Sea-surface temperatures on the Malin Shelf, Irish Sea and in the North Sea (Figure 1) show strong decadal-scale variability. The most recent decades are amongst the warmest in the time-series. There also appears to be a strong degree of synchrony between the regions considered here. However, the last three years have displayed a reduction in the an average temperature, relative to the previous decade: in the North Sea this has corresponded to 0.5 °C, with smaller reductions in other regions. Primary productivity in these regions has shown a high-degree of inter-annual variability (Figure 2). Clear increasing trends in productivity are apparent in the last decade in the Irish Sea and Malin shelf, and to a lesser extent in the North Sea. However, these increases are mainly driven by the NORWECOM model, which is the only data source for the first two regions. The increasing trend seen in NORWECOM does not appear to be supported by ECOSMO and ERSEM. It is therefore difficult to draw conclusions as to the robustness of this observation.

2 Spawning Environment

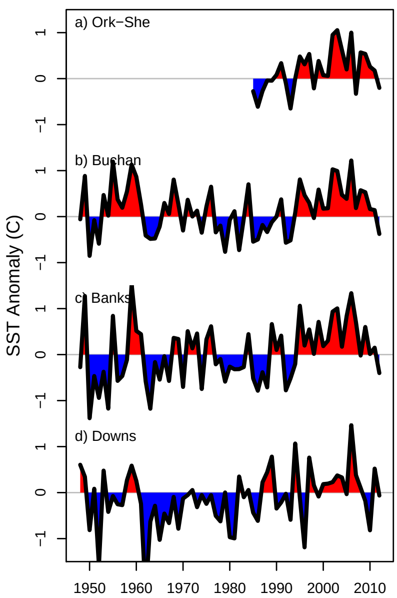


Figure 3: *Anomalies in sea-surface temperatures (SST) averaged over the spawning grounds of the North-Sea Autumn Spawning (NSAS) herring stock during the spawning period. Anomalies are expressed as relative to the period 1985-2000 (inclusive).*

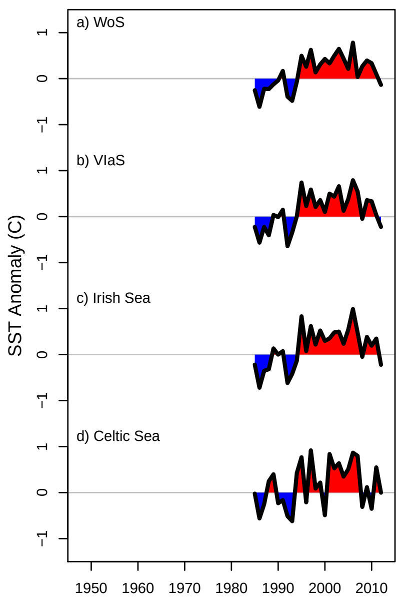


Figure 4: *Anomalies in sea-surface temperatures (SST) averaged over the herring spawning grounds to the west of Great Britain during the spawning period. Anomalies are expressed as relative to the period 1985-2000 (inclusive).*

The temperatures on the North Sea Autumn Spawning (NSAS) spawning grounds suggest anomalous warmth since the mid 1990s (Figure 3. There is also a high degree of sychrony visually apparent between the northern-most components (Orkney-Shetland, Buchan and Banks): this result has been reported elswhere previously (Fässler et al 2011). The most recent years have, however, suggested a return to temperatures last seen in the 1980s-early 1990s. The Downs component has not shown the same strength or persistency in warming.

Temperatures on the spawning grounds to the west of Great Britain (Figure 4) show a high degree of sychrony, particularly between the West of Scotland, VIaS and Irish Sea stocks. Consistent warm anomalies are observed since the last 1990s. The most recent years suggest a cooling trend.

3 Methodology

Data was extracted from the following sources

- **NORWECOM** The NORWegian ECOlogical Model system (NORWECOM) is a coupled physical, chemical, biological model system (Aksnes *et al.* , 1995; Skogen *et al.* , 1995) applied to study primary production, nutrient budgets and dispersion of particles such as fish larvae and pollution. The physical model is based on the three-dimensional, primitive equation, time dependent, wind and density driven Princeton Ocean Model (POM) with 20 bottom following sigma layers and 10km nominal resolution. The chemical–biological model incorporates dissolved inorganic nitrogen (DIN), phosphorus (DIP) and silicate (SI), two different types of phytoplankton (diatoms and flagellates), two detritus (dead organic matter) pools (N and P), diatom skeletals (biogenic silica) and oxygen.

- **ECOSMO** The results stem from a multi decadal simulation (1948-2008) with the coupled physical biological model system ECOSMO. The biogeochemical model resolves 3 nutrient cycles, DOM, 3 groups of POM, oxygen and 3 sediment pools. Plankton is resolved by 3 phytoplankton functional groups and 2 zooplankton functional groups. The model is applied to the coupled system of North Sea and Baltic Sea and resolves the complex water mass and nutrient exchange between the two systems. Details about model description, model setup and results from the long-term simulation are provided by Daewel and Schrum (2013) and Barthel *et al.* (2012).

- **ERSEM** Results were generated from the CEFAS hindcast (1958-2008), performed with the coupled GETM-ERSEM-BFM model. The hydrodynamic model GETM has been linked with the biogeochemical model ERSEM-BFM in a joint programme with the NIOZ institute (Netherlands), which included further development to improve benthic-pelagic coupling. The model is fully baroclinic and currently includes 6 phytoplankton functional groups, 4 zooplankton functional groups, 5 benthic functional groups and pelagic and benthic bacteria. The bed is divided in 3 separate sediment layers based on redox characteristics. The hindcast uses ECMWF ERA40 and Operational Hindcast meteorological data, oceanic climatologies on the open boundaries and the OSPAR ICG-EMO database for daily riverine flow and nutrients. See van Leeuwen *et al.* (2012) for more details.

- **OSTIA** The Operational Sea Surface Temperature and Sea Ice Analysis (OSTIA; Donlon *et al.* , 2011) is run operationally at the UK Met Office to produce daily analyses of global sea surface temperature and sea ice concentration. Remotely sensed and in situ observations are assimilated onto a background field based on the previous day's analysis, with a slight relaxation to climatology. Data for 1985-2006 are taken from an OSTIA reanalysis performed by Roberts-Jones *et al.* (2012). Data from 2007 onwards are taken from the operational system.

Data was selected and averaged in two ways thought to be of relevance to the biology and physiology of the stocks considered within HAWG. The first approach (section 1) focused on characterising the regional environment. Sea surface temperature (SST) were obtained from all four data sources, and primary production (PP) estimates from the three biogeochemical models. Annual averages over the regional domains defined by the following boundaries

- **Irish sea** 55N, West coast of Great Britain, 53N, East coast of Ireland.
- **Malin shelf** West and North coast of Great Britain, 4W, 61N, 200m isobath, 10W, 55N, Irish coast, 55N.
- **North Sea** East and North coast of Great Britain, 4W, 61N, Nowegian Coast, 8E, Danish-German-Dutch-Belgium coast

Primary production estimates, however, are associated with appreciable biases. These products were therefore combined into a single PP product by considering the relative anomalies in each individual product.

The second approach focused on the enviroment of the spawning grounds, where recruitment strength is thought to be determined (e.g. Payne *et al.* 2008). Estimates of SST derived for each spawning component were calculated based from averages over the spatial (Figure 5) and temporal (Figure 6) spawning domains.

In all cases, anomalies were defined based on the period 1985-2000, which was common to all data sources. An anomaly integated across all data sources was then calculated based on a linear mixed-effects model

$$\begin{aligned} y_{ij} &\sim t_i + d_j + \epsilon_{ij} \\ d_j &\sim N\left(0, \sigma_d^2\right) \\ \epsilon_{ij} &\sim N\left(0, \sigma_\epsilon^2\right) \end{aligned} \tag{1}$$

where y_{ij} is the anomaly obtained in year i from data source j, t_i is the year effect, d_j is the model effect and ϵ_{ij} are the residuals. The data source effect, d_j, is assumed to a normally distributed random-effect. The year effects, t_i are used as the index for each year plotted above.

4 References

Aksnes, D., Ulvestad, K., and Balino, B. 1995. Ecological modelling in coastal waters: towards predictive physical-chemical-biological simulation models. Ophelia, 41: 5–36. Apollo Books.

Barthel, K, Schrum, C, Daewel, U, Årthun, M, Pushpadas, D, (2012). Resolving frontal structures: On the computational costs and pay-off using a less diffusive but computational more expensive advection scheme. Ocean Dynamics DOI 10.1007/s10236-012-0578-9.

Daewel, U and Schrum, C., (2013). Simulating long-term dynamics of the coupled North and Baltic Sea ecosystem with ECOSMO II: model description and validation. Accepted for publication by Journal of Marine System.

Donlon, C. J., M. Martin, J. D. Stark, J. Roberts-Jones, E. Fiedler and W. Wimmer, 2011: The Operational Sea Surface Temperature and Sea Ice analysis (OSTIA). Remote Sensing of the Environment. doi: 10.1016/j.rse.2010.10.017.

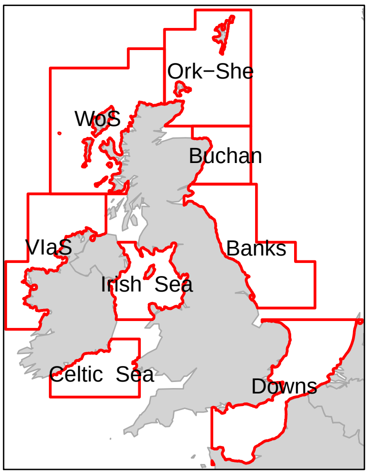


Figure 5: *Spatial regions over which averages for each spawning component have been calculated*

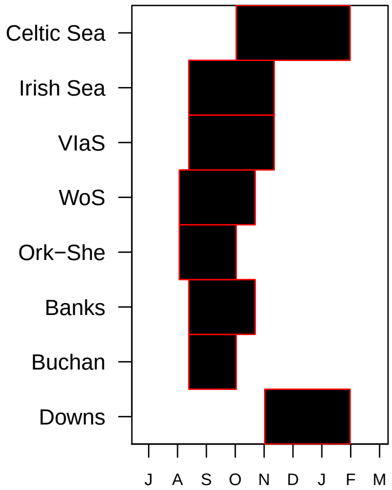


Figure 6: *Temporal windows over which averages for each spawning component have been calculated*

Fässler, S. M. M., Payne, M. R., Brunel, T., and Dickey-Collas, M. 2011. Does larval mortality influence population dynamics? An analysis of North Sea herring (Clupea harengus) time series. Fisheries Oceanography, 20: 530–543. http://doi.wiley.com/10.1111/j.1365-2419.2011.00600.x

van Leeuwen, S.M., J. van der Molen, P. Ruardij, L. Fernand, T. Jickells, 2012, Modelling the contribution of Deep Chlorophyll Maxima to annual primary production in the North Sea, Biogeochemistry, DOI: 10.007/s10533-012-9704-5

Payne, M. R., Hatfield, E. M. C., Dickey-Collas, M., Falkenhaug, T., Gallego, A., Groger, J., Licandro, P., et al. 2008. Recruitment in a changing environment: the 2000s North Sea herring recruitment failure. ICES Journal of Marine Science, 66: 272–277.

Roberts-Jones, J., E. K. Fiedler and M. J. Martin, 2012: Daily, Global, High-Resolution SST and Sea Ice Reanalysis for 1985–2007 Using the OSTIA System. J. Climate, 25, 6215–6232.

Skogen, M. D., and Søiland, H. 1998. A users guide to NORWECOM 2.0: The Norwegian Ecological Model System. Fisken og Havet, 18: 1–42.

Estimates of discarded herring by Dutch pelagic freezer trawler fishery in 2003-2012

A.T.M. van Helmond & H.M.J. van Overzee
IMARES, Wageningen UR

From 2002 onwards discarding by Dutch commercial pelagic freezer trawlers fishing in European waters is monitored under the European Data Collection Framework (DCF). The Dutch fleet of freezer trawlers use a mid-water pelagic trawl to target pelagic species. Their most important fishing grounds in European waters are situated on the continental slope west of the British Isles, in the English Channel, along the British eastern coast, the northern North Sea and the Norwegian Sea (Figure 1).

The Dutch pelagic discard sampling programme aims at sampling twelve trips per year, corresponding with a sampling coverage of around 10% (in number of trips). In 2012, 12 trips were monitored on board pelagic freezer trawlers (Table 1; Figure 1). Herring discards were observed during 7 trips, 6 trips on board Dutch flagged vessels and 1 trip on board a French flagged vessel (Figure 2). As it can be assumed that the foreign flagged vessels exhibit the same fishing behaviour as Dutch flagged vessels, all sampled trips were treated as if they belonged to the Dutch fleet.

Discard estimates for 2012 for herring have been derived from the sampling programme. Total discard weight per species and trip has been raised to fleet level (Table 1) by multiplying the sampled average per year for the sampled trips with the total number of trips of the Dutch fleet in that year. The raised herring discards, solely based on sampled information, are presented in Table 1. In 2012, the raised herring discards were estimated at about 1421 tonnes (CV 62%). This corresponds with 2% of the total catch of the Dutch pelagic freezer trawler fleet (Table 1, Figure 3).

The data collected by the scientific observers show that occasionally part of or the whole catch is discarded without sorting; relatively large amounts of catch are released via the conveyer belt from the cooling tanks or directly from the net. In this working document this type of discarding is referred to as "unsampled discard[1]". As it is impossible for the observers to biologically sample discard events, accurate numbers per species cannot be calculated. It is therefore decided to not include these events in the raised species specific discards. While we recognize that by not including them this results in an underestimation of the herring discards, we believe that leaving

---

[1] This type of discarding is internationally often described as slippage (Borges *et al.*, 2008). However, we believe that this term does not sufficiently describe this process as the terminology suggest that catch is only directly discarded from the net.

out this correction is decreasing the noise in the data, and therefore a more desirable approach in estimating species specific discards. In 2012, unsampled discards are estimated at 1431 tonnes (raised by total number of trips per year).

The annual landings of the Dutch pelagic fleet show that this fishery is seasonal. It is therefore not surprising that the discarding of herring differs between fishing season. Discarding of herring was observed during quarters 2, 3 and 4 in 2012. The length frequency shows that there appears to be very little selection by size between landed and discarded herring (Figure 3).

Due to poor sampling resolution it is not possible to estimate herring discards by stock or create numbers at age matrices (see Dickey-Collas et al., 2007; Borges et al., 2008). The variance will increase when attempting to estimate to stock or area level. Therefore, due to higher level of stratifications, at present only total annual discards of herring can be estimated.

Table 1: Overview of the fleet activity, number of trips observed, raised herring discards (tonnes) and Standard Error in the Dutch pelagic freezer trawler fleet per year (2003-2012)

Year	Number trips pelagic Dutch flagged fleet	Number sampled trips	Herring discards (tonnes)	Standard Error
2003	131	5	6350	4452
2004	131	6	2825	2398
2005	142	12	3683	1835
2006	122	12	2747	1448
2007	124	12	2729	1011
2008	110	12	1052	387
2009	93	11[a]	2173	1136
2010	91	8[b]	646	417
2011	88[#]	15[c]	1019*	286
2012	85	12[d]	1421	886

[a] This includes 9 trips on board Dutch flagged vessels, 1 trip on board a German flagged vessel and 1 trip on board a British flagged vessel

[b] is includes 5 trips on board Dutch flagged vessels, 1 trip on board a German flagged vessels and 2 trips on board British flagged vessels

[c] This includes 14 trips on board Dutch flagged vessels and 1 trip on board a French flagged vessel

[d] This includes 8 trips on board Dutch flagged vessels, 2 trips on board a French flagged vessels and 2 trips on board German flagged vessels

[#] Number of trips have been adjusted

* Adjusted according to most recent information (see comment above)

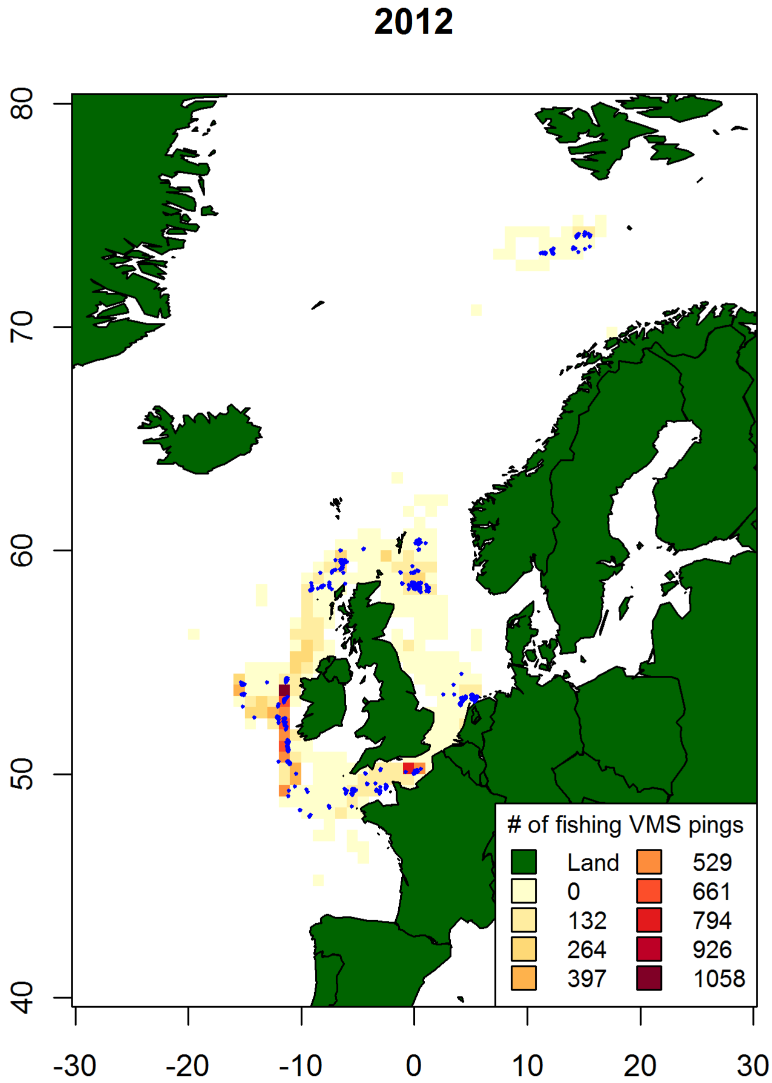


Figure 1: Distribution of the Dutch pelagic fleet (based on VMS data) and positions of **all** sampled pelagic discard trips per haul for 2012 (blue points).

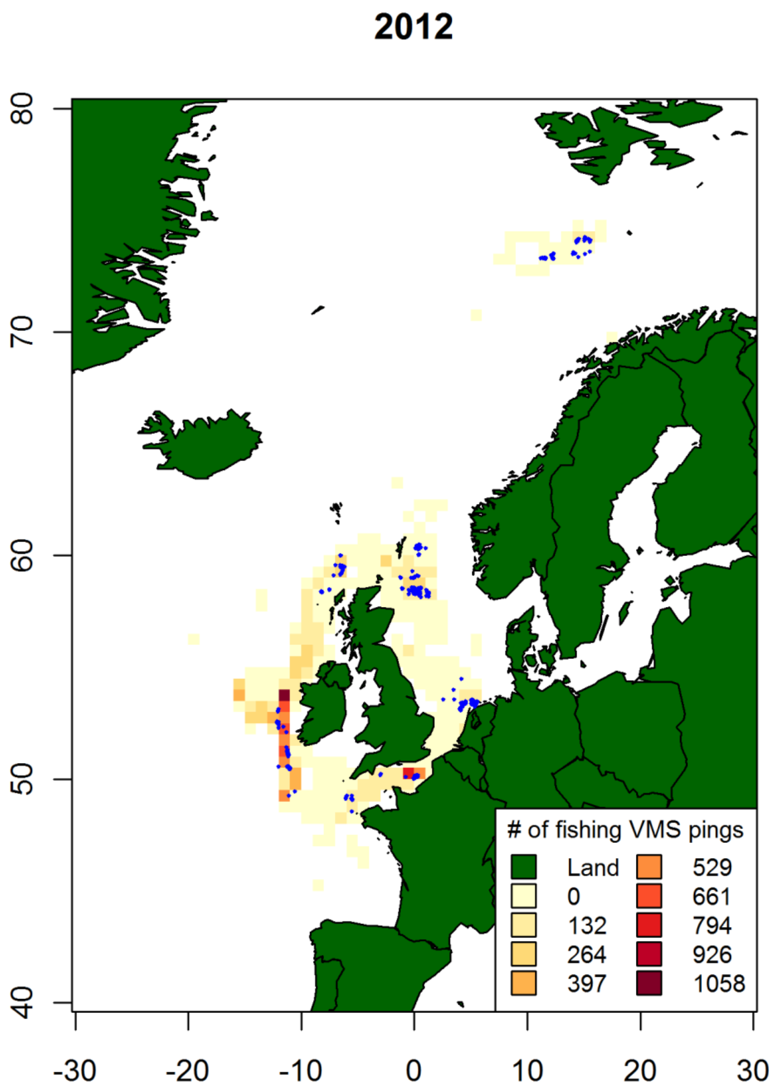


Figure 2: Distribution of the Dutch pelagic fleet (based on VMS data) and positions of the sampled pelagic discard trips per haul for 2012 where **herring** discards were observed (blue points).

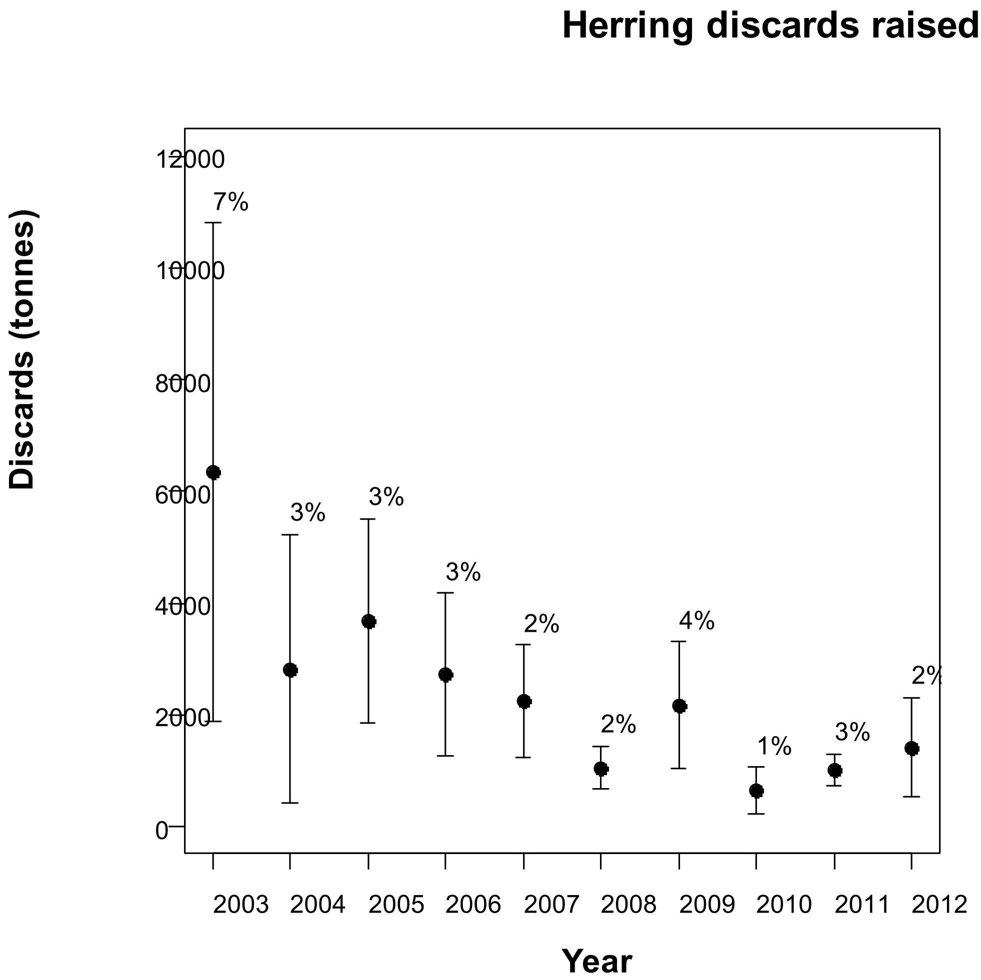


Figure 3: Raised herring discards (tonnes) by the Dutch pelagic freezer trawler fleet per year (2003-2012) from all ICES areas and corresponding percentage of discards to total catch of the fleet. Error bars denote ± standard error of the estimates of discards.

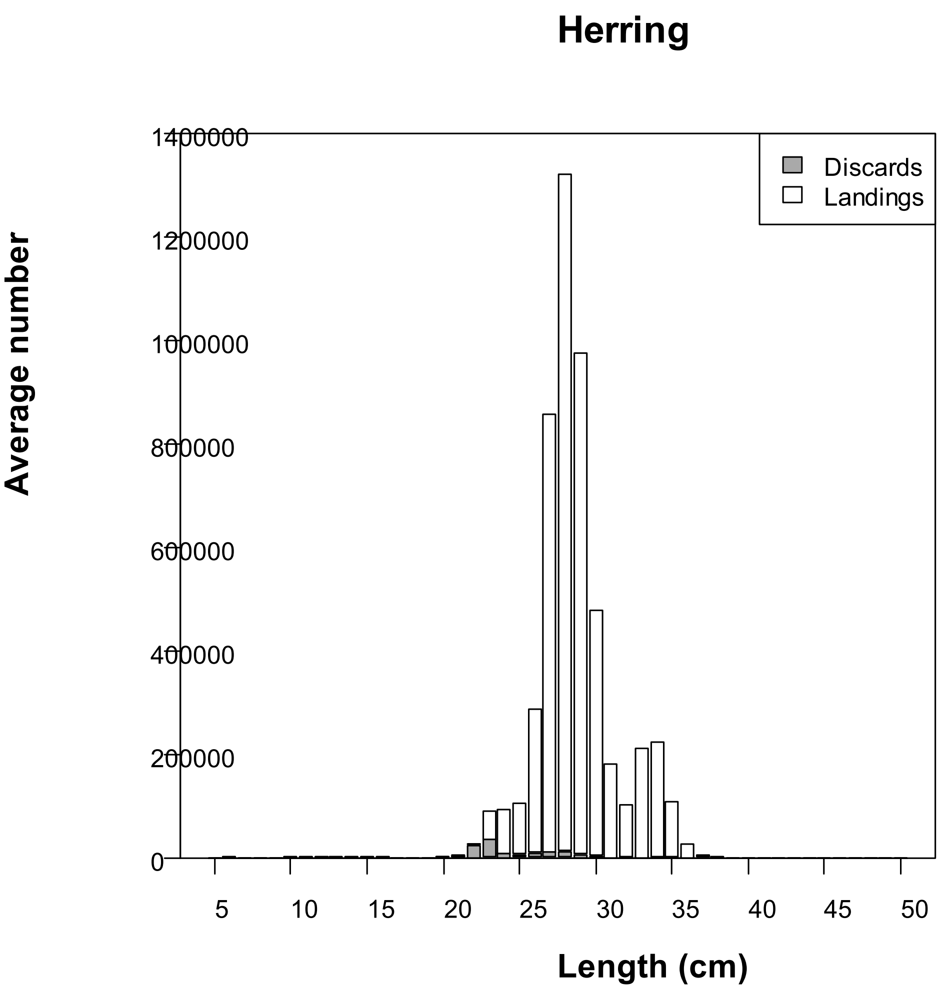


Figure 3: Average number herring landed and discarded against length (cm) by the sampled Dutch pelagic freezer trawlers for 2012.

References

Borges, L., O.A. van Keeken, A.T.M. van Helmond, B. Couperus & M. Dickey-Collas, 2008. What do pelagic freezer-trawlers discard? ICES Journal of Marine Science, 65: 605-611.

Dickey-Collas, M., M.A. Pastoors & O.A. van Keeken, 2007. Precisely wrong or vaguely right: simulations of the inclusion of noisy discard data and trends in fishing effort on the stock assessment of North Sea plaice. ICES Journal of Marine Science, 64: 1641-1649.

Helmond, A.T.M. & H.M.J. van Overzee, 2012. Estimates of discarded herring by Dutch flagged vessels 2003-2011. Working Document for the ICES Herring Assessment Working Group 2012.

Annex 1: List of Participants

Herring Assessment Working Group South of 62° N [HAWG]

12–21 March 2013

LIST OF PARTICIPANTS

Name	Address	Phone/Fax	Email
Lotte Worsøe Clausen Co-chair	National Institute of Aquatic Resources, Section for Population Ecology and Genetics Charlottenlund Slot, Jægersborg Alle 1 DK-2920 Charlottenlund Denmark	Phone +45 33963364 Fax +45 33963333	law@aqua.dtu.dk
Beatrice Roel Co-chair	Centre for Environment, Fisheries and Aquaculture Science (CEFAS) Lowestoft Laboratory Pakefield Road NR33 0HT Lowestoft Suffolk United Kingdom	Phone +44 1 502 52 4358 Fax +44 1502 524 511	beatriz.roel@cefas.co.uk
Valerio Bartolino	Department of Aquatic Resources Swedish University of Agricultural Sciences Turistgatan 5, 45321 Lysekil, Sweden	Phone +46761268049	valerio.bartolino@slu.se
Mikael van Deurs	DTU Aqua - National Institute of Aquatic Resources Section for Fisheries Advice Charlottenlund Slot Jægersborg Alle 1 2920 Charlottenlund Denmark	Phone +45 33 96 34 38 Fax +45 33 96 33 80	mvd@aqua.dtu.dk
Afra Egan	Marine Institute Rinville Oranmore Co. Galway Ireland	Phone +353 9173 0400 Fax +353 9173 0470	afra.egan@marine.ie
Sascha Fassler	IMARES P.O. Box 68 1970 AB IJmuiden Netherlands	Phone +31 371 487474	sascha.fassler@wur.nl
Tomas Gröhsler	Johann Heinrich von Thünen-Institute, Institute of Baltic Sea Fisheries Alter Hafen Süd 2 D-18069 Rostock Germany	Phone +49 381 811 6104 Fax +49 381 811 6199	tomas.groehsler@vti.bund.de
Emma Hatfield	Marine Scotland - Science 375 Victoria Road Aberdeen AB11 9DB United Kingdom	Phone +44 1224 295434 Fax +44 1224 295511	e.hatfield@marlab.ac.uk
Niels Hintzen	IMARES P.O. Box 68 1970 AB IJmuiden Netherlands	Phone +31 317 487 090 Fax +31 317 487326	niels.hintzen@wur.nl
Cecilie Kvamme	Institute of Marine Research P.O. Box 1870 Nordnes 5817 Bergen Norway	Phone +47 55 23 69 31 Fax +47 55 23 68 30	cecilie.kvamme@imr.no

Name	Address	Phone/Fax	Email
Susan Mærsk Lusseau	Marine Scotland - Science 375 Victoria Road Aberdeen AB11 9DB United Kingdom	Phone: +44 1224 295654 Fax +44 1224 295511	s.lusseau@marlab.ac.uk
Henrik Mosegaard	National Institute of Aquatic Resources, Section for Population Ecology and Genetics Charlottenlund Slot, Jægersborg Alle 1 DK-2920 Charlottenlund Denmark	Phone +45 33 96 34 61 Fax +45 33 96 33 33	hm@aqua.dtu.dk
Marta Moyano	Marta Moyano University of Hamburg Olbersweg 24 22767 Hamburg Germany	Phone +49 Fax +49	marta.moyano@uni-hamburg.de
Richard Nash	Institute of Marine Research P.O. Box 1870 Nordnes 5817 Bergen Norway	Phone +47 55 23 68 55 Fax +47 55 23 85 31	Richard.Nash@imr.no
Cormac Nolan	Marine Institute Rinville Oranmore Co. Galway Ireland	Phone +353 91387200 Fax +353 91387201	cormac.nolan@marine.ie
Mark Payne	DTU Aqua - National Institute of Aquatic Resources Section for Fisheries Advice Charlottenlund Slot Jægersborg Alle 1 2920 Charlottenlund Denmark	Phone +45 3396 3474 Fax +45 3396 3333	mpa@aqua.dtu.dk
Anna Rindorf	DTU Aqua - National Institute of Aquatic Resources Jægersborg Allé 1 2920 Charlottenlund Denmark	Phone +45 33 96 33 78 Fax +45 33 96 33 33	ar@aqua.dtu.dk
Norbert Rohlf	Thünen Institute of Sea Fisheries Palmaille 9 D-22767 Hamburg Germany	Phone +49 40 38905 166 Fax +49 40 38905 263	norbert.rohlf@ti.bund.de
Pieter-Jan Schön	Agri-food and Biosciences Institute (AFBI) AFBI Headquarters 18a Newforge Lane BT9 5PX Belfast United Kingdom	Phone +44 28 90255015 Fax +44 28 90255004	pieter-jan.schon@afbini.gov.uk
Claus Reedtz Sparrevohn	Danish Pelagic Producers Organisation Willemoesvej 2 9850 Hirtshals Denmarkl	Phone +45 Fax +45	crs@pelagisk.dk
Yves Vérin	IFREMER Boulogne-sur-Mer Centre P.O. Box 699 F-62 321 Boulogne Cedex France	Phone +33 321 995 600 Fax +33 321 995 601	yves.verin@ifremer.fr

Annex 2 Recommendations

Stock	Recommendation	Justification	Recipient
Sprat in general	Initiation of studies specifically targeted at elucidating the stock structure and boundaries in the Northeast Atlantic region and the provision of definitions of stocks of sprat within the ICES area.	There is insufficient current or new information to evaluate the stock composition of sprat in the north-eastern Atlantic. To undertake meaningful management of sprat it is imperative to define the stocks in the ICES area. To meet the requirement of defining the stocks within this area there is an absolute necessity for new research on the genetic structure of sprat populations in the area and studies to elucidate movements of individuals between or within the ICES management areas. From WKSPRAT 2013.	National institutes, WGIPEM, SIMWG
Herring in general	Evaluation of the effect of gravel extraction and other bottom-disturbing activities on herring spawning grounds for herring spawning success.	Gravel substrate is important fish habitat for herring spawning. Herring spawning and nursery areas are sensitive and vulnerable to anthropogenic influences. Activities that have an impact on the spawning habitat of herring, such as extraction of marine aggregates (such as gravel and sand) and construction, can impact spawning. Herring abandon and repopulate spawning grounds and an absence of spawning in any particular year does not mean that the spawning ground is not required to maintain a resilient herring population.	WGEXT
Herring and sprat	Creation and publication of a user-manual for the SAM model	A large number of ICES WGs are using SAM as stock assessment model. HAWG recommends the need for the development of appropriate documentation on SAM, which is currently sparse and highly incomplete. In the specific, HAWG would find useful both a user manual and a more technical manual.	ICES

Greater North Sea herring and sprat	Set up an expert group or case study with the express remit to examine the MIK survey and its generation of a recruitment index for the North Sea herring stock. Coordination between groups necessary.	The HAWG currently has a survey (IBTSO, MIK samples of 0-wr fish) which has been an extremely good indicator of recruitment in North Sea herring. Since the survey was set up there have been changes in the sub-components of the herring stock. It appears now that this survey may start to underestimate one of the components ("Downs") and it is necessary to examine the survey design and analyses to ensure that this survey can provide the quality recruitment forecasts it has in the past. HAWG requests that WGALES set up an expert group with the express remit to examine the MIK survey and its ability to deliver a recruitment index for the North Sea herring stock. It is envisioned that this group will need to examine the survey design (including gear types and selectivity and spatial and temporal coverage), sampling protocols, herring larval ecology, studies currently underway (examine larvae abundances and cohort tracking, an investigation of the size distributions and potential missing data in the MIK and an examination of MIK gear selectivity in regard to small larvae), modern analytical techniques and protocols for the delivery of a recruitment index. These questions are viewed as critical to the long-term benchmark planning for this stock, and that this may be an ideal case study for WGISDAA.	WGALES, WGISDAA
Greater North Sea and Celtic Seas herring and sprat	Making briefing sheets on the current state of the ecosystem for the herring stocks	HAWG benefited greatly from the generation of the "environmental briefing sheet" prepared by WGOOFE, providing a concise overview of the state of the environment thought to be relevant to the stocks assessed by HAWG. HAWG would like to thank	WGOOFE, WGSAM

		WGOOFE its efforts in this direction, and to continue this collaboration: suggestions for further develops are contained in HAWGs report. However, this represents only the bottom-up part of the system: HAWG would therefore very much like to see the development of a corresponding "top-down" briefing sheet, characterizing the current state of predatory and competitive influences of other species on the dynamics of the groups stocks. The Working Group on Multispecies Assessment Models (WGSAM) would be an ideal candidate for the production of such a product, and therefore encourages WGSAM to enter a dialogue about the generation of such an overview.	

Annex 3– Stock Annex North Sea Herring

Quality Handbook	ANNEX: hawg-her47d3

Stock specific documentation of standard assessment procedures used by ICES.

Stock:	North Sea Autumn Spawning Herring (NSAS)
Working Group:	Herring Assessment WG for the Area south of 62°N
Date:	16 February 2012
Authors:	M. Dickey-Collas, M. Payne, N. Hintzen, H. Mosegaard, L.A.W. Clausen, N. Rohlf, E.M.C. Hatfield, S.M. Lusseau, K. Enberg, V. Bartolino, P. Munk, C. Zimmermann,

A. General

A.1. Stock definition:

Autumn spawning herring distributed in ICES area IV, Division IIIa and VIId. The stock consists of four major spawning components; contributions of these individual components to the total stock differ over time. Mixing with other stocks occurs, especially in Division IIIa (with western Baltic spring spawning herring). Recent studies have shown that the different spawning aggregations of this stock are genetically homogeneous (Mariani *et al*., 2005; Reiss *et al*., 2009).

A.2. Fishery

North Sea Autumn Spawners are exploited by a variety of fleets, ranging from small purse seiners to large freezer trawlers, of different nations (Norway, Denmark, Sweden, Germany, The Netherlands, Belgium, France, UK, Faroe Islands). The majority of the fishery takes place in the Orkney-Shetland area and northern North Sea in the 2^{nd} and 3^{rd} quarters, and in the English Channel (Division VIId) in the 4^{th} quarter. Juveniles are caught in Division IIIa and as by-catch in the industrial fishery in the central North Sea. For management purposes, four fleets are currently defined: Fleet A is harvesting herring for human consumption in IV and VIId, but includes herring by-catches in the Norwegian industrial fishery; Fleet B is the industrial (small mesh, <32 mm mesh size) fleet of EU nations operating in IV and VIId. North Sea Autumn spawners are also caught in IIIa in Fleets C (human consumption) and D (small mesh).

A.3. Ecosystem aspects:

Herring is the key pelagic species in the North Sea and is thus considered to have major impact as prey and predator to most other fish stocks in that area (Dickey-Collas *et al*., 2010).

The North Sea is semi-enclosed and situated on the continental shelf of north-western Europe and is bounded by England, Scotland, Norway, Sweden, Denmark, Germany, the Netherlands, Belgium and France. It covers an area of ~750 000 km^2 of which the greater part is shallower than 200 m. It is a highly productive (>300 $gC\ m^{-2}\ yr^{-1}$) ecosystem but with primary productivity varying considerably across the sea. The highest values of primary productivity occur in the coastal regions, influenced by terrestrial inputs of nutrients, and in gyre areas such as the Dogger Bank and at tidal fronts. Changes observed in trophic structure or diversity may be indicative changes in resilience of this ecosystem (Thrush *et al.*, 2009). This trend may partially be a response to inter-annual changes in the physical oceanography of the North Atlantic (Reid *et al.*, 2001).

Herring are an integral and important part of the pelagic ecosystem in the North Sea. As plankton feeders they form an important part of the food chain up to the higher trophic levels. Both as juveniles and as adults they are an important source of food for some demersal fish, birds and for sea mammals (see review by Dickey-Collas *et al*., 2010). Over the past century the top predator, man, has exerted the greatest influence on the abundance and distribution of herring in the North Sea. Spawning stock biomass has fluctuated from estimated highs of around 4.5 million tonnes in the late 1940s to lows of less than 100 000 tonnes in the late 1970s (Mackinson, 2001; Mackinson and Daskalov, 2007; Simmonds 2007). The species has demonstrated robustness in relation to recovery from such low levels once fishing mortality is curtailed in spite of recruitment levels being adversely affected (Nash *et al*., 2009; Payne *et al*., 2009).

Their spawning and nursery areas, being near the coasts, are particularly sensitive and vulnerable to anthropogenic influences (Röckmann *et al*., 2011). The most serious of these is the ever increasing pressure for marine sand and gravel extraction and the development of wind farms. This has the potential to seriously damage and to destroy the spawning habitat and disturb spawning shoals and destroy spawn if carried out during the spawning season. It also has the potential to destroy traditional spawning grounds which are currently unused but likely to be recolonised (Schmidt *et al*., 2009). Similarly, trawling at or close to the bottom in known spawning areas can have the same detrimental effects. It is possible that the disappearance of spawning on the western edge of the Dogger Bank could well be attributable to such anthropogenic influences.

In more recent years the oil and gas exploration in the North Sea has represented a potential threat to herring spawning although great care has been taken by the industry to restrict their activities in areas and at times of known herring spawning activity.

By-catch and Discard

By-catch consists of the retained 'incidental' catch of non-target species and discard is a deliberately (or accidentally) abandoned part of the catch returned to the sea as a result of economic, legal, or personal considerations. This section therefore deals with these two elements of the fishery, looking specifically at fishery-related issues. Cetacean, seabird and other threatened, rare and charismatic species which may form part of a by-catch are considered separately in the next section. Discarding is illegal for Norwegian vessels, and slippage and high grading are now illegal for EU vessels if quota is still available and the fish are above minimum landing size.

Incidental Catch: The incidental catch of non-target species in the North Sea pelagic herring fishery in general is considered to be low (Borges *et al*., 2008). A study by Pierce *et al.* (2002) investigated incidental catch from commercial pelagic trawlers over the period January to August 2001. The target species, herring, accounted for 98% by weight of the overall catch with an overall incidental catch of 2.3% made up of mackerel, haddock, horse mackerel and whiting. However, onboard sampling during 2002, by Scottish and German observers, found substantial discards of herring, taken as by-catch in the mackerel fishery over the 3rd and 4th quarters, after herring quotas had been exhausted. This was not found in a study of the Dutch fleet (Borges *et al*., 2008) where the herring fishery was found to be relatively "clean". Updates of the time series of Dutch discarding due to sorting suggest an approximate discard of <5% of the catch (Helmond and Overzee, 2010a).

Discards and slipping: The indications are that large-scale discarding is not widespread in the directed North Sea herring fishery. A number of direct-observer surveys have been conducted on Scottish, Dutch and Norwegian pelagic trawlers, (Napier *et al*, 1999; 2002; Borges *et al*., 2008; van Helmond & Overzee, 2011). The overall discard rate was less than 5% of the landed catch. It is likely that there are different discard rates between the specific fishing types. There is disagreement about the amount of slippage compared to discarding by the differing fleets (**slippage**- fish released from the nets whilst still in the water but still resulting in the mortality of the majority of pelagic fish, **discarding**- fish dumped back into the sea after having been brought on board). In freezer trawlers discarding can occur through sorting the catch and through emptying of tanks via the processing belts without sorting. For both pursers and trawlers 'poor' fish quality was a significant cause of discarding. Another reason is the processing capacity of freezer trawlers when catches are abundant (Helmond and Overzee, 2010b). The strength of year classes influences discarding behaviour, particularly of undersized fish. The influence of strong herring year classes was apparent in the composition of discards with smaller, younger fish accounting for a high proportion of the fish discarded in 2001. Since the mid 2000s the stronger recruitment of mackerel has probably led to an increase in discarding due to mixed hauls of herring and mackerel.

Ecosystem Considerations. A potential ecosystem impact of the North Sea herring fishery is the removal of fish that could provide other "ecosystem services". The North Sea ecosystem needs a trophic link to graze the plankton and act as prey for other organisms. If herring biomass is very low, other species, such as sandeel, may replace its role (it has been suggested that the shift from herring to sandeel as prey for seals along the English coast in the 1970s, resulted from the collapse of the herring stock), or the system may shift in a more dramatic way. The interaction of herring with cod and Norway pout population dynamics has been alluded to (Cushing, 1980; Huse *et al*., 2008; Fauchald, 2010), and Speirs *et al*. (2010) suggest that the current biomass of herring will prevent the recovery of the cod population even if fishing mortality on cod is reduced. Large populations of predator fish like saithe, cod and whiting, but also to some degree large cetacean or seal populations, will also impact the herring biomass (ICES WGSAM REPORT –ICES, 2011). However, many of the current ecosystem models are very sensitive to the assumptions about herring, or do not include herring as a predator and prey species, thus it is difficult to test the impact of increasing or reducing the herring biomass on the ecosystem functioning as a whole. It is highly likely that, for Good Environmental Status (GES), the North Sea requires a certain threshold of herring biomass.

Interactions with Rare, Protected or charismatic mega fauna: Interactions between the directed North Sea herring fishery with rare, protected or charismatic mega fauna species are, in general, considered to be low. Species which may interact with the fishery are considered below.

Cetacean by-catch: Since 2000, the Sea Mammal Research Unit (SMRU) of St. Andrew's University in Scotland, under contract to DEFRA, has carried out a number of surveys to estimate the level of by-catch in UK pelagic fisheries. SMRU, in collaboration with the Scottish Pelagic Fishermen's Association, placed observers on board thirteen UK vessels for a total of 190 days at sea, covering 206 trawling operations around the UK. No cetacean by-catch was observed in the herring pelagic fishery in the North Sea. Pierce *et al.* (2002) also reports that no by-catches of marine mammals were observed over 69 studied hauls and considers that the underlying rate for marine mammals in the pelagic fisheries studies (pelagic trawls in IVa and VIa) is no more than 0.05 (i.e. five events per 100 hauls) and may well be considerably lower than this. Consequently, the cetacean by-catch by the pelagic trawl fishery can be regarded as negligible. This was also confirmed by a UK observer programme that ended in 2003 (Northridge, pers. Comm.) and Dutch observers (1 catch from 2007-2009 over 210 days observed; Couperus, 2009; ICES 2011b).

***Seal by-catch*:** The by-catch of seals in directed pelagic herring fishery in the North Sea is reported to be "very rare" (Aad Jonker, pers. comm.). Independent verification also confirms this to be so, with perhaps one animal being caught by the whole North Sea fleet a year (Bram Couperus (IMARES, pers. comm.). Northridge (2003) observed 49 seals taken in 312 pelagic trawl tows throughout UK waters and reports that the fishery in north-western Scotland has the highest observed seal by-catch levels of UK pelagic trawl fisheries, possible amounting to dozens per year. Although not confirmed, it was assumed that the majority were grey seal *Halichoerus grypus*. This species is mainly distributed around the Orkneys and Outer Hebrides – out of a UK population of 129 000, only around 7 000 and 5 900 are distributed off the Scottish and English North Sea coasts respectively (SCOS, 2002), and so by-catch rates in the North Sea are likely to be substantially less than off the NW Scottish coast. The eastern Atlantic population of the grey seal is not considered to be threatened.

***Other by-catch*:** Sharks are occasionally caught by pelagic trawlers in the North Sea, although this is rare, with a maximum of two fish per trip (Aad Jonker, pers. comm.). Survival rates are apparently high; sharks are released during or after the cod-end has been emptied. The species are unknown, although blue shark *Prionace glauca*, which preys primarily upon schooling fishes such as anchovies, sardines and herring, are known to have been caught by pelagic trawls off the SW English coast (Bram Couperus (IMARES, pers. comm.). Gannets (*Morus bassanus*), which frequently dive at and around nets, were observed by Napier *et al.* (2002) entangled in the nets but were not present in samples. Actual mortality rates of caught gannets have not been assessed in detail, and some have been observed alive after release from the gear. An extrapolation from observed mortalities corresponds to around 560 gannet deaths per year, although this is based on a relatively low sample frame. Seabird by-catch in the North Sea is considered to be comparatively rare. Off NW Scotland, 1-3 birds may be caught, especially in grounds off St. Kilda (Aad Jonker (former freezer trawler skipper), pers. comm.). IMARES observers in the North Sea only recorded one incident of seabird by-catch over 10 trips (Bram Couperus, pers. comm.).

B. Data

B.1. Commercial catch:

Commercial catch data are obtained from national laboratories of nations exploiting herring in the North Sea. Since 1999 (catch data 1998), these labs have used a spreadsheet to provide all necessary landing and sampling data. This spreadsheet which was developed originally to ease the handling of Mackerel data supplied to its (then parent) Working Group (WGMHSA) and it was then further adapted to the special needs of the Herring Assessment Working Group (HAWG). The current version used for reporting the catch data is v1.6.4. Traditionally, the SALLOCL-application (Patterson, 1998) is then used to allocate samples to catches that do not contain direct biological samples. This programme gives the needed required standard outputs on sampling status and biological parameters. It also clearly documents any decisions made by the species co-ordinators for filling in missing data and raising the catch information of one nation/quarter/area with information from another data set.

Since 2007, the commercial catch and sampling data have also been stored and processed using the InterCatch database. In the first year, larger discrepancies (up to 5 %) between the two applications occurred, but since 2008 the estimates of CANON, CATON and WECA have been highly comparable. However, InterCatch operates on the basis of Subdivisions and lacks the capacity to store catch information by rectangle and catch-length frequency distribution. This level of data division is a prerequisite of the HAWG. Both data collation methods are, therefore, still used in parallel.

The "wonderful table" lists all of the information on area TACs and estimated catches of herring in both the North Sea and Division IIIa, to show the derivation of the total catch of North Sea autumn spawning herring (NSAS) each year. The following figure explains where the estimates in the wonderful table are derived from;

Year		2007	2008	
Sub-Area IV and Division VIId: TAC (IV and VIId)				
Recommended Divisions IVa, b [1]	22			
Recommended Divisions IVc, VIId	14			
Expected catch of spring spawners				
Agreed Divisions IVa,b [2]	TAC human consumption in IVa and b	303.5	174.6	Total TAC for human consumption in North Sea
Agreed Div. IVc, VIId	TAC human consumption in IVc and VIId	37.5	26.7	
Bycatch ceiling in the small mesh fishery	TAC industrial fishery	31.9	18.8	
CATCH (IV and VIId)				
National landings Divisions IVa,b [3]		326.8		
Unallocated landings Divisions IVa,b		21.9		
Discard/slipping Divisions IVa,b [4]		0.1		
Total catch Divisions IVa,b [5]		348.8		
National landings Divisions IVc, VIId [3]		34.3		
Unallocated landings Divisions IVc,VIId		4.7		
Discard/slipping Divisions IVc, VIId [4]		-		
Total catch Divisions IVc, VIId		39.0		Herring caught in the North Sea
Total catch IV and VIId as used by ACFM [5]		**387.8**		
CATCH BY FLEET/STOCK (IV and VIId) [10]				
North Sea autumn spawners directed fisheries (Fleet A)		379.6		NS catch human consumption
North Sea autumn spawners industrial (Fleet B)		7.1		NS catch industrial fishery
North Sea autumn spawners in IV and VIId total		**386.7**		
Baltic-IIIa-type spring spawners in IV		1.1		Catch of WBSS in IV, estimated by splitting
Coastal-type spring spawners		0.0		e.g. spring spawner in river estuaries (Thames, Wash)
Norw. Spring Spawners caught under a separate quota in IV [20]		0.7		direct information from Norway
Division IIIa: TAC (IIIa)				
Predicted catch of autumn spawners	22			
Recommended spring spawners	22			
Recommended mixed clupeoids				
Agreed herring TAC		69.4	51.7	
Agreed mixed clupeoid TAC				
Bycatch ceiling in the small mesh fishery		15.4	11.5	
CATCH (IIIa)				
National landings		47.3		
Catch as used by ACFM		47.4		
CATCH BY FLEET/STOCK (IIIa) [10]				
Autumn spawners human consumption (Fleet C)		16.4		
Autumn spawners mixed clupeoid (Fleet D) [19]		3.4		
Autumn spawners other industrial landings (Fleet E)				
Autumn spawners in IIIa total		**19.8**		Catch of NSAS in IIIa, estimated by splitting
Spring spawners human consumption (Fleet C)		25.3		
Spring spawners mixed clupeoid (Fleet D) [19]		2.3		
Spring spawners other industrial landings (Fleet E)				
Spring spawners in IIIa total		**27.6**		
North Sea autumn spawners Total as used by ACFM		**406.5**		

Transparency of data handling by the Working Group. The current practice of data handling by the Working Group is that the data received by the co-ordinators are available in a folder called "archive" (found on the ICES W-drive; refer to the ICES data centre for the correct link). These high-resolution data are not reproduced in the report. The archived data contain the disaggregated dataset (disfad), the allocations of samples to un-sampled catches (alloc), the aggregated dataset (sam.out) and (in some cases) a document describing any problems with the data in that year. Since 2007, the corresponding datasets are also stored in InterCatch, where they are accessible to the stock coordinators only.

Current methods of compiling fisheries assessment data. The stock co-ordinator is responsible for compiling the national data to produce the input data for the assessments. In addition to checking the data, the major task involved is to allocate samples of catch numbers, mean length and mean weight-at-age to un-sampled catches. There are, at present, no defined criteria on how this should be done, but the following general process is implemented by the stock co-ordinators. Searches are made for appropriate samples by gear (fleet), area and quarter. If an exact match is not available the search will move to a neighbouring area if the fishery extends to this area in the same quarter. More than one sample may be allocated to an un-sampled catch; in this case a straight mean or weighted mean of the observations may be used. If there are no samples available, the search will move to the closest non-adjacent area by gear (fleet) and quarter.

The Working Group acknowledges the effort some members have made to provide "corrected" data, which in some cases differ significantly from the officially reported catches. Most of this valuable information is gathered on the basis of personal knowledge of the fishery and good relations between the scientist responsible and the fishermen. In addition, the Working Group recognises, and would like to highlight, the inherent conflict of interest between obtaining details of unallocated catches by country and increasing the transparency of data handling by the Working Group.

Uncertainty in the catch data. A thorough examination of the precision of the international market sampling for North Sea herring and its influence on the assessment was carried out in 2001 for the period 1991 to 1998 (ICES, 2001db). The conclusion was that the fishery is well sampled. Estimates of catch-at-age delivered by the combined international sampling programme for North Sea herring were rather precise and the contribution of this variability to the overall precision of the assessment at the time was relatively small and acceptable.

Several institutes already routinely calculate the uncertainty associated with the numbers -at -age through the COST raising procedure. With the move to an assessment model that can readily incorporate a-priori information regarding uncertainty in the input data it is essential to formalise the provision of such catch precision estimates and for the Working Group to develop methods for aggregating these to reflect the uncertainty in the aggregated catch data.

Sampling of commercial catch: Sampling of commercial catch is conducted by the national institutes. HAWG has recommended for years that sampling of commercial catches should be improved for most of the stocks. In January 2008, a new directive for the collection of fisheries data was implemented for all EU member states (Commission Regulations 2008/949/EC, 2008/199 and 2008/665). The provisions in the "data directive" define specific sampling levels. As most of the nations participating in the fisheries on herring assessed here have to obey this data directive, the definitions applicable for herring and the area covered by HAWG are given below:

Area	*sampling level per 1000 t catch*		
Baltic area (IIIa (S) and IIIb-c)	***1 sample of which***	***100 fish measured and***	***50 aged***
Skagerrak (IIIa (N))	***1 sample***	***100 fish measured***	***100 aged***
North Sea (IV and VId):	***1 sample***	***50 fish measured***	***25 aged***
NE Atlantic and Western Channel ICES areas II, V, VI, VII (excluding d) VIII, IX, X, XII, XIV	***1 sample***	***50 fish measured***	***25 aged***

Exemptions to the above mentioned sampling rules are:

Concerning lengths:

(1) the national programme of a Member State can exclude the estimation of the length distribution of the landings for stocks for which TACs and quotas have been defined under the following conditions:

i) the relevant quotas must correspond to less than 5 % of the Community share of the TAC or to less than 100 tonnes on average during the previous three years;

ii) the sum of all quotas of Member States whose allocation is less than 5 % must account forless than 15 % of the Community share of the TAC.

If the condition set out in point (i) is fulfilled, but not the condition set out in point (ii), the relevant Member States may set up a coordinated programme to achieve the implementation of the sampling scheme described above for their overall landings, or another sampling scheme, leading to the same precision.

Concerning ages:

(1) the national programme of a Member State can exclude the estimation of the age distribution of the landings for stocks for which TACs and quotas have been defined under the following conditions:

i) the relevant quotas correspond to less than 10 % of the Community share of the TAC or to less than 200 tonnes on average during the previous three years;

ii) the sum of all quotas of Member States whose allocation is less than 10 %, accounts for less than 25 % of the Community share of the TAC.

If the condition set out in point (i) is fulfilled, but not the condition set out in point (ii), the relevant Member States may set up a coordinated programme as mentioned for length sampling.

If appropriate, the national programme may be adjusted until 31 January of every year to take into account the exchange of quotas between Member States.

B.2. Biological

Weight-at-age

Catch-at-age data (catch numbers-at-age, mean weights-at-age in the catch, mean length-at-age) are derived from the raised national figures received from the national laboratories. The data are obtained either by market sampling or by onboard observers, and processed as described above. Information on recent sampling levels and nations providing samples should be provided as part of the working group report (typically sec. 2.2.).

Mean weights-at-age in the stock and proportions mature (maturity ogive) are derived from the June/July international acoustic survey (see next paragraph). All 1 winter-ring fish are assumed to be immature, and all fish over five winter-rings are assumed to be mature.

For North Sea herring, increasing fish size has been observed from 1940 to 1980, possibly resulting from a decreasing competition for food while the stock collapsed (Burd 1984; Saville, Bailey *et al*. 1984). Particularly large year-classes may also suffer from intra-cohort competition and have a slower growth than average ones (ICES 2008). Superimposed to these density-dependent effects, environmental factors such as plankton production (Shin and Rochet 1998) and temperature (Brunel and Dickey-Collas 2010) also influence growth. There is no study dealing specifically with variations in North Sea herring maturation, but it has been shown for other stocks having also collapsed and recovered in the recent history, that maturation was closely related to growth (i.e. faster growth resulting in earlier maturation) (Engelhard and Heino 2004; Melvin and Stephenson 2007).

Maturity

Growth and maturation variations are the expression of phenotypic plasticity in response to variability in environmental factors such as food level (Berrigan and Charnov 1994), temperature (Atkinson 1994), and density-dependent processes (Engelhard and Heino 2004).

Maturation seems to be closely related to growth. Poor growth between age 1 and 2 often leads to a low proportion of mature individuals at age 2. If growth is also poor between age 2 and 3, maturation is further delayed. As the assessment of North Sea herring and the projections are based on smoothed stock weight data, most of the inter-annual variability in growth is filtered out. Therefore the weights at age used for the prediction (assumed same as last year of data) are not too different from the weight observed in the data in the assessment of the following year. Brunel 2012 showed, however, that the assumption made for the maturity ogive used in the projections (an average of the last three years of data) generates large errors, particularly for slow maturing cohorts. However, given the absence of a predictive model for growth, and hence maturation, it seems difficult to propose an alternative to improve this situation.

The precision of the maturity-, sex-, and age estimates are analysed every 3-4th year according to a pre-set schedule defined by ICES and PGCCDBS. Through exchanges and workshops, the individual estimates of maturity stage, sex, and age are subject to a quality check by calibrating the laboratories involved in supplying data on those biological parameters. From these workshops, estimates of the uncertainty around the estimates of maturity, sex and age are available for consideration by the HAWG.

Natural Mortality

Natural mortality at age was previously fixed by age for the entire time series of the assessment, as calculated by the equivalent of the current ICES multispecies working group in 1987 and was used up to 2011 (ICES 1987; Table B2.1). From 2012 onwards, the assumed fixed natural mortality at age is replaced with a variable (over time) natural mortality at age in the assessment. The multi-species stock assessment model for the North Sea (SMS key-run 2010) has been used to inform the variable natural mortality pattern. Annual total predation and background mortality estimates from the SMS model, spanning 1963 to 2010, were obtained and scrutinized for patterns.

Table B2.1. Previous metrics for natural mortality (M) used for the assessment of North Sea autumn spawning herring. Taken from ICES 1987.

Age	Herring Assessment WG meetings in years				Multispecies WG meetings		
	1964-1970	1970-1983	1984-1986	1987	1984[1]	1985[2]	1986[3]
0	0.20	0.10	1.00	1.00[4]	1.07	0.82	1.067[4]
1	0.20	0.10	0.80	1.00	0.46	0.84	1.023
2	0.20	0.10	0.10	0.30	0.13	0.16	0.253
3	0.20	0.10	0.10	0.20	0.44	0.30	0.274
4	0.20	0.10	0.10	0.10	0.13	0.12	0.131
5	0.20	0.10	0.10	0.10	0.19	0.13	0.131
6	0.20	0.10	0.10	0.10	0.10	0.12	0.117
7	0.20	0.10	0.10	0.10	0.10	0.10	0.100
8+	0.20	0.10	0.10	0.10	0.10	0.10	0.100

1 Anon. (1984b) key-run, mean 1974-1983.
2 Anon. (1986b) key-run, mean 1974-1984.
3 Anon. (1987a) key-run, mean 1978-1982.
4 Mortality rate per half year.

The Multispecies VPA carried out in 1986 was, according to Anon. (1987a), an improvement on the 1985 MSVPA mainly because:

Many different predators have herring in their diet. However, young herring age groups are primarily eaten by cod, saithe and whiting, where whiting mainly predates on age 2-4herring. The contribution of saithe and cod alone makes up for nearly 90% of the predation mortality from age 4 onwards. Predation mortality by cod has gone down in the period 1995-2010 while predation mortality has gone up for saithe. In the years 2008 – 2010 however total predation mortality has gone down rapidly. This trend or shift in predation mortality might imply a change in predator biomass or a diet shift.

Cod shows a nearly continuous decline in biomass while saithe has increased considerably over the years up to 2005 but has crashed in the most recent years. These trends in cod and saithe biomass are in agreement with the trends observed in the single species assessments. Herring mortality (ages 2 and older) has, according to the SMS key-runs, increased over the period 1991-2007 but seems to have reduced again in the more recent years. This trend is in close agreement with the development of the saithe stock, while the decline in the cod stock seems to have been compensated by the saithe increase over the years.

To capture these highly variable dynamics, and allow for extrapolation of the time series both backwards (1947 to 1962) and forwards in time (2011 onwards) a loess smoother (span 0.5) is fit through the variable natural mortality estimates at ages 0-7. M on age 8+ is assumed to be the same as that at age 7.

B.3. Surveys

B.3.1 Acoustic: ICES Co-ordinated Acoustic Surveys for herring in North Sea, Skagerrak and Kattegat (HERAS)

The ICES Coordinated acoustic surveys started in 1979 around Orkney and Shetland with the first major coverage in 1984. An index derived from that survey has been used in assessments since 1994 with the time-series data extending back to 1989. The survey was extended to IIIa to include the overlapping western Baltic spring spawning stock in 1989, and the index has been used with a number of other tuning indices since 1991. The early survey had occasionally covered VIa (North) during the 1980s and was extended westwards in 1991 to cover the whole of VIa (North). Since 1991, this survey provides the only tuning index for VIa (North) herring and from 2008 for the whole Malin Shelf. By carrying out the co-ordinated survey at the same time from the Kattegat to Donegal, all herring in these areas are covered simultaneously, reducing uncertainly due to area boundaries as well as providing input indices to three distinct stocks. The surveys are co-ordinated under ICES Working Group for International Pelagic Surveys (WGIPS).

The acoustic recordings are carried out using Simrad EK60 38 kHz sounder echo-integrator with transducers mounted on the hull, drop keel or towed bodies. Prior to 2006, Simrad EK500 and EY500 were also used. Further data analysis is carried out using either BI500, Echoview or Echoann software. The survey track is selected to cover the area giving a basic sampling intensity over the whole area based on the limits of herring densities found in previous years. A transect spacing of 15 nautical miles is used in most parts of the area with the exception of some relatively high density sections, east and west of Shetland, north of Ireland and in the Skagerrak where short additional transects are carried out at 7.5 nautical miles spacing, and in the southern area, where a 30 nautical miles transect spacing is used.

The following target strength to fish length relationships have been used to analyse the data:

herring	TS = 20 log L - 71.2 dB
sprat	TS = 20 log L -71.2 dB
gadoids	TS = 20 log L - 67.5 dB
mackerel	TS = 21.7 log L - 84.9 dB

Data are reported through a standardised data exchange format and uploaded into the FishFrame database, currently held at DTU Aqua, Charlottenlund, Denmark. National estimates are aggregated through FishFrame during WGIPS to calculate global estimates for the North Sea, VIa (North) the Malin Shelf and the western Baltic Sea. The exchange format currently holds information on the ICES statistical rectangle level, with at least one entry for each rectangle covered, but more flexible strata are accommodated by allowing multiple entries for abundance belonging to different strata. Data submitted consists of the ICES rectangle definition, biological stratum, herring abundance by proportion of autumn spawners (North Sea and VIa North) and spring spawners (western Baltic), age and maturity, and survey weight (survey track length). Data are presented according to the following age/maturity classes: 1 immature (maturity stage 1 or 2), 1 mature (maturity stage 3+), 2 immature, 2 mature, 3 immature, 3 mature, 4, 5, 6, 7, 8, 9+ mature. In addition to proportions-at-age, data on mean weights and mean length are reported at age/maturity by biological strata. Data are combined using an effort weighted mean based on survey effort reported as number of nautical miles of cruise track per statistical rectangle. A combined survey report is produced annually. Apart from the Biomass index for 1-9+-ringers, mean weights-at-age in the catch and proportions mature are derived from the survey to be used in the NSAS assessment.

Precision estimates on the biological samples obtained during the acoustic surveys are available since 2012 (WGIPS 2012). Average weight and length values with corresponding standard deviations have been computed for North Sea herring (based on the combined biological information collected during the Dutch, German, Danish and Scottish acoustic survey) and the Malin Shelf area (based on Irish survey data in 2012). Bootstrapping is used to characterise uncertainty in maturity-at-age. Details on the results are given in the Working Group report of WGIPS (ICES, 2012).

Precision estimates of the spawning stock biomass estimates obtained from the acoustic surveys are available for the period 2004-2011. In the precision estimation exercise done during WGIPS 2012, uncertainty in global mean acoustic density estimates is characterised. Because mean size of adult herring does not vary a lot (most adult age classes have mean lengths of 25-30 cm), uncertainty in mean acoustic density should give a good, albeit conservative, estimate of uncertainty in total stock biomass. Areas containing the vast majority of adult herring (90-95%) in the North Sea have traditionally been covered by the Netherlands and Scotland. In the areas covered by the other nations participating in the international survey, a great proportion of immature herring is encountered. Schools and aggregations of immature herring will exhibit different morphological and acoustic characteristics that are not representative of the adult portion of the stock. Therefore, only data from the Netherlands and Scotland were used to estimate uncertainty in the mean acoustic density and stock size of the North Sea herring SSB.

Bootstrapping was used to estimate uncertainty in the mean acoustic density. Bootstrapping was done by stratum, treating observations from vessels equally and using lengths of survey track as weights when calculating mean density. Estimates of mean acoustic density were calculated for 1000 bootstrap replicates per stratum. The overall mean acoustic density is the mean of these 1000 bootstrap estimates, and confidence limits were obtained as quantiles of the distribution.

The results of this exercise for the period 2004 -2011 are shown below. The level of acoustic uncertainty is the same order of magnitude, with the exception of the survey in 2006, when the distribution of the acoustic density values was much wider than usual.

Table B.3.1: Confidence intervals obtained from 1000 bootstrap replicates of acoustic survey data based on the Dutch and Scottish North Sea herring surveys.

Year	95% C.I. lower [%]	95% C.I. upper [%]	50% C.I. lower [%]	50% C.I. lower [%]
2004	-20.4	+21.0	-7.5	+7.2
2005	-23.0	+24.6	-8.8	+8.5
2006	-34.8	+43.9	-15.3	+13.3
2007	-17.2	+17.4	-5.6	+5.8
2008	-25.2	+28.3	-9.7	+8.8
2009	-22.7	+26.1	-8.9	+8.3
2010	-19.7	+23.7	-7.4	+7.0
2011	-17.2	+20.3	-6.6	+6.3

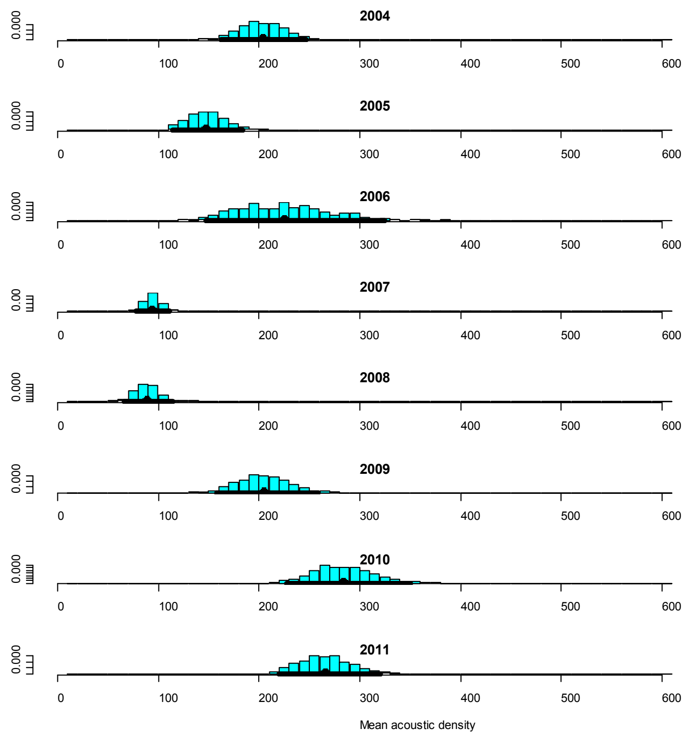


Figure B.3.1.1: Distribution of mean acoustic density (in m²/nmi²), by year, based on 1000 bootstrap replicates of acoustic data from the Dutch and Scottish North Sea herring surveys. Mean acoustic density is indicated with a black dot on the x-axis, while the horizontal bar shows 95% confidence limits.

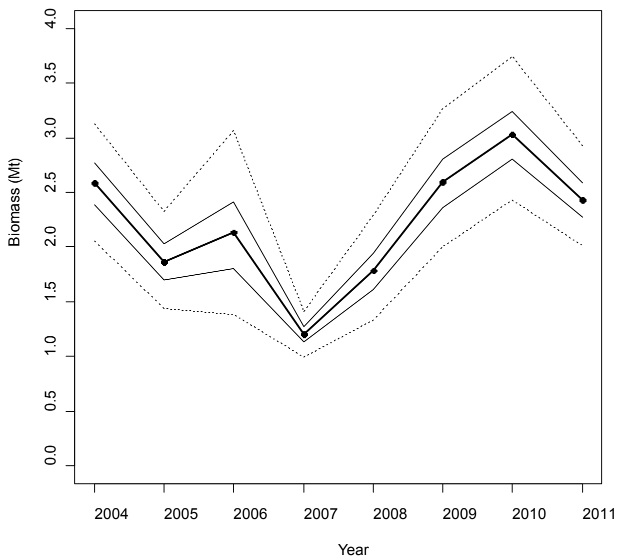


Figure B.3.1.2: Approximate 50% and 95% confidence limits for North Sea herring SSB (x1 000t) estimates from the acoustic survey. The confidence limits are based on the assumption that confidence limits for annual estimates of mean acoustic density can be translated to confidence limits of biomass estimates by expressing them as relative deviations from the mean values. These confidence limits only account for spatio-temporal variability of acoustic observations.

B.3.2 International Bottom Trawl Survey (IBTS-1Q):

The International Bottom Trawl Survey (IBTS) started out as the International Young

Herring Survey (IYHS) in 1966 with the objective of obtaining annual recruitment indices for the combined North Sea herring populations (Heesen *et al*., 1997). It has been carried out every year since, and it was realized that the survey could provide recruitment indices not only for herring, but for roundfish species as well. The survey was standardised gradually from 1977, and is considered fully standardised from 1983 onwards, where it became known as the International Bottom Trawl Survey (IBTS). Examination of the catch data from the 1st quarter IBTS showed that these surveys also gave indications of the abundances of the adult stages of herring, and subsequently the catches have been used for estimating 2-5+ ringer abundances. The surveys are carried out in 1st quarter (February) and in 3rd quarter (August-September) using standardized procedures among all participants. The standard gear is a GOV trawl, and at least two hauls are made in each statistical rectangle. In 2007 the IBTS was extended into English Channel. In 1977 sampling for late stage herring larvae was introduced at the IBTS 1st quarter, using Isaacs-Kidd Midwater trawl (IKMT). These catches appeared as a good indicator of herring recruitment. However, examination of IKMT performance showed deficiencies in its catchability of herring larvae, and a more applicable gear, a ring net (MIK) was suggested as an alternative gear. Hence, gear type was changed in the mid 1990s, and the MIK has been the standard gear of the programme since. This ring net is of 2 meter in diameter, has a long two-legged bridle, and is equipped with a black netting of 1.5 mm mesh size. Two oblique hauls (to a maximum depth of either 100m or 5m from the bottom) per ICES statistical rectangle are made at night.

Indices of 2-5+ ringer herring abundances in the North Sea (1st quarter). Fishing gear and survey practices were standardised from 1983 onwards and herring abundance estimates of 2-5+ ringers are available since. Catches in Division IIIa are not included in this index. These estimates are determined by the standard IBTS methodology developed by the ICES IBTS working group. The time-series was used in North Sea herring assessment until 2011. During the Benchmark in 2012, it was decided not to include the 2-5+ index in the assessment due to a general inability of the index to track cohorts and poor precision.

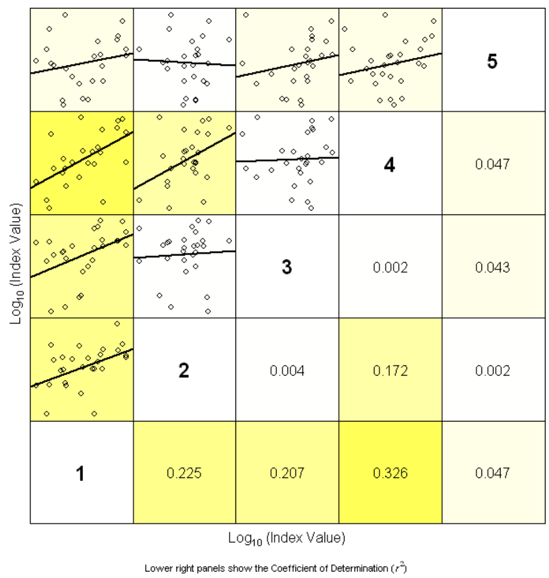


Figure B.3.2.1: Fitted linear relationships of cohort trends within the IBTS surveys. Internal consistency of cohorts in the IBTS-1Q survey.

Index of 1-ringer recruitment in the North Sea (1^{st} quarter). The 1-ringer index of recruitment is based on trawl catches in the entire survey area, hence, all 1-ringer herring caught in Division IIIa is included in this index. Indices are calculated as an area weighted mean over means by ICES statistical rectangle, and are available for year classes 1977 to recent. The Downs herring hatch later than the other autumn spawned herring and generally appears as a smaller sized group during the 1st quarter IBTS. A recruitment index of smaller sized 1-ringers is calculated using the standard procedure, but solely based on abundance estimates of herring <13 cm (ICES CM 2000/ ACFM:10, and ICES CM 2001/ ACFM:12).

IBTS0 index of 0-ringer recruitment in the North Sea (1^{st} quarter). The catches of late stage herring larvae (using the MIK gear) are used to calculate an 0-ringer index of autumn spawned herring in the North Sea and used as a proxy for recruitment strength (Nash & Dickey-Collas 2005). A flowmeter at the gear opening is used for estimation of volume filtered by the gear, and using this information together with information on bottom depth, the density of herring larvae per square meter is estimated for each haul.

Data storage: The data are initially tabulated in an excel sheet where the data are scrutinised for consistency and quality and the different correction factors that standardise the data amongst nations is applied. The data are then uploaded to the ICES "eggsandlarvae" database where the historic data are also held. This database is used for a range of larval species and different sets of data can be selected and downloaded and can be accessed by contacting the ICES secretariat.

Index Calculation: The mean herring density (in no. per m^2) in statistical rectangles is raised to mean within sub-areas, and based on areas of these sub-areas an index of total abundance is estimated. The series provides estimates for sub-areas as well as the total index.

In order to consider "skewness" in sampling intensity due to less intense or no sampling in some areas, the averaging of densities is first done for statistical rectangles and subsequently for defined, larger sections. Finally, abundances are found for the sections and these are summed for the total area.

In order to exclude the Downs larvae, which are too patchily distributed and too young (might reach extreme abundances), the abundances of larvae south of 54°N for which the mean size at station is below 20 mm are excluded before calculating the standard IBTS0 index.

The procedure is the following:

1. Averages of no-per-m^2 is calculated for each rectangle
2. Averages of no-per-m^2 for rectangles are averaged for sections defined by:

If stat1 is the first two digits of "statistical rectangle" and stat4 is the two last then:

if stat4<F2 and stat1>39 and stat1<46 then section='cw';

if stat4>F1 and stat1>39 and stat1<46 then section='ce';

if stat4<F2 and stat1<40 and stat1>34 then section='sw';

if stat4>F1 and stat1<40 and stat1>34 then section='se';

if stat4<F2 and stat1>45 then section='nw';

if stat4>F1 and stat1>45 then section='ne';

if stat4>F8 then section='ka';

if stat1<35 then section='ch';

3. Averages of no-per-m^2 for subareas are multiplied by section-area factors defined by:

if section='cw' then af=28;

if section='ce' then af=33;

if section='sw' then af=12;

if section='se' then af=30;

if section='nw' then af=27;

if section='ne' then af=11;

if section='ka' then af=10;

if section='ch' then af=10;

miksec=section average in no-per-m^2 *af*3086913600;

4 The index is then the sum of all abundances in sections (which amount to an estimate of the total number of larvae)

IBTS0 = sum of miksec.

Summary of data missing and data excluded due to data inconsistencies: The following section contains information about the completeness of the survey data used to calculate the IBTS0 index over the years. The information has been gathered from the annual Herring Assessment Working Group reports where such issues are normally reported and are listed by year. Further details are available in the respective Working Group reports.

1977 Scottish data have no larvae length measurements and therefore no mean length.

1978 Swedish data have no larvae length measurements and therefore no mean length.

1983 North-western part not surveyed

2002 No French data available. Dutch data excluded from data base and index calculation

2010 Dutch data excluded from database and index calculation

2011 Swedish part of survey in IIIa not carried out

B.3.3. Larvae:

Surveys of larval herring have a long tradition in the North Sea. Sporadic surveys started around 1880, and available scientific data goes back to the middle of the 20th century. The co-ordination of the International Herring Larvae Surveys in the North Sea and adjacent waters (IHLS) by ICES started in 1967, and from 1972 onwards all relevant data are achieved in a data base (ICES PGIPS). The surveys are carried out annually to map larval distribution and abundance (Heath 1993; Schmidt *et al.*, 2009). Larval abundance estimates derived from these surveys are used as relative indicators of the herring spawning biomass in the assessment.

Nearly all countries surrounding the North Sea have participated in the history of the IHLS. Most effort was undertaken by the Netherlands, Germany, Scotland, England, Denmark and Norway. A number of other nations have contributed occasionally. A sharp reduction in ship time and number of participating nations occurred in the end of the 1980s. Since 1994 only the Netherlands and Germany contribute to the larvae surveys, with one exception in 2000 when also Norway participated.

Larvae Abundance Index (LAI): The total area covered by the surveys is divided into 4 sub areas corresponding to the main spawning grounds. These sub areas have to be sampled in different given time intervals. The sampling grid is standardized and stations are approximately 10 nautical miles apart. The standard gear is a GULF III or GULF VII sampler (Nash *et al.*, 1998). The abundance of newly hatched larvae (less than 10 mm total lengt; 11 mm for the Southern North Sea) are used as the basis for the index calculation. To estimate larval abundance, the mean number of larvae per square meter obtained from the ichthyoplankton hauls is raised to rectangles of 30x30 nautical miles and the corresponding surface area. These values are summed up within the given unit and provide the larval abundance per unit for a given time interval.

Multiplicative Larval Abundance Index (MLAI): The use of both LAI and LPE (Larval Production Estimates) estimates as indices of spawning stock biomass rely on a complete coverage of the survey area. Due to the substantial decline in ship time and sampling effort since the end of the 1980s, these indices could not be calculated in their traditional form since 1994. Instead, a multiplicative model was developed for calculating a Multiplicative Larvae Abundance Index (MLAI, Patterson & Beveridge, 1995). In this approach the larvae abundances are calculated for a series of sampling units. The total time series of data are used to estimate the year and sampling unit effects on the abundance values. The unit effects are used to fill un-sampled units so that an abundance index can be estimated for each year.

Calculation of the linearised multiplicative model is done using the equation:

$$\ln(LAI_{year,LAI\ unit}) = MLAI_{year} + MLAI_{LAI\ unit} + u_{year,\ LAI\ unit}$$

where $MLAI_{year}$ is the relative spawning stock size in each year, $MLAI_{LAI\ unit}$ are the relative abundances of larvae in each sampling unit and $u_{year,\ LAI\ unit}$ are the corresponding residuals (Gröger *et al.*, 1999, 2000). The unit effects are setup so that the first sampling unit is used as a reference (Orkney/Shetland 01-15.09.72) and the parameters for the other sampling units are redefined as differences from this reference unit. The model is fitted the Larval Abundance Indices dervived above ($LAI_{year,\ LAI\ unit}$). The MLAI is updated annually and represents all larval data since 1972. The time series has previously been used as an spawning stock index of the spawning stock biomass in the herring assessment.

The MLAI, however, assumes that the sampling unit effects ($MLAI_{LAI\ unit}$) are constant throughout the time series: in response to this limitation, another larval abundance index (**SCAI- Spawning Component Abundance Index**) was developed (Payne 2010). The SCAI index, like MLAI, also models the LAIs as the basic data unit. However, rather than considering the sampling units as providing information about the entire stock, as in the MLAI, the SCAI considers them to be representative of the individual spawning components. Furthermore, the SCAI can be considered as analogous to a simple biomass model applied at the component level, and therefore autocorrelation is explicitly incorporated i.e. the abundance estimated in one year also provides information about the expected level in neighbouring years. Breaks in the time-series are therefore not a problem for the SCAI, as it can effectively “bridge” these the gaps in a sensible manner based upon the modelled auto-correlation structure. SCAI can therefore provide information about the dynamics of the individual components: summing these component-wise indices together therefore also provides an estimate of the abundance of the combined stock. Furthermore, the sum of the fitted abundance indices across all components is a proxy for the biomass of the total stock, even though they only model processes at the component level.

When comparing the model fit of the SCAI and the MLAI, no significant differences occur. Both indices provide comparable survey trends on the SSB estimation. However, preference is given to the SCAI, as it give insight into the dynamics of the individual spawning components, in addition to the total spawning stock.

Details regarding the development and calculation of the SCAI index can be found in (Payne 2010). The code for generating the SCAI index is available on the herring stock assessment code repository, http://hawg.googlecode.com in the directory /trunk/NSAS/data/SCAI.

B.4. Commercial CPUE

Not used in this stock.

B.5. Other relevant data

B.5.1 Separation of North Sea Autumn Spawners and IIIa-type Spring Spawners

North Sea autumn spawners (NSAS) and IIIa-type spring spawners occur in mixtures in fisheries operating in Divisions IIIa and IVaE (ICES, 1991/Assess:15; Clausen *et al*., 2007): mainly 2+ ringers of the western Baltic spring spawners (WBSS) and 0-2-ringers from the NSAS, including winter spawning Downs herring. In addition, several local spawning stocks have been identified with a minor importance for the herring fisheries (ICES, 2001a).

Priori to 1996, the method for separation of these components was based on the use of vertebral counts as described in former reports of this Working Group (ICES 1990). The method assumes that for autumn spawners, the mean vertebral count is 56.5 and for spring spawners 55.80. The fractions of spring spawners (fsp) are estimated from the formula (56.50-v)/(56.5-55.8), where v is the mean vertebral count of the (mixed) sample with the restriction that the proportion should be one if fsp>=1 and zero if fsp<=0. The method is quite sensitive to within-stock variation (e.g. between year classes) in mean vertebral counts.

The method for separation of the herring stock components has developed the past decade. Prior to 1996, the splitting key used by ICES was calculated from a sample-based mean vertebral count using a cut-off algorithm for calculating the proportion of WBSS in a sample as MIN(1,MAX(0,(VSsample-55.8)/(56.5-55.8))), where VSsample is the sample mean vertebrae count and assuming a population mean VS of 55.8 for WBSS and 56.5 for NSAS. This method is still being used to split samples of Norwegian catches from the transfer area in IVa East. In the period from 1996 to 2001 splitting keys were constructed using information from a combination of vertebrae count and otolith microstructure (OM) methods (ICES, 2001a). From 2001 and onwards, the splitting keys have been constructed solely using the otolith microstructure method which uses visual inspection of season-specific daily increment pattern from the larval origin of the otolith, with the exception of the splitting key made for the mixture area in Sub Division IVaE, where vertebrae counts currently is the only method used to split the mixed stock (Mosegaard and Madsen, 1996; ICES, 2004; Clausen *et al*., 2007).

Otolith shape analysis has been used to discriminate between populations for a variety of species and for herring this approach has had increasing success with development of imaging techniques and statistical methods. Both temporal and geographical separation of populations give rise to variation in the shape of otoliths (Messieh, 1972; Lombarte, 1992; Arellano *et al*., 1995). These variations may suggest differences in the environmental conditions of the dominant habitats of populations within a species. However, both genetic and environmental influences have been reported as relevant in determining otolith shape (Cardinale *et al*., 2004). Using Fourier Series Shape Analysis on otoliths from Alaskan and northwest Atlantic herring, Bird *et al*. (1986) showed that otolith shape reflects population differences as well as differences between year classes of the same population. Sagittal otoliths have certain morphological features that are laid down early in the ontogeny of the fish (Gago, 1993), and measurements of internal otolith shape in adult herring has proven a powerful tool for stock discrimination (Burke *et al*., 2008).

Image analysis software (MATLAB) has been developed to automatically extract otolith contour curves and calculate 60x4 Elliptic Fourier Coefficients from one or two herring sagittal otoliths per image in batches with more than 1000 images.

From 2009 otolith shape analysis has been used as a supplementary method to increase sample size for estimating stock proportions of NSAS and WBSS in mixing areas of Division IIIa. For each assessment year individual population identity has been established by OM visual inspection and used as a baseline for assignment of shape characteristics to the involved stock components. A baseline of about 800-1200 otoliths with known hatch type has then been used as calibration in an age structured discriminant analysis where additionally 3000-4000 otolith shapes have been assigned to one of the two hatch types using a combination of shape Elliptic Fourier Coefficients, otolith metrics, fish metrics, length, weight and maturity as well as longitude, latitude, and seasonal parameters.

B.5.1.1. Validation

The purpose of classifying individual spawning type is to estimate proportions of the two major stock components, by age, in both catches and surveys from the different areas and seasons. Combining OM with otolith shape and fish meristic characters in a discriminant analysis approach is expected to increase precision of the estimated stock proportions. Validation of the shape and meristic based methodology was performed using samples of known spawning type from OM analysis.

OM and otolith shape data from the 2010 HAWG was used as a typical example of the procedure for estimating proportions of hatch type representing North Sea autumn and winter spawners and western Baltic spring spawners in the samples. The data was disaggregated into age groups 0, 1, 2 and 3+ and individuals of known autumn/winter or spring hatched types were used to assign the corresponding shape parameters and fish metrics from the same individuals by cross validated nonparametric nearest neighbour discriminant analysis.

The individual assignment of 1279 otoliths into known hatch type varied somewhat among hatch types and ages (2%-100%) but exhibited an overall error rate of 15.7% (see text table), however, more importantly, the average absolute error of the proportions of WBSS was only 2%, indicating the robustness of the method for up-scaling the baseline to the larger production sample.

Stock assignment data from 2009 commercial samples of herring in Division IIIa

		assigned to type		known type	estimated	deviasion		% error in	
Age group	known type	WBSS	NSAS	number	number	Individ. assignm.	prop.	Individ. assignm.	prop.
0	WBSS	34	13	47	44	13	3	27.7%	-6.4%
	NSAS	10	145	155	158	10	3	8.2%	1.9%
1	WBSS	188	72	260	254	72	6	27.7%	-2.3%
	NSAS	66	204	270	276	66	6	26.1%	2.2%
2	WBSS	288	14	302	305	14	3	4.6%	1.0%
	NSAS	17	3	20	17	17	3	82.4%	-15.0%
3+	WBSS	216	4	220	221	4	1	1.8%	0.5%
	NSAS	5	0	5	4	5	1	100.0%	-20.0%
		824	**455**	**1279**	**1279**	**201**	**26**	**15.7%**	**2.0%**

B.5.1.2. Conclusions

The two management stocks mixing in Division IIIa represent a complex underlying sub-population structuring, where local adaptation, especially in the WBSS component (Bekkevold *et al.*, 2005) may drive an evolutionary divergence of otolith shape and create within-stock variation patterns. Nearest neighbour discriminant analysis has been chosen to avoid biased proportions in this situation; however the results still exhibit a small trend in the proportion error with changing proportions. The overall proportion error of 2% is in the order of, or less than, reported assignment errors using OM visual inspection (Clausen *et al.*, 2007) and would probably increase precision of the total production sample in relation to the baseline. However the subject needs a more thorough analysis including all years in the emerging time series.

In the present case where distinction between two stocks may be based on genotypic as well as phenotypic expressions of contrasting life history characteristics, the chances of successful discrimination are substantial and appear to mainly depend on sampling effort.

The current vertebral count based estimation of WBSS in catches of herring in the transfer area of IVa East should be combined with an OM calibrated method exploiting differences in meristic characters among stocks such as maturity index, length-weight- age relationships etc. This appears to be a way forward to a more reliable estimate of the catches of WBSS in the North Sea.

The separation of Downs and other components of the NSAS are yet to be implemented and prior to such an increase in variables (and sources of uncertainty) comparative analysis of assessments with and without such splitting is needed. Such analyses are not yet a possibility and assessment models capable of running assessments on several stocks simultaneously are highly warranted. Analysis of the stock proportions and their sources of variation at different sampling levels is an important tool when planning the optimal sampling strategy for precise estimates of stock proportions at age.

B.5.2 Mixing of North Sea spawning components

The biomass of herring in the North Sea is dominated by autumn spawning fish (NSAS). The known spawning grounds, located along the east coast of Great Britain, show fine spatial structure (Dickey-Collas *et al.*, 2010; Figure B.5.2.1) and significant events have occurred at the individual bank level (e.g. recolonisation of the Aberdeen bank ground (Corten, 1999), loss of the Dogger Bank population). However, the individual local spawning groups are typically grouped into four “spawning components” that spawn at four main locations: Orkney/Shetland; Buchan; Banks; and Downs. These spawning components exhibit different growth rates, meristic characteristics and recruitment patterns (Bjerkan, 1917; Cushing and Bridger, 1966). The different components mix during part of the year and most likely experience different fishing pressures but are assessed and managed as one unit (Simmonds, 2007). Genetic studies have not shown a clear distinction between the components of herring in the North Sea (Ruzzante *et al.*, 2006; Gaggiotti *et al.*, 2009). Despite a decline in abundance of several orders of magnitude during the stock collapse in the late 1970s (Cushing, 1992; Dickey-Collas *et al.*, 2010), there has been no loss of genetic diversity (Mariani *et al.*, 2005). The current definition of the North Sea herring stock of autumn and winter spawners as a single management unit appears to have operated well in the past (Reiss *et al.*, 2009; Simmonds, 2009), despite changes in the relative strengths of the different spawning components and in their relative importance during collapse and recovery.

This complex sub-stock structure of North Sea herring, with its different spawning components, results in the production of offspring with different morphometric and physiological characteristics, different growth patterns and differing migration routes (see Figure B.5.2.1). A healthy North Sea herring stock is not just one where the fishing mortality on the stock is sustainable and the biomass of herring high enough to maintain successful recruitment and other ecosystem services (such as prey for top predators), but also where the phenotypic complexity and sub-stock structure is maintained, thus increasing the resilience of the population (see Schmidt *et al.*, 2009).

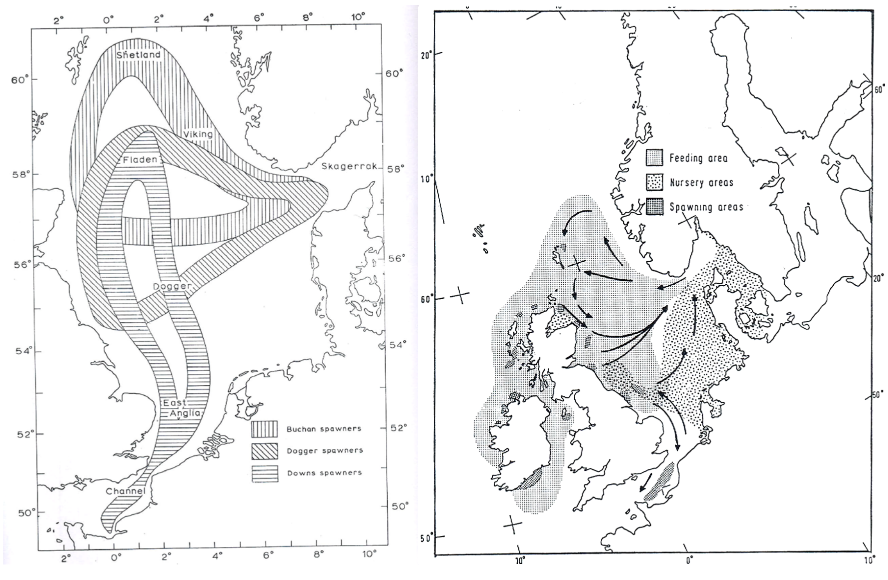


Figure B.5.2.1. Schematic of assumed generalised migration patterns of North Sea herring, taken from Cushing and Bridger (1966) and Burd (1978).

The productivity of the spawning components also varies. The three northern components show similar population trends and differ from the Downs component (Payne 2010); this appears to be influenced by different environmental drivers (Fässler *et al.*, 2011). Although the different components mix outside their spawning season and are exploited together, each component is thought to have a high degree of population integrity (Iles and Sinclair, 1982) and, therefore, could be expected to have relatively unique population dynamics.

The individual spawning components have been surveyed on a regular basis by the annual international herring larval survey (IHLS) since the early 1970s (Heath, 1993). These surveys enable investigation of the dynamics of each component (Payne, 2010; Figure B5.2.2).

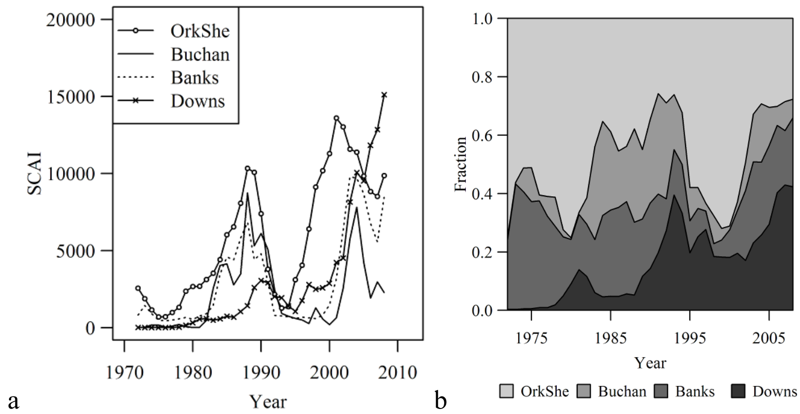


Figure B.5.2.2 a) Time series of spawning component abundance index (SCAI) for each individual component in the North Sea autumn spawning herring stock b) Time series of the fraction contribution of each spawning component to the total North-Sea autumn spawning herring stock, as estimated from the spawning component abundance indices (SCAIs). Shaded areas are arranged from top to bottom according to the north-to-south arrangement of the components.

The individual components each follow a broad trend reflecting that of the total stock (i.e. collapse in the late 1970s, peaks in around 1990 and 2000. Appreciable differences also exist, especially between the winter spawning Downs and the other autumn spawning components, leading to the contribution to the stock by each component varying over time (Figure B.5.2.2). The Orkney/Shetland component is generally the largest but its contribution has varied between 25% and 80%, whereas, the Downs component has varied from almost negligible in the 1970s to 40% of the stock in recent times (Payne, 2010). In some years there may be a gradient in the spatial distribution by component but this is not true for all years (Bierman *et al.*, 2010).

The variation in the component abundances has important implications for the input of NSAS juveniles into sub-division IIIa. Each component represents a spatially and temporally different starting point for the larvae that are ultimately observed in the Skagerrak as juveniles. In making the transition from spawning ground to nursery ground, the different components will experience different conditions (food availability, temperature, and predation) along the way. Accounting for these differences in both starting points and the number of larvae seeded is therefore critical to predicting the number of individuals that make it to the nursery grounds.

In addition there are still historic spawning grounds that have not been recolonised since the collapse of the herring stock in the 1970s (Figure B.5.2.3; taken from Corten 2002).

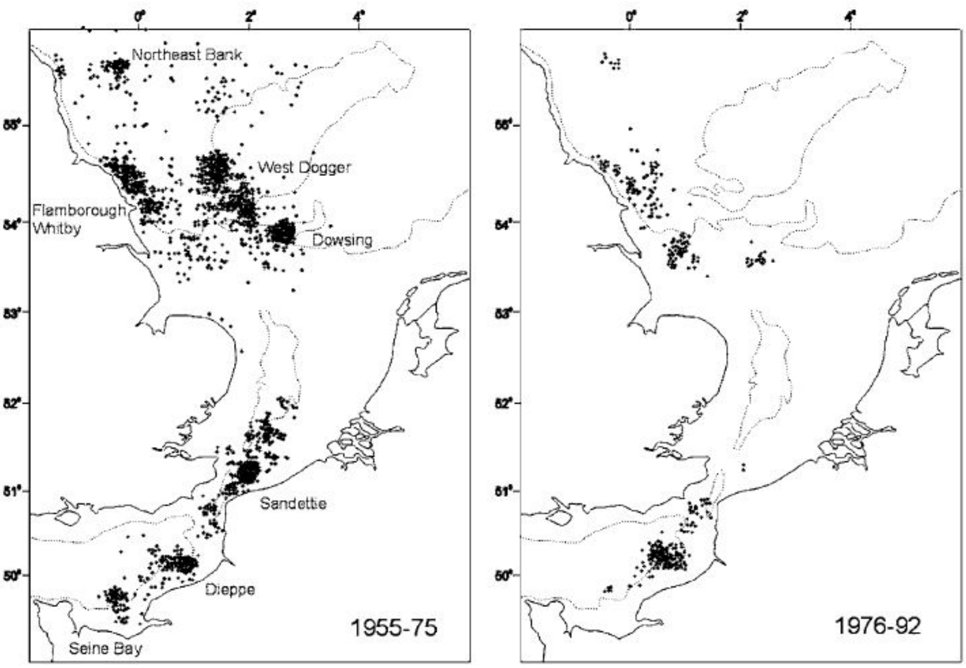


Figure B.5.2.3. The number of spawning grounds in the central and southern North Sea. Each dot represents a catch of spawning herring. Data combined from Dutch fisheries from before the stock collapse (1955–1975) and for the period of the recovery (1976–1992). From Corten 2002.

C. Historical Stock Development

C.1. Choice of Stock assessment model

The North Sea autumn spawning (NSAS) herring stock was assessed using the assessment model ICA (Statistical Catch at Age with a separable period and VPA part) from the mid 1990s until 2011. Despite the computational limitations when the model was first created, it was generally regarded as performing well and was considered 'ahead of its time'. However, in later years, a number of technical problems with this assessment became apparent, including non-convergence of the model, its ability to only take a maximum of fifty-nine years of data, the inability to fix technical issues (the core minimisation library is no longer maintained resulting in the inability to compile the ICA Fortran code). Advances in computational power and the development of new assessment methods ultimately led to this model being superseded.

The WKPELA benchmark meeting in February 2012 developed and evaluated the "state-space" modelling approach for NSAS herring. This modelling framework has a number of highly desirable characteristics, such as the stochastic treatment of all observations, a full statistical framework for evaluating model results, open source and cross platform source code, and an extremely high degree of flexibility allowing ready customisation to the peculiarities of the stock. The state-state approach was first pioneered by Gudmundsson (1987; 1994) and Fryer (2002): however, the computationally intensive nature of the method has meant that state-space models have hereto not yet become widespread. Recent advances in both software and hardware in recent years have, however, opened the door to these approaches.

C.2. Model used as basis for advice:

The NSAS herring assessment model is based on the state-space assessment model (SAM) (Nielsen *et al.*, 2012). Version details and model configuration are listed below.

Technical details of the SAM framework can be found in the peer-reviewed literature (Nielsen *et al.*, 2012)

SAM Model details:

The SAM source code is available from the "Stock assessment" version control repository, http://code.google.com/p/stockassessment/ : the code used corresponds to revision 7.

Scripts, packages and running environment

The SAM environment detailed above is encapsulated into the Fisheries Library in R (FLR) (Kell *et al.*, 2007) in the form of the package "FLSAM". All assessments are performed with version 0.50 (2012-02-29) of FLSAM, together with version 2.4 of the FLR library (FLCore). The FLCore and FLSAM packages are hosted under version control at the "R-forge" repository, https://r-forge.r-project.org/projects/flr/ Built packages of FLSAM are available from the HAWG stock assessment repository, http://hawg.googlecode.com. All scripts to perform the assessment are available from the same location in the folder "/trunk/NSAS".

C.3. Assessment model configuration

Input data types and characteristics

(Y=data year)

Name	*Type*	*Year range*	*Age range*	*Data Modifications*	*Variable from year to year?*
Caton	***Catch in tonnes***	***1947 to Y***	**-**	**-**	***Yes***
Canum	***Catch-at-age in numbers***	***1947 to Y***	***0-8+***	***See note 1***	***Yes***
Weca	***Weight-at-age in the commercial catch***	***1947 to Y***	***0-8+***	**-**	***Yes***
West	***Weight-at-age of the spawning stock at spawning time.***	***1947 to Y***	***0-8+***	***See note 2***	***Yes***
Mprop	***Proportion of natural mortality before spawning***	***1947 to Y***	***0-8+***	**-**	***No***
Fprop	***Proportion of fishing mortality before spawning***	***1947 to Y***	***0-8+***	**-**	***No***
Matprop	***Proportion mature-at-age***	***1947 to Y***	***0-8+***	**-**	***Yes (from 1983 onwards: constant prior to this)***
Natmor	***Natural mortality***	***1963 to 2010***	***0-8+***	***See note 3***	***Yes***

[1] Catch-at-age data for the years 1978-1979 are exclude from the assessment model fit. All other data, including the fishery-independent surveys, are included.

[2] The procedure to calculate the weight-at-age in the stock (*west*), given a set of weight-at-age values as calculated from the acoustic survey, has been standardised and applied uniformly to the raw data. *West* values used in the assessment are calculated as the running mean of data in the assessment year together with the preceding two years (*i.e.*, $s_i=(w_{i-2}+w_{i-1}+w)/3$, where s_i is the smoothed weight and w_i is the raw weight in year *i*)

[3] Natural mortality estimates are derived from the SMS model used in WGSAM (ICES, 2011). The input data to the assessment are then smoothed values (loess smoother,

span=0.5, order=2) of the raw SMS model annual M values, which are variable both at-age and over the time period 1963 – 2010. Natural morality in years outside this time-period are filled and estimated for each age as a five year running mean in the forward direction for 2011+ (*i.e.* $m_i = (M_{i-1}+M_{i-2}+M_{i-3}+M_{i-4}+M_{i-5})/5$ where m_i is the smoothed natural mortality and M_i is the raw natural mortality in year i) and in the reverse direction for years prior to 1963 i.e. $m_i = (M_{i+1}+M_{i+2}+M_{i+3}+M_{i+4}+M_{i+5})/5$. There is currently no agreed approach about how to handle revisions to the natural mortality time series: this issue will need to be reviewed when new estimates become available.

Type	*Name*	*Year range*	*Age range (wr)*
Tuning fleet	***IBTS Q1***	***1984 to Y+1***	***1***
Tuning fleet	***IBTS-0***	***1992 to Y+1***	***0***
Tuning fleet	***HERAS***	***1989 to Y (1997 to Y for age 1)***	***1-8+***
Tuning fleet	***SCAI***	***1972 to Y***	***SSB***

Many of the data time series are made available with a 9+ age group. In such situations, an age 8+ plus group value is produced by arithmetic sum of age 8 and 9 for numbers-at-age variables and an arithmetic mean for other variables.

Model configuration

An example of the SAM model configurations used in the FLSAM package, for the 2011 assessment, is given below. Note that the “maxyear” argument in the range slot should be set to value of the intermediate year in other situations

An object of class "FLSAM.control"

Slot "name":

[1] "NSAS Herring"

Slot "desc":

[1] "North Sea Autumn Spawning Herring Assessment"

Slot "range":

```
      min       max plusgroup   minyear   maxyear   minfbar   maxfbar
        0         8         8      1947      2011         2         6
Slot "fleets":
  catch     SCAI   HERAS IBTS-Q1   IBTS0
      0        3       2       2       2
Slot "plus.group":
plusgroup
     TRUE
Slot "states":
         age
  fleet     0  1  2  3  4  5  6  7  8
  catch     1  2  3  4  5  6  7  8  8
  SCAI     NA NA NA NA NA NA NA NA NA
  HERAS    NA NA NA NA NA NA NA NA NA
  IBTS-Q1  NA NA NA NA NA NA NA NA NA
  IBTS0    NA NA NA NA NA NA NA NA NA
Slot "logN.vars":
```

```
0 1 2 3 4 5 6 7 8
1 2 2 2 2 2 2 2 2
Slot "catchabilities":
         age
  fleet    0  1  2  3  4  5  6  7  8
  catch   NA NA NA NA NA NA NA NA NA
  SCAI    NA NA NA NA NA NA NA NA NA
  HERAS   NA  3  3  4  4  5  5  5  5
  IBTS-Q1 NA  1 NA NA NA NA NA NA NA
  IBTS0    2 NA NA NA NA NA NA NA NA
Slot "power.law.exps":
         age
  fleet    0  1  2  3  4  5  6  7  8
  catch   NA NA NA NA NA NA NA NA NA
  SCAI    NA NA NA NA NA NA NA NA NA
  HERAS   NA NA NA NA NA NA NA NA NA
  IBTS-Q1 NA NA NA NA NA NA NA NA NA
  IBTS0   NA NA NA NA NA NA NA NA NA
Slot "f.vars":
         age
  fleet    0  1  2  3  4  5  6  7  8
  catch    1  1  2  2  3  3  4  4  4
  SCAI    NA NA NA NA NA NA NA NA NA
  HERAS   NA NA NA NA NA NA NA NA NA
  IBTS-Q1 NA NA NA NA NA NA NA NA NA
  IBTS0   NA NA NA NA NA NA NA NA NA
Slot "obs.vars":
         age
  fleet    0  1  2  3  4  5  6  7  8
  catch    3  4  4  4  4  4  6  6  6
  SCAI    NA NA NA NA NA NA NA NA NA
  HERAS   NA  4  5  5  5  5  6  6  6
  IBTS-Q1 NA  1 NA NA NA NA NA NA NA
  IBTS0    2 NA NA NA NA NA NA NA NA
Slot "srr":
[1] 0
Slot "timeout":
[1] 3600
```

This example configuration encapsulates the following configuration options and bindings:

Minimum age 0, maximum age 8

The model is configured to cover the full time series of catch data plus the intermediate year i.e. from 1947 to the intermediate year. In the above example, the intermediate year is 2011.

Mean fishing mortality is defined as ages 2-6

The four data sources are included in the following manner

"Catch at age" observations are treated as a fishing fleet (fleet =0)

The SCAI index is treated as an SSB index (fleet=3)

The HERAS, IBTS-Q1 and IBTS0 indices are treated as numbers-at-age indices (fleet=2)

The oldest age (8) is treated as a plus group. This is specified in the range slot, and again in the "plus.group" slot

The fishing mortalities at each age are estimated by independent random walks (one for each age), with the exception of ages 7 and 8+, which are represented by a single common random walk. This is expressed in the model configuration above by binding the "state" parameters for ages 7 and 8.

The variances in the estimated numbers at age (logN.vars) are represented by two parameters – one variance for the age 0 numbers and a second for the other ages.

Catchabilities of the individual surveys are bound as follows:

The IBTS 1Q and IBTS0 surveys, each of which contain only a single age group, are represented each with a single catchability parameter (catchabilities slot)

The HERAS survey is represented by three catchability parameters: one for ages 1-2, one for ages 3-4 and one for ages 5-8 (catchabilities slot)

All observations are represented with a linear relationship (i.e. no parameters activated in the "power-law" slot)

The variances of the fishing mortality random walks (f.vars) are bound together in sequential-age pairs i.e. four parameters are used, one for age 0-1, one for age 2-3, one for age 4-5, and one for age 6-8

The observation variances of the surveys (obs.vars slot) are bound as follows:

Both the IBTS-1Q and IBTS0 indices are fitted with their own observation variances

The HERAS observation variances are bound into three groups: one covering age 1 on its own, one for ages 2-5 and one for ages 6-8+.

The catch observation variances are also bound into three groups: one covering age 0 on its own, one for ages 1-5, and one for ages 6-8+.

No stock-recruitment relationship is imposed upon the model i.e the "srr" slot is set equal to 0.

The model is not allowed to use more than one hour to converge ie the "timeout" slot is set of 3600

Other notes

Survey data in the intermediate year should be included wherever possible. In particular, the IBTS-1Q and IBTS0 surveys performed in January and February should be ready in time for the assessment meeting (typically in March).

There is no method in the current version of SAM to explicitly bind or alter the representation of the SCAI SSB index in the model, i.e. the catchabilities, observation variances and use of a power-law model

It is not possible with the current configuration of the SAM framework to reliably estimate the fishing mortality around the time of the closure of the fishery (late 1970s) as the associated rapid changes in F are a clear violation of the model assumptions. Catch data from 1978-1979 are excluded from the assessment for this reason. Furthermore, the fishing mortalities estimated by the model during this time are not considered reliable and therefore F values from 1977-1980 should not be reported. SSB and recruitment, however, can still be estimated during this period (albeit with increased uncertainties). Stock summary plots and tables should be adjusted manually to reflect these limitations.

D. Short-Term Projection

A multi-fleet, multi-option, deterministic short-term prediction tool (MFSP) has been used for many years and an FLR implementation of the tool has replaced the MFSP from 2009 onwards. The good agreement between predicted biomass for the intermediate year and SSB taken from the assessment one year after demonstrates that the current prediction procedure for stock numbers works well. The FLR implementation has been extended to allow Monte-Carlo simulations, enabling a stochastic approach by varying population parameters. The stochastic approach is used for illustration purposes only while the deterministic approach is used to provide advice.

Method

Both the Short Term Forecast Module North Sea (STFMNS, Hintzen) and the MFSP program were extensively tested in 2009 to ensure that they both gave identical results. For the North Sea herring stock, managers have agreed to constrain the total out-take at levels of fishing mortalities for ages 0-1 and 2-6, and need options to show the trade-off between fleets within those limits. In total four fleets are considered; a dedicated human consumption fishery in the North Sea, an industrial fishery in the North Sea, a dedicated human consumption fishery in IIIa also taking NSAS, and an industrial fishery in IIIa also taking NSAS. In the short term predictions, recruitment in the TAC year (intermediate year) is taken directly as predicted from the assessment model, and recruitment in the advice year is assumed similar to the recruitment regime of lower productivity since 2002.

Input data

Fleet Definitions

The current fleet definitions are:

North Sea

Fleet A: Directed herring fisheries with purse seiners and trawlers. By-catches in industrial fisheries by Norway are included.

Fleet B: Herring taken as by-catch under EU regulations.

Division IIIa

Fleet C: Directed herring fisheries with purse seiners and trawlers

Fleet D: By-catches of herring caught in the small-mesh fisheries

The fleet definitions are those defined in Section A.2 above.

In some years, it has been agreed that Norway can take parts of its IIIa quota in the North Sea. When estimating the expected catch in the intermediate year, it is assumed that this transfer takes place, hence the assumed catch by the C-fleet of both stocks combined is reduced and the catch by the A-fleet increased with the agreed amount.

Input Data for Short Term Projections: All the input data for the short term projections are shown in the table below:

Type	*Name*	*Basis*
Weca	***Weight-at-age in the commercial catch***	***The 3 year average mean weights-at-age for each fleet are used for all prediction years, unless there are indications that some year class has abnormal growth***
West	***Weight-at-age of the spawning stock at spawning time.***	***The weights at age applied in the last assessment year are used for all prediction years. These are running averages of the raw data calculated as the running mean of data in the assessment year (Y) together with the preceding two years (i.e., Y-2,Y-1,Y)***
F	***Fishing mortality-at-age in the stock***	***Selection by fleet-at-age is calculated by splitting the total fishing mortality in the assessment year at each age proportionally to the catch numbers by fleets at that age. These selections-at-age are used for all years in the prediction. For illustration purposes only: Variability in the total fishing mortality is generated from a multi-variate random distribution informed by the variance-co-variance matrix as obtained from the assessment output***
N	***Stock numbers***	***For the start of the intermediate year the stock numbers at age by 1. Jan that year are taken from the calculateions made by SAM. For illustration purposes only:Variability in the numbers-at-age is generated from a multi-variate random distribution informed by the variance-co-variance matrix as obtained from the assessment output***
Mprop	***Proportion of natural mortality before spawning***	***Standard value of 0.67***
Fprop	***Proportion of fishing mortality before spawning***	***Standard value of 0.67***
Matprop	***Proportion mature-at-age***	***Average of maturity-at-age of the most recent three years. For illustration purposes only:Varies over time by sampling from historic observations on maturity-at-age values***
Natmor	***Natural mortality***	***Average of mortality-at-age of the most recent five years from the smoothed SMS output***
R	Recruitment in Intermediate (Y+1), Advice(Y+2) and Continuation (Y+3) years	***Recruitment in the intermediate year is estimated inside the SAM assessment model. Recruitment in the advice and continuation year[1] is calculated as the weighted geometric mean of the years 2002 to year Y. The inverse variance estimate, obtained from SAM, is used as weighting criteria. For illustration purposes only:Variability in the stock numbers propagates through in the recruitment estimates.***

[1] For the prediction years, the recruitment has, in recent years, been set to the geometric mean of the recruitments of the year classes from 2002 onwards, as estimated in the assessment of the data year. The low recruitment was assumed because all the year classes from 2002 onwards have been poor except for 2008 year class. Analysis of the time series of SSB and recruitment data by the SGRECVAP (ICES, 2006) clearly indicates a shift in the recruitment success after 2001. The underlying cause for the change in 2001 is not clear, but there is no evidence to justify an assumption of long term average recruitment in the near future. Consequently, the advice is adapted to the current low recruitment regime.

Prediction

Assumptions for the intermediate year.

A-fleet: The TAC for the A fleet has been over-fished every year since 2003 until 2008. Since 2009 however, there is no indication of over-fishing anymore. Hence, catches equal the TAC in the intermediate year.

The catches by the B-fleet have been well below the by-catch quota for the B-fleet. The quota has been reduced recently, and the fraction used has increased. Therefore, the fraction of the TAC in the intermediate year is assumed to be equal to the fraction used in the assessment year. Also the C and D fleets have NSAS catches well below the total Division IIIa quota, partly because the quota also includes WBSS herring. For 2010, the same fraction as in 2009 was assumed; previously a 3 year average has been used in some cases.

Management Option Tables for the TAC year

The EU-Norway agreement on management of North Sea herring was updated in 2008, to adapt to the present reduced recruitment, accounting for the results by WKHMP (ICES, 2008). The revised rule specifies fishing mortalities for juveniles (F0-1) and for adults (F2-6) not to be exceeded, at 0.05 and 0.25 respectively, for the situation where the SSB is above 1.5 million tonnes. When the SSB is below 1.5 million tonnes F is reduced to give

F2-6 = 0.25-(0.15*(1500-SSB)/700),

with allowance for a stronger reduction in TAC if necessary. Below 0.8 million tonnes F2-6 = 0.1 and F0-1 = 0.04.

Furthermore, there is a constraint at 15% change in the TAC from one year to the next. The F0-1 and F2-6 stated in the rule are assumed to apply to the total F summed over all fleets. The SSB referred to is taken to be the SSB in the prediction year. For example, the fishing mortalities for 2010 should reflect its consequence for SSB in 2010.

Catches by the C and D fleet influence the fishing opportunities for the B-fleet in particular, since the NSAS herring caught by these fleets mostly are at age 0-2. The assumed catch of NSAS herring by the C and D fleets is derived according to a likely TAC for WBSS herring in a three step procedure:

1) The fraction of the total TAC for WBSS that is taken in Division IIIa is assumed to be the same as the average of the last 3 years, giving an expected catch of WBSS in Division IIIa.
2) The WBSS caught in Division IIIa is allocated to the C and D fleets assuming the same share as the average of the last 3 years. The total expected catch of WBSS in IIIa is split accordingly, which gives expected catch of WBSS by fleet.
3) Using the ratio between NSAS and WBSS in the catches by each fleet, the total catch by fleet and the catch of NSAS by fleet are derived from the catch of WBSS by fleet.

These expected catches of NSAS by the C and D fleets are used as catch constraints in the prediction.

The basis for deriving these catches is weak. The main purpose is to provide realistic assumptions on the impact of these fleets when predicting the catches for the North Sea fleets. The effect of other assumptions for the C and D fleet should be calculated if needed, but are not presented in the advice.

The catches for the A and B fleets are derived according to the harvest rule.

When the harvest rule leads to SSB below the trigger biomass (1.5 million tonnes), an iterative procedure is needed to find a fishing mortality and a corresponding SSB in accordance with the rule. At present, this is done by a numerical minimisation.

E. Medium-Term Projections

Medium-term projections are not carried out for this stock

F. Long-Term Projections

Long-term projections are not carried out for this stock

G. Biological Reference Points

The North Sea herring is nominally being managed by a precautionary management plan. It has been considered that the critical issue is identifying the risk of SSB falling below Blim. The following sections on limit reference points is adapted from ICES WKHMP (ICES CM 2008 (ACOM:27)) and explores and discusses the issues about precautionary status of the management of North Sea herring.

	Type	Value	Technical basis
Management plan	F_{MP}	$F_{0\text{-}1} = 0.05$ $F_{2\text{–}6} = 0.25$	If SSB greater than SSB_{MP} upper trigger of 1.5 million t (based on simulations).
		$F_{0\text{-}1} = 0.05$ $F_{2\text{–}6} = 0.25 – (0.15*(1500000-SSB)/700000)$	If SSB between SSB_{MP} triggers 0.8 and 1.5 million t (based on simulations).
		$F_{0\text{-}1} = 0.04$ $F_{2\text{–}6} = 0.10$	If SSB less than SSB_{MP} lower trigger of 0.8 million t (based on simulations).
MSY Approach	MSY $B_{trigger}$	not defined	
	F_{MSY}	0.25	Simulations under different productivity regimes, research between 1996 and 2010.
Precautionary approach	B_{lim}	800 000 t	< 0.8 million t; poor recruitment has been experienced. Defined in 1997/2008.
	B_{pa}	1.3 million t	B trigger in the previous harvest control rule.
	F_{lim}	not defined	
	F_{pa}	$F_{2\text{-}6} = 0.25$	Target Fs in the harvest control rule.

The benchmark assessment performed in WKPELA 2012 revised the perception of the stock and the current management plan is preconditioned on the former perception of the stock from the then applied assessment methodology. HAWG question the validity of the current management plan. The analysis carried out by WKPELA 2012 implies that the reference points for NSAS may have shifted under the perception of the stock assessment and thus a full revision of the existing management plan for NSAS is highly warranted.

Currently the reference points listed in the above table are considered appropriate for the NSAS stock until revised in the upcoming MSE.

Concept of a management plan (harvest control rule)

In a harvest control rule, parameters (trigger and targets) serve as guidance to actions according to the state of the stock (ICES Study Group on the Precautionary Approach, ICES, 2002). These should be chosen according to management objectives, one of which should be to have a low risk of bringing the SSB to unacceptably low levels. In an evaluation of a harvest rule, one will use simulations with a 'virtual stock' which as far as possible resembles the stock in question to evaluate the risk as the probability of the virtual SSB being below the B_{lim} value. Within the constraints needed to keep the risk to B_{lim} low, parameters of the rule will be chosen to serve other management objectives, e.g. to ensure a high long term yield and stable catches over time. Such a management plan would be classed by ICES as precautionary provided the risk of SSB being below B_{lim} is sufficiently low.

The current management plan for NSAS is due revision in 2012.

MSY framework for North Sea herring

There is no ICES MSY framework biomass trigger point for this stock as the MP is thought to have primacy over the ICES MSY framework when providing advice.

In 2010 ACOM agreed with HAWG that Fmsy for NSAS was 0.25. This was supported by WKFRAME2. The analyses carried out by WKPELA 2012 suggested that MSY reference points may vary over time. Further, WKPELA suggested that a minor increase in Fmsy might be appropriate given the increase in SSB resulting from the FLSAM benchmark assessment. An Fmsy around 0.3 was considered. However, associated uncertainty with the WKPELA Fmsy has not yet been estimated. Such estimate is required to determine whether the WKPELA proposed estimate is significantly different from the ACOM agreed Fmsy. Therefore, and until a full evaluation of Fmsy under the current perception of the stock is carried out, Fmsy for NSAS remains = 0.25.

Concept of precautionary reference points

Conceptually, precautionary reference points are different from parameters in a harvest control rule. In the precautionary approach, as interpreted by ICES, the function of the reference points is to ensure that the SSB is above the range where recruitment may be impaired or the stock dynamics is unknown. The real limit is represented by B_{lim}, while the B_{pa} takes assessment uncertainty into account, so that if SSB is estimated at B_{pa}, the probability that it is below B_{lim} shall be small. The F_{lim} is the fishing mortality that corresponds to B_{lim} in a deterministic equilibrium. The F_{pa} is related to F_{lim} the same way as B_{pa} is related to B_{lim} (ICES, 2002). In the advisory practice, F_{pa} has been the basis for the advice unless the SSB has been below B_{pa}, where a reduction in F has been advised. Furthermore, F_{pa} and B_{pa} are currently used to classify the state of stock and rate of exploitation relative to precautionary limits. Precautionary reference points have been used by ICES to provide advice and classify the state of the stock in the absence of other information, such as extensive evaluations of management plans.

ICES will accept that a harvest control rule is in accordance with the precautionary approach as long as it implies a low risk to being below B_{lim}, even if other reference points may be exceeded occasionally. When a rule is regarded as precautionary, ICES gives its advice according to the rule. If the rule is followed, then ICES classifies exploitation as precautionary. Within this framework, other precautionary reference points generally will be redundant. However, the precautionary reference points may also be used to classify the stock with respect to precautionary limits, which may lead to a conflicting classification. This discrepancy is still unresolved. The management plan will reduce fishing mortality accordingly. Following the acceptance by ACFM that the management plan is precautionary (and the findings of WKHMP), HAWG has considered that the parameters of the management plan should take primacy over the management against precautionary reference points F_{pa} or B_{pa}.

The precautionary reference points for this stock were adopted in 1998. The analysis carried out by WKPELA 2012 implies that the reference points have shifted under the perception of the stock assessment, thus a thorough scientific process is necessary to revise the existing reference points.

Concept of precautionary reference points

Conceptually, precautionary reference points are different from parameters in a harvest control rule. In the precautionary approach, as interpreted by ICES, the function of the reference points is to ensure that the SSB is above the range where recruitment may be impaired or the stock dynamics is unknown. The real limit is represented by B_{lim}, while the B_{pa} takes assessment uncertainty into account, so that if SSB is estimated at B_{pa}, the probability that it is below B_{lim} shall be small. The F_{lim} is the fishing mortality that corresponds to B_{lim} in a deterministic equilibrium. The F_{pa} is related to F_{lim} the same way as B_{pa} is related to B_{lim} (ICES, 2002). In the advisory practice, F_{pa} has been the basis for the advice unless the SSB has been below B_{pa}, where a reduction in F has been advised. Furthermore, F_{pa} and B_{pa} are currently used to classify the state of stock and rate of exploitation relative to precautionary limits. Precautionary reference points have been used by ICES to provide advice and classify the state of the stock in the absence of other information, such as extensive evaluations of management plans.

ICES will accept that a harvest control rule is in accordance with the precautionary approach as long as it implies a low risk to being below B_{lim}, even if other reference points may be exceeded occasionally. When a rule is regarded as precautionary, ICES gives its advice according to the rule. If the rule is followed, then ICES classifies exploitation as precautionary. Within this framework, other precautionary reference points generally will be redundant. However, the precautionary reference points may also be used to classify the stock with respect to precautionary limits, which may lead to a conflicting classification. This discrepancy is still unresolved. The management plan will reduce fishing mortality accordingly. Following the acceptance by ACFM that the management plan is precautionary (and the findings of WKHMP), HAWG has considered that the parameters of the management plan should take primacy over the management against precautionary reference points F_{pa} or B_{pa}.

H. Other Issues

H.1 Biology of the species in the North Sea

The herring (Clupea harengus) is a pelagic species which is widespread in its distribution throughout the North Sea. Herring originated in the Pacific and colonised the Atlantic approximately 3 million years ago (Geffen, 2009). Herring evolved from fish that spawned in rivers and at some later date re-adapted to the marine environment (Geffen, 2009). The herring's unique habit is that it produces benthic eggs which are attached to a gravely substrate on the seabed (Geffen, 2009). The spawning grounds in the southern North Sea are located in the beds of rivers which existed in geological times and some groups of spring spawning herring still spawn in very shallow inshore waters and estuaries. Spawning typically occurs on coarse gravel (0.5-5 cm) to stone (8-15 cm) substrates and often on the crest of a ridge rather than hollows. For example, in a spawning area in the English Channel, eggs were found attached to flints 2.5-25 cm in length, where these occurred in gravel, over a 3.5 km by 400m wide strip.

As a consequence of the requirement for a very specific substrate, spawning occurs in small discrete areas in the near coastal waters of the western North Sea (Schmidt *et al.*, 2009). They extend from the Shetland Islands in the north through into the English Channel in the south. Within these specific areas actual patches of spawn can be extremely difficult to find.

The fecundity of herring is length related and varies between approximately 10 000 and 60 000 eggs per female (Damme *et al.*, 2009). This is a relatively low fecundity for a teleost. The age of first maturity is 3 years old (2-ringers) but the proportion mature-at-age may vary from year to year dependent on growth. Over the past 15 years the proportion mature at age 3 years (2-ringers) has ranged from 47% to 86% and for 4 year old fish (3-winter ringers) from 63% to 100%. Above that age, all are considered to be mature.

The benthic eggs take about three weeks to hatch dependant on the temperature. In other regions there is evidence of large interannual variability of egg mortality (Richardson *et al.*, 2011). The larvae on hatching are 6 mm to 9 mm long and rise, due to buoyancy changes, in the water column to become planktonic (Dickey-Collas *et al*, 2009). Their yolk sac lasts for a few days during which time they will begin to feed on phytoplankton and small zooplankton. Their planktonic development lasts around three to four months during which time they are passively subjected to the residual drift which takes them to various coastal nursery areas on both sides of the North Sea and into the Skagerrak and Kattegat (Heath *et al.*, 1997). The environmental impact during this phase is crucial to life cycle closure and probably controls the spawning season of the components (Hufnagl & Peck 2011).

Herring continue to be mainly planktonic feeders throughout their life although there are numerous records of them taking small fish, such as sprat and sandeels, on an opportunistic basis. Calanoid copepods, such as Calanus, Pseudocalanus and Temora and the euphausiids, Meganyctiphanes and Thysanoessa still form the major part of their diet during the spring and summer (Hardy, 1924; Savage, 1937; Bainbridge and Forsyth, 1972; Last, 1989) and are responsible for the very high fat content of the fish at this time. They also consume fish eggs (Segers *et al.*, 2007).

In the past, herring age has been determined by using the annual rings on the scales. In more recent years the growth rings on the otolith have proved more reliable for age determination. Herring age is expressed as number of winter rings on the otolith rather than age in years as for most other teleost species where a nominal 1 January birth date is applied. Autumn spawning herring do not lay down a winter ring during their first winter and therefore remain as ‘0’ winter ringers until the following winter. When looking at year classes, or year of hatching, it must be remembered that they were spawned in the year prior to their classification as ‘0’ winter ringers.

North Sea herring comprise both spring and autumn spawning groups, but the major fisheries are carried out on the offshore autumn/winter spawning fish. The spring spawners are found mainly as small discrete coastal groups in areas such as The Wash, the Thames estuary, Danish Fjords and the now extinct Zuiderzee herring. Juveniles of the spring spawning stocks are found in the Baltic, Skagerrak and Kattegat, and may also be found in the North Sea as well as Norwegian coastal spring spawners. There is thought to be an input of larvae from the west of Scotland (Heath, 1989).

The main autumn spawning begins in the northern North Sea in August and progresses steadily southwards through September and October in the central North Sea to November and as late as January in the southern North Sea and eastern English Channel. The widespread but discrete location of the herring spawning grounds throughout the western North Sea has been well known and described since the 19th century (Heincke, 1898; Bjerkan, 1917). This led to considerable scientific debate and eventually to investigation and research on stock identity. The controversy centred on whether or not the separate spawning grounds represented discrete stocks or 'races' within the North Sea autumn spawning herring complex (McQuinn, 1997). Resolution of this issue became more urgent as the need for the introduction of management measures increased during the 1950s. The International Council for the Exploration of the Sea (ICES) encouraged tagging and other studies for separating the spawning components and a review of all the historic evidence to resolve this problem and innovative approaches to assessing mixed and connective stocks (Kell *et al.*, 2009; Secor *et al.*, 2009). The conclusions were the basis for establishing the working hypothesis that the North Sea autumn spawning herring comprise a complex of at least four spawning components each with separate spawning grounds, migration routes and nursery areas. There is mixing between these components during the summer.

The main four spawning components are:

The Orkney/Shetland component which spawns from July to early September in the Orkney/Shetland area. Nursery areas for fish up to two years old are found along the east coast of Scotland and also across the North Sea and into the Skagerrak and Kattegat.

The Buchan component which spawns from August to early September off the Scottish east coast. Nursery areas for fish up to two years old are found along the east coast of Scotland and also across the North Sea and into the Skagerrak and Kattegat.

The Banks or central North Sea component, which derives its name from its former spawning grounds around the western edge of the Dogger Bank. These spawning grounds have now all but disappeared and spawning is confined to small areas along the English east coast, from the Farne Islands to the Dowsing area, from August to October. The juveniles are found along the east coast of England, down to the Wash, and also off the west coast of Denmark.

The Downs component which spawns in very late autumn through to February in the southern Bight of the North Sea and in the eastern English Channel. The drift of their larvae takes them north-eastwards to nursery areas along the Dutch coast and into the German Bight (Burd, 1985).

At certain times of the year, individuals from the four stock units may mix and are caught together as juveniles and adults but they cannot be readily separated in the commercial catches other than using otolith methods (Clausen *et al*, 2007; Bierman *et al.*, 2009). However North Sea autumn spawning herring are managed as a single unit with the understanding that they comprise many spawning components.

A further complication is that juveniles of the North Sea stocks are found outside the North Sea in the Skagerrak and Kattegat areas and are caught in various fisheries there. The proportions of juveniles of North Sea origin found in these areas varies with the strength of the year class, with higher proportions in the Skagerrak and Kattegat when the year class is good.

In recent decades, recruitment strength is determined during the larval phase (Nash and Dickey-Collas, 2005; Oeberst *et al.*, 2009) and larval mortality in the first few weeks of life, although differing between components, co-varies with recruitment strength (Fassler *et al*., 2011).

H.2 Stock dynamics, regulation and catches through 20th century

Over many centuries the North Sea herring fishery has been a cause of international conflict sometimes resulting in war, but in more recent times in bitter political argument. The North Sea herring fishery has a long history and catches between 1600 and 1850 were usually between 40 000 and 100 000 tonnes per year (Poulsen, 2006). Catching opportunities for the fishery were known to be variable. Since the 1900s the annual average catch was 450 Kt. Changes in fleet catching potential have been driven both by changes in catching power and accessibility and responses to markets, particularly the demand from urban populations in the nineteenth century and for fish meal and oil in the twentieth century. Most of these changes have resulted in greater exploitation pressures that increasingly led to the urgent need to ensure a more sustainable exploitation of North Sea herring. Such pressures really began to exert themselves for the first time during the 1950s when the spawning stock biomass of North Sea autumn spawning herring fell from above 4 million tonnes in 1947 to 1.4 million tonnes by 1957 (Simmonds, 2007; 2009). That period also witnessed the decline and eventual disappearance of a traditional autumn drift net fishery in the southern North Sea (Burd, 1978).

At the time, and with the exception of the 12-mile coastal zone, the North Sea was still a free fishing area and the stock was exploited by fleets from at least 14 different nations (ICES, 1977). Despite the conclusions of the ICES Herring Assessment Working Group becoming more alarming each year (ICES, 1977), the North East Atlantic Fisheries Convention (NEAFC) had no mandate to impose measures unless they were agreed by all member states (Ackefors, 1977). As a consequence, NEAFC could only agree on measures that constituted no real obstacle to any of the national fleets involved (Simmonds, 2007).

The annual landings from 1947 through to the early 1960s were high, but stable, averaging around 650 000t (Cushing and Bridger, 1966). Over the period 1952-62, the high fishing mortality (F 0.4 ages 2-6) resulted in a rapid decline in the spawning stock biomass from around 5 million tonnes to 1.5 million tonnes.

Figure H.2.1 illustrates the dynamics in modelled selectivity (F/Fbar) over the past 60 years, shown by age and year in pentads (five year groupings). It is evident that the fishing mortality imposed on the NSAS is quite variable even on a yearly scale, though general patterns can be discerned for the specific age-groups.

Fishing mortality on the herring in the central and northern North Sea began to increase rapidly in the late 1960s and had increased to F1.3 ages 2-6, or over 70% per year of those age classes, by 1968. Landings peaked at over 1 million tonnes in 1965, around 80% of which were juvenile fish. This was followed by a very rapid decline in the SSB and the total landings. By 1975 the SSB had fallen to 83 500 t, although the total landings were still over 300 000 t (Simmonds, 2007). At the same time, spawning in the central North Sea had contracted to the grounds off the east coast of England whilst spawning grounds around the edge of the Dogger Bank were no longer used. Recruitment collapsed. This heralded the serious decline and collapse of the North Sea autumn spawning herring stock which led to the moratorium on directed herring fishing in the North Sea from 1977 to 1981 (Cushing, 1992; Dickey-Collas *et al*., 2010).

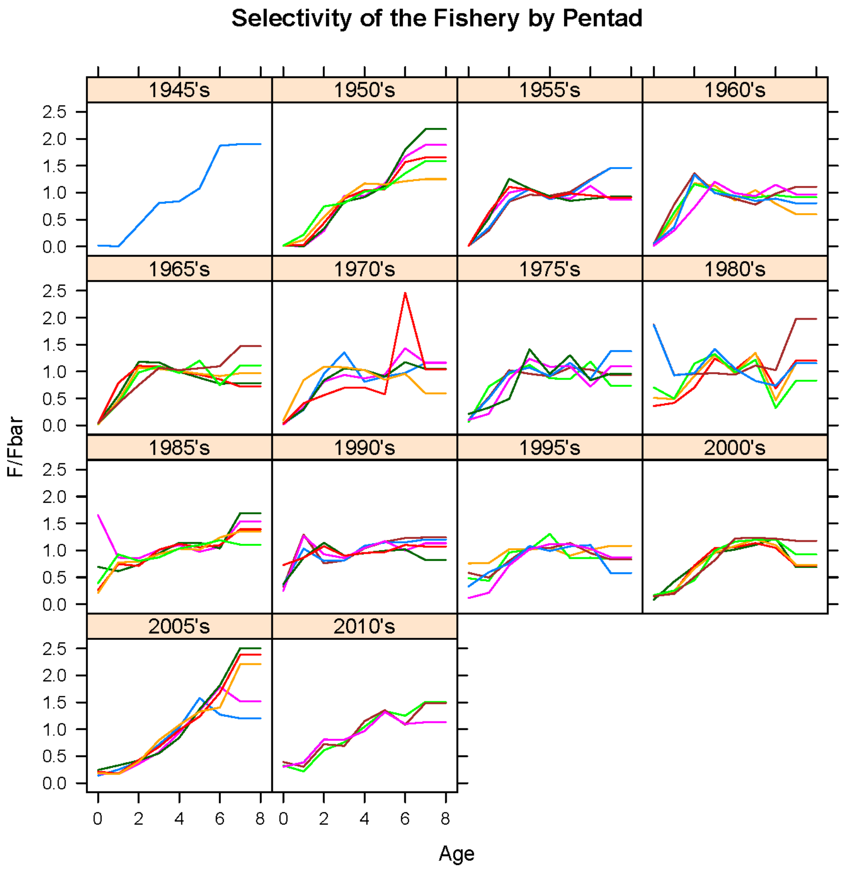


Figure H.2.: Selectivity (F/Fbar) over the past 60 years, shown by age and year (each year in individual colours) in pentads

On the 1st of January 1977, all countries around the North Sea extended their exclusive economic zones (EEZ) to 200 miles (Coull, 1991). The North Sea was no longer a free fishing area and suddenly national governments could introduce conservation measures within their own areas. Using this opportunity, the British government was the first (March 1st, 1977) to declare a total ban on all directed herring fisheries in the British EEZ (Coull, 1991). Other governments were slow to follow. The scientific argument that a closure of the fishery was required finally persuaded all other countries to join in. By the end of June 1977, all directed herring fisheries in the North Sea ceased.

In general, the fishing ban was well respected, except in the Channel area where local trawlers continued to fish small quantities of spawning herring (ICES, 1982). Also, herring could still be landed as a by-catch taken in other fisheries, and limited directed fishing did occur on this basis. It was during this time that the European Union agreed on a Common Fisheries Policy and took responsibility for the management in all community waters. Some fleets moved to exploit herring stocks in adjacent areas. Following reports of a recovery of the Downs component, a small TAC for the southern North Sea and Channel area was set in 1981 and 1982. The ban on directed fishing in other areas of the North Sea was lifted in June 1983.

International larvae surveys and acoustic surveys were used to monitor the state of the stocks during the moratorium. By 1980 these surveys were indicating a modest recovery in the SSB from its 1977 low point of 52 000 t. By 1981 the SSB had increased to over 200 000 t. This was associated with an increase in the productivity of the stock, i.e. apparent compensatory recruitment (Nash *et al*., 2009). Once the fishery re-opened in 1981 the North Sea autumn spawning herring stock was managed by a Total Allowable Catch (TAC) constraint through the EU Common Fisheries Policy and agreement with Norway. The TAC was only applied to the directed herring fishery in the North Sea which exploited mainly adult fish for human consumption. Targeted fishing for herring for industrial purposes was banned in the North Sea in 1976 but there was a 10% by-catch allowance in the fisheries for other species, including the small meshed fisheries for industrial purposes, mainly for sprat. Following the re-opening of the now controlled fishery the SSB steadily increased, peaking at 1.3 million tonnes in 1989. Annual recruitment was well above the long-term average over this period. The 1985 year class was the biggest recorded since 1960 and the third highest in the records dating back to 1946 (Nash *et al*., 2009). Landings also steadily increased over this period reaching a peak of 876 000 tonnes in 1988. This resulted from a steady increase in fishing mortality to Fages 2-6 = 0.6 (ca. 45%) in 1985 and a high by-catch of juveniles in the industrial fisheries for sprat. Following a period of four years of below average recruitment (year classes 1987-91), SSB fell rapidly to below 500 000 tonnes in 1993. Fishing mortality further increased, averaging Fages 2-6=0.75 (ca. 52%) over the period 1992–95, and recorded landings regularly exceeded the TAC. The North Sea industrial fishery for sprat developed rapidly over this period with the annual catch increasing from 33 000 tonnes in 1987 to 357 000 tonnes by 1995. With the 10% by-catch limit as the only control on the catch of immature herring, there was a consequent high mortality on juvenile herring averaging 76% of the total catch in numbers of North Sea autumn spawners over this period.

During the summer of 1991 the presence of the parasitic fungus Ichthyophonus spp. was noted in the North Sea herring stock. All the evidence suggested that the parasite was lethal to herring and that its occurrence could have a significant effect on natural mortality in the stock and ultimately on spawning stock biomass. High levels of infection were recorded in the northern North Sea north of latitude 60°N whilst infection rates in the southern North Sea and English Channel were very low. Efforts were made to estimate the prevalence of the disease in the stock through a programme of research vessel and commercial catch sampling. This led to estimates of annual mortality up to 16% (Anon., 1993) which was of the same order as the estimate of fishing mortality at the time. It was recognised that the behavioural changes and catchability of infected fish affected the reliability of the estimate of prevalence of the disease in the population. The uncertainty about the effect on stock size varied between estimates of 5% to 10% and 20%. Continued monitoring of the progress of the disease showed that by 1994 the prevalence in the northern North Sea had fallen from 5% in 1992 to below 1% and confirmed that the infection did not appear to be spreading to younger fish. Ultimately it was concluded that the disease had caused high mortality in the northern North Sea during 1991 and subsequently declined to the point where, by 1995, the increase in natural mortality induced by the disease was insignificant.

The increased fishing pressure during the first half of the 1990s and the disease-induced increase in natural mortality led to serious concerns about the possibilities of a stock collapse similar to that in the late 1970s. Reported landings continued at around 650 000 tonnes per year whilst the spawning stock began to decline again from over 1 million tonnes in 1990. The assessments at that time were providing an overly optimistic perception of the size of the spawning stock. It was, for example, not until 1995 that it was realised that the SSB in 1993 had already fallen below 500 000 tonnes. This was well below the minimum biologically accepted level of 800 000 tonnes (MBAL) which had been set for this stock at that time.

The herring stock apparently recovered during the late 2000s and in 2011 some regulatory measures were amended: A licence scheme introduced in 1997 by UK/Scotland, to reduce misreporting between the North Sea and VIaN, was relaxed, and the minimal amount of target species in the EU industrial fisheries in IIIa was reduced to 50% (for sprat, blue whiting and Norway pout).

H.3 Current Fisheries

There are at least four techniques used to fish for herring in the North Sea:

i. Human consumption fishery using mid-water trawl by single or pair RSW (refrigerated seawater) trawlers (mesh size 40-44 mm). These are not allowed to carry sorting equipment on board and thus cannot process the catch whilst at sea (other than emptying tanks or slipping catch from the net). They either land their catch as caught or pass it on to a processing vessel. Their catching potential is limited by the size of their tanks. This fishery is operated by vessels from the UK- Scotland, Denmark and Norway.

ii. Human consumption fishery using mid-water trawl by single or paired pelagic freezer trawlers (mesh size 40 mm). These catch and then process on-board, offloading frozen blocks of sorted and categorised fish. Their catching potential is limited by their processing capacity, usually 200-250 tonnes per day. This fishery is operated by vessels from Germany, The Netherlands, France and UK-England.

iii. Human consumption fishery using purse seine by RSW trawlers. Purse seine nets are used to encircle the shoals of herring rather than chase them with trawls. These vessels do not carry sorting equipment. Their catching potential is limited by the size of their tanks. This fishery is operated by vessels from Norway, Sweden and Denmark.

iv. Industrial fishery as bycatch. The herring is caught when targeting sprat or Norway pout using mid-water trawls with fine mesh nets (<32mm). Their catching potential is limited by the size of their tanks and a maximum bycatch percentage of herring. This fishery is operated by Denmark.

All of these fishing methods use fishers experience and acoustic techniques to find the shoals of fish. The mid-water trawls (single and paired) and purse seines are damaged if contact is made with the seabed. The fleets are characterised by a few vessels (all >40m), with even fewer owners. For example the German, Dutch, English and biggest French vessels are all owned by three companies operating out of the Netherlands.

H.4 Management and ICES advice

Management plan

In 1996, the total allowable catches (TACs) for herring caught in the North Sea (ICES areas IV and Division VIId) were changed mid-year with the intention of reducing the fishing mortality by 50% for the adult part of the stock and by 75% for the juveniles. For 1997, the regulations were altered again to reduce the fishing mortality on the adult stock to 0.25 and for juveniles to less than 0.1 with the aim of rebuilding the SSB up to 1.1 million t in 1998 (Simmonds, 2007).

According to the EU and Norway agreement adopted in December 1997, efforts should be made to maintain the SSB above the MBAL (Minimum Biologically Acceptable Level) of 800 000 tonnes. An SSB reference point of 1.3 million t was set above which the TACs would be based on an F= 0.25 for adult herring and F= 0.12 for juveniles. If the SSB fell below 1.3 million tonnes, other measures would be agreed and implemented taking account of scientific advice. A management plan was agreed by EU and Norway in 2008. ICES evaluated this management plan and concluded that the plan was consistent with the precautionary approach and the MSY approach. The stock is managed according to this EU-Norway Management agreement, the relevant parts of the text are included here for reference:

1. Every effort shall be made to maintain a minimum level of Spawning Stock Biomass (SSB) greater than 800 000 tonnes (B_{lim}).
2. Where the SSB is estimated to be above 1.5 million tonnes the Parties agree to set quotas for the directed fishery and for by-catches in other fisheries, reflecting a fishing mortality rate of no more than 0.25 for 2 ringers and older and no more than 0.05 for 0 - 1 ringers.
3. Where the SSB is estimated to be below 1.5 million tonnes but above 800 000 tonnes, the Parties agree to set quotas for the direct fishery and for by-catches in other fisheries, reflecting a fishing mortality rate on 2 ringers and older equal to:

   0.25-(0.15*(1 500,000-SSB)/700 000) for 2 ringers and older, and no more than 0.05 for 0 - 1 ringers
4. Where the SSB is estimated to be below 800 000 tonnes the Parties agree to set quotas for the directed fishery and for by-catches in other fisheries, reflecting a fishing mortality rate of less than 0.1 for 2 ringers and older and of less than 0.04 for 0-1 ringers.
5. Where the rules in paragraphs 2 and 3 would lead to a TAC which deviates by more than 15 % from the TAC of the preceding year the parties shall fix a TAC that is no more than 15 % greater or 15 % less than the TAC of the preceding year.
6. Notwithstanding paragraph 5 the Parties may, where considered appropriate, reduce the TAC by more than 15 % compared to the TAC of the preceding year.
7. By-catches of herring may only be landed in ports where adequate sampling schemes to effectively monitor the landings have been set up. All catches landed shall be deducted from the respective quotas set, and the fisheries shall be stopped immediately in the event that the quotas are exhausted.
8. The allocation of the TAC for the directed fishery for herring shall be 29 % to Norway and 71 % to the Community. The bycatch quota for herring shall be allocated to the Community.
9. A review of this arrangement shall take place no later than 31 December 2011.
10. This arrangement enters into force on 1 January 2009.

The EU–Norway agreement calls for a review of the current plan no later than December 2011. This has however not been performed and the demand for a full scale Management Strategy Evaluation and thus a revision of the North Sea Herring Management Plan has now increased considerably in the light of the changes made in the benchmark assessment performed in WKPELA 2012. The benchmark assessment has led to considerable revisions the perception of the stock and suggests that Fmsy as well as a target-F should be reconsidered, and thus the harvest control rules for the stock need evaluation against exceptional variations in biology, testing for robustness under varying starting conditions in population size and changes in the North Sea Ecosystem. This should be done as a collaborative iterative process between scientists, managers and stakeholders. To facilitate the process, it would be useful if the trade-off between the objectives of stability and long term yield could be expressed clearly.

Spawning component diversity

As noted above, the North Sea herring stock can effectively be viewed as a metapopulation consisting of at least four unique sub-populations (and potentially more). Maintaining the diversity of spawning components is widely recognized as being crucial to the successful and sustainable exploitation of herring stocks. Large differences in exploitation pressures between the components in the past has lead to wide changes in the composition of the total stock e.g. prior to 1980, the Downs component comprised less than a few percent of the total stock, whereas in 2010 it was nearly 50% (Cushing 1992; Payne 2010).

Traditionally the EU sets a separate sub-TAC, from within its own North Sea herring TAC, for the southern North Sea and eastern English Channel. This is designed to protect the Downs spawning component as it aggregates to spawn. Downs herring is assumed to be more susceptible to the impacts of exploitation (Cushing, 1992). This sub-TAC is re-negotiated every year and is generally fixed at approximately 11-14% of the total TAC (EU and Norway; see Council regulation (EU) No 57/2011).

The working group responsible therefore needs to provide advice regarding the current component diversity of the stock. The SCAI indices are currently the main source of information in this regard, and therefore should be presented as part of the advice for this stock. Other indicators, where available, should also be presented alongside the SCAI.

Other Management measures

There are other management tools currently used for the North Sea herring fishery:

i. Minimum landing size for herring for human consumption fisheries of 20cm in the North Sea (Council regulation (EC) No 850/98).

ii. Closed areas for both herring and/or sprat fisheries to protect either spawning or juveniles (Council regulation (EC) No 850/98). These closed areas are relatively small and localised, and usually seasonal (Figure H.3.1).

iii. The industrial fishery is not only limited by the bycatch ceiling which is set every year based on the EU/Norway management plan (Council regulation (EU) No 57/2011) but also by a by-catch percentage for each haul. This was initially set such that 10% of the catch of the sprat can be herring (Council regulation (EC) No 850/98) but in recent years this by-catch proportion has been increased to 20% of the catch as the total mixed catch has declined.

iv. In 2009, the EU and Norway agreed a ban on high grading in the North Sea and eastern English Channel (Council Regulation (EC) No 43/2009). This prevented the discarding of fish of a size that could be landed for which there was still quota available.

Within and between the countries in the fishery, the TAC is greatly swapped, with ITQs (or de facto ITQs) in most countries and some countries selling much of their annual quota (e.g. Belgium). As the fishery catches against an area TAC and the advice is for a stock TAC, the landings against the TAC do not completely reflect the exploitation on the stock, or the true catches from the stock. Fisheries scientists reallocate catch from areas IV and IIIa, based on sampling, to determine the catches from the stock. In addition, there are two boundary areas where misreporting has been a problem: ICES areas IV/IIIa and IVa/VIa. There are different regulatory solutions to each. Area-misreporting from catches taken in ICES area IV to IIIa is allowed through EU/Norway agreements, i.e. herring caught in IV can be written off against IIIa quota. In contrast, in the northern North Sea there are specific licensing regulations to prevent area misreporting, that control the landing of herring catches from and at the border of ICES areas IVa and Via.

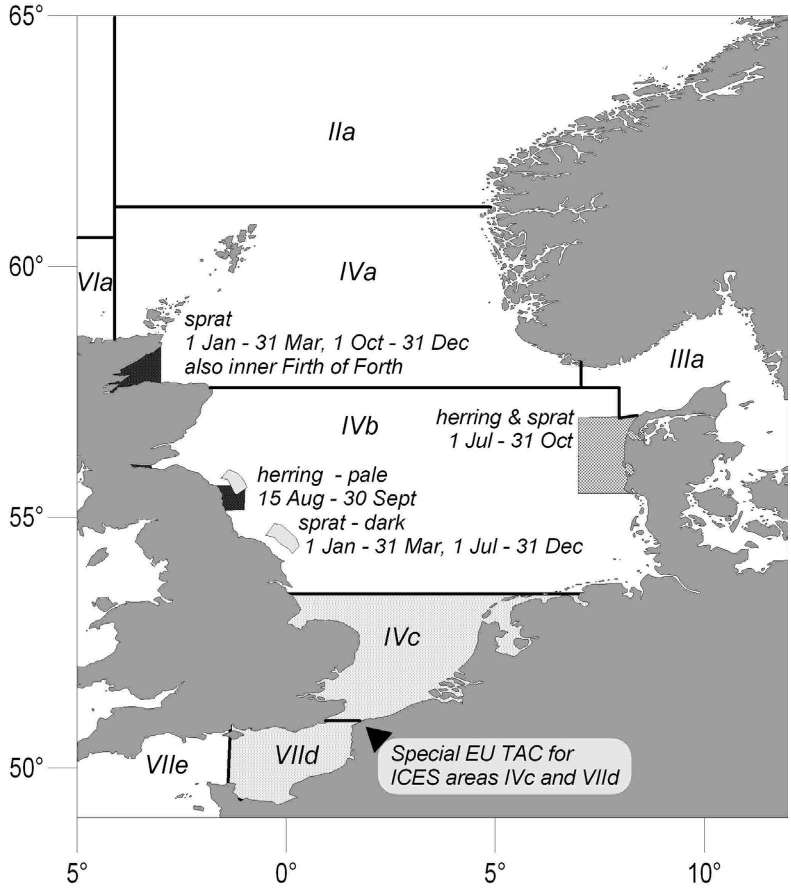


Figure H.3.1. ICES areas and areas closed to fishing on herring and sprat under EU legislation. Black areas denote three small sprat closures to protect juvenile herring. Pale areas denote two closures on the herring fisheries to protect spawning herring around the Banks spawning ground. The shaded area to the west of Denmark is closed to the juvenile herring and the sprat fishery (although there is no targeted juvenile herring fishery).

H.5 Terminology

The WG uses “rings” rather than “age” or “winter rings” throughout the report to denominate the age of herring, with the intention to avoid confusion. It should be observed that, for autumn spawning stocks, there is a difference of one year between “age” and “rings”. HAWG in 1992 (ICES, 1992) stated that:

“The convention of defining herring age rings instead of years was introduced in various ICES Working Groups around 1970. The main argument to do so was the uncertainty about the racial identity of the herring in some areas. A herring with one winter ring is classified as 2-years-old if it is an autumn spawner, and one-year-old if it is a spring spawner. Recording the age of the herring in rings instead of in years allowed scientists to postpone the decision on year of birth until a later date when they might have obtained more information on the racial identity of the herring.

The use of winter rings in ICES Working Groups has introduced a certain amount of confusion and errors. In specifying the age of the herring, people always have to state explicitly whether they are talking about rings or years, and whether the herring are autumn- or spring spawners. These details tend to get lost in Working Groups reports, which can make these reports confusing for outsiders, and even for herring experts themselves. As the age of all other fish species (and of herring in other parts of the world) is expressed in years, one could question the justification of treating west-European herring in a special way. Especially with the present trend towards multispecies assessment and integration of ICES Working Groups, there might be a case for a uniform system of age definition throughout all ICES Working Groups.

However, the change from rings to years would create a number of practical problems. Data files in national laboratories and at ICES would have to be adapted, which would involve extra costs and manpower. People that had not been aware of the change might be confused when comparing new data with data from old working group reports. Finally, in some areas (notably Division IIIa), the distinction between spring- and autumn spawners is still hard to make, and scientists preferred to continue using rings instead of years.

The Working Group discussed at length the various consequences of a change from rings to years. The majority of the Group felt that the advantages of such a change did not outweigh the disadvantages, and it was decided to stick to the present system for the time being."

The text table below gives an example for the correlation between age, rings and year class for the different spawning types in late 2002:

Year class (autumn spawners)	2001/2002	2000/2001	1999/2000	1998/1999
Rings	0	1	2	3
Age (autumn spawners)	1	2	3	4
Year class (spring spawners)	2002	2001	2000	1999
Rings	0	1	2	3
Age (spring spawners)	0	1	2	3

I. References

Ackefors, H. 1977. Production of Fish and Other Animals in the Sea. Ambio, 6: 192-200.

Anon. 1993. Working Document to Second ICES special meeting on *Ichthyophonus* in herring held at the SOAFD Marine Laboratory, Aberdeen, Scotland 21-22 January 1993.

Arellano, R.V., Hamerlynck, O., Vincx, M., Mees, J., Hostens, K., and Gijselinck, W. 1995. Changes in the ratio of the sulcus acusticus area to the sagitta area of *Pomatoschistus minutus* and *P. lozanoi* (Pisces, Gobiidae). Mar. Biol., 122: 355-360.

Atkinson, D. 1994. Temperature and Organism Size - a Biological Law for Ectotherms. Adv. Ecol. Res., 25: 1-58.

Bainbridge, V. and Forsyth, D.C.T. 1972. An ecological survey of a Scottish herring fishery. Part V: The plankton of the northwestern North Sea in relation to the physical environment and the distribution of the herring. Bull. Mar. Ecol., 8: 21-52.

Bekkevold, D., André, C. Dahlgren, T.G. Clausen, L.A.W., Torstensen, E., Mosegaard, H., Carvalho, G.R., Christensen, T.B., Norlinder, E., and Ruzzante, D.E. 2005. Environmental correlates of population differentiation in Atlantic herring. Evolution, 59: 2656–2668.

Berrigan, D. and Charnov, E.L. 1994. Reaction Norms for Age and Size at Maturity in Response to Temperature - a Puzzle for Life Historians. Oikos, 70: 474-478.

Bierman, S.M., Dickey-Collas, M., Damme, C.J.C. van, Overzee, van H.J., Pennock-Vos, M.G., Tribuhl, S.V., and Clausen, L.A.W. 2010. Between-year variability in the mixing of North Sea herring spawning components leads to pronounced variation in the composition of the catch. ICES J.mar. Sci., 67: 885-896

Bird J.L., Eppler D.T., and Checkley D.M. 1986. Comparison of herring otoliths using Fourier series shape analysis. Can. J. Fish. Aquat. Sci., 43: 1228-1234.

Bjerkan P. 1917. Age, maturity and quality of North Sea herrings during the years 1910-13. Rep. Norw. Fish. Mar. Invest. III no 1.

Borges L, van Keeken O.A. van Helmond, A.T.M., Couperus, B., Dickey-Collas, M. 2008. What do pelagic freezer-trawlers discard? ICES J. mar Sci., 65: 605–611.

Brunel, T. 2012. Variability in growth and maturation in North Sea herring and implication of short term predictions. WD to WKPELA 2012.

Brunel, T. and Dickey-Collas, M. 2010. Effects of temperature and population density on von Bertalanffy growth parameters in Atlantic herring : a macro-ecological analysis. Mar. Ecol. Prog. Ser. 405: 15-28.

Burd, A.C. 1978. Long term changes in North Sea herring stocks. Rapp. P.-v. Réun. Cons. Int. Explor. Mer, 172: 137-153.

Burd, A.C. 1984. Density dependent growth in North Sea herring. ICES CM 1984/H:4

Burd, A.C. 1985. Recent changes in the central and southern North Sea herring stocks. Can. J. Fish. Aquatic Sci., 42: 192-206.

Burke, N., Brophy, D., and King, P. A. 2008. Otolith shape analysis: its application for discriminating between stocks of Irish Sea and Celtic Sea herring (*Clupea harengus*) in the Irish Sea. ICES J. mar. Sci., 65: 1670–1675.

Cardinale, M., Doering-Arjes, P., Kastowsky, M., and Mosegaard, H. 2004. Effects of sex, stock, and environment on the shape of known-age Atlantic cod (*Gadus morhua*) otoliths Can. J. Fish. Aquat. Sci. 61: 158–167

Clausen, L.A.W., Bekkevold, D., Hatfield, E.M.C., and Mosegaard, H. 2007. Application and validation of otolith microstructure as stock identifier in mixed Atlantic herring (*Clupea harengus*) stocks in the North Sea and western Baltic. ICES J. mar. Sci., 64:1–9.

Corten, A. 1999. The reappearance of spawning Atlantic herring (*Clupea harengus*) on Aberdeen Bank (North Sea) in 1983 and its relationship to environmental conditions. Can. J. Fish. Aquat. Sci., 56: 2051–2061.

Corten, A. 2002. The role of conservatism in herring migrations. Reviews in Fish Biology and Fisheries, 11: 339-361.

Coull, J.R. 1991. The North Sea herring fishery in the twentieth century. In The development of integrated sea use management, pp 122-138. Ed by Smith, H.D. and Vallega, A. Routledge, New York.

Couperus, A.S. 1997. Interactions Between Dutch Midwater Trawl and Atlantic Whitesided Dolphins (*Lagenorhynchus acutus*) Southwest of Ireland. Northw. Atl. Fish. Sci., 22: 209–218.

Couperus, A.S. 2009. Annual Report of the Netherlands to the European Commission on the implementation of Council Regulation 812/2004 on cetacean bycatch Results of fishery observations collected during 2008. Centre for Visserij Onderzoek report: CVO 09.006.

Cushing D. H. 1980. The decline of the herring stocks and the gadoid outburst. J. Cons. int. Explor. Mer, 39: 70-81.

Cushing, D.H. 1992. A short history of the Downs stock of herring. ICES J. mar. Sci., 49: 437-443.

Cushing, D.H. and Bridger, J.P. 1966. The stock of herring in the North Sea and changes due to the fishing. Fishery Invest. Lond., Ser.II, XXV, No.1,123pp.

Damme, C.J.G. van, Dickey-Collas, M., Rijnsdorp, A.D., and Kjesbu, O.S. 2009. Fecundity, atresia and spawning strategies in Atlantic herring. C. J. Fish. Aquat. Sci., 66: 2130-2141.

Dickey-Collas, M., Bolle, L.J., van Beek, J.K.L., and Erftemeijer, P.L. A. 2009. Variability in transport of fish eggs and larvae. II. The effects of hydrodynamics on the transport of Downs herring larvae. Mar. Ecol. Prog. Ser., 390: 183-194.

Dickey-Collas, M., Nash, R.D.M., Brunel, T., Damme, C.J.G. van, Marshall, C.T., Payne, M.R., Corten, A., Geffen, A.J., Peck, M.A., Hatfield, E.M.C, Hintzen, N.T., Enberg, K., Kell, L.T., and Simmonds, E.J. 2010. Lessons learned from stock collapse and recovery of North Sea herring: a review. - ICES J. mar. Sci., 67: 1875-1886.

EC REGULATION (EC) No 199/2008 of 25 February 2008 concerning the establishment of a Community framework for the collection, management and use of data in the fisheries sector and support for scientific advice regarding the Common Fisheries Policy

EC REGULATION (EC) No 665/2008 of 14 July 2008 laying down detailed rules for the application of Council Regulation (EC) No 199/2008 concerning the establishment of a Community framework for the collection, management and use of data in the fisheries sector and support for scientific advice regarding the Common Fisheries Policy

EC DECISION of 6 November 2008 adopting a multiannual Community programme pursuant to Council Regulation (EC) No 199/2008 establishing a Community framework for the collection, management and use of data in the fisheries sector and support for scientific advice regarding the common fisheries policy (2008/949/EC)

EC REGULATION (EC) No 43/2009 of 16 January 2009 fixing for 2009 the fishing opportunities and associated conditions for certain fish stocks and groups of fish stocks, applicable in Community waters and, for Community vessels, in waters where catch limitations are required

Engelhard, G.H. and Heino, M. 2004. Maturity changes in Norwegian spring-spawning herring *Clupea harengus*: compensatory or evolutionary responses? Mar. Ecol. Prog. Ser. 272: 245-256.

Fässler, S.M., Payne, M.R., Brunel, T, and Dickey-Collas, M. 2011. Does larval mortality influence population dynamics? An analysis of North Sea herring (*Clupea harengus*) time series Fish. Oceanogr., 20: 530–543.

Fauchald, P. 2010. Predator–prey reversal: A possible mechanism for ecosystem hysteresis in the North Sea? Ecology, 91: 2191–2197.

Fryer R.J., 2002. TSA: is it the way? Appendix D in report of Working Group on Methods on Fish Stock Assessment. ICES CM 2002/D:01.

Gaggiotti, O.E., Bekkevold, D., Jørgensen, H.B., Foll, M., Carvalho, G.R., Andre, C, and Ruzzante, D.E. 2009. Disentangling the effects of evolutionary, demographic, and environmental factors influencing genetic structure of natural populations: Atlantic herring as a case study. Evolution. 63:2939-51.

Gago, F.J. 1993. Morphology of the saccular otoliths of 6 species of lanternfishes of the genus Symbolophorus (Pisces myctophidae). Bull. Mar. Sci., 52: 949-960.

Geffen, A.J. 2009. Advances in herring biology: from simple to complex, coping with plasticity and adaptability. ICES J. Mar. Sci., 66: 1688–1695.

Gröger, J., and Schnack, D. 1999. History and status quo of the international herring larvae survey (IHLS) in the North Sea. Information für die Fischwirtschaft aus der Fischereiforschung, 46: 29–33.

Gröger, J., Schnack, D., and Rohlf, N. 2000. Optimisation of survey design and calculation procedure for the international herring larvae survey in the North Sea. Archiv für Fischerei und Meeresforschung, 49: 103–116.

Gudmundsson, G. (1987). Time series models of fishing mortality rates. ICES C.M. D:6.

Gudmundsson, G. (1994). Time series analysis of catch-at-age observations. Appl.~Statist. 43 117-126.

Hardy, A.C. 1924. The herring in relation to its animate environment. Part 1. The food and feeding habits of herring with specific reference to the east coast of England. Fishery Invest., Lond., Ser. II, 7(3), 1-53

Heath, M.R. 1989. Transport of larval herring (*Clupea harengus* L.) by the Scottish coastal current. Rapp. P.-v Cons. Reun. Int. Explor. Mar, 191: 85-91.

Heath, M.R. 1993. An evaluation and review of the ICES herring larval surveys in the North Sea and adjacent waters. Bull. Mar. Sci., 53: 795-817.

Heath, M., Scott, B. and Bryant, A.D. 1997. Modelling the growth of herring from four different stocks in the North Sea. J. Sea Res., 38: 413-436.

Heincke, F. 1898. Naturgeschichte des Herings. Abhandl. Deutschen Seefisch Ver II

Helmond van A.T.M. and Overzee, van H.M.J. 2010a. Estimates of discarded herring by Dutch flagged vessels 2003-2009 and other PFA vessels in 2009. Working Document to the Herring assessment working Group. 4pp.

Helmond van A.T.M. and Overzee, van H.M.J. 2010b. Can pelagic freezer trawlers reduce discarding?. Working Document to the Herring assessment working Group. 4pp.

Heessen, H.J.L., Dalskov, J. and Cook, R.M. 1997. The International Bottom Trawl Survey in the North Sea, the Skagerrak and Kattegat. ICES CM 1997/Y:31. 23pp

Hufnagl, M., and Peck, M. A. 2011. Physiological individual-based modelling of larval Atlantic herring (*Clupea harengus*) foraging and growth: insights on climate-driven life-history scheduling. ICES Journal of Marine Science, 68: 1170–1188.

Huse, G., Salthaug, A., and Skogen, M.D. 2008. Indications of a negative impact of herring on recruitment of Norway pout. ICES J. mar. Sci., 65: 906–911.

ICES. 1977. Assessment of herring stocks south of 62°N, 1973 – 1975. ICES Cooperative Report Series No. 60, 117 pp.

ICES. 1982. Report of the Herring Assessment Working Group South of 62°N (HAWG). ICES CM 1982/Assess:17. 127 pp.

ICES. 1987. Report of the Herring Assessment Working Group for the Area South of 62°N Copenhagen, 24 March -- 3 April 1987 CM1987/Assess:19: 212pp

ICES 1991. Report of the Herring Assessment Working Group for the Area South of 62°N. ICES CM 1991/Assess:15.

ICES. 1992. Report of the Herring Assessment Working Group for the Area South of 62°N. ICES CM 1992/Assess:11

ICES 1996. Report of the Herring Assessment Working Group for the Area South of 62°N (HAWG). ICES CM 1996/Assess:10

ICES 1998. Study Group on Precautionary Approach to Fisheries Management. ICES CM 1998/ACFM:10.

ICES 2000. Report of the Herring Assessment Working Group for the Area South of 62°N (HAWG). ICES CM 2000 / ACFM:10

ICES 2001a. Herring Assessment WG for the Area South of 62° N. CM 2001/ACFM:12.

ICES 2001b. The Precision of International Market Sampling for North Sea Herring and its Influence on Assessment. ICES CM 2001/P:21. 22 pp

ICES 2002. ICES Study Group on the Precautionary Approach, ICES CM 2002d/ACFM:10.

ICES 2004. Report of the Herring Assessment Working Group for the Area South of 62ºN (HAWG). ICES CM 2004/ACFM:18. 548pp.

ICES 2006. Report of the Study Group on the Recruitment Variability in North Sea Planktivorous fish (SGRECVAP). ICES 2006 CM /LRC:03

ICES 2007. Workshop on Limit and Target Reference Points. (WKREF). ICES CM 2007/ACFM:05

ICES 2008. Report of the Workshop on Herring Management Plans (WKHMP). ICES CM 2008/ACOM:27.

ICES 2011a. Report of the Working Group on Multispecies Assessment Methods (WGSAM). ICES CM 2011/SSGSUE:10

ICES 2011b. Report of Working Group on Bycatch of Protected Species Fishing Behaviour. ICES CM 2011/ACOM:26. 75pp

ICES 2012. Report of the Working Group on International Pelagic Acoustic Surveys (WGIPS). ICES 2012 CM / SSGESST:21

Iles, T. D. and Sinclair, M. 1982. Atlantic herring: stock discreteness and abundance. Science, 215: 627-633.

Kell, L. T., Mosqueira, I., Grosjean, P., Fromentin, J-M., Garcia, D., Hillary, R., Jardim, E., Mardle, S., Pastoors, M. A., Poos, J. J., Scott, F., and Scott, R. D. 2007. FLR: an open-source framework for the evaluation and development of management strategies. – ICES Journal of Marine Science, 64: 640–646.

Kell, L.T., Nash, R.D.M., Dickey-Collas, M., Pilling, G.M., Hintzen, N.H., and Roel, B.A. 2009. Lumpers or splitters? - evaluating recovery and management plans for metapopulations of herring. ICES J. Mar. Sci., 66: 1776-1783.

Kuklik, I., and Skóra, K.E. 2003. By-catch as a potential threat for harbour porpoise (*Phocoena phocoena* L.) in the Polish Baltic Waters. NAMMCO Scientific Publications.

Last, J.M. 1989. The food of herring *Clupea harengus*, in the North Sea, 1983-1986. J Fish Biol, 34: 489-501.

Lombarte, A., and Lleonart, J. 1993. Otolith size changes related with body growth, habitat depth and temperature. Envir. Biol. Fishes 37: 297-306.

Mackinson S. 2001. Representing trophic interactions in the North Sea in the 1880s, using the Ecopath mass-balance approach. In Fisheries impacts on North Atlantic ecosystems: models and analyses, pp. 35-98. Ed. by S. Guenette, V. Christensen, and D. Pauly. Fisheries Centre Research Reports, 9 (4).

Mackinson, S., and Daskalov, G. 2007. An ecosystem model of the North Sea to support an ecosystem approach to fisheries management: description and parameterisation. Science Series, Technical Reports, Cefas Lowestoft, 142: 195pp.

Mariani, S. Hutchinson, W.F. Hatfield, E.M.C., Ruzzante D.E., Simmonds, J., Dahlgren, T.G., Andre, C.,Brigham, B., Torstensen, E., and Carvalho, G.R. 2005. North Sea herring population structure revealed by microsatellite analysis. Mar Ecol Prog Ser 303: 245–257, 2005

McQuinn, I.H. 1997. Metapopulations and the Atlantic herring. Rev. Fish Biol. Fish., 7: 297-329.

Melvin, G.D. and Stephenson, R.L. 2007. The dynamics of a recovering fish stock: Georges Bank herring. ICES J. mar. Sci. 64: 69-82.

Messieh S.N. 1972. Use of otoliths in identifying herring stocks in southern gulf of St. Lawrence and adjacent waters. J. Fish. Res. Board. Can., 29: 1113-1118.

Morizur, Y., Berrow, S.D., Tregenza, N.J.C., Couperus, A.S., and Pouvreau, S. 1999. Incidental catches of marine-mammals in pelagic trawl fisheries of the Northeast Atlantic. Fish. Res., 41: 297–307.

Mosegaard, H. and Madsen, K. P. 1996. Discrimination of mixed herring stocks in the North Sea using vertebral counts and otolith microstructure. ICES C.M. 1996/H:17: 8 pp.

Napier, I.R., Newton, A.W. and Toreson, R. 1999. Investigation of the Extent and Nature of Discarding from Herring and Mackerel Fisheries in ICES Sub-Areas IVa and VIa. Final Report. EU Study Contract Report 96/082. North Atlantic Fisheries College, Shetland Islands, UK. June 1999.

Napier, I.R., Robb, A. and Holst, J. 2002. Investigation of Pelagic Discarding. Final Report. EU Study Contract Report 99/071. North Atlantic Fisheries College and the FRS Marine Laboratory. August 2002.

Nash, R.D.M. and Dickey-Collas, M. 2005. The influence of life history dynamics and environment on the determination of year class strength in North Sea herring (*Clupea harengus* L.). Fish Oceanogr., 14: 279-291.

Nash, R.D.M., Dickey-Collas, M. & Milligan, S.P. 1998. Descriptions of the Gulf VII/Pro-Net and MAFF/Guildline unencased highspeed plankton samplers. J. Plankton Res., 20: 1915-1926.

Nash, R.D.M., Dickey-Collas, M., and Kell, L.T. 2009. Stock and recruitment in North Sea herring (*Clupea harengus*); compensation and depensation in the population dynamics. Fish. Res., 95: 88-97.

Nielsen, A. *et al*. 2012. State-space models as an alternative to overparameterised stock assessment models. In preparation.

Northridge, S.P. 2003. Seal by-catch in fishing gear. SCOS Briefing Paper 03/13. NERC Sea Mammal Research Unit, University of St. Andrews, UK pp1

Oeberst, R., Klenz, B., Gröhsler, T., Dickey-Collas, M., Nash, R.D.M., and Zimmermann, C. 2009. When is year-class strength determined in western Baltic herring? ICES J. mar. Sci., 66: 1667–1672.

Patterson, K.R. 1998: A programme for calculating total international catch-at-age and weight-at-age. WD to HAWG 1998.

Patterson, K.R. and Beveridge, D.S. 1995. Report of the herring larvae surveys in the North Sea and adjacent waters in 1994/1995. ICES CM 1995/H:21

Payne, M.R. 2010. Mind the gaps: a model robust to missing observations gives insight into the dynamics of the North Sea herring spawning components. ICES J. mar. Sci., 67: 1939-1947.

Payne, M.R., Hatfield, E.M.C., Dickey-Collas, M., Falkenhaug, T., Gallego, A., Gröger, J., Licandro, P., Llope, M., Munk, P., Röckmann, C., Schmidt, J.O., and Nash, R.D.M. 2009. Recruitment in a changing environment: the 2000s North Sea herring recruitment failure. ICES J, mar, Sci., 66: 272-277.

Pierce, G.J., Dyson, J. Kelly, E., Eggleton, J., Whomersley, P., Young, I.A.G., Santos, M.B, Wang, J., and Spencer, N.J. 2002. Results of a short study on by-catches and discards in pelagic fisheries in Scotland (UK). Aquat. Living. Resour. 15: 327-334.

Poulsen, B. 2006. Historical exploitation of North Sea herring stocks – an environmental history of the Dutch herring fisheries, c. 1600–1860. PhD dissertation, Centre for Maritime and Regional Studies, Department of History and Civilization, University of Southern Denmark.

Reiss, H., Hoarau, G., Dickey-Collas, M., and Wolff, W.G. 2009. Genetic population structure of marine fish: mismatch between biological and fisheries management units. Fish Fish., 10: 1467-2979.

Reid, P. C., Holliday, N. P. and Smyth, T. J. 2001. Pulses in the eastern margin current and warmer water off the north west European shelf linked to North Sea ecosystem changes. Mar. Ecol. Progr. Ser. 215, 283–287

Richardson, D.E, Hare, J.A., Fogarty, M.J., Link, J.S. 2011. Role of egg predation by haddock in the decline of an Atlantic herring population. PNAS 108: 13606-13611

Röckmann, C. Dickey-Collas, M., Payne, M.R. and van Hal, R. 2011. Realized habitats of early-stage North Sea herring: looking for signals of environmental change ICES J. mar. Sci., 68: 537–546.

Ruzzante, D.E., Mariani, S., Bekkevold, D., André, C. Mosegaard, H., Clausen, L.A.W, Dahlgren, T.G., Hutchinson, W.F., Hatfield, E.M.C., Torsensen, E., Brigham, J., Simmonds, E.J., Laikre, L., Larsson, L.C., Stet, R.J.M., Ryman, N. and Carvalho, G.R. 2006. Biocomplexity in a highly migratory pelagic marine fish, Atlantic herring. Proc. R. Soc. Lond. Ser. B, 273: 1459–1464.

Savage, R.E. 1937. The food of the North Sea herring in 1930-1934. Fishery Invest., Lond., Ser. II, 15(5), 1-60

Saville, A., Bailey, R.S. *et al*. 1984. Variations in growth of herring in the Shetland area and to the west of Scotland in relation to population abundance. ICES CM 1984/H:61.

Schmidt, J.O., Damme, C.J.G. van, Röckmann, C., and Dickey-Collas, M. 2009. Recolonisation of spawning grounds in a recovering fish stock: recent changes in North Sea herring. Sci. Mar., 73S1: 153-157.

SCOS 2002. Scientific advice on matter relating to the management of seal populations. Natural Environment Research Council, UK.

Secor, D.H., Kerr, L.A., and Cadrin, S.X. 2009. Connectivity effects on productivity, stability, and persistence in a herring metapopulation model. ICES J. mar. Sci., 66: 1726–1732.

Segers, F.H.I.D., Dickey-Collas, M., and Rijnsdorp, A.D. 2007. Prey selection by North Sea herring (*Clupea harengus* L.), with special regard to fish eggs. ICES J. mar. Sci., 64: 60-68.

Shin, Y. J. and Rochet, M. J. 1998. A model for the phenotypic plasticity of North Sea herring growth in relation to trophic conditions. Aquat. Living Resour. 11: 315-324.

Simmonds, E.J. 2007. Comparison of two periods of North Sea herring stock management: success, failure, and monetary value. ICES J.mar. Sci.,, 64: 686–692.

Simmonds, E.J. 2009. Evaluation of the quality of the North Sea herring assessment. ICES J.mar. Sci., 66: 1814-1822.

Speirs, D.C., Guirey E.J., Gurney W.S.C., and Heath, M.R. 2010. A length-structured partial ecosystem model for cod in the North Sea. Fish. Res., 106: 474–494.

Thrush, S.F., Hewitt, J.E., Dayton, P.K. Giovanni, C., Lohrer, A.M., Norkko,A., Norkko, J. and Chiantore, M. 2009. Forecasting the limits of resilience: integrating empirical research with theory. Proc. R. Soc. B 276, 3209-3217.

Van Helmond, A.T.M. and van Overzee, H.M.J. 2011. Estimates of discarded herring by Dutch flagged vessels 2003-2010. Working Document to ICES HAWG 2011.

Annex 4-Stock Annex: Herring WBSS

Stock	Western Baltic Spring spawning herring (WBSS)
Working Group	Herring Assessment Working Group for the Area South of 62ºN
Date	19.02.2013
Authors	L.Worsøe Clausen, V. Bartolino, H. Mosegaard, T. Gröhsler, P. Polte

A. General

A.1. Stock definition and biology

Stocks

Most herring populations are migratory and often congregate on common feeding and wintering grounds where aggregations may consist of mixtures of individuals from several populations. Thus herring spawning components uphold significant levels of reproductive isolation, possibly affected by selective differences among spawning and/or larval habitats (Limborg *et al.*, 2012). Genetic stratification is likely maintained by mechanisms of natal homing, larval retention and natural selection (Gaggiotti *et al.*, 2009). In the Western Baltic tagging and genetic studies suggest that three to four more or less well-described stock components, that either spawn and use the area as nursery or migrate through it: Rügen herring (abbreviated RHS), local (autumn) spawning Fehmarn herring, herring from the Kattegat and Inner Danish waters, and potentially other Western Baltic herring stocks, each of which have different contributions to the fishery and ecosystem. The RHS are assumed to make up the majority of the western Baltic Sea herring in the area (ICES, 2010) and the stock spawn around the Geifswalder Bodden, mainly in March–May, but with some autumn spawning also (e.g. Nielsen *et al.*, 2001; Bekkevold *et al.*, 2007).The other herring populations occurring in the area are found in many of the bays in the area, where at least Kiel, Møn, Schlei, Flensburg, Fåborg, and Fehmarn have been reported as spawning sites for these apparently less abundant herring stocks. Thus the WBSS stock has a complex mixture of different herring populations predominantly spawning during spring, but also local spring-, autumn- and winter spawning stock components. The exact proportions of these stocks are hitherto unknown; however, they are observed in the area to some degree and could potentially be important parts of the total amount of herring available for the fishery.

Given a complex stage-dependent migration pattern, the different components mix during part of the year (Figure 1) and most likely experience different fishing pressures but are assessed and managed as one unit.

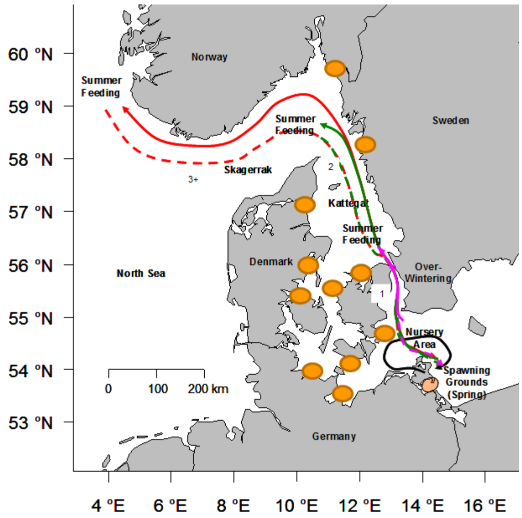


Figure 1. General migration patterns of the WBSS; the numbers indicates the age-dependent migration pattern; the yellow circles indicate local spawning populations (redrawn from M. Payne).

The majority of 2+ ringers migrate out of the area during the 2nd quarter of the year, through the Sound and Belt Sea and propagate into the western part of the Skagerrak and the eastern North Sea to feed (Payne *et al.*, 2009). The extent of the migration is age dependent, where the younger individuals migrates up into Kattegat and Skagerrak and the older fish migrate all the way out into the eastern North Sea. Towards the end of summer the herring aggregate in the eastern Skagerrak and Kattegat before they migrate to the main wintering areas in the southern part of the Kattegat, the Sound and the Western Baltic (ICES, 1991; Nielsen *et al.*, 2001). The extent of the migration is season dependent and variable over time (Clausen *et al.*, 2006).

These distribution patterns had yet to be fully quantified, however, they have been examined in a recent study of the temporal and spatial coverage of all available data in terms of current biological understanding of stock components, their distribution in the Western Baltic and IIIa using combined information from fisheries catches and International surveys in the Western Baltic Sea (including the Sound) and Kattegat, Skagerrak over the past decade. The major migration routes indicated by the temporal-spatial distribution of the herring stock components over time shows for the largest herring stock (the Rügen herring) an outmigration from the spawning sites during April–June through all Belts. This migration is not performed in large dense schools; these form during the summer feeding in Skagerrak and Kattegat. The school formation is retained during the overwintering, which mainly occurs in the Southern Kattegat and the Sound.

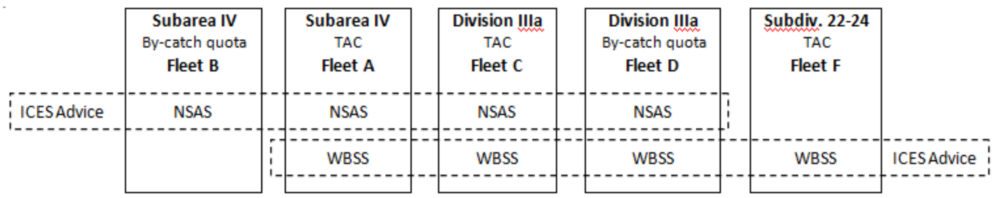
The fishery on WBSS takes place in the eastern North Sea, Division IIIa and the Western Baltic. In these areas the stock complex mixes with another large herring stock complex; the North Sea Autumn Spawners (NSAS). All spring-spawning herring in the eastern part of the North Sea (IVa&b east), Skagerrak (Subdivision 20), Kattegat (Subdivision 21) and the Western Baltic (Subdivisions 22, 23 and 24) are treated as one stock despite the local stock diversity. Given the mixing with the NSAS, the ICES Herring assessment Working Group (HAWG) make use of biological samples routinely collected to estimate the stock composition of the annual catches. The analysis of stock composition in commercial samples for stock assessment and management purposes of the herring populations in the North Sea and adjacent areas has been routine since the beginning of the 1990s. Recent development of the stock identification methodology has opened for a monitoring of the local stock components beyond the general spawning components of spring-autumn-and winter spawners; however this is not part of the routine treatment of herring catches yet.

The current definition of the Western Baltic herring stock of spring, autumn and winter spawners as a single management unit appears to have been operational in the past, despite potential changes in the relative strengths of the different spawning components and in their relative importance during collapse and recovery.

Methods for stock separation

Background

ICES advises on catch options by fleet for the entire distribution of WBSS and NSAS herring stocks separately. However, the fisheries are managed by areas covering the geographical distribution of the stocks (see the following text diagram).



The method for separation of the herring stock components in the catches has developed over the past decade. Prior to 1996, the splitting key between NSAS and WBSS herring used by ICES was calculated from a sample-based mean vertebral count. This uses a cut off algorithm for calculating the proportion of western Baltic spring-spawning herring (WBSS) in a sample as:

MIN(1,MAX(0,(VSsample-55.8)/(56.5–55.8)))

where VSsample is the sample mean vertebrae count and assuming a population mean VS of 55.8 for WBSS and 56.5 for NSAS. This method is still being used to split samples of Norwegian catches from the transfer area in IVa East.

In the period from 1996 to 2001 splitting keys were constructed using information from a combination of vertebrae count and otolith microstructure (OM) methods (ICES, 2001). From 2001 and onwards, the splitting keys have been constructed solely using the otolith microstructure method which uses visual inspection of season-specific daily increment patterns from the larval origin of the otolith, with the exception of the splitting key made for the mixture area in Subdivision IVa East, where vertebrae counts currently is the only method used to split the mixed-stock (Mosegaard and Madsen, 1996; ICES, 2004; Clausen *et al.*, 2007).

Otolith shape analysis has been used to discriminate between populations for a variety of species and for herring this approach has had increasing success with development of imaging techniques and statistical methods. Both temporal and geographical separation of populations gives rise to variation in the shape of otoliths (Messieh, 1972; Lombarte and Lleonart, 1993; Arellano *et al.*, 1995). These variations may suggest differences in the environmental conditions of the dominant habitats of populations within a species. However both genetic and environmental influences have been reported as important in determining otolith shape (Cardinale *et al.*, 2004). Using Fourier Series Shape Analysis on otoliths from Alaskan and Northwest Atlantic herring, Bird *et al.* (1986) showed that otolith shape reflects population differences as well as differences between year classes of the same population. Sagittal otoliths have certain morphological features that are laid down early in the ontogeny of the fish (Gago, 1993), and measurements of internal otolith shape in adult herring has proven a powerful tool for stock discrimination (Burke *et al*., 2008).

Image analysis software (MATLAB) has been developed to automatically extract otolith contour curves and calculate 60x4 Elliptic Fourier Coefficients from one or two herring sagittal otoliths per image in batches with more than 1000 images.

From 2009 and on otolith shape analysis has been used as a supplementary method to increase sample size for estimating stock proportions of NSAS and WBSS in the mixing areas of Division IIIa. For each assessment year individual population identity has been established by OM visual inspection and used as a baseline for assignment of shape characteristics to the involved stock components. A baseline of about 800–1200 otoliths with known hatch type has then been used as calibration in an age-structured discriminant analysis where additionally 3000–4000 otolith shapes have been assigned to one of the two hatch types using a combination of shape Elliptic Fourier Coefficients, otolith metrics, fish metrics, length, weight and maturity as well as longitude–latitude and seasonal parameters.

Validation

The purpose of classifying individual spawning type is to estimate proportions of the two major stock components by age in catches and surveys from the different areas and seasons. Combining OM with otolith shape and fish meristic characters in a discriminant analysis approach will increase precision of the estimated stock proportions if errors in estimated proportions are low. Validation of the shape and meristic based methodology may be performed using samples of known spawning type (from OM analysis) and classifying subsets by shape/meristics to test for bias and variation in estimated proportions.

OM and otolith shape data from the 2010 HAWG were used as a typical example of the procedure for estimating proportions of hatch type representing North Sea autumn and winter spawners and western Baltic spring spawners in the samples. The data were disaggregated into age groups 0, 1, 2 and 3+ and individuals of known autumn/winter or spring hatched types were used to assign the corresponding shape parameters and fish metrics from the same individuals by cross-validated nonparametric nearest neighbour discriminant analysis.

The accuracy of individual assignment of 1279 otoliths into known hatch type varied somewhat among hatch types and ages (2%–100%) but exhibited an overall error rate of 15.7% (see Table 4.1.1). However, more importantly, the average absolute error of the proportions of WBSS was only 2%, indicating a reasonably robust method for upscaling the baseline to the larger production sample.

		assigned to type		known type	estimated	deviasion		% error in	
Age group	known type	WBSS	NSAS	number	number	Individ. assignm.	prop.	Individ. assignm.	prop.
0	WBSS	34	13	47	44	13	3	27.7%	-6.4%
	NSAS	10	145	155	158	10	3	8.2%	1.9%
1	WBSS	188	72	260	254	72	6	27.7%	-2.3%
	NSAS	66	204	270	276	66	6	26.1%	2.2%
2	WBSS	288	14	302	305	14	3	4.6%	1.0%
	NSAS	17	3	20	17	17	3	82.4%	-15.0%
3+	WBSS	216	4	220	221	4	1	1.8%	0.5%
	NSAS	5	0	5	4	5	1	100.0%	-20.0%
		824	**455**	**1279**	**1279**	**201**	**26**	**15.7%**	**2.0%**

Table 4.1.1. Stock assignment data from 2009 commercial samples of herring in Division IIIa.

A.2. Fishery

Fleet definitions

The fleet definitions used since 1998 for the fishery in Division IIIa are:

- **Fleet C**: directed fishery for herring in which trawlers (with 32 mm minimum mesh size) and purse seiners participate.
- **Fleet D**: All fisheries in which trawlers (with mesh sizes less than 32 mm) and small purse seiners, fishing for sprat along the Swedish coast and in the Swedish fjords, participate. For most of the landings taken by this fleet, herring is landed as bycatch.

Danish and Swedish bycatches of herring from the sprat, Norway pout and blue-whiting fisheries are included in fleet D.

In Subdivisions 22–24 most of the catches are taken in a directed fishery for herring and some as bycatch in a directed sprat fishery. All landings from Subdivisions 22–24 are treated as one fleet.

The fishery

The Western Baltic herring fishery is a multinational fishery that seasonally targets herring in the eastern parts of the North Sea (Eastern IVa,b), the Skagerrak and Kattegat (Division IIIa) and Western Baltic (SD 22–24). The main fleets come from Denmark, Sweden, Norway and Germany, while Poland has a minor fishing activity in the area. After 1996 the fishery is roughly concentrated in the first and the third quarter of the year, whereas earlier the fishery was more spread over the year since it constituted a substantial part of the 16 mm industrial fishery.

The fishery is regulated according to an area TAC (herring catches in the IIIa and SD 22–24), but the assessment and fisheries advice is stock based (Western Baltic spring spawning herring (WBSS) to which estimates of potential WBSS catches from the neighbouring area of the eastern North Sea are added.

The fishery for human consumption has mostly single-species catches, although in recent years some mackerel bycatch can have occurred in the trawl fishery for herring. Discarding in the herring fishery in the eastern North Sea is low, with 2–4% discarded by weight (van Helmond and Overzee, 2011). In Division IIIa and SD 22–24 discarding is considered negligible because all sizes are equally valuable and hence there are no incentives for highgrading since hence.

The bycatch of sea mammals and birds is low enough to be below detection levels based on observer programmes (ICES, 2011a). At present there is a very limited industrial fishery in Division IIIa and hence a limited bycatch of juvenile herring. Further, herring bycatch quota is allocated in both the North Sea and Area IIIa. The sprat fishery in SD 22–24 operates with a certain degree of herring bycatch which is closely monitored and counted against the sprat quota (up to 8% herring allowed).

A.3. Ecosystem aspects

Herring is presumably the key pelagic species in the IIIa and Western Baltic and is thus considered to have major impact as prey and predator to most other fish stocks in that area.

Although knowledge on crucial variables affecting larval herring survival increased since the latest stock collapse in the 1970s, the understanding of particular mechanisms of early herring life-history mortalities is still a major task of fishery science in the North Atlantic Ocean. Dominant drivers of larval survival and year-class strength of recruitment are considered to be linked to oceanographic dispersal, sea temperatures and food availability in the critical phase when larvae start feeding actively. However, research on larval herring survival dynamics indicates that driving variables might not only vary at the population level and by region of spawning but also by larval developmental stage Since WBSS herring relies on inshore, transitional waters for spawning and larval retention, the suit of environmental variables driving reproduction success potentially differs from other North Atlantic stocks recruiting from coastal shelf spawning areas. The suite of variables driving early ontogenetic development and major survival bottlenecks is subject of ongoing research.

Rügen herring is considered a significant component of WBSSH. Results on time-series analysis of larval herring growth and survival dynamics indicate that distinct hatching cohorts contribute differently to the number of 1+winter ring (wr) recruits in the overall western Baltic Sea. The abundances of the earliest larval stage (5–9 mm TL) explains 62% of the variability of later stage larval abundance and 61% of the variability of surviving (1+ group) juveniles. This indicates important pre-hatching survival bottlenecks associated with spawning and egg development. Furthermore, findings demonstrate that hatching cohorts occurring later during the spawning season contribute most to the surviving year class whereas earlier hatching cohorts do not result in significant growth and survival. This could be explained by limited food supply at hatching prior to spring plankton blooms, indicating an additional bottleneck at the critical period when larvae start feeding.

Availability of suitable prey at the critical period after yolk consumption is generally considered the predominant survival bottleneck in larval fish ecology. However, analyses of zooplankton prey abundance in strong vs. weak year classes did not reveal significant food limitation in the eutrophic waters of Greifswald Bay. However, besides prey abundance larval growth and survival might also be affected by the nutritional quality of prey. Comparative results on essential fatty acid contents of larvae and prey from two different spawning grounds showed no significant differences of larval growth conditions in Kiel Canal and Greifswald Bay. The food quality, however, was found to be generally important for larval growth. Accordingly, even when prey availability is plentiful in mixed, natural feeding conditions, larval growth is affected by nutritional value of prey.

Along the inshore–offshore gradients of Western Baltic watersheds, transitional waters, such as bays, lagoons and estuaries seem to represent significant areas for herring reproduction as i) important spawning grounds and ii) retention of early development stages. It still remains a major challenge to quantify the role of small scale drivers and stressors for overall recruitment strength. The rationale in hypothesizing cascading scale effects is supported by current WBSSH recruitment time-series and the relationship of indices derived on differing spatial scales. The regular correspondence of the regional larval index (4.6.2) with recruitment patterns of WBSSH stock implies a relation between larger scale recruitment success and regional survival bottlenecks. On the other hand the N20 time-series provides a sound background to test the magnitudes of regional effects on the overall WBSSH stock.

The pelagic fisheries on herring claim to be some of the "cleanest" fisheries in terms of bycatch, disturbance of the seabed and discarding (ICES, 2010). Pelagic fish interact with other components of the ecosystem, including demersal fish, zooplankton and other predators (sea mammals, elasmobranchs and seabirds). Thus a fishery on pelagic fish may impact on these other components via second order interactions. There is a paucity of knowledge of these interactions, and the inherent complexity in the system makes quantifying the impact of fisheries very difficult. As such the discard ban is not believed to make any changes in the fishery or fishing pattern.

Another potential impact of the Western Baltic herring fishery is the removal of fish that could provide other "ecosystem services." The ecosystem needs a biomass of herring to graze the plankton and act as prey for other organisms. If herring biomass is very low other species, such as sandeel, may replace its role or the system may shift in a more dramatic way. There is, however, no recent research on the multispecies interactions in the foodweb in which the WBSS interact.

B. Data

B.1. Commercial catch

Misreporting of commercial catches induces bias on the estimated fishing mortality and stock size. The potential of such a bias should be taken into account when decisions on reference points and long-term management plans are taken. Misreporting is not only a question of landing species under a different name but can also be a result of reporting catch in a different area than the catches took place. Area misreporting has probably taken place in IIIa and the adjacent North Sea, where catches from the North Sea have been reported in IIIa. The reason for this misreporting has been due to the size differences of herring in the two areas, where the optimal sized herring were caught in the North Sea but reported as taken from IIIa.

Misreporting is understood to have taken place for the Danish catches during the period from 1997 to 2008. The Danish reported landings have been corrected for this misreporting each year in the period 2002–2009 based on information from the industry, week-by-week evaluation of the fishing trips, and since 2004 by using VMS data.

All Norwegian herring catches in IIIa between 1995–2001 are understood to have been taken in the North Sea and this was corrected for. However, since 2008 management has allowed optional transfers (flexibility in terms of where to take the IIIa TAC), where part of the TAC in IIIa legally could be caught in the North Sea.

It is unclear to what extent Swedish catches reported in IIIa in period 1991–2008 have been reported to the correct area. Similar to Denmark it is suspected that some North Sea catches have been reported as IIIa catches. For the period post-2008 misreporting in Danish and Swedish fishery has been judged unlikely primarily due to new regulations prohibiting the vessels to fish in two management areas in one trip; the flexibility in where to take the IIIa TAC (North Sea or IIIa) is also thought to decrease the incitement for area misreporting.

Conclusively, the past area misreporting has been corrected for year-by-year and thus the catch matrix applied in the assessment can be considered as accurate as possible.

There is at present no information about the relevance of local herring populations in relation to the fisheries and their possible influence on the stock assessment. Recent studies on the genetic differentiation among spawning aggregations in the Skagerrak suggests a potential high representation of these local spawning stocks (Bekkevold *et al.*, 2005). Other results suggest that at least the mature proportion of the different stock components shares migration patterns and feeding areas (Ruzzante *et al.*, 2006; van Deurs and Ramkaer, 2007).

B.2. Biological parameters for assessment

Mean weights-at-age in the catch in the 1st quarter were used as stock weights.

In order to check if this is a valid assumption and represents the actual weights in the stock, the index was compared to the average weights in the catch by age during the whole year. The relationship followed the expected pattern where the weight of the younger age classes in the catch are somewhat higher than in the stock as these are taken as an average over the whole year allowing for growth. From age class 4 the relation between weight in catch and weight in stock followed a 1:1 line as expected. Thus the use of weight in the catch in quarter 1 is a sound indicator for the weight in the stock and does not give a biased representation of the stock.

The proportion of F and M before spawning was assumed constant. F-prop was set to be 0.1 and M-prop 0.25 for all age groups.

Natural mortality was assumed constant at 0.2 for all years and 2+ ringers. A predation mortality of 0.1 and 0.2 was added to the 0 and 1 ringers, which resulted in an increase in their natural mortality to 0.3 and 0.5, respectively (Table 3.6.4). The estimates of predation mortality were derived as a mean for the years 1977–1995 from the Baltic MSVPA (ICES 1997/J:2).

The maturity ogive was assumed constant between years:

W-RINGS	0	1	2	3	4	5	6	7	8+
Maturity	**0.00**	**0.00**	**0.20**	**0.75**	**0.90**	**1.00**	**1.00**	**1.00**	**1.00**

Catch sampling for size-at-age and stock identity.

In terms of method reliability, the issue of sampling for biological data for the splitting between NSAS and WBSS is an important factor; without a robust and appropriate sampling strategy, the basis for the splitting is somewhat impaired. When sampling commercial catches for the biological composition concerning the proportions of the two herring stocks, it is crucial that the sampling scheme and coverage mirrors the actual distribution of the fishery. The sampling coverage compared to the reported catches by ICES rectangle over the period 2002–2011 is shown in Figure 4.7.1.1

It is apparent that catches concentrate in the northwestern part of Area IIIa, while sampling intensity is highest in the northeastern area.

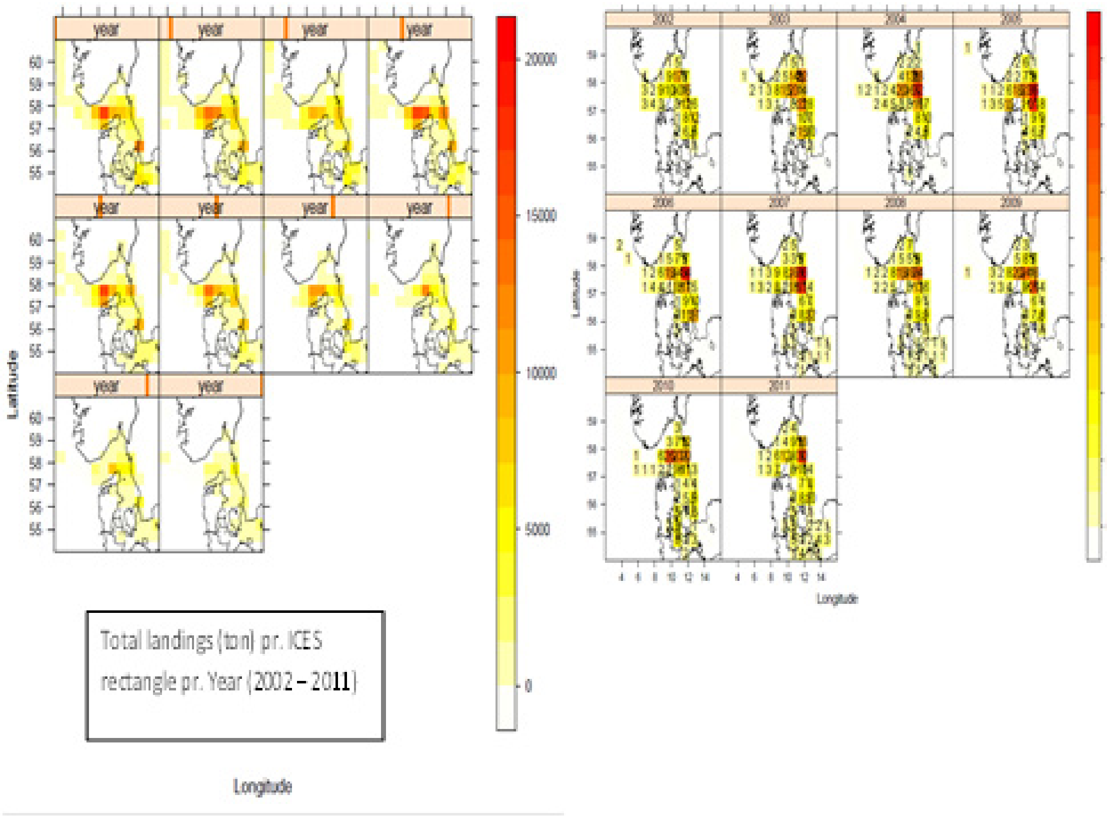
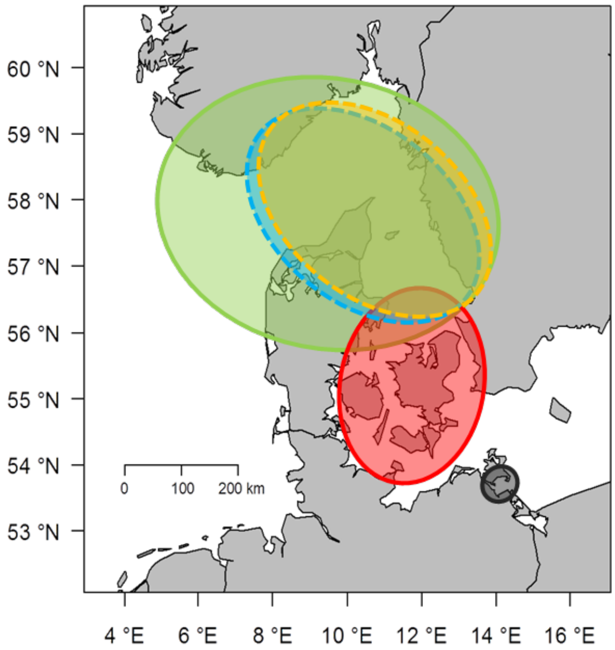


Figure 4.7.1.1. Number of samples by rectangle (right panel) and average landings in tonnes per year by ICES rectangle (left panel) over the period 2002–2011.

In order to get a solid base for estimation of the removals by the fishery, it is of utmost importance that all parts of the distribution area and the fishery herein are covered by the biological sampling. Though the sampling coverage has improved the past years and at present covers the entire distribution area and follows the spatial and temporal distribution of the catches, there is still room for improvement; the sampling in recent periods very poorly covers the Area IVaE (Figure 4.7.1.1). Thus it is highly recommended that the sampling intensity in Subdivision IVaE and eastern parts of IVb is substantially increased.

B.3. Surveys

The WBSS stock has several survey indices available as tuning indices for the assessment (Figure 4.7.2.1). During the benchmark process, an objective selection of survey datasets for inclusion in the stock assessment was performed. In essence, any dataset included should increase the net amount of information, adding more signal than noise. The signal-to-noise ratio in a survey depends on both the noise level and the magnitude of the underlying signal itself (i.e. for a given constant noise level, signals that vary slightly will always be harder to detect than those that vary widely). For example, sample size, survey design, spatial coverage (including how well the spatial distribution of the stock is captured), and consistency of performance can all contribute significant amounts of noise to survey data. In the following the available surveys are described shortly as well as their status as tuning indices.



Survey name	Method	Season	Time-series	Ages	Colour code
GERAS	Acoustic	October	1991-2011	0 to 8	
HERAS	Acoustic	June/July	1991-2013	0 to 8+	
IBTS Q1	Bottom trawl	February/March	1991-2014	1 to 4	
IBTS Q3	Bottom trawl	September	1991-2015	1 to 4	
N20	Larvae sampling	September	1992-2011	0	

Figure 4.7.2.1. Spatial and temporal survey coverage of the WBSS herring stock complex.

GERAS

The GERman Acoustic Survey (GERAS) has since 1993 included the Subdivisions 21 (Southern Kattegat, 41G0–42G2) to 24 as a part of BIAS (Baltic International Acoustic Survey). The survey is being carried out on the German R/V 'Solea' in October (GERAS). Further details of GERAS can be found in ICES reports from the Working Group of International Pelagic Surveys (WGIPS) and Baltic International Fish Survey Working Group (WGBIFS). The survey design and the specific settings of the hydroacoustic equipment follow the guidelines of the 'Manual for the Baltic International Acoustic Surveys (BIAS)', which is part of the WGBIFS report (ICES, 2012).

Recent results of GERAS indicated that in SD 24, which is part of the WBSSH management area, a considerable fraction of CBH is present and correspondingly erroneously allocated to WBSSH stock indices. Accordingly, a Stock Separation Function (SF) based on growth parameters was established to identify the fraction of CBH in the WBSSH area and applied to survey data from the German Acoustic Survey GERAS from 2005–2011. Results showed a distinct fraction of CBH in SD 24 and indicated that applying the SF greatly improved both abundance and biomass indices for WBSSH (WD 01: Gröhsler, Oeberst and Schaber).

WKPELA 2013 thoroughly compared the performance of the GERAS with and without the CBH component and as a result, the GERAS without the CBH component is applied in the assessment (ICES, 2013).

In order to analyse the external consistency between GERAS and the non-larvae surveys, the pairwise correlations of index time-series between all combinations surveys and for each age class respectively in order to analyse to what extent surveys indicate the same development in herring abundance over time. GERAS displayed high external consistency with IBTS-Q1 for age-3 and for the larval survey when correlating the larvae-index in year i with age class 1 in year i+1 and age class 2 in year i+2, etc.

Thus conclusively; both versions of the GERAS are suitable as indices for the WBSS, however, if judging solely on the internal consistency, the 'new' version appear better fit than the version including the CBH.

HERAS

The ICES Coordinated acoustic surveys for herring in the North Sea, Skagerrak and Kattegat gives an index of numbers-at-age for 1–9+-ringers, mean weights-at-age in the stock and proportions mature-at-age. This index has been used in assessments of NSAS since 1994 with the time-series data extending back to 1989. Over the years the survey has been extended to cover Division IIIa to include the overlapping western Baltic spring-spawning stock, the whole of VIa (North) and since 2008 the whole Malin Shelf. By carrying out the coordinated survey at the same time from the Kattegat to Donegal, all herring in these areas are covered simultaneously, reducing uncertainty due to area boundaries as well as providing input indices to three distinct stocks. The surveys are coordinated under the ICES Working Group for International Pelagic Surveys (WGIPS) and full technical details of the survey can be found in the latest WGIPS report (e.g. ICES, 2012).

The internal consistency of HERAS was analysed following the same procedure as applied for GERAS.

As shown in Figure B.3.1, HERAS displayed high internal consistency for ages 3–6, but no internal consistency for ages 1–3.

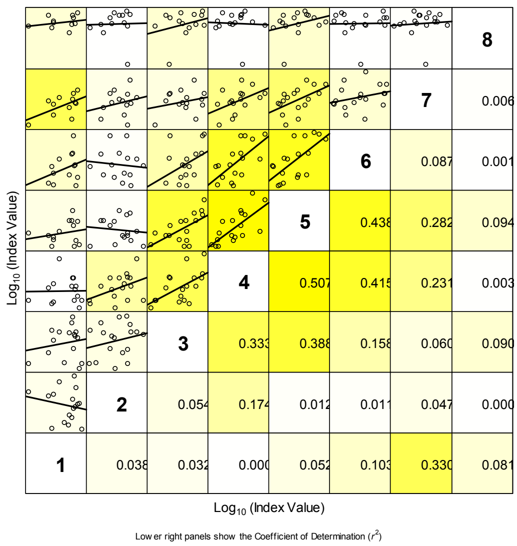


Figure B.3.1. Correlation coefficient diagram for acoustic survey by cohort.

The external consistency between HERAS and the non-larvae surveys was analysed following the same procedure as described for GERAS above. HERAS showed a relatively high consistency with IBTS-Q3 for age-4.

Conclusively; the HERAS index consistently provides age-disaggregated information on WBSS herring. There is a strong internal consistency when tracking cohorts as obtained from the acoustic survey time-series and it correlates with other indices on the older age groups. Thus the time-series derived from the acoustic survey from 1996 to the present is regarded as a relatively good and precise indicator for abundance -at-age. **HERAS is used as one of the tuning indices in the assessment.**

IBTS Q1 and Q3

The International Bottom Trawl Survey (IBTS) in Division IIIa is part of the IBTS surveys in the North Sea. The survey started out as the International Young Herring Survey (IYHS) in 1966 with the objective of obtaining annual recruitment indices for the combined North Sea herring populations (Heessen *et al.*, 1997). It has been carried out every year since. The survey is considered fully standardized from 1983 onwards, when it became known as the International Bottom Trawl Survey (IBTS). Examination of the catch data from the 1st quarter IBTS showed that these surveys also gave indications of the abundances of the adult stages of herring, and subsequently the catches have been used for estimating 2–5+ ringer abundances. The surveys are carried out in 1st quarter (February) and in 3rd quarter (August–September). During the HAWG 2002 the IBTS survey data (both quarter) were revised from 1991 to 2002 and was deemed unfit as indices for the WBSS, however, as part of the WKPELA benchmark the suitability of these indices were re-evaluated.

The internal consistency of both surveys was analysed following the procedure described for GERAS, and in general the internal consistency in the two IBTS time-series was less than for the acoustic surveys. Overall consistency was highest among older fish and in IBTS-Q1 (Figure B.3.2).

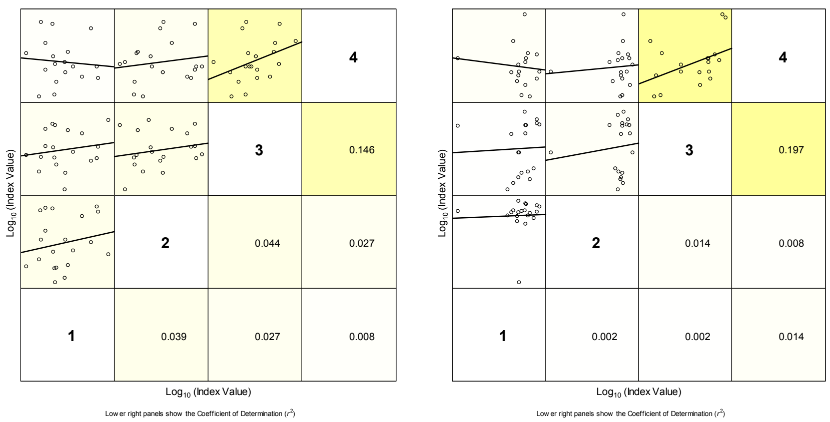


Figure B.3.2. Correlation coefficient diagram for IBTS Q1 (left panel) and IBTS Q3 (right panel) survey by cohort.

The external consistency between the IBTS surveys and the non-larvae surveys was analysed following the same procedure as described for GERAS above. The external consistency between HERAS and IBTS-Q3 for age-4 and between IBTS-Q1 and IBTS-Q3 for age 1 was relatively high. Therefore, **IBTS Q1 and Q3 are used as indices in the assessment.**

N20

The inshore waters of Strelasund/Greifswalder Bodden (ICES SD 24) are considered the main spawning area of Ruegen herring which represents a significant component of the WBSS stock. The German Institute of Baltic Sea Fisheries (TI-OF), Rostock, monitors the density of herring larvae as a vector of recruitment success since 1977 within the frame work of the Ruegen Herring Larvae Survey (RHLS). N20 delivers a unique high-resolution dataset on larval herring growth and survival dynamics in the Western Baltic Sea (see WD 09; Oeberst *et al.*, 2009 for detailed description).

In 2006 the rationale and methodology of the survey has been reviewed twice by external scientists (Dickey-Collas and Nash, 2006; Dickey-Collas and Nash, 2011) and the conclusions of this process was that the survey design of the RHLS was greatly improved and efforts were made to test many of the underlying assumptions (ICES, 2013, WD 09). The data collected provide an important baseline for detailed investigation of spawning- and recruitment ecology of WBSS herring stocks. As a fishery-independent indicator of stock development, the recruitment index is incorporated into the ICES Herring Assessment Working Group (HAWG) advice since 2007 as the only 0-group recruitment index for the assessment of WBSS herring.

The consistency/ability of the N20 to match the recruitment of the WBSS stock was analysed by correlating the larvae-index in year i with age class 1 in year i+1 and age class 2 in year i+2, etc. Figure B.3.3 shows the consistency between the N20 and the 'New GerAS' which proved to be the survey fitting the N20 best. The index from the Larvae survey is externally highly consistent with GERAS age 1 (best for the new time-series) and to some extent with age 0 in the same survey. Therefore, **the N20 is used as index in the assessment.**

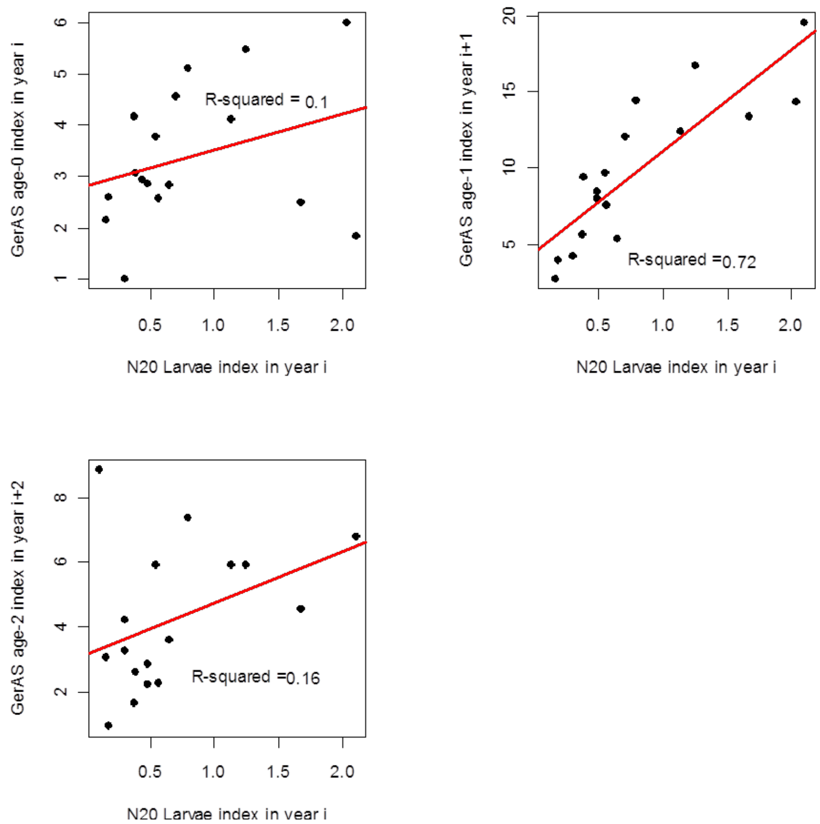
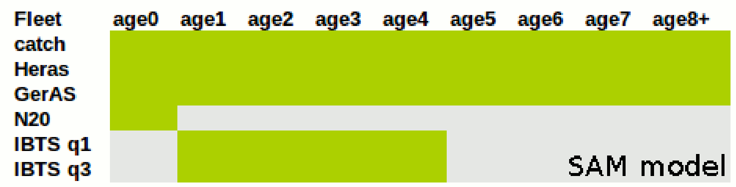


Figure B.3.3. Correlation coefficient diagram for N20 with the 'New GerAS' Survey by age group.

Conclusively, the survey indices used in the assessment are the following:



B.4. Commercial cpue

None.

B.5. Other relevant data

None.

C. Assessment: data and method

Model used: State–space model SAM

Software used: SAM (via web-interface https://www.stockassessment.org)

Model Options chosen:

Minimum age: 0

Maximum age: 8+

Coupled ages of fishing mortality states: 0,1,2,3,4,5,6,7+

Correlated random walk on F

Coupled ages of HERAS catchability: 1,2,3,4,5,6,7+

Coupled ages of GerAS catchability: 0,1,2,3,4,5,6,7+

Coupled ages of IBTS q1 catchability: 1,2,3,4

Coupled ages of IBTS q3 catchability: 1,2,3,4

Coupled ages of F variance: 0,1,2+

Coupled ages of logN variance: 0,1+

Coupled ages of catch observation variance: 0,1,2+

Coupled ages of HERAS observation variance: 1,2,3–6,7+

Coupled ages of GerAS observation variance: 0–3,4–5,6+

Coupled ages of IBTS q1 observation variance: 1–4

Coupled ages of IBTS q3 observation variance: 1–2,3–4

FBAR age: 3–6

Input data types and characteristics:

Type	Name	Year range	Age range	Variable from year to year Yes/No
Canum	Catch-at-age in numbers	1991–last data year	0–8+	Yes
Weca	Weight-at-age in the commercial catch	1991–last data year	0–8+	Yes
West	Weight-at-age of the spawning stock at spawning time.	1991–last data year	0–8+	Yes, assumed as the Mw in the catch first quarter
Mprop	Proportion of natural mortality before spawning	1991–last data year	0–8+	No, set to 0.25 for all ages in all years
Fprop	Proportion of fishing mortality before spawning	1991–last data year	0–8+	No, set to 0.1 for all ages in all years
Matprop	Proportion mature-at-age	1991–last data year	0–8+	No, constant for all years
Natmor	Natural mortality	1991–last data year	0–8+	No, constant for all years

Presently used Tuning data:

Type	Name	Year range	Age range
Tuning fleet 1	Danish part of HERAS in Division IIIa	1991–last year data Except 1999	1–8+
Tuning fleet 2	German part of BIAS in SDs 22–24	1994–last year data Except 2001	0–8+
Tuning fleet 3	N20 larval survey, Greifswalder Botten	1992–last year data	0
Tuning fleet 4	IBTS quarter 1	1991–last year data	1–4
Tuning fleet 5	IBTS quarter 3	1991–last year data	1–4

D. Short-term projection

Model used: Age structured

Software used: Rscript (integrated in the SAM web-interface https://www.stockassessment.org)

Initial age structure of the stock for the intermediate year: SAM estimates of survivors (except age0 and age1)

Recruitment (age0): Geometric mean of the recruitment over the five years previous to the assessment year

Age1: calculated by simple exponential decay [$N_{1,t+1} = N_{0,t} \cdot e^{-(F_0+M_0)}$] assuming the same geometric mean recruitment in the year of the assessment

Natural mortality: The same constant vector used for all years in the assessment

Maturity: The same constant vector used for all years in the assessment

F and M before spawning: The same values used for all the years in the assessment

Weight-at-age in the stock: Average weight of the last three years

Weight-at-age in the catch: Average weight of the last three years

Exploitation pattern (selectivity): Average selection pattern of the last three years

Intermediate year assumptions: Catch constraint with the following assumptions:

In case an optional transfer of quota between IIIa and the North Sea is agreed by managers, the Pelagic RAC will provide HAWG with an estimate of the proportion of the TAC for IIIa that will be fished in the North Sea in the assessment year. This estimate will be provided at least two weeks before the working group meeting. If this information is not available, then the proportion of the TAC not taken in IIIa will be assumed to be the average of the most recent three years for which data are available (including only those years where an optional transfer was applied).

The proportion of the Norwegian quota in Division IIIa that is assumed to be caught as NSAS in Subarea IV will be assumed to be the same as last year, and subtracted from the TAC for the C-fleet in Division IIIa.

The fractions of the catch by fleet to the above reduced total TAC in the assessment year is the same as in the previous year.

The proportion of WBSS in the catches in by fleet are assumed equal to the previous year.

Stock–recruitment model used: None

Procedures used for splitting projected catches: Projected catches are for WBSS herring only, therefore no splitting is needed.

E. Medium-term projections

No medium-term projections are carried out for this stock.

F. Long-term projections

No long-term projections are carried out for this stock.

G. Biological reference points

New precautionary biomass reference points were defined at WKPELA 2013. MSY reference points may be revised at HAWG 2013.

	TYPE	VALUE	TECHNICAL BASIS
MSY	MSY $B_{trigger}$	110 000 t	Based on management plan development and the lowest observed SSB in the 2008 assessment.
Approach	F_{MSY}	0.25	Management plan evaluations (ICES, 2008).
	B_{lim}	90 000 t	$B_{lim} = B_{loss}$, the 2011 estimate, estimated in 2012.
Precautionary	B_{pa}	110 000 t	95% confidence interval of the last year's estimate.
Approach	F_{lim}	Not defined	
	F_{pa}	Not defined	

H. Other issues

None.

I. References

Arellano, R.V., Hamerlynck, O., Vincx, M., Mees, J., Hostens, K., and Gijselinck, W. 1995. Changes in the ratio of the sulcus acusticus area to the sagitta area of *Pomatoschistus minutus* and *P. lozanoi* (Pisces, Gobiidae). Mar. Biol., 122: 355–360.

Bekkevold, D., André, C. Dahlgren, T.G. Clausen, L.A.W., Torstensen, E., Mosegaard, H., Carvalho, G.R., Christensen, T.B., Norlinder, E., and Ruzzante, D.E. 2005. Environmental correlates of population differentiation in Atlantic herring. Evolution, 59: 2656–2668.

Bekkevold, D., Clausen, L.A.W., Mariani, S., André, C., Christensen, T.B. and Mosegaard, H. 2007. Divergent origins of sympatric herring population components determined using genetic mixture analysis. Marine Ecology Progress Series 337: 187–196.

Bird J.L., Eppler D.T., and Checkley D.M. 1986. Comparison of herring otoliths using Fourier series shape analysis. Can. J. Fish. Aquat. Sci., 43: 1228–1234.

Burke, N., Brophy, D., and King, P. A. 2008. Otolith shape analysis: its application for discriminating between stocks of Irish Sea and Celtic Sea herring (*Clupea harengus*) in the Irish Sea. ICES J. mar. Sci., 65: 1670–1675.

Cardinale, M., Doering-Arjes, P., Kastowsky, M., and Mosegaard, H. 2004. Effects of sex, stock, and environment on the shape of known-age Atlantic cod (*Gadus morhua*) otoliths Can. J. Fish. Aquat. Sci. 61: 158–167.

Clausen L.W., Davis C.G. and Hansen S. 2006. Report of the sandeel otolith ageing workshop.

Clausen, L. A. W., Bekkevold, D., Hatfield, E. M. C., and Mosegaard, H. 2007. Application and validation of otolith microstructure as a stock identification method in mixed Atlantic herring (*Clupea harengus*) stocks in the North Sea and western Baltic. – ICES Journal of Marine Science, 64: 377–385.

Clausen, L.A.W, C. Ulrich-Rescan, M. van Deurs, and D. Skagen. 2007. Improved advice for the mixed herring stocks in the Skagerrak and Kattegat. EU Rolling Programme; Fish/2004/03.

Dickey-Collas, M.; Nash, R. 2006. Review of Rugen herring larvae survey project, IMARES report C079/06: 17 p.

Dickey-Collas, M.; Nash, R. 2011. Review of Rugen herring larvae survey project, IMARES report C069/11: 11 p.

Gaggiotti, O. E., Bekkevold, D., Jørgensen, H. B. H., Foll, M., Carvalho, G. R., Andre, C., and Ruzzante, D. E. 2009. Disentangling the effect of evolutionary, demographic and environmental factors influencing genetic structure of natural populations: Atlantic herring as a case study. Evolution, 63: 2939–2951.

Gago, F. J. (1993). Morphology of the saccular otoliths of six species of lanternfishes of the genus Symbolophorus (Pisces: Myctophidae). Bulletin of Marine Science 52, 949–960.

Heessen, H. J. L., Dalskov, J., and Cook, R. M. 1997. The International Bottom Trawl Survey in the North Sea, the Skagerrak and Kattegat. ICES Document CM 1997/Y: 31. 25 pp.

ICES. 1991. Report of the Herring Assessment Working Group for the Area South of 62°N. ICES CM 1991/Assess:15.

ICES. 1997. Report of the Study Group on Multispecies Model Implementation in the Baltic. ICES CM 1997/J:2.

ICES. 2004. Report of the Herring Assessment Working Group for the Area South of 62ºN (HAWG). ICES CM 2004/ACFM:18. 548pp.

ICES. 2010. Report of the Herring Assessment Working Group for the Area South of 62n (HAWG), 15–23 March 2010, ICES Headquarters, Copenhagen, Denmark. 688 pp.

ICES. 2012. Report of the Baltic international Fish Survey Working Group (WGBIFS). ICES CM 2012/SSGESST:02, Ref. SCICOM, ACOM.

ICES. 2012. Report of the Working Group of International Pelagic Surveys (WGIPS), 3–7 December 2012, ICES Headquarters, Copenhagen, Denmark. ICES CM 2012/SSGESST:22. 317 pp.

ICES. 2013. Report of the Benchmark Workshop on Pelagic Stocks (WKPELA 2013), 4–8 February 2013, Copenhagen, Denmark. ICES CM 2013/ACOM:46.

Limborg, M.; Helyar, S.J.; de Bruyn, M.; Taylor, M.I.; Nielsen, E.E.; Ogden, R.; Carvalho, G.R.; FPT CONSORTIUM and Bekkevold, D. 2012 Environmental selection on transcriptome-derived SNPs in a high gene flow marine fish, the Atlantic herring (*Clupea harengus*) Molecular Ecology. 21(15) 3686–3703.

Lombarte, A., and Lleonart, J. 1993. Otolith size changes related with body growth, habitat depth and temperature. Envir. Biol. Fishes 37: 297–306.

Messieh S.N. 1972. Use of otoliths in identifying herring stocks in southern gulf of St. Lawrence and adjacent waters. J. Fish. Res. Board. Can., 29: 1113–1118.

Mosegaard, H. and Madsen, K. P. 1996. Discrimination of mixed herring stocks in the North Sea using vertebral counts and otolith microstructure. ICES C.M. 1996/H:17: 8 pp.

Nielsen, J. R., Lundgren, B., Jensen, T. F., and Staehr, K. J. 2001. Distribution, density and abundance of the western Baltic herring (*Clupea harengus*) in the Sound (ICES Subdivision 23) in relation to hydrographical features. *Fisheries Research* 50, 235–258.

Payne, M. R., Clausen, L. W., and Mosegaard, H. 2009. Finding the signal in the noise: objective data-selection criteria improve the assessment of western Baltic spring-spawning herring. ICES Journal of Marine Science, 66: 1673–1680

Ruzzante,D.E., Mariani,S., Bekkevold,D., Andre,C., Mosegaard,H., Clausen,L.W., Dahlgren,T.G., Hutchinson,W.F., Hatfield,E.M.C., Torstensen,E., Brigham,J., Simmonds,E.J., Laikre,L., Larsson,L.C., Stet,R.J.M., Ryman,N. and Carvalho,G.R. 2006. Biocomplexity in a highly migratory pelagic marine fish, Atlantic herring. Proceedings of the Royal Society B-Biological Sciences 273, 1459–1464.

van Deurs, M. and Ramkaer, K. 2007. Application of a tag parasite, *Anisakis* sp., indicates a common feeding migration for some genetically distinct neighbouring populations of herring, *Clupea harengus*. Acta Ichthyologica et Piscatoria, 37: 73–79.

van Overzee, H.J.M and van Helmond, A.T.M. 2011. Discard sampling of the Dutch pelagic freezer fishery in 2010. CVO report 11.010.

Annex 5 – Stock Annex Herring in the Celtic Sea and VIIj

Quality Handbook	Herring in Celtic Sea and VIIj

Stock specific documentation of standard assessment procedures used by ICES

Stock:	Herring in the Celtic Sea and VIIj
Working Group:	Herring Assessment Working Group for the area south of 62^0
Date:	March 2013
Authors:	Afra Egan, Maurice Clarke, Andrew Campbell and Deirdre Lynch

This annex was updated in 2012 to reflect the change to the period used to calculate GM recruitment for the short term forecast.

A. General

The herring (*Clupea harengus*) to the south of Ireland in the Celtic Sea and in Division VIIj comprise both autumn and winter spawning components. For the purpose of stock assessment and management, these areas have been combined since 1982. The inclusion of VIIj was to deal with misreporting of catches from VIIg. The same fleet exploited these stocks and it was considered more realistic to assess and manage the two areas together. This decision was backed up by the work of the ICES Herring Assessment Working Group (HAWG) in 1982 that showed similarities in age profiles between the two areas. In addition, larvae from the spawning grounds in the western part of the Celtic Sea were considered to be transported into VIIj (ICES, 1982). Also it was concluded that Bantry Bay which is in VIIj, was a nursery ground for fish of south coast (VIIg) origin (Molloy, 1968).

A study group examined stock boundaries in 1994 and recommended that the boundary line separating this stock from the herring stock of VIaS and VIIb,c be moved southwards from latitude 52°30'N to 52°00'N (ICES, 1994). However, a recent study (Hatfield, *et al* 2007) examined the stock identity of this and other stocks around Ireland. It concluded that the Celtic Sea stock area should remain unchanged.

Some juveniles of this stock are present in the Irish Sea for the first year or two of their life. Juveniles, which are believed to have originated in the Celtic Sea move to nursery areas in the Irish Sea before returning to spawn in the Celtic Sea. This has been verified through herring tagging studies, conducted in the early 1990s, (Molloy, *et al* 1993) and studies examining otolith microstructure (Brophy and Danilowicz, 2002). Recent work carried out also used microstructure techniques and found that mixing at 1 winter ring is extensive but also suggests mixing at older ages such as 2 and 3 ring fish. The majority of winter spawning fish found in adult aggregations in the Irish Sea are considered to be fish that were spawned in the Celtic sea (Beggs et al, 2008).

Age distribution of the stock suggests that recruitment in the Celtic Sea occurs first in the eastern area and follows a westward movement. After spawning herring move to the feeding grounds offshore (ICES, 1994). In VIIj herring congregate for spawning in autumn but little is known about where they reside in winter (ICES, 1994). A schematic representation of the movements and migrations is presented in Figure 1. Figure 2 shows the oceanographic conditions that will influence these migrations.

The management area for this stock comprises VIIaS, VIIg, VIIj, VIIk and VIIh. Catches in VIIk and VIIh have been negligible in recent years. The linkages between this stock and herring populations in VIIe and VIIf are unknown. The latter are managed by a separate precautionary TAC. A small herring spawning component exists in VIIIa, though its linkage with the Celtic Sea herring stock area is also unknown.

A.2. Fishery

Historical fishery development

Coastal herring fisheries off the south coast of Ireland have been in existence since at least the seventeenth century (Burd and Bracken, 1965). These fisheries have been an important source of income for many coastal communities in Ireland. There have been considerable fluctuations in herring landings since the early 1900s.

In the Celtic Sea, historically, the main fishery was the early summer drift net fishery and the Smalls fishery which also took place in the summer. In 1933 several British vessels, mainly from Milford Haven, began to fish off the coast of Dunmore East and the winter fishery gained importance. The occurrence of the world war changed the pattern of the herring fishery further with little effort spent exploiting herring in the immediate post war years (Burd and Bracken, 1965). Landings of herring off the south west coast increased during the 1950s.

In 1956 Dunmore East was considered as the top herring port in Ireland with over 3,000 t landed. This herring was mainly sold to the UK or cured and sent to the Netherlands (Molloy, 2006). During this time many boats from other European countries began to exploit herring in this area during the spawning period. This continued until the 1960s when catches began to fall. In 1961 the Irish fishery limits changed whereby non-Irish vessels were prohibited from fishing in the inshore spawning grounds (Molloy, 1980). Consequently, continental fleets could no longer exploit herring on the Irish spawning grounds. They had to purchase herring from Irish vessels in order to meet requirements (Molloy, 2006).

During the period from 1950-1968 the fleet exploiting the stock changed from mainly drift and ring nets to trawls. Further fluctuations in the landings were evident during this time with high quantities of herring landed from 1966 – 1971 (Molloy, 1972). In the mid-sixties, the introduction of mid-water pair trawling led to greater efficiency in catching herring and this method is still employed today. Overall the 1960s saw a rise in herring landings with 1969 seeing a rise to 48,000t. The North Sea herring fisheries were becoming depleted and several countries were turning to Ireland to supply their markets. Prices also increased and additional vessels entered the fleet (Molloy, 1995). Increases in effort led to increased catches initially but this did not continue and this combined with poor recruitment began the decline of the fishery. It was eventually closed in April 1977 and remained closed until November 1982 (Molloy, 2006). When the fishery reopened the management area now included VIIj also. In 1983 a new management committee was formed.

Fishery in recent years

In the past, fleets from the UK, Belgium, The Netherlands and Germany as well as Ireland exploited Celtic Sea herring. In recent years however this fishery has been prosecuted entirely by Ireland. This fishery is managed by the Irish “Celtic Sea Herring Management Advisory Committee", established in 2000 and constituted in law in 2005.

The Irish quota is managed by allocating individual quotas to vessels on a weekly basis. Participation in the fishery is restricted to licensed vessels and these licensing requirements have been changed. Previously, vessels had to participate in the fishery each year to maintain their licence. Since 2004 this requirement has been lifted. This has been one of the contributing factors to the reduction in number of vessels participating in the fishery in recent seasons (ICES, 2005b). Fishing is restricted to the period Monday to Friday each week, and vessels must apply a week in advance before they are allowed to fish in the following week. Triennial spawning box closures are enshrined in EU legislation (Figure 3).

The stock is exploited by two types of vessels, larger boats with RSW storage and smaller dry hold vessels. The smaller vessels are confined to the spawning grounds (VIIaS and VIIg) during the winter period. The refrigerated seawater (RSW) tank vessels target the stock inshore in winter and offshore during the summer feeding phase (VIIg). There has been less fishing in VIIj in recent seasons.

The fleet can be classified into four categories of vessels:

Category 1: "Pelagic Segment".	Refrigerated seawater trawlers
Category 2: "Polyvalent RSW Segment".	Refrigerated seawater or slush ice trawlers
Category 3: "Polyvalent Segment".	Varying number of dry hold pair trawlers,
Category 4: Drift netters.	A negligible component in recent years, very small vessels

The term "Polyvalent" refers to a segment of the Irish fleet, entitled to fish for any species to catch a variety of species, under Irish law. Since 2002 fishing has taken place in quarter 3, targeting fish during the feeding phase on the offshore grounds around the Kinsale Gas Fields. These fish tend to be fatter and in better condition than winter-caught fish. In 2003 the fishery opened in July on the Labadie Bank and caught large fish. In 2004-2006 it opened in August and in 2007 and in 2008 began in September. Only RSW and bulk storage vessels can prosecute this fishery. Traditional dry-hold boats are unable to participate.

In recent years, the targeting fleet has changed. The fleet size has reduced but an increasing proportion of the catch is taken by RSW and bulk storage vessels and less by dry-hold vessels. There has been considerable efficiency creep in the fishery since the 1980s with greater ability to locate fish.

A.3. Ecosystem aspects

The ecosystem of the Celtic Sea is described in ICES WGRED (2007b). The main hydrographic features of this area as they pertain to herring are presented in Figure 2.

Temperatures in this area have been increasing over the last number of decades. There are indications that salinity is also increasing (ICES, 2006a). Herring are found to be more abundant when the water is cooler while pilchards favour warmer water and tend to extend further east under these conditions (Pinnegar, *et al* 2002). However, studies have been unable to demonstrate that changes in the environmental regime in the Celtic Sea have had any effect on productivity of this stock.

Herring larval drift occurs between the Celtic Sea and the Irish Sea. The larvae remain in the Irish Sea for a period as juveniles before returning to the Celtic Sea. Catches of herring in the Irish Sea may therefore impact on recruitment into the Celtic Sea stock (Molloy, 1989). Distinct patterns were evident in the microstructure and it is thought that this is caused by environmental variations. Variations in growth rates between the two areas were found with Celtic Sea fish displaying fastest growth in the first year of life. These variations in growth rates between nursery areas are likely to impact recruitment (Brophy and Danilowicz, 2002). Larval dispersal can further influence maturity at age. In the Celtic Sea faster growing individuals mature in their second year (1 w. ring) while slower growing individuals spawn for the first time in their third year (2 winter ring). The dispersal into the Irish Sea which occurs before recruitment and subsequent decrease in growth rates could thus determine whether juveniles are recruited to the adult population in the second or third year (Brophy and Danilowicz, 2003).

The spawning grounds for herring in the Celtic Sea are well known and are located inshore close to the coast. These spawning grounds may contain one or more spawning beds on which herring deposit their eggs. Individual spawning beds within the spawning grounds have been mapped and consist of either gravel or flat stone (Breslin, 1998). Spawning grounds tend to be vulnerable to anthropogenic influences such as dredging and sand and gravel extraction. The main spawning grounds are displayed in Figure 4, whilst the distributions of spawning and non-spawning fish are presented in Figure 5.

Herring are an important component of the Celtic sea ecosystem. There is little information on the specific diet of this stock. Farran (1927) highlighted the importance of *Calanus* spp. copepods and noted that they peaked in abundance in April/May. Fat reserves peak in June to August (Molloy and Cullen, 1981). Herring form part of the food source for larger gadoids such as hake. A study was carried out which looked at the diet of hake in the Celtic Sea. This study found that the main species consumed by hake are blue whiting, poor cod and Norway Pout. Quantities of herring and sprat were also found in fish caught in the northern part of the Celtic sea close to the Irish coast. Large hake, >50cm tended to have more herring in their stomachs than smaller hake (Du Buit, 1996).

Recent work by Whooley *et al*. (2011) shows that fin whales *Balaenoptera physalus* are an important component of the Celtic Sea ecosystem, with a high re-sighting rate indicating fidelity to the area. There is a strong peak in sightings in November, and fin whales were observed actively feeding on many occasions, seeming to associate with sprat and herring shoals. These authors go on to suggest that the peak in fin whale sightings in November may coincide with the inshore spawning migration of herring. Fin whales tend to be distributed off the south coast in VIIg in November, but further east, in VIIaS by February (Berrow personal communication). This suggests that their occurrence coincides with peak spawning time in these areas. The peak in fin whale sightings was in 2004 (Irish Whale and Dolphin Group unpublished data), coinciding with the lowest population estimate of herring.

By Catch

By catch is defined as the incidental catch of non target species. There are few documented reports of by catch in the Celtic Sea herring fishery. A European study was undertaken to quantify incidental catches of marine mammals from a number of fisheries including the Celtic Sea herring fishery. Small quantities of non target whitefish species were caught in the nets. Of the non target species caught whiting was most frequent (84% of tows) followed by mackerel (32%) and cod (30%). The only marine mammals recorded were grey seals (*Halichoerus grypus*). The seals were observed on a number of occasions feeding on herring when the net was being hauled and during towing. They appear to be able to avoid becoming entangled in the nets. It was considered unlikely by Berrow, *et al* 1998, that this rate of incidental catch in the Celtic Sea would cause any decline in the Irish grey seal population. Results from this project also suggested that there was little interaction between the fishing vessels and the cetaceans in this area. Occasional entanglement may occur but overall incidental catches of cetaceans are thought to be minimal (Berrow, *et al* 1998). The absence of any other by caught mammals does not imply that by catch is not a problem only that it did not occur during this study period (Morizur, *et al* 1999).

Discards

Catch is divided into landings (retained catch) and discards (rejected catch). Discards are the portion of the catch returned to the sea as a result of economic, legal, or personal considerations (Alverson *et al* 1994). In the 1980s a roe (ovary) market developed in Japan and the Irish fishery became dependent on this market. This market required a specific type of herring whose ovaries were just at the point of spawning. A process developed whereby large quantities of herring were slipped at sea. This type of discarding usually took place in the early stages of spawning and was reduced by the introduction of experimental fishing (Molloy, 1995). This market peaked in 1997 and has been in decline since with no roe exported in recent years. Markets have changed with the majority of herring going to the European fillet market.

Presently there are no estimates of discards for this fishery used in assessments. Berrow, *et al* 1998 also looked at the issue of discarding during the study on by catch. The discard rate was found to be 4.7% and this compares favourably with other trawl fisheries. Possible reasons for discarding were thought to be the market requirements for high roe content and high proportions of small herring in the catch. Overall this study indicated that the Celtic Sea herring fishery is very selective and that discard rates are well within the figures estimated for fishery models.

Since the demise of the roe fishery, it is considered that the incentive to discard is less. However it is known that discarding still takes place, in response to a constrained market situation.

B. Data

B.1. Commercial Catch

The commercial catch data are provided by national laboratories belonging to the nations that have quota/fisheries for this stock. In recent years, only Ireland has been catching herring in this area, and the data are derived entirely from Irish logbook data. Figure 6 shows the trends in catches over the time series. Ireland acts as stock coordinator for this stock. Commercial catch at age data are submitted in Exchange sheet v 1.6.4. These data are processed either using SALLOCL (Patterson, 1998b), or using *ad hoc* spreadsheets, usually the latter. The relevant files are placed on the ICES archive each year.

Intercatch

Since 2007, InterCatch, which is a web-based system for handling fish stock assessment data, was also used. National fish stock catches are imported into InterCatch.

Stock coordinators then allocate sampled catches to unsampled catches, aggregate them to stock level and download the output. The InterCatch stock output can then be used as input for the assessment models. The comparisons to date have been very good and it is envisaged that this system will replace SALLOCL and other previously used systems. InterCatch cannot deal with catches from two calendar years therefore for example data from the 2008/2009 season are uploaded to InterCatch as 2008 figures. Catches from quarter 1 2009 are entered as being from quarter 1 2008.

B.2 Biological

Sampling Protocol

Sampling is performed as part of commitments under the EU Council Regulation 1639/2001.Sampling (of the Irish catches) is conducted using the following protocol

- Collect a sample from each pair of boats that lands. Depending on the size range, a half to a full fish box is sufficient. If collecting from a processor make sure sample is ungraded and random.
- Record the boat name, ICES area, fishing ground, date landed for each sample.
- Randomly take 75 fish for ageing. Record length in 0.5cm, weight, sex, maturity (use maturity scale for guideline). Extract the otolith taking care not to break the tip and store it in an otolith tray. Make sure the tray is clean and dry.
- Record a tally for the 75 aged fish under “Aged Tally” on the datasheet.
- Measure the remaining fish and record a tally on the measured component of the datasheet

Ageing Protocol

Celtic Sea herring otoliths are read using a stereoscopic microscope, using reflected light. The minimum level of magnification (15x) is used initially and is then increased to resolve the features of the otolith. Herring otoliths are read within the range of 20x – 25x. The pattern of opaque (summer) and translucent (winter) zones is viewed. The winter (translucent) ring at the otolith edge is counted only in otoliths from fish caught after the 1st April. This “birth date” is used because the assessment year for Celtic Sea and Division VIIj herring runs from this date to the 31st March of the following year (ICES, 2007). This ageing and assessment procedure is unique in ICES. A fish of 2 winter rings is a 3 year old. This naming convention applies to all ICES herring stocks where autumn spawning is a significant feature.

Age composition in the catch

In recent years there is a decreasing proportion of older fish present in the catch. Figure 7 shows the age composition of the catches over the time series. It is clear that there is a truncation of older age classes with low amounts caught in recent years.

Precision in Ageing

Precision estimates from the ageing data were carried out in the HAWG in 2007, for the 2006/2007 season (ICES, 2007). Results found that CVs are highest on youngest and oldest ages that are poorly represented in the fishery. The main ages present in the fishery had low CVs, of between 5% and 13%, which is considered a very good level of precision. In the third and the fourth quarter, estimates of 1 wr on CS herring were also remarkably precise. An overall precision level of 5% was reached in Q1 and Q4 in the 2007/2008 season.

Mean Weights and Mean Lengths

An extensive data set on landings is available from 1958. Mean weights at age in the catch in the 4th and 1st quarter are used as stock weights. Trends in mean weights at age in the catches are presented in Figure 8, and for weights in the spawning stock in Figure 9. Clearly there has been a decline in mean weights since the early 1980s, to the lowest values observed.

Mean length at age from a historic source (Burd and Bracken, 1965) combined with Irish data is presented in Figure 10. Data from 1921 to 1963 are taken from Burd and Bracken (1965) and from 1964 onwards are taken from the Irish dataset. Mean length for the main age groups increased to above the long term average from the late 1950s, and reached a peak in 1975. After that mean length declined, falling below the long term average again, by the early 1990's (Lynch, 2011).

Natural Mortality

The natural mortality is based on the results of the MSVPA for North Sea herring. Natural mortality is assumed to be as follows:

1 ringer	1
2 ringer	0.3
3 ringer	0.2
4 and subsequent ringer	0.1

Maturity Ogive

Clupea harengus is a determinate one-batch spawner. In this stock, the assessment considers that 50% of 1 ringers are mature and 100% of two ringers mature. The percentage of males and females at 1 winter ring are presented in Figure 11. It shows wide fluctuations in percentage maturity from year to year (Lynch, 2011).

It is to be noted that the fish that recruit to the fishery as 1-ringers are probably precocious early maturing fish. Late maturing 1-ringers may not be recruited. Thus maturity at 1-ringer in the population as a whole may be different to that observed in the fishery. Late maturing 1-, 2- and even 3-ringers may recruit from the Irish Sea. Brophy and Danilowicz (2002) showed that late maturing 1-ringers leave the Irish Sea and appear as 2-ringers in the Celtic Sea catches. Beggs, 2008 WD indicated that some older fish also stay in the Irish Sea and return as 3- or even 4-ringers to the Celtic Sea. It is possible that when stock size was low, the relative proportion of late maturing fish from the Irish Sea was greater. This may explain why observed maturity in the catches was later in those years.

B.3. Surveys

Acoustic

Acoustic surveys have been carried out on this stock from 1990-1996, and again from 1998-2010. During the first period, two surveys were carried out each year designed to estimate the size of the autumn and winter spawning components. The series was interrupted in 1997 due to the non-availability of a survey vessel. Since 2005, a uniform design, randomised survey track, uniform timing and the same research vessel have been employed. A summary of the acoustic surveys is presented in Table 1.

Revision of acoustic time series

A review of the acoustic survey programme was conducted to check the internal consistency of the previous surveys and produce a new refined series for tuning the assessment (Doonan, 2006, unpublished). The old survey abundance at age series is presented in Table 2 and the revised survey time series is shown in the Table 3 (ICES, 2006).

The surveys were divided into two series, early and late, based on how far from the south coast of Ireland the transects extended. The early group, 1990-91 to 1994-95, extended to about 15 nautical miles offshore with two surveys, one in autumn and another in winter. This design aimed to survey spawning fish close inshore with two surveys, the results of which could be added, the two legs covering the two main spawning seasons. The off shore limits were extended in 1995 and some of these surveys had more fish off shore than close inshore. This changed the catchability, suggesting the later series should be separated from the earlier one. Consequently the years before 1995 were removed. This is not considered to be a problem because the earlier series would contribute little to the assessment anyway.

The autumn surveys did not cover the southwest Irish coast of VIIj in all years (3 years missing). In order to correct for this, the missing values were substituted with the mean of the available western bays SSB estimates, 7 800 t (11 values, range from 0 to 16 000 t). Numbers-at-age in these surveys were adjusted upwards by the ratio of the adjusted SSB in the SW to the south coast SSB. The current time series included autumn surveys only.

Analysis errors were found in the surveys from 1998 onwards. The 2003 biomass (SSB, 85 500 t) was re-analysed after the discovery of errors in the spreadsheets used to estimate biomass. The errors affected the calculation of the weighted mean of the integrated backscatter when positive samples had lengths shorter than the base one (here, 15 minutes) and the partitioning of the backscatter for a mixture of species. Also, no account was taken of different sampling frequencies within a 10x20 minute cell (the analysis unit). The 2003 SSB came mainly from two cells that included an intensive survey in Waterford Harbour and these cells had an SSB of about 68 000 t, which was reduced to 7 300 t when all errors were corrected. There were some minor corrections in three other cells. The revised total biomass was 24 000 t and the revised spawning biomass was 22 700 t.

In addition, the cell means took no account of the implicit sampling area of transects so that the biomass coming from a large sample value depended on the number of transects passing through the cell. The data were re-analysed using mean herring density by transect as the sample unit and dividing the area into strata based on transect spacing. Areas with no positive samples were excluded from the analysis (since they have zero estimates). Zigzags in bays were analysed as before. For each stratum, a mean density was obtained from the transect data (weighted by transect length) and this was multiplied by the stratum area to obtain a biomass and numbers-at-age. The overall total was the sum of the strata estimates. The same haul assignments as in the original analysis were used. At the same time, a CV was obtained based on transect mean densities, i.e. a survey sample error. For surveys before 1998 and the western part survey in 2002, a CV was estimated using;

$$\sqrt{\log(1.3^2)/n}$$

where n is the number of positive sample values (15 minute of survey track) from Definite and Probably Herring categories. This was based on the data from the autumn surveys in 1998, 2000, 2001, 2002, and 2005.

Current acoustic survey implementation

The acoustic data are collected using the Simrad ER60 scientific echosounder. The Simrad ES-38B (38 KHz) split-beam transducer is mounted within the vessels drop keel or in the case of a commercial vessel mounted within a towed body. The survey area is selected to cover area VIIj, and the Celtic Sea (areas VIIg and VIIaS). Transect spacing in these surveys has varied between 1 to 4 nmi. For bays and inlets in the southwest region (VIIj) a combined zigzag and parallel transect approach was used to best optimise coverage. Offshore transect extension reached a maximum of 12 nmi, with further extension where necessary to contain fish echotraces within the survey area.

The data collected is scrutinised using Echoview® post processing software. The allocated echo integrator counts (S_a values) from these categories were used to estimate the herring numbers according to the method of Dalen and Nakken (1983). The following target strength to fish length relationships is used for herring.

$$TS = 20 \log L - 71.2 \text{ dB per individual } (L = \text{length in cm})$$

Acoustic Survey Time Series

The acoustic survey design has been standardised and the timing has been consistent each year since 2005. The 2002 and 2003 surveys had similar timing and are comparable to the uniform time series. In the benchmark assessment (2007) the time series used was from 1995-2006. At the time of the benchmark, there were not enough comparable consistent surveys available for tuning. In 2009, four consistent surveys (2005-2008) and two additional fairly consistent surveys (2002-2003) were available. The 2010 assessment also used the 2009 survey.

Irish Groundfish Survey

The IGFS is part of the western IBTS survey and has been carried out on the *RV Celtic Explorer* since 2003. The utility of the IGFS as a tuning series was investigated (Johnston and Clarke, 2005 WD). Strong year effects were evident in the data. Herring were either caught in large aggregations or not at all. The signals from this survey were very noisy, but when a longer time series is developed, it will at least provide qualitative information. The absence of the 2001 year class was supported in the survey data in 2004.

French EVHOE Survey

The Herring Assessment Working group in 2006 had access to data from the French EVHOE quarter 4 western IBTS survey (GOV trawl). The French survey series is from 1997 to 2005 and displayed very variable observed numbers at age between years. Consequently, further exploration of the series was not performed.

UK Quarter 1 survey

The UK quarter 1 survey was also explored and strong year and age effects, particularly at 2- and 5-ringers were found. Due to strong year and age effects and because it was discontinued in 2002 this survey is considered unsuitable as a recruit index (ICES 2006:ACFM 20).

While these data are useful for comparisons between surveys, as with the Irish data, at the moment it is difficult to see how these data can be used in an assessment. The data, particularly towards the end of the time series are very noisy and the absence of very small (juvenile) fish, particularly 1 ringers for the majority of time series is not encouraging (Johnston and Clarke, 2005).

Irish and Dutch juvenile herring trawl surveys

Juvenile herring surveys were carried out from 1972 – 1974 by Dutch and Irish scientists. These surveys aimed to get information on the location and distribution of young herring. They were also used to examine if young herring surveys in the Irish Sea could provide abundance indices for either the Irish Sea or Celtic Sea stocks. Further young fish surveys were carried out in the Irish Sea from 1979 – 1988. They were discontinued when it was decided that it was not possible to use the information as recruitment indices for the Celtic Sea or Irish Sea stocks despite earlier beliefs (Molloy, 2006). This was because it was not known what proportion of the catches should be assigned to each stock.

Northern Ireland GFS surveys

These surveys take place in quarters 1 and 3 each year. Armstrong et al (2004) presented a review of these surveys. They are likely to be useful if the natal origin can be established. Further work in this area is required to examine if this survey can be used as a recruit index for Celtic Sea Herring.

Larval Surveys

Herring larval surveys were conducted in the Celtic Sea between October and February from 1978 to 1985 with further surveys carried out in 1989 and 1990. These surveys provided information on the timing of spawning and on the location of the main spawning events as well as on the size of autumn and winter spawning components of the stock. The larval surveys carried out after the fishery reopened in 1982 showed an increase in the spawning stock (Molloy, 1995).

The surveys covered the south coast and stations were positioned 8 nautical miles apart in a grid formation. A Gulf III sampler, with 275 μm mesh was used to collect the samples. The total abundance of <10mm larvae (prior to December 15th) or <11mm (after December 15th) was calculated by raising the numbers per m^2 by the area represented by each station. The mean abundance of <11mm larvae in December – February gave the winter index which when multiplied by 1.465 and added to the Autumn index to give a single index of the whole series (Grainger *et al* 1982). Larval surveys have not been undertaken in this area since 1989 and until the acoustic survey became established, no survey was available to tune the assessment.

B.4. Commercial CPUE

In the 1960s and 1970s CPUE (Catch per unit effort) data from commercial herring vessels were used as indices of stock abundance because there were no survey data available. These data provided an index of changes that were occurring in the fishery at the time. CPUE data were used to tune the assessment (Molloy, 2006). However it is likely that the decline in the stock in the 1970s was not picked up in the CPUE until it was at an advanced stage. It is now demonstrated that CPUE data does not provide an accurate index of herring abundance, as they are a shoaling fish.

C. Historical Stock Development

Time Periods in the Fishery

This fishery can be divided into time periods. A number of factors have changed in this fishery overtime such as the markets, discards and the water allowance. These changes have implications for the trustworthiness of the catch data used in the assessment. The time periods are presented in the Table 4. The recent biological history of the stock is presented in Table 5. It is clear that growth rate has changed over time. Mean length and mean weight at age have declined by about 15% and 30% respectively since the late 1970s. Fish are shorter and lighter at age now than at any time in the series. Trends in mean weights in the catch and in the stock are presented in Figure 8 and Figure 9.

Exploration of basic data

Data exploration consisted of examining a number of features of the basic data. These analyses included log catch ratios, cohort catch curves in survey and catch at age series. Log catch ratios were constructed for the time series of catch at age data, as follows:

log[C(a,y)/C(a+1,y+1)]

These are presented in Figure 12. It can be seen that 1-ringers, and the oldest ages, have a noisy signal, being poorly represented in the catches. There was an increase in ratios in 1998, that seems quite abrupt. Overall there is a trend towards greater mortality in recent years. The increased mortality visible in the older ages corresponds with the truncation in oldest ages in the catch at age profile. It can also be seen that the gross mortality signal was low in 2002, corresponding to the big decrease in catch in that year. The signal increased again in 2003, concomitant with increasing catch. Log catch ratios by cohort are presented in Figure 13.

The total mortality (Z) over ages 2-7 for the cohorts 1958-1997 is presented in Figure 14 and in Table 6. Fluctuations are evident with an increasing trend in recent years. Total mortality was low for cohorts 1956 to 1964. Cohorts in the late 1960s seem to display higher Z, but those from 1975 to 1982 displayed the highest Z (0.6 to 1.1). The most recent year classes for which enough observations are available (1991-1997) show higher Z again, in the range about 0.6 to 1.0. Cohort catch curves were also constructed from the catch at age data across ages 2-5 (Figure 15) and the survey data for year classes where enough data were available (Figure 16). A secondary peak corresponding to the 2003/2004 season is obvious in the cohort catch curves. The same patterns in raw mortality are visible, but the Zs from the acoustic survey are somewhat higher than those from the commercial data. This may be explained as differing catchability between the two, and it should be noted when interpreting the assessment results below.

In conclusion only the cohorts from before the stock collapsed and a few from the late 1980s contributed many of the older fish that appear in the catches. Raw mortality signals, from cohort catch curves suggest that some of the recent year classes have displayed a higher total mortality.

Assessments 2007-2013

In 2007, a benchmark assessment used a variety of models including ICA (Patterson, 1998), separable VPA, XSA, CSA and Bayesian catch at age methods. In addition an analysis of long term dynamics of recruitment was conducted. Simulations of various fishing mortalities were conducted based on stock productivity. Though no final model formulation was settled upon, the assessment provided information on trends. ICA was preferred to XSA because it is more influenced by younger ages that dominate the stock and fishery, and because of consistency. The settings that had been used before 2007 were found to produce the most reasonable diagnostics.

In 2007 it was considered that the assumption that a constant separable pattern could be used may not have been valid and it was recommended that future benchmark work should consider models that allow for changes in selection pattern.

Also in 2007 a reduction of the plus group to 7+ was recommended. This change did not achieve better diagnostics in 2007, but exploratory assessments in 2008 did find that this change improved the diagnostics.

In 2008 and 2009, the working group continued to explore different assessment settings in ICA. The working group treated these explorations as extensions of the benchmark of 2007. In 2008 ICA was replaced by FLICA and the same stock trajectories were found in each.

In 2009 a final analytical assessment was proposed and was conducted using FLICA (flr-project.org). This assessment was based on exploratory work done in 2008 and 2009. The refinements to the benchmark assessment of 2007 were as follows:

- Further reduction of plus group to 6+
- Exclusion of acoustic surveys before 2002, because a sufficient series of comparable surveys was now available.

The assessment showed improved precision and coherence between the catch at age and the survey data. The survey residuals were lower since 2002 which is reflected in better tuning diagnostics.

The model formulation used for ICA in the 2007 benchmark and the final assessment carried out in 2009 -2013 are presented in the table below. The stock trajectory, based on the most recent assessment is presented in Figure 17.

ICA Settings	**2007 Benchmark**	**Final Assessments in 2009 -2013**
Separable period	6 years (weighting = 1.0 for each year)	6 years (weighting = 1.0 for each year)
Reference ages for separable constraint	3	3
Selectivity on oldest age	1.0	1.0
First age for calculation of mean F	2	2
Last age for calculation of mean F	6	5
Weighting on 1 ringers	0.1	0.1
Weighting on other age classes	1.0	1.0
Ages for acoustic abundance estimates	2-5	2-5
Plus group	9	6

Update Assessments

In 2013 the same procedure as in 2009 -2012 was carried out.

Estimation of terminal year Recruitment

Recruits (1-ring) are poorly represented in the catch and only one observation of their abundance is available. Therefore an adjustment is made, by replacing 1-ring abundance from ICA.out with GM recruitment from (1995 – final year – 2).

In 2011 geometric mean recruitment was calculated from 1981-2009. This time period was used because it represents the current perceived recruitment regime where recruitment has been fluctuating around the mean (ICES, HAWG 2011). In 2012 GM recruitment was calculated from 1981-2010. This was continued in 2013.

Input data types and characteristics:

TYPE	NAME	YEAR RANGE	AGE RANGE	VARIABLE FROM YEAR TO YEAR YES/NO
Caton	Catch in tonnes	1958-2012	1-6+	Yes
Canum	Catch at age in numbers	1958-2012	1-6+	Yes
Weca	Weight at age in the commercial catch	1958-2012	1-6+	Yes
West *	Weight at age of the spawning stock at spawning time.	1958-2012	1-6+	Yes
Mprop	Proportion of natural mortality before spawning	1958-2012	1-6+	No
Fprop	Proportion of fishing mortality before spawning	1958-2012	1-6+	No
Matprop	Proportion mature at age	1958-2012	1-6+	No
Natmor	Natural mortality	1958-2012	1-6+	No

* mean weights in the stock in the new plus group were re-weighted using catch numbers at age.

Tuning data:

TYPE	NAME	YEAR RANGE	AGE RANGE
Acoustic Survey	CSHAS	2002-2012	2-5

Analysis of productivity over time

To account for the influence of the ecosystem on the productivity of this herring stock (ICES, 2007, Chapter 1) the methods of Nash and Dickey-Collas (2005) were applied. The recruit per spawner ratio was calculated. These calculations formed the basis for the detection of periods of high and low production of the stock (Figure 18).

The next step was to calculate the net and surplus production of the whole stock, including the recruits and the growth of all non-recruits, the natural and the fishing mortality. To subtract the influence of the spawning stock biomass a hockey stick and a Ricker stock recruitment relationship were fitted to the data to obtain the residuals of the recruits of a given year. The residuals were used to remove the year effect from the estimation of the stock size and to gain the net production and the surplus production respectively without the effect of the SSB on the number of recruits. Contrary to ICES (2007, Technical Minutes) the stock recruit model is not presented. This is because the model is not considered a good fit to the data and because the aim of this analysis is to examine recruitment, having removed the effect of SSB.

The data used in this analysis was derived from the assessment outputs from the HAWG in 2006 (ICES, 2006 ACFM:20, Table 1.8.3.1).

Calculation of the surplus production

$$Ps = Br + Bg - M$$

where Br is the biomass of the recruits, Bg the gain of biomass due to growth of all fish excluding the recruits and M the natural mortality. The net production equals the surplus production minus the fishing mortality (F).

The Celtic Sea herring stock had a low productivity throughout the whole time series, compared to other stocks (ICES, 2007). The net and surplus production is very noisy displaying no clear trend. The impact of a varying F was tested using the Hockey Stick stock recruitment relationship (Figure 18). The stock showed variable production over time (Figures 19 and 20). It can be seen that $F_{0.1}$ is associated with high though variable surplus production over the series, whilst F's greater than 0.4 are associated with reduced productivity in the most recent years. This analysis demonstrates the benefits of harvesting at an F of around $F_{0.1}$. Exploitation in the range of recent F (~0.7-1.2) is detrimental to stock productivity.

D. Short-Term Projection

Short term forecasts were routinely performed until 2004. There was no final assessment from 2005-2008 and therefore no short term forecast was conducted. A forecast was again carried out in 2009 - 2013. The method used in 2009 and 2010 was the "Multi fleet Deterministic Projection" software (Smith, 2000). From 2011-2013 the forecast was carried out using FLR. A short-term projection is carried out under the following assumptions. From 2009-2011, recruitment was set at geometric mean, from 1995 - minus the most recent two years. In 2012 HAWG changed the period for calculation of geometric mean to 1981-2009 (excluding the two most recent years). The current recruitment regime has been observed to be similar to that in the 1980s and early 1990s, with several strong year classes recruiting in recent years. This procedure was followed in 2013 also. Mean weights in the catch and in the stock were calculated as means over the last three years. Selection is taken from the most recent assessment. Population number of 2 ringers in the intermediate season was calculated by the degradation of geometric mean recruitment using the equation below, following the same procedure as in previous years.

$$N_{t+1} = N_t * e^{-Ft+Mt}$$

E. Medium-Term Projections

Yield per recruit analyses have been conducted for this stock since the mid 1960s, though not necessarily every year. Recent analyses have used the "Multi Fleet Yield Per Recruit" software and using FLR. A comparison of the results is shown in the table below. Based on the most recent yield per recruit $F_{0.1}$ is estimated to be 0.17 (Figure 21).

Table 7 presents estimates of $F_{0.1}$ from the literature and from yield per recruit analyses conducted over time. $F_{0.1}$ estimates from the YPR analysis have been in the range 0.16-0.19. F_{max} has been undefined in recent studies but earlier work suggested values of around 0.45, based on the good recruitment regime of the 1960s. Fmsy for this stock is 0.25.

F. Long-Term Projections

A long term plan has been proposed for Celtic Sea herring and simulations have been carried out in conjunction with this work. HCS10 (Skagen, 2010) was used to project the stock forward twenty years and screen over a range of possible trigger points, F values and % constraints on TAC change. It was agreed by the Irish industry that a target F of 0.23 would be proposed and that 61 000 t would be used as a trigger biomass. Once the stock falls to this level, reductions in F would be implemented. A 30% constraint in TAC change would also apply. Simulations have shown that this combination of options shows that the risk of falling below the breakpoint which is 41 000 t is less than 5% over the simulation period (Egan and Clarke, 2011 WD 11).

G. Biological Reference Points

B_{pa} is based on a low probability of low recruitment and is currently 44 000 t.

B_{lim} is set at B_{loss} and is 26 000 t (ICES, 2001).

F_{pa} and F_{lim} are not defined. F_{msy} has not been as 0.25 and $F_{0.1}$ as 0.17.

The reference points for this stock have not been revised in recent years. There is some evidence that B_{lim} should be revised upwards, to the point of recruitment impairment estimated by Egan and Clarke (2011, WD No 11). These authors showed a changepoint in a segmented regression at 41 000 t.

H.1. Biology of the species in the distribution area

Herring shoals migrate to inshore waters to spawn. Their spawning grounds are located in shallow waters close to the coast and are well known and well defined. This stock can be divided into autumn and winter spawning components. Spawning begins in October and can continue until February. A number of spawning grounds are located along the South coast, extending from the Saltee Islands to the Old Head of Kinsale. These grounds include Baginbun Bay, Dunmore East Co Waterford, around Capel and Ballycotton Islands and around the entrance to Cork Harbour (Molloy, 2006). The areas surrounding the Daunt Rock and old Head of Kinsale have also been recognised as spawning grounds (Breslin, 1998). These spawning grounds are shown in Figures 2 -.5.

Herring are benthic spawners and deposit their eggs on the sea bed usually on gravel or course sediments. The yolk sac larvae hatch and adopt a pelagic mode of life.

When referring to spawning locations the following terminology is used (Molloy, 2006)

- A <u>spawning bed</u> is the area over which the eggs are deposited
- A <u>spawning ground</u> consists of one or more spawning beds located in a small area.
- A <u>spawning area</u> is comprised of a number of spawning grounds in a larger area

Spawning grounds are typically located in high energy environments such as the mouth of large rivers and areas where the tidal currents are strong. Herring shoals return to the same spawning grounds each year (Molloy, 2006).

Herring produce benthic eggs that are adhered to the bottom substrate where they remain until hatching. Fertilized eggs hatch into larvae in 7-10 days depending on the water temperature[1]. The size of the egg determines the size of the larvae. Larger eggs have a greater chance of survival but this must be balanced against environmental conditions and the inverse relationship between fecundity and egg size (Blaxter and Hunter, 1982).

A study on fecundity of Celtic Sea herring, conducted in the 1920s found that the eggs produced by spring spawners were 25% bigger than those autumn spawners but were less numerous (Farran, 1938). Later studies of Celtic Sea herring fecundity by Molloy (1979), found that there were two spawning populations with the autumn one being most important.

The relationship between fecundity and length has been calculated for both spawning components of Celtic Sea herring. The regression equations are as shown in Molloy, 1979, are as follows:

Autumn spawning component: Fecundity = 5.1173 L – 56.69 (n=53)

Winter spawning component: Fecundity = 3.485 L – 35.90 (n=37)

The larval phase is an important period in the herring life cycle. Larvae use their oil globule for food and to provide buoyancy. Currents transport the newly hatched larvae to areas in the Celtic Sea or to the Irish Sea (Molloy, 2006). The conditions experienced during the larval phase as well as during juvenile phase are likely to have some influence on the maturation of Celtic Sea herring. Fast growing juveniles can recruit to the population a year earlier than slow growing juveniles. Faster growth may also lead to increased fecundity (Brophy and Danilowich, 2003). Fluctuating environmental conditions play an important role in the growth and survival of herring in this area.

The juveniles tend to remain close inshore, in shallow waters for the first two years of their lives, in nursery areas. There are many of these nursery areas around the coast. The minimum landing size for herring is 20cm and therefore these juvenile herring are not caught by the fishery in the early stages of their life cycle (Molloy, 2006).

Celtic Sea herring have undergone changes in growth patterns and a declining trend in mean weights and lengths can be seen over time. It is important to detect these changes from a management perspective because changes can have an impact on the estimation of stock size. Growth has an impact on factors such as maturity and recruitment (Molloy, 2006). Trends in mean weights and lengths are currently being examined over the time series and possible links to environmental factors investigated (Lynch, 2011).

The locations of spawning and non spawning fish in the Celtic Sea are shown in Figure 5. This is based on the knowledge of fishermen and shows spawning herring are found close inshore and non spawning fish are found in areas further off shore.

[1] http://www.gma.org/herring/biology/life_cycle/default.asp

H.2. Management and ICES Advice

The assessment year is from 1st April to 31st March. However for management purposes, the TAC year is from 1st January to 31st December.

The first time that management measures were applied to this fishery was during the late 1960s. This was in response to the increasing catches particularly off Dunmore East. The industry became concerned and certain restrictions were put in place in order to prevent a glut of herring in the market and a reduction in prices. Boat quotas were introduced restricting the nightly catches and the number of boats fishing. Fishing times were specified with no weekend fishing and herring could not be landed for the production of fishmeal. A minimum landing size was also introduced (Molloy, 1995).

The TAC (total allowable catch) system was introduced in 1972, which meant that yearly quotas were allocated. This continued until 1977 when the fishery was closed. During the closure a precautionary TAC was set for Division VIIj. This division was not assessed analytically (ICES, 1994). After the closure of this fishery a new management structure was implemented with catches controlled on a seasonal basis and individual boat quotas were put in place (Molloy 1995).

Table 8 shows the history of the ICES advice, implemented TACs and ICES' estimates of removals from the stock. It can be seen that the implemented TAC has been set higher than the advice in about 50% of years since the re-opening of the fishery in 1983. The tendency for the TAC to be set higher than the advice has also increased in recent years. It can also be seen that ICES catch estimates have been lower than the agreed TAC in most years.

This fishery is still managed by a TAC system with quotas allocated to boats on a weekly basis. Participation in the fishery is restricted to licensed vessels. A series of closed areas have been implemented to protect the spawning grounds, when herring are particularly vulnerable. These spawning box closures were implemented under EU legislation.

The committee set up to manage the stock has the following objectives.

- To build the stock to a level whereby it can sustain annual catches of around 20,000 t.
- In the event of the stock falling below the level at which these catches can be sustained the Committee will take appropriate rebuilding measures.
- To introduce measures to prevent landings of small and juvenile herring, including closed areas and/or appropriate time closures.
- To ensure that all landings of herring should contain at least 50% of individual fish above 23 cm.
- To maintain, and if necessary expand the spawning box closures in time and area.
- To ensure that adequate scientific resources are available to assess the state of the stock.
- To participate in the collection of data and to play an active part in the stock assessment procedure.

The Irish Celtic Sea Herring Management Advisory Committee has developed a rebuilding plan for this stock. This Committee proposes that this plan be put forward for Council Regulation for 2009 and subsequent years. The plan incorporates scientific advice with the main elements of the EU policy statement on fishing opportunities for 2009, local stakeholder initiatives and Irish legislation.

Rebuilding plan

1. For 2009, the TAC shall be reduced by 25% relative to the current year (2008).
2. In 2010 and subsequent years, the TAC shall be set equal to a fishing mortality of $F_{0.1}$.
3. If, in the opinion of ICES and STECF, the catch should be reduced to the lowest possible level, the TAC for the following year will be reduced by 25%.
4. Division VIIaS will be closed to herring fishing for 2009, 2010 and 2011.
5. A small-scale sentinel fishery will be permitted in the closed area, Division VIIaS. This fishery shall be confined to vessels, of no more than 65 feet in length. A maximum catch limitation of 8% of the Irish quota shall be exclusively allocated to this sentinel fishery.
6. Every three years from the date of entry into force of this Regulation, the Commission shall request ICES and STECF to evaluate the progress of this rebuilding plan.
7. When the SSB is deemed to have recovered to a size equal to or greater than B_{pa} in three consecutive years, the rebuilding plan will be superseded by a long-term management plan.

Evaluation of the Management Plan

The proposed rebuilding plan for Celtic Sea and Division VIIj herring is estimated to be in accordance with the precautionary approach, if the target fishing mortality of $F_{0.1}$ is adhered to.

2010 Advice

The advice for 2010 was based on the rebuilding plan.

The rebuilding plan is due to end in 2011 when it is expected to be replaced by a long term management plan. In early 2011 the Irish industry agreed a long term management plan. The plan has not yet been evaluated.

The text of the proposed plan is below.

Text of the proposed Long term management plan Herring in the Celtic Sea and Division VIIj.

1. Every effort shall be made to maintain a minimum level of Spawning Stock Biomass (SSB) greater than 41,000 t, the level below which recruitment becomes impaired.

2. Where the SSB, in the year for which the TAC is to be fixed, is estimated to be above 61,000 t ($B_{trigger}$) the TAC will be set consistent with a fishing mortality, for appropriate age groups, of 0.23 (F_{target}).

3. Where the SSB is estimated to be below 61,000 tonnes, the TAC will be set consistent with a fishing mortality of:

   $$SSB * 0.23 / 61,000$$

4. Where the rules in paragraphs 2 and 3 would lead to a TAC which deviates by more than 30 % from the TAC of the preceding year, the TAC will be fixed such that it is not more than 30 % greater or 30 % less than the TAC of the preceding year.

5 Where the SSB is estimated to be below 41,000 tonnes, Sub-Division VIIaS will be closed until the SSB has recovered to above 41,000 tonnes.

6. Where the SSB is estimated to be below 41,000 tonnes, and Sub-Division VIIaS is closed, a small-scale sentinel fishery will be permitted in the closed area. This fishery will be confined to vessels, of no more than 50 feet in registered length. A maximum catch limitation of 8% of the Irish quota will be exclusively allocated to this sentinel fishery.

7. Notwithstanding paragraphs 2, 3 and 4, if the SSB is estimated to be at or below the level consistent with recruitment impairment (41,000 t), then the TAC will be set at a lower level than that provided for in those paragraphs.

8. No vessels participating in the fishery, if requested, will refuse to take onboard any observer for the purposes of improving the knowledge on the state of the stock. All vessels will, upon request, provide samples of catches for scientific analyses.

9. Every three years from the date of entry into force of this Regulation, the Commission will request ICES and STECF to review and evaluate the plan.

10. This arrangement enters into force on 1st January, 2012.

If this plan is agreed and accepted it will then undergo a more detailed evaluation before it will be used as a basis for scientific advice.

H.4. Terminology

The WG uses “rings” rather than “age” or “winter rings” throughout the report to denominate the age of herring, with the intention to avoid confusion. It should be observed that, for autumn spawning stocks, there is a difference of one year between “age” and “rings”. HAWG in 1992 (ICES 1992/Assess:11) stated that

“The convention of defining herring age rings instead of years was introduced in various ICES working groups around 1970. The main argument to do so was the uncertainty about the racial identity of the herring in some areas. A herring with one winter ring is classified as 2-years-old if it is an autumn spawner, and one-year-old if it is a spring spawner. Recording the age of the herring in rings instead of in years allowed scientists to postpone the decision on year of birth until a later date when they might have obtained more information on the racial identity of the herring.

The use of winter rings in ICES working groups has introduced a certain amount of confusion and errors. In specifying the age of the herring, people always have to state explicitly whether they are talking about rings or years, and whether the herring are autumn- or spring spawners. These details tend to get lost in working group reports, which can make these reports confusion for outsiders, and even for herring experts themselves. As the age of all other fish species (and of herring in other parts of the world) is expressed in years, one could question the justification of treating West-European herring in a special way. Especially with the present trend towards multispecies assessment and integration of ICES working groups, there might be a case for a uniform system of age definition throughout all ICES working groups.

However, the change from rings to years would create a number of practical problems. Data files in national laboratories and at ICES would have to be adapted, which would involve extra costs and manpower. People that had not been aware of the change might be confused when *comparing new data with data from old working group reports. Finally, in some areas (notably Division IIIa), the distinction between spring- and autumn spawners is still hard to make, and scientists preferred to continue using rings instead of years.*

The Working Group discussed at length the various consequences of a change from rings to years. The majority of the Group felt that the advantages of such a change did not outweigh the disadvantages, and it was decided to stick to the present system for the time being."

The text table below gives an example for the correlation between age, rings and year class for the different spawning types in late 2002:

YEAR CLASS (AUTUMN SPAWNERS)	2001/2002	2000/2001	1999/2000	1998/1999
Rings	0	1	2	3
Age (autumn spawners)	1	2	3	4
Year class (spring spawners)	2002	2001	2000	1999
Rings	0	1	2	3
Age (spring spawners)	0	1	2	3

References

Alverson, D.L., Freeberg, M.H., Murawski, S.A., Pope, J.G. (1994) A global assessment of fisheries bycatch and discards. FAO Fisheries Technical Paper. No. 339. Rome, FAO. 1994. 233p.

Armstrong, M., Clarke, W., Peel, J., McAliskey, M., McCurdy, W., McCorriston, P., Briggs, R., Schön, P.-J., Bloomfield, S., Allen, M. and Toland, P. (2004). Survey indices of abundance for herring in the Irish Sea (Area VIIaN): 1992 – 2003. Working Document to ICES HAWG 2004.

Beggs, S., Schon, P.J., McCurdy, W, Peel., J., McCorriston, P., McCausland, I (2008). Seasonal origin of 1 ring+ herring in the Irish Sea (VIIaN) Management Area during the annual acoustic survey. Working Document to the herring assessment working group 2008.

Berrow, S. D., M. O'Neill, Brogan, D. (1998). "Discarding practices and marine mammal bycatch in the Celtic Sea herring fishery. "Biology and Environment: Proceedings of the Royal Irish Academy 98B(1): 1-8.

Blaxter, J.H.S., Hunter, J.R. (1982) The Biology of the Clupeoid Fishes. Advances in Marine Biology, Vol 20, pp. 1-223. Academic Press, London.

Breslin J.J. (1998) The location and extent of the main Herring (*Clupea harengus*) spawning grounds around the Irish coast. Masters Thesis: University College Dublin

Brophy, D and Danilowicz, B.S., (2002). Tracing populations of Atlantic herring (*Clupea Harengus* L.) in the Irish and Celtic Seas using otolith microstructure. ICES Journal of Marine Science, 59: 1305-1313

Brophy, D and Danilowicz, B.S., (2003) The influence of pre recruitment growth on subsequent growth and age at first spawning in Atlantic herring (*Clupea harengus* L.) ICES Journal of Marine Science, 60: 1103-1113

Burd, A. C. (1958). "An analysis of sampling the East Anglian herring catches." Journal du Conseil International Pour L'exploration de la Mer 24(1): 94 pp.

Burd, A. C. and J. Bracken (1965). "Studies on the Dunmore herring stock. 1. A population assessment." Journal du Conseil International Pour L'exploration de la Mer 29(3): 277-300.

Clarke, M. and Egan, A. (2008). Rebuilding Celtic Sea herring and the development of a long term management plan. ICES CM 2007 O:09.

Codling E and Kelly, C.J. (2005) F-PRESS: a stochastic simulation tool for developing fisheries management advice and evaluating management strategies. Irish Fisheries Investigation Series No. 17 2006 34pp ISSN 05787476

Corten, A, (1974) Recent changes in the stock of Celtic Sea herring {*Clupea harengus* L.) J. Cons. int. Explor. Mer, 35 (2): 194-201. Fevrier 1974.

Dalen, J. and Nakken, O. (1983) “On the application of the echo integration method”ICES CM 1983/B:19

Doonan, I. (2006). A review of herring acoustic surveys conducted by the Marine Institute. Galway : Marine Institute. Unpublished briefing document to MI>

Dransfeld, L (2006) From ecology to fisheries management: Celtic Sea Herring. Reports from the FSS mini symposia 2004 –2005

Du Buit, M.H. (1996). Diet of Hake (*Merluccius merluccius*) in the Celtic Sea. Fisheries Research 28: 381-394.

Farran, G. P. (1927). "The reproduction of *Calanus finmarchicus* off the south coast of Ireland." Journal du Conseil International Pour L'exploration de la Mer 2(2): 13 pp.

Farran, G. P. (1938). "On the size and numbers of the Ova of Irish Herrings." Journal du Conseil International Pour L'exploration de la Mer 13(1).

Grainger, R. J., Barnwall, Cullen, A. (1982). "Herring larval surveys in the Celtic Sea in 1981/82." ICES CM H:38: 16 pp.

Grainger, R.J.R. (1983) Managing the recovery of the Celtic Sea and Division VIIj herring stock ICES CM:1983 H:30

Grainger, R. J., E. Barnwall, Cullen, A (1984). "Herring larval surveys in the Celtic Sea and Division VIIj in 1983/1984." ICES CM H:29: 14 pp.

Hay, D.E. *et al* 2001. Taking Stock: An Inventory and Review of World Herring Stocks in 2000. Herring Expectations fro a new Millennium, Alaska Sea Grant College Program. AK-SG-04, 2001

Hatfield *et al*, 2007 (WESTHER, Q5RS-2002-01056): A multidisciplinary approach to the identification of herring (*Clupea harengus* L.) stock components west of the British Isles using biological tags and genetic markers.

ICES (1982). Report of the Herring Assessment Working Group South of 62ºN (HAWG) - Part 2 of 2. Copenhagen, ICES: 18 pp

ICES (1983). Report of the Herring Assessment Working Group South of 62ºN (HAWG) ICES C.M. 1983/Assess:9

ICES (1990). Report of the Herring Assessment Working Group South of 62ºN (HAWG) ICES C.M. 1990/Assess:14

ICES 1992. Report of the Herring Assessment Working Group for the Area South of 62°N. ICES CM 1996/Assess:11.

ICES (1994). Report of the Study group on Herring Assessment and Biology in the Irish Sea and Adjacent Waters. Belfast, Northern Ireland, ICES CM 1994/H:5

ICES (1994b). Herring assessment working group for the Area South of 62ºN. ICES CM 1994/Assess:13

ICES (1995). Report of the Herring Assessment Working Group South of 62ºN (HAWG) ICES C.M. 1995/Assess:13

ICES (1996). Report of the Herring Assessment Working Group South of 62ºN (HAWG) ICES C.M. 1996/Assess:10

ICES (1997). Report of the Herring Assessment Working Group South of 62ºN (HAWG) ICES C.M. 1997/Assess:8

ICES (1999). Report of the Herring Assessment Working Group South of 62ºN (HAWG) ICES C.M. 1999/ACFM:12

ICES (2000). Herring assessment working group for the Area South of 62ºN (HAWG) ICES CM 2000/ACFM:10

ICES (2001) Report on the study group on the further development of the precautionary approach to fishery management. ICES CM:2001/ACFM:11.

ICES (2002).Report of the Herring Assessment Working Group South of 62ºN (HAWG) ICES CM:2002/ACFM:12.

ICES 2003. Report of the Study Group on Precautionary Reference Points for Advice on Fishery Management. ICES CM 2003/ACFM:15.

ICES (2004).Report of the Herring Assessment Working Group South of 62ºN (HAWG) ICES CM:2004/ACFM:18.

ICES (2005): Report of the ICES Advisory Committee on Fishery Management, Advisory Committee on the Marine Environment and Advisory committee on Ecosystems. Volume 5. Avis du Ciem

ICES (2005b) Herring Assessment Working Group for the Area South of 62ºN (HAWG). ICES CM 2005/ACFM: 16

ICES (2005c): Report of the Study group on Regional Scale Ecology of Small Pelagics (SGPESP) ICES CM:2005/G:06

ICES (2006a). Report of working group for regional ecosystem description (WGRED). ICES CM 2006/ACE:03.

ICES (2006). Herring Assessment Working Group for the Area South of 62ºN (HAWG). ICES CM 2006/ACFM: 20

ICES (2007). Report of the Herring Assessment Working Group South of 62ºN (HAWG). Copenhagen, ICES CM/2007/ACFM:11: 546 pp.

ICES (2007b). Report of the Working Group for Regional Ecosystem description (WGRED). ICES:CM/2007 ACE:02

ICES (2008). Report of the Herring Assessment Working Group South of 62ºN (HAWG). Copenhagen, ICES CM/2008/ACOM:02: 613 pp.

Johnston, G and Clarke, M. (2005) An exploration of the Irish groundfish survey as a recruit index for Celtic Sea Herring. Working Document 20: ICES Herring Assessment Working Group 2005.

Kelly, C.J., Campbell, A., (2006). Use of FPRESS in Celtic Sea Herring. Marine Institute Internal Briefing Document.

Lynch, D. (2011). Long term changes in the biology of Celtic Sea Herring . MSc. Thesis, Trinity College Dublin.

Nash, R. and Dickey-Collas, M. (2005). The influence of life history dynamics and environment on the determination of year class strength in North Sea herring (*Clupea harengus* L.). Fisheries Oceanography, 14: 279–291.

Molloy, J. (1968). Herring Investigations on the Southwest Coast of Ireland, 1967. ICES CM:68/H:14

Molloy, J. (1969). A review of the Dunmore East herring fishery (1962-1968). Irish Fish. Invest., Series B (Marine) 6: 21 pp.

Molloy, J. (1972). "Herring fisheries on the south and south - west coasts 1971 - 1972." Fisheries Leaflet 37: 13 pp.

Molloy, J (1979). Fecundities of Celtic Sea Autumn and Winter Spawning Herring. ICES CM/H:47

Molloy, J. (1980). The assessment and management of the Celtic Sea herring stock. ICES Marine Science Symposia. 1980. 177: 159-165.

Molloy, J., Cullen, A. (1981). "The fat content of Irish herring." Fisheries Leaflet(107).

Molloy, J. (1984). "Density dependent growth in Celtic Sea herring." ICES CM 1984/H:30: 13 pp.

Molloy, J. (1989) The closure of herring spawning grounds in the Celtic Sea and Division VIIj. Fisheries Leaflet 145: 5pp

Molloy, J., Barnwall, E., Morrison, J (1993). "Herring tagging experiments around Ireland, 1991." Fisheries Leaflet(154): 7 pp.

Molloy, J. (1995). The Irish herring fisheries in the twentieth century: their assessment and management. Occasional Papers in Irish Science and Technology, Royal Dublin Society: 1-16.

Molloy, J., 2006. The Herring Fisheries of Ireland (1990 – 2005), Biology, Research, Development and Assessment.

Morizur, Y., S. D. Berrow, et al. (1999). "Incidental catches of marine-mammals in pelagic trawl fisheries of the northeast Atlantic." Fisheries Research 41(3): 297-307.

Patterson, K.R. (1998). Integrated Catch at Age Analysis Version 1.4. Scottish Fisheries Research Report. No. 38

Patterson, K.R., (1998b) A programme for calculating total international catch at age and weight at age. Marine Laboratory Aberdeen.

Pinnegar, J.K., Jennings, C., O Brien, M., Polunin, N.C.V. (2002) Long term, changes in the trophic level of the Celtic Sea fish community and fish market price distribution. Journal of Applied Ecology 39, 377 – 390

Skagen, D.W. 2003. Programs for stochastic prediction and management simulation (STPR3 and LTEQ). Program description and instruction for use. WD at HAWG 2003.

Smith, 2000 Multi Fleet Deterministic Projection. Unpublished document.

STECF (2006) Commission Staff Working Paper, 23rd Report of the Scientific, Technical and Economic Committee for Fisheries, Second Plenary, November 2006.

Whooley, P., Berrow, S. & Barnes, C. 2011 Photo-identification of fin whales (*Balaenoptera physalus* L.) off the south coast of Ireland. *Marine Biodiversity Records* **4**, 1-7.

http://flr-project.org/

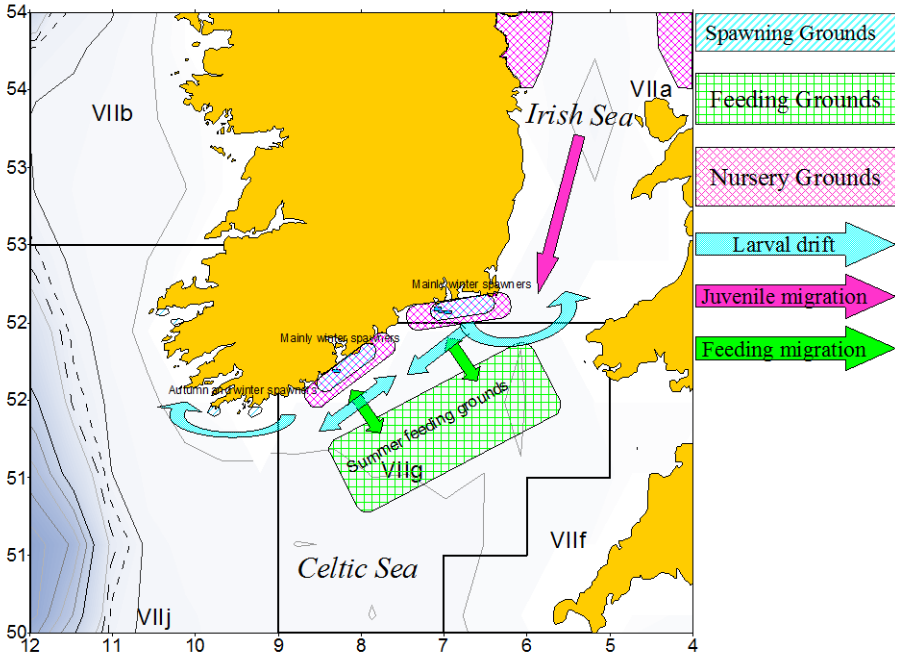


Figure 1. Herring in the Celtic Sea. Schematic presentation of the life cycle of Celtic Sea and VIIj Herring (ICES, 2005c, SGRESP).

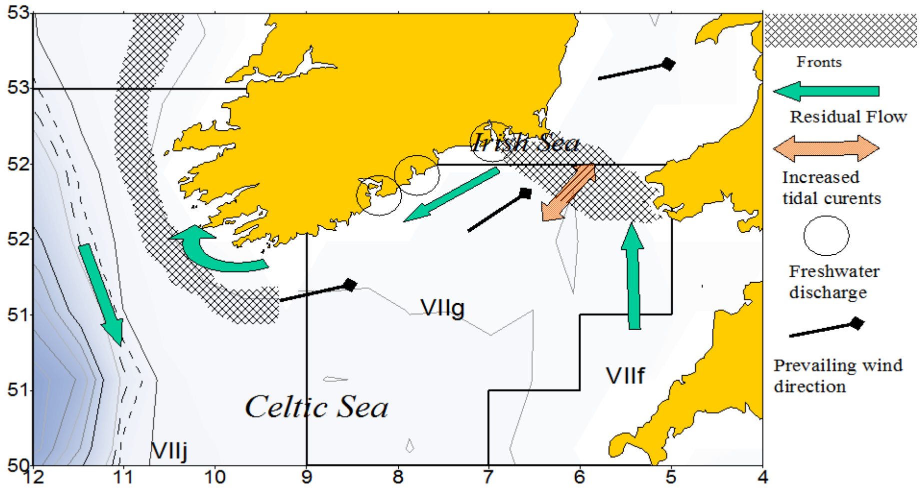


Figure 2. Herring in the Celtic Sea. Schematic presentation of prevailing oceanographic conditions in the Celtic Sea and VIIj (ICES, 2005c, SGRESP).

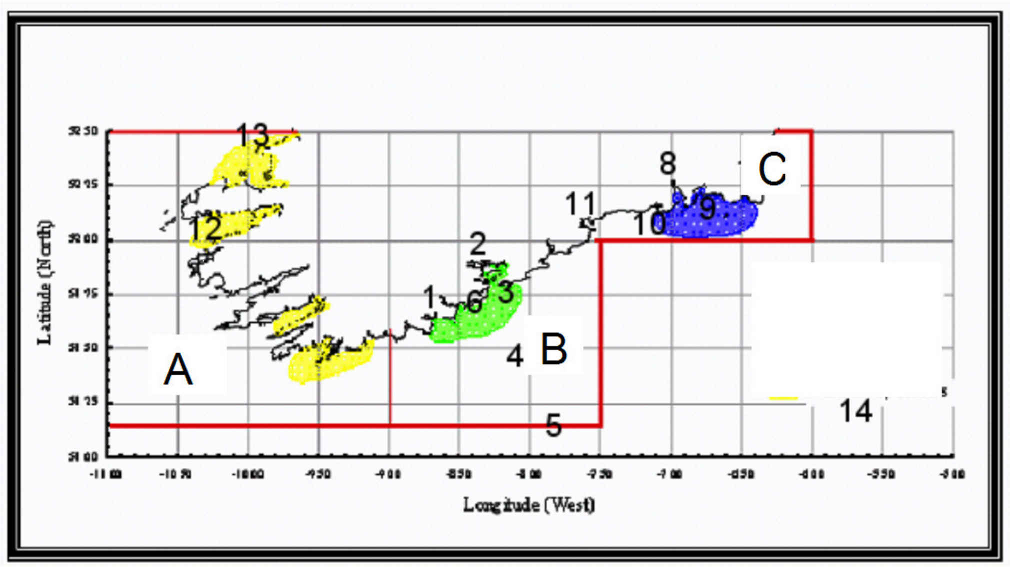


Figure 3. Herring in the Celtic Sea. Areas mentioned in the text and spawning boxes A, B and C, south of Ireland. One of these boxes is closed each season, under EU legislation. 1 Courtmacsherry, 2 Cork Harbour, 3 Daunt Rock, 4 Kinsale Gas Field (Rigs), 5 Labadie Bank, 6 Kinsale, 8 Waterford Harbour, 9, Baginbun Bay, 10, Tramore Bay/ Dunmore East, 11, Ballycotton Bay, 12, Valentia Island, 13 Kerry Head to Loop Head, 14, The Smalls. The spawning boxes A-C correspond to ICES Divisions VIIj, VIIg and VIIaS respectively.

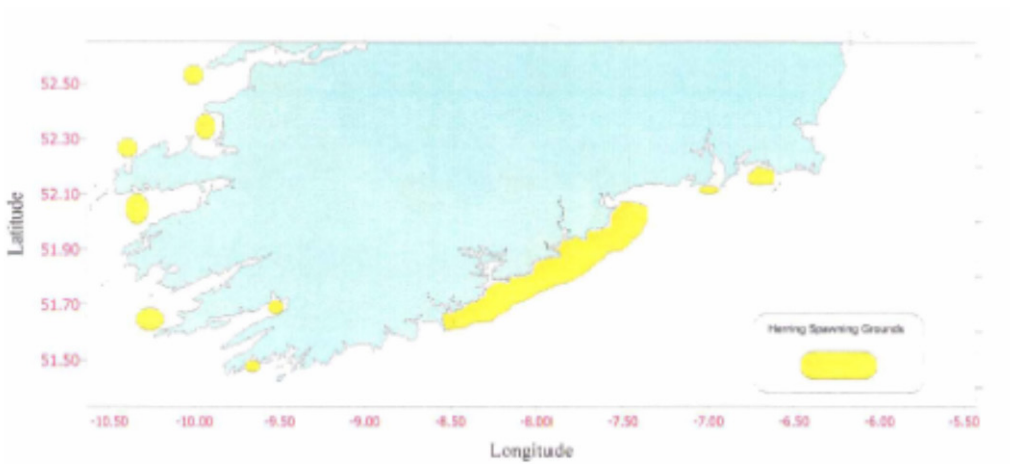


Figure 4. Herring in the Celtic Sea. Spawning ground of herring along the south coast of Ireland, inferred from information on the Irish herring fishery (Breslin, 1998).

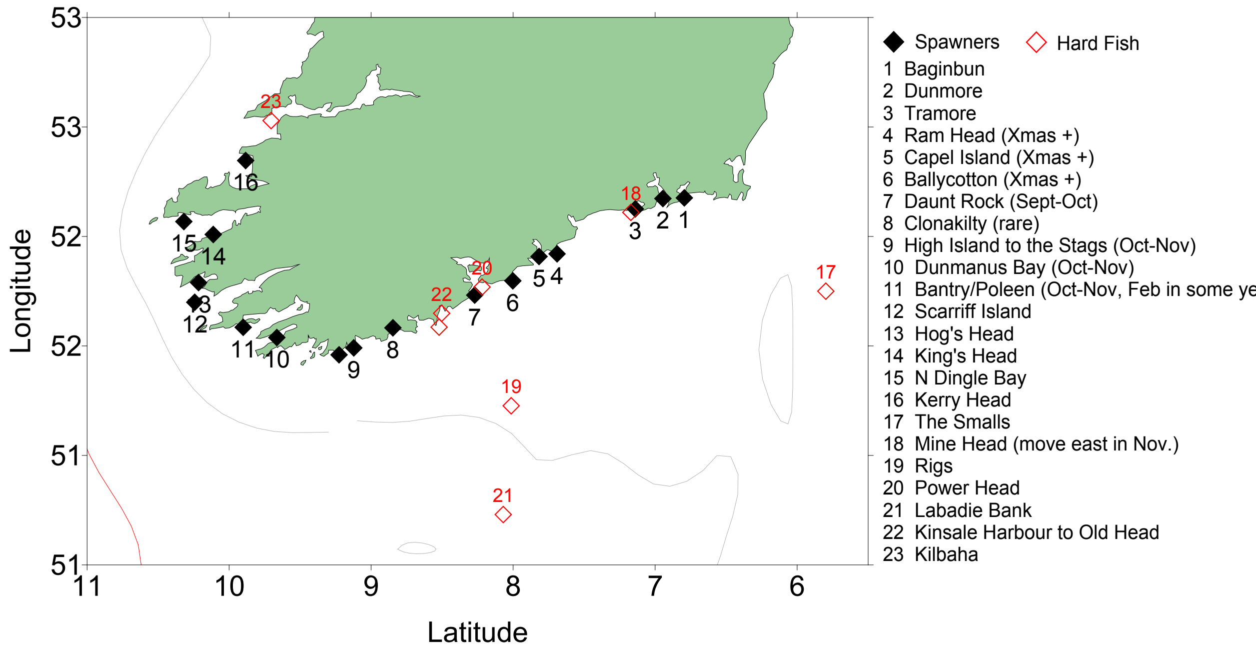


Figure 5. Herring in the Celtic Sea. Location of spawning (closed symbol) and non spawning (open symbol) herring in the Celtic Sea and SW of Ireland, based on expert fishemens' knowledge.

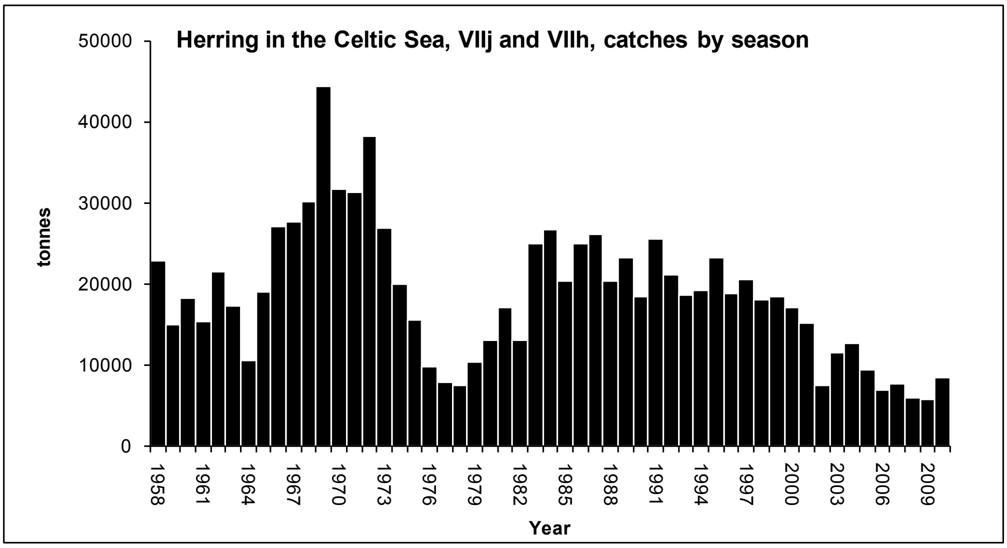


Figure .6. Herring in the Celtic Sea. ICES estimates of herring catches (tonnes) per season 1958/1959 to 2010/2011.

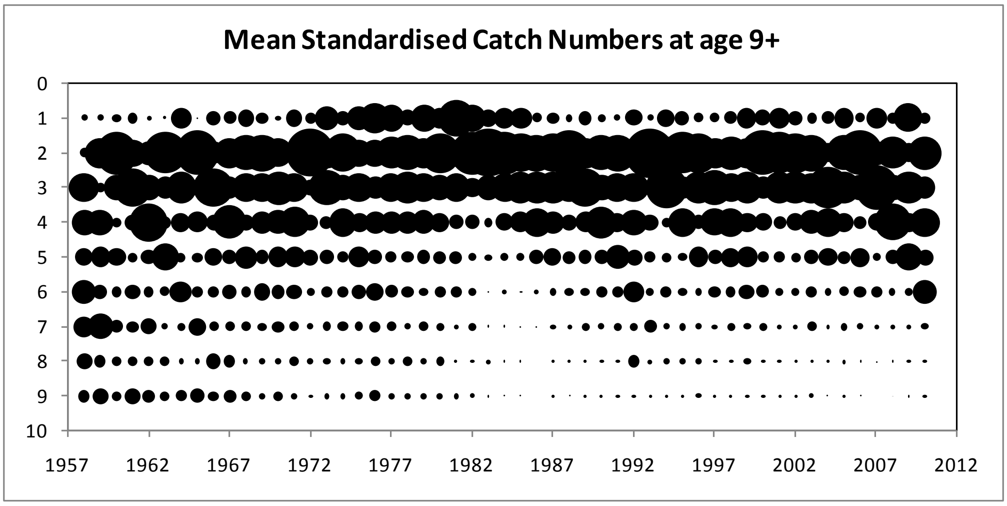


Figure 7. Herring in the Celtic Sea. Catch numbers at age standardised by yearly mean. 9+

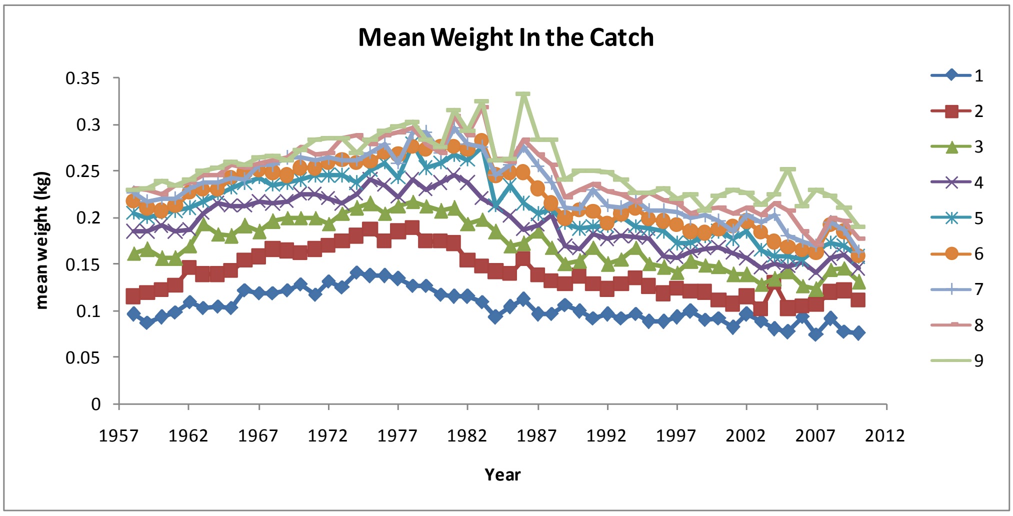


Figure 8. Herring in the Celtic Sea. Trends over time in mean weights in the catch.

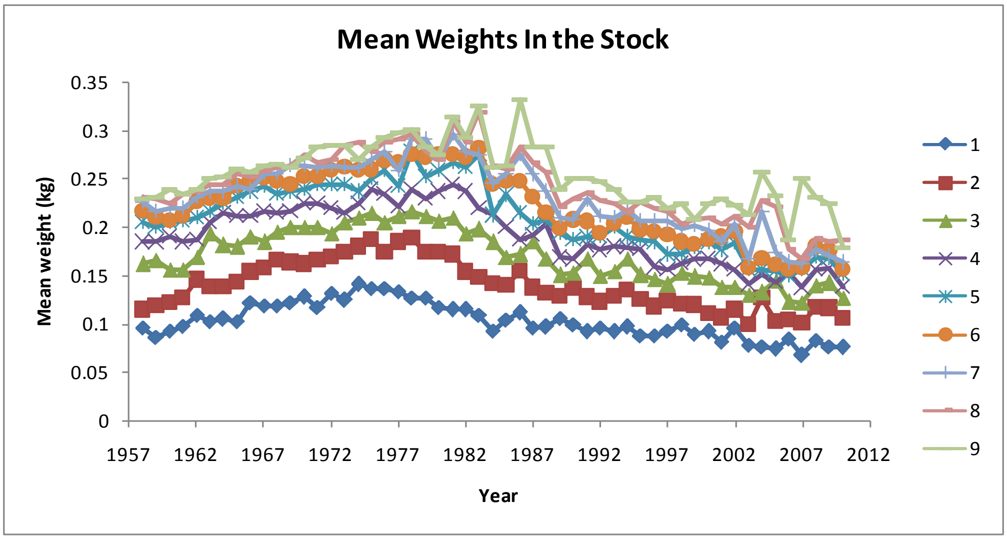


Figure 9. Herring in the Celtic Sea. Trends over time in mean weights in the stock at spawning time.

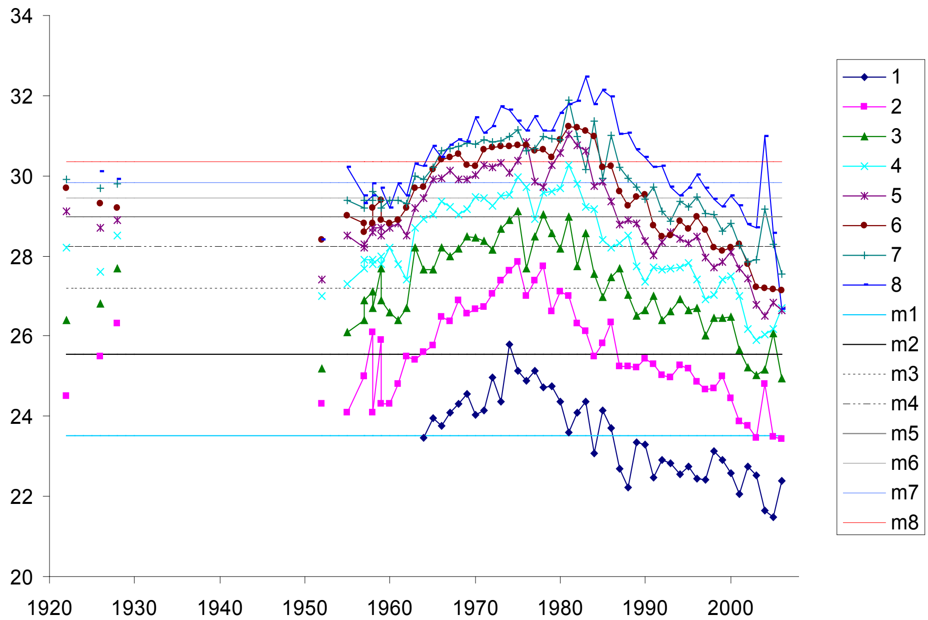


Figure 10. Herring in the Celtic Sea. Mean length at age from historic sources (Burd et al, 1965) and references therein. Data from 1964 onwards are Irish data. Long term means are shown for each age and are labelled m1-m8. The data from the 1920s are depicted as single years though they represent a group of years (Lynch, 2011).

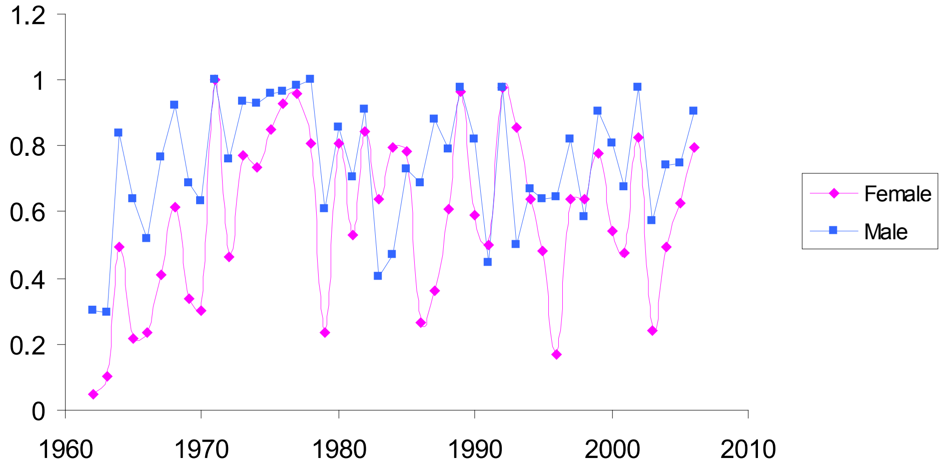
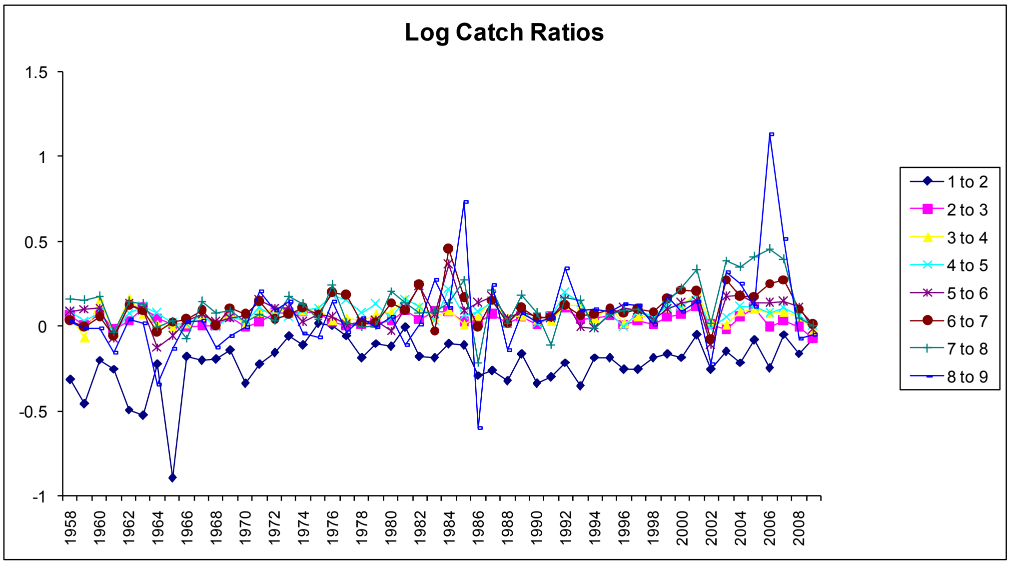


Figure 11: Herring in the Celtic Sea. Percentage maturity in males and females at 1 winter ring (Lynch, 2011).



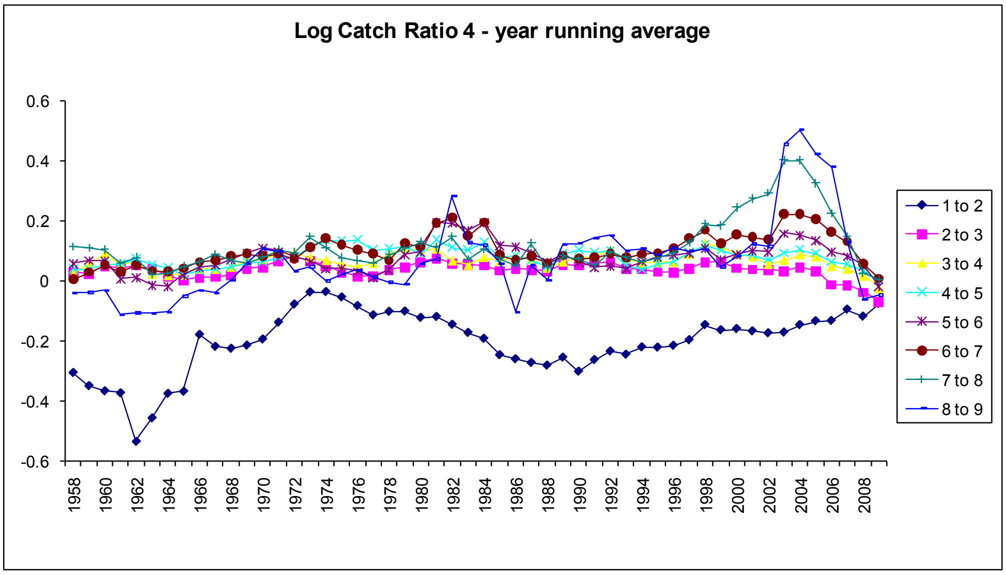


Figure 12. Herring in the Celtic Sea. Log catch ratios (above) and log catch ratios smoothed with a 4 year moving average for each age group for the time series 1958-2010.

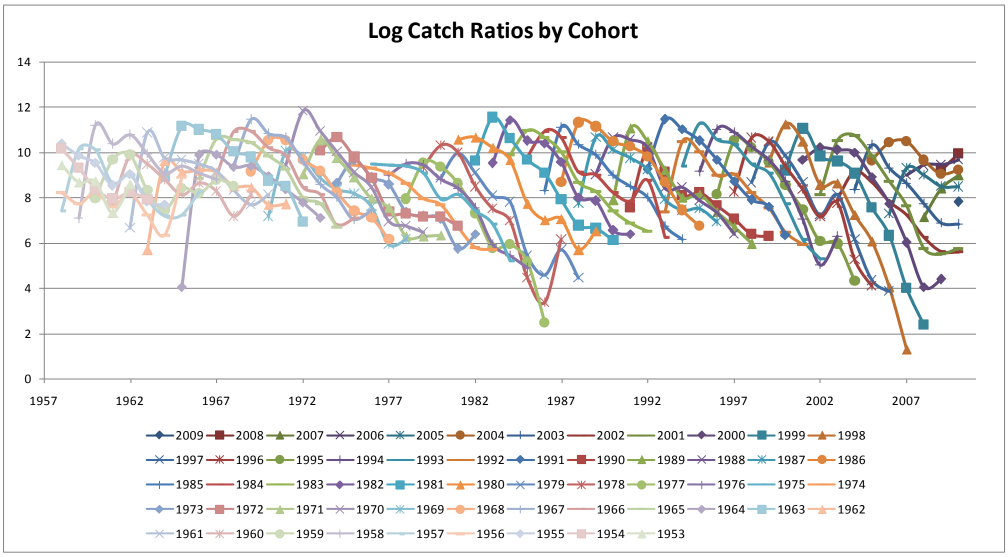


Figure 13. Herring in the Celtic Sea. Log Catch Ratios by cohort

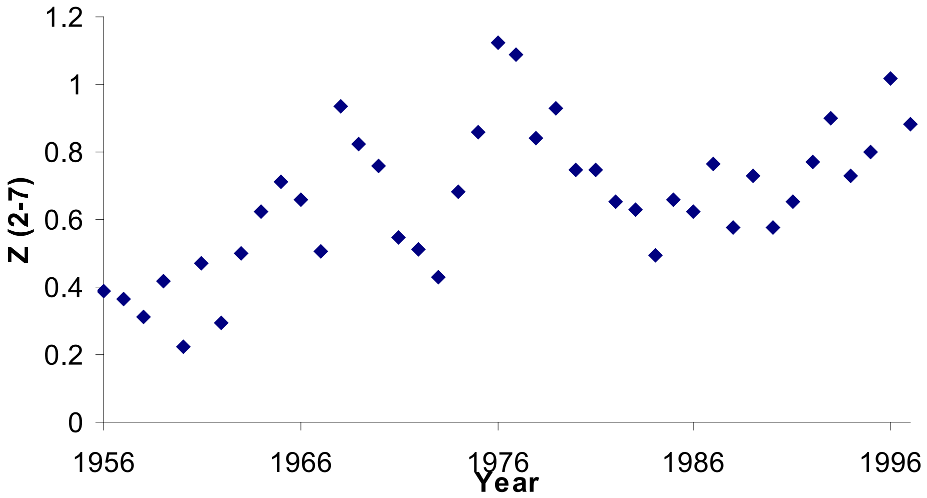


Figure 14: Herring in the Celtic Sea. Total mortality (Z) estimated from cohort catch curves (2-7 ringer) for cohorts 1958 to 1997.

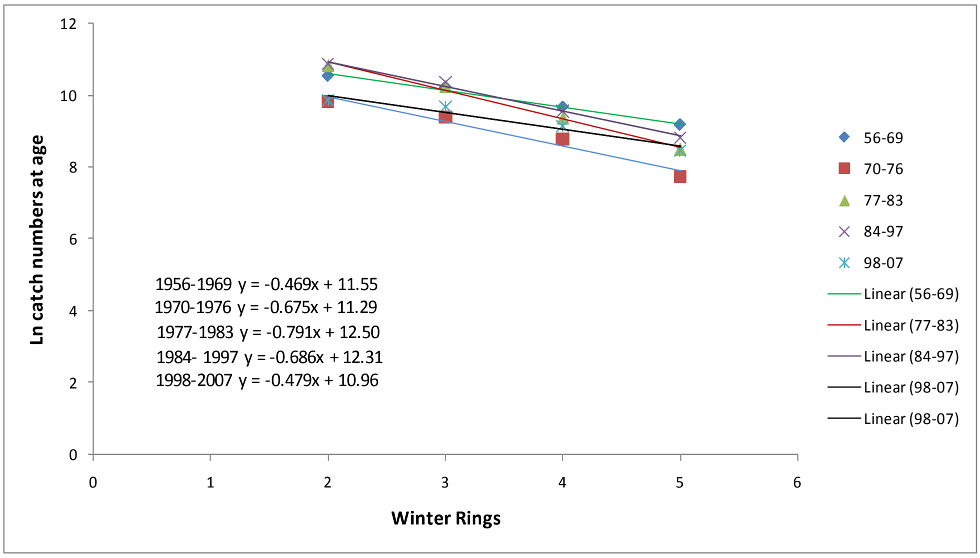


Figure 15. Herring in the Celtic Sea. Cohort catch curves (2-5 ringer), averaged over several year classes, from catch at age data.

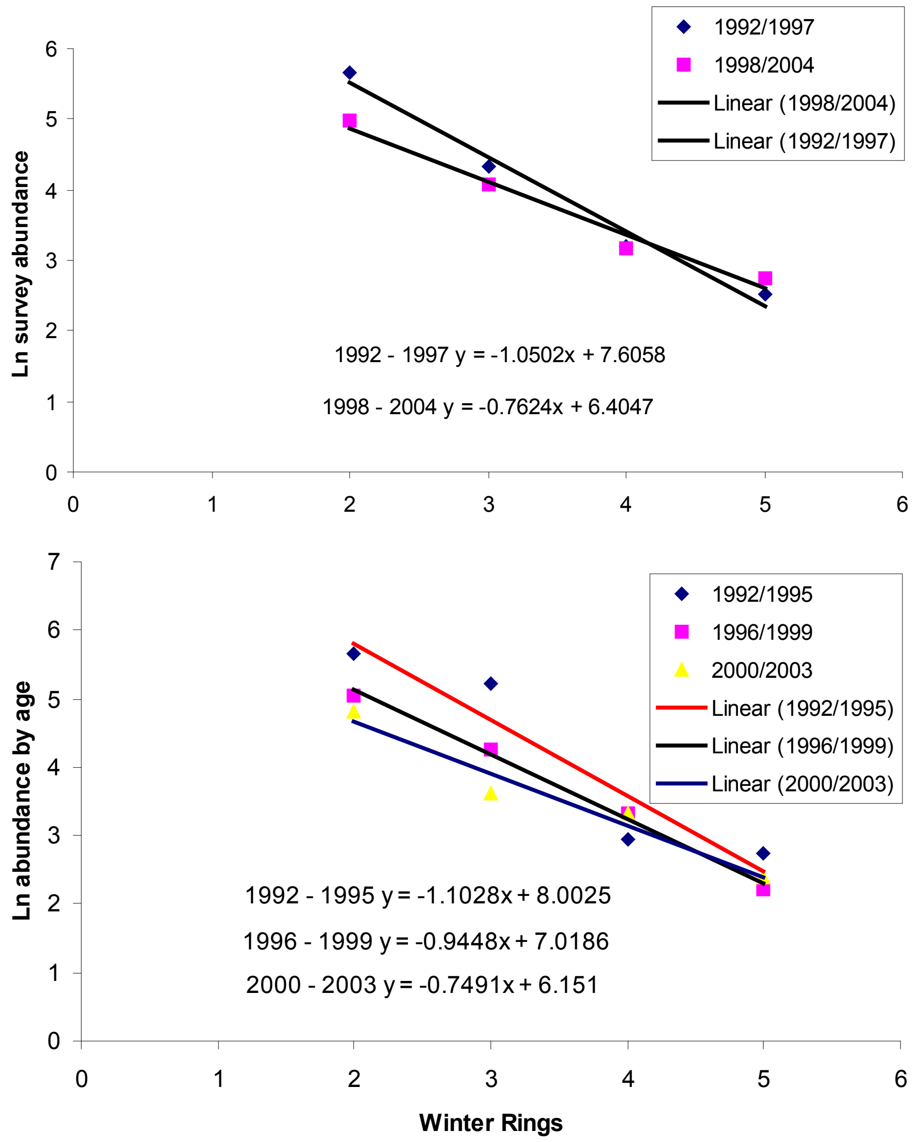


Figure 16. Herring in the Celtic Sea. Cohort catch curves (2-5 ring) based on acoustic survey abundance. Upper panel shows means for two periods, and below for three time periods, over the same series of surveys

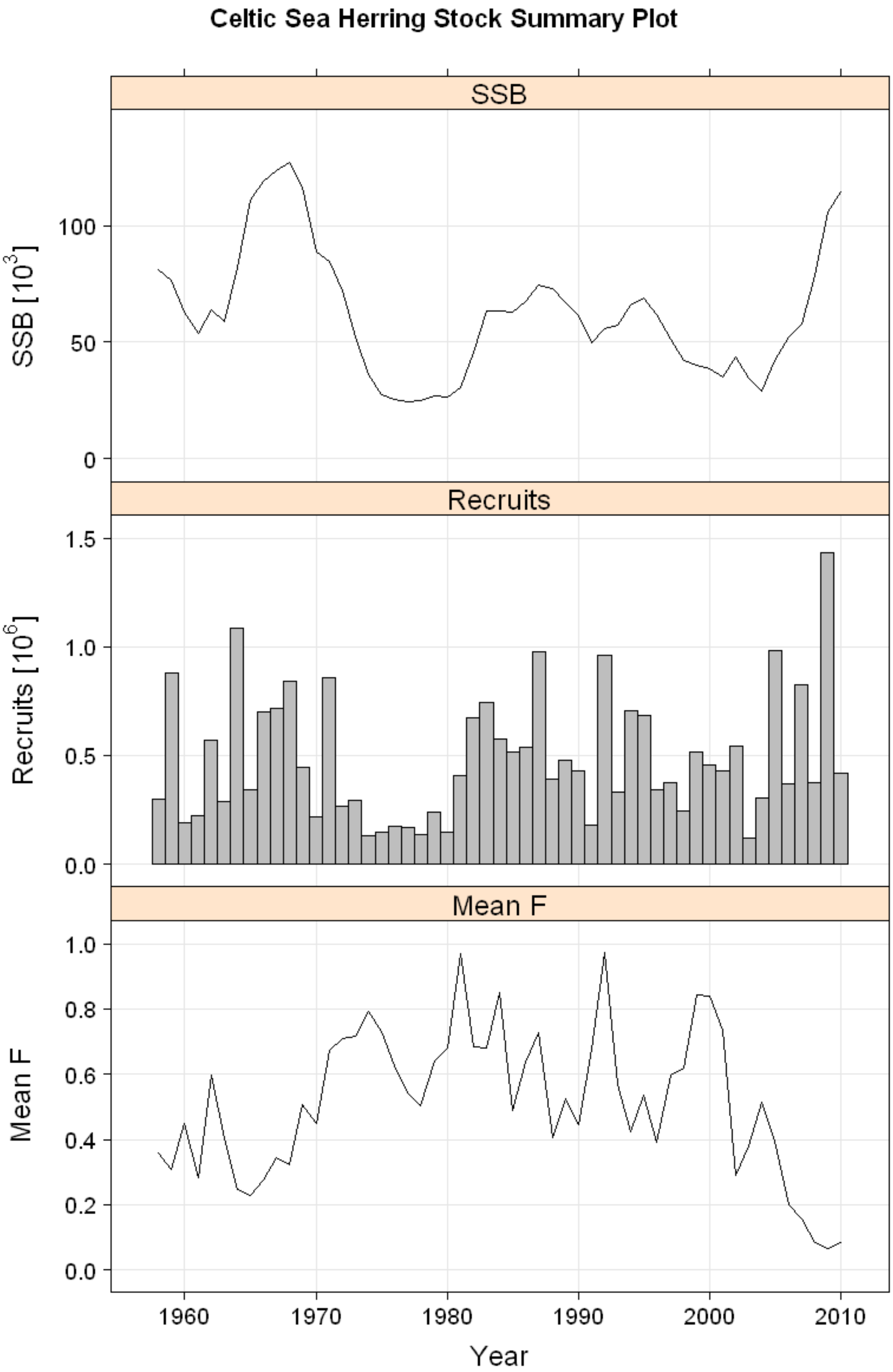


Figure 17. Herring in the Celtic Sea. SSB, F and recruitment (1-ringer) from the final assessment in 2011.

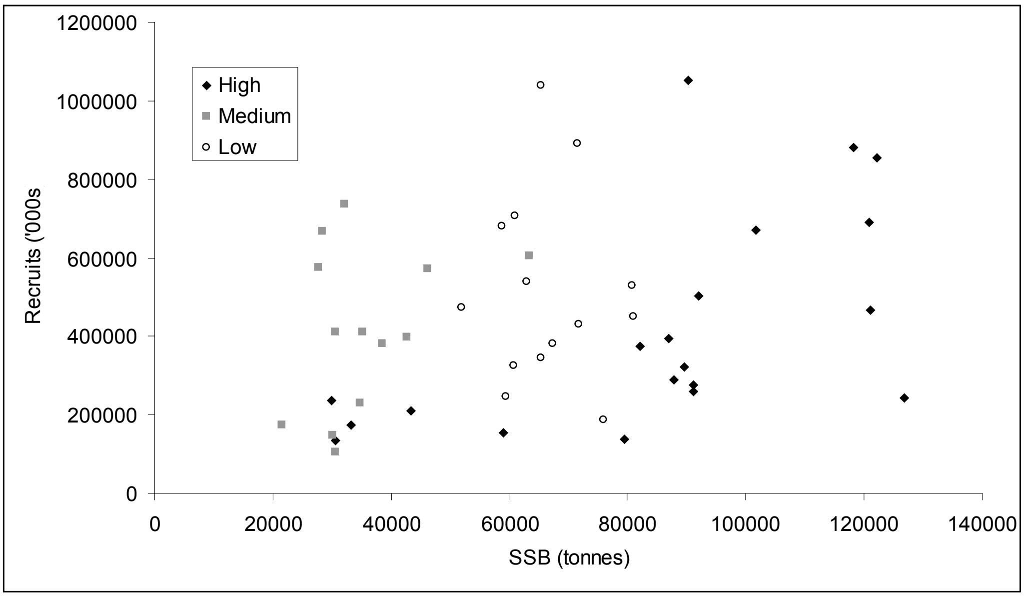


Figure 18. Herring in the Celtic Sea. Stock recruit relationship from ICA base case runs. Data classified according to quality of input data, see Table 4.

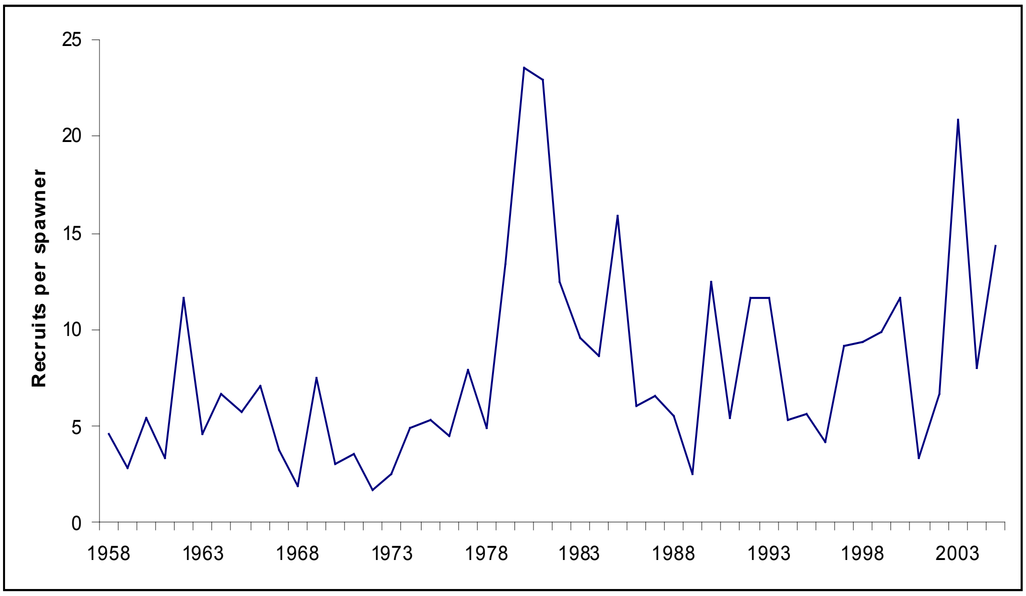


Figure 19. Herring in the Celtic Sea. Recruits per spawner, in '000s/tonnes

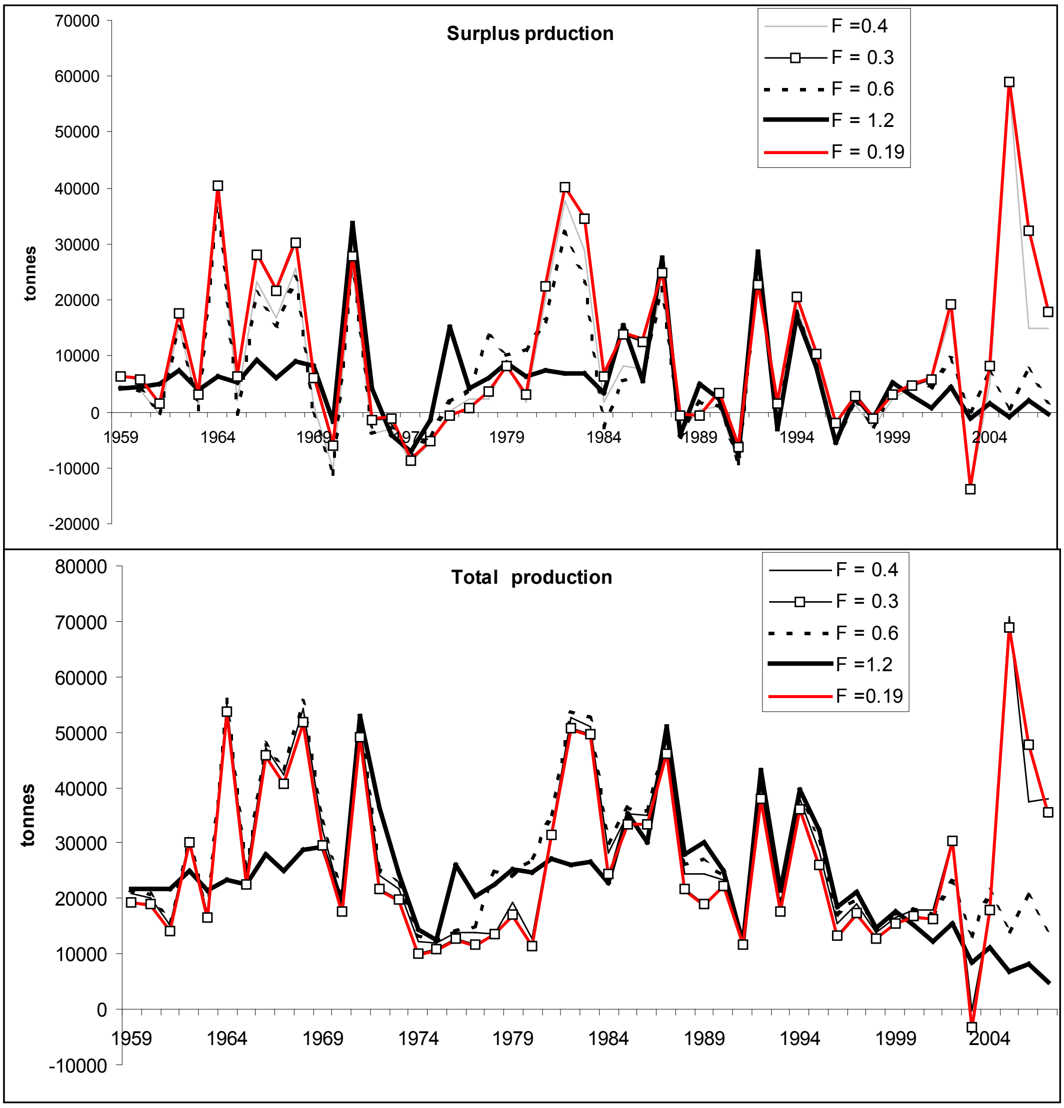


Figure 20. Herring in the Celtic Sea. Total and surplus production in the time series over a range of fishing mortalities.

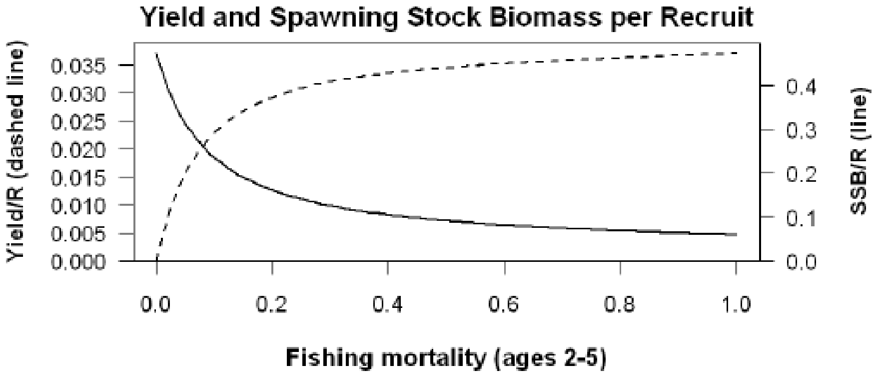


Figure 21. Herring in the Celtic Sea. Yield per recruit carried out in 2011.

Table 1. Herring in the Celtic Sea. Acoustic surveys of Celtic Sea and VIIj herring, by season. Number of surveys per season and type indicated along with biomass and SSB estimates. Shaded sections show surveys not used in tuning, in most recent assessment.

Season	No.	Type	Survey Timing	SSB
1990/1991	2	Autumn and winter spawners	Oct and Jan/Feb	-
1991/1992	2	Autumn and winter spawners	Nov/Dec and Jan	-
1992/1993	2	Autumn and winter spawners	Nov and Jan	-
1993/1994	2	Autumn and winter spawners	Nov and Jan	-
1994/1995	2	Autumn and winter spawners	Nov and Jan	-
1995/1996	2	Autumn and winter spawners	Nov and Jan	36
1996/1997	1	Autumn and winter spawners	Oct/Nov and Jan	151
1997/1998	-	No survey		-
1998/1999	1	Autumn spawners	Nov and Jan	100
1999/2000	1	Feeding phase	July	-
1999/2000	1	Winter-spawners	Nov and Jan	-
2000/2001	2	Autumn and winter spawners	Oct and Jan	20
2001/2002	2	Pre-spawning	Sept and Oct	95
2002/2003	1	Pre-spawning	Sept/Oct	41
2003/2004	1	Pre-spawning	Oct/Nov	20
2004/2005	1	Pre-spawning	Nov/Dec	-
2005/2006	1	Pre-spawning	Oct	33
2006/2007	1	Pre-spawning	Oct	36
2007/2008	1	Pre-spawning	Oct	46
2008/2009	1	Pre-spawning	Oct	90
2009/2010	1	Pre-spawning	Oct	91
2010/2011	1	Pre-spawning	Oct	122

Table 2. Herring in the Celtic Sea. Original acoustic survey abundance at age as used by ICES until HAWG 2006.

	1990 1991	1991 1992	1992 1993	1993 1994	1994 1995	1995 1996	1996* 1997	1997 1998	1998* 1999	1999** 2000	1999 2000	2000 2001	2001 2002	2002 2003	2003 2004	2004 2005	2005 2005	2006 2007
0	205	214	142	259	41	5	3	-	-	13	-	23	19	0	25	26	13	-
1	132	63	427	217	38	280	134	-	21	398	23	18	30	41	73	13	54	21
2	249	195	117	438	127	551	757	-	157	208	97	143	160	176	323	29	125	211
3	109	95	88	59	160	138	250	-	150	48	85	36	176	142	253	32	26	48
4	153	54	50	63	11	94	51	-	201	8	16	19	40	27	61	16	50	14
5	32	85	22	26	11	8	42	-	109	1	21	7	44	6	16	3	20	11
6	15	22	24	16	7	9	1	-	32	1	8	3	23	8	5	1	5	1
7	6	5	10	25	2	8	14	-	30	0	2	2	17	3	2	0	1	-
8	3	6	2	2	3	9	1	-	4	0	1	0	11	0	0	0	-	-
9+	2	-	1	2	1	5	2	-	1	0	0	1	23	0	0	0	-	-
Total	904	739	882	1107	399	1107	1253		705	677	252	250	542	404	758	119	292	305
Biomass (000't)	103	84	89	104	52	135	151		111	58	30	33	80	49	89	13	33	37
SSB (000't)	91	77	71	90	51	114	146		111	23	26	32	74	39	86	10	30	36

* Autumn survey

** Summer survey

Table 3. Herring in the Celtic Sea. Revised acoustic series as used by HAWG.

	2002 2003	2003 2004	2004 2005	2005 2006	2006 2007	2007 2008	2008 2009	2009 2010	2010 2011
0	0	24	-	2	-	1	99	239	5
1	42	13	-	65	21	106	64	381	346
2	185	62	-	137	211	70	295	112	549
3	151	60	-	28	48	220	111	210	156
4	30	17	-	54	14	31	162	57	193
5	7	5	-	22	11	9	27	125	65
6	7	1	-	5	1	13	6	12	91
7	3	0	-	1	-	4	5	4	7
8	0	0	-	0	-	1		6	3
9	0	0	-	0	-	0		1	
							-		
Abundance	423	183	-	312	305	454	769	1,147	1,414
SSB	41	20	-	33	36	46	90	91	122
CV	49	34	-	48	35	25	20	24	20
Design	AR	AR		R	R	R	R	R	R

Table 4. Herring in the Celtic Sea. Rudimentary history of the Irish fishery since 1958.

Time period	1958-1977	1977-1983	1983-1997	1998-2004	2004-2007
Type of fishery	Cured fish	Closure	Herring roe	Fillet/whole fish	Fillet/whole fish
Quality of catch data	High	Medium	Low	Medium/low	High
Source of catch data	Auction data	Auction data	Skipper logbook estimate	Skipper logbook estimate	Weighbridge landings
Discard Levels	Low	Low	High	Medium	Medium
Incentive to discard	None	None	Maturity stage	Size grade, market	vs. quota
Alloowance for water*	na	na	na	20%*	2%*

*** RSW only. These vessels are more dominant in recent years.**

Table 5. Herring in the Celtic Sea. Biological history of the stock.

	1958-1972	1973-1977	1978-1980	1981-1983	1984-1995	1996-2008
MW 2-ring (kg) median	0.146	0.181	0.179	0.158	0.135	0.115
ML 2-ring (cm) median	26.4	27.5	27.1	26.3	25.2	24.4
Z (cohort catch curve)	0.22 - 0.93	0.42 - 1.12	0.74 - 0.93	0.62 - 0.74	0.49 - 0.89	0.48 - 1.01
GM recruitment 10^6	448	167	168	587	514	340
Recruitment anomaly	positive	negative	negative	positive	positive	both
SSB (000 t)	53 - 126	27 to 52	25 - 26	30 - 63	49 - 68	24 - 70
F (2-5 r)	0.23 - 0.71	0.55 - 0.80	0.50 - 0.68	0.68 - 0.87	0.40 - 0.98	0.12 - 0.88

Table 6. Celtic Sea and VIIj herring. Total mortality Z estimated from cohort catch curves.

Cohort	Z (2-7 ring)	Cohort	Z (2-7 ring)
1956	0.39	1977	1.09
1957	0.37	1978	0.84
1958	0.31	1979	0.93
1959	0.42	1980	0.75
1960	0.22	1981	0.75
1961	0.47	1982	0.65
1962	0.30	1983	0.63
1963	0.50	1984	0.50
1964	0.62	1985	0.66
1965	0.71	1986	0.62
1966	0.66	1987	0.76
1967	0.51	1988	0.58
1968	0.93	1989	0.73
1969	0.82	1990	0.57
1970	0.76	1991	0.65
1971	0.55	1992	0.77
1972	0.51	1993	0.90
1973	0.43	1994	0.73
1974	0.68	1995	0.80
1975	0.86	1996	1.02
1976	1.12	1997	0.88

Table 7. Celtic Sea and VIIj herring. Estimates of estimates of $F_{0.1}$, F_{max} and F_{msy} from the literature and HAWG work.

	$F_{0.1}$	F_{max}	F_{msy}	MSY	Comments	Reference
1965	-	>0.5		12 – 15 000 t	Years for calculation had lower recruitment	Burd and Bracken, 1965
1969	-	~0.45		22 000 t	Years for calculation had higher recruitment	Molloy, 1969
1974	-	>0.5		14 000 *	Fmsy calculated for periods of high and low recruitment	Corten, 1974
1983	0.16				Yield/Biomass ratio	HAWG, 1983
1990	0.16					HAWG, 1990
1994	0.16					HAWG, 1994
1995	0.16					HAWG, 1995
1996	0.16					HAWG, 1996
1997	0.1					HAWG, 1997
1999	<0.2					HAWG, 1999
2000	<0.2					HAWG, 2000
2002	0.17				MFYPR software	HAWG, 2002
2003	0.17				MFYPR software	HAWG, 2003
2004	0.17				MFYPR software	HAWG, 2004
2007	0.19				MFYPR software	HAWG, 2007
2009	0.17				MFYPR software	HAWG 2009
2010	0.18		0.25		HCS 10 Software	HAWG 2010
2011	0.17				FLR	HAWG 2011

*endorses Molloy (1969) provided that recruitment is at level 1966 – 1969

Table 8 Celtic Sea and VIIj herring. Advice history.

Year	ICES Advice	Predicted catch to corresp to advice	Agreed TAC	Official Landings	Discards	Estimated Catch[1]
1974	NEAFC TAC		32	20	-	19.74
1975	Reduce F, TAC ≤ 25,000		25	16	-	15.13
1976	TAC between 10,000 and 12,000		10.8	10	-	8.2
1977	No Fishing	0	0	8	-	7.1
1978	No Fishing	0	0	8	-	15.5
1979	TAC set for VIIj only, No fishing in Celtic Sea	0	6	10	-	12.1
1980	TAC set for VIIj only, No fishing in Celtic Sea		6	9	-	9.2
1981	TAC set for VIIj only, No fishing in Celtic Sea		6	17	-	16.8
1982	TAC		8*	10	-	9.5
1983	TAC		8*	22	4	22.18
1984	TAC	13	13	20	3.6	19.7
1985	TAC	13	13	16	3.1	16.23
1986	No specific TAC, preferred overall catch 17,000t		17	13	3.9	23.3
1987	Precautionary TAC	18	18	18	4.2	27.3
1988	TAC	13	18	17	2.4	19.2
1989	TAC	20	20	18	3.5	22.7
1990	TAC	15	17.5	17	2.5	20.2
1991	TAC (TAC excluding discards)	15 (12.5)	21	21	1.9	23.6
1992	TAC	27	21	19	2.1	23
1993	Precautionary TAC (including discards)	20–24	21	20	1.9	21.1
1994	Precautionary TAC (including discards)	20–24	21	19	1.7	19.1
1995	No specific advice	-	21	18	0.7	19
1996	TAC	9.8	16.5–21	21	3	21.8
1997	If required, precautionary TAC	< 25	22	20.7	0.7	18.8
1998	Catches below 25	< 25	22	20.5	0	20.3
1999	F = 0.4	19	21	19.4	0	18.1
2000	F < 0.3	20	21	18.8	0	18.3
2001	F < 0.34	17.9	20	19	0	17.7
2002	F<0.35	11	11	11.5	0	10.5
2003	Substantially less than recent catches	-	13	12	0	11
2004	60% of average catch 1997–2000	11	13	12	-	11
2005	60% of average catch 1997–2000	11	13	10	-	8
2006	Further reduction 60% avg catch 2002–2004	6.7	11	9	-	8.5
2007	No fishing without rebuilding plan	--	9.4	9.6	-	8.3
2008	No targeted fishing without rebuilding plan	--	7.9	7.8	-	6.9
2009	No targeted fishing without rebuilding plan		5.9	6.2	-	5.8
2010	Fmgt 0.19	10.15	10.15			
2011	See scenarios					

*** TAC from 1st Oct – 31st Mar**

1) Calendar year

Annex 6 – Stock Annex Herring in VIaN

Quality Handbook	ANNEX: Hawg-her47d3

Stock specific documentation of standard assessment procedures used by ICES.

Stock:	Herring in VIa (North)
Working Group:	Herring Assessment WG for the Area south of 62°N
Date:	18 March 2013
Authors:	E.M.C. Hatfield, E.J. Simmonds and A. Edridge

The section on short term forecast has been updated in 2012 to reflect the changes recommended by the 2011 Advice Drafting Group in 2010. Advice is now based on the average Fsq of the last three years in the assessment

A. General

A.1. Stock definition

The stock is distributed over ICES Division VIa (N). Some of the larger adults typically found close to the shelf break may be caught in division Vb.

A.2. Fishery

The dominant fleet fishing in VIa (N) since 1957 has been the Scottish fleet. In the early years the Scottish fishery was prosecuted using a mixture of vessel size and gear, including gill nets, ring-nets and trawls. The boats were small, and targeted the coastal stock, primarily fishing in the winter. Until 1970 the only other nations fishing in this area on a regular basis were the former German Federal Republic, and to a much lesser extend the Netherlands. These fleets operated in deeper water near the shelf edge.

In 1970 a large increase in exploitation occurred with the entry of fleets from Norway and the Faroes, and an increased Netherlands catch. In addition, considerably smaller catches were taken by France and Iceland.

Throughout this period juvenile herring catches from the Moray Firth, in the north-east of Scotland, were included in the VIa catch figures, as tagging programs showed there to be some links between herring spawning to the west of Scotland and the Moray Firth juveniles.

Prior to 1982 herring stocks in ICES Area VIa were assessed as one stock, along with the herring by-catch from the sprat fishery in the Moray Firth. In the 1982 herring assessment working group report, and in subsequent years, Area VIa was split into a northern and a southern area at 56°N (ICES, 1982).

In 1979 and 1981 the fishery was closed. After re-opening the nature of the fishery changed to an extent, with fewer Scottish boats targeting the coastal stock than before the closure. The Scottish domestic pair trawl fleet and the Northern Irish fleet operated in shallower, coastal areas, principally fishing in the Minches and around the Island of Barra in the south; younger herring are found in these areas. Since 1986 Irish trawlers have operated in the south of the area, from the VIa (S) line up to the south-western Hebrides. The Scottish and Norwegian purse seine fleets targeted herring mostly in the northern North Sea, but also operated in the northern part of VIa (N). An international freezer-trawler fishery operated in deeper water near the shelf edge where older fish are distributed. These vessels are mostly registered in the Netherlands, Germany, France and England. In recent years the catch of these fleets has become more similar.

In recent years the Scottish fleet has changed to a predominantly purse-seine fleet to a trawl fleet. Norwegian vessels fish less in the area than in the past. Scottish catches still comprise around half of the total, the rest is dominated by the offshore, international fishery.

A recent EU-funded programme WESTHER has elucidated stock structures of herring throughout the western seaboard of the British Isles using a combination of morphometric measurements, otolith structure, genetics and parasite loads. The results provide information on mixing of stocks within and beyond VIa (N).

A.3. Ecosystem aspects

Herring are an important prey species in the ecosystem and also one of the dominant planktivorous fish.

Herring fisheries tend to be clean with little bycatch of other fish. Scottish discard observer programs since 1999 indicate that discarding of herring in these directed fisheries are at a low level. These discard observer programs have recorded occasional catches of seals and zero catches of cetaceans.

In addition to being a valuable protein resource for humans, herring represent an important prey item for many predators including cod and other large gadoids, dogfish and sharks, marine mammals and sea birds. Because the trophic importance of herring puts its stocks under immense pressure from constant exploitation, it is important that management takes into account all anthropogenic, environmental and biological variables.

A.4. Biology of the species in the distribution area

The Atlantic herring, *Clupea harengus*, is numerically one of the most important pelagic species in North Atlantic ecosystems with widespread distribution around the Scottish coast. Within the Northeast Atlantic they are encountered from the north of Biscay to Greenland, and east into the Barents Sea. It is thought that herring stocks comprise many reproductively isolated subpopulations through specific spawning grounds and seasons (e.g. autumn and spring spawners), but the taxonomic status of these subpopulations remains unclear.

Herring are demersal spawners and produce dense beds of benthic eggs deposited on gravelly substrates. This behaviour is considered to be an evolutionary remnant of herrings’ river spawning past. Each female produces a single batch of eggs per year, releasing a ribbon of eggs that adheres to the benthos; the male sheds milt while swimming a few centimetres above the female. This particular behaviour renders herring vulnerable to anthropogenic activity such as offshore oil and gas industries and gravel extraction.

The eggs take about three weeks to hatch, dependant on the temperature. The larvae on hatching are 6-9mm long and are immediately planktonic. Their yolk sac lasts for about a week during which time they will begin to feed on phytoplankton and crustacean larvae. Their planktonic development lasts around three to four months during which time they are passively subjected to the residual drift which takes them to coastal nurseries. The habitats of juveniles are primarily pelagic, and hydrographical features such as temperature and the depth of thermocline, as well as abundance of zooplankton affect their distribution. Adult fish are pelagic and found mostly in continental shelf seas to depths up to 200m. They form large shoals with diurnal migration patterns through the water column which can be associated with the availability of prey and stage of maturity. In the winter the feeding activity and growth are very slow. Herring can reach 40cm in length and have a maximum lifespan of 10 years although most herring range between 20-30cm and are less than 7 years.

Assessing age and year class for herring can be problematic due to the extended spawning season of autumn spawners from September to January. Using the convention of January 1st as the birthday, 0-group refer to fish born between 3 and 18 months ago but 0-group autumn spawners belong to a different class from 0-group spring spawners. Time series of a stock's age structure helps its management and it is vital that they are extended for all the '*West of Scotland*' herring components in the VIaN (North), VIaS (South) and VIb areas.

There are many hypotheses as to the cause of the irregular cycles shown in the productivity of herring stocks (weights-at-age and recruitment), but in most cases it is thought that the environment plays a key role (through prey, predation and transport). The VIaN herring stock has shown a marked decline in productivity during the late 1970s and has remained at a low level since then. ICES identifies that the VIaN stock is currently fluctuating at low levels and is being exploited above F_{msy}.

WESTHER and SGHERWAY

WESTHER was an EU-funded project, to review, the stock identity of herring west of the British Isles. A number of factors were examined including.

- Morphometrics and meristic characteristics
- Internal parasites
- Otolith microstructure and microchemistry
- Genetics

Results from this project identified distinct spawning grounds and spawning components. It was recommended that the stocks to the west of the British Isles should be managed as two stocks, the Malin Shelf stock and the Celtic Sea stock. Management plans should be fleet and area based in order to prevent the local depletion of any population unit in the areas (WESTHER, Q5RS-2002-01056). Further work on the management of these stocks was conducted by SGHERWAY (Study Group on the evaluation of assessment and management strategies of the western herring stocks) which met for the first time in late 2008 with further meetings in 2009 and 2010. This group had three main terms of reference and the findings of each are presented below:

1) Evaluate the utility of a synoptic acoustic survey in the summer for the Hebrides, Malin and Irish shelf areas, in conjunction with WGIPS surveys of VIaN and the North Sea.

The synoptic Malin Shelf survey began in 2008 and covers all areas in which mixing of the various western herring stocks is likely to occur at that time. However, such time-series will not be available for a number of years. The amount of mixing between stocks cannot be resolved by the current sampling regime in the Malin Shelf survey. Consequently, a sampling programme has been developed to allow proper identification of fish population origins, making use of otolith and body shape techniques. Analyses will be compared to the fish of known spawning origin collected during the EU project WESTHER. This sampling programme has been initiated in the 2010 synoptic acoustic survey.

2) Explore a combined assessment of the three stocks and investigate its utility for advisory purposes

A combined assessment of the three stocks VIaN, VIaS/VIIb,c and VIIaN (called the Malin Shelf metapopulation) was explored and its utility for advisory purposes investigated. It was found that the combined assessment gives important information on the Malin Shelf metapopulation, though it is unlikely to be useful for management advice purposes.

3) Evaluate, through simulation, alternative management strategies for the metapopulation of VIaN, VIaS and VIIaN and the best way to maintain each spawning component in a healthy state.

Alternative management strategies for the metapopulation of VIaN, VIaS and VIIaN were investigated to show how metapopulations can be sustainably managed. This study has shown that managing metapopulations is only possible with detailed information on fisheries independent data. However, whenever subcomponents of the metapopulation differ considerably in abundance, sustainable management is impossible for the smallest subcomponent. Where there is uncertainty of stock identification fishing mortality should be kept at low levels. Whenever identification rates increase, fishing mortality may also be increased.

The work of this study group concluded in 2010.

B. Data

B.1. Commercial catch

Commercial catch is obtained from national laboratories of nations exploiting herring in VIa (N). Since 1999 (catch data 1998), these labs have used a spreadsheet to provide all necessary landing and sampling data, which was developed originally for the Mackerel Working Group (WGMHSA) and further adapted to the special needs of the Herring Assessment Working Group. The current version used for reporting the 2002 catch data was v1.6.4. The majority of commercial catch data of multinational fleets was provided on these spreadsheets and further processed with the SALLOCL-application (Patterson, 1998a). This program gives the needed standard outputs on sampling status and biological parameters. It also clearly documents any decisions made by the species co-ordinators for filling in missing sampling data and raising the catch information of one nation/quarter/area with information from another data set.

Transparency of data handling by the Working Group. The current practice of data handling by the Working Group is that the data received by the co-ordinators is available in a folder called "archive". These high-resolution data are not reproduced in the report. The archived data contains the disaggregated dataset (disfad), the allocations of samples to unsampled catches (alloc), the aggregated dataset (sam.out) and (in some cases) a document describing any problems with the data in that year.

Current methods of compiling fisheries assessment data. The species co-ordinator is responsible for compiling the national data to produce the input data for the assessments. In addition to checking the major task involved is to allocate samples of catch numbers, mean length and mean weight-at-age to unsampled catches. There are at present no defined criteria on how this should be done, but the following general process is implemented by the species co-ordinators. Searches are made for appropriate samples by gear (fleet) area quarter, if an exact match is not available the search will move to a neighbouring area if the fishery extends to this area in the same quarter. More than one sample may be allocated to an unsampled catch, in this case a straight mean or weighted mean of the observations may be used. If there are no samples available the search will move to the closest non-adjacent area by gear (fleet) and quarter, but not in all cases.

Until 2003 the VIa(N) catch data extended back to the early 1970s; since 1986 the series has run from 1976 to present. In 2004 the data set was extended back to 1957. Details are given below.

Historic Catches from 1957 to 1975

The working group has obtained preliminary estimates of catch and catch-at-age for the period 1957 to 1975. These have been estimated from records of catch presented in HAWG reports from 1973, 1974, 1981 and 1982. Intervening reports were also consulted to check for changes or updates during the period. Catch-at-age data were available from 1970 to 1975 from the 1982 Working Group report, and catches-at-age for the period 1957 to 1972 were estimated from paper records of catch-at-age by national fleets for 1957 to 1972, held at FRS Marine Laboratory Aberdeen. The fishing practices of national fleets were established for the period 1970 to 1980 from catches in VIa and VIa (N) recorded in the 1981 and 1982 Working Group reports respectively. This procedure suggested that, on average, more than 90% of catch by national fleet could be fully assigned to either VIa (N) or VIa (S). The remaining catch was assigned assuming historic proportions. During this period catches were split into autumn and spring spawning components; anecdotal information on trials to verify this separation suggests it was not a robust procedure. Currently about 5% of herring in VIa (N) is found to be spent at the time of the acoustic surveys in July, and thought to be spring spawning herring. However, at present the Working Group assesses VIa (N) herring as one stock, regardless of spawning stock affiliation. In the earlier period higher proportions were allocated as spring spawners. Currently the designated 'spring spawning' component is not included in the catch at age matrix, but the catch tones express the full amount giving rise to SoP differences in the early years. Similarly, a small Moray Firth juvenile fishery was also included in VIa (N) catch in earlier years because it was thought that these juveniles were part of the VIa (N) stock. Separating this component in the historic data was difficult, and as the fishery ceased in the very early 70s this has no implications for current allocation of these fish. The Moray Firth is, geographically, part of IVa (ICES stat. rectangles 44E6, 44E7, 45E6) and is now managed as part of that area. Currently there are no juvenile herring catches from the Moray Firth. A full detail of the analysis carried out is provided as an appendix (Appendix 11) to the 2004 Working Group report. Further investigations are required before determining the correct actions concerning the 'spring spawners' in early period. The consequence of this is to slightly reduce the apparent stock size in the early years, when is already at an all time high. It has no implications for fitting of any survey data, or influence on the B_{lim} reference point, however, it might further increase the high R seen at high SSB in a S/R relationship.

Allocation of catch and misreporting

This fishery has had a strong tradition of misreporting before 2000, though this has reduced in recent years. It is believed that the shortfall between the TAC and the catch was used to misreport catches from other areas (from IVa to the east and from VIa (S) to the south). In the past, fishery-independent information confirmed that large catches were being reported from areas with low abundances of fish, and informal information from the fishery and from other sources confirmed that most catches of fish recorded between 4°W and 5°W were most probably misreported North Sea catches. The problem was detailed in the Working Group report in 2002 (ICES 2002/ACFM:12). Improved information from the fishery in 1998 - 2002 allowed for re-allocation of many catches due to area misreporting (principally from VIa (N) to IVa (W)). This information was obtained from only some of the fleets

As a result of perceived problems of area misreporting of catch from IVa into VIa (N), Scotland introduced a fishery regulation in 1997 with the aim to improve reporting accuracy. Under this regulation, Scottish vessels fishing for herring were required to hold a license either to fish in the North Sea or in the west of Scotland area (VIa (N)). Only one licensed option could be held at any one time. However in 2004, the requirement to carry only a single license was rescinded. Area misreporting of catch taken in area IVa into area VIa (N) then increased in 2004 and continued in 2005. It is possible, therefore, that the relaxation of this single area license contributed to a resurgence in area misreporting. In 2007, as in 2006, there was no misreporting from IVa into VIa (N). New sources of information on catch misreporting from the UK became available in 2006 (see the 2007 HAWG report). This information was associated with a stricter enforcement regime that may be responsible for the lack of that area misreporting since 2006.

The Butt of Lewis box, (a seasonal closure to pelagic fishing of the spawning ground in the north west of the continental shelf in area VIa(North) since the late 1970s was opened to fishing in 2008 following a STECF review in 2007. It has not been possible to show either beneficial or deleterious effects from this closure.

Catches are included in the assessment. Biases and sampling designs are not documented. Discards are not included, though data from some fleets suggest these are very minor. Slippage and high grading are not recorded.

B.2. Biological

Catch-at-age data (catch numbers-at-age, mean weights-at-age in the catch, mean length-at-age) are derived from the raised national figures received from the national laboratories. The data are obtained either by market sampling or by onboard observers, and processed as described in Section B.1 above. For information on recent sampling levels and nations providing samples, see Section 2.2. in the most recent HAWG report.

Proportions mature (maturity ogive) and mean weights-at-age in the stock derived from the acoustic survey (see next section) have been used since 1992 and 1993, respectively. Prior to these years, time-invariant values were used.

Biological sampling of the catches was extremely poor in recent history (particularly in 1999). This was particularly the case for the freezer trawler fishery that takes the larger component of the stock based around the shelf break. The lack of samples was due in part to the fact that national vessels tend to land in foreign ports, avoiding national sampling programs. The same fleet is thought to high grade. The long length of fishing trips makes observer programs difficult. Even when samples are taken, age determination is limited for most nations.

Sampling has improved over the last few years. The number of age readings per 1,000 t of catch increased from the low in 1999 of 52 to a high in 2001 of 93. Numbers have decreased again since then to 57 per 1,000 t in 2003. From 1999 to 2003 the sampling has been dominated by Scotland (ranging between 70 and 98% of the age readings), except in 2001, when only 43% of the age determination was on Scottish landings in VIa (N).

Natural mortality (M) varies with age (expressed in number of winter rings) according to the following:

Rings	M
1	1
2	0.3
3	0.2
4+	0.1

Those values have been held constant from 1957 to date. Those values correspond to estimates for North Sea herring based on recommendations by the Multi-species WG (Anon. 1987a) that were applied to adjacent areas (Anon. 1987b).

B.3. Surveys

B.3.1 Acoustic survey –MSHAS_N

An acoustic survey has been carried out for VIa (N) herring in the years 1987, 1991-2012.

Biomass estimated from the acoustic survey tends to be variable. Herring are found in similar area each year, namely south of the Hebrides off Barra Head, west of the Hebrides and along the shelf edge.

The stock is highly contagious in its spatial distribution, which explains some of the high variability in the time series. Effort stratification has improved with knowledge of the distribution and this may be less of a problem in more recent years. The survey uses the same target strength as for the North Sea surveys and there is no reason to suppose why this should be any different. Species identification is generally not a great problem.

Review of acoustic survey time-series

In 2009, an examination of the time series of the spawning stock biomass (SSB) data derived from the annual acoustic survey for the west of Scotland herring stock, in preparation for a publication on the survey time-series, showed a number of discrepancies between the values given in the original survey reports, the PGHERS (or combined survey) reports, the HAWG reports and the combined acoustic survey data archive held in the Marine Lab. Aberdeen. The discrepancies could not be easily explained by simple means, e.g., the original survey report included data east of 4°W that was then subtracted for the SSB estimate later.

A simple calculation of the values in the survey assessment input files was performed:

Catch numbers-at-age in the survey * weights-at-age in the stock * proportion mature

to derive an estimate of the SSB. This showed up further discrepancies that warranted closer examination. Initially it was not certain from where the discrepancies may have arisen, and they were only in certain years.

The aim of this exercise was to produce a new set of survey input files of catch numbers-at-age in the survey (*fleet*), weights-at-age in the stock (*west*) and proportion mature (*matprop*), with the correct values within and the reasons for those choices documented. The details are given in full in Hatfield and Simmonds (WD05 HAWG 2010). Several changes were calculated for 1987, 1991, 1993, 1994, 1995, 1997, 1999, 2000, 2001 and 2005. The full SSB time series, incorporating these revisions, is given in Table Annex 6-1 below.

The 1987 acoustic survey was carried out in November, and not in July like all but one of the subsequent surveys. Consequently, neither the actual proportions mature in July nor the mortalities between July and November were known and the historical values of weights-at-age and proportions mature were used. The survey was, initially, retained to lengthen the time series. This is no longer an issue. It is, therefore, recommended that the 1987 survey value be removed from the time series, to give a modified time-series (1991 onwards) of 19 years (to 2009).

B.3.2 Larvae survey

Larvae surveys for this stock were carried out from 1973 to 1993. Larval production estimates (LPE) and a larval abundance index (LAI) were produced for the time series. These values were used in the assessment, the LPE until 2001. However, in 2002 it was decided that the LAI had no influence on the assessment and has not been used since. Documentation of this survey time-series is given in ICES CM 1990/H:40.

B.4. Commercial CPUE

Not used for pelagic stocks

B.5. Other relevant data

C. Historical Stock Development

An experimental survey-data-at-age model was formulated at the 2000 HAWG. In 1999 and 1998 a Bayesian modification to ICA was used to account for the uncertainty in misreporting.

The ICA assessment (Patterson 1998a), implemented in FLR (Kell 2007) as FLICA, has exhibited substantial revision both up and down over the last few years, largely due to the noisy survey used for tuning the assessment. The model settings were last explored in detail in 2009 (ICES 2009/ACOM:03). The conclusion was that continuing with the current weighting and model settings is an acceptable solution, until more data, possibly as a result of the extended surveys from SGHERWAY, are available.

Model used: FLICA Software R / ICA (Patterson 1998b)

Model Options chosen:

Separable constraint over last 8 years (weighting = 1.0 for each year)

Reference age = 4

Constant selection pattern model

Selectivity on oldest age = 1.0

First age for calculation of mean F = 3

Last age for calculation of mean F = 6

Weighting on 1-rings = 0.1; all other age classes = 1.0

Weighting for all years = 1.0

All indices treated as linear

No S/R relationship fitted

Lowest and highest feasible F = 0.02 and 0.5

All survey weights equal i.e., 1.0 with the exception of 1 ringers in the acoustic survey weighted to 0.1.

Correlated errors assumed i.e., = 1.0

No shrinkage applied

Input data types and characteristics:

Type	Name	Year range	Age range	Variable from year to year Yes/No
Caton	Catch in tonnes	1957 – last data year	NA	Yes
Canum	Catch at age in Numbers	1957 – last data year	1-9+	Yes
Weca	Weight at age in the commercial catch	1957-1972 1973-1981 1982-1984 1985-last data year	1-9+ 1-9+ 1-9+ 1-9+	No No No Yes
West	Weight at age of the spawning stock at spawning time.	1957 - 1992 1993-last data year	1-9+ 1-9+	No Yes
Mprop	Proportion of natural mortality before spawning	1957-last data year	NA	No
Fprop	Proportion of fishing mortality before spawning	1957-last data year	NA	No
Matprop	Proportion mature at age	1957 - 1991 1992-last data year	1-9+ 1-9+	No Yes
Natmor	Natural mortality	1957 – last year	1-9+	No

Tuning data:

Type	Name	Year Range	Age Range
Tuning fleet 1	VIa (N) Acoustic Survey	1991- last data year	1-9+

D. Short-Term Projection

In 2005 the Working Group tested an HCR applicable to VIa (N) (ICES 2005/ACFM:16), which was accepted by ICES as precautionary. This has formed the basis for the proposed agreement and was implemented in December 2008 by the European Commission.

Model used: Age structured Software used: MFDP ver 1a

Initial stock size: Taken from the last year of the assessment. Geometric mean recruitment of 1-ringers (1989 to the year prior to the last data year) replaces recruitment for 1-ringers in both the intermediate year and TAC year. This period has been chosen as it represents the lower productivity regime experienced by the stock in this recent period. Population numbers of 2-ringers in the intermediate year are calculated by the degradation of geometric mean recruitment (1989-2010) using the equation below:

$N_{t+1} = N_t * e^{-Ft+Mt}$

Maturity: Mean of the last three years of the maturity ogive used in the assessment.

F and M before spawning: Set to 0.67 for all years.

Weight at age in the stock: Mean of the last three years in the assessment.

Weight at age in the catch: Mean of the last three years in the assessment.

Exploitation pattern: Mean of the previous eight years (eight because this is the assessment model assumption of 8 years separable period).

Intermediate year assumptions: **F** constraint, based on an average of $F_{3\text{-}6}$ for the most recent 3 years. Stock recruitment model used: None used. Until 2010 HAWG the advice basis was a TAC constraint. The ADGCS advised the change to the above F constraint in 2010.

Procedures used for splitting projected catches: Not relevant

E. Medium-Term Projections (done intermittently)

Model used: STPR as described in Skagen (2003)

Initial stock size: Population parameters Terminal year survivors from ICA assessment with recruits replaced as in short term projections (D above). Drawn from a multivariate lognormal distribution with mean equal to the values estimated in the stock assessment model, and with covariance as estimated in the same model fit. Geometric mean recruitment for 1- and 2-ringers is used to replace the values in the assessment for the first projected year, covariance at age 2 retained and used for age 1 and 2.

Natural mortality: Mean of the last three years in the assessment.

Maturity: drawn randomly by year from 1990 to present.

F and M before spawning: Set to 0.67 for all years.

Weight at age in the stock: drawn randomly by year from 1990 to present.

Weight at age in the catch: drawn randomly by year from 1990 to present.

Exploitation pattern: from the eight year separable model

Intermediate year assumptions: TAC constraint

Stock recruitment model used: Variable Hockey-Stick or Beverton Holt fitted to recent data (1989 on) , but other options tested for robustness max year three years prior to the assessment.

F. Biological Reference Points

The report of SGPRP (ICES 2003/ACFM:15) proposed a B_{lim} of 50,000 t for VIa (N) herring. This is calculated from the values in the converged part of the VPA (1976-

1999) and the Working Group endorsed this value in 2003 (ICES 2003/ACFM:17).

Suggested Precautionary Approach reference points:

B_{LIM} is 50,000 t	B_{PA} be set at 75,000 t

Technical basis:

B_{LIM}: B_{LOSS} Estimated SSB for sustained recruitment	Bpa: 1.5 * Blim

G. Other Issues

G.1 Terminology

The WG uses "rings" rather than "age" or "winter rings" throughout the report to denominate the age of herring, with the intention to avoid confusion. It should be observed that, for autumn spawning stocks, there is a difference of one year between "age" and "rings". HAWG in 1992 (ICES 1992/Assess:11) stated that:

"The convention of defining herring age rings instead of years was introduced in various ICES working groups around 1970. The main argument to do so was the uncertainty about the racial identity of the herring in some areas. A herring with one winter ring is classified as 2-years-old if it is an autumn spawner, and one-year-old if it is a spring spawner. Recording the age of the herring in rings instead of in years allowed scientists to postpone the decision on year of birth until a later date when they might have obtained more information on the racial identity of the herring.

The use of winter rings in ICES working groups has introduced a certain amount of confusion and errors. In specifying the age of the herring, people always have to state explicitly whether they are talking about rings or years, and whether the herring are autumn- or spring spawners. These details tend to get lost in working group reports, which can make these reports confusing for outsiders, and even for herring experts themselves. As the age of all other fish species (and of herring in other parts of the world) is expressed in years, one could question the justification of treating West-European herring in a special way. Especially with the present trend towards multispecies assessment and integration of ICES working groups, there might be a case for a uniform system of age definition throughout all ICES working groups.

However, the change from rings to years would create a number of practical problems. Data files in national laboratories and at ICES would have to be adapted, which would involve extra costs and manpower. People that had not been aware of the change might be confused when comparing new data with data from old working group reports. Finally, in some areas (notably Division IIIa), the distinction between spring- and autumn spawners is still hard to make, and scientists preferred to continue using rings instead of years.

The Working Group discussed at length the various consequences of a change from rings to years. The majority of the Group felt that the advantages of such a change did not outweigh the disadvantages, and it was decided to stick to the present system for the time being. "

The text table below gives an example for the correlation between age, rings and year class for the different spawning types in late 2002:

Year class (autumn spawners)	**2001/2002**	**2000/2001**	**1999/2000**	**1998/1999**
Rings	0	1	2	3
Age (autumn spawners)	1	2	3	4
Year class (spring spawners)	2002	2001	2000	1999
Rings	0	1	2	3
Age (spring spawners)	0	1	2	3

H. Management and ICES Advice

COUNCIL REGULATION (EC) No 1300/2008 of 18 December 2008 established a multi-annual management agreement for the stock of herring distributed to the west of Scotland and the fisheries exploiting that stock.

F = 0.25 if SSB > 75 000 t 20% TAC constraint.

F = 0.20 if SSB < 75 000 t but > 62 500 t 20% constraint on TAC change.

F = 0.20 if SSB <62 500 t but > 50 000 t 25% constraint on TAC change

F = 0 if SSB < 50 000 t.

There is derogation from the above constraints. If STECF considers that the herring stock in the area west of Scotland is failing properly to recover, the TAC constraints may differ from those in the management agreement. This plan is similar but not identical to the proposed plan.

I. References

Anon, 1982. Herring Assessment Working Group for the Area South of 62°N. ICES C.M. 1982/Assess:7.

Anon. 1987a. Report of the ad hoc Multispecies Assessment WG. ICES, Doc. C.M. 1987/Assess:9.

Anon. 1987b. Report of the Herring Assessment Working Group for the Area South of 62°N. ICES Doc. C.M. 1987/Assess:19.

Anon. 1990. Report of the ICES Herring Larvae Surveys in the North Sea and adjacent waters. ICES CM 1990/H:40

ICES 1992. Report of the Herring Assessment Working Group for the Area South of 62°N. ICES 1992/Assess:11

ICES 1996. Report of the Herring Assessment Working Group for the Area South of 62°N. ICES CM 1996/Assess:10.

ICES 2002. Report of the Herring Assessment Working Group for the Area South of 62° N. CM 2001/ACFM:12.

ICES 2003. Report of the Study Group on Precautionary Reference Points for Advice on Fishery Management. ICES CM 2003/ACFM:15

ICES 2003. Report of the Herring Assessment Working Group for the Area South of 62° N. ICES 2003/ACFM:17

Patterson, K.R. 1998a: A programme for calculating total international catch-at-age and weight-at-age. WD to HAWG 1998.

Patterson, K.R. 1998b. Integrated Catch at Age Analysis Version 1.4. Scottish Fisheries Research Report. No. 38.

Simmonds, J., Keltz, S., 2007. Management implications and options for a stock with unstable or uncertain dynamics: West of Scotland herring. ICES J. Mar. Sci., 64: 000-000.

Skagen, D.W. 2003. Programs for stochastic prediction and management simulation (STPR3 and LTEQ). Program description and instruction for use. WD to HAWG 2003.

Table Annex 6-1. Time series of spawning stock biomass (SSB) from the VIa (North) acoustic survey, incorporating the revised values calculated in 2009.

Year	**1991**	**1992**	**1993**	**1994**	**1995**
SSB (t)	410 000	351 460	845 452	533 740	452 300
Year	**1996**	**1997**	**1998**	**1999**	**2000**
SSB (t)	370 300	175 000	375 890	460 200	444 900
Year	**2001**	**2002**	**2003**	**2004**	**2005**
SSB (t)	359 200	548 800	739 200	395 900	222 960
Year	**2006**	**2007**	**2008**	**2009**	**2010**
SSB (t)	471 700	298 860	788 200	578 757	308 055
Year	**2011**				
SSB (t)	457 900				

Annex 7 - Stock Annex Herring in Division VIa South and VIIb,c

Quality Handbook	ANNEX: Herring VIaS and VIIb, c

Stock specific documentation of standard assessment procedures used by ICES

Stock:	Herring in VIaS and VIIb, c
Working Group:	Herring Assessment Working Group for the area south of 62°N
Date:	March 2013
Authors:	Afra Egan and Maurice Clarke

A1. General

The herring (*Clupea harengus*) to the northwest of Ireland comprise both autumn and winter/spring spawning components. The age distribution of the catch and vertebral counts were used to distinguish these components (Bracken, 1964, Kennedy, 1970). Spawning takes place from September until March and may continue until April (Molloy and Kelly, 2000). Spawning in VIIb has traditionally taken place in the autumn and in VIaS, spawning occurs later in the autumn and in the winter.

For the purpose of stock assessment and management, these areas have been separated from VIaN since 1982 and are split at 56° N. This split is based on work carried out by working groups in the late 1970s and early 1980s which found that the stocks exploited off the west coast of Scotland were biologically different from those off the north coast of Ireland. A second new assessment area was also recommended by the 1981 Working Group (ICES, 1981). The Irish landings were taken mainly in the southern part of VIa and in VIIb, c. These catches were found to be biologically very similar with respect to age composition and spawning. It was decided at the 1981 working group to combine the areas and conduct a joint assessment (Molloy, 2006).

A herring tagging experiment was carried out in 1992 in order to investigate the movements and annual migrations of herring around the Irish Coast. 20,000 herring were tagged in total with 10,000 of these off the west coast. Some fish moved northwards and were recaptured along the north coast between July and February, in the main fishing areas. 90% of the fish tagged along the west coast were recovered from the Donegal Bay area. The maturity stages of the recaptured fish, suggests that the fish were migrating inshore towards spawning grounds (Molloy, *et al* 1993). There were no returns from north of Donegal although it is possible that there may not have been much fishing activity in the area at this time (Molloy and Kelly, 2000).

Biology

A study group on herring assessment and biology in the Irish Sea and adjacent areas met in 1994 (ICES, 1994). This meeting highlighted the problems associated with the assessment of herring stocks around Ireland. This group recommended that the boundary line separating Celtic Sea herring stock from the stock of VIaS and VIIb be moved southwards from latitude 52°30′N to 52°00′N (ICES, 1994). A Schematic presentation of the life cycle of herring to the west and northwest of Ireland is shown in Figure 1. The spawning, nursery and feeding grounds are shown as well as the direction of larval drift and migration.

WESTHER and SGHERWAY

WESTHER was an EU-funded project, to review, the stock identity of herring west of the British Isles. A number of factors were examined including.

- Morphometrics and meristic characteristics
- Internal parasites
- Otolith microstructure and microchemistry
- Genetics

Results from this project identified distinct spawning grounds and spawning components. It was recommended that the stocks to the west of the British Isles should be managed as two stocks, the Malin Shelf stock and the Celtic Sea stock. Management plans should be fleet and area based in order to prevent the local depletion of any population unit in the areas (WESTHER, Q5RS-2002-01056). Further work on the management of these stocks was conducted by SGHERWAY (Study Group on the evaluation of assessment and management strategies of the western herring stocks), which met for the first time in late 2008 with further meetings in 2009 and 2010. This group had three main terms of reference and the findings of each are presented below:

1) Evaluate the utility of a synoptic acoustic survey in the summer for the Hebrides, Malin and Irish shelf areas, in conjunction with WGIPS surveys of VIaN and the North Sea.

The synoptic Malin Shelf survey began in 2008 and covers all areas in which mixing of the various western herring stocks is likely to occur at that time. However, such time-series will not be available for a number of years. The amount of mixing between stocks cannot be resolved by the current sampling regime in the Malin Shelf survey. Consequently, a sampling programme has been developed to allow proper identification of fish population origins, making use of otolith and body shape techniques. Analyses will be compared to the fish of known spawning origin collected during the EU project WESTHER. This sampling programme was initiated in the 2010 synoptic acoustic survey.

2) Explore a combined assessment of the three stocks and investigate its utility for advisory purposes

A combined assessment of the three stocks VIaN, VIaS/VIIb,c and VIIaN (called the Malin Shelf metapopulation) was explored and its utility for advisory purposes investigated. It was found that the combined assessment gives important information on the Malin Shelf metapopulation, though it is unlikely to be useful for management advice purposes.

3) Evaluate, through simulation, alternative management strategies for the metapopulation of VIaN, VIaS and VIIaN and the best way to maintain each spawning component in a healthy state.

Alternative management strategies for the metapopulation of VIaN, VIaS and VIIaN were investigated to show how metapopulations can be sustainably managed. This study has shown that managing metapopulations is only possible with detailed information on fisheries independent data. However, whenever subcomponents of the metapopulation differ considerably in abundance, sustainable management is impossible for the smallest subcomponent. Where there is uncertainty of stock identification fishing mortality should be kept at low levels. Whenever identification rates increase, fishing mortality may also be increased.

The work of this study group concluded in 2010.

A.2. Fishery

Development of this fishery

In the early 1900s the main herring fisheries in Ireland were located off the Donegal coast. Donegal matje herring were important in supplying the German markets. Herring fisheries, which took place every spring and summer off the coast of Donegal, have been under scientific observation since 1921. The fishing grounds were well known and were located between ten and forty miles offshore. Fishing during this time was split into three well defined time periods.

1. December/January
2. May (main fishing took place)
3. September/October

During the 1930s many of the major herring markets disappeared (Molloy, 1995). In contrast to the rapid expansion experienced in the Celtic Sea the revival of the northwest fishery occurred at a slower pace (Molloy, 2006). The revival first became evident in the 1950s when many Scottish ring netters took part in this fishery with many of the Irish boats also using this gear. Then several boats changed to pelagic midwater trawls. The herring fleet continued to expand throughout the 1960s with many skippers becoming experts in pelagic pair trawling (Molloy, 2006).

In the 1970s and 1980s the autumn spawners became more significant and accounted for the majority of the landings. Galway and Rossaveal gained increasing importance as herring ports in the 1970s. In the 1974/75 season landings decreased dramatically and it was the first indication that the stock might have started to decline. The North Sea stock was already in decline and many Dutch boats were fishing off the Irish west coast. TACs were reduced and the stock continued to decline. In 1978 it was advised that the fishery be closed (Molloy, 2006). This closure lasted until 1981 and was reopened with new management units. VIaS and VIIb, c were joined and were assessed separately from VIaN.

In recent years the northern grounds have regained importance with catch also coming from the west coast close to the VIa boundary line (ICES, 2005). Very little fishing now takes place on previously important grounds in Galway Bay and along the Mayo coast (Molloy and Kelly, 2000).

Since the late 1970s considerable changes have taken place in the type of pelagic fishing carried out by Irish boats off the North West Coast, with directed herring fishing having been largely replaced by mackerel fishing (Breslin, 1998).

Fishery in Recent Years

The TAC is taken mainly by Ireland, which has over 90% of the quota. In recent years, only Ireland has exploited herring in this area. The fishery is concentrated in quarters one and four. Landings have decreased markedly from about 44,000 t in 1990 to around 6,600t in 2012. Total catches over the complete time series are shown in the Figure 2. The number of boats participating in this fishery remained constant for a number of years at around 30 vessels. Increases were seen in recent years with 53 vessels landing northwest herring in 2012. The number of vessels engaged in fishing for herring depends very much on the availability of mackerel or horse mackerel. Many of the larger vessels target these species primarily.

The majority of the landings in recent years are taken in quarters one and four with small quantities landed in quarter three. The main age groups are 2, 3, 4 and 5 with older age groups accounting for small proportions of the catch. The proportions of older age groups have been decreasing over the last number of years.

A.3. Ecosystem aspects

Divisions VIaS and VIIb, c are located to the North West and west of Ireland respectively. This area is limited to the southwest by the Rockall Trough, where the transition between the Porcupine Bank and the trough is a steep and rocky slope with reefs of deepwater corals; further north, the slope of the Rockall Trough is closer to the coast line; west of the shelf break is the Rockall Plateau with depths of less than 200m. The shelf area consists of mixed substrates, with soft sediments (sand and mud) in the west and more rocky, pinnacle areas to the east. The area has several seamounts: the Rosemary Bank, the Anton Dohrn sea mount and the Hebrides, which have soft sediments on top and rocky slopes (ICES, 2007b).

The shelf circulation is influenced by the poleward flowing 'slope current', which persists throughout the year north of the Porcupine Bank, but is stronger in the summer. A schematic representation of the oceanographic conditions in this area is presented in Figure 2. Over the Rockall plateau, domes of cold water are associated with retentive circulation. Thermal stratification and tidal mixing generate a northwards running coastal current known as the Irish coastal current which runs northwards along the west coast (ICES, 2007). The main oceanographic features in these areas are the Islay and the Irish Shelf fronts. The waters to the west of Ireland are separated by the Irish shelf front. This front causes turbulence and this may bring nutrients from deep waters to the surface. This promotes the growth of phytoplankton and dinoflagellates where there is increased stratification. Associated with this is increased growth of zooplankton and aggregations of fish. The Islay front persists throughout the winter due to the stratification of water masses of different salinities (ICES, 2006). The ability to quantify any variability in frontal location and strength is an important element in understanding fisheries recruitment (Nolan and Lyons, 2006). These fronts play an important role in the transport of larvae and juveniles.

In the North, most of the continental shelf is exposed to prevailing southwesterly winds and saline oceanic waters cross the shelf edge between Malin head off the north coast of Ireland and Barra head in the Outer Hebrides. The Irish shelf current flows northwards and then eastwards along the north coast of Ireland (Reid *et al*, 2003). Freshwater discharges from rivers such as the Shannon and Corrib interact with the Eastern North Atlantic water on the Irish shelf front to produce the observed circulation pattern (ICES, 2006).

Sea surface temperature data have been collected from Malin head on the North coast of Ireland since 1958. During periods of low winter temperatures, there is less pronounced heating during the summer. This can be seen in 1963, 1978 and 1985-1986. During these years there were also stormy conditions. This is concurrent with the lower winter temperatures (ICES, 2007). There is considerable variability over the complete time series. A definite trend can be identified from the early 1990s. Since 1990 sea surface temperatures measured at stations along the northwest coast of Ireland have displayed a sustained increasing trend, with winter temperatures >6° and higher summer temperatures during the same period (Figure 3), (Nolan and Lyons, 2006).

Environmental conditions can cause significant fluctuations in abundance in a variety of marine species including fish. A study conducted in 1980 found that west coast herring catches showed strong correlations with temperature and salinity at a constant lag of three or four years. Oceanographic variation associated with temperature and salinity fluctuations appears to affect herring in the first year of life, probably during the winter larval drift (Grainger 1980a).

Productivity in this region is reasonably high on the shelf but drops rapidly west of the shelf break. This area is important for many pelagic fish species. The shelf edge is a spawning area for mackerel *Scomber scombrus* and blue whiting *Micromesistius potassou*. Historically, there were important commercial fisheries for many demersal species also. On the shelf, the main resident pelagic species is herring *Clupea harengus* (ICES, 2007b). Preliminary examination of productivity shows that overall productivity in this area is currently lower than it was in the 1980s. Further information on this can be found in the HAWG report 2007 (ICES CM 2007).

Larvae that were spawned on the west and northwest coast follow a northwards drift. Larvae spawned further north off the Donegal coast were found to drift towards the Scottish west coast (Grainger and McArdle, 1985; Molloy and Barnwall, 1988) Studies have shown that the maximum larval depth is below the surface between 5-15m and there has been no evidence of diel migration, or variation in the distribution of different larval size categories (Grainger 1980b). Larvae that hatch further south also follow this northward drift (ICES, 1994). Galway Bay and Donegal Bay, several inshore lochs and also Stanton Bank, an offshore area northwest of the Irish north coast are important nursery areas (ICES, 1994; Anon., 2000). Evidence from the parasitic load of juvenile herring from the Scottish west coast sea lochs from two studies, in the mid 1980s (MacKenzie 1985) and more recently, from 2002-2005 (Campbell et al. 2007), suggests very strongly that this drift pattern occurs from the north and northwest of Ireland and has been doing so for at least the last 20 years (ICES, 2009).

The spawning grounds for herring along the northwest coast are located in inshore areas close to the coast. These spawning grounds may contain one or more spawning beds on which herring deposit their eggs. The timing of spawning is not the same on each spawning ground. Spawning grounds tend to be vulnerable to anthropogenic influences such as dredging and sand and gravel extraction.

Discards

Catch is divided into landings (retained catch) and discards (rejected catch). Discards are the portion of the catch returned to the sea as a result of economic, legal, or personal considerations. Discarding rates in pelagic trawling and seining are generally considered to be low (Alverson *et al*., 1994).

The main market for Irish herring in the late 1980s and early 1990s was the Japanese roe market. The development of this market coincided with a decline in a number of other herring markets. It was therefore only favourable to catch roe herring, whose ovaries are just at the point of spawning. This led to discarding of non roe herring due to the lack of a suitable market. The roe market is no longer the main market for Irish herring. It is not known what the level of discarding is in this stock area and if it is a problem in this fishery.

By Catch

Overall there is a paucity of data relating to by catch and discarding in this area. Interactions between cetaceans and fishing vessels have not been well documented and therefore no information is available. It is not possible therefore to make assumptions regarding implications for the marine ecosystem in area VIaS and VIIb, c.

B. Data

Commercial Catch

The commercial catch data are provided by national laboratories belonging to the nations that have quota for this stock. In recent years, only Ireland has been catching herring in this area, and the data are derived entirely from Irish sampling. Sampling is performed as part of commitments under the EU Council Regulation 1639/2001.

Commercial catch at age data are submitted in Exchange sheet v 1.6.4. These data are usually processed using SALLOCL (Patterson, 1998b). However, since only one country participates in this fishery this system is not required. Ireland acts as stock coordinator for this stock.

InterCatch

Since 2007, InterCatch, which is a web-based system for handling fish stock assessment data, has been used. National fish stock catches are imported into InterCatch. Stock coordinators then allocate sampled catches to unsampled catches, aggregate them to stock level and download the output. The InterCatch stock output can then be used as input for the assessment models. It is envisaged that this system will replace SALLOCL and other previously used systems.

Reallocation of Catches

Since 2007, landings data were revised with respect to reallocation of catches between area VIaS and VIaN, for the years 2000-2005. Before 2000, a comprehensive reallocation was used. For 2000-2005, various procedures were used. These attempted to deal with the increasing Irish catches along the 56° line and opportunistic Irish catches of herring in VIaN during the 4th and 1st quarter mackerel fishery. In some years some catches were reallocated, while in others no reallocations were made. In 2007, it was considered that the most correct procedure was that used before 2000. Therefore a retrospective reallocation has been conducted. It does not adequately consider the Irish herring catches in VIaN, nor does the reallocation consider fishing along the 56° line. However, in the absence of better information on Irish directed herring fishing in VIaN, this procedure provides the best possible method.

B.2. Biological

Sampling Protocol

Landings data are available for this area from 1970. Data on catch numbers at age, mean weights at age and mean lengths at age are derived from Irish data. Sampling is conducted by area and by quarter. Landings from this fishery, at present, are mainly into the port of Killybegs with lesser amounts landed into Rossaveal. Irish samples are collected from these commercial landings. Length frequency and age data is collected by ICES division by quarter. The length frequency data is added together for each division and quarter and raised to the landings for that area and quarter. The sample weight is divided into the catch weight to get the raising factor. The sum of the length frequencies per quarter is multiplied by the raising factor. An age length key is applied to this data and catch numbers at age calculated.

Age Reading Protocol

VIaS\VIIbc herring are currently aged using otoliths and are read using a stereoscopic microscope with reflected light. The minimum level of magnification (15x) is used initially. It is then increased to resolve the features of the otolith. Herring otoliths are generally read in the magnification range of 20x – 25x. The patterns of opaque (summer) and translucent (winter) zones are viewed. The winter (translucent) ring at the otolith edge is counted only in otoliths from fish caught after the 1st January. The first winter ring that is counted is that which corresponds to the second "birth date" of the fish. Therefore a fish of 2 winter rings is a 3 year old. This convention applies to all ICES herring stocks with autumn spawning (Lynch, 2009).

Age composition in the catch

Scales were used in the past for ageing and on average 4 and 5 ringers counted for 46% of the total catch. In 1929 however strong year classes were evident with 4 and 5 ringers making up 85% of the total (Farran, 1928). For the past few years the catch has been mainly composed of 2 ,3, 4 and 5 ringers with decreasing proportions of older fish in the catch. This stock is different from the Celtic Sea in that there is no recruitment failure and the Northwest stock is less reliant on incoming recruitment. The catch numbers at age have been mean standardised and are presented in Figure 4.

Precision Estimates

The precision estimates on 2006 ageing data were worked up using a bootstrap technique. The results of the method found that the relative error is below 20% over the age range 2-6wr. At older ages, estimates of NW herring show higher CVs, which is likely to be due to the relative paucity in the catch.

Mean Weights

Mean weights in the stock (WEST) are calculated using samples taken from Q1 and Q4. A mean weight at age is then calculated. Mean weights in the catch (WECA) are calculated using samples from all quarters of the fishery and a mean weight per age derived.

Trends in mean weights over time

The mean weights in the catch display quite a stable pattern over the time series, although variable weights are only available from the early 1980s. Younger ages (1-6 ring) show an overall downward trend with more fluctuations evident in older ages (7-9 ring). The mean weights in the stock at spawning time have been calculated from Irish samples taken during the main spawning period and show similar patterns to the mean weight in the catch.

Maturity ogive

The maturity ogive used in the assessment considers 1-ringers to be all immature and all subsequent age groups as fully mature. Maturity ogives have been produced from the data collected in the summer acoustic surveys from 2008-2010. The maturity data are presented in the text table below and show variations in the percentage of fish mature and immature at each age class between years.

	2008		2009		2010	
age	**immature**	**mature**	**immature**	**mature**	**immature**	**mature**
1	94	6	100		100	0
2	46	54	36	64	83	17
3	4	96	9	91	17	83
4	0.63	99		100	5	95
5		100		100		100
6	1	99		100		100
7		100		100		100
8		100		100		100
9	20	80		100		100
10		100				

Log Catch Ratios

The log catch ratios (ln $C_{a,y}$/ $C_{a+1,y+1}$) are presented below and are smoothed with a 4-year running average to show the main trends (Figure 5). Data for 1-ringers are noisy because this group is not fully selected by the fishery. The data for older fish are also noisy, particularly in later years, reflecting their relative paucity in the catches and suggest high variability in the exploitation rates of these age groups. These show an upward trend for all fully recruited year classes since the mid nineties. Overall, the catch data show a diminishing range of ages in the catches and older fish are at their lowest levels in the time series.

Catch Curves

Cohort catch curves, were constructed for each year class in the catch at age data (Figure 6). These catch curves show signals in total mortality over the time series. Low mortality seems evident on the very large 1981, 1985 and 1988 year classes. These represent three of the biggest year classes recruited to this fishery. Increasing mortality can be seen from 1990 on, whilst the 1970s cohorts show lower Z. Mortality on age classes 3-6 show fluctuations over the time series with increasing mortality in recent years (Figure 7).

B.3. Surveys

Acoustic Surveys

Acoustic surveys have been carried out in this area since 1994. The timing of these surveys has changed over this period. Initially the surveys were undertaken in the summer in order to coincide with international herring surveys and with the summer feeding period of this stock. From 1999-2003 surveys were undertaken in quarter four in order to survey the autumn spawning component. From 2004-2007 the survey was carried out in quarter one. A problem with the winter acoustic survey series has been synchronising the survey with the peak spawning event to ensure containment of the stock. The winter surveys that were carried out from 2004 – 2007 varied sharply in age profile and biomass estimates, and was not considered reliable. Bad weather often affected the survey as it took place in January. Also it was recognised that synoptic coverage of a stock that spawns over a period from October to February in an area spanning all of Divisions VIaS and VIIb cannot be achieved with a winter survey. Thus the series was discontinued in 2007. The review group of the 2007 assessment highlighted that although there is an acoustic abundance estimate, the historical series is too short to consider it as a tuning survey in an analytical assessment.

In 2007 the WESTHER project recommended that the survey effort along the Malin shelf area (including VIaN, VIaS, VIIb,c, Clyde and Irish Sea) should be increased or diverted to a combined survey on non-spawning herring. In 2008 PGHERS (CM 2008/LRC:01) discussed the possibility of conducting synoptic summer surveys on the Malin shelf. This new time series of summer surveys began in 2008 with effort concentrating on summer feeding aggregations. This time series runs from 2008-2011. This series is not directly comparable with the surveys conducted from 1999-2007, but is consistent in design with those surveys conducted from 1994-1996.

The acoustic data were collected using the Simrad ER60 scientific echosounder. The Simrad ES-38B (38 KHz) split-beam transducer is mounted within the vessels drop keel and lowered to the working depth of 3.3m below the vessels hull or 8.8m below the sea surface.

Acoustic data analysis was carried out using Sonar data's Echoview® (V 3.2) post processing software and was backed up every 24 hrs. Partitioning of data was viewed and agreed upon by 2 scientists experienced in viewing echograms. Where no directed trawling had taken place, biological data from the nearest neighbour was used to determine the size classification of the echotrace.

The following TS/length relationships were used to analyse the data.

Herring	TS =	20logL – 71.2 dB per individual (L = length in cm)
Sprat	TS =	20logL – 71.2 dB per individual (L = length in cm)
Mackerel	TS =	20logL – 84.9 dB per individual (L = length in cm)
Horse mackerel	TS =	20logL – 67.5 dB per individual (L = length in cm)

Larval Surveys

Assessment of this stock was largely based on the results of larval surveys in the 1980s. Herring Larval surveys were first carried out on this stock, by Ireland, in 1981 and continued until 1988. Prior to this the surveys were carried out by the Scottish but only had limited coverage of the assessment area. The survey grid consisted of sampling stations about 18km apart. A gulf III plankton sampler with 275 µm mesh was towed at each station. The samples collected were preserved in 4% formalin. Herring larvae were identified and measured. Only larvae of less than 10mm were used for the assessment. The number of larvae below each square meter was calculated and then multiplied by the area of the sea at each station (Grainger and McArdle, 1981). These surveys did not produce a satisfactory index of stock size because of two very low values in 1984 and 1985 (Molloy, 1989). These surveys were never used in the assessment process. However these surveys did provide valuable information on the distribution of very small larvae and on the location of the spawning grounds (Molloy and Kelly, 2000).

Ground Fish Survey

The IGFS is part of the western IBTS survey and has been carried out on the *RV Celtic Explorer* since 2003. The gear used on the survey is a GOV 36/47 demersal trawl with a 20mm cod end liner to retain juvenile and small fish, including small herring. This survey has been conducted since the early 1990s but is of little utility as a herring recruit index, because the gear, timing and survey vessel changed throughout. Once a sufficient time series becomes available it will be investigated as a possible tuning fleet. The Scottish groundfish survey, which has some coverage of VIaS will also be investigated as an additional tuning fleet.

Scottish MIK net surveys

MIK net surveys were carried out off the west coast of Scotland in 2008 and 2009 and it is thought that these surveys may in time provide a reasonable index of recruitment. In both 2008 and 2009 the hatch dates were back calculated and the majority of the larvae caught were likely to be from winter spawning events from November onwards, with evidence of spawning activity into February. Previous studies have shown that larvae tend to be advected away from the coastal north and northwest of Ireland in a northerly and easterly direction towards the Minches and Hebrides. The results from these two surveys support this. It is likely, therefore, that the majority of the larvae present in both 2008 and 2009 are from spawning events in VIaS and possibly VIIb (ICES, 2009).

Commercial CPUE

Research surveys were not started in Ireland until the mid 1960s and in the absence of this information commercial catch per unit effort (CPUE) data was used as an index of stock size. It is known that CPUE data may not give an accurate index of stock size due to the shoaling nature of pelagic stocks. Fish can aggregate in dense shoals in a small area and CPUE may remain high even though the stock size is low. However the CPUE data collected in the 1960s and 1970s did provide an index of changes that were occurring in the fisheries around Ireland. F was calculated for the Northwest herring stock using this data during this time and showed an increasing trend in F. This CPUE data was used to show the dramatic decline that took place in this stock in the 1970s (Molloy, 2006).

C. Historical Stock Development

Time periods in the fishery

This fishery peaked in the late 1980s, largely as a result of two strong year classes in 1981 and 1985. This corresponded to the highest SSB and a medium level of F. In the late 1980s changes also took place with regard to the location and timing of the fishery. The North and West coast fisheries in December and January were now the most important with smaller amounts taken during the autumn fishery (Molloy, 2006). Since then there has been a downward trend in SSB and recruitment with no evidence of strong year classes entering the fishery. Mean F has been fluctuating but is thought to be at a high level.

Spawning stock size peaked in 1988 and has followed a steady decline since then. Landings have drastically fallen since 1999 (ICES, 2004). Long term changes in the spawning component have occurred in the area and time of spawning. In 1920-1930s there was a north coast fishery that spawned in the North in spring and an autumn fishery that spawned in the west of Donegal. Sligo and Galway had no important fishery. In the '40-50 herring all over Ireland declined and the recovery in the 1960s occurred mainly in Mayo, Sligo and Galway as autumn spawners. Recently there has been a shift to the northern fishery, while little fishing occurs on the west coast of Ireland. The northwest herring fishery was based on hard (stage V) herring but towards the late 1980s the focus shifted to spawning herring.

Assessment

In 1930, Farran made his first attempt to quantify the abundance of the herring stock in this area. In the 1930s many of the previous herring markets disappeared and there was widescale discarding of herring along the Donegal coast. It is thought that during this time that the herring population was at a very low level (Molloy, 1995).

Recent Assessments

In recent years the model used for this stock was a separable VPA. This was used to screen over three terminal fishing mortalities, 0.2, 0.4 and 0.6. In 2009 terminal F of 0.5 was also examined. This was achieved using the Lowestoft VPA software (Darby and Flatman, 1994). Reference age for calculation of fishing mortality was 3-6 and terminal selection was fixed at 1, relative to age 3 winter rings. ICA was used in exploratory assessments with the acoustic surveys as a tuning fleet.

Model used: ICA, FLICA and VPA

No final assessment has been accepted for this stock by the working group. However several scenarios are run, screening over a range of terminal F's (0.2, 0.4, 0.5 and 0.6). In 2006 and 2007 exploratory runs using the ICA model (Patterson, 1998) were performed. In the absence of a sufficient time series in this area the use of the ICA model has discontinued. Exploratory runs are carried out annually using a separable VPA with the settings below.

VPA

A separable VPA is used to track the historic development of this stock.

Software used: Lowestoft VPA Package (Darby and Flatman, 1994).

VPA Settings

- Reference Age = 3
- Selection in the terminal year = 1.0
- Terminal F = 0.2, 0.4, 0.5, 0.6
- 1 Ringers: downweighted to 0.1
- Reference ages for calculation of Mean F= 3-6

ICA (exploratory runs in 2006 and 2007 only)

Model Settings

- Separable constraint over the last 6 years (weighting = 1.0 for each year)
- Reference ages: 3
- Constant selection pattern model
- Selectivity on oldest age: 1.0
- First age for calculation of mean F: 3
- Last age for calculation of mean F: 6
- Weighting on 1 ringers: 0.01   Other age classes: 1.0
- Lowest feasible F: 0.05
- Highest feasible F: 2.0
- Ages for acoustic abundance estimates: 3-4
- Plus group: 9

Input data types and characteristics:

TYPE	NAME	YEAR RANGE	AGE RANGE	VARIABLE FROM YEAR TO YEAR YES/NO
Caton	Catch in tonnes	1957-2012	1-9 +	Yes
Canum	Catch at age in numbers	1957-2012	1-9 +	Yes
Weca	Weight at age in the commercial catch	1957-2012	1-9 +	Yes
West	Weight at age of the spawning stock at spawning time.	1957-2012	1-9 +	Yes
Mprop	Proportion of natural mortality before spawning	1957-2012	1-9 +	No
Fprop	Proportion of fishing mortality before spawning	1957-2012	1-9 +	No
Matprop	Proportion mature at age	1957-2012	1-9 +	No
Natmor	Natural mortality	1957-2012	1-9 +	No

Tuning data: Only used in ICA runs 2006 and 2007

TYPE	NAME	YEAR RANGE	AGE RANGE
Tuning fleet 1	NWHAS	1999-2003	3-4
Tuning fleet 2	NWHAS	2004-2007	3-4

FLICA

In 2012, FLICA was used to conduct an assessment of the stock, using as tuning, the Malin Shelf Acoustic Survey. No information was available with which to separate this stock from VIaN in the tuning index, therefore the survey can be considered an overestimate of abundance of this stock. The final exploratory assessment used the same data as the separable VPAs above, and these settings:

- Catch data with a 7+ plus group. Age 1 down-weighted to 0.1
- Ages 3-6 from the VIa,VIIbc survey data (2008-2011)
- Reference age 4
- Terminal selection on plus group and oldest true age = 1.0

In an attempt to deal with the stock mixing, an approach was taken to conduct a combined assessment for both stocks, and then subtract the population numbers for VIaN (SPALY assessment, Section 5). The remaining population numbers could be considered to be an estimate of stock abundance of VIaS. This approach was not entirely successful, because negative abundances were generated in some of the recent years. This indicates the need to better understand the mixing of this stock and the VIaN stock, and in particular, to understand the contribution of VIaS fish to the VIaN tuning index.

In 2013 an update of the FLICA assessment was carried out using the same settings as the final run in 2012.

- Catch data with a 7+ plus group. Age 1 down-weighted to 0.1
- Ages 3-6 from the Malin Shelf acoustic survey (MSHAS 2008-2012)
- Reference age 4
- Terminal selection on plus group and oldest true age = 1.0

The assessment was tuned using the full Malin shelf acoustic survey time series. This survey is known to contain a mixture of stocks but at present is the best available tuning series. Further work will be carried out later in 2013 to split this survey data and produce an improved tuning series for use in future assessments.

D. Short-Term Projection

Due to the absence of information on recruitment and the uncertainty about the current stock size short term predictions have not been routinely carried out for this stock. In 2011 and 2012, short term predictions were conducted, based on the various sVPA runs, and also on the 2012 FLICA assessment. A recent GM was used as an estimate of recruitment, assuming that the stock is still in a low productivity phase. Interim year catch was taken to be the TAC in VIaS/VIIbc and the Irish quota in VIaN. An updated exploratory short term forecast was carried out in 2013 also.

E. Medium-Term Projections

Model Used: Multi Fleet Yield Per Recruit

Software Used: MFYPR Software

Yield-per-recruit analysis was carried out using MFYPR to provide yield-per-recruit plots for the data produced in the assessment. The values for $\mathbf{F}_{0.1}$ and $\mathbf{F}_{med}$ are 0.17 and 0.31. F_{max} is undefined and this is consistent with many other pelagic species (ICES, 2006).

F. Long-Term Projections

Work was conducted on simulating the long term dynamics of this stock for HAWG 2011. This work focused on using the converged part of the separable VPA exploratory assessments and projecting forward. The analysis aimed to define a range of target F, $B_{trigger}$ and percentage TAC constraints that would be appropriate for this stock. Results are in broad agreement with the work conducted by HAWG in 2010, in developing the MSY approach for this stock (ICES 2010, ACOM:06).

G. Biological Reference Points

In 2007 the technical basis for the selection of the precautionary reference points was examined based on methods used by SGPRP (ICES CM 2001). No alternative biomass and fishing mortality reference points are available. It is clear that recruitment does not show any clear dependence on the SSB and that apart from the very high year classes in the 1980s is showing a decline.

The SGPRP (ICES CM 2003) has reviewed the methodology for the calculation of biological reference points, and applying a segmented regression to the stock and recruit data from the 2002 HAWG assessments. This showed that the fit to the stock and recruit data for this stock was not significant. There was no well defined change point and there was no reason to refine the reference points at that time.

Current reference points

B_{pa} = 81,000 t = the lowest reliable estimate of SSB

B_{llim}= 110,000 t = 1.4 x B_{pa}

F_{pa} = 0.22 = F_{med} (1998)

F_{lim} = 0.33 = F_{loss}

Applying the segmented regression method to the extended time series 1957-2010 (Clarke et al. 2011 found the the breakpoint to be 79,000 t, or 76,000 t if the three large year classes (1963, 1981 and 1985) were removed. Thus, 76,000 t could be considered as the B_{lim} reference points.

H: Other Issues

H.1 Biology of the species in the distribution area

The herring (*Clupea harengus*) is a widely distributed pelagic species in this area. This stock is comprised of different spawning components. Off the west coast the majority of the stock, are autumn spawners. Off the northwest coast distinct spawning units have also been identified. Autumn spawners, that spawn in the Donegal Bay area and winter/spring spawners, that spawn further north off the Donegal coast (Breslin, 1998). Autumn and winter spawners were distinguished by vertebral counts and timing of maturity. Peak spawning times from the autumn component have been inferred by larval surveys and occur late September and October in water temperatures ranging between 10-12ºC (Molloy and Barnwall, 1988).

Herring are benthic spawners and deposit their eggs on the sea bed usually on gravel or course sediments. The yolk sac larvae hatch and adopt a pelagic mode of life.

When referring to spawning locations the following terminology is used (Molloy, 2006)

- A <u>spawning bed</u> is the area over which the eggs are deposited
- A <u>spawning ground</u> consists of one or more spawning beds located in a small area.
- A <u>spawning area</u> is comprised of a number of spawning grounds in a larger area

Spawning grounds are typically located in high energy environments such as the mouth of large rivers and areas where the tidal currents are strong. Herring shoals return to the same spawning grounds each year (Molloy, 2006). The spawning grounds for northwest herring are generally located in shallow waters close to the coast. Spawning in deeper water has also been recorded (Molloy and Kelly, 2000). The exact locations are not well documented. Areas where spawning fish have been found include the mouth of the Shannon, Galway Bay, around the Aran Islands, the stags of Broadhaven and off the coasts of Sligo and Mayo (ICES, 1994). Spawning begins in October and can continue until February.

Fecundity is the number of eggs produced by the female and is proportional to the length of the fish (Molloy, 2006). Several studies were carried out in the early 1980s to analyse the fecundity of winter and autumn spawning components of the North West herring stock and considerable differences were found. Donegal winter spawners produce significantly fewer eggs than autumn spawners. When compared to the Celtic Sea herring stock, Donegal herring have a higher fecundity and begin to spawn earlier (McArdle, 1983). A study conducted in the 1920s found that the eggs produced by winter/spring spawners were 25% bigger than those autumn spawners but were less numerous (Farran, 1938). Grainger (1976) gave the following fecundity-length relationships for autumn spawning components:

Parameter	b	a	n	P
Galway	3.882	-20.981	17	0.001
Donegal	4.137	-27.325	25	0.001

Herring produce benthic eggs that are adhered to the bottom substrate where they remain until the larvae hatch. The larvae are carried by the currents and drift towards the west coast of Scotland (Grainger and McArdle, 1985).

The larval phase is an important period in the herring life cycle. Larvae use their oil globule for food and to provide buoyancy. Their movements and survival are determined by favourable environmental conditions. Larvae originating from spawning grounds off the west coast are carried by currents to the northwest coast of Donegal and may even travel as far as Scotland (Molloy, 2006). Figure 1 shows a schematic presentation of the life cycle of Herring west and northwest of Ireland.

The juveniles tend to remain close inshore, in shallow waters for the first two years of their lives, in nursery areas. There are many of these nursery areas around the coast, for example St. Johns point in Donegal Bay. Other nursery areas on the north coast include Lough Swilly and Sheephaven Bay. In division VIIb, Broadhaven Bay and the inner parts of Galway bay are also nursery grounds (ICES, 1994).The minimum landing size for herring is 20cm and therefore these juvenile herring are not caught by the fishery in the early stages of their life cycle (Molloy, 2006).

Changes in the growth rate of this stock can be seen over time. In the late 1980s a sudden and unexplained drop in mean weights was observed. This had an impact on the estimate of SSB and the advised TAC. The growth rate of this stock has never recovered to the levels before this decline (Molloy, 2006).

Adult herring are found offshore until spawning time, when they move inshore. Occasionally very large herring are found off the Irish coast. Theses herring appear off the north coast and are usually in a spawning or pre spawning condition (Molloy, 2006). The main feeding grounds for this stock extend from Galway west of Ireland to the Stanton Bank and between Tory Island and Malin Head (Molloy 2006).

H.2. Management and ACFM advice

Local Management

Management measures were slowly introduced into this fishery with by-laws restricting fishing in certain areas off the coast in the early 1900s. This type of management continued until the 1930s when fishing was prohibited during April and May, in order to improve the quality of the herring being landed. In the 1970s management measured became more defined. Direct fishing of herring for fishmeal was banned. A minimum landing size of 20cm was implemented and also minimum mesh sizes. TACs were introduced in order to control the amount of herring landing each year from each ICES area (Molloy, 1995).

Various management measures have been introduced to control the exploitation of this stock. From 1972-1978 TACs were set by NEAFC and covered all of Division VIa. The TAC decreased rapidly and the stock was thought to be in decline. This continued until the fishery was closed in 1979 and 1980. During the closure because there was no analytical assessment of VIIb, fishing was allowed to continue on a precautionary basis (ICES, 1994). When the fishery was reopened it was decided to split the area into VIaS and VIaN. Landings from this area increased due to the increased efficiency of the Irish vessels and the participation in this fishery by Dutch vessels (Anon, 2000).

The management of the fishery has improved in recent years and catches have been considerably reduced since 1999. In 2000 the Irish North West Pelagic Management Committee was established to deal with the management of this stock. The assessment period runs concurrently with the annual quota. Quotas are allocated on a fortnightly basis and there is some capacity to carry unused allocation into the following fortnight with overruns being deducted.

In 2000, the Irish North West Pelagic Management Committee was established to deal with the management of this stock. The committee has the following objectives:

- To rebuild this stock to above the B_{pa} level of 110 000 t.
- In the event of the stock remaining below this level, additional conservation measures will need to be implemented.
- In the longer term it is the policy of the committee to further rebuild the stock to the level at which it can sustain annual catches of around 25 000 t.
- Implement a closed season from March to October.
- Regulate effort further through boat quotas allocated on a weekly basis in the open season.

This committee manages the whole fishery for this stock at present, given that Ireland currently accounts for the entire catch.

The current state of the stock is uncertain. Preliminary assessments suggest that SSB may be stable at a low level. The current level of SSB is uncertain but likely to be below B_{lim}. There is no evidence that large year classes have recruited to the stock in recent years. F appears to have increased concomitantly with increases in the catch. F is likely to be above F_{pa} and also likely above F_{lim}.

There is no explicit management plan for this stock. The local Irish management committee developed the objective to rebuild the stock to above B_{pa} and to maintain catches of 25 000 t per year. The implementation of the closed season from March to October has been successful in ensuring that the fishery mainly concentrates on the spawning component in this area. In recent years the ICES advice has remained unchanged. ICES have recommended that a rebuilding plan be put in place that will reduce catches. If no rebuilding plan is established, there should be no fishing. The rebuilding plan should be evaluated with respect to the precautionary approach.

H.4 Terminology

The WG uses "rings" rather than "age" or "winter rings" throughout the report to denominate the age of herring, with the intention to avoid confusion. It should be observed that, for autumn spawning stocks, there is a difference of one year between "age" and "rings". HAWG in 1992 (ICES 1992/Assess:11) stated that

"The convention of defining herring age rings instead of years was introduced in various ICES working groups around 1970. The main argument to do so was the uncertainty about the racial identity of the herring in some areas. A herring with one winter ring is classified as 2-years-old if it is an autumn spawner, and one-year-old if it is a spring spawner. Recording the age of the herring in rings instead of in years allowed scientists to postpone the decision on year of birth until a later date when they might have obtained more information on the racial identity of the herring.

The use of winter rings in ICES working groups has introduced a certain amount of confusion and errors. In specifying the age of the herring, people always have to state explicitly whether they are talking about rings or years, and whether the herring are autumn or spring spawners. These details tend to get lost in working group reports, which can make these reports confusing for outsiders, and even for herring experts themselves. As the age of all other fish species (and of herring in other parts of the world) is expressed in years, one could question the justification of treating West-European herring in a special way. Especially with the present trend towards multispecies assessment and integration of ICES working groups, there might be a case for a uniform system of age definition throughout all ICES working groups.

However, the change from rings to years would create a number of practical problems. Data files in national laboratories and at ICES would have to be adapted, which would involve extra costs and manpower. People that had not been aware of the change might be confused when comparing new data with data from old working group reports. Finally, in some areas (notably Division IIIa), the distinction between spring and autumn spawners is still hard to make, and scientists preferred to continue using rings instead of years.

The Working Group discussed at length the various consequences of a change from rings to years. The majority of the Group felt that the advantages of such a change did not outweigh the disadvantages, and it was decided to stick to the present system for the time being."

The text table below gives an example for the correlation between age, rings and year class for the different spawning types in late 2002:

YEAR CLASS (AUTUMN SPAWNERS)	2001/2002	2000/2001	1999/2000	1998/1999
Rings	0	1	2	3
Age (autumn spawners)	1	2	3	4
Year class (spring spawners)	2002	2001	2000	1999
Rings	0	1	2	3
Age (spring spawners)	0	1	2	3

References

Bracken, J.(1964) Donegal herring investigations 1963/64. ICES CM 1965. Herring committee No. 88

Breslin J.J. (1998) The location and extent of the main Herring (Clupea harengus) spawning grounds around the Irish coast. Masters Thesis: University College Dublin.

Clarke, M.W., Egan, A., Mariani, S and Miller, D. 2011. Long term trends in the population dynamics of northwestern Ireland herring revealed by data archaeology. ICES CM 2011/D:04.

Darby, C.D. and Flatman, S. (1994). Virtual population analysis: version 3.1 (Windows/DOS) user guide. MAFF Information Technology Series No.1. Directorate of Fisheries Research: Lowestoft.

Farran, G.P., (1928): The Herring Fisheries off the North Coast of Donegal. Department of Agriculture Journal. 34, No 2

Farran, G.P.,(1930) Fluctuations in the stock of herrings in the Norh coast of Donegal. Rapports Et Proces-Verbaux Des Reunions Du Conseil Permanent International Pour L'Exploration De La Mer 65(14): 6 pp.

Farran, G. P. (1938). "On the size and numbers of the Ova of Irish Herrings." Journal du Conseil International Pour L'exploration de la Mer 13(1).

Grainger, R.J.(1976). The inter-relationships of populations of autumn spawning herring off the west coast of Ireland. BIM Resource Record Paper. 21 pp.

Grainger, R.J.(1978) A Study of Herring Stocks West Of Ireland and their Relations to Oceanographic Conditions. Phd thesis, University College Galway.

Grainger, R.J., (1980a). Irish West coast herring fluctuations and their relation to oceanographic conditions. Symposium on the Biological basis of Pelagic Stock Management No. 29

Grainger, R. J., (1980b). The distribution and abundance of early herring (Clupea harengus L.) larvae in Galway Bay in relation to oceanographic conditions. Proc. R. Ir. Acad., Sect. B 80:1-60.

Grainger, R. J. and E. McArdle (1981) "Surveys for herring larvae off the northwest and west coasts of Ireland in 1981." Fisheries Leaflet (No 117): 10 pp.

ICES (1981) Report of the Herring Assessment Working Group for the Area South of 62°N. ICES CM 1981/H:08.

ICES (1992). Report of the Herring Assessment Working Group for the Area South of 62°N. ICES CM 1992/Assess:11

ICES (1994). Report of the Study group on Herring Assessment and Biology in the Irish Sea and Adjacent Waters. Belfast, Northern Ireland, ICES CM 1994/H:5

ICES (1994b). Herring assessment working group for the Area South of 62ºN. ICES CM 1994/Assess:13

ICES (2001) Report on the study group on the further development of the precautionary approach to fishery management. ICES CM:2001/ACFM:11

ICES (2003) Study group on Precautionary Reference Points for Advice on Fishery Management (SGPRP). ICES CM 2003/ACFM: 15 (2003)

ICES (2005): Herring Assessment Working Group for the Area South of 62ºN (HAWG). ICES CM 2005/ACFM: 18.

ICES (2005b): Report of the Study group on Regional Scale Ecology of Small Pelagics ICES CM:2005/G:06

ICES (2006). Herring Assessment Working Group for the Area South of 62ºN (HAWG). ICES CM 2006/ACFM: 20.

ICES (2006b). Report of working group for regional ecosystem description (WGRED). ICES CM 2006 ACE:03

ICES (2007). Herring Assessment Working Group for the Area South of 62ºN (HAWG). ICES CM 2006/ACFM: 11.

ICES (2007b). Report of working group for regional ecosystem description (WGRED). ICES CM 2007 ACE:02

ICES (2007c). Working group on Oceanic Hydrography (WGOH). ICES CM 2007 OCC:05

ICES (2009). Study Group on the evaluation of assessment and management strategies of the western herring stocks (SGHERWAY) ICES CM:2009 RCM:15

ICES (2010). Study Group on the evaluation of assessment and management strategies of the western herring stocks (SGHERWAY) ICES 2010 SSGSUE:08

Kennedy, T.D. (1970) The herring fisheries on the North west and West coasts 1970 and 1971. Fishery Leaflet. No. 29

Lynch, D. 2009. Long term changes in the biology of Celtic Sea Herring. MSc. Thesis, Trinity College Dublin.

McArdle, E., (1983) Fecundities of winter spawning herring off the Northwest coast of Ireland. ICES CM 1983/H:59

Molloy, J., (1989) Herring Research – Where do we go from here? Fisheries Research Centre, Unpublished document, 6pp.

Molloy, J., and E. Barnwall. 1988. Herring larval surveys off the west and northwest coasts 1984-1986. Fishery Leaflet 142:8pp.

Molloy, J., Barnwall, E., Morrison, J (1993). "Herring tagging experiments around Ireland, 1991." Fisheries Leaflet(154): 7 pp.

Molloy, J. (1995). The Irish herring fisheries in the twentieth century: their assessment and management. Occasional Papers in Irish Science and Technology, Royal Dublin Society: 1-16.

Molloy, J, Kelly, C. (2000): Herring in VIaS and VIIbc, a review of fisheries and biological information. Report of the workshop between Scientists and Fishermen, Killybegs Fishermen's Organisation, Bruach Na Mara, July 2000.

Molloy, J. (2006): The Herring Fisheries of Ireland (1990 – 2005). Biology, Research and Development.

Nolan, G., and Lyons, K, (2006). Ocean Climate variability on the western Irish shelf, an emerging time series. ICES CM/C:28

Patterson, K.R. (1998) Integrated Catch at Age Analysis Version 1.4. Scottish Fisheries Research Report. No. 38

Patterson, K.R., (1998b) A programme for calculating total international catch at age and weight at age. Marine Laboratory Aberdeen.

Reid, J.B., Evans, P.G.H. and Northridge, S.P. (2003). Atlas of Cetacean distribution in north-west European waters. Joint Nature Conservancy Committee, Peterborough.

WESTHER, Q5RS-2002-01056: A multidisciplinary approach to the identification of herring (*Clupea harengus* L.) stock components west of the British Isles using biological tags and genetic markers.

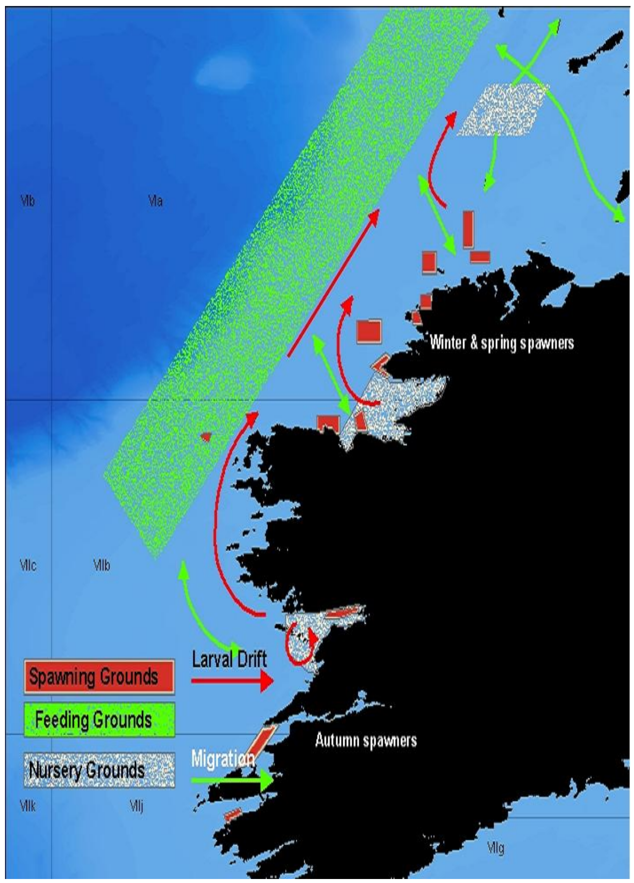


Figure 1: Schematic presentation of the life cycle of Herring west and northwest of Ireland.

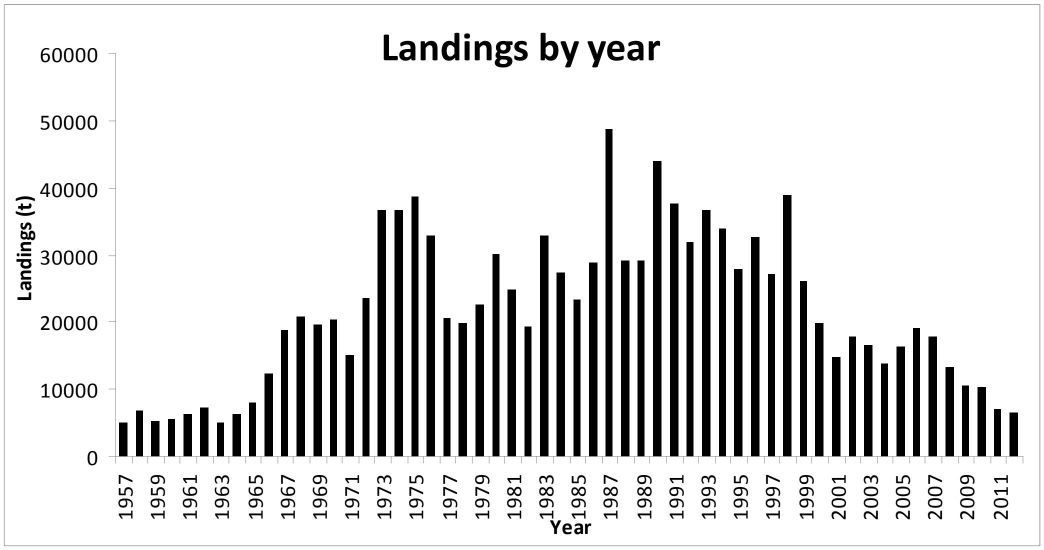


Figure 2: Total landings from VIaS, VIIb,c

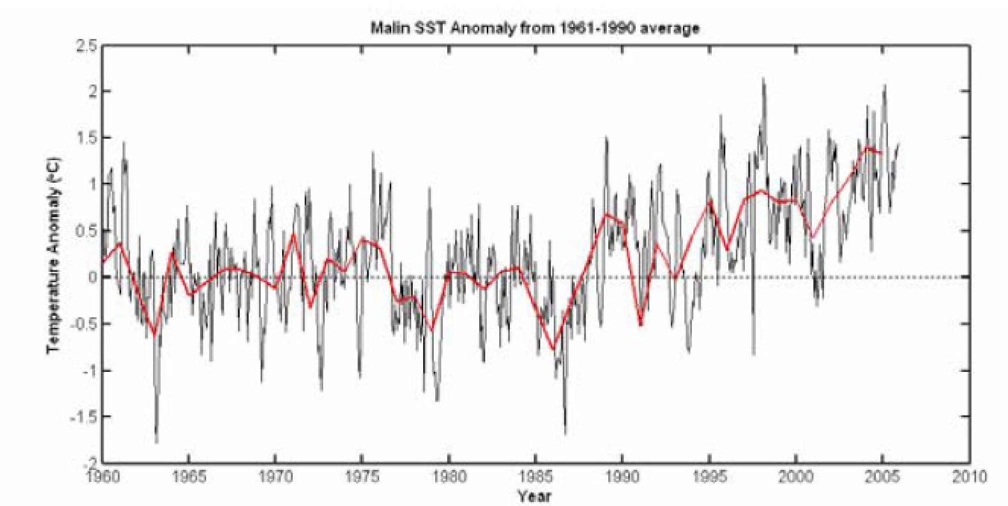
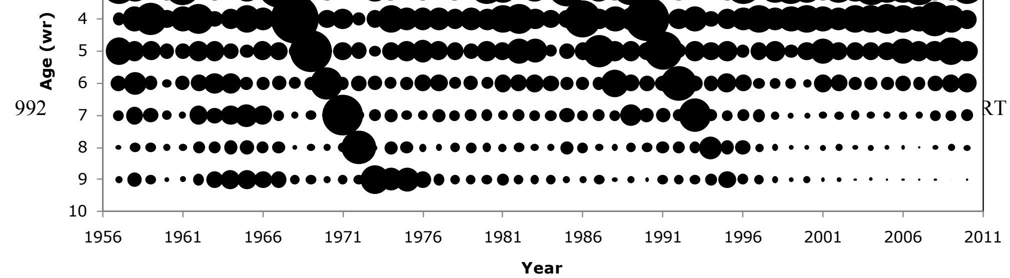


Figure 3: Sea surface temperature anomaly at Malin Head (1960-2005) (Nolan and Lyons, 2006)



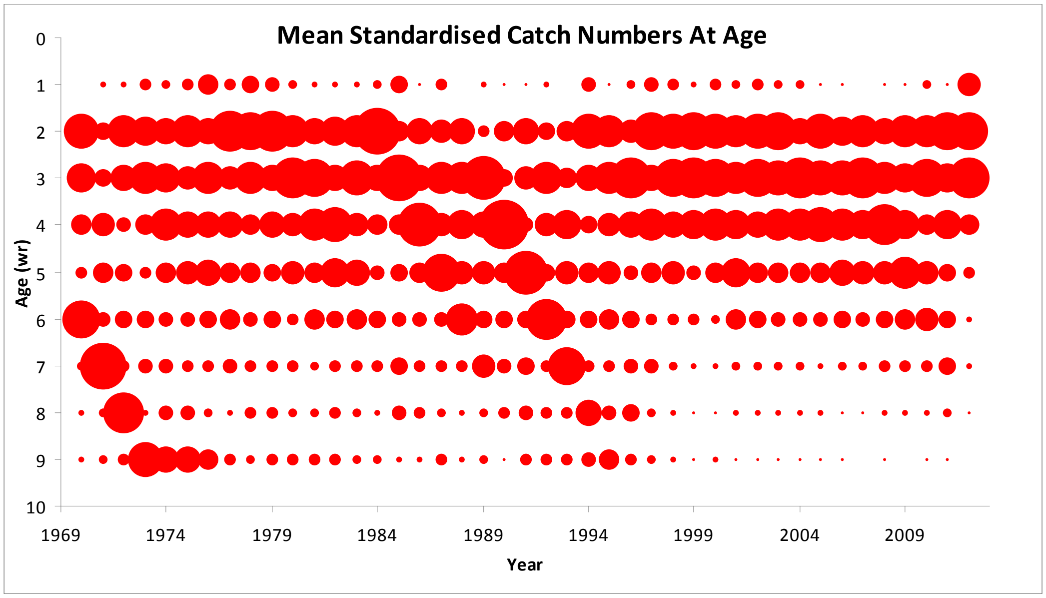
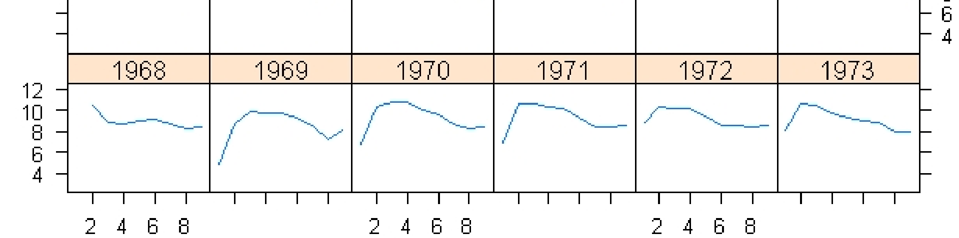
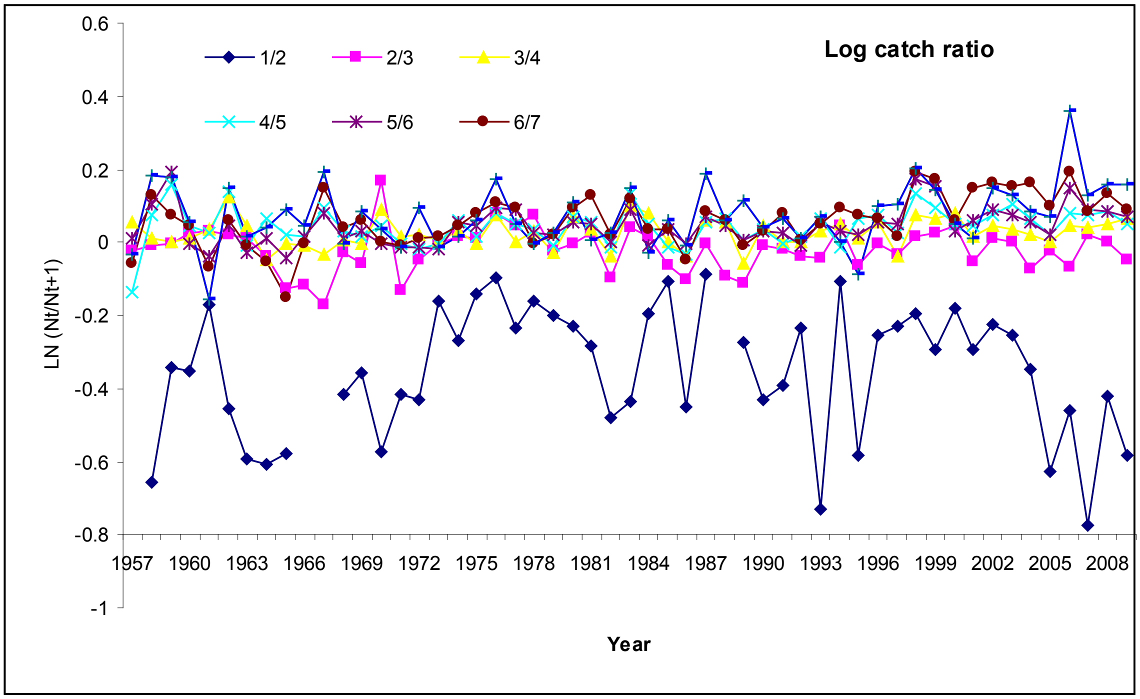


Figure 4: Mean Standardised Catch Numbers at Age





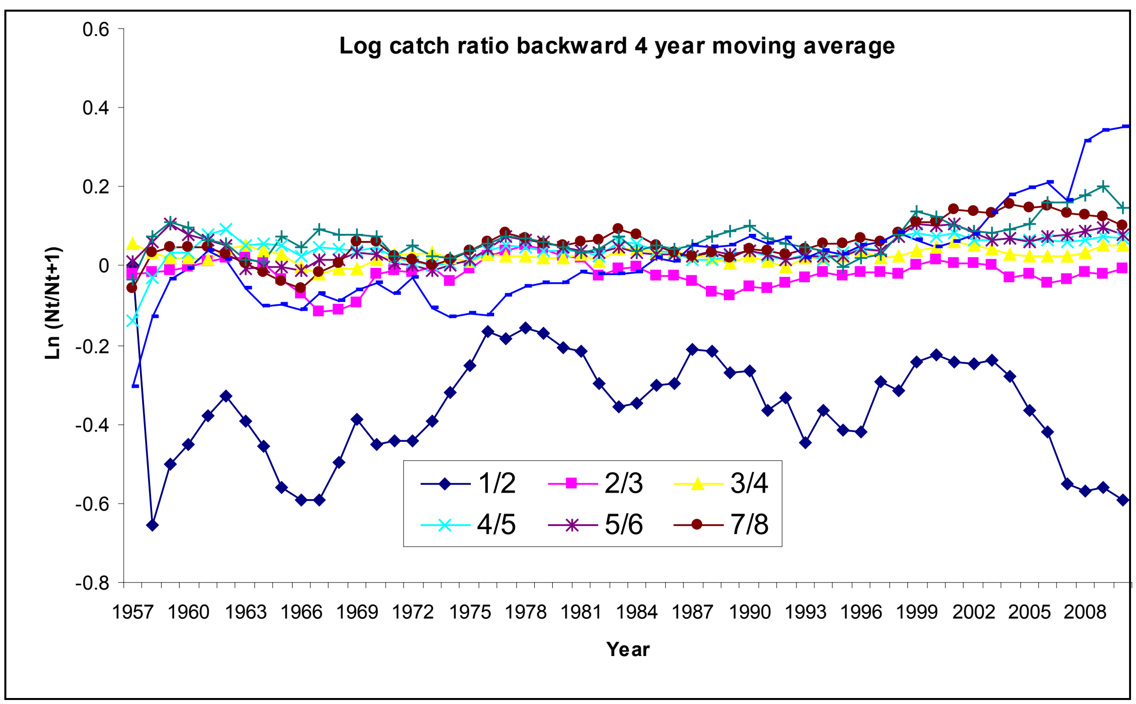
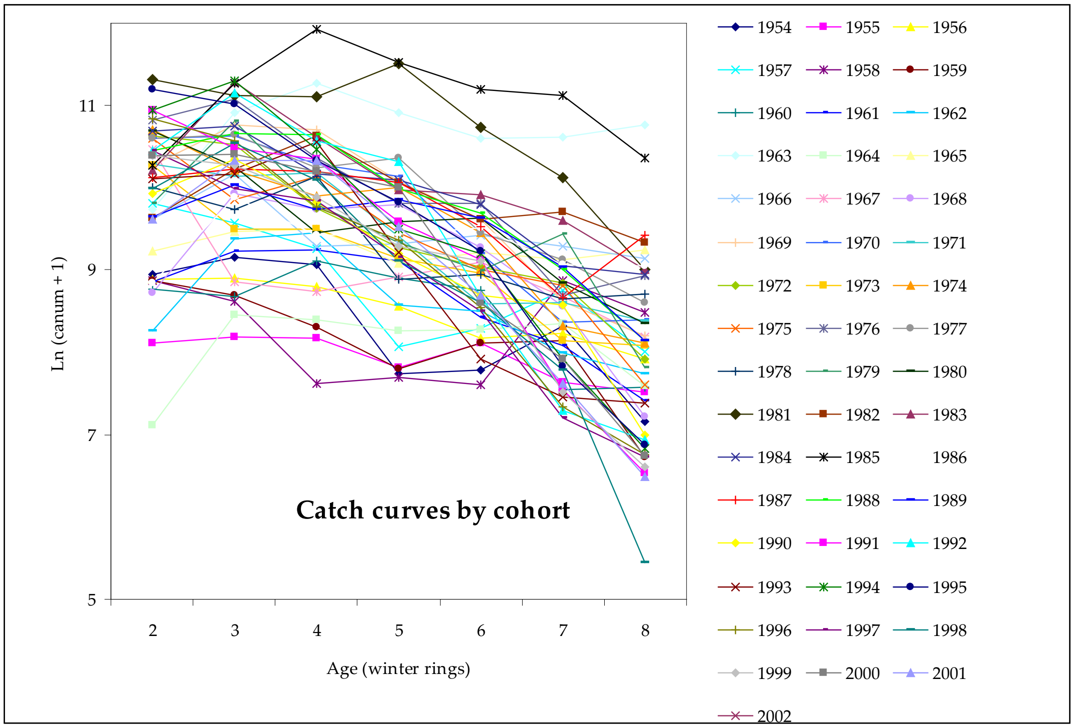


Figure 5. Log catch ratios 1957-2010. Top panel individual years, lower panel applying a backward 4 year moving average smoother.



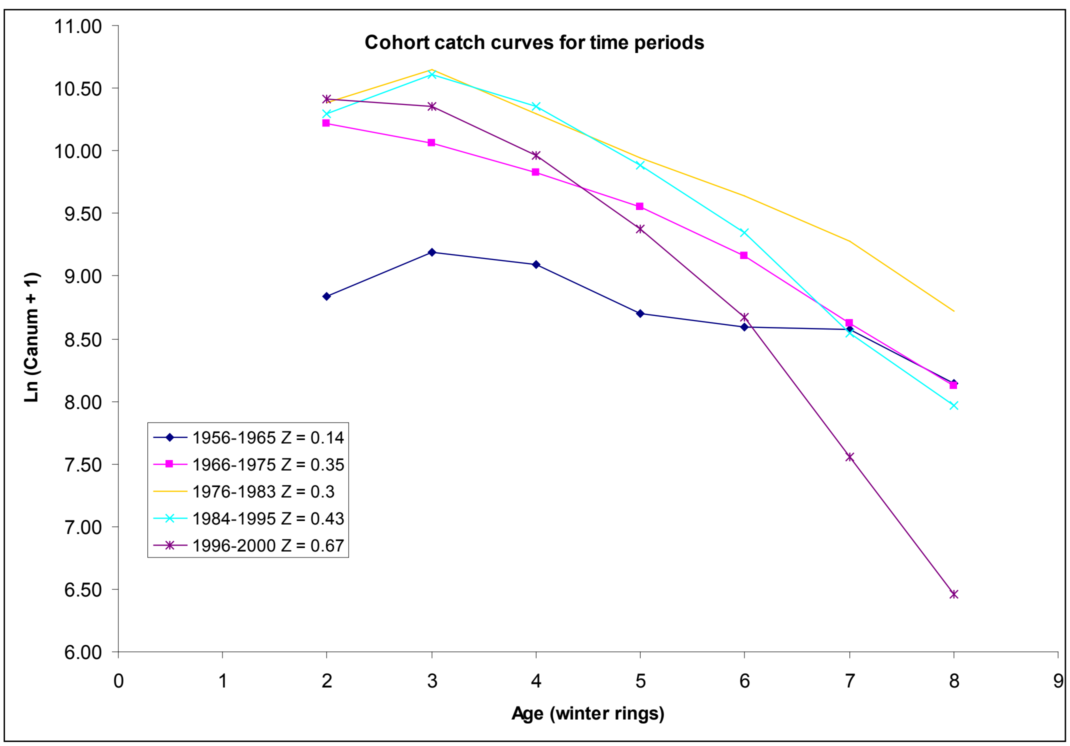


Figure 6: Cohort catch curves by birth year, 1954-2002 (top panel) and for various time periods 1956-2000 (bottom panel).

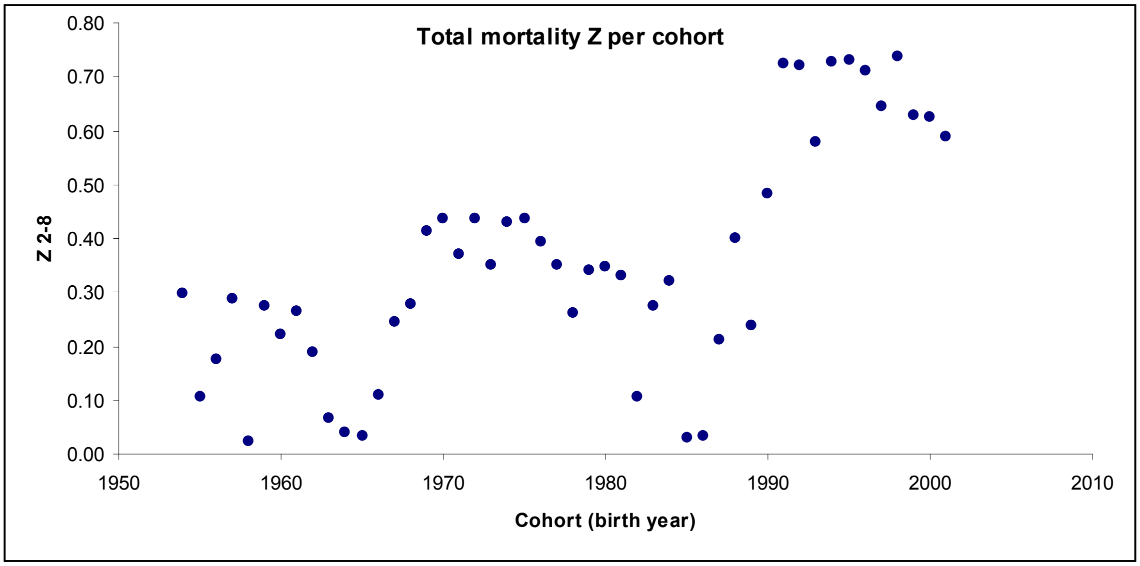


Figure 7: Total mortality (2-8 winter rings) by cohorts born from 1954-2001.

Adjunct to Annex 7 (2011) Extension of VIaS VIIb,c time series

Maurice Clarke

Introduction

The present data series spans 1970 to 2009. It was felt that extending the series back in time would improve our understanding of stock productivity. It was known that sampling of Irish catches began in 1962 (Killybegs only) and in 1963/64 more extensively (Bracken , 1962,1963). Therefore an attempt was made to extend the series at least as far back as 1963. Before this, German and Dutch sampling was understood to have taken place (Molloy pers. comm.), and data were available as far back as 1957.

A similar extension of the VIaN time series was conducted in 2004 (ICES 2004, Appendix 11; Keltz and Simmonds 2004). Also available was an historical series of catch numbers at age for VIa (incl. Moray Firth juvenile fishery) for the years 1957-1980 (ICES HAWG, 1974; 1980; 1981; 1982). The broad approach taken here was to subtract the VIaN extended series (HAWG 2004) from the ViaN historic series.

This document outlines the approach taken to extend the current time series back from 1957-1969.

Materials and methods

The following data were available:

Catch-numbers-at-age VIa (incl. Moray Firth) 1957-1980 (Keltz and Simmonds, 2004, and references therein)

Catch in tones	VIa (south of 57°N)	1967-1980	(HAWG, 1978)
	VIIbc	1970-1980	(HAWG, 1981)

The data presented in HAWG 1978 could not be used because they were for the area south of 57°N, rather than south of 56°N.

Catch in tonnes (CATON)

Catch in tones for VIa S/VIIbc was estimated by subtracting the estimated catch in tones for VIaN (incl. Moray Firth) as presented by ICES (2004). Table 1 shows catch in tones for VIaN (incl. Moray Firth) from various working group reports. It can be seen from this that revisions were only applied in the terminal year, and the data were stable back in time. Table 2 shows the calculations used to achieve the best estimate of VIa S/VIIbc. The VIa total catch in tones was taken from the ICES HAWG 1974. These data were partitioned using the compliment of the raising factor presented by Keltz and Simmonds (2004, Table 11). Their raising factor was used to segregate VIa into VIaN. Thus, the remaining data can be considered as the best estimate of VIaS landings. VIIbc landings (ICES, HAWG, 1981) were added to these data to obtain the best estimate for the stock. The compliment of Keltz and Simmonds' ratio is presented in Table 3. These ratio compliments were calculated over the period 1970 -1980, but were applied to the years 1957 to 1969.

As a check these estimates were compared using the following check on totals by year:

(VIa $_{\text{total, Table 1}}$– ViaN caton $_{\text{HAWG 2010}}$) + VIIbc $_{\text{HAWG 1981}}$) /best estimate from ratio in Table 3..

It can be seen that the data agree very well with the data presented by ICES HAWG (1974) for all of VIa (minus VIaN) and for VIIbc.

Catch in number (CANUM)

Catch in numbers was calculated by subtracting the matrix for VIaN currently used in the assessment (ICES HAWG, 2010) from the historic VIa (incl. Moray Firth) matrix presented in ICES HAWG (1974). The latter data set is presented in Table 4. This approach assumes that catch numbers at age for VIIbc are included in the VIa matrix for the years 1967-1969, as this was the procedure at the time.

Mean weight in the catch and in the spawning stock (WECA and WEST).

In the absence of weight at age data constant values were extended backwards from 1970 to 1957, using 1983 values. This follows the procedure in recent working groups (HAWG, 2010).

Results and Discussion

The best estimate catch in tonnes estimated for VIaS and VIIbc over the time series is presented in Table 3, and in Figure 1.

The catch at age matrix, based on the extension of the data 1957-1969, is presented in Table 5. The value for 5 ring in 1966 was negative, the only instance where this occurred. This value was replaced by interpolation along the cohort.

To test the data further, a Sum-of-Product (SOP) check was performed by multiplying the canum from Table 5 by the new WECA, and comparing it with the reconstructed caton. SOP errors were encountered, of between 0 and 30%. In all but one case, where error was found, the caton was higher. To account for missing catch at age, the canum was raised by this SOP error to produce a final canum (Table 6).

The revision shows that the 1963 year class was very strong, and was the only strong cohort in the catches until the 1981 year class (Figure 2).

Negative values after 1969 in the canum suggests that there additional fish now in the VIAN data series as revised by Simmonds and Keltz (2004). However the VIaN series seems to be internally consistent (John Simmonds pers. comm..). A discrepancy exists in this new dataset with regard to the German Democratic Republic (East German) landings in VIaS (Table 3). Though it is known that such fisheries existed, no information on catch is available.

References

Bracken, J. 1963 Herring investigations in Donegal Bay (1962 and 1963). ICES CM 1963/111, 4 pp.

Bracken, J. 1964 Report on Donegal herring investigations 1963/1964. ICES CM 1964/88, 5 pp.

Keltz and Simmonds, 2004. Annex I to Report of the Herring Assessment Working Group South of 62ºN (HAWG), pp. 551 pp. Copenhagen: ICES

ICES. 1974 Report of the Herring Assessment Working Group South of 62ºN (HAWG), pp. 38 pp. Copenhagen: ICES.

ICES. 1975 Report of the Herring Assessment Working Group South of 62ºN (HAWG), pp. 44 pp. Copenhagen: ICES.

ICES. 1976 Report of the Herring Assessment Working Group South of 62ºN (HAWG), pp. 69 pp. Copenhagen: ICES.

ICES. 1977 Report of the Herring Assessment Working Group South of 62ºN (HAWG) - Part 1 of 2, pp. 86 pp. Copenhagen: ICES.

ICES. 1977 Report of the Herring Assessment Working Group South of 62ºN (HAWG) - Part 2 of 2, pp. 46 pp. Copenhagen: ICES.

ICES. 1978 Report of the Herring Assessment Working Group South of 62ºN (HAWG), pp. 74 pp. Copenhagen: ICES.

ICES. 1979 Report of the Herring Assessment Working Group South of 62ºN (HAWG), pp. 82 pp. Copenhagen: ICES.

ICES. 1980 Report of the Herring Assessment Working Group South of 62ºN (HAWG), pp. 128 pp. Copenhagen: ICES.

ICES. 1981 Report of the Herring Assessment Working Group South of 62ºN (HAWG), pp. 120 pp. Copenhagen: ICES.

ICES. 2004 Report of the Herring Assessment Working Group South of 62ºN (HAWG), pp. 551 pp. Copenhagen: ICES.

ICES. 2007 Report of the Herring Assessment Working Group South of 62ºN (HAWG), pp. 540 pp. Copenhagen: ICES.

Table 1. Catch in tonnes (VIA incl. Moray Firth) from various Herring Working Groups 1974-1981. Data not presented in WG reports for shaded areas.

HAWG	AREA	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
1974	Via	46805	65290	67984	68230	51941	63699	53949	69718	66383	92032	102694	100323	123593	178796	220941	173938	239993							
1974	Moray	1703	1164	2451	906	585	1842	118	660	10278	20734	6507	4985	3100	1385	5666	10242	7219							
1975	Via										92444	102871	100326	124009	179003	221271	174873	247148	205358						
1975	Moray										20734	6507	4985	3100	1385	5666	10242	7219	-						
1976	Via										92444	102871	100326	124009	179003	221271	174873	247148	209561	128240					
1976	Moray										20734	6507	4985	3100	1385	5666	10242	7219	13003	2454					
1977	Via											102871	100326	124009	179003	221271	174873	247148	209561	141263	106504				
1977	Moray											6507	4985	3100	1385	5666	10242	7219	13003	2454	313				
1978	Via												100330	124012	179004	221825	181749	248080	209564	141269	111420	47615			
1978	Moray												4985	3100	1385	5666	10242	7219	13003	2454	313	249			
1979	Via													124012	179004	221825	181749	248080	209564	141269	111420	48568	32371		
1979	Moray													3100	1385	5666	10242	7219	13003	2454	313	205	276		
1980	Via														179004	221825	181749	248080	209564	141269	111420	48568	34388	6028	
1980	Moray														1385	5666	10242	7219	13003	2454	313	205	1502	28	
1981	Via															221825	181749	248080	209564	141269	111420	48568	34388	7602	6661
1981	Moray															5666	10242	7219	13003	2454	313	205	1502	21	273
Total Via incl Moray		48508	66454	70435	69136	52526	65541	54067	70378	76661	113178	109378	105315	127112	180389	227491	191991	255299	222567	143723	111733	48773	35890	7623	6934

Table 2. best estimate of VIaS VIIbc catch in tones, 1957 to 1979.

	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
VIaN summ 2010 HAWG	43438	59669	65221	63759	46353	58195	49030	64234	68669	100619	90400	84614	107170	165930	207167	164756	210270	178160	114001	93642	41341	22156	60
VIaN Caton 2009 HAWG		59669	65221	63759	46353	58195	49030	64234	68669	100619	90400	84614	107170	165930	207167	164756	210270	178160	114001	93642	41341	22156	60
VIaT - VIaN	5070	6785	5214	5377	6173	7346	5037	6144	7992	12559	18978	20701	19942	14459	20324	27235	45029	44407	29722	18091	7432	13734	7563
(ViaT - VIaN)+ VIIbc	5070	6785	5214	5377	6173	7346	5037	6144	7992	12559	19086	21969	20513	17071	22125	31142	50270	50171	46693	36403	20353	21266	22204
VIaS and VIIbc best estimate	5070	6825	5226	5401	6182	7399	5059	6169	8016	12215	18881	20731	19607	20306	15044	23474	36719	36589	38764	32767	20567	19715	22608
(ViaT - VIaN)+ VIIbc / best estimate	1	1.01	1.00	1.00	1.00	1.01	1.00	1.00	1.00	0.97	0.99	0.94	0.96	1.19	0.68	0.75	0.73	0.73	0.83	0.90	1.01	0.93	1.02
Via (s of 57deg) HAWG 1978											26236	24502	24088	21721	18603	26274	41326	28229	28962	17989	7918		
VIIbc HAWG 1981											108	1268	571	2612	1801	3907	5241	5764	16971	18312	12921	7532	14641

Table 3. Ratios used to segregate VIA (incl. Moray Firth) landings into VIa S data. These ratios are the compliments of the ratios used by Keltz and Simmonds (2004). Catch data for German Democratic Republic are not available.

	VIAS	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969
Belgium	1	0	192	24	40	0	0	1	0	0	23	0	0	0
UK (Eng.)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Faeroe Isl.	0	0	0	0	0	0	0	0	0	0	0	0	0	0
France	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Denmark	0	0	0	0	0	0	0	0	0	0	0	0	0	0
German D.R.	0.82													
German F.R.	0.3	0	2578	753	1593	545	3384	1422	1616	1520	4390	5195	4462	4742
Netherlands	0.17	0	0	0	0	0	0	0	12	56	43	778	503	257
Iceland	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ireland	1	5069	4049	4449	3768	5637	4015	3633	4540	6440	7759	12290	13390	11895
UK (N.Irl.)	1	1	6	0	0	0	0	3	1	0	0	0	4	3
Norway	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Poland	0.85	0	0	0	0	0	0	0	0	0	0	618	2372	2710
UK (Scot)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
USSR	0.36	0	0	0	0	0	0	0	0	0	0	0	0	0
unallocated	1													
Moray Firth	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		5070	6825	5226	5401	6182	7399	5059	6169	8016	12215	18881	20731	19607

Table 4. Catch numbers at age for VIa (incl. Moray Firth) as presented in ICES HAWG (1974).

		1974 HAWG	VIa (inc. Moray Firth)							
					AGE (RINGS)					
	0	1	2	3	4	5	6	7	8	9+
1957		6496	80817	66094	26882	38989	21547	9643	1658	4817
1958		15695	33616	152801	43895	28108	32025	19986	10795	8887
1959		54063	74615	38547	124307	27898	18942	18833	8158	9364
1960	21	3940	115501	65703	25388	50558	12196	11096	6770	4856
1961		14473	50809	72914	38321	24455	14296	5791	5370	2887
1962		55278	99167	27189	76706	49002	22707	27787	7614	8435
1963		11890	82849	57688	13310	42796	28698	10171	14585	7885
1964	2781	26609	87652	74309	29583	8857	27075	21347	10109	17655
1965	46891	299701	23351	72085	67768	24525	7001	28806	21475	23515
1966	211639	211675	517616	45317	70793	38471	22691	12656	20790	33175
1967	186598	207947	28648	273723	49755	48320	36143	15226	10397	33967
1968	71425	220870	105348	26031	243304	19679	28436	17699	7275	14389
1969	192368	39160	107189	84565	27604	264558	25795	45908	27932	29258

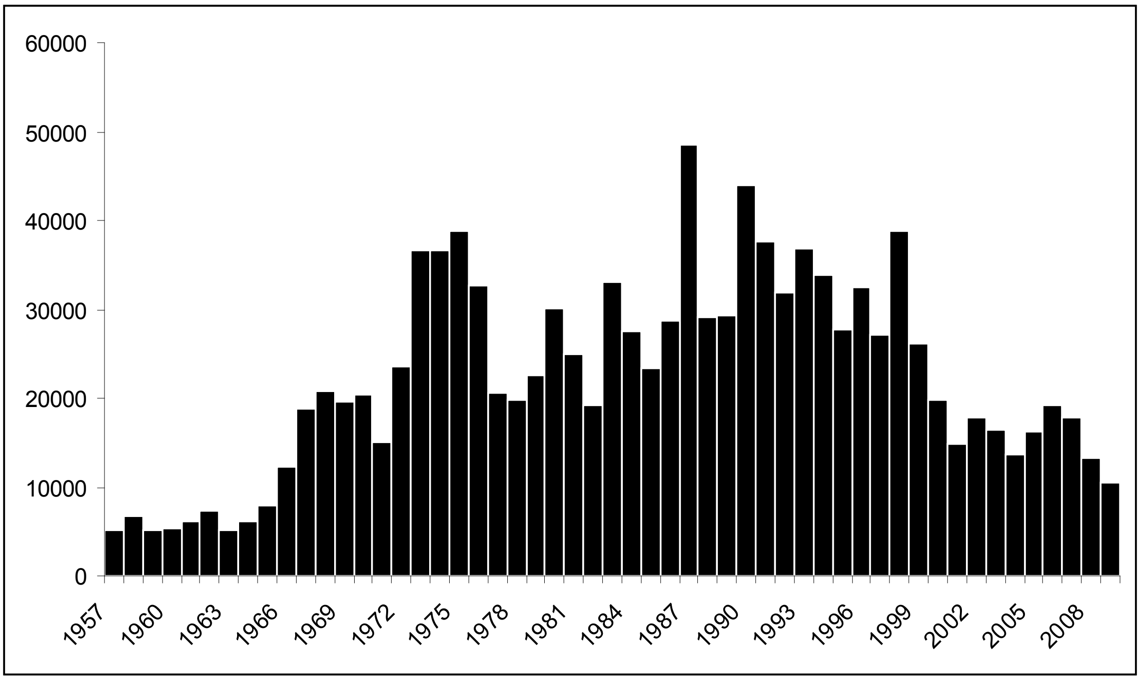


Figure 1. Best estimate of landings in VIaS VIIbc from 1957 to 2009. Data for 1957-1969 reconstructed in the current study.

Table 5. Extended catch at numbers at age matrx for VIaS and VIIbc. Only data for period 1957-1969 were reconstructed. Value for 5-ringer in 1966 was interpolated because it was a negative value (indicated in mauve). The interpolation was conducted either side along the cohort.

6aS and VIIb	1	2	3	4	5	6	7	8	9
1957	0	6195	8008	1120	5010	1657	758	231	394
1958	79	2636	7407	4825	3200	4395	2581	938	1728
1959	971	6643	3284	7917	2952	1610	1834	786	769
1960	379	13377	5413	2607	1677	565	749	424	239
1961	1392	5614	11295	5196	1954	1884	446	556	305
1962	230	6362	4911	9252	4645	2948	3648	1467	1353
1963	94	4602	4233	1451	2279	2528	1484	923	1797
1964	63	5041	4233	2903	1574	2848	2710	1312	2552
1965	218	3584	9443	8393	2260	1881	5915	2550	3984
1966	0	16763	11861	10291	7372	3347	7093	2979	6092
1967	0	1232	55034	12686	9074	6350	3456	4864	8168
1968	615	10910	5033	84182	5691	4854	2022	898	3575
1969	1454	14628	12658	4290	53315	4784	3146	1901	3051
1970	135	35114	26007	13243	3895	40181	2982	1667	1911
1971	883	6177	7038	10856	8826	3938	40553	2286	2160
1972	1001	28786	20534	6191	11145	10057	4243	47182	4305
1973	6423	40390	47389	16863	7432	12383	9191	1969	50980
1974	3374	29406	41116	44579	17857	8882	10901	10272	30549
1975	7360	41308	25117	29192	23718	10703	5909	9378	32029
1976	16613	29011	37512	26544	25317	15000	5208	3596	15703
1977	4485	44512	13396	17176	12209	9924	5534	1360	4150
1978	10170	40320	27079	13308	10685	5356	4270	3638	3324
1979	5919	50071	19161	19969	9349	8422	5443	4423	4090
1980	2856	40058	64946	25140	22126	7748	6946	4344	5334
1981	1620	22265	41794	31460	12812	12746	3461	2735	5220
1982	748	18136	17004	28220	18280	8121	4089	3249	2875
1983	1517	43688	49534	25316	31782	18320	6695	3329	4251
1984	2794	81481	28660	17854	7190	12836	5974	2008	4020
1985	9606	15143	67355	12756	11241	7638	9185	7587	2168
1986	918	27110	27818	66383	14644	7988	5696	5422	2127
1987	12149	44160	80213	41504	99222	15226	12639	6082	10187
1988	0	29135	46300	41008	23381	45692	6946	2482	1964
1989	2241	6919	78842	26149	21481	15008	24917	4213	3036
1990	878	24977	19500	151978	24362	20164	16314	8184	1130
1991	675	34437	27810	12420	100444	17921	14865	11311	7660
1992	2592	15519	42532	26839	12565	73307	8535	8203	6286
1993	191	20562	22666	41967	23379	13547	67265	7671	6013
1994	11709	56156	31225	16877	21772	13644	8597	31729	10093
1995	284	34471	35414	18617	19133	16081	5749	8585	14215
1996	4776	24424	69307	31128	9842	15314	8158	12463	6472
1997	7458	56329	25946	38742	14583	5977	8351	3418	4264
1998	7437	72777	80612	38326	30165	9138	5282	3434	2942
1999	2392	51254	61329	34901	10092	5887	1880	1086	949
2000	4101	34564	38925	30706	13345	2735	1464	690	1602
2001	2316	21717	21780	17533	18450	9953	1741	1027	508
2002	4058	32640	37749	18882	11623	10215	2747	1605	644
2003	1731	32819	28714	24189	9432	5176	2525	923	303
2004	1401	15122	32992	19720	9006	4924	1547	975	323
2005	209	28123	30896	26887	10774	5452	1348	858	243
2006	598	22036	36700	30581	21956	9080	2418	832	369
2007	76	24577	43958	23399	13738	5474	1825	231	131
2008	483	12265	19661	28483	11110	5989	2738	745	267
2009	202	12574	12077	12096	12574	5239	2040	853	17

Table 6. SOP-error-corrected catch numbers at age for VIaS and VIIbc, 1957-1969.

	1	2	3	4	5	6	7	8	9	SOP error
1957	0	994	1644	266	1303	458	218	68	118	0.80
1958	11	432	1553	1171	850	1240	757	282	529	0.79
1959	117	935	591	1651	673	390	462	203	202	0.92
1960	57	2350	1217	678	477	171	236	137	78	0.73
1961	194	920	2366	1260	519	531	131	167	93	0.79
1962	29	925	913	1991	1094	738	950	392	367	0.89
1963	14	831	978	388	667	786	480	306	607	0.71
1964	10	907	974	773	459	882	873	434	858	0.72
1965	26	496	1672	1721	507	448	1467	649	1031	0.93
1966	0	2168	1962	1971	1545	745	1643	708	1472	1.00
1967	0	159	9077	2422	1896	1409	798	1152	1968	1.00
1968	63	1315	776	15020	1111	1007	436	199	805	1.07
1969	164	1940	2147	842	11455	1092	747	463	756	0.97

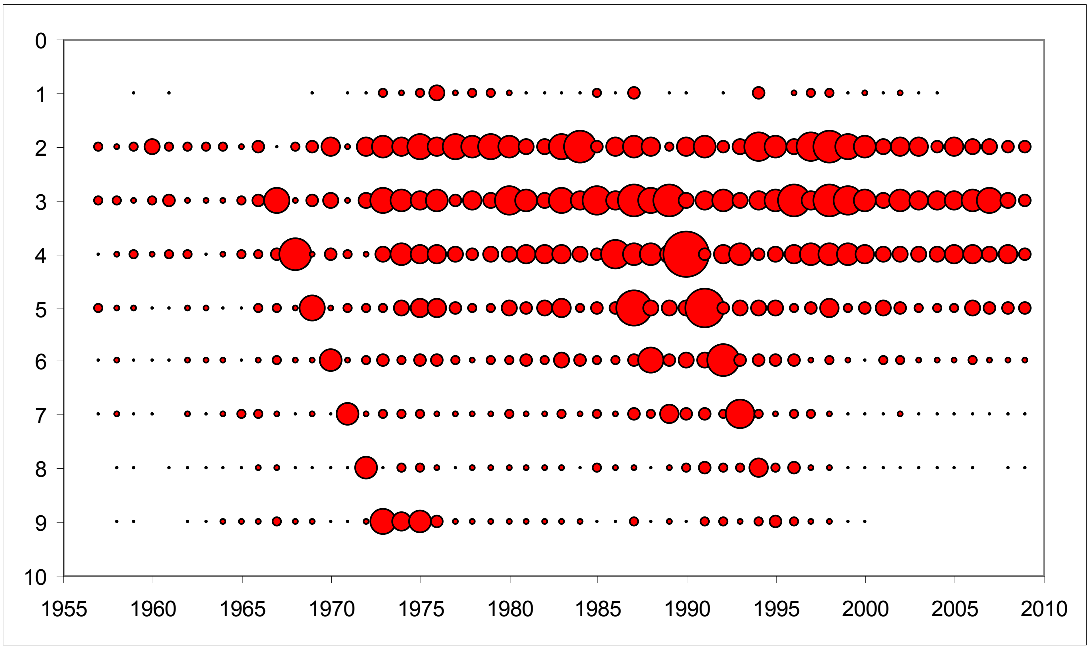


Figure 2. Bubble plot of catch numbers at age for extended series in VIaS and VIIbc.

Annex 8 - Stock Annex Irish Sea Herring VIIa (N)

Quality Handbook	ANNEX:_hawg-nirs

Stock specific documentation of standard assessment procedures used by ICES.

Stock:	Irish Sea herring (VIIa(N)
Working Group	Herring Assessment Working Group (HAWG)
Date:	**8** March 2012
Revised by	Pieter-Jan Schön

A. General

A.1. Stock definition

Herring spawning grounds in the Irish Sea are found in coastal waters to the west and north of the Isle of Man and on the Irish Coast at around 54ºN (ICES, 1994; Dickey-Collas *et al*., 2001). Spawning takes place from September to November in both areas, occurring slightly later on average on the Irish Coast than off the Isle of Man. ICES Herring Assessment Working Groups from 19XX to 1983 used vertebral counts to separate catches into Manx and Mourne stocks associated with these spawning grounds. However, taking account of inaccuracies in this method and the results of biochemical analyses, the 1984 WG combined the data from the two components to provide a "more meaningful and accurate estimate of the total stock biomass in the N. Irish Sea." All subsequent assessments have treated the VIIa(N) data as coming from a single stock. During the 1970s, catches from the Manx component were about three times larger than those from the Mourne component. By the early 1980s, following the collapse of the stock, the catches were of similar magnitude. The fishery off the Mourne coast declined substantially in the 1990s then ceased, whilst acoustic and larva surveys in this period indicate that the spawning population in this area has been very small compared to the biomass off the Isle of Man.

The occurrence in the Irish Sea of juvenile herring from a winter-spring spawning stock has been recognized since the 1960s based on vertebral counts (ICES, 1994). More recently, Brophy and Danilowicz (2002) used otolith microstructure to show that nursery grounds in the western Irish Sea were generally dominated by winter-spawned fish. Samples from the eastern Irish Sea were mainly autumn-spawned fish. Recaptures from 10,000 herring tagged off the SW of the Isle of Man in July 1991 occurred both on the Manx spawning grounds and along the Irish Coast with increasing proportions from the Celtic Sea in subsequent years (Molloy *et al*., 1993). The pattern of recaptures indicated a movement towards spawning grounds in the Celtic Sea as the fish matured.

A proportion of the Irish Sea herring stocks may occur to the north of the Irish Sea outside of the spawning period. This was indicated by the recapture on the Manx spawning grounds of 3-6 ring herring tagged during summer in the Firth of Clyde (Morrison and Bruce, 1981). Aggregations of post-spawning adult herring were detected along the west coast of England during an acoustic survey in December 1996 (Department of Agriculture and Rural Development for Northern Ireland, unpublished data), showing that a component of the stock may remain within the Irish Sea.

The results of WESTHER, a recent EU-funded programme aiming to elucidate stock structures of herring throughout the western seaboard of the British Isles have recently been published. Using a combination of morphometric measurements, otolith structure, genetics and parasite loads the conductivity of stocks within and beyond the Irish Sea have been examined. The results of this programme and existing knowledge are currently being evaluated at SGHERWAY in light of the future assessment and management of stocks to the western British Isles.

A.2. Fishery

There have been three types of fishery on herring in the Irish Sea in the last 40 years:

Isle of Man- aimed at adult fish that spawn around the Isle of Man.

Mourne- aimed at adult fish that spawn off the Northern Irish eastern coast.

Mornington- a mixed industrial fishery that caught juveniles in the western Irish Sea.

The Mornington fishery started in 1969 and at its peak it caught 10,000 tonnes per year. It took place throughout the year. The fishery was closed due to management concerns in 1978 (ICES, 1994). In the 1970s the catch of fish from the Mourne fishery made up over a third of the total Irish Sea catch. The fishery was carried out by UK and Republic of Ireland vessels using trawls, seines and drift nets in the autumn. However the fishery declined and ceased in the early 1990s (ICES, 1994). The biomass of Mourne herring, determined from larval production estimates is now 2-4% of the total Irish Sea stock (Dickey-Collas *et al.*, 2001).

The main herring fishery in the Irish Sea has been on the fish that spawn in the vicinity of the Isle of Man. The fish are caught as they enter the North Channel, down the Scottish coast, and around the Isle of Man. Traditionally this fishery supplied the Manx Kipper Industry, which requires fish in June and July. However the fish appeared to spawn slightly later in the year in the 1990s and this lead to problems of supply for the Manx Kipper Industry. In 1998 the Kipper companies decided to buy in fish from other areas. Generally the fishery has occurred from June to November, but is highly dependent on the migratory behaviour of the herring.

The fishery has been prosecuted mainly by UK and Irish vessels. TACs were first introduced in 1972, and vessels from France, Netherlands and the USSR also reported catches from the Irish Sea during the 1970s before the closure of the fisheries from 1978 to 1981. By the 1990s only the fishery on the Manx fish remained, and by the late 1990s this was dominated by Northern Irish boats. The number of Northern Irish vessels landing herring declined from 24 in 1995-96 to 6-10 in 1997-99 and to 4 in 2000. Only two vessels operated in 2002 and 2003. However, total landings have remained relatively stable since the 1980s whilst the mean amount of fish landed per fishing trip has increased, reflecting the increase in average vessel size

A.3. Ecosystem aspects

The main fish predators on herring in the Irish Sea include whiting (*Merlangius merlangus*), hake (*Merluccius merluccius*) and spurdog (*Squalus acanthias*). The size composition of herring in the stomach contents indicates that predation by whiting is mainly on 0-ring and 1-ring herring whilst adult hake and spurdogfish also eat older herring (Armstrong, 1979; Newton, 2000; Patterson, 1983). Sampling since the 1980s has shown cod (*Gadus morhua*), taken by both pelagic and demersal trawls in the Irish Sea, to be minor predators on herring. Small clupeids are an important source of food for piscivorous seabirds including gannets, guillemots and razorbills (ref…) which nest at several locations in and around the Irish Sea. Marine mammal predators include grey and harbour seals (ref.) and possibly pilot whales, which occur seasonally in areas where herring aggregate.

Whilst small juvenile herring occur throughout the coastal waters of the western and eastern Irish Sea, their distribution overlaps extensively with sprats (*Sprattus sprattus*). The biomass of small herring has typically been less than 5% of the combined biomass of small clupeids estimated by acoustics (ICES, 2008 ACOM:02). However in recent years the proportions have increased in favour of small herring (ICES, 2009 ACOM:??).

There are irregular cycles in the productivity of herring stocks (weights-at-age and recruitment). There are many hypotheses as to the cause of these changes in productivity, but in most cases it is thought that the environment plays an important role (through transport, prey, and predation). Coincident periods of high and low production have been seen in the herring in VIaN and Irish Sea herring. Exploitation and management strategies must account for the likelihood of productivity changing. The Irish Sea herring stock has shown a marked decline in productivity during the late 70's and remained on a low level since then.

Changes in Environment

There has been an increase in water temperatures in this area (ICES, 2006) which is likely to affect the distribution area of some fish species, and some changes of distribution have already been noted. Temperature increase is likely to affect stock recruitment of some species. In addition, the combined effects of over exploitation and environmental variability might lead to a higher risk of recruitment failure and decrease in productivity (ICES, 2007).

B. Data

B.1. Commercial catch

National landings estimates

The current ICES assessment of Irish Sea herring extends back to 1961, and is based on landings only. ICES WG reports (ICES 1981, 1986 and 1991) highlight the occurrence of discarding and slippage of catches, which can occur in areas where adult and juvenile herring co-occur. Discarding has been practised on an increasing scale since 1980 (ICES, 1986). This increase is primarily related to the onset of slippage of catches that coincided with the cessation of the industrial fishery in early 1979 (ICES, 1980). As a result of sorting practices, slippage has led to marked changes in the age composition of the catch since 1979 and considerable change in the mean weights at age in the catch of the three youngest age groups (ICES 1981). Estimates of discarding were sporadically performed in the 1980s (ICES, 1981, 1982, 1985 and 1986), but there are no estimates of discarding or slippage of herring in the Irish Sea fisheries since 1986. Highly variable annual discard rates are evident from the 1980s surveys. For example, discards estimates of juvenile herring (0-group) for the Mourne stock taken in the 1981 *Nephrops* fishery was estimated at 1.9×10^6 of vessels landing in Northern Ireland, which amounts to approximately 20% of the Mourne fishery (ICES 1982). In 1982, at least 50% of 1-group herring caught were discarded at sea by vessels participating in the Isle of Man fishery (ICES, 1983). A more comprehensive survey programme to determine the rate of discarding in 1985 revealed discard estimates of 82% by numbers of 1-ring fish, 30% of 2-ring and 6% of 3-ring fish, with the dominant age group in the landed catch being 3 ring (ICES, 1986). A similar survey in 1986, however, found the discarding of young fish fell to a very low level (ICES, 1987). The 1991 WG discussed the discard problem in herring fisheries in general and suggested possible measures to reduce discarding. No quantitative estimates were given, but reports of fishermen suggesting discards of up to 50% of catch as a result of sorting practices by using sorting machines (ICES, 1991). The variation in discard rates since 1980, as a result of changes in discard practices, can probably be attributed to several changes in the management of the fishery. These include the availability of different fishing areas, the change to fortnightly catch quotas per boat (ICES, 1987) and level of TAC, where lower discard rates are observed with a higher TAC (ICES, 1989). The level of slippage is also related to the fishing season, since slippage is often at a high level in the early months (ICES, 1987). Due to the variable nature of discard estimates and the lack of a continuous data series, it has not been included in the annual catch at age estimates (with the exception of the 1983 assessment when the catch in numbers of 1-ringers was doubled based on a 50% discard estimate of this age group).

Landings data for herring in Division VIIa(N) are generally collated from all participating countries providing official statistics to ICES, namely UK (England & Wales, Northern Ireland, Scotland and the Isle of Man), Ireland, France, the Netherlands and what was formally the USSR. The data for the period 1971 to 2002 are reported in the various Herring Assessment Working Group Reports and are reproduced in Table 1. The official Statistics for Irish landings from VIIa have been processed to remove data from the Dunmore East fishery in area VIIa(S), and represent landings from VIIa(N) only.

Over the past three decades, the WG highlighted the under- or misreporting of catches as the major problem with regards to the accuracy of the landing data. Related to this are the problems of illegal landings during closed periods and paper landings. Area misreporting was also recognised (ICES, 1999), although a less prominent problem that is mostly corrected for.

The 1980 WG first identified the problem of misreporting of landings based on the results of a 3-year sampling programme, which was initiated after 1975 when herring were being landed in metric units at ports bordering the Irish Sea (1 unit = 100 kg nominal weight). The study showed the weight of a unit to be very variable, but was usually well in excess of 100 kg. An initial attempt to allow for misreporting using adjusted catches made very little difference to any of the values of fishing mortality (ICES, 1980). Subsequently, despite serious concerns about considerable under-reporting being raised (ICES 1990, 1994, 2000 and 2001), the WG made no attempts to examination the extent of the problem. This uncertainty signifies no estimates of under-reporting and consequently no allowance for under-reporting of landings has been made. Considerable doubt was raised as to the accuracy of landing data over the period 1981-87 (ICES, 1994). However, after apparent re-examination all WG landing statistics are assumed to be accurate up to 1997 (ICES, 2000), but with no reliable estimates of landings from 1998-2000 (ICES, 2001). The WG acknowledged that poor quality landing data bring the catch in numbers at age data into question and hence the accuracy of any assessment using data from such periods (ICES, 1994).

In 2002 the ICES assessment was extended back to include data for 1961-1970 with the intention of showing the stock development prior to the large expansion in fishing effort and stock size in the early 1970s. This has now been extended further back to 1955. Landings data for this period were extracted from the UK fisheries data bases (England & Wales, Scotland and Northern Ireland: Table 1, columns 8-10) and publications by Bowers and Brand (1973) for Isle of Man landings (column 11). Landings data for Ireland and France were not available.

To estimate the VIIa(N) herring landings for Ireland and France during 1955-1970, the NE Atlantic herring catches for each country were obtained from the FAO database (column 16). Using the ICES landings data for each country (column 17) the mean proportion of the VIIa(N) catch to the NE Atlantic catch during 1971 to 1981 was estimated (column 18). This was applied to the NE Atlantic catches from each country, for the period 1955 to 1970, to give an estimated landing for both France and Ireland (column 19). These landings were added to the known catches from the CEFAS database to give the total landings. The landings data (tonnes) used in the assessment are given in Table 1, column 14. It is anticipated that landings data for VIIa(N) for years prior to 1971 can be extracted from the Irish databases. However, the French landings will remain as estimates. As yet there has been no analysis of magnitude of errors in the old data. Need discussion on errors due to misreporting

Catch at age data

Age classes in the ICES Canum file refer to numbers of winter rings in otoliths. As the Irish Sea stock comprises autumn spawners, *i*-ring fish taken in year *y* will comprise fish in their i_{th} year of life if caught prior to the spawning season and $(i+1)_{th}$ year if caught after the spawning period. An *i*-ring fish will belong to year-class *y*-2. As spawning stock is estimated at spawning time (autumn), spawning stock and recruitment relationships require estimates of recruitment of *i*-ring fish in year *y* and estimates of SSB in year *i*-2. The current assessment estimates recruitment as numbers of 1-ring fish.

The most recent description of sampling and raising methods for estimating catch at age of herring stocks is in ICES (1996). This includes sampling by UK(E&W) and Ireland, but not UK(NI) and Isle of Man

UK(NI):A random sample of 10-20kg of herring is taken from each landing into the main landing port (Ardglass) by the NI Department of Agriculture and Rural Development. Samples are also collected from any catches landed into Londonderry. Prior to the 1990s, the samples were mostly processed fresh. During the 1990s, there was an increasing tendency for samples to be frozen for a period of weeks before processing. No corrections have been applied to weight measurements to allow for changes due to freezing and defrosting. The length frequency (total length) of each sample is recorded to the nearest 0.5cm below. A sample of herring is then taken for biological analysis as follows: one fish per 0.5 cm length class, followed by a random sample to make the sample up to 50 fish.

Otoliths are removed from each fish, mounted in resin on a black slide and read by reflected light. Ages are assigned according to number of winter rings.

Length frequencies (LFDs) for VIIa(N) catches are aggregated by quarter. The weight of the aggregate LFD is calculated using a length-weight relationship derived from the biological samples. The LFD is then raised to the total quarterly landings of herring by the NI fleets. A quarterly age-length key, derived from commercial catch samples only, is applied to the raised LFD to give numbers at age and mean weight at age.

IOM: IOM sampling covers the period 1923 – 1997. Samples are collected from any landings into Peel, by staff of the Port Erin Marine Laboratory (Liverpool University). The sampling and raising procedures are the same as described for UK(NI) with the following exceptions: i) the weight of the aggregate quarterly LFD is obtained from the original sample weights rather than using a length-weight relationship, and ii) the biological samples are random rather than stratified by length. The 1993 ICES herring assessment WGs noted a potential under-estimation by one ring, of herring sampled in the IOM. This was caused by a change in materials used for mounting otoliths and appears to have been a problem for ageing older herring in 1990-92. This was since rectified. However, the bias for the 1990-92 period has not yet been quantified and will be examined in the near future.

Ireland: Irish sampling of VIIa(N) herring covers the period 19xx – 2001. Some samples are from landings into NI but transported to factories in southern Ireland. Irish sampling schemes for herring in Div. VIa(S), VIIb, Celtic Sea and VIIj are described in ICES (1996). Methods for sampling catches in VIIa(N) are similar. The procedure is the same as described above for UK(NI) except that the biological samples are random rather than length stratified. ICES (1996) notes that a length-stratified scheme should be adopted to ensure proper coverage at the extremes of the LFDs.

Quality control of herring ageing has fallen under the remit of EU funded programmes EFAN and TACADAR, to which the laboratories sampling VIIa(N) herring contribute. An otolith exchange exercise was initiated in 2002 and is currently being completed.

B.2. Biological

Natural Mortality

Natural mortality (M) varies with age (expressed in number of winter rings) according to the following (since 2012):

Rings	M
1	0.787
2	0.380
3	0.353
4	0.335
5	0.315
6	0.311
7+	0.304

These values have been held constant from 1972 to date. These correspond to estimates for North Sea since 2012. A multi-species stock assessment model for the North Sea (SMS key-run 2010) has been used to inform the variable natural mortality pattern. The use of these values are considered preliminary until stock specific estimates can be obtained.

The values used up to the 2011 assessment correspond to estimates for North Sea herring based on recommendations by the Multi-species WG (Anon. 1987a), which were applied to adjacent areas (Anon. 1987b).

Rings	M
1	1
2	0.3
3	0.2
4+	0.1

Maturity at age

Combined, year-specific maturity ogives were used in the 2003 Assessment (ICES 2003). The way those values were derived is documented on Dickey-Collas *et al.* (2003). Prior to 2003 annually invariant estimates of the proportion of fish mature by age were used. Those were based on estimates from the 1970s (ICES, 1994). The use of the variable maturity ogive in 2003 did not change greatly the perception of the stock state (Dickey-Collas *et al., op cit*). Due to inconsistencies in the maturity data collected in 2003, the WG used a mean maturity ogive for the preceding nine years for 2003. The rationale for the 9 years was that there appeared to be a shift in the maturity ogive around 1993. After 2003 all weights and maturity-at-age data were based on corresponding annual biological samples.

SSB in September is estimated in the assessment. The survey larvae estimate is used as a relative index of SSB. The proportions of M and F before spawning are held constant over time in the assessment.

Stock weights

Stock weights at age have been derived from the age samples of the 3rd quarter landings since 1984 (R. Nash *pers comm.*). The stock mean weights for 1975-83 are time invariant and were re-examined in 1985 (Anon. 1985). They result from combining Manx and Mourne data sets. The weights at age of those stocks were considered relatively stable over time. No biological sampling information was available for 2009 and the weights at age for 2009 were replaced by averaging the weight at age observed in 2008 and 2010.

Mean weights

Mean weights-at-age in the catch (1985 to 2007) are given in Table 3. Mean weights-at-age of all ages remained low. There has been a change in mean weight over the time period 1961 to the present (ICES, 2003 ACFM:17). Mean weights-at-age increased between the early 1960s and the late 1970s whereupon there has been a steady decline to the early 1990s, where they remained low. In the assessment, mean weights-at-age for the period 1972 to 1984 are taken as unchanging. In extending the data series back from 1971 to 1961, mean weights-at-age in the catch were taken from samples recorded by the Port Erin Marine Laboratory (ICES, 2003 ACFM:17).

There was some uncertainty in the mean weights-at-age for 2003 presented to the WG, and consequently the WG replaced these with the average mean stock weights-at-age for the preceding five years (1998 to 2002). No biological sampling information was available for 2009 and the weights at age for 2009 were replaced by averaging the weight at age observed in 2008 and 2010.

Mean Lengths

Mean lengths-at-age are calculated using the catch data and are given for the years 1985 to 2006 in Table 4. In general, mean lengths have been relatively stable over the last few years and this trend has continued in 2006.

Catch at length

Catch at length are listed for the years 1990-2004 (Table 5)

B.3. Surveys

The following surveys have provided data for the VIIa(N) assessment:

Survey Acronym	Type	Abundance data	Area and Month	Period
AC(VIIaN)	Acoustic survey	Numbers at age (1-ring and older); SSB	VIIa(N) from 53^{0} 20′N – 55^{o}N; September	1994 – present
NINEL	Larva survey	Production of larvae at 6mm TL	VIIa(N) from 53^{o} 50′N – 54^{o} 50′N; November	1993 – present
DBL	Larva survey	Production of larvae at 6mm TL	East coast of Isle of Man; October	1989 – 1999 (1996 missing)
GFS-oct	Groundfis h survey	Mean nos. caught per 3 n.miles (1&2 ringers), by region	VIIa(N) from 53^{0} 20′N – 54^{o} 50′N (stratified); October	1993 - 1999
GFS-mar	Groundfis h survey	Mean nos. caught per 3 n.miles (1&2 ringers), by region	VIIa(N) from 53^{0} 20′N – 54^{o} 50′N (stratified); March	1993 - 1999

Data from a number of earlier surveys have been documented in the ICES WG reports. These include:

NW Irish Sea young herring surveys (Irish otter trawl survey using commercial trawler; 1980 – 1988)

Douglas Bank (East Isle of Man) larva surveys (ring net surveys; 1974 – 1988) (Port Erin Marine Lab)

Douglas Bank spawning aggregation acoustic surveys (1989, 1990, 1994, 1995) (Port Erin Marine Lab)

Western Irish Sea acoustic survey (July 1991, 1992) (UK(NI))

Eastern Irish Sea acoustic survey (December 1996)

Surveys used in recent assessments are described below.

AC(VIIaN) acoustic survey

This survey uses a stratified design with systematic transects, during the first two weeks of September. Vessel currently used is the R.V. Corystes (UK(NI)) replacing the R.V. *Lough Foyle* (UK(NI)). Starting positions are randomized each year (see recent HAWG reports for transect design and survey results). The survey is most intense around the Isle of Man (2 to 4 n.mile transect spacing) where highest densities of adult herring are expected based on previous surveys and fishery data. Transect spacing of 6 to 10 n.miles are used elsewhere. A sphere-calibrated EK-500 38kHz sounder is employed, and data are archived and analysed using Echoview (SonarData, Tasmania). Targets are identified by midwater trawling. Acoustic records are manually partitioned to species by scrutinising the echograms and using trawl compositions where appropriate. ICES-recommended target strengths are used for herring, sprat, mackerel, horse mackerel and gadoids. The survey design and implementation follows, where possible, the guidelines for ICES herring acoustic surveys in the North Sea and West of Scotland. The survey data are analysed in 15-minute elementary distance sampling units (approx. 2.5 n.miles). An estimate of density by age class, and spawning stock biomass, is obtained for each EDSU and a distance-weighted average calculated for each stratum. These are raised by stratum area to give population numbers and SSB by stratum.

NINEL larva survey

The DARD herring larva survey has been carried out in November each year since 1993. Sampling is carried out on a systematic grid of stations covering the spawning grounds and surrounding regions in the NE and NW Irish Sea (Figure 1). Larvae are sampled using a Gulf-VII high-speed plankton sampler with 280 μm net. Double-oblique tows are made to within 2m of the seabed at each station. Internal and external flow rates, and temperature and salinity profiles, were recorded during each tow. Lengths of all herring larva captured are recorded.

Mean catch-rates (nos.m^{-2}) are calculated over stations to give separate indices of abundance for the NE and NW Irish Sea. Larval production rates (standardised to a larva of 6mm), and birth-date distributions, are computed based on the mean density of larvae by length class. A growth rate of 0.35mm day^{-1} and instantaneous mortality of 0.14 day^{-1} are assumed based on estimates made in 1993 - 1997. More recent studies have indicated a mortality rate of 0.09, and this value is also applied to examine the effect on trends in estimates of larval production

DBL larva survey

Herring larvae were sampled on the east side of the Isle of Man in September or October each year. Double oblique tows with a 60 cm Gulf VII/PRO-NET high-speed plankton sampler with a 40cm aperture nose cone were undertaken on a 5 Nm square grid. The tow profile was followed with a FURUNO net sonde attached to the top of the equipment. The volume of water filtered was calculated from the nose cone mouth flow meter. The samples were preserved in 4% seawater buffered formalin and stored in 70% alcohol.

All herring larvae were sorted from the samples. The numbers of larvae per m^3 were calculated from the volume of water filtered and the number of larvae per tow. Up to 100 larvae from each tow were measured with an ocular graticule in a stereo microscope. Each sample was assigned to a sampling square and the total number of larvae per 0.5mm size class calculated from the average depth of the square and the surface area.

The total production and time of larvae hatch was calculated using an instantaneous mortality coefficient (k) of 0.14 and a growth rate of 0.35 mm d^{-1} in the formula:

$$N_t = N_o e^{-(kt)}$$

Production was calculated as the sum of all size classes/hatching dates. Spawning dates were taken as 10 days prior to the hatching date (Bowers 1952).

The Douglas Bank Larva survey has not been updated since 1999. Examination of the sum of squares surface from SPALY in 2005 indicated that the Douglas Bank larvae index (DBL) was having no influence in the assessment estimates for the current year. Therefore, the WG agreed on removing DBL from the analysis (ICES, 2005). The DBL time series is listed in Table 6

GFS-oct and –mar groundfish surveys

The DARD groundfish survey of ICES Division VIIaN are carried out in March and October at standard stations between 53° 20'N and 54° 45'N (Figure 2). Data from additional stations fished in the St George's Channel since October 2001 have not been used in calculating herring indices of abundance. As in previous surveys, the area was divided into strata according to depth contour and sediment type, with fixed station positions (note that the strata in Fig. 2 differ from those in the September acoustic survey shown in Fig. 1). The sampling gear was a Rockhopper otter trawl fitted with non-rotating rubber discs of approximately 15 cm diameter on the footrope. The trawl fishes with an average headline height of 3.0 m and door spread of 30 - 40 m depending on depth and tide. A 20mm stretched-mesh codend liner was fitted.

During March, trawling was carried out at an average speed of 3 knots across the ground, over a standard distance of 3 nautical miles at standard stations and 1 nautical mile in the St. George's Channel. Since 2002, all survey stations in the October survey have been of 1-mile distance. Comparative trawling exercises during the October surveys and during an independent exercise in February 2003 indicate roughly similar catch-rates per mile between 1-mile and 3-mile tows. It is planned to continue with some comparative trawling experiments during future surveys to improve the statistical power of significance tests between the 1-mile and 3-mile tows.

As the surveys are targeted at gadoids, ages were not recorded for herring. The length frequencies in each survey were sliced into length ranges corresponding to 0-ring and 1-ring herring according to the appearance of modes in the overall weighted mean length frequency for each survey. Some imprecision will have resulted because of the overlap in length-at-age distributions of 1-ring and 2-ring herring. The error is considered to be comparatively small for most of the surveys where clear modes are apparent. There was no clear division between 1-ring and 2-ring herring in the March 2003 groundfish survey, and the estimate for 1-ringers may include a significant component of small 2-ringers. The arithmetic mean catch-rate and approximate variance of the mean was computed for each age-class in each survey stratum, and averaged over strata using the areas of the strata as weighting factors.

Groundfish surveys were used by the 1996 to 1999 HAWG to obtain indices for 0- and 1-ring herring in the Irish Sea. These indices have performed poorly in the assessment and have not been used since 1999. The time-series is listed in Table 7.

B.4. Commercial CPUE

Commercial CPUE's are not used for this stock.

B.5. Other relevant data

C. Historical Stock Development

Model used as basis for advice:

The assessment model is based on the State-space Assessment Model (SAM) (Nielsen et al., 2012). Technical details of the SAM framework can be found in the peer-reviewed literature (Nielsen et al., 2012)

At the Benchmark (WKPELA, 2012) the state-space models SAM model was chosen as the assessment model for Irish Sea herring. . This modelling framework has a number of highly desirable characteristics, such as the stochastic treatment of all observations, a full statistical framework for evaluating model results, open source and cross platform source code, and an extremely high degree of flexibility allowing ready customisation to the peculiarities of the stock.

Assessment model configuration

Input data types and characteristics:

Type	Name	Year range	Age range	Variable from year to year Yes/No
Caton	Catch in tonnes	1961-last data year	NA	Yes
Canum	Catch at age in numbers	1961-last data year	1-8+	Yes
Weca	Weight at age in the commercial catch	1961-1971 1972-1983 1984-last data year	1-8+ 1-8+ 1-8+	Yes No Yes
West	Weight at age of the spawning stock at spawning time.	1961-1971 1972-1983 1984-last data year	1-8+ 1-8+ 1-8+	Yes No Yes
Mprop	Proportion of natural mortality before spawning	1961-last data year	NA	No
Fprop	Proportion of fishing mortality before spawning	11961-last data year	NA	No
Matprop	Proportion mature at age	1961-last data year	1-8+	Yes
Natmor	Natural mortality	1961-last data year	1-8+	No

Tuning data:

Type	Name	Year range	Age range
Tuning fleet 1	AC_VIIa(N)	1994-last data year	1-8+
Tuning fleet 2	NINEL	1993-last data year	SSB

The table below present the SAM configuration options (file model.cfg). In the file text following a hash-mark ("#") is a comment:

```
# Min, max age represented internally in model
 1 8
# Max age considered a plus group? (0 = No, 1= Yes)
 1

# Coupling of fishing mortality STATES (ctrl@states)
 # 1 2 3 4 5 6 7 8 #
 1 2 3 4 5 6 7 7 # catch
 0 0 0 0 0 0 0 0 # FLT01(AC)
 0 0 0 0 0 0 0 0 # NINEL

# Use correlated random walks for the fishing mortalities
# ( 0 = independent, 1 = correlation estimated)
0

# Coupling of catchability PARAMETERS (ctrl@catchabilities)
 # 1 2 3 4 5 6 7 8 #
```

```
0 0 0 0 0 0 0 0 # catch
1 2 3 4 4 4 4 4 # FLT01(AC)
0 0 0 0 0 0 0 0 # NINEL

# Coupling of power law model EXPONENTS (ctrl@power.law.exps)
# 1 2 3 4 5 6 7 8 #
0 0 0 0 0 0 0 0 # catch
0 0 0 0 0 0 0 0 # FLT01(AC)
0 0 0 0 0 0 0 0 # NINEL

# Coupling of fishing mortality RW VARIANCES (ctrl@f.vars)
# 1 2 3 4 5 6 7 8 #
1 1 1 1 1 1 1 1 # catch
0 0 0 0 0 0 0 0 # FLT01(AC)
0 0 0 0 0 0 0 0 # NINEL

# Coupling of log N RW VARIANCES (ctrl@logN.vars)
1 2 2 2 2 2 2 2

# Coupling of OBSERVATION VARIANCES (ctrl@obs.vars)
# 1 2 3 4 5 6 7 8 #
1 2 3 3 4 4 4 4 # catch
5 6 6 7 7 8 8 8 # FLT01(AC)
0 0 0 0 0 0 0 0 # NINEL

# Stock recruitment model code (0=RW, 1=Ricker, 2=BH, ... more in time
0
# Years in which catch data are to be scaled by an estimated parameter (mainly cod related)
0
# Fbar range
4 6

# so called checksum
123 123
```

The options for "`Coupling of fishing mortality STATES`" show that random walk for F is independent by age for the ages 1-6, and combined for age 7 and 8.

It is assumed that F at age is correlated to some degree estimated by the models. Therefore the option for "Use correlated random walks for the fishing mortalities" is set to 1.

The "`Coupling of` catchability `PARAMETERS`" specifies the grouping of ages with respect to survey catchability. For the ACVIIa(N) survey there is assumed an age dependent catchability for age 1-3, and a combined (the same) catchability ages 4-8.

In the ACVIIa(N) survey a linear relation between CPUE and stock size is assumed, such that the options for "`Coupling of power law model EXPONENTS`" are all set to 0.

The variance for the random walk for F ("`Coupling of fishing mortality RW VARIANCES "`) is assumed the same for all ages.

The "`Coupling of OBSERVATION VARIANCES`" specifies the options for observation noise for both catches and survey indices. For catches the observation variance is age dependent for age 1 and 2. For ages 3-4 the variance is assumed the same, and different from the variance for ages 5-8. For the ACVIIa(N) survey the variance is set the same within the groups of age 1, 2-3, 4-5 and 6-8.

There is no obvious relation between SSB and recruitment, but recruitment seems to be correlated between years. To reflect this, the "`Stock recruitment model code`" is set to 0=Random Walk.

D. Short-Term Projection

Model used: Age structured

Software used: MFDP ver 1a

Initial stock size: Taken from the last year of the assessment. 1-ring recruits taken from a geometric mean for the years 1995 to two years prior to the terminal year.

Maturity: Mean of the previous three years of the maturity ogive used in the assessment.

F and M before spawning: Set to 0.9 and 0.75 respectively for all years.

Weight at age in the stock: Mean of the previous three years in the assessment.

Weight at age in the catch: Mean of the previous three years in the assessment.

Exploitation pattern: Mean of the previous three years (not scaled to the last year, as the terminal estimate of F is not considered more informative)

Intermediate year assumptions: TAC constraint.

Stock recruitment model used: None used

Procedures used for splitting projected catches: Not relevant

E. Medium-Term Projections

F. Long-Term Projections

Not done

G. Biological Reference Points

Until there is confidence in the assessment the Working Group decided not to revisit the estimation of $\mathbf{B}_{pa}$ (9,500 t) and $\mathbf{B}_{lim}$ (6,000 t). There were no new points to add to the discussions and deliberations presented in 2000 (ICES 2000/ACFM:10).

H. Other Issues

I. References

Anon. 1985. Report of the Herring Assess. WG for the Area South of 62oN. ICES Doc.

Anon. 1987a. Report of the ad hoc Multispecies Assessment WG. ICES, Doc. C.M. 1987/Assess:9.

Anon. 1987b. Report of the Herring Assess. WG for the Area South of 62oN. ICES Doc C.M. 1987/Assess:19.

Bowers, A.B. 1952 Studies on the herring (Clupea harengus L.) in Manx waters:- The autumn spawning and the larval and post larval stages. Proc. Liverpool Biol. Soc. 58: 47-74.

Bowers, A.B. and Brand, A.R. 1973.Stock-size and recruitment in Manx herring. Rapp …. 164: 37-41.

Brophy, D. and Danilowicz, B. 2002. Tracing populations of Atlantic herring (Clupea harengus L.) in the Irish and Celtic Seas using otolith microstructure. – ICES Journal of Marine Science, 59: 1305-1313.

Dickey-Collas, M., Nash, R.D.M. and Armstrong, M.J. 2003. Re-evaluation of VIIa(N) herring time series of catch and maturity at age, and the impact on the assessment. ICES herring Assessment Working Group Document. 8pp.

Dickey-Collas, M., Nash, R.D.M. and Brown, J. 2001. The location of spawning of Irish Sea herring (Clupea harengus). J. Mar. Biol. Assoc., UK., 81: 713-714.

ICES 1980 Report of the Herring Assessment Working Group for the Area South of 62 °N. ICES C.M. 1980/H:4

ICES 1981 Report of the Herring Assessment Working Group for the Area South of 62 °N. ICES C.M. 1981/H:8

ICES 1982 Report of the Herring Assessment Working Group for the Area South of 62 °N. ICES C.M. 1982/Assess:7.

ICES 1983 Report of the Herring Assessment Working Group for the Area South of 62 °N. ICES C.M. 1983/Assess:9.

ICES 1985 Report of the Herring Assessment Working Group for the Area South of 62 °N. ICES C.M. 1985/Assess:12.

ICES 1986 Report of the Herring Assessment Working Group for the Area South of 62 °N. ICES C.M. 1986/Assess:19.

ICES 1987 Report of the Herring Assessment Working Group for the Area South of 62 °N. ICES C.M. 1987/Assess:19.

ICES 1989 Report of the Herring Assessment Working Group for the Area South of 62 °N. ICES C.M. 1989/Assess:15

ICES 1990. Report of the Herring Assessment Working Group for the Area South of 62 oN. ICES C.M. 1990/Assess: 14. (mimeo).

ICES 1991. Report of the Herring Assessment Working Group for the Area South of 62°N. ICES CM 1991/ACFM:15.

ICES 1994. Report of the study group on herring assessment and biology in the Irish Sea and adjacent waters. ICES C.M. 1994/H:5. 69pp.

ICES 1996. Landings statistics and biological sampling. Working Document. 1996 ICES Herring Assessment WG.

ICES 1998. Report of the Herring Assessment Working Group for the Area south of 62ºN. ICES CM 1998/ACFM:14.

ICES 2000. Report of the Herring Assessment Working Group for the Area South of 62°N. ICES CM 2000/ACFM:12.

ICES 2001. Report of the Herring Assessment Working Group for the Area South of 62°N. ICES CM 2001/ACFM:10.

ICES 2003. Report of Herring Assessment WG for the Area South of 62º N. CM 2003/ACFM:17.

ICES 2005. Report of Herring Assessment WG for the Area South of 62º N. ICES CM 2004/ACFM: 16.

Molloy, J.P., Barnwall, E. and Morrison, J. 1993. Herring tagging experiments around Ireland in 1991. Dpt. of Marine. Dublin. Fish. Leaf. No. 154. 1993.

Morrison, J.A. and Bruce, T. 1981. Scottish herring tagging experiments in the Firth of Clyde 1975-1979 and evidence of affinity between Clyde herring and those in adjacent areas. ICES CM 1981/H:53.

Newton, P. 2000. The trophic ecology of offshore demersal teleosts in the North Irish Sea. PhD Thesis, Univ. Liverpool.323 pp.

Patterson, K.R. 1983. Some observations on the Ecology of the Fishes of a Muddy Sand Ground in the Irish Sea. PhD. Thesis. Univ. Liverpool.

Table 1. Biological sampling of Irish Sea (VIIa(N)) landings. Country denotes sampling nation.

	Coverage	% of landings sampled	No of samples	Total landings	landings by Q?	IRELAND				NORTHERN IRELAND				ISLE OF MAN				OTHERr UK/UK OFFSHORE				TOTAL			
Year						Landings	Samples	Lengths	Ages	Landings	Samples	Lengths	Ages	Landings	Samples	Lengths	Ages	Landings	Samples	Lengths	Ages	Landings	Samples	Lengths	Ages
1988	(4)					**2579																	0	0	0
1989	(3) temp spread good		88	4962	NO	1430	21	1843	555		45	11464	2249		21	5173	1057		1	96	0	4962	88	18576	3861
1990	p(1,2)	68%	100	6312	YES	1699	44	5176	1022	2322	38	9310	1900	542	18	5276	897	179/1570	0	0	0	6312	100	19762	3819
1991	g	90%	138	4398	YES	80	5	1255	247	3298	105	16724	2484	629	28	8280	1392	0/391	0	0	0	4398	138	26259	4123
1992	g	98%	32	5270	YES	406	3	593	99	4120	16	1588	770	741	13	3488	680	3	0	0	0	5270	32	5669	1549
1993	p (1)	65%	48	4408	YES	0	5	1378	245	3632	34	3744	832	776	9	1560	448	0	0	0	0	4408	48	6682	1525
1994	v.g	95%	59	4828	YES	0	21	569	100	3956	43	3691	1175	716	14	3724	614	156	0	0	0	4828	59	7984	1889
1995	g (1)	87%	85	5076	YES	0	21	569	100	3860	75	8282	2545	615	8	2182	400	601	0	0	0	5076	85	11033	3045
1996	g (1,5)	70%	51	5301	YES	100	1	537	55	4335	45	4813	1050	537	5	997	228	329	0	0	0	5301	51	6347	1333
1997	g (1,2)	91%	34	6649	YES	0	2	473	50	5679	25	2900	1199	765	7	2246	340	205	0	234	76	6649	34	5853	1665
1998	g (2)	84%	31	4904	YES	0	2	150	50	4131	29	2979	1450	0	0	0	0	7732	0	0	0	4904	31	3129	1500
1999	g (2)	72%	32	4127	YES	0	4	0	200	2967	28	2518	1400	0	0	0	0	11602	0	0	0	4127	32	2518	1600
2000	v.g	97%	28	2002	YES	0	5	932	0	2002	23	1915	1150	0	0	0	0	0	0	0	0	2002	28	2847	1150
2001	p (2)	70%	31	5461	YES	862	8	1031	222	3786	23	2915	1149	86	0	0	0	7272	0	0	0	5461	31	3946	1371
2002	p (1)	62%	9	2392	YES	286	0	0	0	2051	9	949	450	4	0	0	0	51	0	0	0	2392	9	949	450
2003			9	2399	YES	0				2399	9	1132	445												
2004			9	2531	YES	749	2	190	133	1782	7	991	350												
2005			26	4387	YES	1153	5	1312	372	3234	21	4135	1018												
2006			22	4402	YES	581	8	2248	549	3821	14	1982	686												
2007			29	4629	YES	0				4629	29														
2008			19	4895	YES	0				4895	19														
2009	p (6)			4594	YES					4594	4											4594			
2010	g (2)	79%	31	4894	YES					4894	31	4115	1517									4894	31	4115	1517

COVERAGE: Sum of the landings (by Q and Nation(UK disaggregated))/total landings. From 1993 (possibly from 1990) to date landings and sampling levels are presented by quarter so coverage is related to this level of detail:

VERY GOOD (v.g) : all landings which individually are >10% of the total were sampled, all Q for which there were landings were sampled

GOOD (g) : landings that constitute the majority of the catch (adding to approx 70% or more of total) were sampled

POOR (p) : some of the large landings not sampled

(1): unsampled quarters

(2): large landings with few samples or unsampled. High level of sampling corresponds to 1 sample per 100t landed (WG rep 1997)

(3): Comment from WG rep. From 1990 going back, Report landings and sampling levels are shown aggregated for the whole year. UK landings lumped in one figure.

(4): no information in the WGrep of level of sampling prior to 1988. Sampling levels believed to be good. Actual figures to be provided by R. Nash, M Armstrong and CEFAS after going back to their labs.

(5): NO samples for NI landings in 4th Q, there is a suspicion that the figures correspond to 'paper landings'.

[1]Samples applied to NI landings: [2]Large unsampled landings.

(6): no samples taken from pair trawlers landings.

Table 2: Data and method used to estimate landings from Division VIIa(N) herring.

																Estimates of maximum likely catch for VIIa(N) incl. of French and ROI catches							
Column No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16		17		18		19	
	ICES table							British Isles catches						**CATCH IN ASSESS-MENT**		NE Atlantic catch		ICES 7a catch		% of NE atlantic		max likely catch	
	Ireland	UK	France	Netherlands	USSR/ Russia	Unallocated	Total	England	Northern Ireland	Wales	Manx	Irish	Total			France	Ireland	France	Ireland	France	Ireland	France	Ireland
1955								0	0	72	3815		3887	**8056**		60500	4900					3630	539
1956								5	0	20	4762		4787	**8743**		52000	7600					3120	836
1957								21	0	1638	2832		4491	**7966**		36100	11900					2166	1309
1958								31	0	12	2482		2525	**6261**		38800	12800					2328	1408
1959								20	0	96	3577		3693	**7833**		40400	15600					2424	1716
1960								1	0	9	2093		2103	**6607**		36200	21200					2172	2332
1961								32	0	144	1941		2117	**5710**		36600	12700					2196	1397
1962								4	0	21	1528		1552	**4343**		29100	9500					1746	1045
1963								5	0	34	974		1013	**3947**		33500	8400					2010	924
1964								2	0	0	556		558	**3593**		35000	8500					2100	935
1965								1629	0	398	1135		3162	**5923**		26400	10700					1584	1177
1966								2041	0	46	596		2683	**5666**		22400	14900					1344	1639
1967								2911	0	8	1959		4878	**8721**		20600	23700					1236	2607
1968								1504	0	5	3253		4762	**8660**		22800	23000					1368	2530
1969								3591	0	63	5044		8698	**14141**		27100	34700					1626	3817
1970								4662	0	16	9782		14461	**20622**		24400	42700					1464	4697
1971	3131	21861	1815				26807							**26807**		23500	31200	1815	3131	0.08	0.10		
1972	2529	23337	1224	260			27350							**27350**		29900	47800	1224	2529	0.04	0.05		
1973	3614	18587	254	143			22598							**22598**		30800	38900	254	3614	0.01	0.09		
1974	5894	27489	3194	1116	945		38638							**38638**		21199	39608	3194	5894	0.15	0.15		
1975	4790	18244	813	630	26		24503							**24503**		25645	29752	813	4790	0.03	0.16		
1976	3205	16401	651	989			21246							**21246**		20466	22227	651	3205	0.03	0.14		
1977	3331	11498	85	500			15414							**15414**		4164	23436	85	3331	0.02	0.14		
1978	2371	8432	174	98			11075							**11075**		4201	27717	174	2371	0.04	0.09		
1979	1805	10078	455				12338							**12338**		3596	27454	455	1805	0.13	0.07		
1980	1340	9272	1				10613							**10613**		6126	36917	1	1340	0.00	0.04		
1981	283	4094					4377							**4377**		6952	29926			0.00	0.00		
1982	300	3375				1180	4855							**4855**									
1983	860	3025	48				3933							**3933**						0.06	0.11		
1984	1084	2982					4066							**4066**									
																Estimates of maximum likely catch for VIIa(N) incl. of French and ROI catches							
Column	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16		17		18		19	

No.																							
	ICES table						British Isles catches							**CATCH IN ASSESS-MENT**		NE Atlantic catch		ICES 7a catch		% of NE atlantic		max likely catch	
	Ireland	UK	France	Netherlands	USSR/ Russia	Unallocated	Total	England	Northern Ireland	Wales	Manx	Irish	Total			France	Ireland	France	Ireland	France	Ireland	France	Ireland
1985	1000	4077				4110	9187							**9187**									
1986	1640	4376				1424	7440							**7440**									
1987	1200	3290				1333	5823							**5823**									
1988	2579	7593					10172							**10172**									
1989	1430	3532					4962							**4962**									
1990	1699	4613					6312							**6312**									
1991	80	4318					4398							**4398**									
1992	406	4864					5270							**5270**									
1993	0	4408					4408							**4408**									
1994	0	4828					4828							**4828**									
1995	0	5076					5076							**5076**									
1996	100	5180				22	5302							**5302**									
1997	0	6651					6651							**6651**									
1998	0	4905					4905							**4905**									
1999	0	4127					4127							**4127**									
2000	0	2002					2002							**2002**									
2001	862	4599					5461							**5461**									
2002	286	2107					2393							**2393**									
2003	0	2399					2399							**2399**									
2004	749	1782					2531							**2531**									
2005	1153	3234					4387							**4387**									
2006	581	3821					4402							**4402**									
2007	0	4629					4629							**4629**									
2008	0	4895					4895							**4895**									
2009	0	4594					4594							**4594**									
2010	0	4894					4894							**4894**									

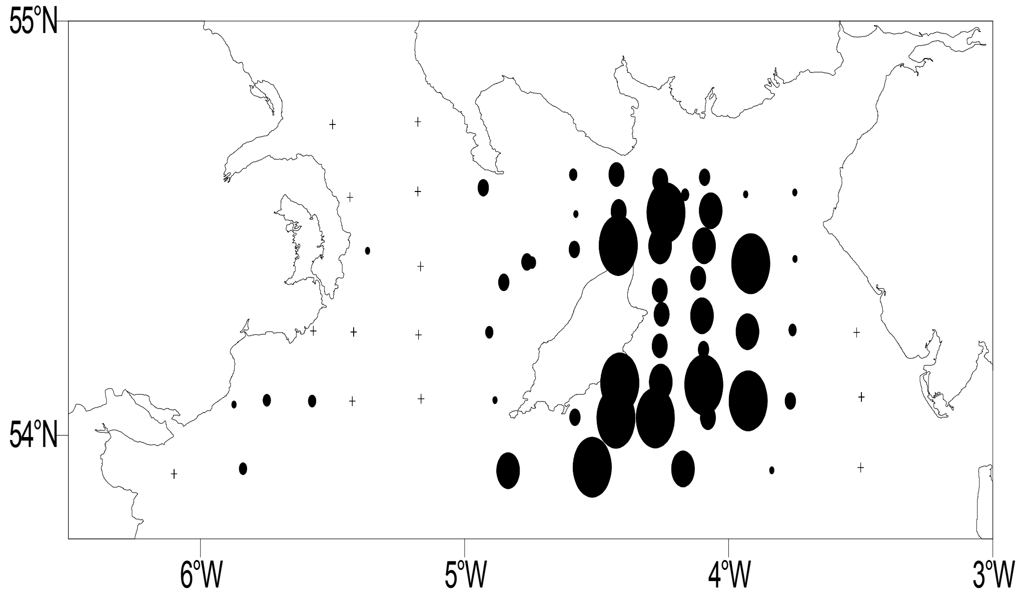
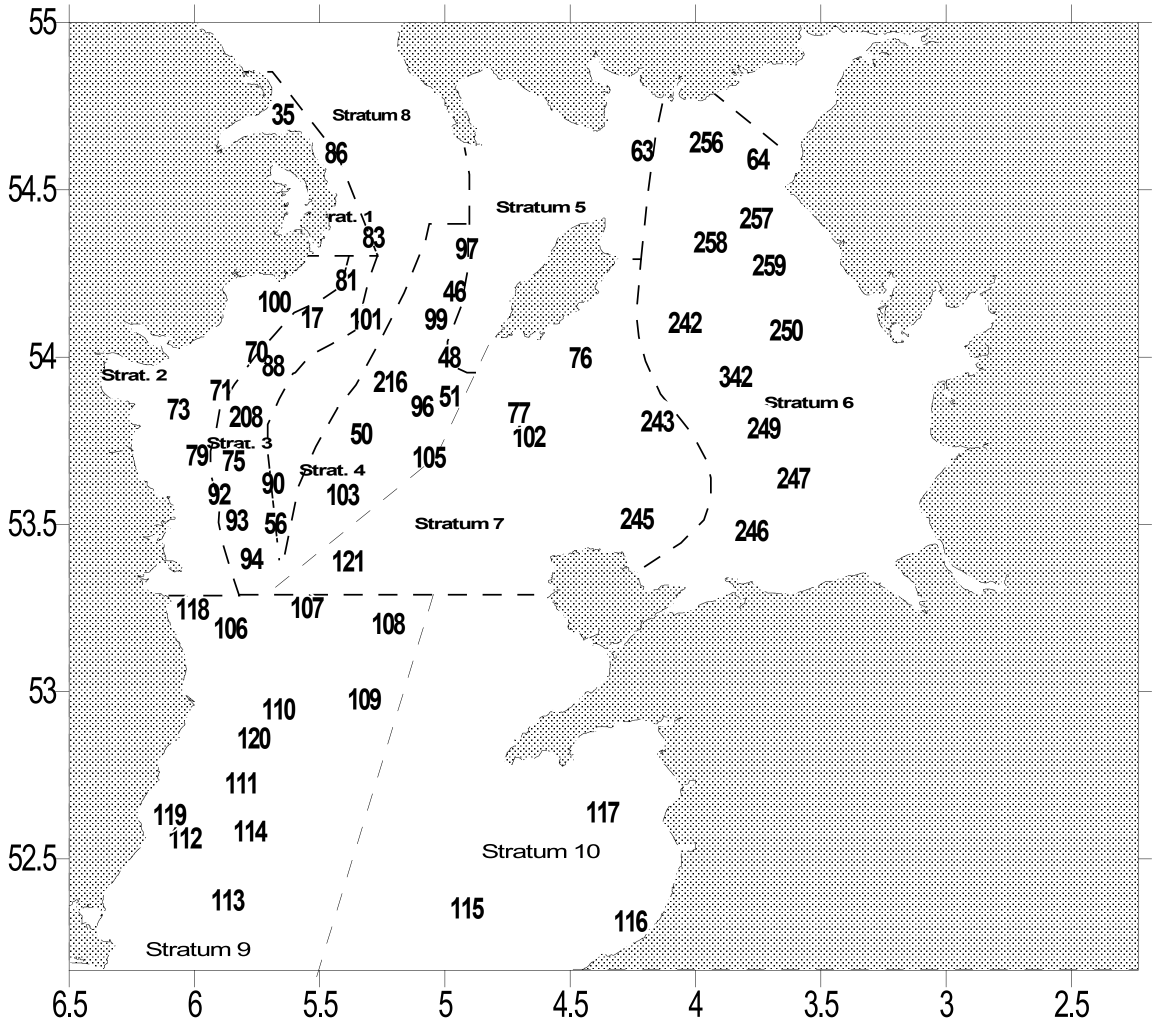


Figure 1. Sampling stations for larvae in the North Irish Sea (NINEL). Sampling is undertaken in November each year.



Key to strata:
1. Irish Coast (N), <100m, Mixed sediments
2. Irish Coast, < 50m, sand and finer sediments
3. Irish Coast, 50 - 100m, Muddy sediments
4. W and SW Isle of Man, 50 - 100m, mud and muddy sand
5. N Isle of Man, <50m, gravel sediments
6. Eastern Irish Sea, <50m, sand and finer sediments
7. S. Isle of Man, <100m, gravel sediments
8. Deep western channel and North Channel >100m
9. St George's Channel west; sandy/mixed sediments; <100m
10. St George's Channel east; sandy/mixed sediments; <100m

Figure 2. Standard station positions for DARD groundfish survey of the Irish Sea in March and October. Boundaries of survey strata are shown. Indices for the "Western Irish Sea" use data from strata 2 - 4. Indices for the "Eastern Irish Sea" use data from stratum 6 only (few juvenile herring are found in stratum 7). (Note different stratification to Fig. 1.). New stations fished in the St Georges Channel (strata 9 and 10) since October 2001 are not included in the survey indices. Stratum 5 (1 station only in recent years) is also excluded from the index. There are no stations in stratum 8 due to difficult trawling conditions for the gear used in the survey. Station 121 in stratum 7 has been fished only once and is excluded from the index.

Table 3. Irish Sea Herring Division VIIa(N). Mean weights-at-age in the catch.

Year	Weights-at-age (g) Age (rings)							
	1	2	3	4	5	6	7	8+
1985	87	125	157	186	202	209	222	258
1986	68	143	167	188	215	229	239	254
1987	58	130	160	175	194	210	218	229
1988	70	124	160	170	180	198	212	232
1989	81	128	155	174	184	195	205	218
1990	77	135	163	175	188	196	207	217
1991	70	121	153	167	180	189	195	214
1992	61	111	136	151	159	171	179	191
1993	88	126	157	171	183	191	198	214
1994	73	126	154	174	181	190	203	214
1995	72	120	147	168	180	185	197	212
1996	67	116	148	162	177	199	200	214
1997	64	118	146	165	176	188	204	216
1998	80	123	148	163	181	177	188	222
1999	69	120	145	167	176	188	190	210
2000	64	120	148	168	188	204	200	213
2001	67	106	139	156	168	185	198	205
2002	85	113	144	167	180	184	191	217
2003*	81	116	136	160	167	172	186	199
2004	73	107	130	157	165	187	200	205
2005	67	103	136	156	166	180	191	209
2006	64	105	131	149	164	177	184	211
2007	67	112	135	158	173	183	199	227
2008	71	110	135	153	156	182	196	206
2009*	68	107	133	155	165	182	194	212
2010	53	106	131	145	153	164	175	172

*** Average for the preceding five years**

Table 4. Irish Sea Herring Division VIIa(N). Mean length-at-age in the catch.

Year	Lengths-at-age (cm) Age (rings)							
	1	2	3	4	5	6	7	8+
1985	22.1	24.3	26.1	27.6	28.3	28.6	29.5	30.1
1986	19.7	24.3	25.8	26.9	28.0	28.8	28.8	29.8
1987	20.0	24.1	26.3	27.3	28.0	29.2	29.4	30.1
1988	20.2	23.5	25.7	26.3	27.2	27.7	28.7	29.6
1989	20.9	23.8	25.8	26.8	27.8	28.2	28.0	29.5
1990	20.1	24.2	25.6	26.2	27.7	28.3	28.3	29.0
1991	20.5	23.8	25.4	26.1	26.8	27.3	27.7	28.7
1992	19.0	23.7	25.3	26.2	26.7	27.2	27.9	29.4
1993	21.6	24.1	25.9	26.7	27.2	27.6	28.0	28.7
1994	20.1	23.9	25.5	26.5	27.0	27.4	27.9	28.4
1995	20.4	23.6	25.2	26.3	26.8	27.0	27.6	28.3
1996	19.8	23.5	25.3	26.0	26.6	27.6	27.6	28.2
1997	19.6	23.6	25.1	26.0	26.5	27.1	27.7	28.2
1998	20.8	23.8	25.2	26.1	27.0	26.8	27.2	28.7
1999	19.8	23.6	25.0	26.1	26.5	27.1	27.2	28.0
2000	19.7	23.8	25.3	26.3	27.1	27.7	27.7	28.1
2001	20.0	22.9	24.8	25.7	26.2	26.9	27.5	27.8
2002	21.1	23.1	24.8	26.0	26.6	26.7	27.0	28.1
2003	21.1	23.7	25.0	26.5	26.9	27.1	27.8	28.5
2004	20.7	23.1	24.6	25.8	26.1	27.1	27.6	28.3
2005	20.0	22.6	24.5	25.5	26.0	26.6	27.1	27.8
2006	19.5	22.7	24.3	25.3	26.0	26.6	26.9	28.0
2007	20.1	23.0	24.1	25.1	25.8	26.2	26.7	27.8
2008	20.0	22.7	24.1	25.0	25.2	26.3	26.9	27.3
2009*	-	-	-	-	-	-	-	-
2010	19.2	23.2	24.3	25.0	25.2	25.8	26.3	26.1

***no commercial samples available**

Table 5. Irish Sea Herring Division VIIa (N). Catch-at-length for 1990-2010. Numbers of fish in thousands.

Length	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
14															
14.5															
15			95												
15.5			169							10					
16	6		343			21	21	17		19	12	9			
16.5	6	2	275			55	51	94		53	49	27			13
17	50	1	779		84	139	127	281	26	97	67	53			25
17.5	7	4	1106		59	148	200	525	30	82	97	105			84
18	224	31	1263		69	300	173	1022	123	145	115	229			102
18.5	165	56	1662		89	280	415	1066	206	135	134	240	36		114
19	656	168	1767	39	226	310	554	1720	317	234	164	385	18		203
19.5	318	174	1189	75	241	305	652	1263	277	82	97	439	0	29	269
20	791	454	1268	75	253	326	749	1366	427	218	109	523	0	73	368
20.5	472	341	705	57	270	404	867	1029	297	242	85	608	18	215	444
21	735	469	705	130	400	468	886	1510	522	449	115	1086	307	272	862
21.5	447	296	597	263	308	782	1258	1192	549	362	138	1201	433	290	1007
22	935	438	664	610	700	1509	1530	2607	1354	1261	289	1748	1750	463	1495
22.5	581	782	927	1224	785	2541	2190	2482	1099	2305	418	1763	1949	600	2140
23	2400	1790	1653	2016	1035	4198	2362	3508	2493	4784	607	2670	2490	1158	2089
23.5	1908	1974	1156	2368	1473	4547	2917	3902	2041	4183	951	2254	1552	1380	2214
24	3474	2842	1575	2895	2126	4416	3649	4714	3695	4165	1436	3489	1029	1273	2054
24.5	2818	2311	2412	2616	2564	3391	4077	4138	2769	3397	1783	4098	758	1249	2269
25	4803	2734	2792	2207	3315	3100	4015	5031	2625	2620	2144	5566	776	1163	1749
25.5	3688	2596	3268	2198	3382	2358	3668	3971	2797	1817	1791	4785	1335	1211	1206
26	4845	3278	3865	2216	3480	2334	2480	3871	3115	1694	1349	3814	1570	1140	823
26.5	3015	2862	3908	2176	2617	1807	2177	2455	2641	1547	840	2243	1552	1573	587
27	3014	2412	3389	2299	2391	1622	1949	1711	2992	1475	616	1489	776	1607	510
27.5	1134	1449	2203	2047	1777	990	1267	1131	1747	867	479	644	433	1189	383
28	993	922	1440	1538	1294	834	906	638	1235	276	212	496	162	726	198
28.5	582	423	569	944	900	123	564	440	170	169	58	179	108	569	51
29	302	293	278	473	417	248	210	280	111	61	42	10	36	163	
29.5	144	129	96	160	165	56	79	59	92		12	0	36	129	
30	146	82	70	83	9	40	32	8	84		6	9		43	
30.5	57	36	36	15	27	5	0	5	3					43	
31	54	12	2	4		1	2							43	
31.5	31	3													
32	29														
32.5															
33															
33.5															
34															

Table 5 (continued). Irish Sea Herring Division VIIa (N). Catch-at-length for 1990-2010. Numbers of fish in thousands.

Length	2005	2006	2007	2008	2009*	2010
14					-	
14.5					-	
15					-	
15.5			16		-	93
16		2			-	107
16.5	1	44	33	1	-	487
17	39	140	69	3	-	764
17.5	117	211	286	11	-	1155
18	291	586	852	34	-	1574
18.5	521	726	2088	64	-	1405
19	758	895	2979	85	-	866
19.5	933	1246	3527	108	-	673
20	943	984	3516	100	-	787
20.5	923	1443	2852	133	-	888
21	1256	1521	3451	192	-	1470
21.5	1380	1621	2929	217	-	1758
22	1361	2748	3821	271	-	2363
22.5	1448	3629	3503	229	-	3362
23	1035	4358	4196	322	-	4530
23.5	1256	2920	3697	264	-	5232
24	1276	3679	3178	259	-	4559
24.5	1083	2431	2136	204	-	3616
25	1086	3438	1503	148	-	3083
25.5	584	2198	952	114	-	2582
26	438	1714	643	78	-	1777
26.5	203	605	330	42	-	950
27	165	445	147	23	-	460
27.5	60	155	72	10	-	216
28	45	104	33	12	-	9
28.5	18	9	26	1	-	
29	12	46			-	9
29.5			7		-	
30					-	
30.5					-	
31					-	
31.5					-	
32					-	
32.5					-	
33					-	
33.5					-	
34					-	

***no commercial samples available.**

Table 6. Irish Sea herring Division VIIa(N). Northern Ireland groundfish survey indices for herring (Nos. per 3 miles).

(a) 0-ring herring: October survey

	Western Irish Sea			Eastern Irish Sea			Total Irish Sea		
Survey	Mean	N.obs	SE	Mean	N.obs.	SE	Mean	N. obs	SE
1991	54	34	22						
1992	210	31	99	240	8	149	177	46	68
1993	633	26	331	498	10	270	412	44	155
1994	548	26	159	8	7	5	194	41	55
1995	67	22	23	35	9	18	37	35	11
1996	90	26	58	131	9	79	117	42	50
1997	281	26	192	68	9	42	138	43	70
1998	980	26	417	12	9	10	347	43	144
1999	389	26	271	90	9	29	186	43	96
2000	202	24	144	367	9	190	212	38	89
2001	553	26	244	236	11	104	284	45	93
2002	132	26	84	18	11	10	63	45	31
2003	1203	26	855	75	11	47	446	45	296
2004	838	26	292	447	11	191	469	45	125
2005	1516	26	1036	256	11	152	627	45	363
2006	4677	26	2190	2140	11	829	2468	45	822
2007	215	26	82	263	11	114	177	45	52
2008	1075	26	436	540	11	505	599	45	247
2009	3073	26	1803	8908	11	4186	4499	45	1730
2010	2123	26	974	6071	11	2844	3075	45	1147

Table 6. (Continued) Irish Sea herring Division VIIa(N). Northern Ireland groundfish survey indices for herring (Nos. per 3 miles).

(b) 1-ring herring: March Surveys.

	Western Irish Sea			Eastern Irish Sea			Total Irish Sea		
Survey	Mean	N.obs	SE	Mean	N.obs.	SE	Mean	N.obs	SE
1992	392	20	198	115	10	73	190	34	77
1993	1755	27	620	175	10	66	681	45	216
1994	2472	25	1852	106	9	51	923	39	641
1995	1299	26	679	73	8	32	480	42	235
1996	1055	22	638	285	9	164	487	39	230
1997	1473	26	382	260	9	96	612	43	137
1998	3953	26	1331	250	9	184	1472	43	466
1999	5845	26	1860	736	9	321	2308	42	655
2000	2303	26	853	546	10	217	1009	44	306
2001	3518	26	916	1265	11	531	1763	45	381
2002[a]	2255	25	845	185	11	84	852	44	294
2002[b]	7870	26	5667	185	11	84	2794	45	1960
2003	2103	26	876	896	11	604	1079	45	382
2004	6611	25	2726	491	11	163	2486	44	945
2005	7274	26	3097	1240	8	375	3001	42	1121
2006	4249	26	1687	2630	11	813	2496	45	662
2007	9340	26	3051	631	11	388	3480	45	1066
2008	2310	26	568	404	11	141	956	45	204
2009	11738	26	2853	1490	11	664	4638	45	1357
2010	2327	26	525	6304	11	3782	3272	45	1470

a. Unusually large catch removed, b. unusually large catch retained.

Table 6. (Continued) Irish Sea herring Division VIIa(N). Northern Ireland groundfish survey indices for herring (Nos. per 3 miles.).

(c) 1-ring herring: October Surveys

	Western Irish Sea			Eastern Irish Sea			Total Irish Sea		
Survey	Mean	N.obs	SE	Mean	N.obs.	SE	Mean	N.obs	SE
1991	102	34	34	n/a	n/a	n/a	n/a	n/a	n/a
1992	36	31	18	20	8	11	21	46	8
1993	122	26	66	4	10	2	44	44	23
1994	490	26	137	17	6	10	176	40	47
1995	153	22	61	3	9	1	55	35	21
1996	30	26	13	2	9	1	11	42	5
1997	612	26	369	0.2	9	0.2	302	43	156
1998	39	26	15	13	9	10	53	43	35
1999	81	26	41	104	9	95	74	43	40
2000	455	24	250	74	9	52	579	38	403
2001	1412	26	641	5	11	3	513	45	223
2002	370	26	111	4	11	2	291	45	158
2003	314	26	143	410	11	350	267	45	144
2004	710	26	298	103	11	74	299	45	108
2005	3217	25	1467	18	11	12	1121	44	507
2006	1458	26	669	40	11	18	523	45	231
2007	6194	26	3169	1569	11	1379	2758	45	1218
2008	1922	26	1207	1930	11	1210	1410	45	626
2009	3169	26	2115	112	11	55	1146	45	732
2010	2318	26	1115	173	11	72	935	45	391

Table 7. Irish Sea Herring Division VIIa (N). Larval production (10^{11}) indices for the Manx component.

Year	Douglas Bank		
		Isle of Man	
	Date	Production	SE
1989	26 Oct	3.39	1.54
1990	19 Oct	1.92	0.78
1991	15 Oct	1.56	0.73
1992	16 Oct	15.64	2.32
1993	19 Oct	4.81	0.77
1994	13 Oct	7.26	2.26
1995	19 Oct	1.58	1.68
1996			
1997	15 Oct	5.59	1.25
1998	6 Nov	2.27	1.43
1999	25 Oct	3.87	0.88

Annex 9 – Stock Annex – Sprat in the North Sea

Stock specific documentation of standard assessment procedures used by ICES.

Stock	Sprat in the North Sea
Working Group	Herring Assessment Working Group (HAWG)
Date	13 February 2013
Authors	WKSPRAT 2013

A. General

A.1. Stock definition

Sprat (*Sprattus sprattus* Linnaeus 1758) in ICES area IV (North Sea) is treated as a single management unit. However, questions have recently been raised about the geographic distribution of this stock and its interaction with neighbouring stocks: in particular, large abundances have been observed close to the southern boundaries of the stock (ICES HAWG 2009). The apparent overlap between North Sea sprat and English Channel sprat is very strong, whereas the overlap between North Sea sprat and Kattegat sprat is not as strong and varies between years.

A detailed genetic study has been performed to analyze the population structure of sprat over large ranges, from scales of seas to regions (Limborg *et al*., 2009, 2012). The study was performed with individuals from the Baltic Sea, Danish waters, Kattegat, North Sea, Celtic Sea and Adriatic Sea (Figure 2). The analysis partitioned the samples into groups based upon their genetic similarity (Figure 3). The Adriatic Sea population exhibited a large divergence from all other samples. The samples from the North Sea, Celtic Sea and Kattegat were separated from the Baltic Sea samples, with the Belt Sea (Kattegat) sample in between. The authors concluded that there exists a barrier to gene flow from the North Sea to the Baltic Sea, with the Belt Sea being a transition zone. This analysis supports the separation of sprat into three stocks as currently employed by ICES (i.e. subdivision VIId (English Channel), subdivision IIIa (Skagerrak/Kattegat) and division IV (North Sea). Glover *et al* (2011) found a significant difference between sprat in the Norwegian fjords and the North Sea, but further research on is required on the populations in the fjords on the Norwegian and Swedish Skagerrak coast and the populations in the IIIa.

Differences in length at age and recruitment indices support separation of stocks in IIIa and IV. There is uncertainty about whether peripheral populations, such as those in the Moray Firth NE Scotland and Firth of Forth E Scotland may be disconnected from the main stock in the southern North Sea. Surveys in the Wadden Sea show a declining population trend there that is opposite to the recent increases in the North Sea stock. However, this could be caused by a shift in distribution of the North Sea sprat stock rather than separate stocks.

There is a necessity to determine whether the sprat in the North Sea (area IV) constitute a stock or whether they encompass one or both the adjoining populations of sprat (i.e. IIIa or VII (English Channel)). This is vital for establishing the correct assessment/stock units in the area.

There is a geographically isolated sprat population in the Moray Firth in northeast Scotland which appears to have little connectivity with the main stock in the southern North Sea. There is another geographically isolated sprat population in the Firth of Forth in east Scotland which also appears to have little connectivity with the main stock in the southern North Sea. Both of these populations have supported sprat fisheries in the past. There are sprats in the Wadden Sea and in the outer Thames estuary, areas that are more closely connected to the main sprat population in the southern North Sea but which may represent populations with distinct dynamics. Also the Norwegian fjords have sprat populations and a coastal sprat fishery. These sprats are, however, not managed as North Sea sprat.

The Moray Firth sprat stock supports internationally important populations of birds and marine mammals. Part of the area has been designated as a Special Protection Area for aggregations of sea ducks (especially red-breasted mergansers). Sprat abundance in the Moray Firth is believed to have fallen to low levels in the 1990s, and most of these birds have left the area.

The Firth of Forth supported a local sprat fishery that caught sprats in the inner parts of the Firth (east of the Forth Bridges). Landings peaked at ca. 20,000 tonnes in the late 1960s. The stock supported large numbers of breeding common terns in the Firth of Forth. When the stock collapsed in the early 1980s, the fishery closed and has remained closed up to the present, and common tern numbers in the region fell considerably. There is evidence from fishermen and from natural predators that sprat biomass has increased in the Firth of Forth. Breeding common tern numbers have now recovered, their breeding success is high, and they feed predominantly on sprats, catching fish in the same area in the inner Firth of Forth that had previously supported the sprat fishery (Jennings *et al*. 2012).

The outer Thames estuary has been designated a Special Protection Area for red-throated divers as it holds the largest winter aggregation of these birds in Europe. It is thought that sprats are important in their diet.

Under the auspices of the National Park Schleswig-Holstein Wadden Sea, a survey of sprat abundance in the German part of the Wadden Sea has been carried out each year since 1991 (Vorberg 2009). The abundance index shows a progressive decline in sprat abundance in the German Wadden Sea, a trend that is the opposite to the trend in abundance in the North Sea as a whole. Common terns in the Wadden Sea feed predominantly on sprats and show declines in breeding success and reductions in breeding numbers that correlate with the Wadden Sea sprat abundance index (Dänhardt and Becker 2011). This suggests either that there is a separate stock of sprats in the Wadden Sea with dynamics that are independent from the main North Sea sprat stock, or that sprats have altered in distribution such that their abundance in the Wadden Sea has declined despite increases in the North Sea as a whole.

Given that dependent predator populations are most likely to aggregate in coastal areas such as those listed above, there is a need to consider the extent to which these local coastal populations of sprats are, or are not, linked to the main North Sea stock which is the subject of the assessment and target of the fishery.

A.2. Fishery

The majority of the sprat landings are taken in the Danish industrial small-meshed trawl fishery. The Norwegian sprat fishery has mainly been carried out by purse seiners. From about 2000, pelagic trawlers were licensed to take part in the sprat fishery in the North Sea, In the first years the catches taken by trawlers were low but in the last years their share of the total Norwegian catches has increased. The Danish and Norwegian landings are mainly used for reduction purposes.

The Norwegian vessels have a maximum vessel quota when fishing in the EU zone. They are not allowed to fish in the Norwegian zone before the quota has been taken in the EU-zone.

In the last decade, also the UK, Sweden, Germany and the Netherlands occasionally landed small amounts of sprat.

In 2007 a new quota regulation (IOK) for the Danish vessels was implemented and realized from 2008 and onwards. The regulation gives quotas to the vessel, but these can be traded or sold. A large number of small vessels have been taken out of the fishery and their quotas sold to larger vessels. Today the Danish fleet consists of 18-20 large vessels.

Historically, the bycatch of juvenile herring in the industrial sprat fisheries has been problematically high (Hoffman *et al* 2004). To reduce this bycatch, an area closed to the sprat fishery (the "sprat box") was established off the western coast of Denmark (from Vadehavet to Hanstholm) in October 1984. It was estimated that about 90% of the bycatches of juvenile herring in the industrial fisheries was taken within this box, and the intention of the sprat box was thus to reduce this juvenile herring bycatch.

Despite the establishment of this sprat box, the juvenile herring bycatches increased in the early 1990's, partly because of larger incoming year classes having a wider distribution (Hoffman *et al* 2004). It was concluded that there was no clear connection between the sprat box and the decrease in herring bycatches in the period 1984-1996. The sprat box is still in operation (Fiskeridirektoratet 2007). An experimental fishery was conducted in the box in 2012 to determine whether there is basis for changing the box (changing spatial coverage or removing it).

After 1996, the bycatch mortality of juvenile herring was reduced (ICES HAWG 2009). This coincided with the introduction of a bycatch limit on herring in the industrial fisheries and improvements in the catch sampling.

The sprat fishery is regulated by a bycatch-quota on herring in the Danish industrial fishery. Once this is exceeded, all industrial fisheries are ceased (including for Norway pout, blue whiting). The directed sprat fishery is regulated by a % minimum limit for sprat in the haul of 60%. Discarding in the sprat fishery in the North Sea is considered low; however, if the bycatch% of herring is exceeded in a haul, the haul is not taken and this may be regarded as slippage/discarding. In the Norwegian North Sea sprat fishery, there is a maximum bycatch-limit of 10% herring. Herring bycatches are taken from the vessel's quota of North Sea herring. The degree of mixing with juvenile herring varies both within and between years, related to the size and distribution of the juvenile herring population.

Evaluation of the quality of the catch data

Due to large but unknown bycatches of juvenile North Sea herring in the industrial sprat fisheries prior to 1996 (Hoffman *et al* 2004), sprat landings are only considered reliable from 1996 onwards. The reduction in bycatches of juvenile herring in 1996 coincides with the introduction of a bycatch limit on herring in the industrial fisheries, and improvements in catch-sampling.

The bycatches in the Danish industrial small-meshed trawl fishery for sprat (1998-2009) have been estimated from samples of the commercial catches. The major bycatches are herring (4.2-11.1% in weight), horse mackerel (0.0-1.6%), whiting (0.2-1.5%), haddock (0.0-0.1%), mackerel (0.0-2.2%), cod (<0.0%), sandeel (0.0-10.0%) and other (0.3-2.4%). Although these catches are relatively small by weight, they are often juveniles, and therefore can represent a significant number of individuals.

There exists no information about the bycatches of the other fleets.

A.3. Ecosystem aspects

Sprat is an important part of the diet of numerous species, including demersal fish, zooplankton seabirds and other predators (marine mammals and elasmobranchs). The major natural sources of sprat removals include whiting, mackerel, horse mackerel and seabirds (Fig. A.3.1). Thus a fishery on sprat may impact on these other components via second order interactions. There is a paucity of knowledge of effects of a shortage of sprat on the majority of these species, with the exception of seabirds in the breeding season. Other species impact on sprat through inducing natural mortality. This effect is estimated in the multispecies SMS model of the North Sea (WKSPRAT 2013).Sprat can be very important for breeding seabirds in southern areas of the North Sea (Durinck *et al* 1991, Wilson *et al*. 2004). Estimates from 1985 have shown that the total seabird consumption in the North Sea could be on the same level as the fisheries (Hunt and Furness (ed.) 1996). In winter, when sandeel are not available to most seabirds (because they are buried in the sand) many of the seabirds that overwinter in the North Sea take sprat as part of their diet. However, it is uncertain whether sprat abundance in the North Sea will affect seabird breeding success or overwinter survival.

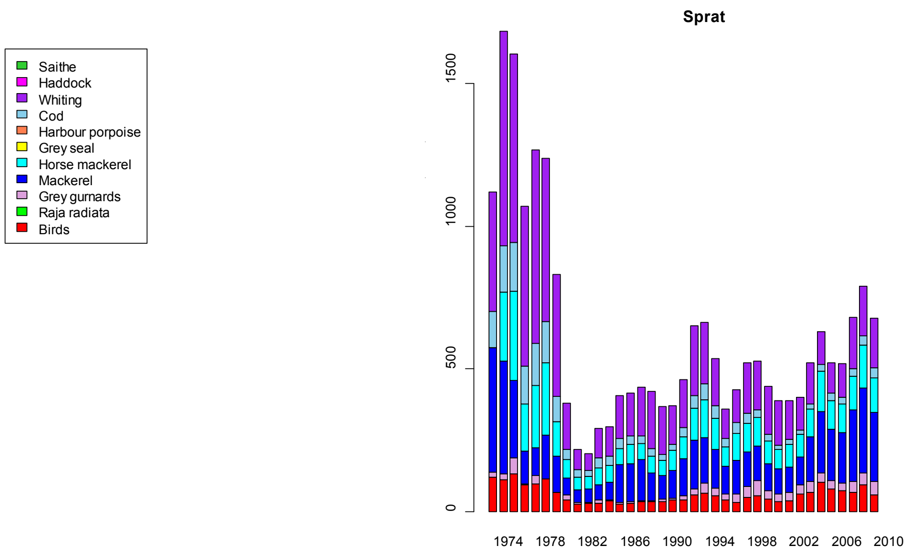


Figure. A.3.1 Biomass (1000t) of sprat eaten by predator. Data from SMS updated run (WKSPRAT 2013).

B. Data

B.1. Commercial catch

The majority of the sprat landings are taken in the Danish industrial small-meshed trawl fishery. The Norwegian sprat fishery is, since 2000, carried out by purse seiners and pelagic trawlers. The landings are mainly used for reduction purposes. In the last decade, also the UK, Sweden, Germany and the Netherlands occasionally landed small amounts of sprat.

The commercial catches are sampled for biological parameters. In the most recent years Denmark, Norway, UK and the Netherlands have sampled their sprat catches. The sampling intensity for biological samples, i.e., age and weight-at-age is mainly performed following the EU regulation 1639/2001, requiring 1 sample per 2000 tonnes.

By far the majority of the biological samples are collected by Denmark (90%). Seasonal sampling intensity reflect fishing patterns, hence, most samples are collected in quarter 3 and 4 and in SE North Sea. All samples collected within div. IV are combined irrespective of nationality. The method suggested by Rindorf and Lewy (2001) was used to assure that the estimation is optimized when sampling is sparse. This method is used to estimate an age-length-key for each combination of year, time and area. The estimated proportion at a given age was considered to be reliable when the number of fish sampled of the given age or older exceeded 50 or the confidence limits of the estimate were less than +/- 25%. When the number of fish aged is too low to allow a reliable estimation on a given spatial level, higher aggregation levels were used.

Level	Space	Time
1	4 statistical rectangles	Quarter
2	16 statistical rectangles	Quarter
3	North Sea	Quarter
4	North Sea	Half year
5	North Sea	Year

The probability of being of a given age is set to zero at lengths outside the interval of lengths observed for this age +/- 1 cm unless the given age was not observed at all and more than 50 fish were sampled, in which case the probability was set to zero for all lengths. Overdispersion (Rindorf and Lewy 2001) was not estimated.

The number of sprat of each age (0 to 4+) per kg and the mean weight per individual of each age in each length distribution sample was estimated by combining the age length key, length distribution specific to that statistical rectangle and period and weight at length estimates.

In Danish samples, the weight at length was determined for all samples length measures whereas in the Norwegian samples, weight was determined for fish age determined. To achieve an estimate of weight at length in the Norwegian samples, a monthly weight-length relationship was estimated for each sandeel sampling area and used to estimate weight for each length group. If no Norwegian samples were taken in the given month and sandeel sampling area, the monthly weight length relationship estimated from the combined Danish and Norwegian data were used.

The average number per age per kg and their mean weight at a given spatial and temporal scale was estimated as the average of that recorded in individual samples when at least 5 samples were available. Mean weight was only estimated when the total number of fish in the samples of a given age in the area exceeded 10. When less than 5 samples were taken at the finest aggregation level, the next aggregation level was used and so forth. Hence, for each area, quarter and year, the average number sprat per age and kg and tons of sprat caught was estimated and the level noted. If the total North Sea sampling resulted in less than 10 sprat of a particular age, the mean weight over all years was used.

The Danish landings per statistical rectangle and month from 1991 an onwards are known from samples for species composition taken by the Fishery Inspectors for control of the bycatch regulation. At least one sample (10-15 kg) per 1000 tons landings is taken and these samples are used to estimate average species composition by area (ICES rectangles) and month. This species/area/period key, logbook data (spatial distribution) and landings slip data (quantity) are used to derive the Danish WG estimates of landings of sprat. These data were assumed to represent the spatio-temporal distribution of both the Danish and international catches in the years 1991 to 2002.

From 2002, the catch by statistical rectangle of Norway was provided as input and included together with the Danish data.

The total international catch in tonnes taken by Denmark and other countries as reported to ICES was distributed on statistical rectangles and quarter in the particular year according to the distributions described above.

The catch in numbers per age (1000s), month and statistical rectangle was estimated as the product of catches and the number of sprat per age per kg in the particular area. The mean weight is estimated as the weighted average mean weight (weighted by catch in numbers of the age group in the statistical rectangle). Mean weight is given in kg.

B.2. Biology

Sprat in the North Sea has a prolonged spawning season ranging from early spring to late autumn. Early in the year the start of the spawning is triggered by the water temperature (Alheit *et al*. 1987; Alshuth 1988a; Wahl and Alheit 1988). Sprat is a batch spawner, producing up to 10 batches in one spawning season and 100-400 eggs per gram of body weight (Alheit 1987; George 1987). The majority of the sprat in age groups 1+ in the summer acoustic surveys in June-July are spawners (ICES WGIPS 2010).

Disagreements in the age reading in North Sea sprat have been reported (*e.g*. Torstensen *et al*. 2004). Problems with correct age determination may arise from three main sources; a) individuals may over winter as larvae and a winter-ring may not be discernible; b) more than one translucent zone may be formed in a specific year and thereby adding false winter zones to the total count as suggested for other species like sand eel; c) the reader's qualification. Validation of annual ring formation from primary increment formation in otoliths has to either rely on a daily periodicity of the primary increments all year round or an annual cycle in the pattern of the otolith microstructure (Panella 1971).

Studies of microstructures in sprat otoliths (sagittae) have demonstrated structural differences between what are defined as true and false translucent (winter) rings (Mosegaard and Baron 1999). When the translucent ring is deposited the width of the daily increments gradually reduces in width. This pattern can be found in true winter rings in the sagittae of sprat aged 0 – 2 years old. A false winter ring has no gradual reduction in the width of the daily rings in front of it, neither immediately after the translucent zone. Thus, in otoliths where the age reader is in doubt whether a translucent zone is true or false, the validity of the ring can be examined by reading the otolith microstructure. The accuracy of the age readings was analysed applying the daily ring widths of the annotated winter-rings by an experienced age reader. The text table below shows the results for the experienced Danish age reader; the accuracy for the 1 group is very high (94% correct) and a bit lower for age group 2 (89% correct).

		Validated age		
	Year	1	2	3
	1	90	2	0
	2	5	36	0
Read age	3	0	2	5

Read age vs. validated age for an experienced age reader

A frequent source of error when age reading sprat is the identification of the first wintering probably due to the prolonged spawning period where a subset of a cohort may over winter as larvae and a winter-ring may not be discernible. The encouraging results above are based on one agereader and thus the results of an ongoing exchange under the PGCCDBS on sprat from the North Sea and Celtic Sea should be taken into account when these are available (ICES 2013). However applying the new image analysis techniques (annotating rings, validation by microstructure) will potentially increase both accuracy and precision of the age estimations of sprat.

Mean weights-at-age in the spawning stock is taken as the mean weight-at-age in the catch at spawning time, which is defined as Quarter 3.

B.3. Surveys

Three surveys cover this stock. Two International Bottom Trawl Surveys (IBTS) cover the stock in the first and third quarters of the year, respectively. Additionally, the herring acoustic survey (HERAS) covers the same area during June-July.

The appropriateness and suitability of these surveys for use in the assessment of the North Sea sprat stock, was examined by the WKSPRAT (2013).

B.3.1 International Bottom Trawl Surveys (IBTS)

Background

The North-Sea International Bottom Trawl Surveys started as a coordinated international survey in the mid-1960s as a survey directed towards juvenile herring. The gear used was standardised in 1977 to use the GOV trawl, but took time to be phased in. By 1983 all participating nations were using this gear, and the index can be considered consistent from this point onwards. A third-quarter North Sea IBTS survey using the same methodology was started in 1991 and can be considered consistent from its initiation. IBTS Surveys were also performed in the North Sea in the second and fourth quarters in the period 1991-1996, but are not considered further here (ICES 2006). More details on the surveys are available from the manual (ICES 2012).

Suitability

Internal and external (between IBTS Q1 and IBTS Q3 and between IBTS and HERAS) consistency analyses provide r^2 values > 0.2 for most pairwise comparisons

(WKSPRAT 2013). Further, IBTS data are fitted reasonably by the assessment model with CVs around 0.6, although not as well as the acoustic HERAS index.

Internal Consistency

Internal consistency in IBTS Q1 is in general higher than in IBTS Q3 (Figures 4 and 5). In IBTS Q3 internal consistency is only present from age-0 to age-1. It should be noted that a good internal consistency is only expected when total mortality is constant over time, which is not the case for sprat.

Catches of North Sea sprat in hauls in the IBTS survey can occasionally be extremely large; this phenomenon has previously been suggested as being important to the dynamics and uncertainty of IBTS survey indices (ICES HAWG 2007, 2009). In order to examine this phenomenon more closely, the importance of each haul to the index was assessed by calculating the individual contribution of each haul to the total. These hauls were then ranked according to size and aggregated to produce an estimate of the cumulative contribution ranked by sized: in this manner, it is therefore possible to assess, for example, the proportional contribution of the largest 20 hauls in a given year. For all years in the both the IBTS Q1 and Q3, the 10 largest hauls contribute at least 35% of the survey index, and in some cases up to 85% of the index. The IBTS Q3 index appears to have more severe problems with large hauls than the Q1 index: in every year, the five largest hauls make up more than 50% of the index. Three methods to estimate the average catch in the IBTS were examined by WKSPRAT (2013): stratified mean, delta-gamma and delta-normal distributed data. The two latter methods assumed a constant spatial distribution of the sprat stock (multiplicative effect of 4-square area on catch rates). The methods were evaluated based on their consistency with the HERAS acoustic survey. The delta-gamma distribution and the stratified mean each showed the highest correlation in half the cases. Hence, both would appear to be reasonable methods for estimating survey indices. The group chose to proceed with the stratified mean, as no consistent improvement could be reached by using the other two methods and as the assumption of constant distribution may not be valid in periods of environmental change or changes in stock abundance.

B.3.2. Herring Acoustic Survey (HERAS)

Background

The Herring Acoustic Survey is a summer acoustic survey that has been performed by an international consortium since the 1980s. Sprat has been reported as a separate species in this survey from 1996 onwards. However, as the survey is targeted towards herring, which are generally in the northern half of the North Sea during summer, coverage in the southern-half has received less attention. The area covered was expanded progressively over time, and by 2004 covered the majority of the stock, reaching 52°N (the eastern entrance to the English Channel) and all of the way into the German Bight (ICES PGHERS 2005). The coverage of this survey has remained relatively unchanged since 2004 (*e.g.* ICES PGIPS 2009) and we consider the survey from this point and onwards.

Suitability

The acoustic survey indices were investigated in WKSPRAT (2013) to determine the start year which corresponded to the highest internal consistency (Figure 6). This was found to be 2001, corresponding to a correlation of 1 to 2 year olds of 0.58 and of 2 to

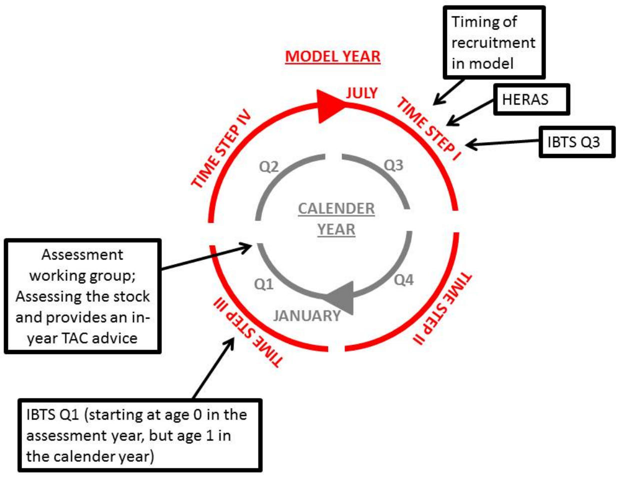
3 year olds of 0.67 (P<0.05 in both cases, n=12). The acoustic indices were very well fit by the assessment.

B.4. Commercial cpue

None available.

C. Assessment methodology

The sprat assessment is made using SMS (Lewy and Vinther 2004) with quarterly time steps. Three surveys are included, IBTS Q1 ages 1-4+ (1974 and onward), IBTS Q3 ages 1-3 (1991 and onward) and HERAS (Q3) ages 1-3 (2001 and onward). 0-group sprat are unlikely to be fully recruited to the GOV in Q3 and this age group was excluded from runs. The age distribution of quarterly catches of less than 5000 tons is very poorly estimated: with two exceptions, these are based on less than 5 samples (from a total of 148 quarters sampled). As these catches are too small to have any major effect on the stock, they were removed from the likelihood estimation to avoid problems caused by the low sampling level.



In order to be able to give timely advice and to follow the natural life cycle of sprat, the input data were shifted to model a year going from July to June. Hence, 2000 season 1 refers to 2000 quarter 3, 2000 season 2 refers to 2000 quarter 4, 2000 season 3 refers to 2001 quarter 1 and 2000 season 4 refers to 2001 quarter 2. SSB and recruitment was estimated at July 1st. In figures and tables with assessment output and input, the years refer to the shifted model year (1 July to 30 June) and in each figure and table it is noted whether it is model year or the calendar year apply (when the model year is given the year refers to the year at the beginning of the model year; for example: 2000 refers to the model year 2000/2001). The following schematic illustrates the shifted model year relative to the calendar year and provides an overview of the timing of surveys etc.

Natural mortality by age, quarter and year as estimated in the multispecies model is used in the assessment. Annual maturity ogives are used after 1994. Before 1994 fixed maturity ogives is used.

The details of the default model settings are summarized in the following table.

Option	North Sea (Div. IV)
Data first year	1974
Time step	Quarterly (model year running from 1 July to 30 June)
First age	Age 0
Last age	Age 3+
Recruitment time	Start of 1st season (in the model year)
Age range for use of catch data in likelihood	Age 0 – age 3+
Last age with age dependent fishing selection	Age 2
Objective function weighting (catch, survey, S/R)	1.0, 1.0, 0.01
Minimum CV of catch observations	0.1
Minimum CV of survey observations	0.3
Minimum CV of S/R relation	0.2
Catch observations: variance group	Age 0 Age 1 Age 2 + Age 3
Treatment of zero catch observations	Not used in likelihood
Year ranges for constant exploitation pattern	1974–1996 & 1997–
Ages for seasonal exploitation pattern	Age 0 Age 1 Age 2 Age 3
Ages for calculation of mean F	Age 1 & age 2
Exclusion of catch data (no or very small catches are available)	< 5000 t (see the main text above)
Catch Variance	Calculated within SMS
Survey variance	Free parameter
S/R variance	Calculated within SMS
Inflexion point (B_{lim})	90 000
Survey	IBTS Q1: Age 0 – Age 3 (1974-) IBTS Q3: Age 1– Age 3 (1991-) HERAS: Age 1 – Age 3 (2001-)

D. Short-Term Projection

Short term projecttions are made using SMS, the reference points described in the section below and 3 year averages of weight-at-age, proportion mature, and the natural mortality for the incoming year. By the time of the assessment (HAWG is held in March) information is lacking on catches in quarter 1 and 2 (Jan – June). These are estimated by using a value that corresponds to *x* % of the TAC, where *x* is the catch in quarter 1 and 2 relative to the combined catch of quarter 3 + 4 averaged over the three previous years (but *x* * TAC should not exceed what is remaining of the TAC). The 25% lower fractile boundary of the long term recruitment mean (1992-2012) is used as the recruitment input in the projection.

Model used: SMS

Software used*:* R

Initial stock size: unknown

Maturity: average of the last 10 years

F and M before spawning: average of the last 3 years

Weight at age in the stock: average of the last 3 years

Weight at age in the catch: average of the last 3 years

Exploitation pattern: average of the last 3 years

Catches in quarter 1 and 2 (Jan – June) are estimated using a value that corresponds to *x* % of the TAC, where *x* is the catch in quarter 1 and 2 relative to the combined catch of quarter 3 + 4 averaged over the three previous years (but *x* * TAC should not exceed what is remaining of the TAC).

Stock recruitment model used:

Geometric recruitment mean for the entire time-series is used as the recruitment input in the projection

E. Medium-Term Projections

No projections are performed.

F. Long-Term Projections

No projections are performed.

G. Biological Reference Points

The stock and recruitment relationship generated from the mordel output data indicates an increasing relationship between the SSB and recruitment, and no breakpoint for a hockey stick relationship could be estimated by the model. Blim was not sensitive to choice of approach (ICES 2003), and ended up between 80 000 and 100 000 t. The following approaches were attempted: Increasing relationships, a "cloud" for data from 1991 onwards(B_{lim} = B_{loss} =82 000 t), and a hockey stick with a predefined breakpoint (where years of very high recruitment preferentially should be above B_{lim} and years of very low recruitment below B_{lim}). The lowest B_{lim} came out of the B_{loss} approach. It was decided that ensuring thatyears of very good recruitment occurred when the stock was above B_{lim} and years of very low recruitment occurred when the stock was below Blim were important criteria given the appearance of the relationship. Hence, a B_{lim} of 90 000 t and B_{pa} of 142 000 t was agreed. B_{pa} is defined as the upper 90% confidence interval of B_{lim} and calculated based on a terminal SSB CV of 0.28.

H. Other Issues

None.

I. References

Alheit, J. 1987. Variation of batch fecundity of sprat, Sprattus sprattus, during spawning season. ICES CM 1987/H:44.

Alheit, J., Wahl, E., and Cibangir, B. 1987. Distribution, abundance, development rates, production and mortality of sprat eggs. ICES CM 1987/H:45.

Alshuth, S. 1988. Seasonal variations in length-frequency and birthdate distribution of juvenile sprat (Sprattus sprattus). ICES CM 1988/H:44.

Durinck J., Skov H. and Danielsen F. 1991. The winter food of guillemots Uria-aalge in the Skagerrak. Dansk ornitologisk forenings tidsskrift 85: 145-150.

George, M.R. 1987. Ovarian maturation cycle of sprat, Sprattus sprattus. ICES CM 1987/H:47.

Glover, K., Skaala, Ø., Limborg, M., Kvamme,.C., Torstensen, E. 2011. Microsatellite DNA reveals population genetic differentiation among sprat *(Sprattus sprattus)* sampled throughout the Northeast Atlantic, including Norwegian fjords. ICES Journal of Marine Science (2011), 68 (10), 2145-2151. Doi:10. 1093/icesjms/fsr153

Hoffman E, Dolmer P, Nordberg E, Blanner P 2004. Beskyttede havområder i Norden. TemaNord 2004: 543.

Hunt G.L. and Furness R.W. (ed) 1996. Seabird/fish interactions, with particular reference to seabirds in the North Sea. ICES cooperative research report no. 216.

ICES 2003. *ICES. 2003c. Report of the Study Group on Precautionary Reference Points for Advice on Fishery Management. p. 81. ICES Document CM 2003/ACFM: 15*

ICES 2006. Report of the Workshop on Implementation in DATRAS of Confidence Limits Estimation of, 10-12 May 2006, ICES Headquaters, Copenhagen. 39 pp.

ICES HAWG. 2007. Report of the Herring Assessment Working Group South of 62 N (HAWG), 13 -22 March 2007, ICES Headquarters. ICES CM 2007/ACFM:11. 538pp.

ICES HAWG. 2009. Report of the Herring Assessment Working Group for the Area South of 62 N, 17-25 March 2009, ICES Headquarters, Copenhagen. 648 pp.

ICES PGHERS 2005. Report of the Planning Group on Herring Surveys (PGHERS), ICES CM 2005/G:04.

ICES PGIPS. 2009. Report of the Planning Group of International Pelagic Surveys (PGIPS), 20–23 January 2009, Aberdeen, Scotland, UK. ICES CM 2009/LRC:02. 217 pp.

ICES WGIPS 2010. Report of the Working Group for International Pelagic Surveys. ICES CM 2010/SSGESST:03.

ICES 2012. Manual for the international bottom trawl surveys. Revision VIII. http://www.ices.dk/products/SurveyProtocols/SISP1-IBTSVIII.pdf

ICES WKSPRAT 2013. Benchmark workshop on sprat stocks. 11-15 February 2013, ICES HQ, Copenhagen. ICES CM 2013 / ACOM:48.

Lewy, P. and Vinther, M. 2004. A stochastic age-length-structured multispecies model applied to North Sea stocks. ICES C.M. 2004/FF:20.

Limborg, M.T., Pedersen,J.S., Hemmer-Hamsen,J., Tomkiewicz,J., Bekkevold, D. 2009. Genetic population structure of European sprat (*Sprattus sprattus*): differentiation across a steep environmental gradient in a small pelagic fish. Marine ecology progress series 379: 213-224.

Limborg, M.T., Hanel, R., Debes, PV., Ring, AK., André, C., Tsigenopoulos, CS. and Bekkevold, D. 2012, Heredity, (2012)109, 96-107. Imprints from genetic drift and mutation imply relative divergence times across marine transition zones in a pan-European small pelagic fish (*Sprattus sprattus*). Heredity, (2012)109, 96-107.

Mosegaard H. and Baron P.R. 1999. Validation of annual rings by primary increment characteristics in herring and sprat sagitta otoliths. Lecture at EFAN meeting, notes can be found on the internetsite www.efan.no

Panella, G. 1971. Fish otoliths: Daily growth layers and periodical patterns, Science 173: 1124-1127

Rindorf, A. and Lewy, P. (2001). Analyses of length and age distributions using continuation-ratio logits. Can. J. Fish. Aquat. Sci. 58: 1141-1152.

Torstensen E., Eltink, A.T.G.W., Casini, M., McCurdy, W.J., Clausen, L.W. 2004. Report of the Work Shop on age estimation of sprat.

Wahl, E., and Alheit, J. 1988. Changes in the distribution and abundance of sprat eggs during spawning season. ICES CM 1988/H:45.

Wilson L.J., Daunt F. And Wanless S. 2004. Self-feeding and chick provisioning diet differ in the Common Guillemot Uria aalge. Ardea 92: 197-207.

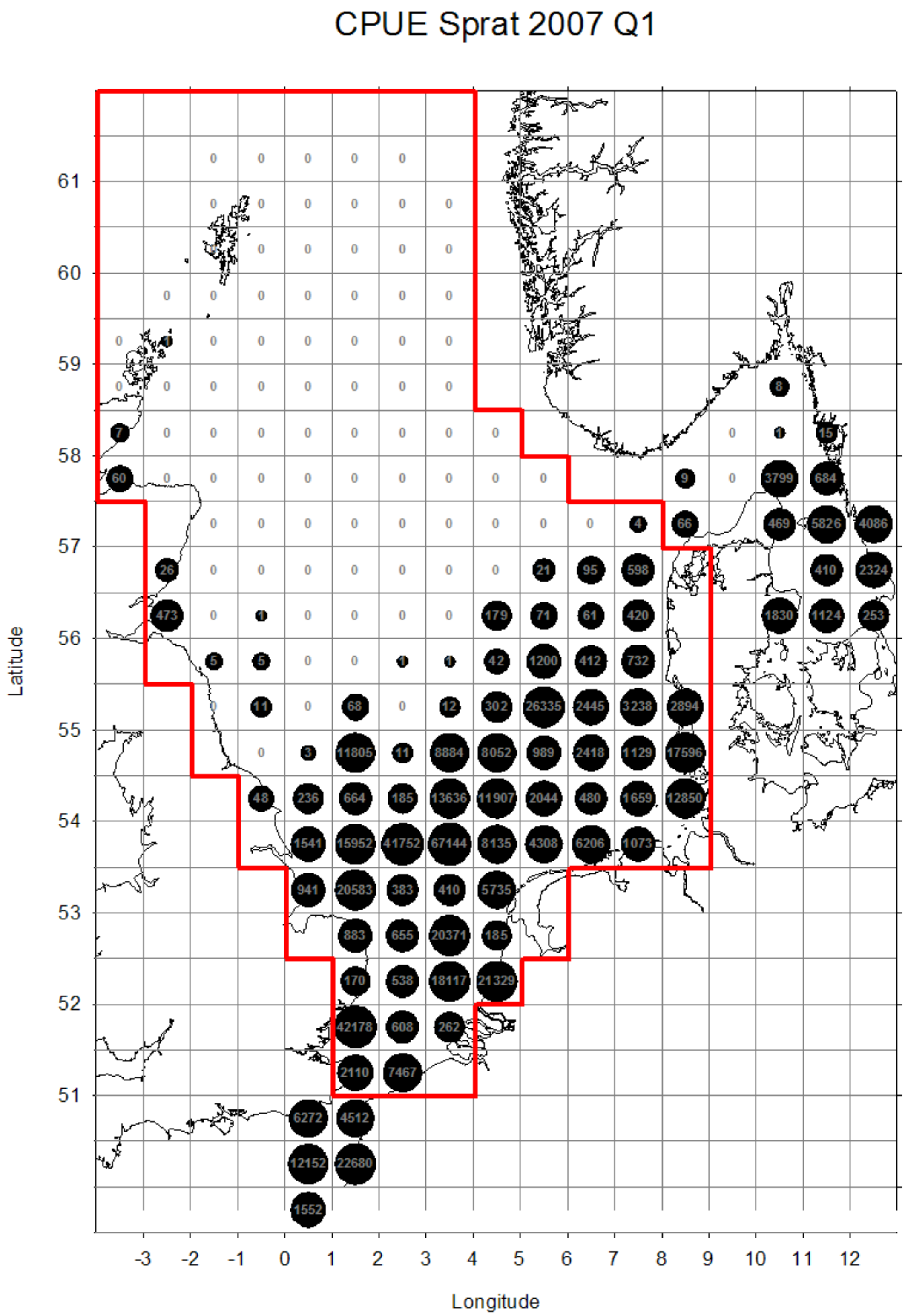


Figure 1. North Sea sprat. IBTS log cpue from subareas; IV, IIIa, VII. The red area encircles the management area used for North Sea sprat. After ICES HAWG 2009.

Figure 2. North Sea sprat. Sampling stations (Limborg *et al*. 2009).

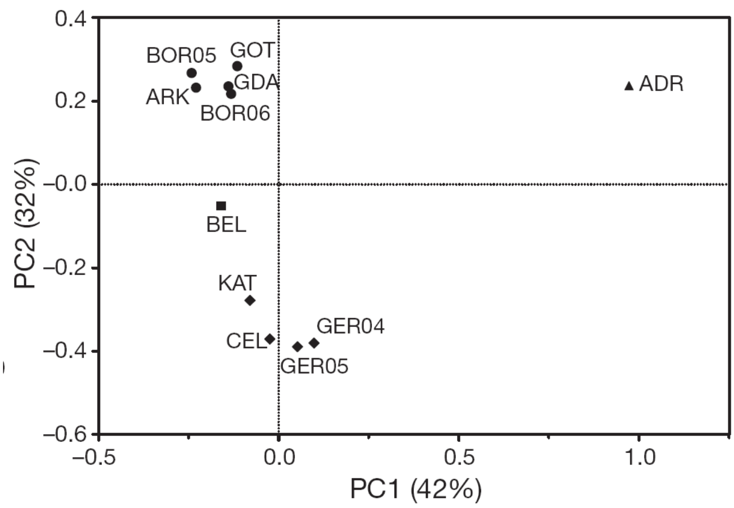


Figure 3. North Sea sprat. Plot of the generic variance in the samples. ADR = Adriatic Sea, ARK = Arkona Basin, BEL = Danish Belt, BOR = Bornholm Basin, CEL = Celtic Sea, GDA = Gdansk Deep, GER = German Bight (North Sea), GOT = Gotland Basin (Limborg *et al*. 2009).

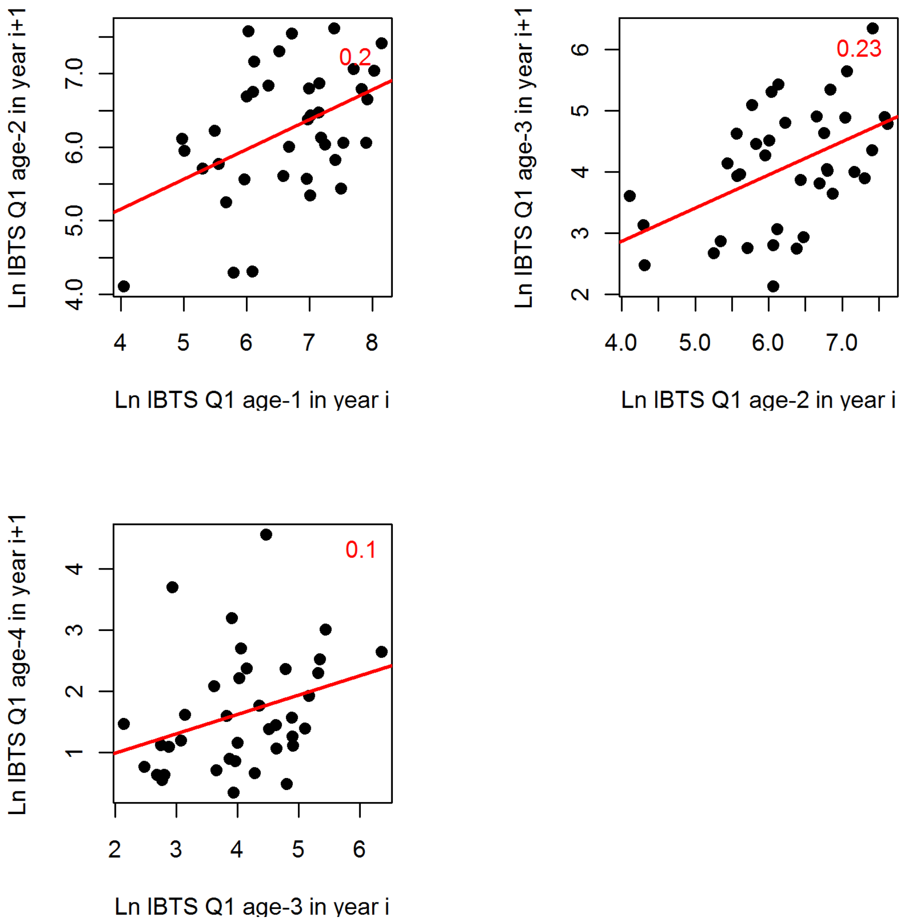


Figure 4. North Sea sprat. Internal consistency analysis from the IBTS Q1 survey. The coefficient of determination (r^2) is provided and is based upon log-transformed values.

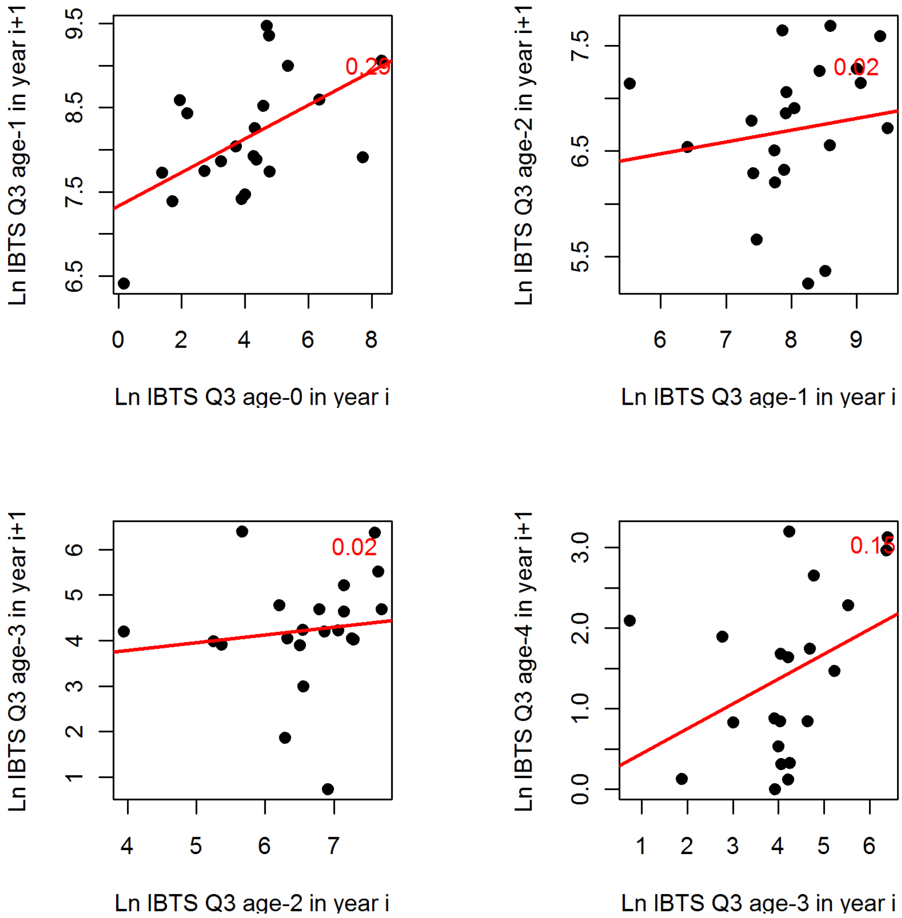


Figure 5. North Sea sprat. Internal consistency analysis from the IBTS Q3 survey. The coefficient of determination (r^2) is given and is based upon log-transformed values.

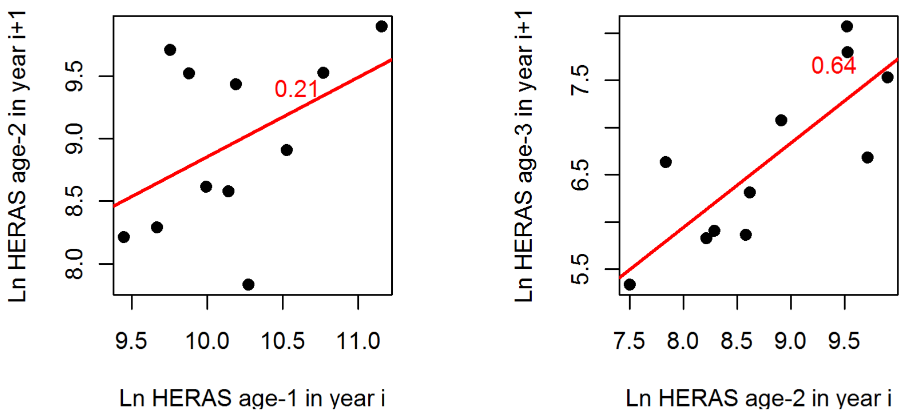


Figure 6. North Sea sprat. Internal consistency analysis from the herring acoustic survey, HERAS. The coefficient of determination (r_2) is given and is based upon log-transformed values.

Annex 10 – Stock Annex Sprat in Division IIIa

Quality Handbook	ANNEX: Sprat IIIa

Stock specific documentation of standard assessment procedures used by ICES.

Stock:	Sprat in Division IIIa
Working Group:	Herring Assessment Working Group (HAWG)
Date:	12 February 2013
Authors:	WKSPRAT 2013

A. General

A.1. Stock definition

Sprat distributed in ICES area IIIa is managed as one stock unit. Analyses of genetic population structure of European sprat (*Sprattus sprattus*) indicate a genetic differentiation in samples of sprat from Kattegat compared to adjacent areas (North Sea and the Baltic) (Limborg *et al* 2009, 2012). This genetic differentiation mirrors the gradient in mean surface salinity. This work is based on neutral markers, which are relatively insensitive. The genetic differentiation of sprat in Skagerrak and in the Swedish and Norwegian fjords on the coasts of Skagerrak, have not been thoroughly studied, even though Glover *et al.* (2011) indicates that sprat from the Oslo fjord differ from North Sea sprat. Further research on this issue is required.

A.2. Fishery

Sprat in IIIa are exploited by fleets from Denmark, Norway and Sweden. The Danish sprat fishery consists of trawlers using a < 16 mm mesh size and the landings are used for fishmeal and oil production. Some of the sprat landings from Denmark and Sweden are bycatches in the herring fishery using 16 mm mesh-size cod ends. The sprat fishery in Sweden can be dated back to the 1910s, and it was initially carried on exclusively in inshore waters. An important change took place in 1929 when the purse seine was used for the first time for taking sprat off the Swedish west coast (Southern Bohuslän). But when trawling began in earliest 1933, open sea fishing increased in importance especially with the introduction of the floating trawl.

Today sprat in IIIa for human consumption is caught with fine-mesh purse seines and ring nets mainly during autumn and winter in the Skagerrak. Fisheries take place throughout the year using ring nets, mid-water trawls and bottom trawls.

The Norwegian sprat fishery in Division IIIa is a traditional inshore purse seine fishery (vessels < 28 m) for human consumption. The Norwegian sprat fishery is seasonal, taking place from 1 August and onwards, and sprat is protected from 1 January to 31 July.

The majority of the landings are generally made by the Danish fleet. In 1997 a mixed-clupeoid fishery management regime was changed to a new agreement between the EU and Norway that resulted in a TAC for sprat as well as a bycatch ceiling for herring. Catches are taken in all quarters, though usually with lower catches in the second quarter. Denmark has a total ban on the sprat fishery in Division IIIa from May to September. Norway has a general ban on the coastal sprat fishery from 1 January to 31 July.

There was a considerable increase in landings from about 10,000 t in 1993 to a peak of 96,000 t in 1994. However, the data prior to 1996 are considered less reliable due to the implementation of the new improved Danish monitoring scheme in 1996. From 1996 the landings have varied between 9,000 t (2008) and 40,000t (2005).

A.3. Ecosystem aspects

In the North Sea, sprat is an important part of the diet of numerous species, including demersal fish, zooplankton seabirds and other predators (marine mammals and elasmobranchs). The major natural sources of sprat removals in the North Sea include whiting, mackerel, horse mackerel and seabirds.

It is considered that there are fewer predator populations in IIIa than in the North Sea. For an analytical assessment it is not possible to include annual estimates of sprat consumption by predators as done for the North Sea stock, but it is possible to estimate average predation consumption.

A major source of uncertainty with IIIa sprats is the extent to which these fish derive from migrations of fish from the North Sea stock into IIIa. This question should be a priority for future investigations.

B. Data

B.1. Commercial catch

Commercial catch data are submitted to ICES from the nations exploiting sprat in Division IIIa. The sampling intensity for biological samples, i.e., age and weight-at-age is mainly performed following the EU regulation 1639/2001 as Denmark and Sweden, landing most of the catches, follows this regulation. This provision requires 1 sample per 2000 tonnes landed.

The majority of commercial catch and sampling data are submitted in the Exchange sheet. Data are also uploaded to Intercatch, which is maintained by ICES. Intercatch is still in development and is not completely satisfactory in terms of flexibility and outputs. Thus HAWG still request the Excel sheet, e.g. for getting the catch distribution by square.

The stock co-ordinator allocates samples of catch numbers, mean length and mean weight-at-age to unsampled catches using appropriate samples by gear (fleet), area and quarter. If an exact match is not available then a neighbouring area with IIIa in the same quarter is used. If this also proves insufficient, data from the same half year is used.

B.2. Biological

Mean-weight-at-age for all ages is in the range seen the last years. Mean weights-at-age for 1996-2003 are presented in ICES (2005).

No estimation of natural mortality is made for this stock.

B.3 Surveys

Three surveys cover this stock. The International Bottom Trawl Surveys (IBTS) cover the stock in Div. IIIa in the first and third quarter of the year. Additionally, the herring acoustic survey (HERAS) covers the same area during June-July.

The appropriateness and suitability of these surveys for use in the assessment of the IIIa sprat stock, was examined by the WKSPRAT in 2013.

B.3.1 International Bottom Trawl Survey (IBTS)

The International Bottom Trawl Surveys started as an international coordinated survey in the mid-1960s directed towards juvenile herring. The gear used was standardised in 1977 to use the GOV trawl, but it took time to be phased in. By 1983 all participating nations were using this gear, and the index can be considered consistent from this point onwards. A third-quarter North Sea IBTS survey using the same methodology was started in 1991 and can be considered consistent from its initiation.

B.3.2 Herring Acoustic Survey (HERAS)

The Herring Acoustic Survey is a summer acoustic survey that has been performed as an ICES coordinated survey since the 1980s. Sprat has been reported as a separate target species in this survey from 1996 onwards. The coverage of this survey in Division IIIa has remained relatively unchanged (*e.g*. ICES PGIPS 2009).

Acoustic estimates of sprat have been available from the ICES co-ordinated Herring Acoustic surveys since 1996. In Division IIIa, sprat has mainly been observed in the Kattegat. Estimates of sprat abundance by age are only available from 2006 onwards.

B.4. Commercial CPUE

Not used for this stock.

B.5. Other relevant data

None

C. Assessment: data and method

No assessment of the sprat stock in Division IIIa has been presented since the mid-1980ies. Various methods have been explored without success (ICES CM 2007/ACFM:11).

D. Short-Term Projection

The stock is assessed by examining trends in IBTSQ3 age 1, IBTSQ1 age 1 and 2 and HERAS age 1. Other ages did not show internal and external consistency. Together, these two ages represent 77% of the landed biomass when used for in-year advice.

WKSPRAT proposed using the IBTS Q1 age 1 as an indicator of the incoming year class and IBTSQ1 age 2, IBTSQ3 age 1 the previous year and HERAS age 1 the previous year as indicators of age 2. These should provide in year advice for IIIa based on the ICES data limited stock approach (Category 3/4 DLS: ICES CM 2012/ACOM 68). Together, this provides an index of the sprat which will be age 1 and 2 in the beginning of July. These two age groups make up 77% of the catch biomass on average.

Method

WKSPRAT identified the useful survey indices for IIIa sprat as

- IBTS Q1 Age 1
- IBTS Q1 Age 2
- IBTS Q3 Age 1
- HERAS Age 1

As there were several indices of approximately equal quality, it was necessary to combine these into a single index. This was performed separately for the two cohorts (the cohorts with 1 and 2 winter rings in quarter 1). The cohort with one winter ring in the last available IBTS Q1 had only one survey index available whereas the cohort with 2 winter rings in the last available IBTS Q1 had three survey indices. To combine these three, all survey indices were expressed in relative deviation from the mean:

$$I = \frac{S_y - \sum_{i=1}^{N} S_i/N}{\sum_{i=1}^{N} S_i/N}$$

Where I is the index of a given age in a given survey, S is the survey catch per unit effort (or total number in the case of acoustic estimates), i are the different survey years and N is the number of years in which the survey is available. Indices of 2 winter ring sprat in quarter 1 were produced as:

$$\bar{I} = \frac{\sum_{j=1}^{M} I_j}{M}$$

Where subscript j denotes the survey (IBTS Q1 age 2 in the given year, IBTS Q3 age 1 in the previous year and HERAS age 1 in the previous year) and M is the number of surveys available (1 to 3 depending on year). A combined index for the two cohorts making up the majority of the catch was the produced as a weighted average of the cohort specific indices. Weights used were the average proportion of the weight of the catch which consisted of the particular age group over the past 3 years. With this method, the weights assigned to the two indices were 0.49 for the 1 winter ring index and 0.52 for the 2 winter ring index. The resulting anomaly index was multiplied by a precautionary buffer of 20% into a catch multiplier CM for the 2014 of:

$$CM_y = \frac{(1 + \bar{I}_y)}{(1 + (\bar{I}_{y-1} + \bar{I}_{y-2} + \bar{I}_{y-3} + \bar{I}_{y-4})/4)} * (1 - 0.2)$$

Where y indicates year.

If the index $\bar{I}$ exceeds 0.2 or falls below -0.2, it is replaced by an uncertainty cap of 0.2 and -0.2, respectively, so the minimum and maximum value of CM are 0.64 and 0.96. After 2014, the uncertainty cap has already been applied and the CM for 2015-2016 will be

$$CM = (1 + \bar{I})$$

The catch multiplier is used to estimate next year's TAC as

$$TAC_y = CM(C_{y-1} + C_{y-2} + C_{y-3})/3$$

Results

The anomalies in the survey indices are seen in Fig. 9.7.1 and the total index in Fig. 9.7.2. Further, the proportion of all commercial catches (in biomass) consisting of fish with more than 2 winter rings is given in Fig. 9.7.3. Applying the rule stated under methods, the catch multiplier is estimated at 0.64. As the average catch over the last three years is 10 605 t, the TAC using this method will be 6 787 t which is well below the historical minimum of 8 700 t.

An Excel-sheet for doing these calculations can be found under Team Web Site > HAWG 2013 > Report 2013 > Draft Report > Sec 09 Sprat in Division IIIa > Tables.

E. Medium-Term Projections

Not performed

F. Long-Term Projections

Not performed

G. Biological Reference Points

No precautionary reference points are defined for this stock.

H. Other Issues

None

I. References

Glover, K., Skaala, Ø., Limborg, M., Kvamme,.C., Torstensen, E. 2011. Microsatellite DNA reveals population genetic differentiation among sprat (*Sprattus sprattus*) sampled throughout the Northeast Atlantic, including Norwegian fjords. ICES Journal of Marine Science (2011), 68 (10), 2145-2151. Doi:10. 1093/icesjms/fsr153

ICES 2005. Herring Assessment Working Group for the Area South of 62ºN (HAWG). ICES CM 2005/ACFM:16.

ICES PGIPS 2009. Report of the Planning Group of International Pelagic Surveys (PGIPS). 20–23 January 2009, Aberdeen, Scotland, UK. ICES CM 2009/LRC:02. 217 p.

Limborg, M.T., Hanel, R., Debes, PV., Ring, AK., André, C., Tsigenopoulos, CS. and Bekkevold, D. 2012. Imprints from genetic drift and mutation imply relative divergence times across marine transition zones in a pan-European small pelagic fish (*Sprattus sprattus*). Heredity, (2012)109, 96-107.

Limborg, M.T., Pedersen, J.S., Hemmer-Hamsen,J., Tomkiewicz,J., Bekkevold, D. 2009. Genetic population structure of European sprat (*Sprattus sprattus*): differentiation across a steep environmental gradient in a small pelagic fish. Marine ecology progress series 379: 213–224.

Annex 11 – Stock Annex – Sprat in the Celtic Seas Region

Sprat in VI and VII, minus VIIde

Stock	Sprat in Subarea VI and Divisions VIIa–c and f–k (Celtic Sea and West of Scotland)
Working Group	HAWG
Date	February 2013
Revised by	WKPELA 2013 / Beatriz Roel

A. General

A.1. Stock definition

Most sprat fisheries in the Celtic Seas area are sporadic and occur in different places at different times. Separate fisheries have taken place in the Minch, and the Firth of Clyde (VIaN); in Donegal Bay (VIaS); Galway Bay and in the Shannon Estuary (VIIb); in various bays in VIIj; in VIIaS and in the Irish Sea (VIIaN):

The stock structure of sprat populations in this ecoregion is not clear. There is insufficient information to conclude that Subareas VI and VII constitute a management unit for sprat, and further work is required and further work is required to solve this. For the time being, ICES will give advice covering the whole area.

A.2. Fishery

Most sprat in the Celtic Seas ecoregions are caught by small pelagic vessels that also target herring, mainly Irish, English and Scottish vessels. In Ireland, many polyvalent vessels target sprat on an opportunistic basis. At other times these boats target demersals and tuna, as well as pelagics. Targeted fishing takes place when there are known sprat abundances. However the availability of herring quota is a confounding factor in the timing of a sprat targeted fishery around Ireland. In Ireland, larger sprats are sold for human consumption whilst smaller ones for fish meal. Other countries mainly land catches for industrial purposes.

Sprat may also be caught in mixed shoals with herring. The level of discarding is unknown.

No TACs or quotas for sprat exist in this ecoregion. Most sprat catches are taken in small-mesh fisheries for either human consumption or reduction to fishmeal and oil. It is not clear whether bycatches of herring in sprat fisheries in Irish and Scottish waters are subtracted from quota.

A.3. Ecosystem aspects

It is difficult to assess predation impacts on sprats in this area. This is particularly true of Area VIa where sprats tend to be aggregated in sealochs where predator populations are likely to differ from those in open sea areas of VIa.

Information on seabird diets is available for part of the area. The very limited data on seabird diets from Irish Sea colonies (for kittiwakes, auks and terns) suggests that sprats are more important in seabird diets in this area than is generally the case elsewhere.

Chivers *et al*. (2012) showed that kittiwakes breeding at colonies in the Irish Sea fed predominantly on sprats, at least in the two years of their study. Their data also suggested a link between diet composition and breeding success, with kittiwake breeding success in their Irish Sea study colonies being higher when sprats formed a higher proportion of the kittiwake diet. Royal Society for the Protection of Birds (RSPB) observers carried out surveys of kittiwake numbers during sprat acoustic surveys in the Irish Sea in 1995 and 1996 and found no evidence of a correlation between sprat densities and kittiwake densities at sea (P-J. Schön, pers. comm.).

B. Data

B.1. Commercial catch

Landings are considered representative of catches; there are no indications of discarding or misreporting. There is no information on catches in number /length, or weight in the catch for sprat in this ecoregion. No data on mean length, weight-at-age or maturity-at-age in the catch are available.

Division VIa (west of Scotland and northwest of Ireland)

Landings have been dominated by UK-Scotland and Ireland. The Scottish fisheries have taken place in both the Minch and in the Firth of Clyde. The Irish fishery has always been in Donegal Bay. Despite the wide separation of these areas, the trends in landings between the two countries are similar, though the UK data have always been higher. Irish data may be underestimated, due to difficulties in quantifying the landings from vessels of less than 10 m length.

Scottish landings were consistently above 4000 t in the 1970s, declining to about 1000 t in 1979. They fluctuated between 500 t and 4000 t until 1994 and then increased markedly to over 8000 t in 1999, after which they have declined substantially.

Division VIIa (Irish Sea)

The main historic fishery was by Irish boats, in the 1970s, in the western Irish Sea. This was an industrial fishery and landings were high throughout the 1970s, peaking at over 8000 t in 1978. The fishery came to an end in 1979, due to the closure of the fishmeal factory in the area. It is not known what proportion of the catch was made up of juvenile herring, though the fishing grounds were in the known herring nursery areas. In the late 1990s and early 2000s, UK vessels landed up to 500 t per year. In recent years a trial fishery for sprat was carried out by the vessels that fish herring in the area. This was carried out to investigate the feasibility of a clean commercially viable sprat fishery. The results of the trials were inconclusive and plans to conduct further experiments are under discussion. Irish Landings from 1950–1994 may be from VIIaN or VIIaS. Recent Irish landings are mainly from VIIaS, mainly Waterford Harbour.

Divisions VIIbc (west of Ireland)

Sporadic fisheries have taken place, mainly in Galway Bay and the Mouth of the Shannon. The highest recorded landing was in 1980 and 1981 during the winter of 1980/1981, when over 5000 t were landed by Irish boats. This fishery took place in Galway Bay in the winter of 1980/1981 (Department of Fisheries and Forestry (1982). Since the early 1990s landings fluctuated from very low levels to no more than 700 t per year. Irish data may be underestimated, due to difficulties in quantifying the landings from vessels of less than 10 m length.

Divisions VIIg-k (Celtic Sea)

Sprat landings in the Celtic Sea from 1985 onwards are ICES estimates. In the Celtic Sea, Ireland has dominated landings. Patterns of Irish landings in Divisions VIIg and VIIj are similar, though the VIIj landings have been higher. Landings for VIIg and VIIj were aggregated in this report. Landings have increased from low levels in the early 1990s, with catches fluctuating between 0 t in 1993 and just under 4200 t in 2005. Irish data may be underestimated, due to difficulties in quantifying the landings from vessels of less than 10 m length.

B.2. Biological

Sampling results of landings (in number length, mean length, weight-at-age or maturity, or weight in the landings) are not available for sprat in this ecoregion.

B.3. Surveys

There are many surveys taking place in this area. Only the ones that are considered relevant to describe trends in (part of the) sprat population in the area are described here.

	Survey acronym	Full name	Type of survey / gear	Comments	Years	Quarter
2	**SWIBTS**	South West International Bottom Trawl Survey	GOV	**Survey has been terminated;** Index should be split between VIIa and Celtic (North)	2003–2011	Q4
6	ACVIaLochs	Scottish Sea lochs surveys	acoustic/ mid-water trawl	Survey targeted for sprat in six lochs inside the Isle of Skye. No fisheries in this area, doesn't cover the stock.	2001–2005	Q1Q4
7	**SWCGFS6a**	Scottish Western Coast VIa Groundfish Survey - Quarter 1	GOV	**Age–length information** may be of value in absence of fishery data.	1981–2012	Q1
8	**SWCGFS6a**	Scottish Western Coast VIa Groundfish Survey - Quarter 4	GOV	**Age–length information** may be of value in absence of fishery data.	1990–2012	Q4
10	ACclydeQ3	Clyde acoustic survey for herring and sprat	acoustic/ midwater trawl	Survey-series discontinued but may be informative in combination with new survey (11).	1985–1989	Q3
11	ACclydeQ4	Clyde acoustic survey for herring and sprat	acoustic/ midwater trawl	Survey is **informative for sprat**, to be continued; no fisheries in the area	2012–	Q4
12	**AC(VIIaN)**	Irish Sea Acoustic Survey	acoustic /midwater trawl	Survey designed for herring but **surveys sprat all right;** no fisheries in the area	1998–2012	Q3

Survey 2) International Bottom Trawl Survey (2003–2011)

In order to derive an index of sprat abundance from this survey the total number of sprat per haul was first standardized to numbers per hour. An average for each rectangle was then calculated on a spatial basis as a basis for an annual index constructed as mean sprat catch per hour trawling. A final index can then be calculated as the mean of the mean number per hour from rectangles fished for at least 75% of the time-series.

Examination of results from the IBTS survey (Figures 6.6.3 and 6.6.4) suggest that the stock has fluctuated during the period of the survey with no indication of stock decline. Regrettably, the IBTS series has now been terminated.

Survey 6) Scottish Sea lochs surveys

Between 2001 and 2005 a series of detailed surveys were carried out in selected mainland Scottish sea lochs, to the east of the Isle of Skye. This survey targeted sprat, but does not cover the stock. There are no fisheries in this area.

This type of survey could inform the assessment in this region but the time-series is not relevant to the current state of the stock.

Survey 7-8) Scottish Western Coast VIa Groundfish Survey; Quarter 1 and Scottish Western Coast VIa Groundfish Survey; Quarter 4

Sprat caught throughout the survey area, even though the survey does not target sprat. Due to gear used and survey design unlikely to produce reliable abundance of sprat.

Age–length information is available and can be used to indicate stock structure. Survey estimates need verification before they are used as indicators of biomass because they are based on a bottom-trawl gear.

Survey 10-11) Clyde Acoustic surveys for herring and sprat

A Clyde herring and sprat acoustic survey was carried out in June/July 1985–1990 and then discontinued. Biomass estimates from all years as well as lengths and ages from some years are available from this survey. In 2012 this survey was reinstated as an October/November survey and results from the first survey are being processed at the moment.

Age and length distribution from this survey are available and can be used to indicate stock structure. The survey will need more datapoints to be able to give stock trend information.

Survey 12) Irish Sea Acoustic Survey

This survey uses a stratified design with systematic transects, during the first two weeks of September. Time-series of sprat biomass are available and the associated CVs are generally low which suggests a more continuous distribution than is the case for herring (M. Armstrong, pers comm.).

The vessel currently used for the surveys is the R.V. Corystes (UK(NI)) replacing the R.V. Lough Foyle (UK(NI)). Starting positions are randomized each year. The survey is most intense around the Isle of Man (2 to 4 nautical mile transect spacing) where highest densities of adult herring are expected based on previous surveys and fishery data. Transect spacing of 6 to 10 NM are used elsewhere. A sphere-calibrated EK-500 38kHz sounder is employed, and data are archived and analysed using Echoview (SonarData, Tasmania). Targets are identified by midwater trawling. Acoustic records are manually partitioned to species by scrutinising the echograms and using trawl compositions where appropriate. ICES recommended target strengths are used for herring, sprat, mackerel, horse mackerel and gadoids. The survey design and implementation follows, where possible, the guidelines for ICES herring acoustic surveys in the North Sea and west of Scotland. The survey data are analysed in 15 minute elementary distance sampling units (approximately 2.5 NM). An estimate of density by age class, and spawning–stock biomass, is obtained for each EDSU and a distance-weighted average calculated for each stratum. These are raised by stratum area to give population numbers and SSB by stratum.

Examination of the time-series of biomass based on this survey suggest that since 2005 the stock has fluctuated at a lower level than in previous years. There are no fisheries for sprat in this area.

B.4. Commercial cpue

Commercial landings per unit of effort were not calculated, because lpue is not considered an indicator relevant to describe the stock. This has to do with the sprat biology (schooling behaviour), the fact that the stock structure is not clear, and indications from the industry that factors unrelated to stock availability determine the landings.

C. Assessment: data and method

No analytic assessment is put forward for this area. The main indicators for sprat in parts of the area are survey indices that are considered representative for stock trends:

a) South West International Bottom Trawl Survey (SWIBTS);

b) Scottish Sea lochs surveys (ACVIaLochs);

c) Scottish Western Coast VIa Groundfish Survey - Q 1 and Q4 (SWCGFS6a; age–length information);

d) Clyde acoustic survey for herring and sprat (ACclydeQ3);

e) Clyde acoustic survey for herring and sprat (ACclydeQ4);

f) Irish Sea Acoustic Survey (AC(VIIaN)).

D. Short-term projection

No short-term projections are put forward.

E. Medium-term projections

No medium-term projections are put forward.

F. Long-term projections

No long-term projections are put forward.

G. Biological reference points

No precautionary reference points are defined for sprat populations in this region.

Molloy and Bhatnagar (1977) estimated $F_{0.1}$ separately for Irish Sea and Celtic Sea sprat populations. They concluded that the Celtic Sea population could withstand a higher F. The estimates of $F_{0.1}$ were F = 0.5 and F = 0.8 for Irish Sea and Celtic Sea respectively.

H. Other issues

H.1. Historical overview of previous assessment methods

Sprat in this area was first assessed by ICES in 2011. No analytic assessment has been put forward so far.

I. References

Chivers, L.S., Lundy, M.G., Colhoun, K., Newton, S.F. and Reid, N. 2012. Diet of black-legged kittiwakes (*Rissa tridactyla*) feeding chicks at two Irish colonies highlights the importance of clupeids. Bird Study 59: 363–367.

ICES. WKSPRAT. 2013. Benchmark Workshop on Sprat Stocks. 11–15 February 2013, ICES HQ, Copenhagen. ICES CM 2013/48.

Molloy, J. and Bhatnagar, K. 1977. "Preliminary Investigations of the Sprat stocks off the South coast of Ireland", Irish Fisheries Leaflet, Department of Agriculture and Fisheries (Fisheries Division) 1977.

Sprat in Divisions VIId,e

Stock	Sprat in Divisions VIId,e.
Working Group	HAWG
Date	February 2013
Revised by	WKPELA 2013 / Beatriz Roel

A. General

A.1. Stock definition

Divisions VIId and VIIe comprise a management unit for sprat, with an annual TAC being set by the EC. However it is not clear if sprat populations in this area constitute a unit stock; and if this is an appropriate management unit. Until more information is available, advice will be given for this unit, mainly based on information from the Lyme Bay (ICES statistical rectangles 29 and 30 E6,7).

Most of the catch is taken in Lyme Bay in Subdivision VIIe, where 88% on average of landed sprat are caught.

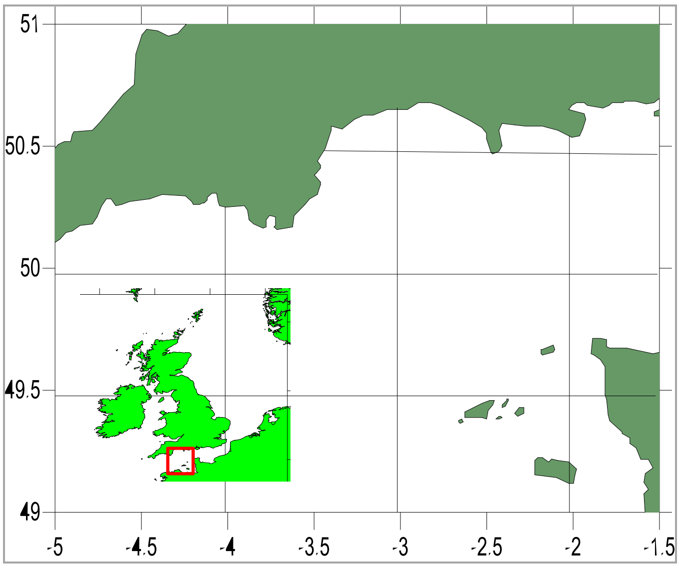


Figure 5.1.2. Sprat in VIId,e, Lyme Bay. ICES statistical rectangles that constitute Lyme Bay are indicated.

A.2. Fishery

In Lyme Bay the primary gear used for sprat is midwater trawl. Within that gear type three vessels under 15 m actively target sprat and are responsible for the majority of landings (since 2003 they took on average 94% of the total landings). Sprat is also caught by driftnet, fixed nets, lines and pots. Most of the landings are sold for human consumption. The fishery starts in August and runs into the following year into February and sometimes March.

Sprat may also be caught in herring fisheries mixed shoals with herring. The level of discarding is unknown.

A.3. Ecosystem aspects

Fishermen find sprat by sonar search and sometimes the shoals have been too far offshore for sensible economic exploitation. Skippers then go back to other trawling activity. This offshore/ near shore shift may be related to environmental changes i. e. temperature and/or salinity.

B. Data

B.1. Commercial catch

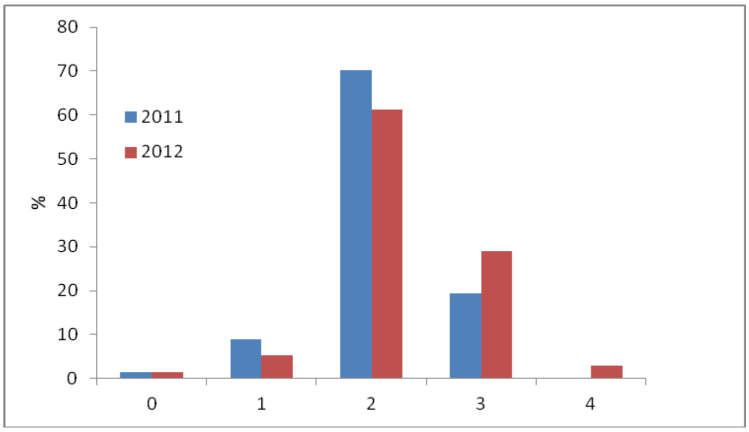
Sprat landings prior to 1985 in VIId,e were extracted from FishBase, from 1985 onwards they are ICES estimates. Since 1985 sprat catch has been taken mainly by UK, England and Wales, with some substantial catches taken by Denmark in the late 1980s. Early landings from Denmark are being looked into as there may be some discrepancies between FishBase and ICES data.

UK landings data are available by gear type from 1981 to date. For trawlers, associated effort was recorded both as number of days and hours fishing. In the case of driftnets effort corresponds to number of hauls times the total number of nets and for gillnet the length of the gear (m) times the number of days fishing. Technological improvements in the fishery such as high technology sonars (such as CH 32), were put in place in the early 1980s.

There is a TAC for sprat for VIId,e, English Channel.

B.2. Biological

Catch sampling information was not available for ICES.. Biological information was collected in the acoustic surveys. Age composition data suggested a majority of age 2 in the survey area. Ages 0, 1, 3 and 4 were also represented. Percentages at age by survey are compared in the plot below.



B.3. Surveys

Acoustic surveys covering the area where the fishery operates were conducted in 2011 and 2012. The surveys are carried out in October, coinciding with the early months of the sprat fishing season, which runs from September to February. The survey included a series of pre-designed parallel, equidistant (10 nautical mile, nmi) transects perpendicular to the coast, covering the ICES rectangles where most of the annual sprat catches in the past decade (Roel *et al.*, 2011) have been made, with particular focus on the western part of Lyme Bay. The pre-designed transects covered a larger area than was feasible, but based on previous experience, it was anticipated that the main sprat concentrations were likely to be found in a relatively small part of the whole area. Given that the location and extent of the sprat distribution was not known in advance of the survey, an adaptive design was adopted, with transects being dropped as the biomass dropped progressively from earlier transects.

A local sprat fishing vessel was chartered for the survey: the 11.98 m FV *Mary Anne*. Although its size restricted its range and speed to some extent, it was imperative to the programme that the survey be conducted using a local fishing vessel experienced in fishing for the target species, i.e. sprat. Also, the aim of the project was to quantify the sprat population targeted by the inshore fishery, and we were confident that the vessel could cover the area of interest adequately.

Acoustic surveying took place during daylight, because sprat disperse into loose aggregations at night (Plirú *et al.*, 2011), so would be more difficult to detect acoustically then. Where possible, the transects were completed from east to west because anecdotal information suggested that sprat move in from the west. Surveying the transects in the opposite direction, therefore, would have increased the likelihood of double counting.

Fisheries acoustic data

Scientific quality acoustic data were collected using a portable EK60 Simrad echosounder operating at 120 kHz, connected to a Furuno GPS. Ping rate was set to 0.4 s^{-1} and pulse duration to 0.256 μs, to collect high-resolution data. The transducer was attached to an over-the-side mount on the port side of the vessel. The mount consisted of a vertically orientated aluminium pole that, when deployed, protruded 2 m below the surface, so that the transducer remained clear of the bubbles formed by the hull during steaming. A 5 inch fin was attached to the aft side of the pole to prevent vortices developing as a result of the drag through the water; they would cause the pole to vibrate during steaming (see van der Kooij *et al.*, 2011, for more detail).

Prior to the survey, the echosounder was successfully calibrated outside Torquay harbour using a 23 mm copper sphere following standard methods (Foote *et al.*, 1987). Depending on weather, the vessel speed during the acoustic transects was a constant 7 knots. Faster than that and in adverse weather, noise would have reduced the quality of the acoustic data.

Acoustic data were recorded continuously. A scanning sonar, traditionally used by the fishery to search for sprat schools, was switched off while running the acoustic transects because it interfered with the acoustic data. When marks were encountered on-transect and a decision made to fish, the vessel would come off-transect and use the sonar to track the schools that had been seen on the echosounder. After completion of the haul, the sonar was switched off again, and the transect resumed where it had been interrupted.

The acoustic data were cleaned and processed after the survey using the processing software Echoview version 5.3 (Myriax). Acoustic data collected during fishing operations and the steam to and from the transect were discarded, retaining only on-transect data. Surface aeration caused by bad weather was removed, setting a surface exclusion line, and acoustic data from closer to the seabed than 0.5 m were also removed, to exclude the strong signals from the seabed. Owing to the presence of occasional noise, interference and weaker scatterings caused by other organisms, several algorithms were applied so that only sprat schools were extracted from the raw data. This included a filter to remove all non-clupeid backscatter and a backscatter threshold (of -60 dB; Figure 2). Sprat schools were identified based on a combination of expert knowledge and trawl catches.

As small numbers of other species were caught in the trawl, acoustic energy was partitioned by species, based on the weight ratios obtained from the trawl catches. Mackerel, however, were not considered because they only give a weak signal at 120 kHz and were automatically filtered out using the algorithm mentioned above.

Trawling

Trawling is conducted using the vessel's standard commercial midwater gear designed to catch sprat. As sprat biomass was calculated from the acoustic data, trawl catches were used only to establish the species composition of the acoustic marks, and to collect biological material on the pelagic fish community, in particular length frequency, and age and maturity information. This meant that only relatively small catches were required, so the skipper ensured this by carefully monitoring the trawl procedure using a combination of the sonar and the netsonde.

Once on board, the catch was sorted by species. Fish were counted and measured to the nearest 0.5 cm or 1.0 cm, depending on species. When catches of a species were very large, a subsample of that species was taken. At every station, however, five sprat from each length category were collected and retained on ice, then once ashore, were frozen and taken on board the RV Cefas Endeavour for further analysis: length, weight, sex and maturity were recorded, and otoliths were extracted for age determination.

Biomass calculation

The acoustic density attributed to sprat (s_A or Nautical Area Scattering Coefficient) was converted into numbers according to standard procedures. First, the TS was calculated for each sprat length group:

$$TS = 20\mathrm{Log}L + b_{20}, \tag{1}$$

where b_{20} was -74.2 dB at 120 kHz (Saunders *et al.*, 2012), and L was the fish length group. This was converted into the backscattering cross section for each length group:

$$\sigma = 4\pi 10^{(TS/10)}, \tag{2}$$

This in turn provided the weighted average backscattering cross section per individual fish. Dividing the s_A or the NASC (mean acoustic energy attributed to sprat) per nmi by this number yielded the mean number of sprat per nmi, which was converted into biomass by multiplying by the mean weight of sprat. Because fish weight could not be determined accurately on board the commercial fishing vessel, the mean weight was derived as follows: a length–weight relationship was calculated based on trawl samples in the area obtained from the international bottom trawl survey which takes place in November. The calculated weight of a sprat at a mean length of 13.27 cm was 16.57 g. The biomass was calculated separately for each of the four ICES rectangles covered in the survey.

B.4. Commercial lpue

A midwater trawl landings per unit of effort (lpue) series were constructed based on the three vessels that take most of the catch around Lyme Bay. Lpue is calculated based on the landings per hour away from port. Annual lpue is presented per hour and by fishing season, which runs from August to February–March depending on the year but referred to by the year when the season started.

Communication with fishermen that target sprat in the Channel has indicated that the fish may not be found on occasions so, if lpue was to be used as an indicator of stock abundance it may be preferable to include all effort spent which would include searching time. If there were no landings in August or March the effort in those months was excluded when computing lpue.

C. Assessment: data and method

For Lyme Bay sprat there is information that can be put forward to inform advice. For the rest of Divisions VIId,e there is insufficient information to assess the state of the stock. The proportion of landings between Lyme Bay and the rest of the area should be monitored to ensure that the assessment covers the main part of the fisheries.

Lyme Bay

Relevant information to inform the advice for the Lyme Bay area are:

- trends in the lpue since 1988;
- trends in the acoustic survey index since 2011.

Exploratory (Schaefer, Bayesian) assessments will be further developed before they can be benchmarked.

D. Short-term projection

No short-term projections are put forward.

E. Medium-term projections

No medium-term projections are put forward.

F. Long-term projections

No long-term projections are put forward.

G. Biological reference points

No precautionary reference points are defined for sprat populations in this region.

H. Other issues

The advice for sprat in Lyme Bay can be better informed if in time the acoustic survey is long enough to be able to tune this with other tuning data such as the lpue and landing statistics such as number or weight in the landings, mean weight-at-age or maturity-at-age. When this is will be the case depends on the length of the time-series (at least five years) and the consistency with other information.

H.1. Historical overview of previous assessment methods

ICES has started to give quantitative advice for this datalimited stock in 2012.

I. References

Foote KG, Knudsen HP, Vestnes G, MacLennan DN, Simmonds E.J. 1987. Calibration of acoustic instruments for fish density estimation: a practical guide. Report No. 144. ICES, Copenhagen.

Plirú A, van der Kooij J, Engelhard GH, Fox CJ, Milligan SP, Hunter E. 2011. Is recruitment of plaice in the Irish Sea constrained by predation of eggs by sprat? Report No. ICES CM 2011/H: 33.

Roel, B. A., Readdy, L., and van der Kooij, J. 2011. Review of UK data for sprat in the English Channel (VIId, e). Working Document presented to the Herring Assessment Working Group 2011, Copenhagen.

Van der Kooij, J., Brown, D., and Roel, B. A. 2011. Western Channel sprat (*Sprattus sprattus* L.) population assessment. FSP Programme Report, 32. 16 pp. Available at: http://www.cefas.defra.gov.uk/media/585780/mf050_report2011_vfinal2.pdf.

Annex 12 Benchmark WKSAN Report 2010

ICES Advisory Committee

ICES CM 2010/ACOM:57

Report of the Benchmark Workshop on Sandeel (WKSAN)

6–10 September 2010

Copenhagen, Denmark

International Council for the Exploration of the Sea
Conseil International pour l'Exploration de la Mer

H. C. Andersens Boulevard 44–46
DK-1553 Copenhagen V
Denmark
Telephone (+45) 33 38 67 00
Telefax (+45) 33 93 42 15
www.ices.dk
info@ices.dk

Recommended format for purposes of citation:

ICES. 2013. Report of the Benchmark Workshop on Sandeel (WKSAN), 6–10 September 2010, Copenhagen, Denmark. ICES CM 2010/ACOM:57. 185 pp.

Contents

Executive summary

A Benchmark Workshop on Sandeel in Subarea IV excluding the Shetland (WKSAN) met at ICES Headquarters in Copenhagen, Denmark on September 6–10, 2010. Dr. Jim Berkson (US) served as the Workshop's Chair, Dr. Ewen Bell (UK) served as the ICES Coordinator, and Dr. Robert Furness (UK) served as an external expert.

WKSAN has adopted the recomendataions of previous ICES Workshops on Sandeel in terms of moving from a single area assessment to assessing separate stock components based on stock structure identified using published information on larval distribution, connectivity, and growth differences. There are now seven separate stock components identified, although analytical assessments are only possible in four areas. In addition to this fundamental change in the treatment of North Sea sandeels, the assessment model structure has evolved to now utilize a statistical catch-at-age model as opposed to a deterministic VPA approach as used in the past. The inclusion of the dredge survey has eliminated historic retrospective patterns in Areas 1–3, a problematic artifact of previous assessments. New analyses demonstrate that the dredge survey in Area 1 allows for greater confidence in short-term forecasts. All of these developments represent significant improvements in assessment and forecast methodology.

Four alternative sandeel management scenarios were presented to WKSAN: the current ICES management plan, the plan being implemented by the Norwegian government in the Norwegian EEZ, a proposal by the Danish Fisherman's Association, and a proposal by the Norwegian Fishermen's Association. All four management plans could be implemented in Areas 1, 2, and 3 using existing data sources with agreed-upon assessment and forecasting methods. Both the Norwegian government's and the Norwegian Fisherman's Association's proposed management scenarios could be implemented in Area 5. Data is insufficient to evaluate whether the management scenarios could be implemented in Areas 4 and 6.

Intensive in-season catch sampling and data processing has been required to provide TAC advice in the past in areas 1–3. The WKSAN determined that pre-season dredge survey information is sufficient to provide TAC advice in Areas 1 and 2 in most years, without requiring the more intensive in-season catch sampling and data processing. Increasing the time-series length and coverage in Areas 3, 5 and 6 may lead to a similar reduction or elimination of the need for more intensive in-year data collection and processing. However, the dredge survey in area 4 cannot be used to produce a stock assessment without additional within season sampling, preferably from fisheries catches.

Improving the assessment will require its further spatial stratification, including providing natural mortality rate estimates by area. Current natural mortality rate estimates were derived from predator stomachs collected 20 years ago region-wide. A new stomach collection study is required to provide updated, area-specific mortality estimates. Additional research priorities include studies of the relationship between sandeel biomass and predator condition, growth or recruitment success to provide better knowledge for setting reference points which takes account of effects on predator populations. A more detailed list of research needs is provided within the document.

Industry representatives from both Denmark and Norway attended the entire WKSAN. Although they were invited to attend as observers, their expertise and

opinions were sought throughout. As a result, they provided useful information throughout the workshop. In particular, they provided critical information on the timing and causes of changes in catchability, which were then incorporated into the assessment model. Industry representatives also provided details on marine spatial planning issues having the potential to impact the sandeel fishery in the future (e.g. windfarms, Natura2000). Their participation was not only welcome, but also necessary.

1 Terms of Reference

2009/2/ACOM57 A **Benchmark Workshop on Sandeel** (External Chair: (to be confirmed) and ICES coordinator: Ewen Bell (UK) and one invited external expert) will be established and will meet in ICES HQ, Copenhagen, Denmark, 6–10 September 2010 to:

a) Evaluate the appropriateness of data and methods to determine stock status and investigate methods for short term outlook taking agreed or proposed management plans into account for the stocks listed in the text table below. The evaluation shall include consideration of fishery-dependent, fishery independent, and life history data currently being collected for use in the current assessment work and the proposed assessment;

b) Agree and document preferred method for evaluating stock status and (where applicable) short-term outlook and update the assessment handbooks as appropriate;

c) Develop recommendations for future improving assessment methodology and data collection;

d) d) As part of the evaluation:

i) conduct a one day data compilation workshop. Stakeholders shall be invited to contribute data (including data from non-traditional sources) and to contribute to data preparation and evaluation of data quality. As part of the data compilation workshop consider the quality of data including discard and estimates of misreporting of landings;

ii) consider the possible inclusion of environmental drivers for stock dynamics in the assessments and outlook;

iii) evaluate the role of stock identity and migration;

iv) evaluate the role of multispecies interactions on the assessments.

Stock	Assessment Lead
Sandeel in Subarea IV excluding the Shetland	Steen Christensen, Denmark

The Benchmark Workshop will report for the attention of ACOM by 16 September 2010.

2 Stock Identity

Past ICES sandeel expert groups have reported that the single North Sea stock assumption is invalid (ICES AGSAN 2007-9). This is important because past management regimes have failed to avoid local depletion in some areas and to account for regional differences in productivity and catch rates. The sub-stock area based approaches presented in this report (Figure 2.1) follow recommendations for area divisions in ICES AGSAN (2009). The area divisions agreed are based on estimates of larval exchange between fishing grounds. This section summarises why this approach is appropriate for the benchmark. Sandeel inhabit shallow, turbulent sandy areas, where the content of silt and clay is low (Macer, 1966; Reay, 1970; Wright *et al.*, 2000; Holland *et al.*, 2005). Because of the limited availability of such substrate (Wright *et al.*, 1998), the distribution of post-settled sandeels is highly patchy (Macer, 1966; Wright *et al.*, 2000; Freeman *et al.*, 2004; Holland *et al.*, 2005). Following settlement sandeels are rarely found further than 15 km away from known habitat (Wright, 1996; Engelhard *et al.*, 2008) and the maximum distance travelled by tagged individuals displaced from grounds was only 64 km over 1–3 years (Gauld, 1990). As sandeel eggs are demersal and the larvae are only pelagic for 50–90 days at a time prior to the appearance of strong density driven currents there is generally little exchange across the entire North Sea (Wright and Bailey, 1996; Proctor *et al.*, 1998; Jensen, 2001; Munk *et al.*, 2002; Christensen *et al.*, 2008). Nevertheless, model simulations of larval transport suggest that aggregations of banks at scales from 50–300 kms apart can be connected by the annual dispersal and advection of larvae (Proctor *et al.*, 1998; Christensen *et al.*, 2008). Hence attempts to sub-divide the North Sea into sub-population areas have focussed on the exchange of larvae between grounds.

The first proposal for area divisions was presented in 1998 based on larval hatching areas as starting locations, estimates of passive transport derived from a 35 km grid resolution 2 D sea circulation model and observations of pre-settled 0-group distribution (Proctor *et al.*, 1998; Wright *et al.*, 1998; see also Pedersen *et al.*, 1999). The basis for area divisions proposed by AGSAN2 (2009) used fishing grounds as starting locations and a bio-physical model of sandeel larval drift derived from a 5 km grid 3 D sea circulation model (Christensen *et al.*, 2007, 2008 and 2009). There was generally high agreement in the stock divisions proposed in both studies. Both attempts at defining areas first distinguished the northwest (area 4) as being hydrographically isolated from other grounds in the North Sea. Other divisions based on these models were similar with the exception of the new area 2 near the Danish coast. To avoid the division of some fishing grounds suggested by the latest drift model, AGSAN2 (2009) proposed some minor modifications to area boundaries.

Regional differences in productivity between the area divisions have been indicated from differences in size, maturity and fecundity-at-age, particularly with respect to area 4 and other areas (Jensen *et al.*, 2001; Boulcott *et al.*, 2007; Boulcott and Wright, in press). Even within the proposed divisions, differences in recruitment and local mortality patterns coupled with the limited movement of settled fish, can give rise to significant differences in length composition at scales > 28 kms (Jensen *et al.*, in press).

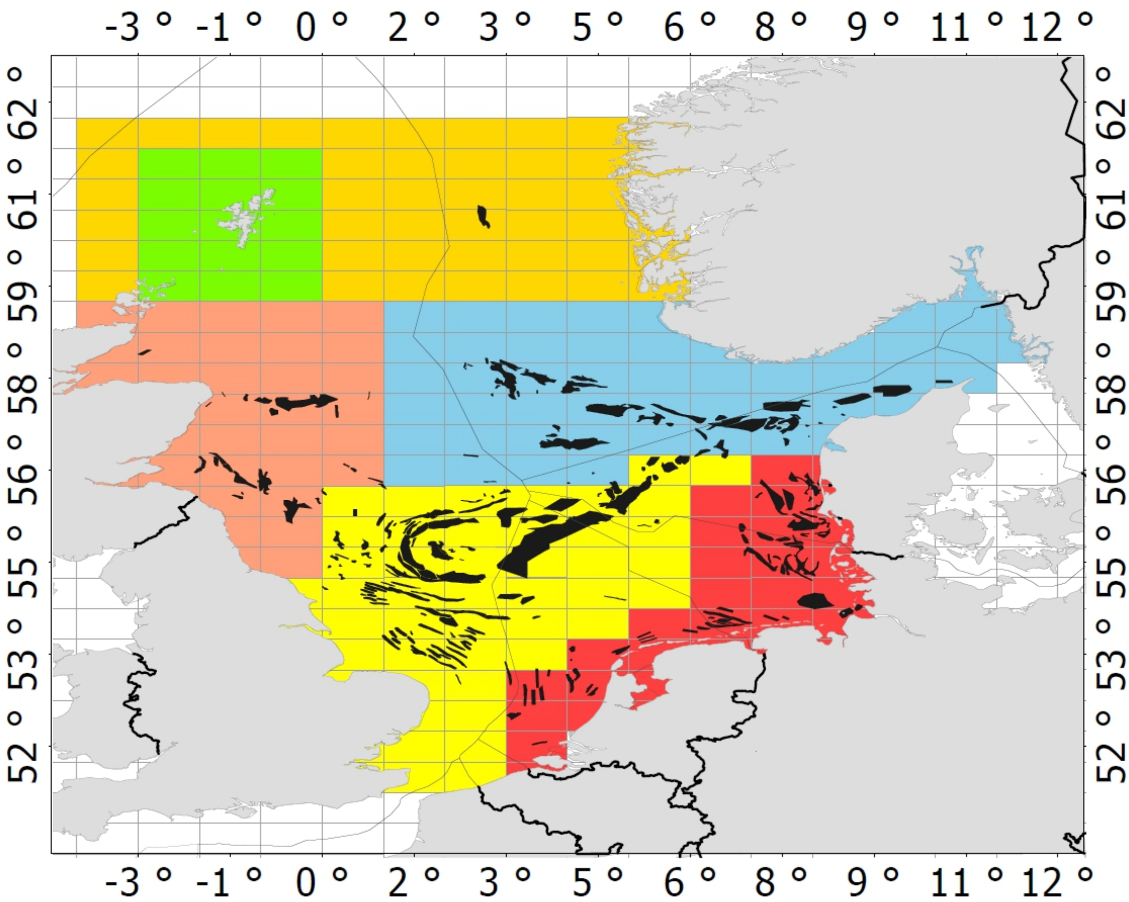


Figure 2.1. Sandeel assessment regions as defined by AGSAN (2009). Yellow denotes area 1, red area 2, blue area 3, pink area 4, orange area 5 and green area 6.

3 Ecosystem aspects

Sandeels are small, short-lived, lipid-rich, shoaling fish. As such, they represent high quality food for many predatory fish, seabirds and marine mammals (Greenstreet *et al*., 1997; 1998; Brown *et al*., 2001; Stafford *et al*., 2006; Macleod *et al*., 2007; Daunt *et al*., 2008). They are especially important in the diet of top predators during the summer, as sandeels then spend much time feeding during the day on zooplankton but burying in the sand at night (Freeman *et al*., 2004; Engelhard *et al*., 2008; Greenstreet *et al*., 2010). At other times of year they mainly remain buried in the sand, where they are inaccessible to many predators such as surface-feeding seabirds, though they continue to be eaten by some predatory fish, seals, and diving seabirds which apparently can dig them out of the sand (Hammond *et al*., 1994). Although the larvae drift with currents, and following metamorphosis may select on a local scale where to settle on the basis of sediment composition, they do not show extensive horizontal movements after that life history stage (Gauld, 1990; Wright, 1996; Pedersen *et al*., 1999; Christensen *et al*., 2008, Jensen *et al*., in press).

3.1 Top-down effects on sandeels

Demonstrating top-down effects of predators on sandeel stocks is difficult as it is not amenable to experimentation, but relies on detection of correlations; due to different spatial distributions of key predators it is also quite likely that the relative strength of top-down versus bottom-up control of sandeel abundance may vary between different parts of the North Sea (Frederiksen *et al*., 2007). However, we can assess the likelihood of such top-down effects from information on the amounts of sandeel consumed by different predators; it is unlikely that predators taking only small amounts of sandeel would exert significant top-down effects. Predation rates of seabirds and marine mammals on sandeels are trivial by comparison with predation rates by large fish, as shown by the MSVPA analysis. There is no evidence for depletion of sandeels by seabirds or marine mammals, even locally at major breeding colonies. However, some predatory fish consume very large amounts of sandeels. There is evidence that sandeel stocks increased in abundance in the North Sea following major reductions in the stocks of cod, haddock, whiting, herring, and mackerel, apparently a top-down effect resulting from reduced predation by these fish (Sherman *et al*., 1981).

3.2 Bottom-up effects on sandeels

There is strong evidence that sandeel stocks are affected by bottom-up processes involving climate and changing plankton stocks. A study of early larval survival suggested that the match between hatching and the onset of zooplankton production may be an important contributory factor to year-class variability in this species (Wright and Bailey, 1996). Frederiksen *et al*. (2005) used Continuous Plankton Recorder (CPR) data to develop an index of sandeel larval abundance for the Firth of Forth area. The sandeel larval index was strongly positively related to the abundance of phyto- and zooplankton, suggesting strong bottom-up control of sandeel larval survival (Frederiksen *et al*., 2005). Van Deurs *et al*. (2009) showed for the "North Sea sandeel" in ICES area IV 1983–2006 (with anomalous data from 1996 excluded) that a positive spawning stock–recruitment relationship is decoupled in years associated with high abundances of age-1 sandeels, and that survival success of early larvae depends on the abundance of *Calanus finmarchicus* but not *C. helgolandicus* or total Calanus density (again measured by CPR). They postulated that 0-group sandeels compete with older sandeels for copepods and so recruitment is reduced by the presence of high abundance of older (normally predominantly 1-group) sandeels. This conclusion contradicts an earlier finding by Arnott and Ruxton (2002) who studied the same sandeel area but for 1983–1999 only, and found a significant positive relationship between sandeel recruitment and total Calanus density over that time period. It is suggested by Van Deurs *et al.* (2009) that this changed pattern of correlation reflects coincidence of the switch in Calanus species at the same time as a run of poor recruitment years of sandeels after 1999. Van der Kooij *et al*. (2008) showed that sandeel distribution and abundance on the Dogger Bank was best explained by seabed substrate, temperature and salinity. However, contrary to the authors' expectation, their data showed that sandeel local abundance was not strongly related to zooplankton local density.

3.3 Top-down effects of sandeels on zooplankton

There appears to be no information on sandeels depleting zooplankton densities over their grounds.

3.4 Bottom-up effects of sandeels on higher predators: seabirds

Seabirds are long-lived animals with a low reproductive output. Life-history theory predicts that seabirds should buffer their adult survival rates against fluctuations in their food supply (Boyd *et al*., 2006), and since food-fish are short-lived animals with high but also variable recruitment rates (Jennings *et al*., 2001), it is inevitable that seabirds will experience large changes in the abundance of the food fish on which they depend. They must, therefore, have evolved the ability to cope with variation in food abundance. The literature indicates that, seabird breeding success does show a close correlation with food fish abundance (Furness and Tasker, 2000; Rindorf *et al*., 2000; Davis *et al*., 2005; Frederiksen *et al*., 2005), whereas breeding numbers and adult survival may not track these short-term fluctuations (Boyd *et al*., 2006). Nevertheless, several recent studies do show a trade-off between adult survival rate (Frederiksen *et al*., 2008b) and reproductive performance, as a result of adults increasing investment when food supply declines and so incurring costs (e.g. Davis *et al*., 2005). But variation in breeding success is much greater, and easier to measure, and so is likely to provide a much clearer signal of food shortage (Furness, 2002; Mitchell *et al*., 2004; Mavor *et al*., 2006).

Most species of seabirds in the North Sea suffered delayed breeding and widespread reproductive failures in 2003, 2004, 2005 and 2006 (Frederiksen *et al*., 2004; Mavor *et al*., 2005, 2006, 2007; Reed *et al*., 2006). The most severe problems, including total failures of some species, occurred in Shetland and Orkney in the northernmost part of the North Sea. Although bad weather during the chick-rearing period was partly to blame at some colonies, the main proximate cause of the breeding failures was a lack of high-quality food (Davis *et al*., 2005; Wanless *et al*., 2005). Most seabirds in the North Sea feed mainly on sandeels during the breeding season (Wanless *et al*., 1998; Furness and Tasker, 2000; Furness, 2002). Since the 1970s, sandeels have been the dominant mid-trophic pelagic fish in the North Sea, and around Shetland no other high-lipid prey fish occur in sufficient numbers to support successful breeding of most piscivorous seabirds (Furness and Tasker, 2000). There is thus little doubt that the observed seabird breeding failures were linked to low availability of sandeel prey (Frederiksen *et al*., 2004).

Furness and Tasker (2000) reviewed the ecological characteristics of seabirds in the North Sea and ranked species from highly sensitive (e.g. terns, kittiwake, Arctic skua) to insensitive (e.g. northern gannet) to reductions in sandeel abundance. They argued that the most sensitive seabirds would be those with high foraging costs, little ability to dive below the sea surface, little 'spare' time in their daily activity budget, short foraging range from the breeding site, and little ability to switch diet. This prediction was supported by empirical data from studies at Shetland (Furness and Tasker, 2000; Poloczanska *et al.*, 2004) and at the Isle of May, east Scotland (Frederiksen *et al.*, 2004). As one example, Figure 3.1 shows breeding success of kittiwakes on the Isle of May during years of sandeel fishing in the area and in years without sandeel fishing. Breeding success of kittiwakes in both periods varied with sea surface temperature, but was considerably lower when there was a sandeel fishery in the area where these birds were foraging. In Shetland, breeding success of kittiwakes and Arctic skuas (Figure 3.2) shows very low success during periods of low Shetland sandeel stock biomass (late 1980s and 2000 onwards). Arctic skuas in Shetland feed almost exclusively on sandeels, although they obtain these by stealing them from terns, kittiwakes and auks, and so the link between their breeding success and sandeel stock size is indirect (Davis *et al.*, 2005). We can estimate the amount of sandeels consumed by Arctic skuas from data on the numbers and energy requirements of these birds. The annual consumption of sandeels by Arctic skuas at Shetland in the period 1980–2000 is estimated to have been around 65 tonnes per year. This contrasts strongly with the observation that Arctic skua breeding success at Shetland fell to less than half of the level seen in years of high sandeel abundance when the sandeel stock biomass was below about 30 000 tonnes. The data indicate that Arctic skuas require a sandeel stock biomass about 460 times greater than the amount that they consume, in order to be able to gain energy at a rate sufficient to sustain a good level of breeding success. This seems to be the extreme case, with much lower ratios for kittiwake and even lower for guillemots. Throughout this period, breeding success of gannets remained consistently high in Shetland as those birds were able to switch to feed on adult herring and mackerel, fish too large to be caught (or swallowed) by kittiwakes or Arctic skuas.

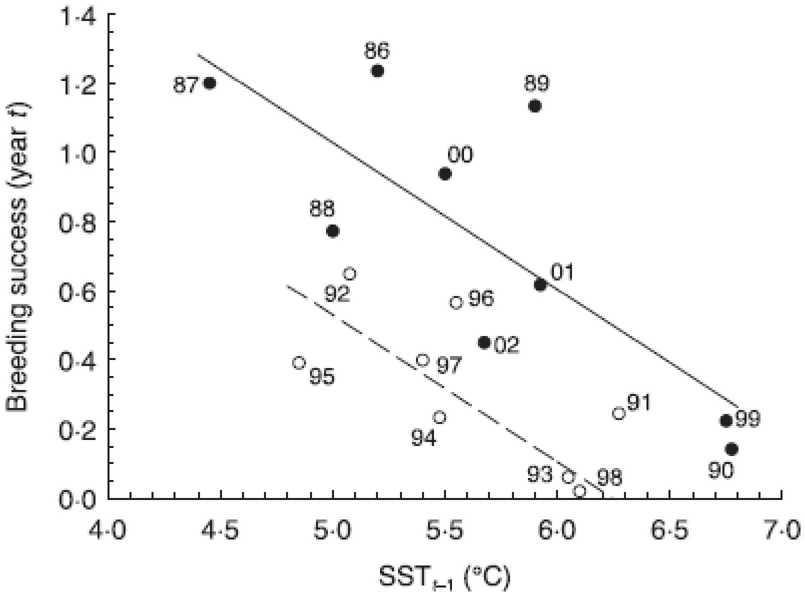


Figure 3.1. Kittiwake breeding success as a function of local SST in February–March of the previous year and presence/absence of the Wee Bankie sandeel fishery. Data labels indicate current year. Regression lines estimated from weighted multiple regression. Filled circles and solid line, non-fishery years; open symbols and dashed line, fishery years. From Frederiksen *et al.*, 2004.

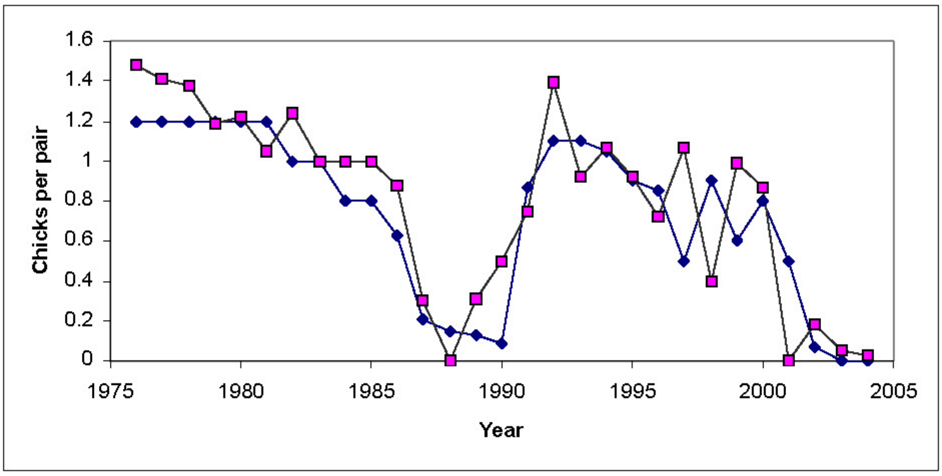


Figure 3.2. Breeding success of black-legged kittiwakes (pink) and Arctic skuas (blue) at Foula, Shetland, during 1976–2004, showing a close correlation between the success of the two species in this time-series, and periods of particularly low success in 1987–1990 and in 2001–2004.

In 2004, breeding success was exceptionally low for most seabird species on the Isle of May, despite sandeel larvae being abundant in the spring of 2003, so this low breeding success was unexpected. Detailed studies showed that the energy content of both sandeels and sprat fed to seabird chicks in 2004 was extremely low, indicating poor food availability for the fish (Wanless *et al.*, 2005). Data from chick-feeding puffins and CPR samples also indicate that the size-at-date of both larval, 0 group and older sandeels has declined substantially since 1973, although it is unclear what the cause of this decline might be (Wanless *et al.*, 2004). There is thus evidence that both abundance and quality of seabird prey is under bottom-up control in this region, and this is likely to have affected seabird breeding success.

3.5 Bottom-up effects of sandeels on higher predators: fish

Sandeel is an important prey species for a range of natural predators (Hislop *et al.*, 1991; WGSAM 2008). Of these, the species most likely to be affected are the species for which the sandeel make up a large proportion of the diet. In the North Sea, this would include whiting, haddock, mackerel, starry ray and grey gurnard (Figure 3.3). These species all have a diet composition consisting of at least 10% sandeel. However, the proportion only exceeds 20% in the diets of western mackerel and starry ray. Of these two, the diet of western mackerel refers only to the time they spend in the North Sea, and hence the overall average percentage is likely to be lower.

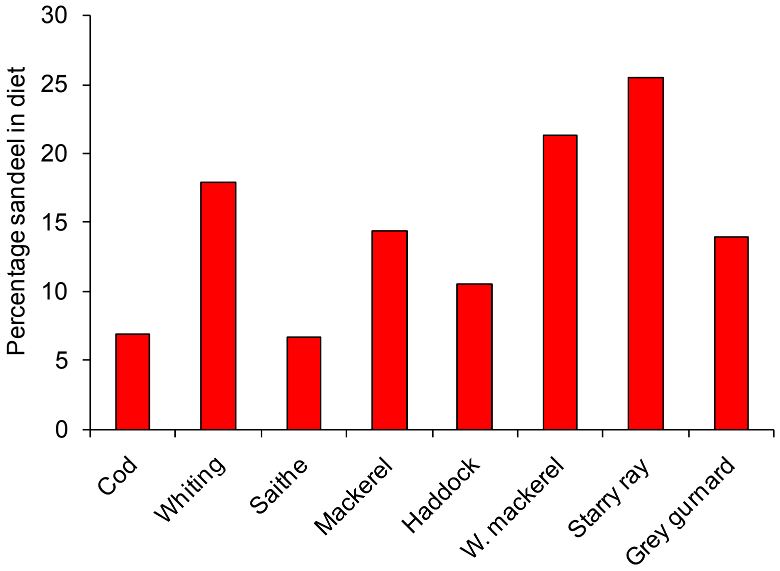


Figure 3.3. Proportion of the diet consisting of sandeel for different predatory fish (ICES 1997)

Whiting might also be affected by a decline in sandeel availability. However they might also switch prey to consume greater quantities of herring and sprat, since populations of these species have increased in recent years, as has the apparent spatial overlap between whiting and sprat distributions. Two sources of recent data are available to test this hypothesis, from research carried out in the Firth of Forth region as part of the EU FP6 IMPRESS project (1997–2003), and from research carried out on western Dogger Bank ('MF0323' project; 2004–2006).

Three gadoid populations (cod haddock, whiting) were sampled at 19 evenly spaced stations in the Firth of Forth (including Wee Bankie and Marr Bank) on seven research cruises. The contribution of sandeels to the diet of the three gadoid predators varied markedly from year to year, although the importance of sandeels in particular years was consistent across all three species. No evidence of any beneficial effect of the local sandeel fishery closure in 2000 on the abundance or biomass of any of the three gadoid predators was apparent, however, there was evidence that fish condition was greater in years when the proportion of sandeel prey in the diet of each predator was higher (Figure 3.4; see also Greenstreet 2006).

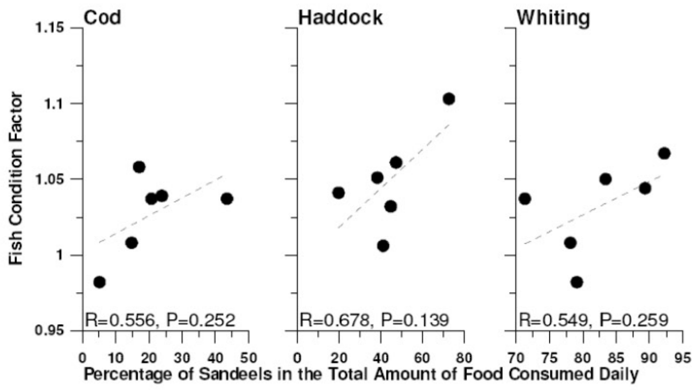


Figure 3.4. Relationship between the body condition of gadoid predators in the Firth of Forth, and the quantity of sandeels consumed (from Greenstreet *et al.*, 2006).

Between 2004 and 2006, CEFAS conducted investigations into sandeels and their predators on the Dogger Bank ('MF0323' project). Two survey grids were sampled each containing 48 stations, the grids were separated by 28 km. The northernmost survey grid ('grid 1'), on an area known as the 'North-West Riff', was characterised as having high sandeel abundance and was an important area for the sandeel fishing fleet. The southernmost grid ('grid 2') on an area known as 'The Hills' was characterised by much lower sandeel abundance, and was less important to the sandeel fishery. Predator stomachs (mostly whiting, plaice, lesser weeverfish, grey gurnard, haddock, and mackerel) were sampled on six research cruises. The diets of all species were found to vary markedly and consistently between the two sampling grids (Pinnegar *et al.*, 2006). Sandeels were much more important to predators (especially whiting and lesser weeverfish) at grid 1, and this coincides with the greater abundance of sandeels at grid 1, as determined by dredge survey during the night.

Clear seasonal differences were observed in predator diets for all species. Diets were much more diverse during autumn as compared to those in spring. Whiting ate substantially more crabs and sprat during the autumn period as well as hyperid amphipods, and much less sandeel at both sampling grids. Sandeels bury themselves in the sediment during autumn/winter months and are thus less accessible to predators, even though they were more abundant in real terms than was the case during the spring. Preliminary analyses (G. Engelhard, unpublished data) suggest that for some predators, most notably lesser weeverfish *Echiichthys vipera*, body 'condition' was slightly better at the high-sandeel site (grid 1) compared to the low-sandeel site (grid 2). An examination of interannual variability in fish body condition revealed that plaice and weever condition was better in sandeel-rich years and at the sandeel-rich survey grid. Whiting and haddock condition was better in sandeel-rich years, but no site difference was apparent in these mobile species which forage over a large area. Grey gurnard and greater sandeel (*Hyperoplus lanceolatus*) condition appeared not to be significantly linked to sandeel numbers, but positively linked to *per-capita* sandeel consumption (condition was better when more sandeels were observed to have been consumed). Thus it was concluded that various predatory fish species do have better condition in years/sites where sandeels are more abundant. In a parallel study carried out in August and October 2006, whiting were sampled aboard commercial fishing vessels all along the North East coast of England (from Flamborough to the Firth of Forth, including the Dogger Bank). It was noted by the crew that the fish caught over areas of hard ground with empty stomachs during the August survey were very thin and of poor condition (Stafford *et al.*, 2006). Where stomachs were not empty, the main contents were small crustaceans in August and fish in October. Fish consumed were often non-commercial prey species such as pipefish or hagfish, although gadoids and clupeoids were also consumed. The data show changes from the 1981 and 1991 ICES 'year of the stomach' sampling exercises, when far more sandeel and clupeoids and far less crustaceans were consumed. The authors of this study (Stafford *et al.*, 2006) speculate that the limited availability of sandeels in 2006 may have been responsible for the poor body condition of the fish in that year and the selection of nutritionally poor prey items such as snake pipefish.

3.6 Other impacts on sandeels

Hassel *et al.* (2004) showed that seismic shooting can kill sandeels, and may impact commercial catches on banks where seismic shooting is occurring. There are concerns that marine wind farms could possibly affect sandeels by altering sediment around turbines and possibly by noise/vibrations. Van Deurs *et al.* (2008) reported that they found no adverse effects of beam trawling on sandeels where beam trawling was carried out over sandeel grounds.

3.7 Implications for ecosystem-based management

Due to the stationary habit of post-settled sandeels, a patchy distribution of the sandeel habitat (Wright *et al.*, 2000; Holland *et al.*, 2005), and a limited interchange of the planktonic stages between the spawning areas, the sandeel stock in IV consists of a number of sub-populations (Pedersen *et al.*, 1999; Christensen *et al.*, 2008). Within these sub-populations, fishing for sandeels may deplete numbers on particular banks. Recent evidence indicates that although closures can lead to rapid recovery of sandeel numbers in some cases (Greenstreet *et al.*, 2010), in others, banks may not be recolonised for some years. Although hydrographical features and the general distribution pattern of the sandeel spawning populations are responsible for most of the variation in recolonisation (Proctor *et al.*, 1998; Christensen *et al.*, 2008), possibly some of the variation in recolonisation of banks after depletion may reflect habitat preferences of sandeels that are seeking sites to settle, with optimal substrate being more attractive (Wright *et al.*, 2000). This pattern may also result from some local movement of settled sandeels between adjacent but especially within banks from poorer habitat to preferred habitat (Jensen *et al.*, in press). There was evidence for such relocation in Shetland, for example, where high fishery catches continued to be taken from Mousa even when all surrounding banks had become depleted, and breeding success of seabirds such as terns and kittiwakes had fallen close to zero due to shortages of sandeels around most of Shetland. Predators dependent on sandeels (such as kittiwakes) may therefore be adversely affected by local or regional depletion of sandeels. Serial depletion of banks in an area seems to be a particular risk. There is a need for sandeel stock assessment and management to take these risks into account. Exact local densities of sandeels needed to sustain healthy populations of predators are not known, and no doubt vary according to a range of ecological conditions and predator communities. But research has shown that certain top predators show particularly strong responses to depletion of sandeels. In particular, kittiwake breeding success tends to correlate strongly with abundance of sandeels over about a 50 km foraging radius around kittiwake colonies. In regions where kittiwakes feed predominantly on sandeels while breeding, which is the case in the North Sea, poor breeding success of these "indicator" seabirds can be used as evidence that the local stock of sandeels is depleted. Such evidence is less direct than can be obtained from dredge or acoustic surveys, but may help to identify problem areas where sandeel aggregations need to be allowed to recover. Sandeel stock assessments and subsequent management should also aim to avoid depletion of stocks to levels where damage to ecosystems becomes evident through its impact on dependent predators. Though the actual level at which these adverse effects occur is presently unknown in most cases, it is clear that a very low stock size will significantly increase the probability of effects on top predators and is hence highly unlikely to be compatible with an ecosystem approach to fisheries.

4 Data availability

4.1 Commercial data

4.1.1 Age composition and mean individual weight

4.1.1.1 Data available

Data available included Danish and Norwegian samples from harbour sampling and Danish samples taken by skippers on board vessels and frozen immediately (available from 1999 onwards). The Danish samples cover both age and length distributions whereas the Norwegian samples cover only length distribution prior to 1997 and both age and length samples after 1997. Sandeel measured for length distribution were weighed in the Danish samples whereas only aged sandeel were weighed from the Norwegian samples. To obtain weight-at-length for Norwegian samples, the parameters of the weight–length relationship (per month year and old Sandeel sampling area; see Figure 4.2.1).

$$W = aL^b$$

were estimated using the sandeel weighed in the Norwegian age samples after 1997 and Danish length-weight relationships before 1997 and weight-at-length estimated for sandeel which were not weighed. All data are combined in the analyses, corresponding to the assumption that the composition of catches taken in a given year and month did not differ between countries and that no differences in age reading existed.

4.1.1.2 Estimating age length keys

Only age readings of *Ammodytes marinus* and unidentified sandeel Ammodytes spp. are used. The method suggested by Rindorf and Lewy (2001) is used to assure that the estimation is optimized when sampling is sparse. This method is used to estimate an age–length-key for each combination of year, time and area (Table 4.1.1). When the number of fish aged is too low to allow a reliable estimation on rectangle level (confidence limits of the estimate exceeds +/- 25%), higher aggregation levels are used (Table 1). When a given age is not observed in an age sample, this is assumed to reflect an absence of this age only if the number of fish sampled of this age or older exceeds 10. Otherwise, the absence of the particular age is assumed to be a result of low sampling efforts, and the probability of being of the particular age compared to the probability of being older taken from a higher aggregation level. The probability of being of a given age is set to zero at lengths outside the interval of lengths observed for this age +/- 2 length groups (1 cm groups from 6 to 20 cm, 2 cm groups between 20 and 30 cm). Overdispersion (Rindorf and Lewy, 2001) was not estimated.

4.1.1.3 Estimating age distributions and mean weight-at-age

The number of *A. marinus* of each age (0 to 4+) per kg and the mean weight per individual of each age in each length distribution sample was estimated by combining the age–length key and the length distribution specific to that square and period (periods given in Table 4.1.1). The average number of sandeel per age per kg and their mean weight in a given rectangle in each month was estimated as the average of that recorded in individual samples when at least five samples were available. Mean weight was only estimated when the total catch of a given age in the square exceeded ten. If the total North Sea sampling resulted in less than ten sandeel of a particular age, the mean weight for that age from the North Sea as a whole was used. When less than five length samples were taken, the next aggregation level (Table 4.1.2), was used. Hence, for each rectangle, month and year, the average number of *A. marinus* per age and kg caught was estimated and the level noted. No correction was made for differences in condition between on-board samples and harbour samples.

4.1.1.4 Estimating catch in ton per rectangle per month

Before 1989, only logbook information stating the catch in directed Danish sandeel fishery is known. As the large majority of the catch in the sandeel fishery consists of sandeel, the distribution of catches in the directed sandeel fishery on rectangle and months were assumed to represent the distribution of sandeel catches. The total catch in tones was derived from the report of the working group on the assessment of Norway pout and sandeel (ICES 1995) and distributed on rectangles and month in the particular year according to the distribution of catches derived from Danish logbooks. From **1989 to 1993**, the landings of sandeel per rectangle and month from the Danish fishery are available at DTU-AQUA. These were used to distribute total landings to rectangle and month. From **1994 to 1998**, international sandeel catches in ton per rectangle per year are available. These catches were distributed to months according to the monthly distribution of Danish catches in the rectangle in the given year. If no Danish catches were recorded from the rectangle, the monthly distribution of the total catches in the ICES division was used. **After 1999**, international sandeel catches in ton per rectangle per month and year are available.

All catches were scaled in order to sum to official ICES landing statistics. Total catches per area are seen in Figure 4.1.1.

4.1.1.5 Estimating catch in numbers and mean weight

The catch in numbers per age (1000s), month and rectangle of sandeel was estimated as the product of sandeel catches in kg and the number-at-age of sandeel per kg in the particular rectangle. The total number in a larger area and longer time period is estimated as the sum over individual rectangles and months in this area. The mean weight is estimated as the weighted average mean weight (weighted by catch in numbers of the age group in the rectangle and month). Mean weight is given in kg. The resulting age-distribution of the catches are seen in Figure 4.1.1.

4.1.1.6 Number of samples taken in each area

The number of biological samples taken was insufficient to conduct analytical assessments for areas 5, 6 and 7 and for area 4 outside the years 1993 to 2005 (Table 4.1.3).

Table 4.1.1. Aggregation levels for age–length keys and length distributions. For sandeel sampling areas, see Figure 4.1.2.

Level	Space	Time
1	Square	Jan–Feb, March, April (1–15),April (16–30), May (1–15), May (16–31), June (1–15), June (16–30), July, Aug, Sep–Oct, Nov–Dec
2	Sandeel sampling areas within asesment areas(Figure 1)	Jan–Feb, March, April (1–15),April (16–30), May (1–15), May (16–31), June (1–15), June (16–30), July, Aug, Sep–Oct, Nov–Dec
3	Aggregated sandeel sampling areas within assessment areas: 1A+1B, 1C, 2A+6, 2B+3, 4+5, 3AS+3AN	Jan–Feb, March, April (1–15),April (16–30), May (1–15), May (16–31), June (1–15), June (16–30), July, Aug, Sep–Oct, Nov–Dec
4	Aggregated sandeel sampling areas within assessment areas: 1A+1B, 1C, 2A+6, 2B+3, 4+5, 3AS+3AN	Jan–Mar, April–May, June–Aug, Sep–Dec
5	Sandeel assessment areas	Jan–Mar, April–May, June–Aug, Sep–Dec
6	Sandeel assessment areas	Jan–June, July–Dec
7	All areas together	Jan–June, July–Dec
8	All areas together	Jan–Dec

Table 4.1.2. Aggregation levels for estimating the number of sandeel per age per kg. For sandeel sampling areas, see Figure 4.1.2.

Level	Space	Time
1	Rectangle	Jan–Feb, March, April, May, June, July, Aug, Sep–Oct, Nov–Dec
2	Sandeel sampling areas within asessment areas(Figure 1)	Jan–Feb, March, April, May, June, July, Aug, Sep–Oct, Nov–Dec
3	Aggregated sandeel sampling areas within assessment areas: 1A+1B, 1C, 2A+6, 2B+3, 4+5, 3AS+3AN	Jan–Feb, March, April, May, June, July, Aug, Sep–Oct, Nov–Dec
4	Aggregated sandeel sampling areas within assessment areas: 1A+1B, 1C, 2A+6, 2B+3, 4+5, 3AS+3AN	Jan–Mar, April–May, June–Aug, Sep–Dec
5	Sandeel assessment areas	Jan–Mar, April–May, June–Aug, Sep–Dec
6	Sandeel assessment areas	Jan–June, July–Dec
7	All areas together	Jan–June, July–Dec
8	All areas together	Jan–Dec

Table 4.1.3. Number of length samples taken in each area and year (Norwegian and Danish samples together).

Area	1	2	3	4	5	All
1982	58	20	9	0	0	87
1983	73	21	15	0	0	109
1984	116	15	31	0	2	162
1985	97	26	9	19	2	151
1986	28	2	39	1	0	70
1987	63	6	65	1	0	135
1988	40	4	76	0	0	120
1989	38	7	47	0	0	92
1990	2	1	39	0	0	42
1991	25	9	53	0	0	87
1992	54	19	49	5	0	127
1993	21	17	112	11	0	161
1994	20	9	79	17	0	125
1995	42	15	74	9	7	140
1996	39	15	164	6	19	224
1997	37	24	180	43	0	284
1998	47	14	167	10	0	238
1999	258	32	72	44	1	406
2000	102	16	80	59	0	257
2001	219	10	93	90	0	412
2002	289	28	114	62	0	493
2003	261	65	164	153	0	643
2004	446	66	183	54	0	749
2005	305	41	49	30	0	425
2006	539	27	98	2	0	666
2007	287	17	257	0	0	561
2008	291	11	164	1	0	467
2009	303	7	125	0	0	435
2010	172	28	279	1	0	480

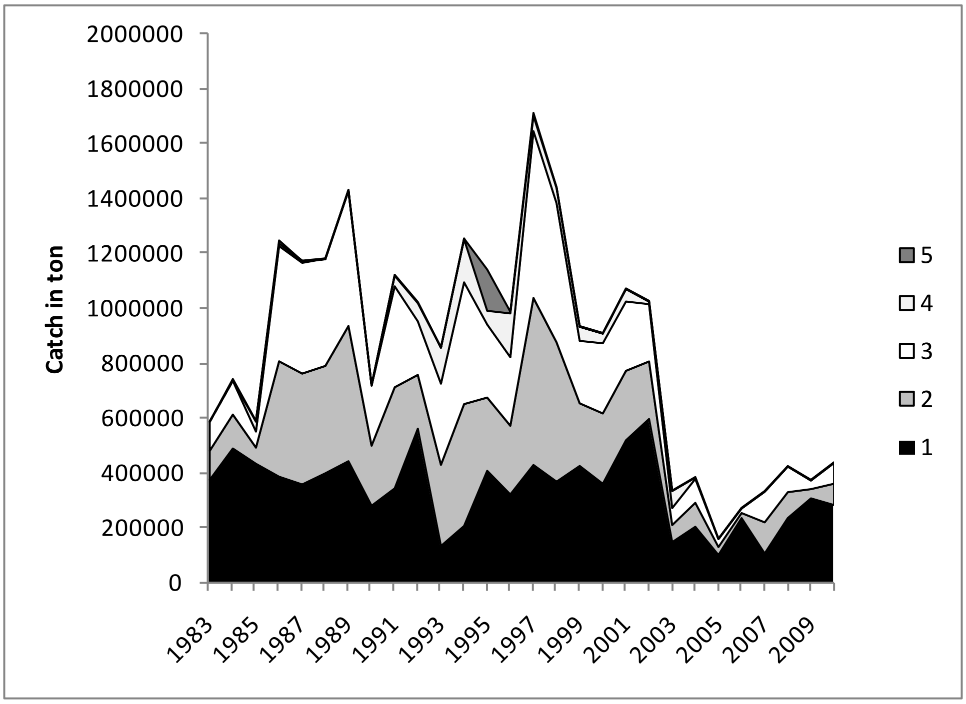


Figure 4.1.1. Total catches per sandeel assessment area (Figure 2.1).

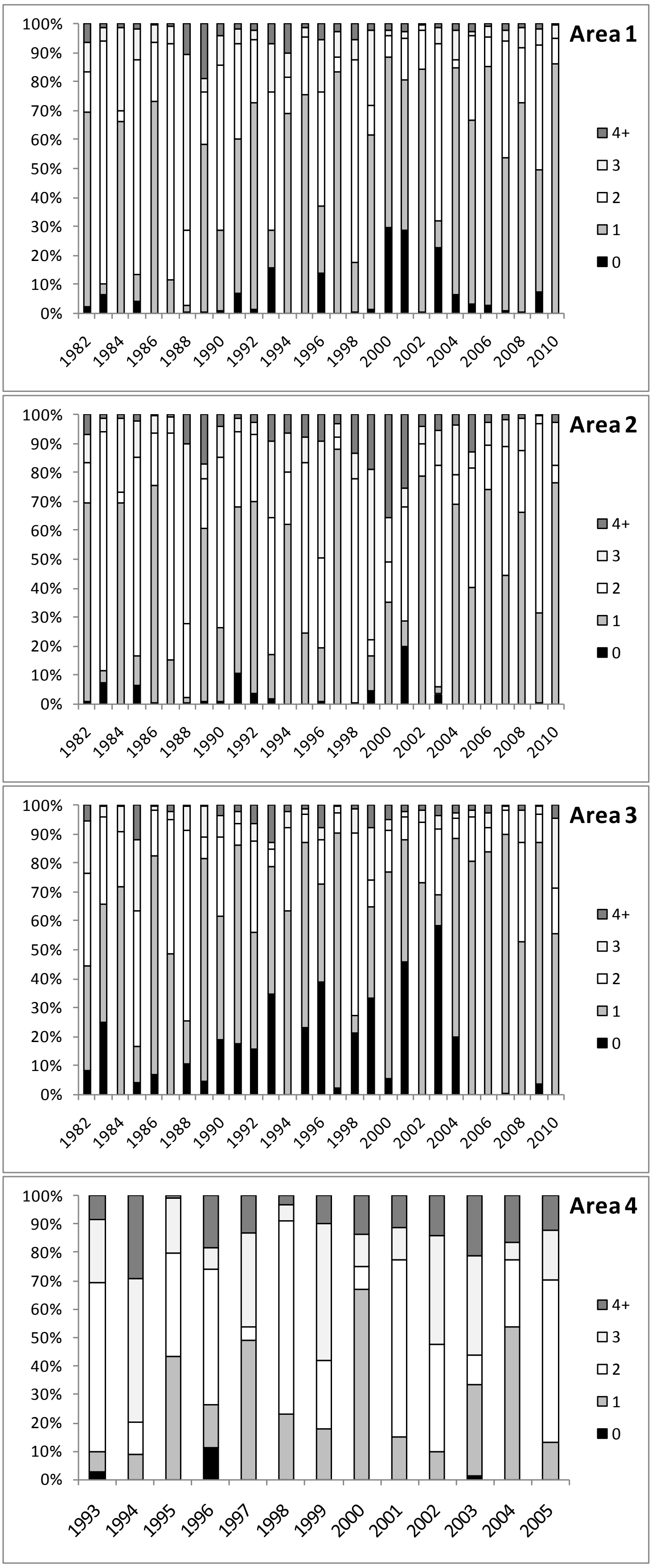


Figure 4.1.2. Development in age composition of biomass in catches in areas 1 to 4.

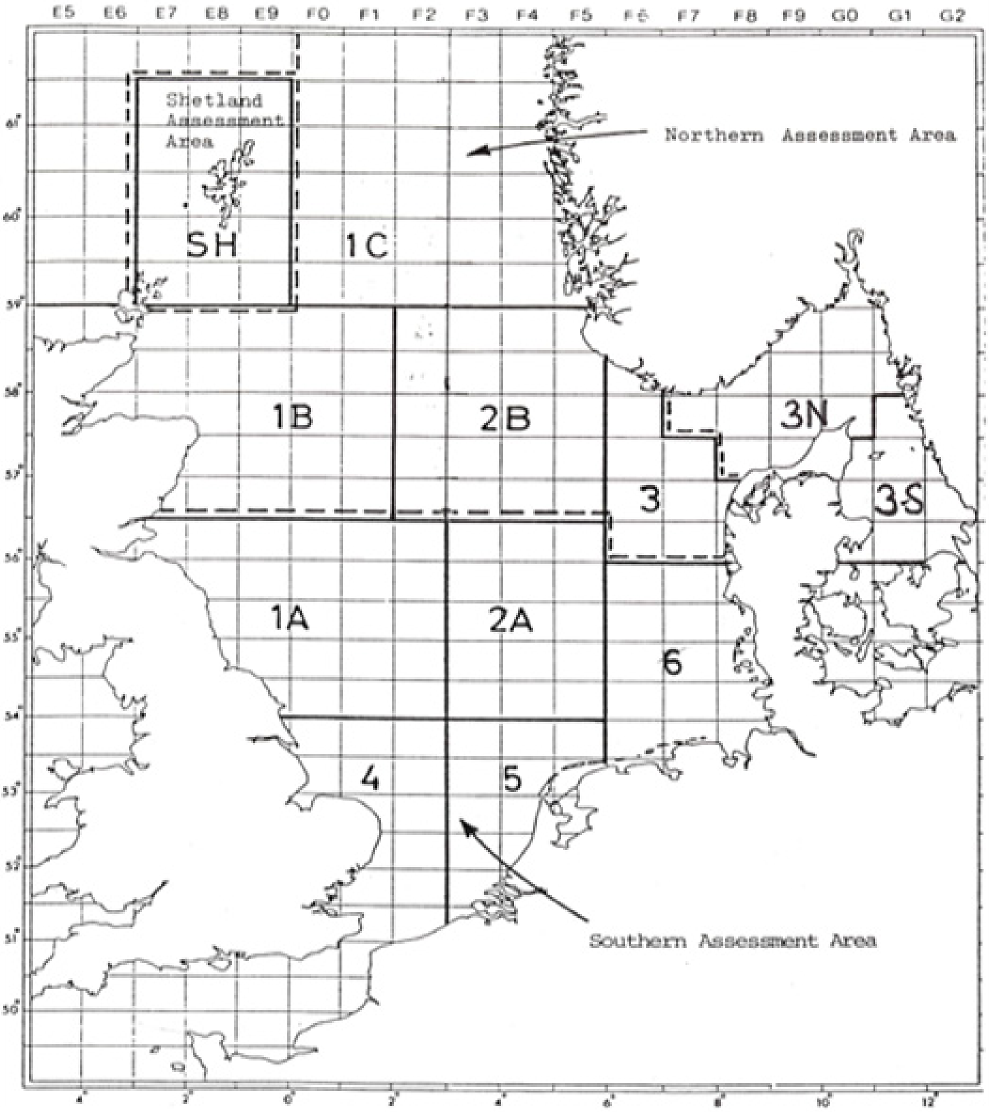


Figure 4.1.3. Historical Sandeel sampling areas used. The areas are identical to the sampling areas given in the report of the working group on the assessment of Norway pout and sandeel (ICES C.M. 1995/Assess: 5) except that the original areas 1C and 2c are joined to one and the border between area 1B and 2B has been moved 1oW. This border was moved to avoid dividing a fishing ground into two.

4.1.2 Estimation of sandeel fishing effort

Estimates of fishing effort is often used in assessment models and the assumption is that on a given day *t*, fishing mortality *F* is

$$F_t = \sum_i q_{t,i} E_{t,i}$$

Where $E_{t,i}$ is effort of vessel *i* on day *t* and $q_{t,i}$ is a catchability coefficient. Often, catchability is assumed to be constant over time and vessels. However, in the case of sandeel, we know this to be wrong as catchability varies with vessel size and the size composition of the fleet has changed over time. In this case, it is preferable to standardise effort to a particular vessel size for which catchability can be assumed constant over time. One way to do this is to use the relationship between catch per unit of effort $cpue_t$, biomass B_t is and catchability:

$$CPUE_{t,i} = \frac{C_{t,i}}{E_{t,i}} = q_{t,i} B_t$$

Where C_t is total catch on that day in combination with the general relationship between vessel size V and catchability apparent from logbook data:

$$CPUE_{t,V} = q_0 \left(\frac{V}{V^*} \right)^b B_t$$

where V^* is a standard vessel size. In this case, q_0 denotes the catchability of a standard vessel and is thus independent of changes in size composition in the fleet. Hence,

$$F_t = q_0 \sum_i \left(\frac{V}{V^*} \right)^b E_{t,i} \qquad (1)$$

To obtain the total standardised effort ($\sum_i \left(\frac{V}{V^*} \right)^b E_{t,i}$) in a given time interval, it is thus necessary to know the size of each vessel, the number of days fished and the value of b. Vessel size can be measured in any desirable unit. In the case of sandeel, the units used have traditionally been gross tonnage *GT*. *KW* standardization was also attempted but consistently explained less of the variation in $cpue_t$.

4.1.2.1 Estimating *b*

For each area, effort was standardized using eq. 1 above. The parameter b was estimated using the model

$$\ln(\hat{CPUE}_{w,r,y,V}) = a_{w,r,y} + b_y \ln\left(\frac{V}{V^*} \right)$$

where indices *sq*, *w* and *y* denote square, week ((Julian day of midpoint of trip/7) rounded to the nearest integer) and year, respectively, V is vessel size, $\hat{CPUE}_{w,r,y,V}$ is median cpue in the given rectangle, week and year for a vessel size of V and a and b are estimated using general linear models with normal error distribution. Observations used to estimate the parameters were Danish logbook records of catch of sandeel per day for the years 1983 to 2010. Cpue was estimated as catch per day fished and allocated for each day to the square where the majority of the catch was taken. Trips were allocated to the week where the middle of the trip occurred.

The parameter estimates of b are given in Table 4.1.3 along with the r^2 of the general linear model and the partial r^2 of the vessel size term (b). Residuals were examined for signs of non-linearity in the relationship between *cpue* and V, but no such signs were found. Apart from random variation, there seems to have been a trend in the effect of vessel size, with initially high values followed by low effects of vessel size in the 1990's and increasing effects in later years (Figure 4.1.2, Table 4.1.4). The temporal development in standardised effort using the new method is broadly similar to that obtained using the old method and in both series, there is a clear drop in effort after 2004 (Figure 4.1.3).

Table 4.1.4. Estimates of *b*, r^2 of the general linear model and the partial r^2 of the vessel size term (*b*) for models of the effect of gross tonnage (*GT*).

	GT			
Year	*b*	r^2 model	Partial r^2 of *b*	Number of observations
1983	0.439	0.612	0.046	1944
1984	0.392	0.650	0.029	3177
1985	0.379	0.582	0.032	5279
1986	0.412	0.550	0.040	5209
1987	0.406	0.671	0.028	3441
1988	0.357	0.531	0.040	6937
1989	0.323	0.529	0.033	9550
1990	0.269	0.389	0.024	7212
1991	0.394	0.548	0.045	7506
1992	0.365	0.598	0.040	8318
1993	0.285	0.501	0.028	6260
1994	0.364	0.542	0.057	6354
1995	0.318	0.550	0.048	6670
1996	0.322	0.588	0.025	5003
1997	0.396	0.621	0.045	5429
1998	0.405	0.587	0.039	4790
1999	0.326	0.537	0.015	4152
2000	0.368	0.526	0.029	4096
2001	0.390	0.518	0.028	4952
2002	0.417	0.688	0.040	3730
2003	0.446	0.538	0.032	3348
2004	0.439	0.513	0.057	3876
2005	0.398	0.597	0.029	1410
2006	0.494	0.702	0.042	1946
2007	0.517	0.644	0.080	834
2008	0.394	0.735	0.025	1189
2009	0.519	0.781	0.047	1791
2010	0.389	0.781	0.035	1996
Mean	0.391	0.596	0.037	
Mean(1982–1989)	0.391	0.601	0.034	
Mean(1990–1999)	0.344	0.546	0.037	
Mean(2000–2010)	0.434	0.638	0.040	

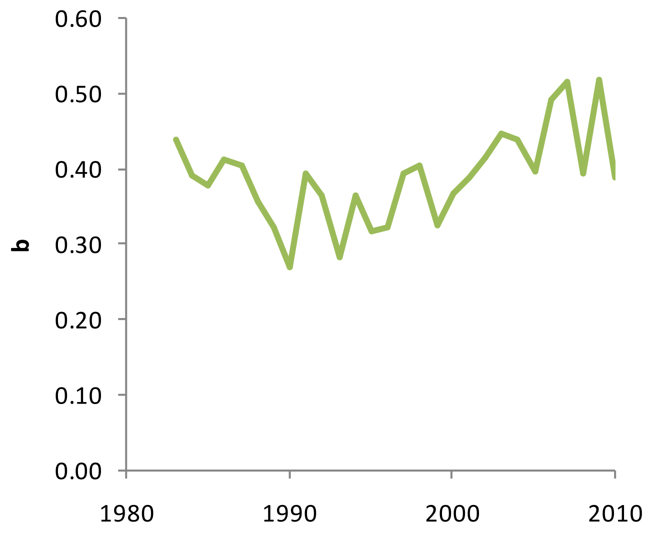


Figure 4.1.2. Temporal development in estimated *b*. Effect of gross tonnage on ln(cpue).

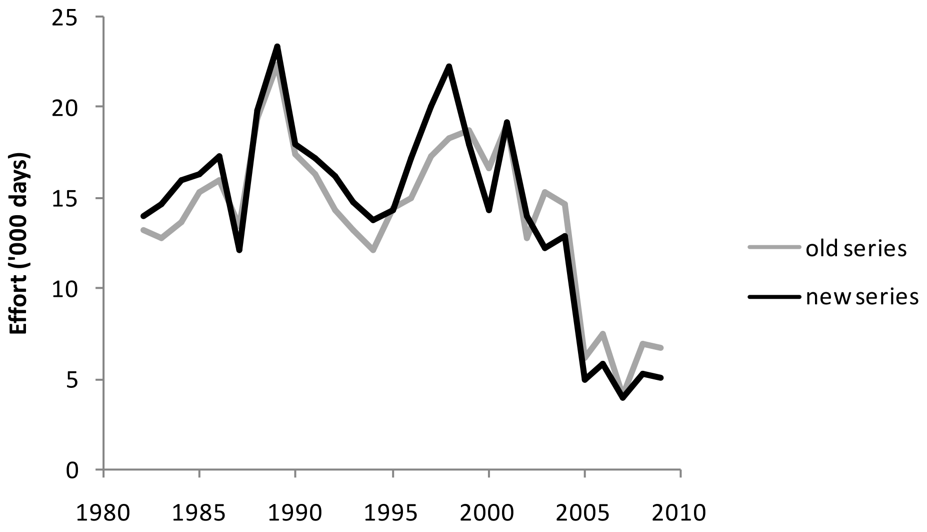


Figure 4.1.3. Temporal development in estimated standardised effort using the new (black) and old (grey) method.

4.1.3 Catch per unit of effort

Using total catches per area and the new estimate of fishing effort, the commercial catch per unit of effort of each age group was estimated. These estimates were evaluated for internal and external consistence (Figures 4.1.4 and 4.1.5). In general, the internal consistency was high in area 1 for all ages, high in area 2 for age 1 only and high in area 4 for age 2 only. In area 3, consistency was low for all ages. External consistency was high between areas 1 and 2, low for all ages but age 1 between areas 1 and 3 and low for all comparisons with area 4.

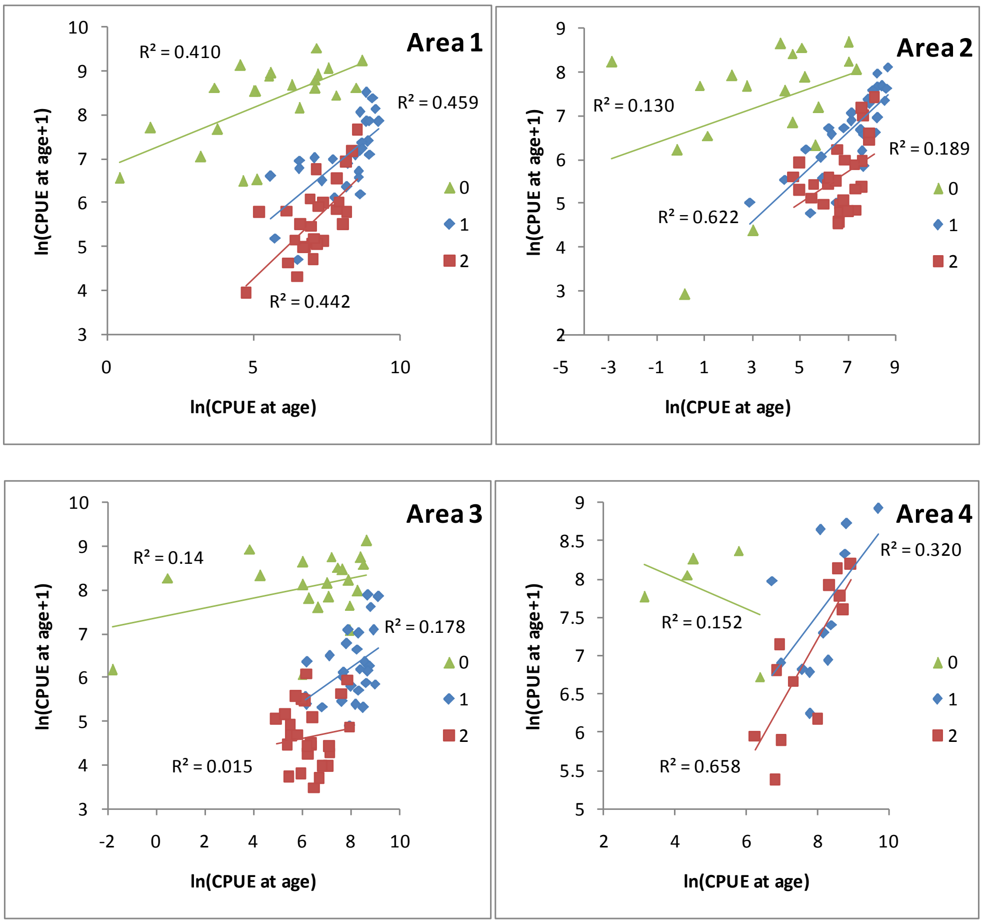


Figure 4.1.4. Internal consistency of commercial cpues (number caught/day) in areas 1 to 4.

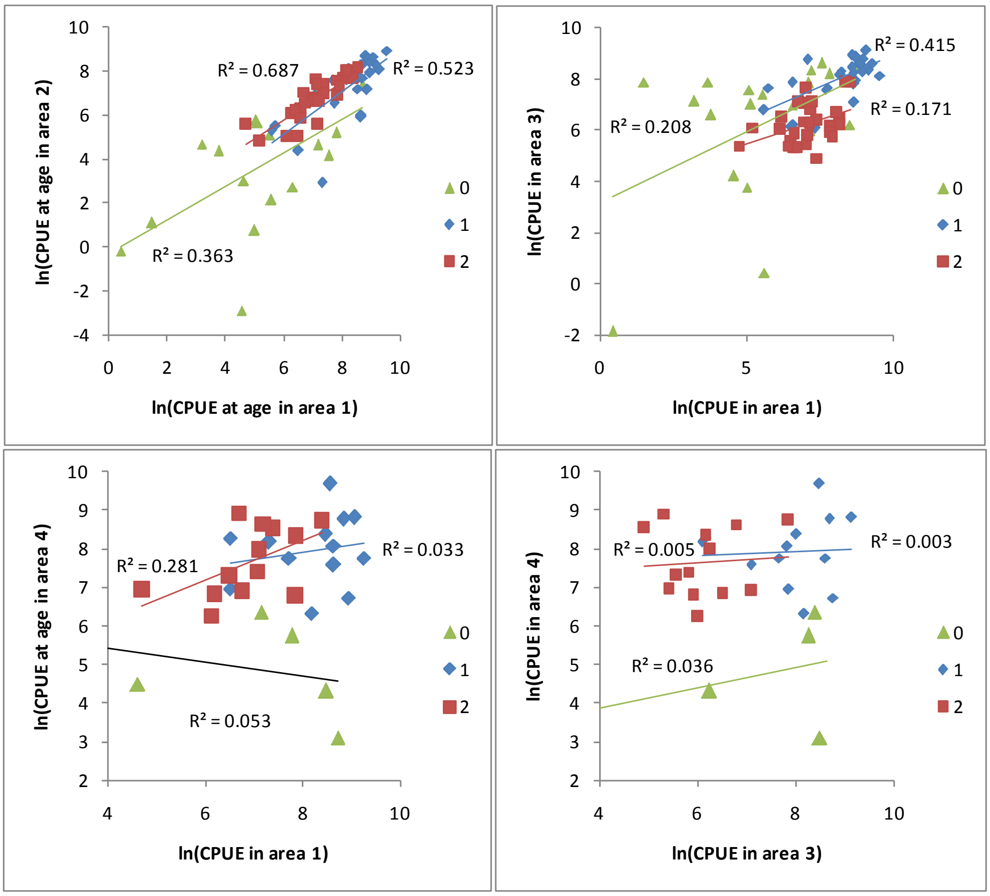


Figure 4.1.5. External consistency of commercial cpues (number caught/day) in areas 1 to 4.

4.2 Survey data

4.2.1 Dredge

Since 2004 DTU Aqua (formerly DIFRES) has carried out a survey with a modified scallop dredge to measure the relative abundance of sandeel in the seabed. The Danish dredge survey is conducted in late November–early December when the 0-group sandeel have been recruited to the settled population and the entire population is assumed to reside in the seabed.

Since 2004 a total of 828 hauls have been made with four dredge types of which 790 were made with types DK1 and DK2 (Table 4.2.1.1). As indicated in Table 4.2.1.1 and Figure 4.2.1.1, the dredge survey covers Areas 1 and 3 except for seven hauls taken in Area 2 in 2005. The data from Area 2 are not included in the present analysis.

Sampling is carried out at fixed positions on known sandeel habitats at known fishing banks in the North Sea from the little Fisher Bank in the North Eastern North Sea, to the Dogger Bank in the South Western North Sea (Figure 4.2.1.1). From 2006 additional positions were sampled in the Norwegian EEZ.

The 2 positions off southern Jutland in 2007 were found to have unsuitable sediment and were thus given low priority and not subsequently sampled in 2008 and 2009. In 2009 three new positions were sampled on the shallow areas of Dogger Bank. On each new position five sediment samples were taken with the Van Veen 0.2 m² grab and five hauls with the mussel dredge (DK2).

The Danish modified scallop dredge survey has been enrolled under the DCF programme with the locations indicated on the map in Figure 4.2.1.5

In order to complement the Danish survey, Marine Scotland Science began a dredge survey in 2008 with the aim of producing a year-class index for area 4, off the north-east UK coast. The survey is targeted at banks off the Firth of Forth and around Turbot bank and is timed to coincide with the Danish sampling. The distribution of stations in 2009 is shown in Figure 4.2.1.2. In addition to the two recent years of data, similar data are also available from research surveys at Firth of Forth banks undertaken in October-November between 1999 and 2003. The data from all years for this region were used to evaluate the utility of dredge surveys in area 4.

Industry representatives at the WKSAN have raised concern about operating above certain wind speeds. Consultations on actual levels should be held and reported back accordingly.

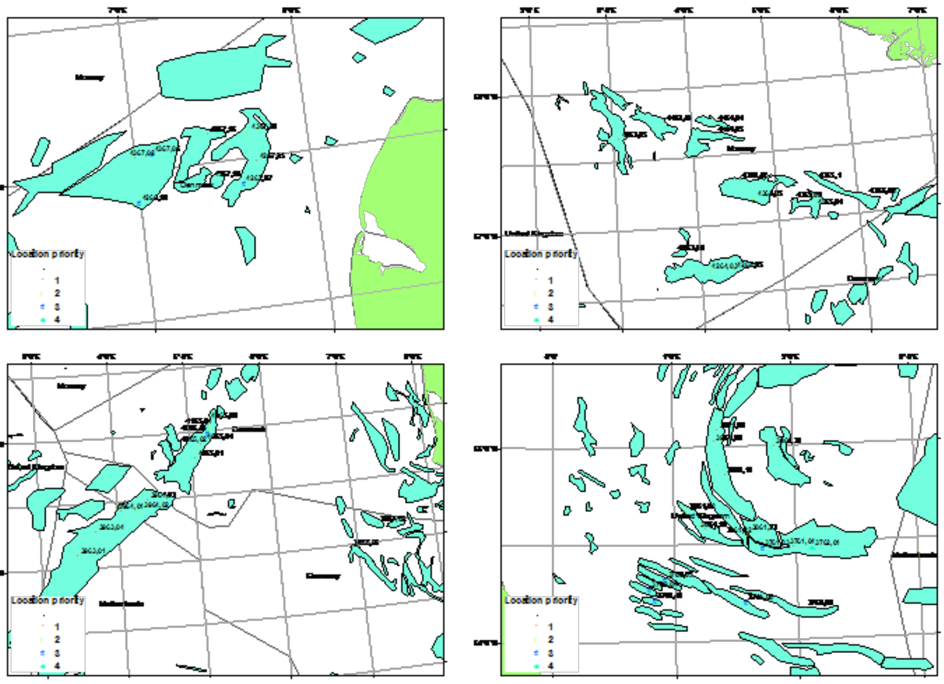


Figure 4.2.1.1 Map showing the sampling locations in the sandeel dredge survey from 2004–2009 in the four subareas (Little Fisher, Norwegian EEZ, Tail End/ South of Jutland and Dogger Bank.

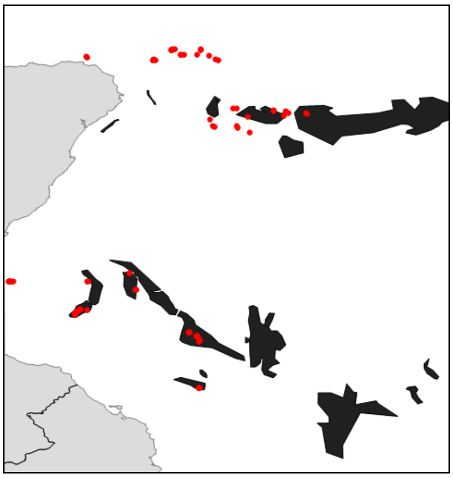


Figure 4.2.1.2. Location of Area 4 dredge stations in 2009, from MSS survey.

4.2.1.1 Description of the gear

During the development of the gear four different dredge types have been tried during the Danish survey: DK1 standard dredge; DK2 Modified standard dredge with video camera and a bottom contact sensor (Figure 4.2.1.3); DK3 Modified standard dredge with an additional net roof; DF1 modified standard dredge with an additional net. As the DF 1 dredge was used on an experimental basis only and analysis indicated that the DK3 dredge had catch rates significantly different from the DK1 and DK2, only data from DK2 (DK1 only as back-up) was used in the present analysis. These two dredges were compared and yielded similar catch rates and therefore their data was aggregated in the analysis.

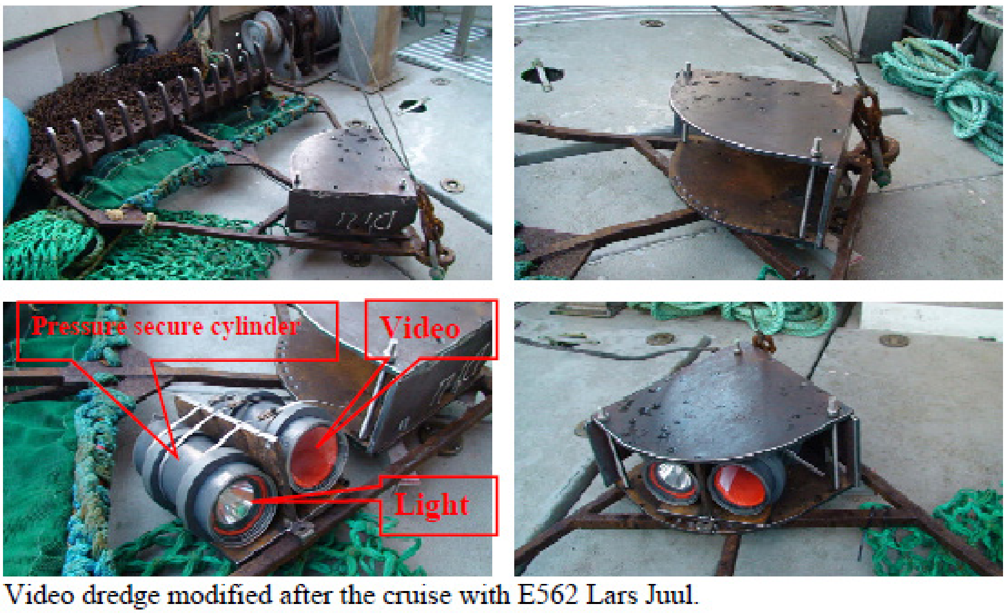


Figure 4.2.1.3. Modified Scallop Dredge DK2 showing set up of video equipment.

The Scottish dredge survey uses a video system mounted on a towing bar (see Appendix A2). It has been shown that the efficiency of this gear can be improved by 61% (CV = 6%) with the addition of a net hood (Figure 4.2.1.4). However, this addition has not been used routinely.

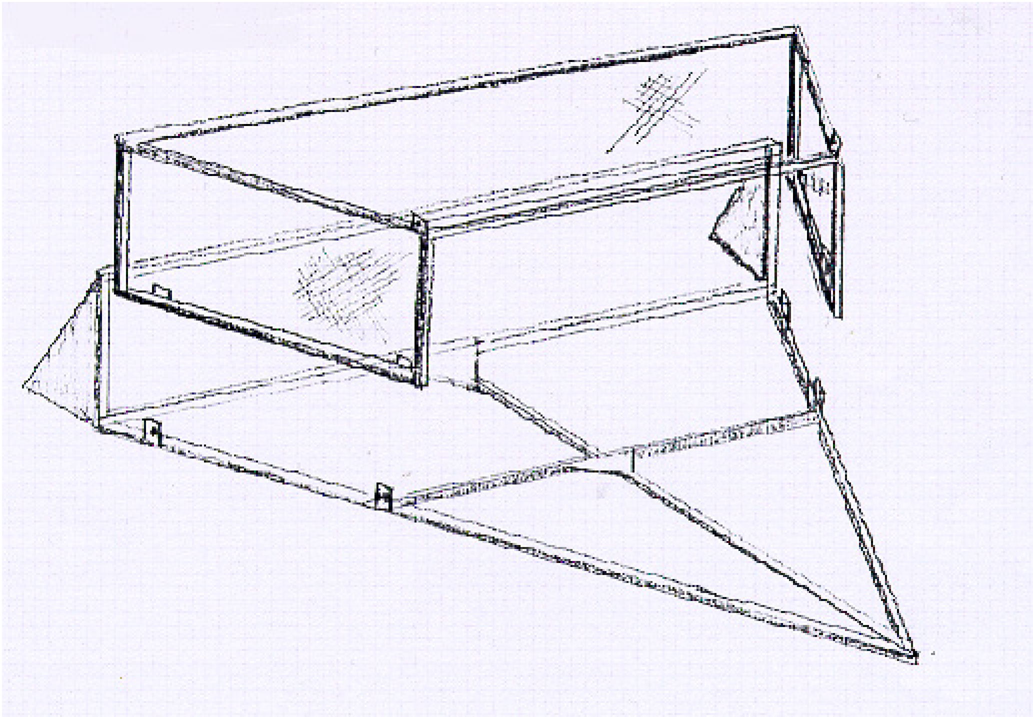


Figure 4.2.1.4. Hood attachment used to compare with conventional dredge.

4.2.1.2 Description of the operation

On every position (stated in Tables 4.2.1.1 and 4.2.1.2) one sediment sample is taken with a Van Veen 0.2 m^2 grab in the Danish survey or a 0.1 m^2 Day grab in the Scottish survey. Thereafter normally 3–5, 10 minutes hauls are conducted with the modified scallop dredge (normally DK2) on the same position. Hauls are conducted within a radius of 0.3 nm from the fixed position. Two mechanical bottom contact sensors register with high frequency the performance of the dredge during operations.

All sandeels from a haul are sorted out from the catch but in cases of large catches only a weight based sub sample is frozen and later worked up in the lab. Length, weight, sex and maturity are registered and otoliths are dissected for age determination. Sub sampling at this level is performed for stomach content and dry weight determination of individuals. Further details of the Danish and Scottish surveys can be found in appendix A1 and A2 respectively.

A varying number of hauls have been made at the different positions over the years (Table 1a). Therefore, calculation of the annual stratified average catch rates (total number caught by hour) for each area was done in a three step procedure: first, for each year, the average catch rate of each position was calculated as the average of the catch rates of all hauls (stations) made on this position, then the average catch rate of each ICES square was calculated as the average of the catch rates of its positions, and finally the average catch rate of each area was calculated as the average of the catch rates of its ICES squares. In other words, the annual average catch rate by area is calculated by:

(1)
$$\overline{CPUE}_a = \frac{\sum_{sq} \overline{CPUE}_{a,sq}}{n_{a,sq}}$$

where

(2)
$$\overline{CPUE}_{a,sq} = \frac{\sum_{pos} \overline{CPUE}_{a,sq,pos}}{n_{a,sq,pos}}$$

where

(3)
$$\overline{CPUE}_{a,sq,pos} = \frac{\sum_{st} \overline{CPUE}_{a,sq,pos,st}}{n_{a,sq,pos,st}}$$

where n: number of hauls, a: area, sq: square, pos: position and st: station.

Table 4.2.1.1. Number of stations (hauls) by area, square and position made by dredges DK1 and DK 2.

			Year						
Area	Square	Position	2004	2005	2006	2007	2008	2009	Total
1			114	135	126	83	63	58	579
	37F0		0	15	14	7	7	8	51
		3760.01					1		1
		3760.03		5					5
		3760.04		5	5	3	1	3	17
		3760.05		5	4	4	2	3	18
		3760.06			5		3	2	10
	37F1		11	24	15	6	3	3	62
		3761.03	6	10	5				21
		3761.04	5	9	5	3	3	2	27
		3761.08		5	5	3		1	14
	37F2		5	5	4	3	4	5	26
		3762.01					3	3	6
		3762.02	5	5	4	3	1	2	20
	38F1		20	30	27	27	13	10	127
		3861.02		5			2		7
		3861.14	5	5	4	3	1	2	20
		3861.19	5	5	5	5	2	2	24
		3861.22	5	5	5	6	3	2	26
		3861.23		5	5	6	1	2	19
		3861.32	5	5	8	7	4	2	31
	39F1		15	13	13	3	6	5	55
		3961.01		2					2
		3961.02					1		1
		3961.22		1					1
		3961.28	10	5	6		2	3	26
		3961.29	5	5	7	3	3	2	25
	39F3		19	9	11	14	9	7	69
		3963.01	10	4	6	6	3	2	31
		3963.04	9	5	5	4	3	3	29
		3963.07				4			4
		3963.08					3	2	5
	39F4		25	14	15	8	10	8	80
		3964.01	10	9	10		1	3	33
		3964.02	10	5		4	3	2	24
		3964.03	5		5	4	6	3	23
	40F5		10	15	17	7	7	7	63
		4065.01	5	5	5	7	3	2	27
		4065.02	5	5	5		3	3	21

			Year						
Area	Square	Position	2004	2005	2006	2007	2008	2009	Total
		4065.03			2				2
		4065.04		5	5		1	2	13
	41F5		9	10	10	8	4	5	46
		4165.01	5	5	5		3	2	20
		4165.02	4	5	5	8	1	3	26
2			0	7	0	0	0	0	7
	38F6		0	4	0	0	0	0	4
		3866.01		4					4
	39F7			3					3
		3967.02		3					3
3			20	13	48	40	46	37	204
	42F3		0	1	5	3		1	10
		4263.02		1	5	3		1	10
	42F4		0	0	1	5	6	0	12
		4264.01					2		2
		4264.03				3	1		4
		4264.05			1	2	3		6
	42F7		15	10	10	4	7	9	55
		4267.08	1						1
		4267.12	10	5			2	3	20
		4267.25	4	5	5	4	2	3	23
		4267.27			5		3	3	11
	43F4		0	0	0	0	7	4	11
		4364.01					3		3
		4364.05					2	1	3
		4364.07					2	3	5
	43F5		0	0	16	9	6	8	39
		4365.04			6	3		2	11
		4365.08			5	3	3	3	14
		4365.1			5	3	3	3	14
	43F6		0	0	6	3	3	3	15
		4366.06			6	3	3	3	15
	43F7		5	2	10	10	11	12	50
		4367.02			5	4	3	3	15
		4367.06					3	3	6
		4367.16		2		4	3	3	12
		4367.23	5		5	2	2	3	17
	44F4		0	0	0	6	6	0	12
		4464.04				3	3		6
		4464.05				3	3		6
Grand Total			134	155	174	123	109	95	790

Table 4.2.1.3. Scottish dredge survey. Number of hauls by ICES rectangle and year.

Rectangle	Year						
	1999	2000	2001	2002	2003	2008	2009
41E7	3	4	3	3	3	18	15
41E8	4	5	3	3	3	8	8
40E8	2	5	0	2	2	6	8

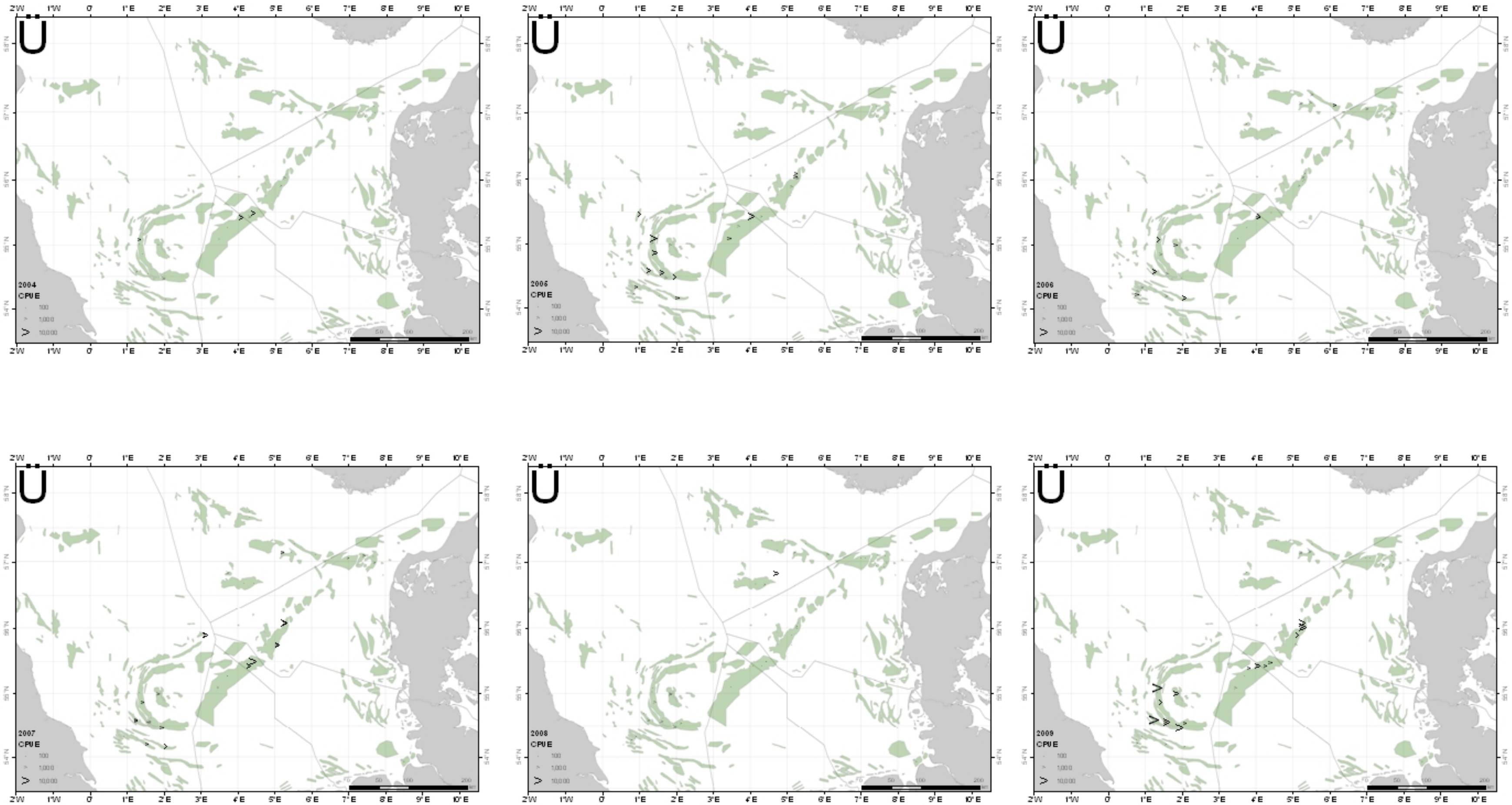


Figure 4.2.1.5. Map of Danish dredge sample locations (2004–2009) with area of circles indicating catch rates per 60 min haul.

4.2.1.3 Time-series, coverage and trends in cpue

The time-series of coverage and catch rates for the Danish dredge survey is detailed in WDA1 in the Appendeces (Christensen, 2010), and a map of locations for the period 2004–2009 with indicated catch rates is found in Figure 3. Standardized cpues for the survey has an apparent slight positive trend for area 1 as well as area 3 in time-series 2004–2009.

4.2.1.4 Internal and external consistency

The internal consistency, i.e. the ability of the survey to follow cohorts, was evaluated for each area by plotting catch rates of an age group in a given year versus the catch rates of the next age group in the following year.

Exploratory analysis indicated that the internal consistency did not improve by standardization to the square means or by weighting by total commercial catches by square or by the size of the sandeel distribution area of the catch rate indices.

Internal consistency of the dredge surveys was high in all areas (Figure 4.2.1.6). External consistency between dredge catch rates and commercial cpues was very high in area 1 with the exception of the oldest fish (age 2) (Figure. 4.2.1.7). In area 3, the consistency was somewhat lower, in particular for 2-year olds in the cpue. In area 4, the consistency with the cpues as used in the assessment was very high for 2+ in the cpues but low for age 1. However, this appeared to be linked to the aggregation level of the data, as consistency between the dredge survey and catch rates based directly on haul time and catches derived from part of the fleet in cooperation between the Danish Fishers and DTU-AQUAed very high consistency for this group (Figure 4.2.1.7).

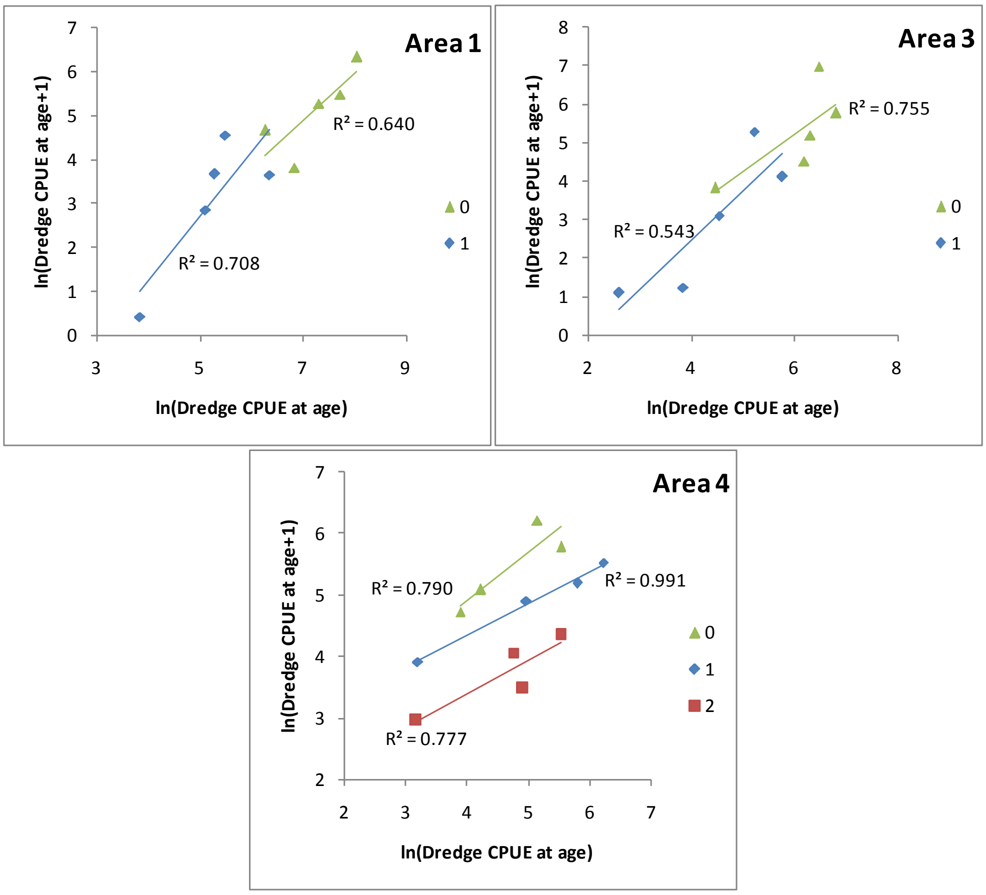


Figure 4.2.1.6. Internal consistency of the dredge survey in areas 1, 3 and 4.

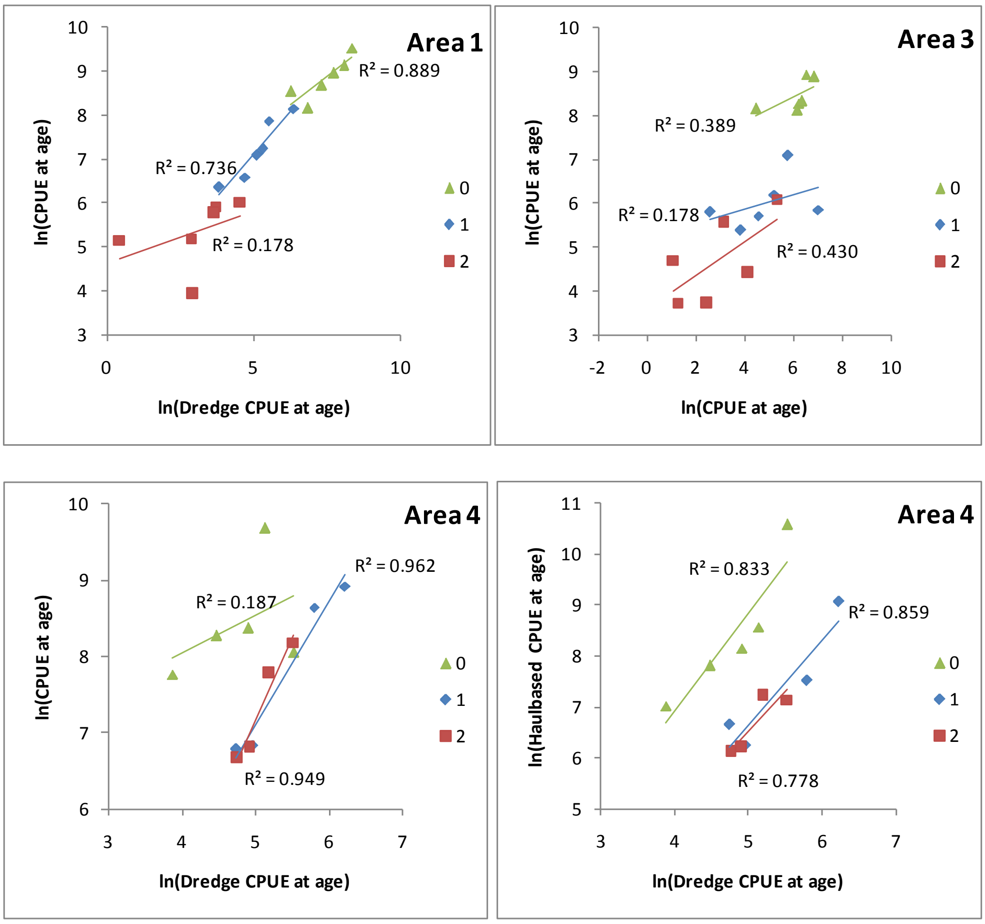


Figure 4.2.1.7. External consistence of dredge surveys compared to commercial cpues as included in the assessment or haul based cpues (no per minute hauled) from the detailed Danish sampling of selected vessels.

4.2.1.5 Error structure

Analysis of variation among stations within locations show a low CV, internal consistency indicate low among year variation within locations, thus the highest error component arrives from among locations. Area effects explain part of this variation but a good coverage within areas is needed to reduce variance on the area index.

Identifying problems

Although survey design in the Scottish dredge survey in area 4 is quite similar to the design in the Danish survey in areas 1 and 3, comparison of internal consistency indicate different age specific catchabilities among areas. This may be explained by a negative size selectivity for sandeels less than 8.5 cm (Appendix A2) and that size at age is much smaller in area 4 than in the other two areas.

4.2.1.6 Index development

Input into assessment

The preseason survey in December with present coverage yields an age structured index including assessment year estimates of maturity ogives for areas 1, 3, and 4; whereas extension of the survey with more locations is needed for production of an index for area 2. However recruitment estimates from area based assessment show a high correlation between area 1 and 2 and thus indicate that the survey index from area 1 may be used as a fisheries independent index proxy for area 2 as well.

Input into short term prediction

The index should be integrated in an update preseason assessment including an appropriate short-term prediction of fishing opportunities.

4.2.2 Acoustic estimates by sandeel fishing ground in the Norwegian EEZ in the North Sea

Acoustic abundance-estimation methods (Simmonds and MacLennan, 2005) using vertical echosounders have been used to estimate numerous pelagic stocks since 1970 (Gjøsæter *et al.*, 1998). When carefully used, the method provides absolute abundance estimates, as demonstrated for capelin (*Mallotus villosus)* stocks in the Barents Sea (Dommasnes and Røttingen, 1985; Toresen *et al.*, 1998), Iceland (Vilhjalmsson, 1994), and Newfoundland (Miller and Carscadden, 1990).

Institute of Marine Research has carried out acoustic sandeel surveys in the North Sea since 2005 with the objective to develop a robust survey methodology for sandeel combining advance acoustic technology and catching devices for sandeel buried in the sediments (Johnsen *et al.*, 2009). Concurrently, we have monitored the sandeel grounds in the Norwegian Economical Zone, and in some surveys also the grounds in the EU EEZ. In this working document we present the methodology used to establish acoustic abundance estimates for the period 2007–2010 for the major sandeel grounds in the Norwegian EEZ.

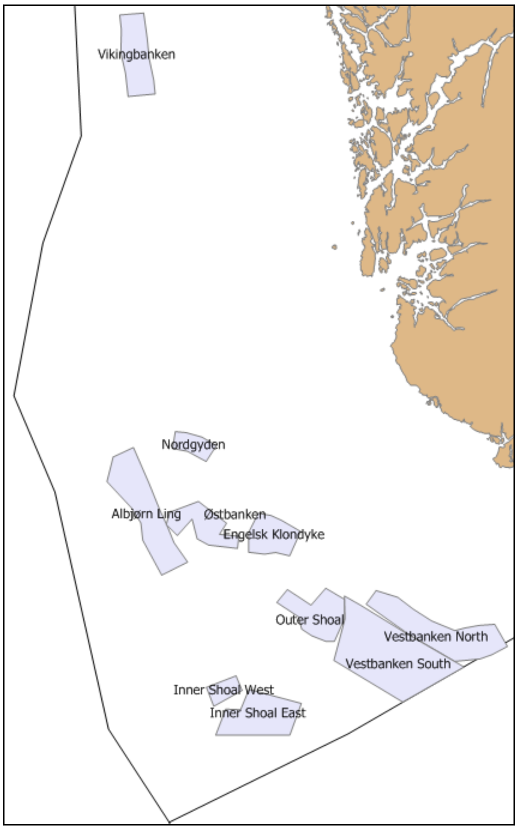


Figure 4.2.2.1. Sandeel fishing grounds in the Norwegian EEZ.

Sandeel fishing grounds in the North Sea have been identified from WMS data (satellite tracking data) of the Danish and Norwegian sandeel fleets. In addition, several Norwegian vessels have generously provided trawl trajectories from the sandeel fishing grounds obtained the last 8–10 years. The fishing grounds form a patchwork of clearly defined areas spread all over the North Sea at depths between 20–70 m, except at the Viking bank were sandeel are found between 90 and 110 m.

Survey grounds in Norwegian EEZ

- Vikingbanken
- Nordgyden
- Albjørn-Ling
- Østbanken (Kadaveret is on the northern part of the ground)
- Engelsk Klondyke
- Inner Shoal West
- Inner Shoal East
- Outer Shoal
- Vestbanken North
- Vestbanken South

These fishing grounds were used to define the survey areas in the Norwegian EEZ, which for all cases included larger areas than the fishing grounds. It has been a slight change in the survey areas in the 2007–2010 periods, but the change is ignorable with regard to the abundance estimates. Figure 1 shows the survey areas used during the 2009 and 2010 surveys.

4.2.2.1 Survey design

Standard random parallel and zig-zag transect designs are used, where the parallel design is mostly used on the larger Vestbanken North and South and on the Outer Shoal. In the planning of the cruise track, the direction of the fishing fields are consider as the track should be perpendicular to the normal industry towing direction.

In general, the effort allocation or the degree of coverage is based on the expected density of sandeel on each ground, and the day light time available is also considered in the planning.

Acoustic data are recorded with an 18, 38, 120, and 200 kHz echosounder system (and also with 70 and 333 kHz in 2009) (Simrad EK60) which was calibrated using standard procedures. The transducers are mounted on a retractable keel in accordance with recommended settings. Pulse duration for all frequencies was 1.024 ms and a ping repetition frequency of typically four Hz was chosen to maximize the number of echoes from small sandeel schools.

The acoustic survey began each morning after sandeel emerged from the seabed and continued until about 20:00 UTC. The data were post-processed using the Large Scale Surveying System (LSSS) (Korneliussen *et al.*, 2006). The borders of the schools were delineated in the 200 kHz echogram because the S_v from sandeel is strongest and the reverberant noise from gas-bearing phytoplankton is lowest at this frequency. The mean nautical area scattering coefficient (NASC) (MacLennan *et al.*, 2002) was measured for each school at each frequency. Frequency responses are now commonly used for the acoustic identification of species (see summaries in Reid, 2000; Simmonds and MacLennan, 2005). Korneliussen and Ona (2002) proved that the relative frequency responses of acoustic targets can be used to identify their taxa or species. The use of relative frequency responses to discriminate between several species was further developed by Anon. (2006) for swim-bladdered fish, such as sardine, anchovy, saithe, cod, Norway pout, and also fish without swim-bladders, such as mackerel. In addition to relative frequency responses, metrics of fish-school morphology and behaviour can sometimes be used to classify echoes, and validated by trawl samples.

The boundary towards the bottom, where schools were in the vicinity of this boundary was cutoff at about 0.3–0.5 meters off the detected bottom to be safe that no bottom echo was included inside the school energy. Scrutinized data was stored to database in bins of 10 m depth and 0.1 nmi (185.2) meters resolution. Distribution maps and computations are made at this resolution.

During the surveys, three different trawls have been used to catch sandeel: a Campelen 1800 bottom trawl; a Harstad pelagic trawl (originally a 16 x 16 fathom Capelin trawl with 5 mm meshes in the codend) to catch schools in the pelagic zone and near the surface; and a large commercial Steintrawl sandeel trawl with a 700 m headline circumference to sample the entire water column. Trawls targeting acoustically identified sandeel schools are restricted to daytime. In addition, a 0.25 m^2 Van Veen grab and a modified scallop dredge (the same as used in the Danish dredge surveys) were used both daytime and night-time to sample fish burrowed into the seabed.

4.2.2.2 Abundance estimation

The acoustic estimates presented in this report use the 38 kHz NASC, and the mean was calculated for data scrutinized as sandeel and collected along the transects (acoustic recordings taken during trawling, etc are excluded).

The number of sandeel in each length group within the surveyed area is then computed as:

$$N_i = f_i \frac{< s_A > \quad A}{< \sigma >},$$

where:

$$f_i = \frac{n_i L_i^2}{\sum_{i=1}^{m} n_i L_i^2},$$

is the "acoustic contribution" from the length group L_i to the total energy. $<s_A>$ is the mean backscattering coefficient [m^2/nmi.^{2}] (NASC) for the survey ground. A is the area of the survey ground [nmi.^{2}] and $<\sigma>$ is the mean backscattering cross section of the sandeel at length L_i. With the present lack of target strength data on sandeel, we have preliminarily used the one suggested at 38 kHz (MacLennan and Simmonds, 1992): $<TS> = 20\log L - 93$ dB where the conversion: $<\sigma> = 4\pi\ 10^{(<TS>/10)}$ is used for estimating the backscattering cross section from the mean TS.

An age–length key estimated based on both data from the survey and catches from the commercial vessels from the area is then used to get number by age. The biomass of the survey area can be computed from the weight–length keys estimated from data sampled during the survey: $w = aL^b$.

4.2.2.3 Acoustic availability

Day and night dredge hauls are on all survey grounds carried out on adjacent positions (pairs) in the survey areas. As all lesser sandeels (age 1+) probably are buried in the seabed at night, the difference in catch rates in dredge at night and the subsequent day at a given location (*i*) will presumably reflect the acoustic availability ($1 - {catch_{di}}/{catch_{ni}}$). Based on the observed day–night ratio, it is possible to adjust the acoustic NASC values with the estimated acoustic availability, but there are relatively large uncertainty connected to such a procedure. A more robust method is therefore to repeat the acoustic survey when the day–night ratio is below a predefined level. During our surveys we have not found high numbers of sandeels in the sand on any of the survey grounds in the Norwegian EEZ.

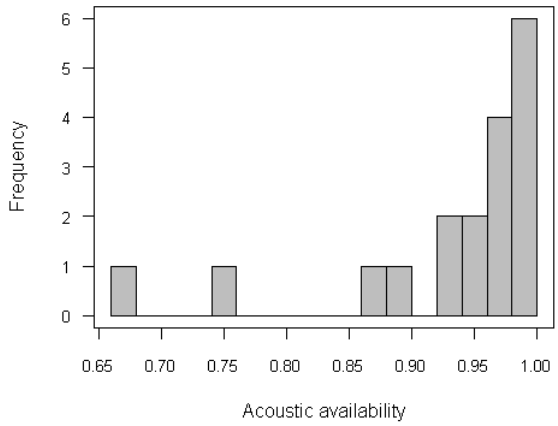


Figure 4.2.2.2. A histogram of the distribution of the acoustic availability defined as $1 - {catct_{di}}/{catch_{ni}}$ where catch rates in dredge at night is compared with the day catches the subsequent day at a given location (*i*). The presented data (n=18) were collected during the 2008 survey and shows stations with night catches larger than 50 sandeels.

4.2.2.4 Results

As pointed out above, the main purpose of the surveys has been to develop a robust survey methodology, which has reduced the effort spent on monitoring the abundance. Still, the results presented below can be regarded as a good indicator of the abundance of sandeel by ground.

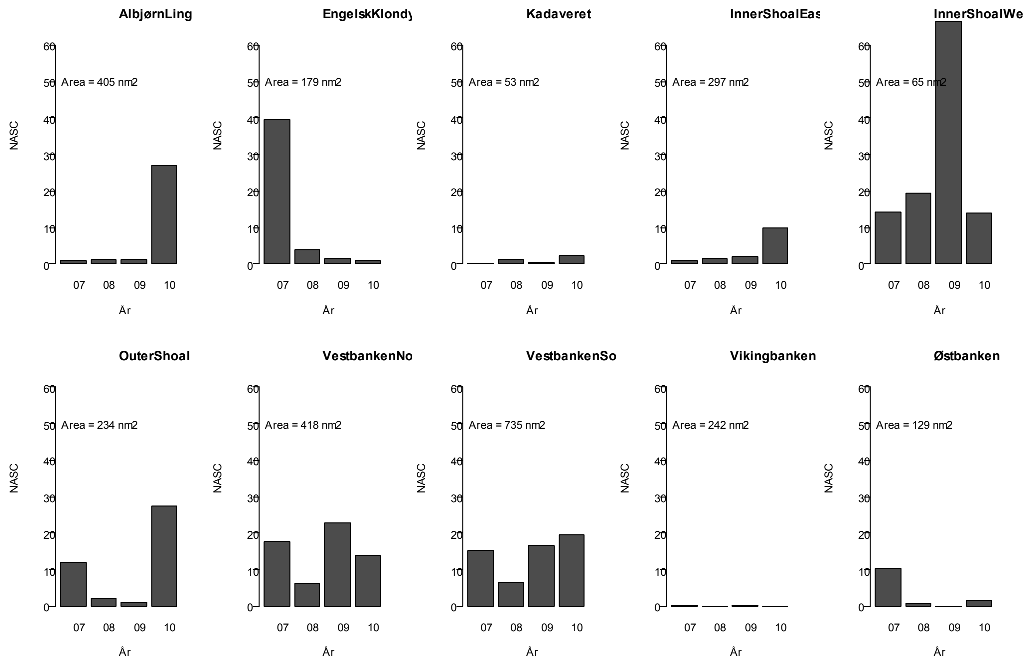


Figure 4.2.2.3. Acoustic densities of sandeel on the survey grounds for the period 2007–2010. Nordgyden is not shown.

4.3 Maturity

4.3.1 Background

Past estimates of spawning–stock size assumed a knife edge age-at-maturity, with all sandeels spawning at age 2. A model of maturity in relation to size, age and area found that this assumption did not hold for all sub-population areas (Boulcott *et al*., 2007). The data used in that publication were collected during dredge surveys in 1999 and 2004. Data from 1999, indicated that a significant proportion of sandeels from area 3 were mature by age 1 (January 1st). In area 4, sandeels were found to mature at a smaller size than in other areas but because of their low growth rate, the proportion mature by age 2 was still less than 1. Unpublished data for area 4 from 2000 were consistent with the published results.

4.3.2 Available time-series of maturity data

A time-series (2004–2009) of spatially resolved maturity data from the Danish December dredge survey for areas 1-3 is held by the Danish institute. The working paper of Steen (Appendix 7) evaluates the assumption of knife edge maturity from these data. Whilst most sandeels from the time-series were mature at age 1, the benchmark group found, contrary to the conclusion of the WD, that there was sufficient deviation from the knife edge age-at-maturity assumption to decide that annual differences should be considered in area based assessments (see Section 5). Low sample sizes for age classes >1 make the application of annually varying maturity ogives dubious. For area 4, only the age maturity key of Boulcott *et al*. (2007) was applied, as there was no time-series of data available.

4.3.3 Applicability to stock–recruitment analysis

A comparison of the stock–recruitment relationship with constant maturity ogives and annually varying ogives for the available years in the Danish dataset did not influence the perception of the SSB breakpoint with the present relatively short time-series.

4.4 Natural mortality

The values of natural mortalities for sandeel used in the previous historical assessment are based on MSVPA model output, and have been kept constant since 1989 (ICES CM 1989/Asssess:13).

The most recent estimate of natural mortality was done in 2008 by the Working Group on Multispecies Assessment Methods (WGSAM) in the latest North Sea key-run (ICES, 2008). The model does not provide spatial estimates of natural mortality. Compared to the MSVPA results used as basis for M in the pre-2010 WGNSSK assessment the WGSAM results are based on almost twice as many stomachs observations including both additional stomach samples for the main predators (cod, haddock, whiting, saithe and mackerel) and additional predators (horse mackerel, grey gurnard, *Raja radiata*, and ten bird species). Figure 4.4.1 shows the partial predation mortality (M2) of sandeel by year as estimated by WGSAM. To obtain the total natural mortality, a value of 0.2 representing additional natural mortality (M1) should be added (M=M1+M2). The average of the estimated annual M is quite close to the values used by the assessment (Table 4.4.1). It should be noted that the sum of the half-year M may deviate from the annual M due to different F in the two half-years. The estimated yearly natural mortality is shown in Figure 4.4.2. It is clear that there has been a significant increase in M since the late 1990s. The natural mortalities by age as estimated by WGSAM show almost equal values for the two half-years (Figure 4.4.3), while the M used by the assessment are much higher in the first half year.

The group considered that since there were updated estimates of half-yearly natural mortality available from WGSAM, these should be used in the assessment. As the trends in natural mortality were only apparent in the end of the time period where the uncertainty is greatest, it was decided not to use annual estimates of M. Instead, the average over the period 1982 to 2007 for each age and half-year was used. However, the group considered it unfortunate that spatially explicit natural mortalities were not available as it is unlikely that natural mortality is constant across the assessment areas.

Table 4.4.1. Natural mortalities for sandeel as used by the ICES assessments and as estimated by WGSAM.

	Assessment			WGSAM 2008
Age	First half year (halfyear^{-1})	Second half year (halfyear^{-1})	Sum (year^{-1})	Average 1982-2007 M=0.2+M2 (year^{-1})
0	-	0.8	0.8	0.96
1	1.0	0.2	1.2	1.04
2	0.4	0.2	0.6	0.86
3	0.4	0.2	0.6	0.68
4	0.4	0.2	0.6	0.64

Table 4.4.2. Agreed natural mortalities for sandeel.

	Assessment		
Age	First half year (halfyear^{-1})	Second half year (halfyear^{-1})	Sum (year^{-1})
0	-	0.96	0.96
1	0.46	0.58	1.04
2	0.44	0.42	0.86
3	0.31	0.37	0.68
4	0.28	0.36	0.64

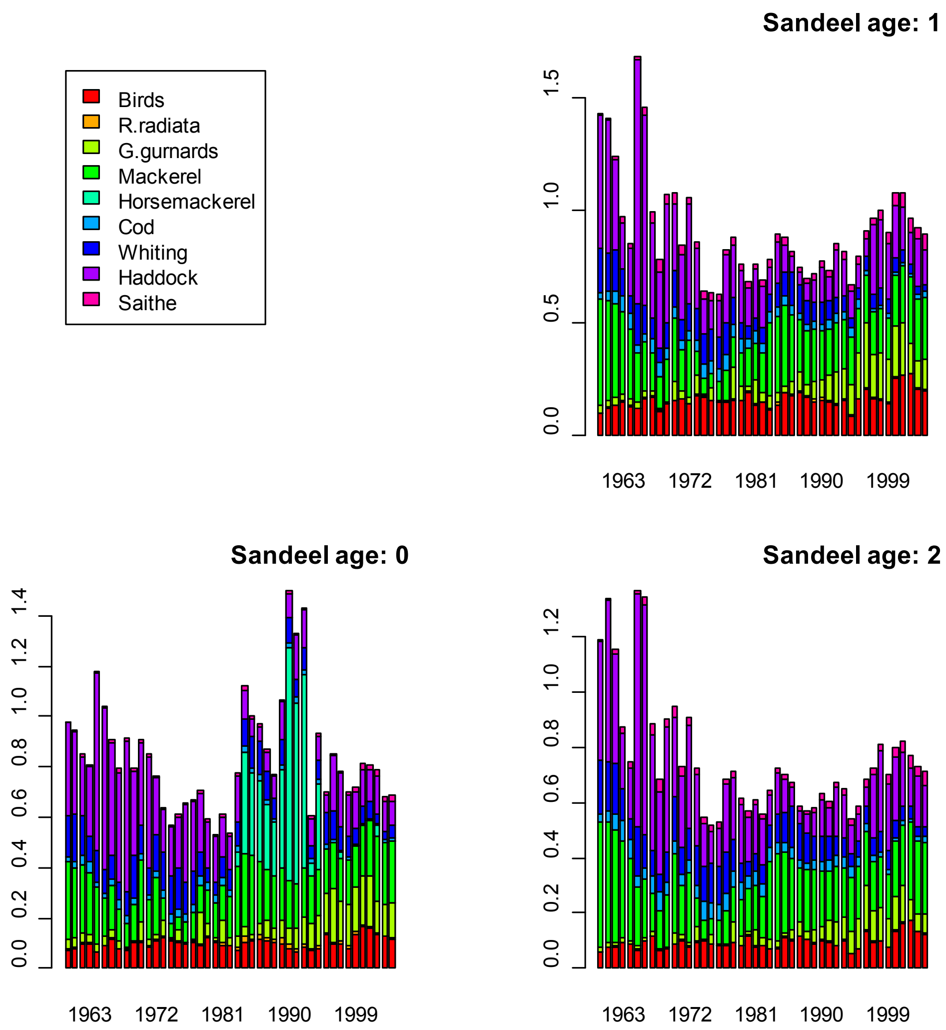


Figure 4.4.1. Partial predation mortality (M2) for the period 1966 to 2007 as estimated by the SMS model, Annual values are used for age 1 and 2, while M2 for age 0 is for the second half year is by half year (from ICES 2008).

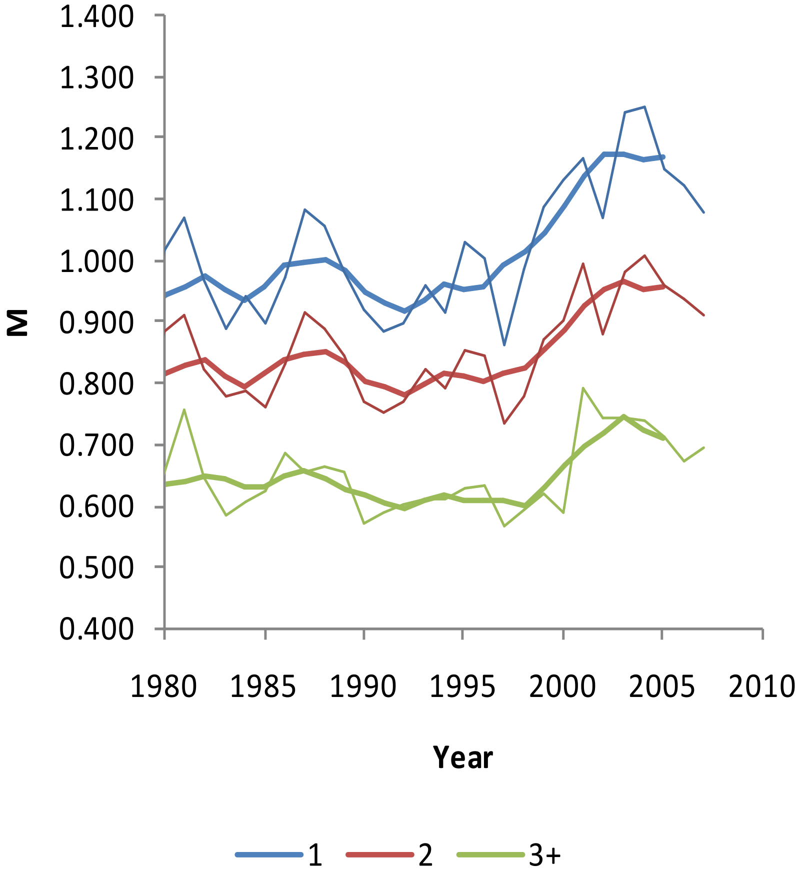


Figure 4.4.2. Yearly natural mortality for different age groups of sandeel estimated by WGSAM (ICES 2008). Heavy lines are 5-year moving averages.

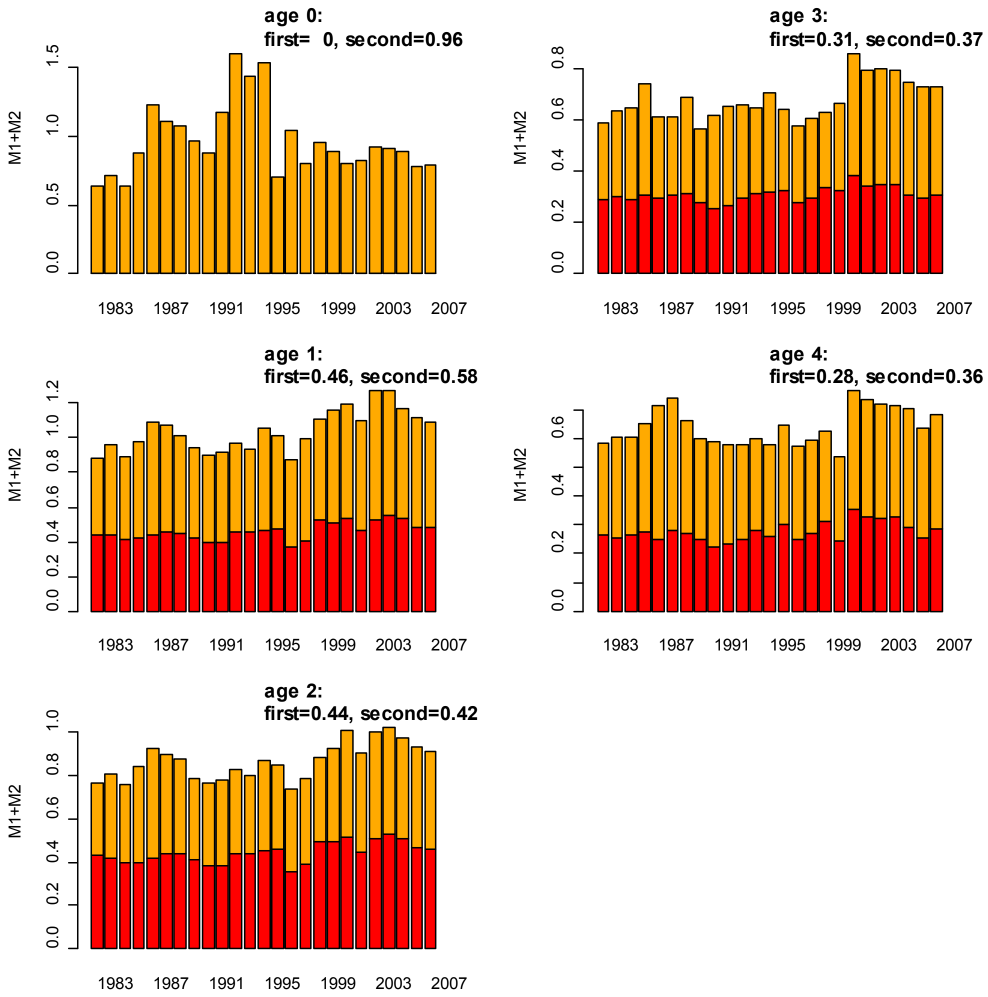


Figure 4.4.3. Natural mortality (M1+M2) of sandeel by half year. Mean values (1982–2007) for first and second half year are presented in the headings.

4.5 Fleet development in vessels and gear in the Danish sandeels fishery 1985–2010

<u>1985–1995</u>: Seven new trawlers were built in 1985. Vessels that could hold about 1000 tonnes and which had bigger engines and propellers compared to the rest of the fleet.

Before 1985, an ordinary vessel had a constant drag at about 6–7 tonnes and a machine at 600–700 hp. An average catch in a good fishery was 40–50 tonnes per set of 3 hours. 4 to 5 set were possible per day.

The new trawlers that were introduced in 1985 had a constant drag at about 20–30 tonnes and a machine at 1500–2000 hp. An average catch in a good fishery was 150–200 tonnes per set of 4–5 hours. 3 set were possible per day.

The new trawlers were able to use a bigger codend, which meant that the sandeels in the codend was kept alive and consequently much larger catches were possible because the trawl did not close.

The small trawlers now started to use as big codends as possible. Too big codends created “dead waters” inside the codend and therefore, the fishing was not effective. So there is an upper end to the size of the codend with regard to the size of the trawl.

In the beginning of the 1990s most of the trawlers were lengthened and stronger engines were put into the vessels. The investment and thereby the improvement of the vessels lead to a much larger fleet of “super” trawlers, at a sizes which made it possible for them to use bigger trawls and bigger codends.

In 1995–2000 and forward Dyneema became a component in the trawl and some trawls used up to 80% Dyneema. This made it possible to make the trawls bigger compared to trawls made of nylon. The Dyneema fibre was thinner compared to nylon at the same strength and thereby the water resistance was much lower allowing bigger trawls to be dragged by the same hp. Where a trawl made of nylon was able to open 18–20 metre the trawl made of Dyneema could open up to 40–50 metre.

From 2000 and forward there has not been any big advancement in the vessels and gear used for targeting sandeels. The big increase seen from 2000 and forward in Figure 4.5.1 is because of a couple of big ships entering the fishery (Figure 4.5.2).

The development in the Norwegian sandeels fishery follows the same pattern as the Danish development.

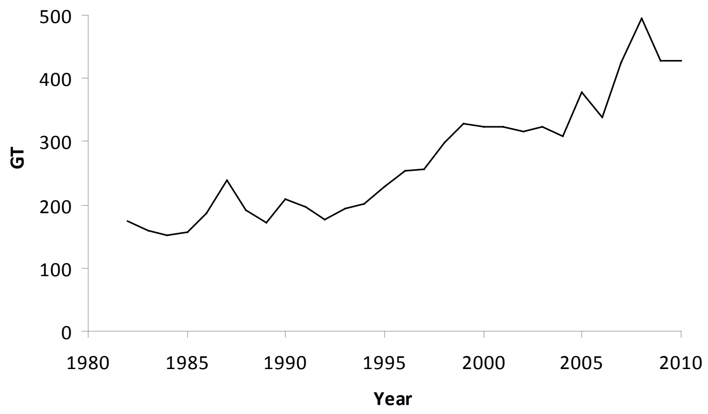


Figure 4.5.1. Development in average vessel size.

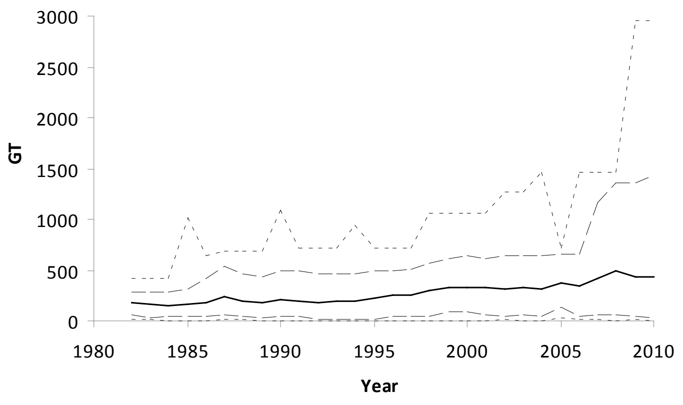


Figure 4.5.2. Development of fishing days weighted average vessel size. Mean (solid), 5 and 95 percentiles (dash) and minimum and maximum vessel size (dotted).

5 Assessment Models

Three assessment models were considered as potential candidates for the historical assessment of the different stock units, a VPA based model (SXSA) (Skagen, 1994) and two statistical catch-at-age models. Prior to the meeting a state-space model was investigated but found to be unstable for these stocks and therefore was not presented to the group. Table 5.1 summarises the differences between the three model approaches.

Previous whole-area assessments of sandeel showed no consistent relationship between effort and F (Figure 5.1). When moving towards a more biologically plausible assessment area there is evidence that fishing effort may be used as a reasonable proxy for fishing mortality (Figure 5.2). This relationship has been used by the statistical catch models as the driver for estimating F.

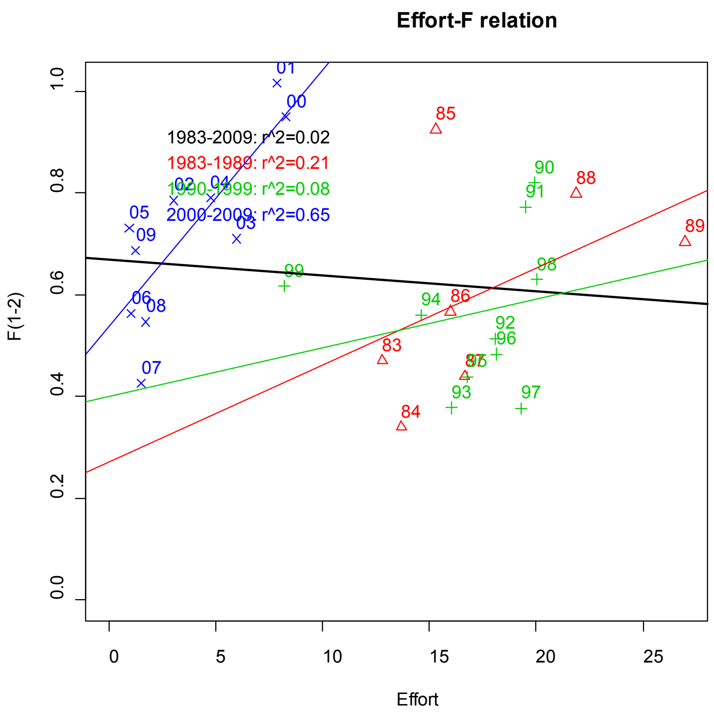


Figure 5.1. Relationship between standardised effort and F from the whole-area assessment (WGNSSK, 2009).

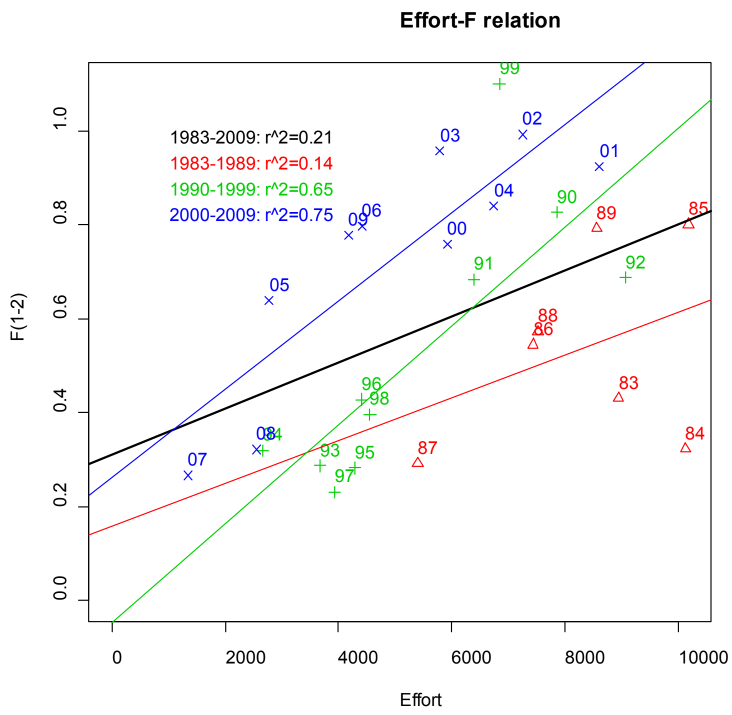


Figure 5.2. Relationship between standardised effort and F derived from a SXSA run for area 1.

5.1 SXSA (EB)

Seasonal XSA (SXSA, Skagen, 1994) has been the model used by ICES (WGNSSK) for the assessment of North Sea Sandeel since the mid nineties. SXSA is essentially a standard VPA, tuned with some index of abundance and split into two seasons. The advantage of using this model over the standard (single season) XSA (Shepherd, 1999) was that SXSA was able to incorporate the different levels of natural mortality considered to occur between the seasons. For assessments undertaken in the second half of the year, landings from the first half of the current year could be incorporated and was also able to give a more up to date estimate of stock status than other methods.

Previous ICES Sandeel assessments have implemented the model as a single stock prosecuted by two fleets (Northern and Southern). Eight tuning fleets were provided, all derived from commercial cpue comprising all combinations of areas and seasons, split into two time periods at 1998 to reflect a change in gear development. The model diagnostics consistently gave cause for concern with large residual patterns and consistent retrospective patterns. The ratio of estimated fishing mortalities between age 1 and 2 were also erratic with large interannual variations. The use of commercial cpue as the only tuning index, although the only tuning-series available was never particularly satisfactory. In addition the same catch numbers are used twice; in the catch at age and in the cpue data, which causes unwanted correlation, and probably the large variation in exploitation pattern from one year to the next. These changes also indicates, that the assumption of fixed catchability-at-age (~fixed exploitation pattern) for tuning fleet is violated.

Following the decision to assess the different stock components separately, a trial run of SXSA was made for area 1 using the newly-revised estimates of natural mortality and maturity. A model run using data up to 2010 failed to give a satisfactory result, the model opting to fit very closely to a single tuning fleet.

5.2 SMS-effort (MV)

Summary

As effort has been shown to be a reasonable proxy for F the SMS model was modified to model fishing mortality as a function of total commercial fishing effort. The new model has options to estimate rates for technical creeping and thereby take into account that the efficiency has increased in the sandeel fishing fleet. The results show that the new model fits to data in a reasonable way, and give results without retrospective bias. Model results show a significant increase in fleet efficiency and a change in exploitation pattern, with more effort directed to the fishing banks with the highest abundance of the one-group sandeel. The model can be applied for assessment with just catch and effort, and for assessment where additional fisheries independent data are available.

Methodology

The SMS model, presently used for the ICES assessment of blue whiting (WGWIDE), and for the North Sea and Baltic Sea multispecies (WGSAM), was modified slightly to estimate fishing mortality from observed effort. In the original SMS version, fishing mortality, $F_{y,q,a}$ was modelled as an extended separable model including a seasonal, age and year effect. The new version substitutes the year effect by observed effort.

$$F_{y,q,a} = \text{SesonEffect}(Y,A1) * \text{AgeEffect}(Y,A2,q) * \text{YearEffect}_y \quad \text{(1, original version)}$$
$$F_{y,q,a} = \text{SesonEffect}(Y,A1) * \text{AgeEffect}(Y,A2,q) * \text{Effort}_{y,q} \quad \text{(2, new version)}$$

where

indices A*1* and *A2* are groups of ages, (e.g. ages 0, 1–2, 3–4) and *Y* is grouping of years (e.g. 1983–1998, 1999–2009). The SMS-effort defines that the years included in the model can be grouped into a number of period clusters (*Y*), for which the age selection and seasonal selection are assumed constant. Fishing mortality is assumed proportional to effort. The grouping of ages for age selection, *A1*, and season selection, *A1*, can be defined independently.

An example of parameterization with maximum annual effort at 1.0 is shown below. (Unique parameters in bold).

	Season effect A1=age 0 and age 1-4										
	First half year						Second half year				
YY	Age 0	Age 1	Age 2	Age 3	Age 4		Age 0	Age 1	Age 2	Age 3	Age 4
1983-1998	0.00*	0.426	0.426	0.426	0.426		1.0*	0.5*	0.5*	0.5*	0.5*
1999-2009	0.00*	0.337	0.337	0.337	0.337		1.0*	0.5*	0.5*	0.5*	0.5*

*** kept constant**

	Age effect A2=age 0, age 1, age2 and age 3-4										
	First half year						Second half year				
YY	Age 0	Age 1	Age 2	Age 3	Age 4		Age 0	Age 1	Age 2	Age 3	Age 4
1983-1998	0.00*	0.488	1.024	1.248	1.248		0.014	0.772	0.847	0.585	0.585
1999-2009	0.00*	0.772	0.857	0.585	0.585		0.010	0.176	0.195	0.133	0.133

"Catchability"-at-age, or more correctly the relation between effort and F by age group, is included in the AgeEffect parameter.

There are two additional options for the SMS-effort version, where technical creeping is taken into account.

$$F_{y,q,a} = \text{SesonEffect}(Y,A1) * \text{AgeEffect}(Y,A2,q) * \text{Effort}_{y,q} * (\text{y-firstYear})^{\text{commonCreep}(Y)} \quad (3)$$
$$F_{y,q,a} = \text{SesonEffect}(Y,A1) * \text{AgeEffect}(Y,A2,q) * \text{Effort}_{y,q} * (\text{y-firstYear})^{\text{ageCreep}(Y,A1)} \quad (4)$$

Equation (3) uses a common creeping exponent for all ages by one or more year clusters (Y), e.g. the efficient increase by 3.8% per year in the first year range, and 2.8% per year in the second. Equation (4) is more flexible as it allows an age dependent creeping exponent. If we assume that we only use one year cluster (the whole year range) an example could be that the technical creep for age 1 is 5.5% per year, while age 2 has a negative exponent, -2.7% (equivalent to parameter=0.973). As the product of effort and "technical creep" express both the fishing power and the directivity towards a specific age group, such an example indicate that there has been an overall increase in (standardised) fishing power, but the fishery has been less directed towards older sandeel in recent years.

SMS is a statistical model where three types of observations are considered: Total international catch-at-age; research survey cpue (and stomach content observations, which are not used here). For each type a stochastic model is formulated and the likelihood function is calculated. As the three types of observations are independent the total log likelihood is the sum of the contributions from three types of observations. A stock–recruitment (penalty) function is added as a fourth contribution.

Catch-at-age

Catch-at-age observations are considered stochastic variables subject to sampling and process variation. Catch-at-age is assumed to be lognormal distributed with log mean equal to log of the standard catch equation The variance is assumed to depend on age and season and to be constant over years. To reduce the number of parameters, ages and seasons can be grouped, e.g. assuming the same variance for age 3 and age 4 in one or all seasons. Thus, the likelihood function, *Lc*, associated with the catches is

$$L_{CATCH} = \prod_{a,y,q} \frac{1}{\sigma_{CATCH\ a,q}\sqrt{2\pi}} \ \exp\left(-\frac{(\log(C_{a,y,q}) - E(\log(C_{a,y,q})))^2}{2\sigma^2_{CATCH\ a,q}} \right)$$

Where

$$E(\log(C_{a,y,q})) = \log\left(\frac{F_{a,y,q}}{Z_{a,y,q}} \ N_{a,y,q}(1-e^{-Z_{a,y,q}}) \right)$$

Leaving out the constant term, the negative log-likelihood of catches then becomes:

$$l_{CATCH} = -\log(L_{CATCH}) \propto NOY \sum_{a,q} \log(\sigma_{CATCH\,a,q}) + \sum_{a,y,q} (\log(C_{a,y,q}) - E(\log(C_{a,y,q})))^2 / (2\sigma^2_{CATCH\,a,q}))$$

Survey indices

Similarly, the survey indices, *cpue(survey,a,y,q),* are assumed to be log-normally distributed with mean

$$E(\log(CPUE_{survey,a,y,q})) = \log(Q_{survey,a} \overline{N}_{SURVEY\ a,y,q})$$

where Q denotes catchability by survey and $\overline{N}_{SURVEY}$ mean stock number during the survey period. Catchability may depend on a single age or groups of ages. Similarly, the variance of log *cpue,* $\sigma(survey,a)$, may be estimated individually by age or by clusters of age groups. The negative log likelihood is on the same form as for catch observations:

$$l_{SURVEY} = -\log(L_{SURVEY}) \propto \sum_{survey,a} NOY_{survey} \sum_{survey,a} \log(\sigma_{SURVEY\,survey,a}) \ +$$
$$\sum_{survey,a,y} (\log(CPUE_{survey,a,y}) - E(\log(CPUE_{survey,a,y}))^2 / (2\sigma^2_{SURVEY\,survey,a}))$$

Stock-recruitment

In order to enable estimation of recruitment in the last year for cases where survey cpue and catch from the recruitment age is missing (e.g. saithe) a stock–recruitment relationship $R_y = R(SSB_y \mid \alpha, \beta)$ penalty function is included in the likelihood function. Assuming that recruitment takes place at the beginning of the third quarter of the year and that recruitment is lognormal distributed the parameters the log penalty contribution, l_{SR}, equals

$$l_{SR} = -\log(L_{SR}) \propto NOY \ \log(\sigma_{SR}) + \sum_{y} ((\log(N_{a=0,y,q=3}) - E(\log(R_y)))^2 / 2\sigma^2_{SR})$$

where

$E(\ln(R_y)) = \ln(\alpha\ SSB_y \exp(-\beta\ SSB_y))$ for the Ricker case. Other stock–recruitment relations (Beverton–Holt and "Hockey stick") and stock-independent geometric mean recruitment have also been implemented. As indicated in equation (26) recruitment-at-age zero in the beginning of the third quarter was considered.

Total likelihood function and parameterisation

The total negative log likelihood function, l_{TOTAL}, is found as the sum of the four terms:

$$l_{TOTAL} = l_{CATCH} + l_{SURVEY} + l_{STOM} + l_{SR}$$

Initial stock size, i.e. the stock numbers in the first year and recruitment over years are used as parameters in the model while the remaining stock sizes are considered as functions of the parameters.

The parameters are estimated using maximum likelihood (ML) i.e. by minimizing the negative log likelihood, l_{TOTAL}. The variance/covariance matrix is approximated by the inverse Hessian matrix. The variance of functions of the estimated parameters (such as biomass and mean fishing mortality) has been calculated using the delta method.

The SMS model was implemented using the AD Model Builder (ADMB Project, 2009), freely available from ADMB Foundation (www.admb-project.org). ADMB is an efficient tool including automatic differentiation for Maximum likelihood estimation of many parameters in nonlinear models.

5.3 TED

The temporally explicit model is a statistical catch-at-age model it is developed to better match seasonal effort allocation pattern used in the sandeel fishery. The model is run separately in three areas, and its results compare well with results from other models (SMS, and XSA). In addition to the estimates produced by SMS and XSA the model is estimating the within year catchability pattern for separate age groups, and from that the instantaneous fishing mortality is computed by multiplying the catchability and the effort corresponding at each specific point in time. The model incorporates the new dredge survey from DTU-Aqua in the two areas (1 and 3) where it is available. Furthermore, the model is stochastic and quantification of uncertainties is a natural part of the model. A detailed model description is available in appendix A3 and model results can be found at:

http://www.nielsensweb.org/sandeelIdx/

5.4 Rationale for model selection

Comparison of the results and diagnostics from the SMS-effort and TED models showed that the ability to fit to the available data was similar for both models. However, as the SMS model is currently used to assess other ICES stocks (blue whiting and multispecies assessments) and therefore of the two statistical models, SMS-effort was the preferred separable approach.

The remaining decision was therefore between a statistical or deterministic model. The group considered that the ability of the SMS model to handle uncertainty in the catch-at-age data gives the SMS-effort model an advantage over the VPA approach. In addition the inability of SXSA to provide a satisfactory fit to the data including 2010 where SMS could provide a fit naturally raised concerns about the stability of the model. This, coupled to the ease of obtaining uncertainty estimates, lead to the Group opting to use SMS-effort for the assessment of Sandeels in the North Sea.

However, even with the move to a more realistic concept of stock definition, the ability of the catch data to track cohort strength remains weak for some areas. This could be a result of variable natural mortality, uncertainty within the age sampling process, spatial variability of fishing patterns by the fleet or (more likely) some combination of all these processes. These factors violate basic assumptions for both models; in particular changing spatial patterns in the fishery violates the assumption of fishing from a single dynamic pool. For the Sandeel fishery changes in the spatial pattern could result from sequentially depleting areas. This would be of less concern in stocks with a greater range of ages as the fishery would have several chances to prosecute a year class on any given, but for sandeels with essentially two main age classes annual changes in fishing pattern may have a significant impact.

	SXSA	SMS-effort	TED
Model type	Deterministic VPA	Statistical catch-at-age	Statistical catch-at-age
Catch at age data	Assumed exact	Observation error estimated within model	Observation error estimated within model
Tuning data	Commercial CPUE & survey	Survey	Survey
Timestep	Half-year	Half-year	Yearly catches, weekly effort
Catchability	Constant by age ('83–98 & '99–)	Constant by age ('83–98 & '99–)	seasonal pattern, constant for all years
Use of Commercial effort	Into cpue	F Proportional to effort	F Proportional to effort
Natural mortality	Half-yearly	Half-yearly	Half-yearly
Ability to estimate technical creep?	none	Possible	Possible
Statistical distribution of parameter estimates	No	Yes (all)	Yes (all)
Forecast internal to model	No	Built-in	No
implementation	Fortran	ADMB & R	ADMB & R
Stock-recruit	None assumed	Can be included in likelihood	None assumed
Number of stocks currently used for	N Sea Norway Pout & North Sea Sandeel	N. Sea multispecies, Baltic multispecies, Blue Whiting (core SMS only)	Bespoke for N Sea Sandeel.
Documentation	Skagen, 1994	Lewy and Vinther, 2004; Vinther 2010	Nielsen, 2010
Peer-reviewed?	ICES acceptance	ICES acceptance (core SMS only)	New model

6 Short-term forecasting

6.1 Pre-season assessment

The investigations using the different models show consistently large retrospective patterns unless the dredge survey is included. Including the dredge survey largely removes this pattern, making it possible to produce unbiased estimate of terminal stock size. Further, the dredge survey shows high consistency both internally and externally in all areas, though the consistency in area 3 is somewhat lower than in the other areas (Figures. 4.2.1.6 and 4.2.1.7). Though there is currently no coverage of area 2 in the dredge survey, recruitment in area 2 is highly correlated with that in area 1 (Figure 4.1.5) and it is therefore possible to use the dredge catch rate in area 1 in the assessment of area 2. In area 3, the consistency of the survey is less and the CV of the SMS predictions is greater. The production of an updated assessment following the December survey should provide reliable estimates of stock size in the areas where the relationship between the assessed stock size and dredge catch rate is good (areas 1 and 2) but the estimates for area 3 would be less reliable. The dredge survey in area 4 cannot be used to produce pre-season assessments until the relationship between stock size and dredge catch in the area can be estimated from a longer time-series than is presently the case.

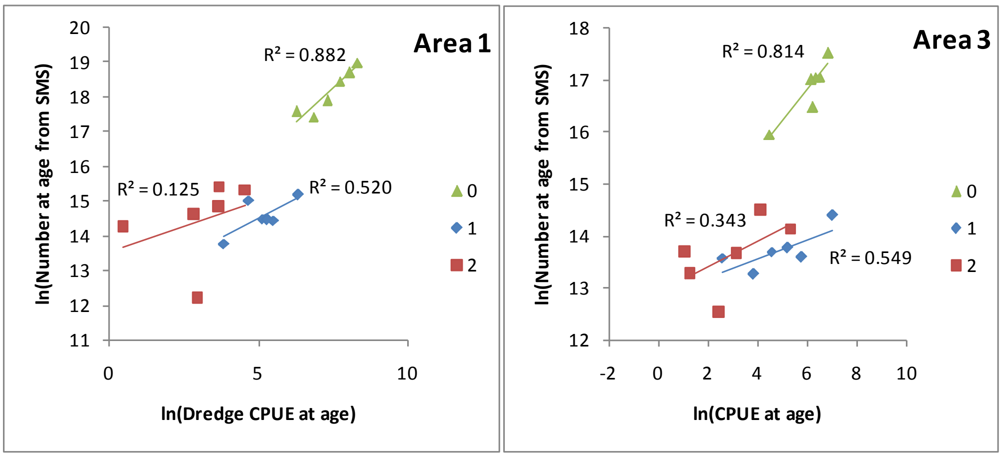


Figure 6.1.1. Relationship between dredge catch rate and SMS predicted stock size at age. Note that the data are not independent as the dredge survey is used in the estimation of stock size.

6.2 In-season monitoring

In-season monitoring using commercial catch rates in the beginning of the season has been used in sandeel management for a number of years. However, it is not clear whether the relationship between early season cpue in stock size is equally good in all areas or even whether it exists in all areas. Therefore, Figure 6.2.1 shows the catch rate prior to first of May (approximately the end of the real time monitoring period) as a function of stock abundance as estimated by the regional SMS models of area 1 and 3. It is clear that the relationship between catch rates in the early part of the season and stock abundance is very tight in area 1, which indicates that real time monitoring can be a valuable tool in in-season assessments of stock size in this area. However, the value of in-season monitoring would appear to be lower in area 3, reflecting the generally lower internal and external consistency in this area of both dredge catch rates and commercial catches. Whereas in area 1, all ages could potentially be used, it is clear that only age 1 can be used with any confidence in area 3. The poorer relationship for 1-year olds in area 3 appeared to be linked to a temporal shift, in catchability as trends in residuals over the period 1993 to 2010 suggested increased catchability after 2000 rather than 1998 in this area. Obviously there is some circularity in the relationship as the assessment is tuned using commercial cpue, but this is the approach taken (out of necessity) for the determination parameters of the in-year TAC revision performed in recent years.

A reliable in-season monitoring requires that both biomass indices and the age-composition of the biomass are available with minimum delay. Commercial catch rates are reported within three days and biological samples from the catch are collected continually. Similarly, the acoustic data are analysed as they are collected. Hence, if in-season monitoring is required, the data are available without additions to the normal sampling programme but with an additional requirement for the speed at which the data are analysed.

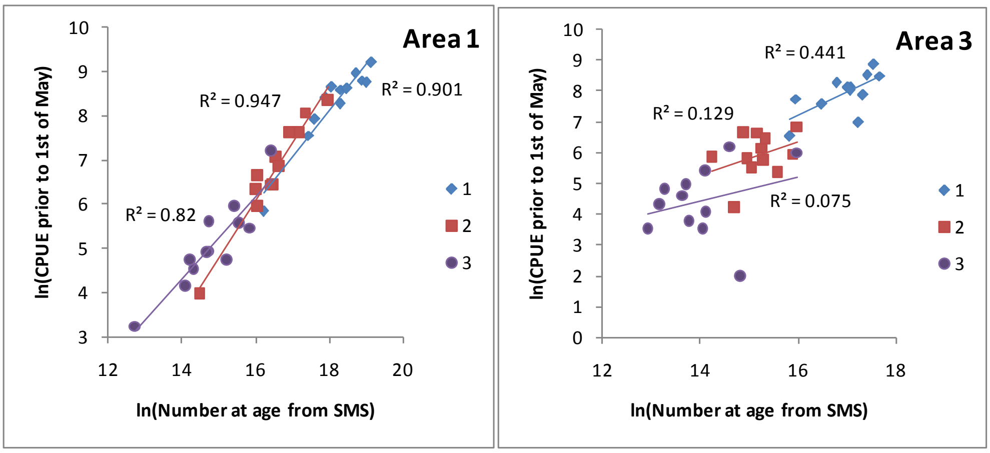


Figure 6.2.1. Catch rate in the real time monitoring period as a function of stock numbers estimated in SMS in area 1 and 3. Years 1998 to 2010.

6.3 Necessary sampling programmes

The rise in importance and reliability of the dredge survey has potential implications for the in-season monitoring programme which has been an important feature of Sandeel assessment and management over the past few years.

6.3.1 Area 1

Statistics show that the dredge survey is sufficiently robust to provide an estimate of the incoming 1-group such that the fishing opportunities for the coming year can be established in January. Although this relationship appears to be robust it may be prudent to continue some level of real-time monitoring in years where the dredge survey result is outside the bounds of the current observations particularly at the lower bound. There will be regular samples passed to DTU-Aqua as part of the standard monitoring process every year, but the requirement for real-time monitoring would only occur when the dredge survey is beyond historically observed bounds.

6.3.2 Area 2

There appears to be a sufficiently robust relationship between the recruitments in areas 1 and 2 to be able to use the same data sources and procedures from area 1 for the estimation of the incoming year class. There should, however, be an increase in the sampling coverage within this area.

6.3.3 Area 3

Pre-season estimates of the incoming year class appear less robust for this area and it is therefore appropriate that in-season monitoring (e.g. acoustic monitoring and age-based commercial cpue) to continue in area 3. The internal and external consistency of the acoustic survey is yet unknown and the consistency of commercial and dredge data is less in area 3 than in the other areas.

6.3.4 Area 4

Whilst it is important to continue Scottish dredge survey the overlap between this and the commercial time series is too short to provide robust estimates of incoming 1-group strength. There has been little or no information for this area from the in-year monitoring system in recent years due to the low commercial effort level expended in the area. Until there is sufficient overlap in the time-series of dredge survey and commercial data there will be no scientific basis to propose a TAC at present.

6.4 Reference points

Inspection of the stock–recruitment plots from area 1, 2 and 3 revealed a decrease in recruitment at low SSB in all areas (Figure 6.4.1). However, no clear plateau was visible and this was reflected in a very flat surface of the likelihood when attempting to estimate an inflection point. Hence, the group considered that the relationship in all areas fell into the category where there is a relationship between R and SSB but no clear plateau. In this category, SGPRP advised that B_{lim} should be set after evaluation of historic patterns (SGPRP 2003, Figures 6.4.2 to 6.4.4). The group did not consider the lack of plateau to have occurred through a consistent fishing down of the stock and hence did not think that there was evidence that B_{lim} was above the range of observed SSBs. It was also considered that a period of continuous low recruitment has only occurred around year 2000 and only in areas 2 and 3. After 2000, there has been a very low SSB in all areas but this followed the poor recruitment years rather than the opposite. For area 1 and 2, B_{lim} was therefore set as the median biomass in these years of low SSB (2000–2006) giving the values 160 000 tons for area 1 and 70 000 tons for area 2. In area 3, the drop in recruitment was also followed by a drop in SSB, but the level in the low period was more variable. For this area, B_{lim} was set at 100 000 tons, encompassing the lowest eight SSBs recorded. The level was set at the highest SSB observed in the period 2001–2007 (the period of low SSBs) rather than the median as there has been no really good recruitment years in the latter half of the period.

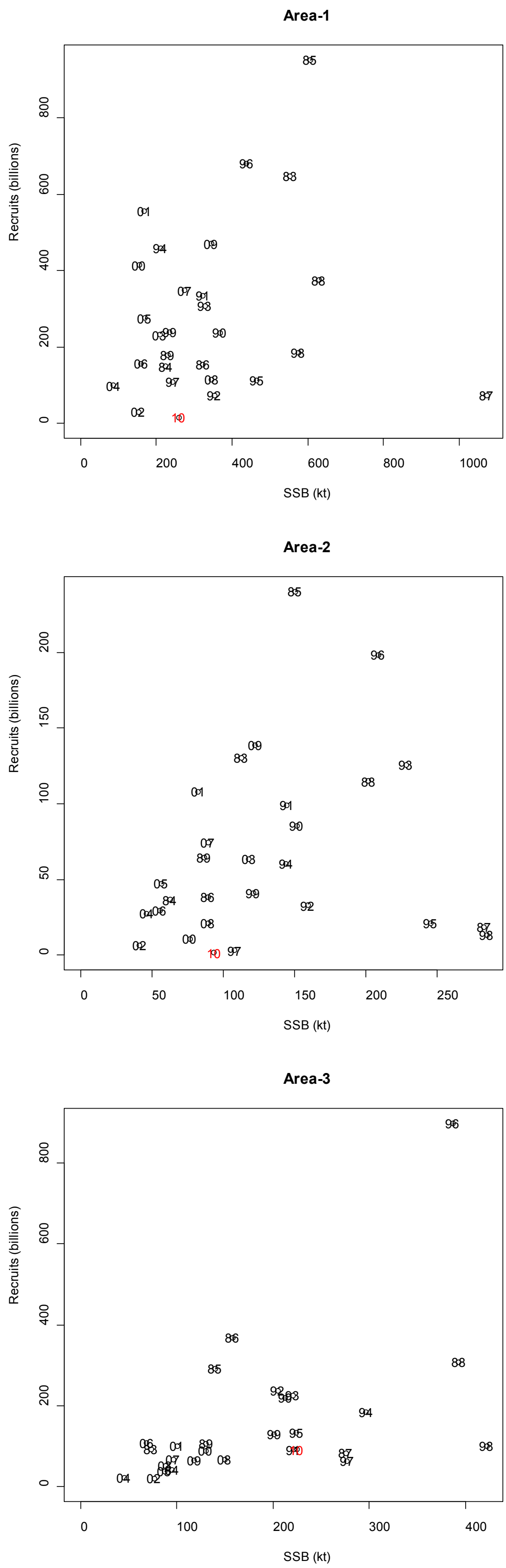


Figure 6.4.1. Stock–recruitment relationship in areas 1 to 3. Note that the recruit estimate for 2010 is based on very little input data and is therefore highly unreliable.

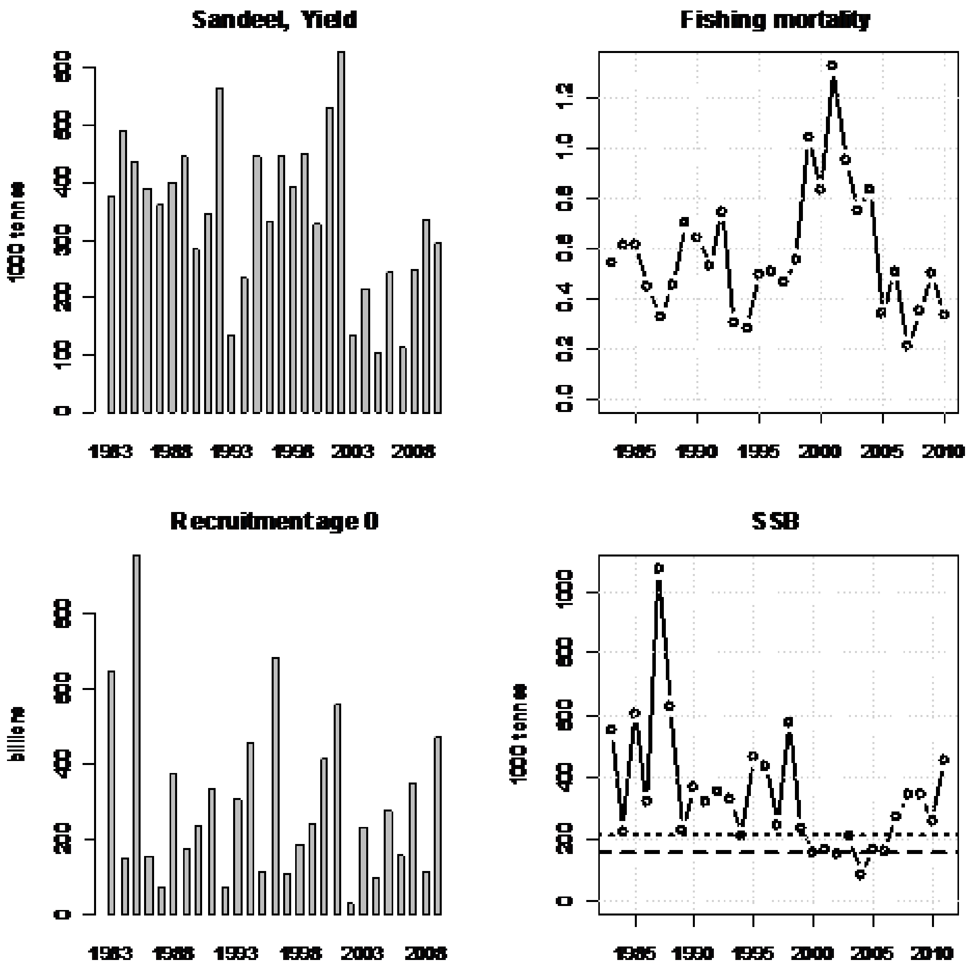


Figure 6.4.2. Stock summary for area 1.

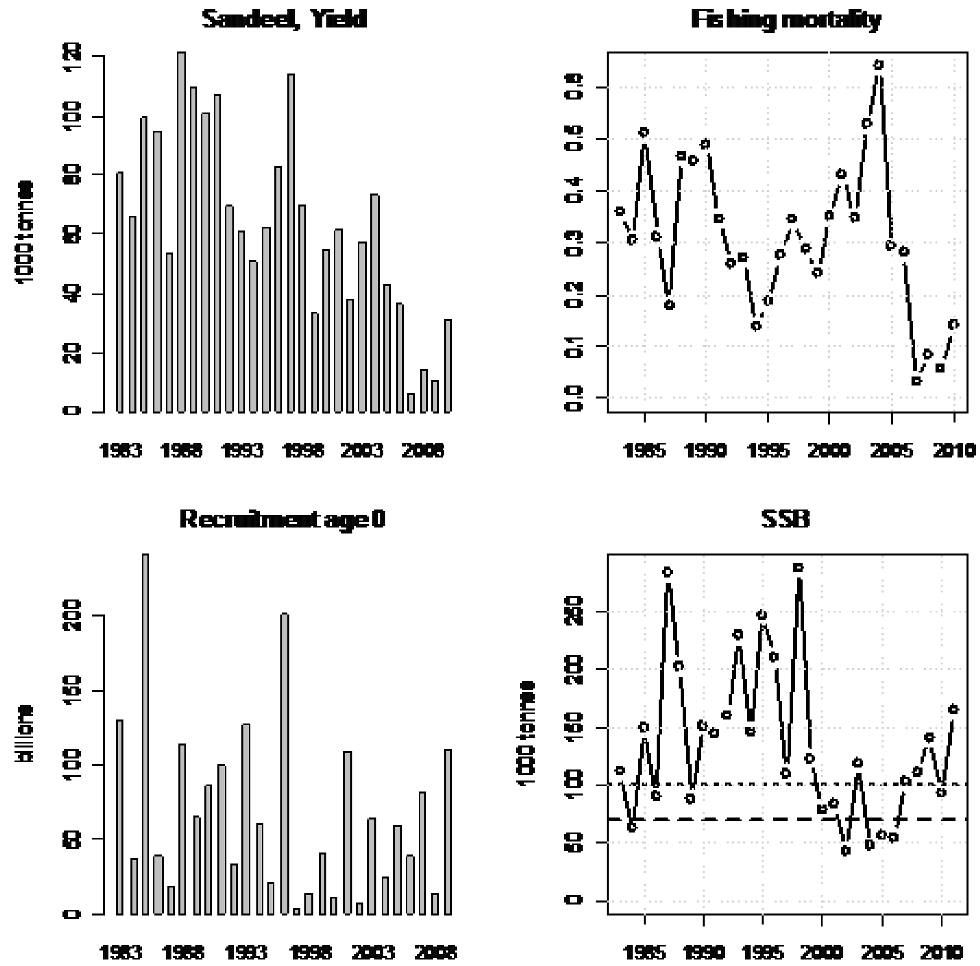


Figure 6.4.3. Stock summary for area 2.

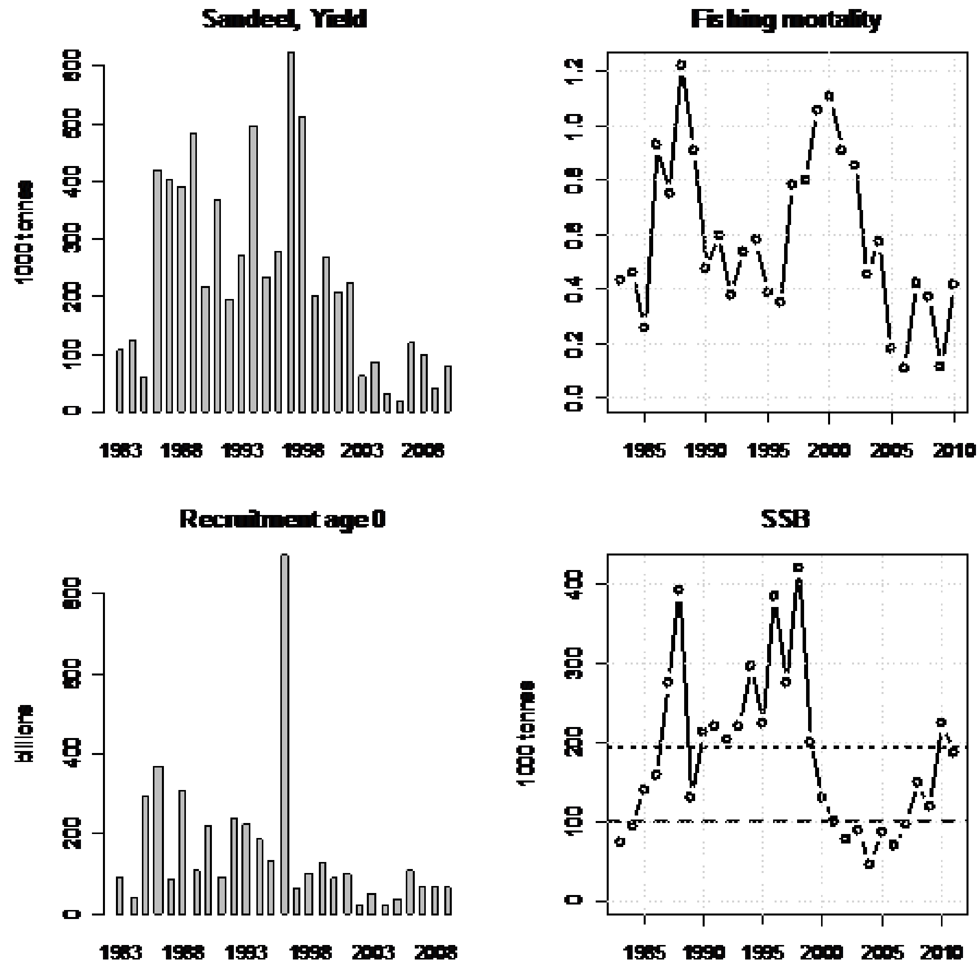


Figure 6.4.4. Stock summary for area 3.

For short-lived species such as Sandeel, the ICES interpretation of the MSY concept uses B_{pa} estimates as the value for $B_{msy\text{-}trigger}$. This means that should advice follow the same escapement strategy as previously used the fishing opportunities for year y must be set at a level which ensures that B_{msy} is achieved in year y+1. No fishery should be allowed if this level of escapement can be achieved.

Table 6.4.1. Summary of Biomass reference points for areas 1–3.

Area	B_{lim}	SSB CV	B_{pa}
1	160 000	18%	215 000
2	70 000	23%	100 000
3	100 000	40%	195 000

The total of the B_{lim} estimates from areas 1, 2 and 3 is 330 kt and substantially below the historical level of 430 kt determined for the whole North Sea. This is partially due to not having areas 4 and 5 included. However, stock biomasses from these areas represent only a small fraction of the total their contribution to the combined total B_{lim} will be equally small. The difference is therefore mainly caused by two changes in the procedure used. Firstly, the new SMS assessments generate lower estimates of

SSB compared to the old data and methodology and secondly, the revised maturity estimates provide lower SSBs at the same biomass of 2+-year olds. Further, the previous B_{lim} level was set in 1998 at the lowest observed spawning stock since there was no indication of a relationship between SSB and recruitment at the time. Since then the stocks have been through a period of lower SSB, some of which have still produced reasonable recruitments, and it is these observations which now inform the selection of reference points.

7 Existing and proposed management plans

7.1 Norwegian EEZ

7.1.1 Background

Landings of sandeel from the North Sea have decreased substantially in recent years. The decrease has been particularly severe in the Norwegian EEZ (Figure 7.1.1). Several banks have not provided landings for the last 8–12 years (Figure 5.3). These fishing banks are considered commercially depleted, i.e. the concentrations are too low to provide a profitable fishery. For several years after 2001 almost all landings from the Norwegian EEZ came from the Vestbank area (Figure 5.4).

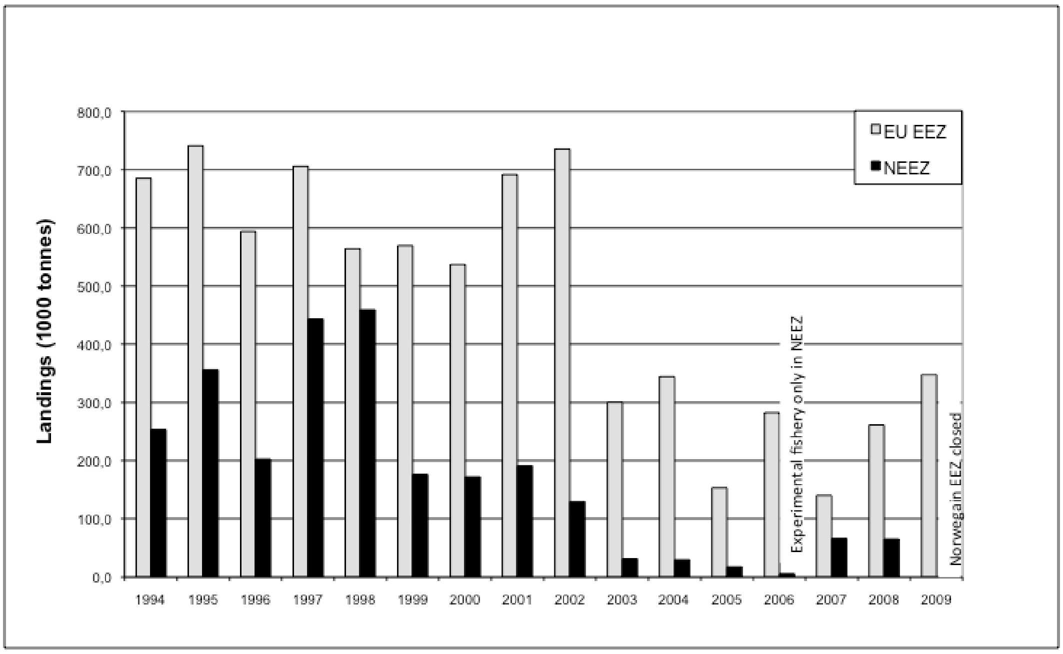


Figure 7.1.1. Landings of sandeel from the EU and Norwegian EEZ 1994–2009.

Some of the more southerly banks were repopulated by new recruitment in 2006, but commercially depleted again in 2007 or 2008; Inner Shoal East and Outer Shoal were commercially depleted in 2007, and English Klondyke, which was closed after the RTM fishery in 2007, was commercially depleted in 2008. The main concentrations of sandeel in the Norwegian EEZ are again found in the Vestbank area (Figure 7.1.2). There are high concentrations on Inner Shoal West too, but this is a very small fishing ground. In the Vestbank area and Inner Shoal West there are natural refuges that prevent the fleet from depleting the local sandeel stocks.

Most of the fishing grounds in the Norwegian EEZ were commercially depleted during a period when the assessment suggested that SSB was well above B_{pa}. In addition, evidence from 2007 and 2008 suggests that fishing grounds can be commercially depleted within a few weeks without marked decreases in cpue in tonnes (AGSAN 2009).

The commercial depletion of fishing grounds and the long-term implications this may have for the local fishery is of major concern. Because the present management of sandeel has not prevented commercial depletion of the majority of the Norwegian sandeel grounds, the Norwegian Department Fisheries and Coastal Affairs requested the Directorate of Fishery and the Institute of Marine Research, in collaboration with the fishing fleet, to propose an alternative management strategy that may prevent commercial depletion of fishing banks.

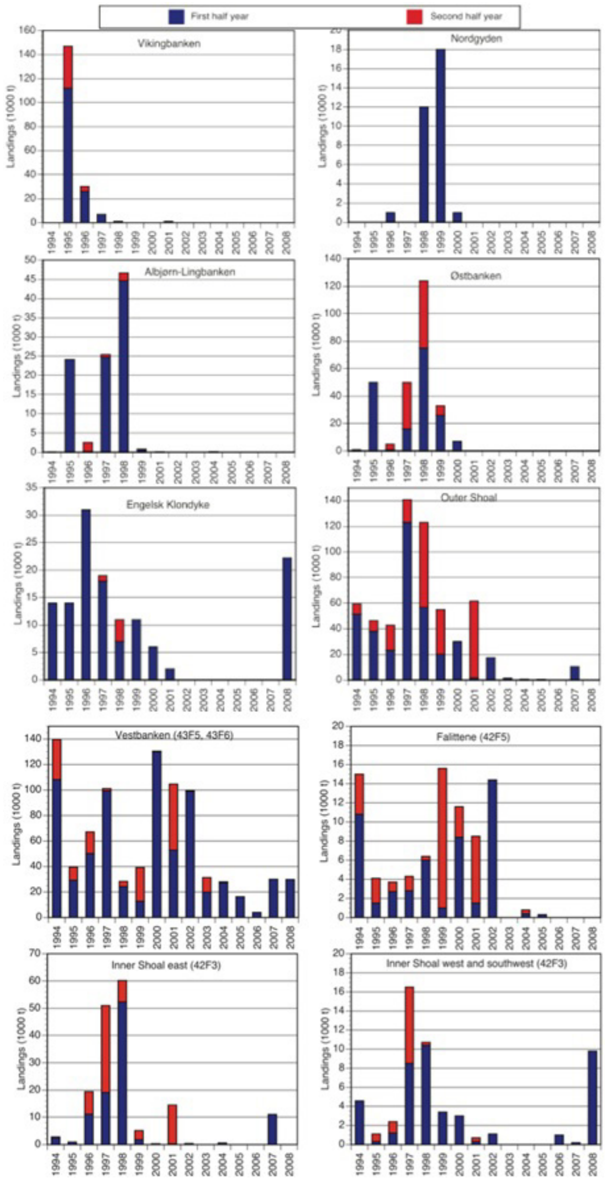


Figure 7.1.2 Sandeel landings from Norwegian fishing banks 1994-2008 in the first (blue) and second (red) half of the year. Landings in second half are mainly 0-group.

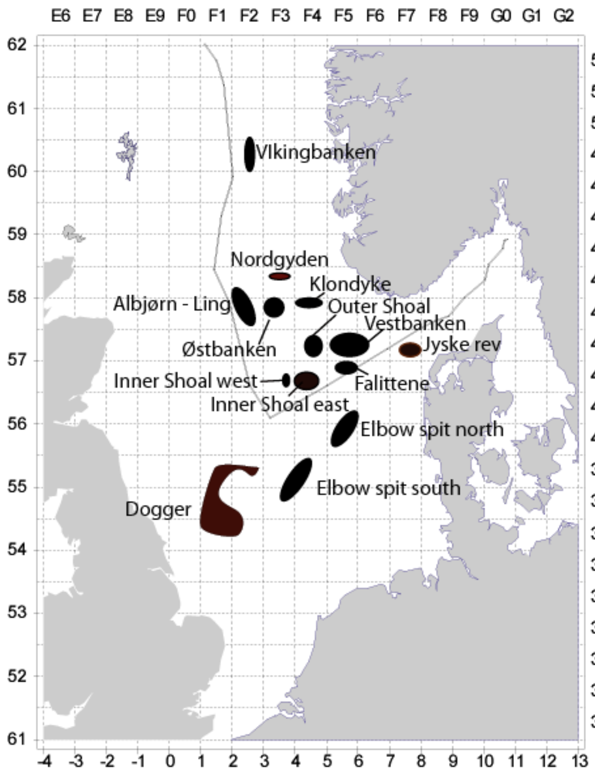


Figure 7.1.3. Sandeel fishing grounds in the Norwegian EEZ and the main fishing grounds in the EU EEZ.

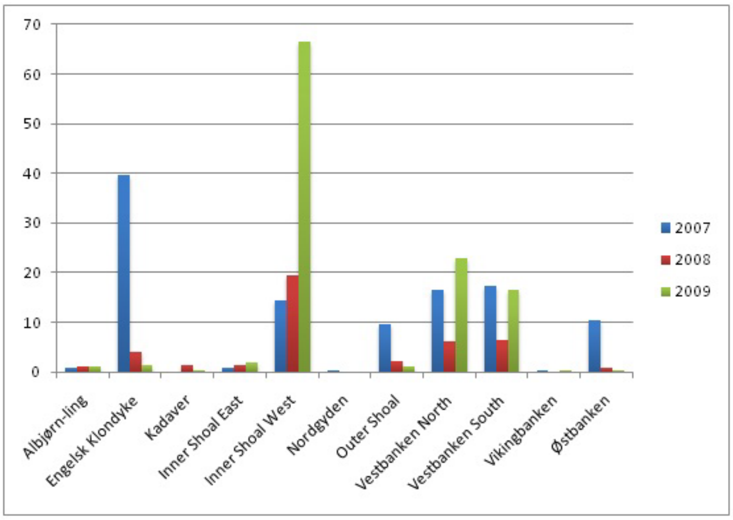


Figure 7.1.4. Relative densities (sA) of sandeel on various fishing grounds in the Norwegian EEZ in April–May 2007, 2008 and 2009.

7.1.2 Proposed management plan

Main objective: Sandeel will be managed spatially to ensure sustainable local spawning stocks in all areas where sandeel is distributed in the Norwegian EEZ, sufficient supply of food for predators and maximise fishing yield.

Method:

1) The Norwegian EEZ have been divided into six areas (may be altered in the future) (see Figure 7.1.5). Each area is divided in two sub-areas. The sub-areas will be opened and closed alternately (year to year). If the spawning-stock in a particular area stock falls below a predefined limit, both sub-areas will be closed.

2) An acoustic survey will be carried out in April–May to measure the abundance of sandeel (I-group and II+-group).

3) Based on results from the acoustic survey there will be an advice on which areas that can be opened for fishing and a proposal of a preliminary TAC for the Norwegian EEZ the following year.

4) Based on the acoustic abundance estimates there will be an in-season evaluation of whether closed area can be re-opened and an update the TAC for the rest of the fishing season.

5) Fishing season is limited to the period April 23 and June 23. The relative late start of the fishing season is to allow sandeel to gain weight and fat. Sandeels are very lean when emerging from the sand in early spring. Stop date is related to hibernation of I^{+}-group sandeel.

6) If the number of sandeel <10 cm comprise more than 10% of the landings a particular fishing ground, the fishing ground will be closed for seven days and then automatically re-opened.

The proposed method is based on the assumptions that the closed sub-areas will protect sandeel from local depletion and that local spawning stocks are important for local recruitment. Although there are observations to support both assumptions, neither has been fully tested. Therefore, the proposed management method should be considered an imperative experiment to improve the dismal situation for sandeel in the Norwegian EEZ.

The spatial management method will be evaluated after each fishing season based on the following success criteria:

1) Prevent local depletion of sandeel.

2) More stable recruitment than during the period 1994–2009.

3) A higher proportion of II^{+}- group sandeel in the landings compared to 1994–2009.

4) Reduced inter-annual variability in landings compared to 1994–2009.

5) Increased landings compared to 2000–2009.

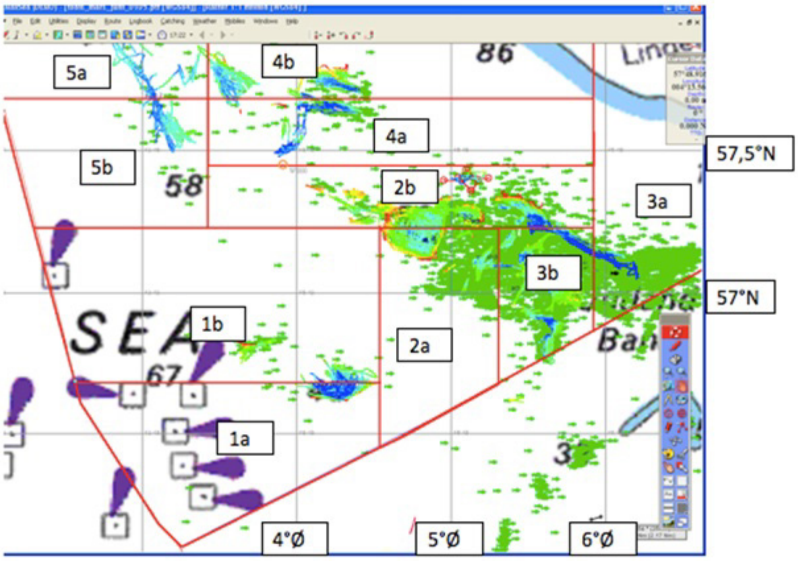


Figure 7.1.5. Management areas.

7.2 ICES / EU

The aim of Real Time Monitoring (RTM) of sandeel is to estimate the abundance of the 2009 year class for a previously established harvest control rule (HCR; see COUNCIL REGULATION (EC) No 23/2010, ANNEX IID). The overall objective of the HCR for 2010 is to ensure that SSB is above B_{pa} in 2011. Fishing and the final TAC in 2010 will depend on the latest stock assessment plus the size of the 2009 year class:

$$TAC_{2010} = -333 + 3.692 * N1$$

Where N1 is the real-time estimate of age group 1 in billions derived from the exploratory fishery in 2010; the TAC is expressed in 1000 tonnes.

The estimate of the 2009 year class (N1) is derived using a regression between historical cpue observations and age 1 cpue as outlined in ICES 2009.

The European Community (EC) requested ICES to provide further advice to allow EC to apply the procedure described in COUNCIL REGULATION (EC) No 23/2010. ICES responded that based on real-time monitoring data available from weeks 15 to 18 in 2010, the estimated stock size of age 1 sandeel in 2010 is approximately 159 billion individuals and the estimated mean weight of an age 1 sandeel in 2010 is 3.12 g.

Using these estimates, the calculated 2010 TAC becomes 253 000 t.

On the basis of subsequent very high catch rates observed in the fishery, STECF was requested to evaluate the RTM sampling and additional information. The final TAC was set at the maximum allowed by the COUNCIL REGULATION (EC) No 23/2010, 400 000 tonnes.

7.3 Danish fishers proposal

The Danish fishermen association's proposal for a management plan with regard to sandeels in the North Sea can be found in appendix A4. The data and survey procedures available today are sufficient enough to implement this proposal as the coming management for sandeels in the North Sea.

7.4 Norwegian fishers proposal

The Norwegian fishermen association's proposal for a management plan with regard to sandeels in the North Sea can be found in appendix A5. The data and survey procedures available today are sufficient enough to implement this proposal as the coming management for sandeels in the North Sea.

8 Marine Spatial Planning and sandeel fisheries

8.1 Marine conservation zones and Natura 2000

In recent years the processes of designating areas to protect the nature in regard to the habitat and bird directive under the Natura2000 have increased. New designated areas under the Natura2000 include some of the most productive sandeel grounds in the North Sea. At this time, it is not possible to tell if the designating of the areas will influence the fishery, as it will be up to scientist to decide how the habitat 1110 "Sandbanks which are slightly covered by sea water all the time" should look like in a favourable conservations status. If this favourable conservations status can be achieved together with an active fishery in the area, will be a very important question to answer in coming years.

The Dogger Bank has always been one of the most important areas of sandeel fishery.

Germany and Holland have designated their parts of the Dogger Bank as Natura2000 areas and England have just suggested their part of the Dogger Bank as a SAC area (special area of conservation). The situation will be that most of the Dogger Bank will end up as Natura2000 area where sandbanks must be protected. The process of Natura2000, where actions plans for obtaining or creating favourable conservations status inside the different areas in the North Sea will be produced, could potentially affect the whole fishery considerably by closing the most important areas for sandeel fishing today.

The Marine Strategy Framework Directive from 2008 are building on top on the habitat- and bird directive by giving member states the opportunity to designate new MPAs on behalf of an ecosystem-based approach to the management of human activities while enabling a sustainable use of marine goods and services. The Marine Strategy Framework Directive can potentially affect the sandeel fishery in the same way as the habitat- and bird directive.

8.2 Windfarms in the North Sea, existing and future plans

The proposed construction of vast windmill farms has the potential to seriously impact sandeel populations, habitat, and fisheries in the North Sea. The United Kingdom Crown Estate is proposing the addition of new windmill farms on important sandeel fishing grounds, including significant portions of the Dogger Bank. Details about the proposals and what is currently known about their potential impacts are presented in Appendix A6. Additional research studies are needed to answer many of the questions concerning the short and long-term impacts of the windmill farms.

8.3 Northeast UK closure

Due to their importance in North Sea food webs, ICES has advised that management should ensure that sandeel abundance be maintained high enough to provide food for a variety of predator species. During the early 1990s a sandeel fishery developed in Area 4, off the Firth of Forth. The landings from this fishery peaked at over 100 000t in 1993 and then subsequently fell. The Firth of Forth area is important for breeding seabirds and the removal of such large quantities of sandeels within their foraging range soon became a matter of concern. In 1999, the U.K called for a moratorium on sandeel fishing adjacent to seabird colonies along the U.K. coast and in response the EU requested advice from ICES. An ICES Study Group was convened in 1999 in response to this request with two terms of reference (ICES 1999):

a) assess whether removal of sandeel by fisheries has a measurable effect on sandeel predators such as seabirds, marine mammals, and other fish species.

b) assess whether establishment of closed areas and seasons for sandeel fisheries could ameliorate any effects. Identify possible seasons/areas as specifically as possible.

This study group noted that there was suggestion of a negative effect of the Firth of Forth fishery on the local sandeel abundance in 1993 which coincided with a particularly low breeding success of seabirds, especially kittiwakes. The study group concluded that there were two reasons for continued concern about this area that provided the basis for a precautionary closure:

1) sandeels supported a number of potentially sensitive seabird colonies (Lloyd *et al.*, 1991).

2) work on population structure indicated that sandeels in this region are reproductively isolated from the main fished aggregations in the North Sea (Wright *et al.*, 1998).

The ICES study group noted that, as sandeel assessments are only conducted for the North Sea, there was no reliable information on the state of the sandeel aggregations near the Firth of Forth, which forms part of area division 4 (see Figure 4). Given available information the study group proposed that kittiwake breeding success was the best practical indicator of sandeel availability at least to seabirds and threshold levels of the breeding success of this species should be used to guide futures decisions on re-opening. After ICES Advisory committees and STECF acceptance of the study group's advice, the EU advised that the fishery should be closed whilst maintaining a commercial monitoring. However, the EU did not accept the use of kittiwake breeding success as a harvest control threshold. A three year closure, from 2000 to 2002, was decided and the Commission was requested to produce annual reports to the Council on the effects of the restrictions in the sandeel fishery in the Firth of Forth area. On the basis of the second of these reports (Wright *et al.*, 2001) and uncertainty over the impact of the closure the commission proposed a further three year extension of the closure. The wording of the Act is stated in article 29a of: "Council Regulation (EC) no 850/98 of 30 March 1998 for the conservation of fishery resources through technical measures for the protection of juveniles of marine organisms". A further scientific review of the closure was made by STECF in 2007, together with other EU fishery closures. That group proposed that it would be prudent to wait for enhanced recruitment and productivity in the area before any re-opening is considered.

Evaluating changes in sandeel abundance in the region has been difficult due to the lack of a single reliable sampling method for assessing sandeel abundance. Nevertheless, the various research (acoustic, trawl and dredge) and commercial abundance indices suggested an initial increase in sandeel abundance during the period of the closure (Greenstreet *et al.*, 2006). This increase began with a relatively large recruitment in the first year of the closure, which would not have been related to any recovery in the spawning stock. Dredge surveys in 1999 and 2000 indicated a detectable decrease on total mortality on 1+ sandeels following the closure. A further indication that sandeel abundance increased in the region, came from the observation that in

2003, when landings in the North Sea as whole had severely declined, 39 060 tonnes were taken in the ICES rectangle adjacent to the closed area near Marr and Berwick banks.

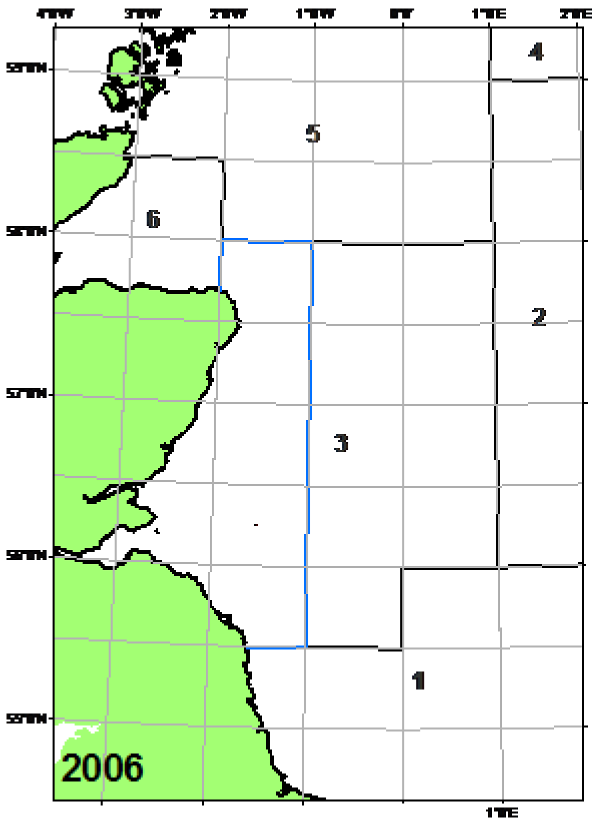


Figure 8.3.1. Chart showing the closed area (blue line).

Kittiwake breeding success has tended to be higher since the fishery closure than in the preceding five years. However, poor breeding success in 2004 seen along the whole of the east UK coast appears partly related to environmental factors affecting the incoming year-class of sandeels. Evidence from studies published since the ICES (1999) study group suggest that the breeding success of this species is not a reliable indicator of sandeel availability to some other coastal seabirds. For example, a downward trend in guillemot breeding success throughout the 1990s has not been reversed by fishery closure (but that species feeds extensively on sprats as well as sandeels in this area). After a series of very poor breeding seasons for seabirds since 2004 on the Isle of May, Firth of Forth, the 2009 season was the most successful in recent years, matching evidence of increased sandeel abundance from the dredge survey. Of six seabird species studied intensively, European shag had its highest productivity on record with only razorbill having productivity below average. All other species studied had their most productive season for at least four years. Sandeels remained the main food of young Atlantic puffins, razorbills and kittiwakes. Comparatively few 1+ group sandeels were present in food samples during the chick-rearing period in 2009, however 0-group appeared in large numbers and were substantially longer than in recent years, again matching dredge results. Kittiwakes had a good season with productivity (0.70 chicks per incubated nest) the highest since

2005 and well above the long-term average. The proportion of sandeel in kittiwake diet (89% by biomass) in 2009 was the highest since 2005.

However, the concern over a possible local impact of sandeel fishing expressed in 1999 has not fundamentally changed. On re-opening, the sandeel aggregations in the Northeast closure could be subject to significant depletion unless there were revised management controls. As originally agreed by the Commission, STECF would have to convene an international meeting of scientists to come up with a consensus on criteria for re-opening.

9 Research recommendations

1) Updated stomach contents studies across areas and times. The primary cause of natural mortality in sandeel is predation, and because of this, studies of predators' stomach contents are used to estimate natural mortality rates. Current natural mortality rate estimates are area-wide and were estimated using stomachs collected twenty years ago. There are several problems with this. First, natural mortality will change over time, as populations of predators, competitors, and prey change. Changes due to both trends over time as well as and year-to-year variation are expected. Natural mortality rates estimated from samples collected from the most abundant predators twenty years ago are not necessarily representative of current rates as both the composition and abundance of predators and prey has changed. The magnitude of the difference cannot be estimated or input to current assessment models without new stomach content studies. Second, the current natural mortality rate is estimated area-wide. Assessments will now be conducted on an area-specific basis and natural mortality rates are expected to vary by area. Using a common region-wide natural mortality rate across all areas does not allow for important variation between areas, and will force the variation to be incorrectly accounted for within the assessment model. This information is critical to the incorporation of an ecosystem approach to assessment and management. To account for time-varying and region-specific natural mortality rates, the following studies are suggested:

   1.1) An analysis of natural mortality based on the stomach contents previously collected, by area. Data from the stomach contents collected twenty years ago are still available and can be identified by area. Using this information, natural mortality rates can be estimated by area for this earlier time period.

   1.2) A new study to collect and identify predator stomach contents reflecting the present composition and abundance of predators. This should be conducted on an area-specific basis, across all areas, allowing for current natural mortality rates to be estimated to use as input in the area-specific stock assessment model.

   1.3) Annual stomach contents studies. Ideally, studies could be conducted on an annual basis allowing for annual estimates of natural mortality rates by area to be incorporated into future assessment models. If annual studies cannot be conducted, studies should be conducted on a regular timeline (i.e. every x years) to ensure significant changes in natural mortality rates over time are discovered and accounted for.

2) Restructuring of otolith sampling effort of the sandeel catch across areas and time. Otolith collection is necessary for identifying the relative proportion of the catch by age. This important component of the assessment varies within and among years, as well as, among areas. In addition, older age classes are least likely to be observed in the fishery, but may be an important component of the catch and population, nonetheless. There is a high degree of autocorrelation of age composition within samples; therefore increasing the sampling of otoliths would increase the likelihood of

identifying older age classes in the catch. Note that this information is also critical for the application of in-season monitoring in those cases when needed.

2.1) It might be possible for the fishermen to provide area-specific samples. Currently samples are collected at landing sites, both samples collected by fishermen as well as landings collected by port agents. Specific catch locations are not identified in the samples collected by port agents, limiting the utility of the samples. To verify the samples taken for in-season monitoring, these samples consist entirely of port samples. Fishermen representing the national fishery associations attending WKSAN have volunteered to collect site-specific samples, which would allow for improved incorporation of this critical information into area-specific assessment models. It would be necessary to identify whether adequate and effective protocols, incorporating appropriate levels of oversight, could be established before this sampling could proceed. In addition, sampling of this kind would be required on a regular basis, and hence, must be dependable to be of any value.

3) <u>Increasing the coverage of the dredge survey across areas and time.</u> The dredge survey is critical to the assessment, providing the status in previous years and management reference points, and just as importantly, to projections of upcoming abundance needed for making management decisions for upcoming fishing seasons. The relative coverage of the dredge survey varies by area. Area 1 currently has the greatest coverage. Because of the extent of coverage in Area 1, the need for in-season monitoring has been relegated to use in only extreme circumstances (e.g. when densities below the range historically observed are recorded), improving the management process for all parties involved. Increasing the coverage of the dredge survey in the other areas has the potential to provide similar benefits. Currently, the greatest benefits would likely come from increasing the coverage in Area 3. Note that samples collected during the dredge survey provide information on population age structure, and in addition, the only information available on maturation. Increasing coverage of the dredge survey would also require increasing the magnitude of aging and maturity studies of the collected samples.

3.1) <u>Successive annual sampling of sandeel habitats outside known fishing banks.</u> This may provide important information to improve area-specific natural mortality rate estimates.

3.2) <u>Studies to develop and evaluate more efficient and robust dredge surveys.</u> Additional standardization should be identified, coordinated and reported back to technical staff responsible for development and maintenance.

4) <u>Ecosystem effects of sandeel density.</u> Currently, assuring that the biomass of sandeel is sufficient to avoid adverse effects on top predators is hampered by the lack of knowledge of the biomass below which these adverse effects occur. Research on the relationship between sandeel biomass and predator condition, growth or recruitment success, could provide better knowledge for setting reference points which do not only assure that recruitment of sandeel is not impaired but also takes account of the fact that adverse effects on predator populations should be avoided.

5) Per-Recruit analyses. Information needed to conduct both yield-per-recruit analyses and spawner-per-recruit analyses is available. Yield-per-recruit analysis provides estimates of fishing rates that likely cause growth overfishing. Spawner-per-recruit analysis provides a proxy for maximum sustainable yield. Both analyses are relatively straightforward to conduct. Both analyses also are based on a large number of assumptions, which may or may not hold for the sandeel population. Completion of these analyses would likely provide helpful information for assessment and management, but the analyses must be conducted, interpreted, and communicated effectively and cautiously, keeping their limitations in mind.

6) Additional dredge survey and fishery monitoring in area 4. Further data from both the dredge survey and fishery monitoring is required in order to provide advice to management for area 4. The dredge survey in area 4 cannot be used to produce a stock assessment until the relationship between stock size and dredge survey catch in the area can be estimated from a longer time-series than is presently the case. This requires not only the continuation of the survey but also within season sampling, preferably from fisheries catches to ensure the compatibility with historical data.

7) Further analysis of the acoustic surveys of sandeel used as input data for assessment. The inclusion of acoustic survey data as input requires an extensive analysis of the internal and external consistency of the survey similar to the analyses performed at the benchmark for the dredge survey.

10 Conclusions

Four alternative sandeel management scenarios were presented to WKSAN: the current EU management plan, the plan being implemented by the Norwegian government in the Norwegian EEZ, a proposal by the Danish Fishermen's Association, and a proposal by the Norwegian Fishermen's Association. All four management plans could be implemented in Areas 1, 2, and 3 using existing data sources with agreed-upon assessment and forecasting methods. Both the Norwegian government's and the Norwegian Fishermen's Association's proposed management scenarios could be implemented in Area 5. Data is insufficient to evaluate whether the management scenarios could be implemented in Areas 4 and 6.

Pre-season dredge survey information is sufficient to provide TAC advice in Areas 1 and 2, without requiring in-season data processing in most cases. Increasing the coverage and time-series length of dredge surveys in other areas may lead to a similar reduction or elimination of the need for in-year processing in those areas.

WKSAN has recommended assessing sandeel stocks by area based on stock structure identified using information on larval drift and other sources described in Section 2. In doing so, assessment has changed from being region-wide to area-specific. Model structure has evolved to now utilize a statistical catch-at-age model as opposed to a deterministic VPA approach as used in the past. The inclusion of the dredge survey has eliminated historic retrospective patterns in Areas 1–3, a problematic artefact of previous assessments. New analyses demonstrate that the dredge survey in Area 1 allows for greater confidence in short-term forecasts.

Improving the assessment will require its further spatial stratification, including providing natural mortality rate estimates by area. Current natural mortality rate estimates were derived from predator stomachs collected 20 years ago region-wide. A new stomach collection study is required to provide updated, area-specific mortality estimates. Additional research priorities include studies of the relationship between sandeel biomass and predator condition, growth or recruitment success to provide better knowledge for setting reference points which takes account of effects on predator populations.

Industry representatives from both Denmark and Norway attended the entire WKSAN and provided useful information throughout the workshop. In particular, they provided critical information on the timing and causes of changes in catchability, which were then incorporated into the assessment model. Industry representatives also provided details on marine spatial planning issues having the potential to impact the sandeel fishery in the future (e.g. windfarms, Natura2000). Their participation was not only welcome, but also necessary.

11 References

Anon. 2006. Species identification methods from acoustic multi-frequency information (SAFAMI). Final Report EU contract Q5RS–2001–02054. 486 pp.

Arnott, S.A., Ruxton, G.D. 2002. Sandeel recruitment in the North Sea: demographic, climatic and trophic effects. Marine Ecology Progress Series 238:199–210.

Boulcott P., Wright P. J. In press. Variation in fecundity in the lesser sandeel: implications for regional management. Journal of the Marine Biological Association of the United Kingdom.

Boyd, I.L., Wanless, S., and Camphuysen, C.J. eds. 2006. *Top predators in marine ecosystems: their role in monitoring and management.* Cambridge University Press, Cambridge.

Brown, E. G., Pierce, G. J., Hislop, J. R. G., Santos, M. B. 2001. Inter-annual variation in the summer diets of harbour seals *Phoca vitulina* at Mousa, Shetland (UK). Journal of the Marine Biological Association of the UK, 81: 325–337.

Christensen, A., Jensen, H., Mosegaard, H., St John, M., Schrum, C. 2008. Sandeel (*Ammodytes marinus*) larval transport patterns in the North Sea from an individual-based hydrodynamic egg and larval model. Canadian Journal of Fisheries and Aquatic Sciences, 65: 1498–1511.

Daunt, F., Wanless, S., Greenstreet, S. P. R., Jensen, H., Hamer, K. C., Harris, M. P. 2008. The impact of the sandeel fishery closure on seabird food consumption, distribution and productivity in the northwestern North Sea. Canadian Journal of Fisheries and Aquatic Sciences, 65: 362–381.

Davis, S.E., Nager, R.G., Furness, R.W. 2005. Food availability affects adult survival as well as breeding success of parasitic jaegers. Ecology, 86, 1047–1056.

Dommasnes, A., and Røttingen, I. 1985. Acoustic stock measurements of the Barents Sea capelin 1972–1984. A review. *In* The proceedings of the Soviet–Norwegian Symposium on the Barents Sea capelin: Bergen, Norway 14–17. August, 1984, pp. 45–108. Ed. by H. Gjøsæter. Institute of Marine Research, Bergen.

Engelhard, G.H., van der Kooij, J., Bell, E.D., Pinnegar, J.K., Blanchard, J.L., Mackinson, S., Righton, D.A. 2008. Fishing mortality versus natural predation on diurnally migrating sandeels *Ammodytes marinus.* Marine Ecology Progress Series 369: 213–227.

Frederiksen, M., Furness, R.W., Wanless, S. 2007. Regional variation in the role of bottom-up and top-down processes in controlling sandeel abundance in the North Sea. Mar. Ecol. Prog. Ser. 337, 279–286.

Frederiksen, M., Jensen, H., Duant, F., Mavor, D.R. Wanless, S. 2008. Differential effects of a local industrial sand lance fishery on seabird breeding performance. Ecological Applications, 18: 701–710.

Frederiksen, M., Wanless, S., Harris, M.P., Rothery, P., Wilson, L.J. 2004. The role of industrial fisheries and oceanographic change in the decline of North Sea black-legged kittiwakes. Journal of Applied Ecology, 41, 1129–1139.

Frederiksen, M., Wright, P.J., Heubeck, M., Harris, M.P., Mavor, R.A., Wanless, S. 2005. Regional patterns of kittiwake *Rissa tridactyla* breeding success are related to variability in sandeel recruitment. Marine Ecology Progress Series 300:201–211.

Freeman, S., Mackinson, S., Flatt, R. 2004. Diel patterns in the habitat utilisation of sandeels revealed using integrated acoustic surveys. Journal of Experimental Marine Biology and Ecology 305: 141–154.

Furness, R. W., Tasker, M. L. 2000. Seabird–fishery interactions: quantifying the sensitivity of seabirds to reductions in sandeel abundance, and identification of key areas for sensitive seabirds in the North Sea. Marine Ecology Progress Series, 202: 253–264.

Furness, R.W. 2002. Management implications of interactions between fisheries and sandeel-dependent seabirds and seals in the North Sea. ICES Journal of Marine Science 59:261–269.

Gauld, J. A. 1990. Spawning and fecundity in the lesser sandeel, *Ammodytes marinus* (Raitt), in the north-western North Sea. Journal of Fish Biology, 36: 611–613.

Gjøsæter, H., Dommasnes, A., and Røttingen, B. 1998. The Barents Sea capelin stock 1972–1997. A synthesis of results from acoustic surveys. Sarsia, 83: 497–510.

Greenstreet, S. P. R. 2006. Does the prohibition of industrial fishing for sandeel have any impact on local gadoid populations? In Management of Marine Ecosystems, pp. 223–235. Ed. by I. L. Boyd, S. Wanless, and C. J. Camphuysen. Cambridge University Press, Cambridge, UK.

Greenstreet, S. P. R., Armstrong, E., Mosegaard, H., Jensen, H., Gibb, I. M., Fraser, H. M., Scott, B., *et al*. 2006. Variation in the abundance of sandeels *Ammodytes marinus* off southeast Scotland: an evaluation of area-closure fisheries management and stock abundance assessment methods. ICES Journal of Marine Science, 63: 1530–1550.

Greenstreet, S. P. R., Bryant, A. D., Broekhuizen, N., Hall, S. J., Heath, M. R. 1997. Seasonal variation in the consumption of food by fish in the North Sea and implications for foodweb dynamics. ICES Journal of Marine Science, 54: 243–266.

Greenstreet, S. P. R., McMillan, J. A., Armstrong, F. 1998. Seasonal variation in the importance of pelagic fish in the diet of piscivorous fish in the Moray Firth, NE Scotland: a response to variation in prey abundance? ICES Journal of Marine Science, 55: 121–133.

Greenstreet, S.P.R., Holland, G.J., Guirey, E.J., Armstrong, E., Fraser, H.M., Gibb, I.M. 2010. Combining hydroacoustic seabed survey and grab sampling techniques to assess "local" sandeel population abundance. ICES Journal of Marine Science 67: 971–984.

Hammond, P. S., Hall, A. J., Prime, J. H. 1994. The diets of grey seals around Orkney and other island and mainland sites in north-eastern Scotland. Journal of Applied Ecology 31: 340–350.

Hassel, A., Knutsen, T., Dalen, J., Skaar, K., Løkkeborg, S., Misund, O. A., Østensen, Ø., Fonn, M., Haugland, E. K. 2004. Influence of seismic shooting on the lesser sandeel (*Ammodytes marinus*). ICES Journal of Marine Science 61: 1165–1173.

Hislop, J. R. G., Robb, A. P., Bell, M. A., Armstrong, D. W. 1991. The diet and food consumption of whiting (*Merlangius merlangus*) in the North Sea. ICES Journal of Marine Science, 48: 139–156.

Holland, G. J., Greenstreet, S. P. R., Gibb, I. M., Fraser, H. M., Robertson, M. R. 2005. Identifying sandeel *Ammodytes marinus* sediment habitat preferences in the marine environment. Marine Ecology Progress Series, 303: 269–282.

ICES. 1995. Report of the Working Group on the Assessment of Norway Pout and Sandeel. ICES C. M. 1995/Assess:5.

ICES. 2008. Report of the Working Group on Multispecies Assessment Methods (WGSAM). ICES CM 2008/RMC:06.

ICES. 2009. Report of the *Ad hoc* Group on Sandeel - II 2009, 19–21 October 2009, ICES HQ. ICES CM 2009/ACOM:51.

Jennings, S., Kaiser, M.J., Reynolds, J.D. 2001. *Marine fisheries ecology*. Blackwell, Oxford.

Jensen, H. 2001. Settlement dynamics in the lesser sandeel *Ammodytes marinus* in the North Sea. Ph.D. dissertation, University of Aberdeen, 230 pp.

Jensen, H., Rindorf, A., Wright P. J., Mosegaard, H. Inferring the location and scale of mixing between habitat areas of lesser sandeel through information from the fishery. ICES Journal of Marine Science. In press.

Johnsen, E., R. Pedersen, *et al*. 2009. "Size-dependent frequency response of sandeel schools." Ices Journal of Marine Science 66(6): 1100–1105.

Korneliussen, R. J., and Ona, E. 2002. An operational system for processing and visualizing multi-frequency acoustic data. ICES Journal of Marine Science, 59(2): 293–313.

Korneliussen, R. J., Eliassen, I. K., Heggenlund, Y., Patel, R., Godø, O. R., Giertsen, C., Patel, D., Nornes, E. H., Bekkvik, T., Knudsen, H. P., and Lien, G. 2006. The Large Scale Survey System - LSSS, a new post processing system for multifrequency echo sounder data. ICES WGFAST Report 2006.

Macer, C. T. 1996. Sandeels (*Ammodytidae*) in the south-western North Sea: Their biology and fishery. MAFF Fishery Invest.London ser.II 24(6), 1–55.

MacLennan, D. N. and Simmonds, E. J. Fisheries Acoustics, Chapman and Hall. 1992. 352 pp.

MacLennan, D. N., Fernandes, P. G., and Dalen, J. 2002. A consistent approach to definitions and symbols in fisheries acoustics. ICES Journal of Marine Science, 59: 365–369.

Macleod, C.D., Santos, M.B., Reid, R.J., Scott, B.E., Pierce, G.J. 2007. Linking sandeel consumption and the likelihood of starvation in harbour porpoises in the Scottish North Sea: could climate change mean more starving porpoises? Biology Letters 3: 185–188.

Mavor, R.A., Parsons, M., Heubeck, M., Schmitt, S. 2005. *Seabird numbers and breeding success in Britain and Ireland, 2004.* UK Nature Conservation Report. Joint Nature Conservation Committee, Peterborough.

Mavor, R.A., Parsons, M., Heubeck, M., Schmitt, S. 2006. *Seabird numbers and breeding success in Britain and Ireland, 2005.* UK Nature Conservation Report. Joint Nature Conservation Committee, Peterborough.

Mavor, R.A., Parsons, M., Heubeck, M., Schmitt, S. 2007. *Seabird numbers and breeding success in Britain and Ireland, 2006.* UK Nature Conservation Report. Joint Nature Conservation Committee, Peterborough.

Miller, D. S., and Carscadden, J. E. 1990. A biomass estimate from a hydroacoustic survey for capelin (*s*) in NAFO division 3N and observations on the Soviet fishery for capelin in division 3NO. NAFO SCR Doc. 90/61. 5 pp.

Mitchell, P.I., Newton, S.F., Ratcliffe, N., Dunn, T.E. 2004. Seabird populations of Britain and Ireland. T and AD Poyser, London.

Munk, P., Wright, P. J. and Pihl, N. J. 2002. Distribution of the Early Larval Stages of Cod, Plaice and Lesser Sandeel across Haline Fronts in the North Sea. Estuarine, Coastal and Shelf Science, 55: 139–149.

Pedersen, S. A., Lewy, P., Wright, P. 1999. Assessments of the lesser sandeel (*Ammodytes marinus*) in the North Sea based on revised stock divisions. Fisheries Research, 41: 221–241.

Pinnegar, J.K., van der Kooij, J., Engelhard, G.H., Blanchard, J.L., Warr, K.J., Righton, D. 2006. Small-scale variability in fish diet and whether or not this reflects local patterns of prey availability. ICES CM 2006/F:07.

Poloczanska, E. S., Cook, R. M., Ruxton, G. D., and Wright, P. J. 1999. Fishing vs. natural recruitment variation in sandeels as a cause of seabird breeding failure at Shetland:a modelling approach. ICES Journal of Marine Science, 61: 788–797.

Proctor R., Wright P. J. and Everitt A. 1998. Modelling the transport of larval sandeels on the north-west European shelf. Fisheries Oceanography, 7: 347–354.

Reay P.J. 1970. Synopsis of biological data on North Atlantic sandeels of the genus *Ammodytes*. FAO Fisheries Synopsis, No. 82.

Reed, T.E., Wanless, S., Harris, M.P., Frederiksen, M., Kruuk, L.E.B., Cunningham, E.J.A. 2006. Responding to environmental change: plastic responses vary little in a synchronous breeder. Proceedings of the Royal Society Series B, 273, 2713–2719.

Reid, D. G. 2000. Echo trace classification. ICES Cooperative Research Report, 238: 115–482.

Rindorf, A., Wanless, S., Harris, M. P. 2000. Effects of changes in sandeel availability on the reproductive output of seabirds. Marine Ecology Progress Series, 202: 241–252.

Sheperd, J. G. 1999. Extended survivors analysis: An improved method for the analysis of catch-at-age data and abundance indices. ICES Journal of Marine Science, 56: 584–591. 1999.

Skagen, D. W. 1994. Revision and extension of the Seasonal Extented Survivors Analysis (SXSA). Working document to the ICES Norway Pout and Sandeel Assessment WG, 1994.

Sherman, K., Jones, C., Sullivan, L., Smith, W., Berrien, P., Ejsymont, L. 1981. Congruent shifts in sandeel abundance in western and eastern North Atlantic ecosystems. Nature, 291: 486–489.

Simmonds, E. J., and MacLennan, D. N. 2005. Fisheries Acoustics: Theory and Practice. 2nd edn. Blackwell Publishing, Oxford, England. 437 pp.

Stafford, R., Whittaker, C., Velterop, R., Wade, O., Pinnegar, J. 2006. Final Report, Programme 13: North Sea Whiting Stomach Contents. Fisheries Science Partnership: 2006/07. 25pp.

Toresen, R., Gjøsæter, H., and de Barros, P. 1998. The acoustic method as used in the abundance estimation of capelin (*Mallotus villosus* Müller) and herring (*Clupea harengus* Linné) in the Barents Sea. Fisheries Research, 34(1): 27–37.

Van der Kooij, J., Scott, B.E., Mackinson, S. 2008. The effects of environmental factors on daytime sandeel distribution and abundance on the Dogger Bank. Journal of Sea Research 60: 201–209.

Van Deurs, M., van Hal, R., Jensen, H., Tomczak, M.T., Dolmer, P. 2008. A spatially and temporally explicit analysis of beam-trawling on sandeel fishing grounds in the North Sea. Working Document to ICES AGSAN2.

Van Deurs, M., van Hal, R., Tomczak, M.T., Jónasdóttir, S.H., Dolmer, P. 2009. Recruitment of lesser sandeel *Ammodytes marinus* in relation to density dependence and zooplankton composition. Marine Ecology Progress Series 381: 249–258.

Vilhjalmsson, H. 1994. The Icelandic capelin stock. Journal of the Marine Research Institute, Reykjavik, Iceland XII, Number 1. 288 pp.

Wanless, S., Harris, M. P., Greenstreet, S. P. R. 1998. Summer sandeel consumption by seabirds breeding in the Firth of Forth, south-east Scotland. ICES Journal of Marine Science, 55: 1141–1151.

Wanless, S., Harris, M.P., Redman, P., Speakman, J. 2005. Low energy values of fish as a probable cause of a major seabird breeding failure in the North Sea. Marine Ecology Progress Series, 294, 1–8.

Wanless, S., Wright, P.J., Harris, M.P., Elston, D.A. 2004. Evidence for decrease in size of lesser sandeels *Ammodytes marinus* in a North Sea aggregation over a 30-yr period. Marine Ecology Progress Series, 279, 237–246.

Wright P. J., Jensen H. and Tuck I. 2000. The influence of sediment type on the distribution of the lesser sandeel, *Ammodytes marinus*. Journal of Sea Research, 44: 243–256.

Wright, P. J. 1996. Is there a conflict between sandeel fisheries and seabirds? In: Aquatic predators and their prey, pp. 154–165. Ed. by S. P. R. Greenstreet and M. L. Tasker. Fishing News Books, Blackwell Science, Oxford. 191 pp.

Wright, P. J., Jensen, H., Tuck, I. 2000. The influence of sediment type on the distribution of the lesser sandeel, *Ammodytes marinus*. Journal of Sea Research, 44: 243–256.

Wright, P.J. and Bailey, M.C. 1996. Timing of hatching in *Ammodytes marinus* from Shetland waters and its significance to early growth and survivorship. Marine Biology 126, 143–152.

12 Stock Annex–Sandeel in IV

Quality Handbook Annex__SAN-NSEA

Stock-specific documentation of standard assessment procedures used by ICES

Working Group	North Sea Demersal Working Group
Updated	09/09/2010 Steen Christensen (sc@aqua.dtu.dk)

General

Stock definition

For assessment purposes, the European continental shelf was divided into four regions for sandeel assessment purposes up to 1995: Division IIIa (Skagerrak), northern North Sea, southern North Sea, and Shetland Islands and Division VIa. These divisions were based on regional differences in growth rate and evidence for a limited movement of adults between divisions (e.g. ICES CM 1977/F:7, ICES CM 1991/Assess:14.). The two North Sea divisions were revised in 1995, and it was decided to amalgamate the two stocks into a single stock unit with two fleets, one fleet in the northern North Sea and one in the southern North Sea. The Shetland sandeel stock was assessed separately. ICES assessments used these stock definitions from 2005 to 2009.

However, larval drift models (Proctor *et al*., 1998; Christensen *et al*., 2007, 2008 and 2009) and studies on growth differences (e.g. Boulcott *et al*., 2007) indicate that the assumption is invalid and that the total stock is divided in several sub-populations as first proposed by Wright *et al*. (1998). On the basis of the latest information ICES (ICES CM 2009\ACOM:51) suggested that the North Sea should be divided into six sandeel assessment areas as indicated in Figure 4.2. ICES assessment used these stock definitions from 2010 onwards (ICES 2010, (WKSAN 2010)).

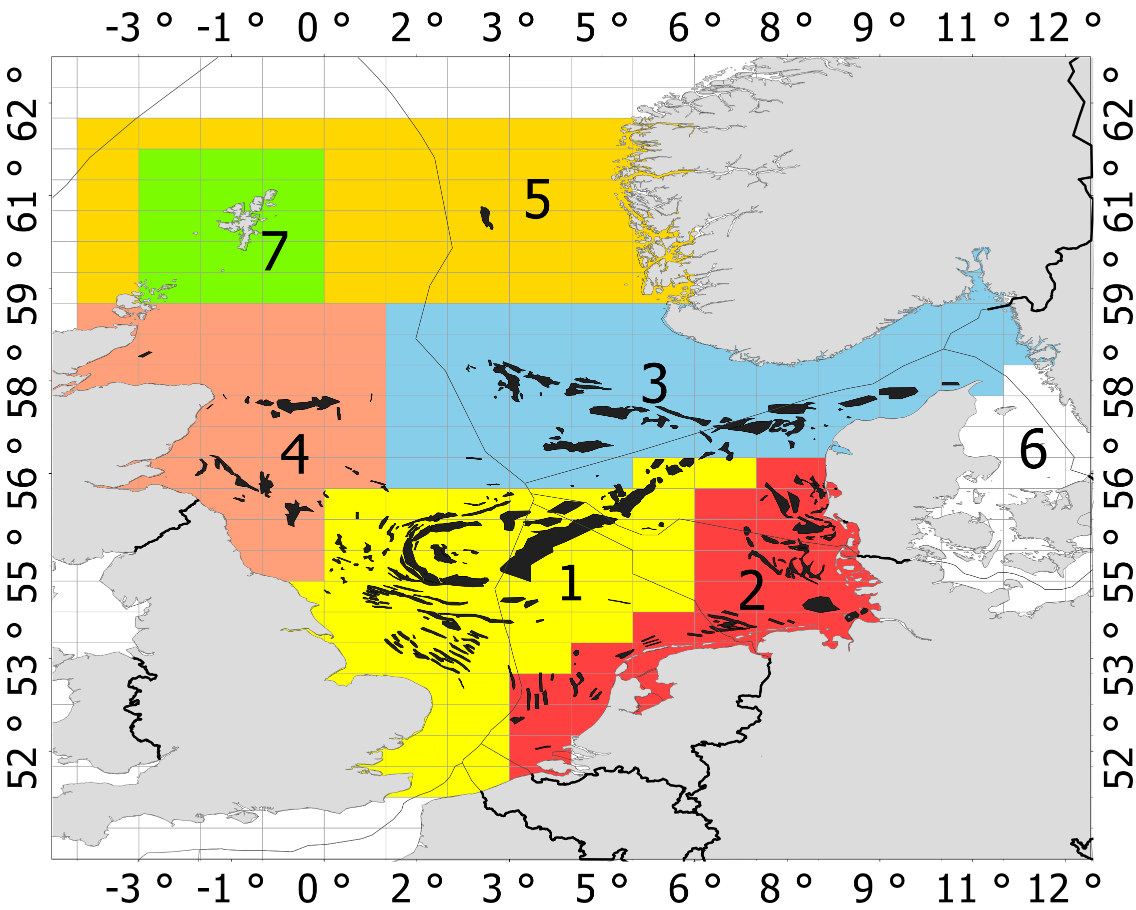


Figure 4. 2. Sandeel fishing banks (black areas), EEZ borders, and assessment areas: eastern area (red), northern area (blue), southern area (yellow), western area (dark orange), Shetland area (green) and Viking bank area (light orange).

Fishery

Technical measures for the sandeel fishery include a minimum percentage of the target species at 95% for meshes <16 mm, or a minimum of 90% target species and maximum 5% of the mixture of cod, haddock, and saithe for 16 to 31 mm meshes.

Most of the sandeel catch consists of the lesser sandeel *Ammodytes marinus*, although small quantities of other *Ammodytoidei* spp. are caught as well. There is little bycatch of protected species (ICES WGNSSK 2004).

The fishery is seasonal. The geographical distribution of the sandeel fishery varies seasonally and annually, taking place mostly in the spring and summer. In the third quarter of the year the distribution of catches generally changes from a dominance of the west Dogger Bank area back to the more easterly fishing grounds.

The sandeel fishery developed during the 1970s, and landings peaked in 1999 with 1.2 million tons. There was a significant shift in landings in 2003. The average landings of the period 1994 to 2002 was 880 000 tons whereas the average landings of the period 2003 to 2009 was 288 000 tons.

As indicated in Figure 3.2, Denmark is the main contributor to the sandeel landings. Up to 2002 Denmark in average contributed 73% of the total landings and after 2002 83%.

Figure 3.3 indicates the sandeel landings by assessment area (Figure 3.1). The Figure indicates that in average 84% of the total landings came from the areas 1 and 3 in the period 1994 to 2009. However, there has been a significant shift in the relative contribution of the two areas over the period. Up to 2002 area 1 and 3 contributed 46 and 37% respectively whereas their contributions were 65 and 20% in the period 2003 to 2009.

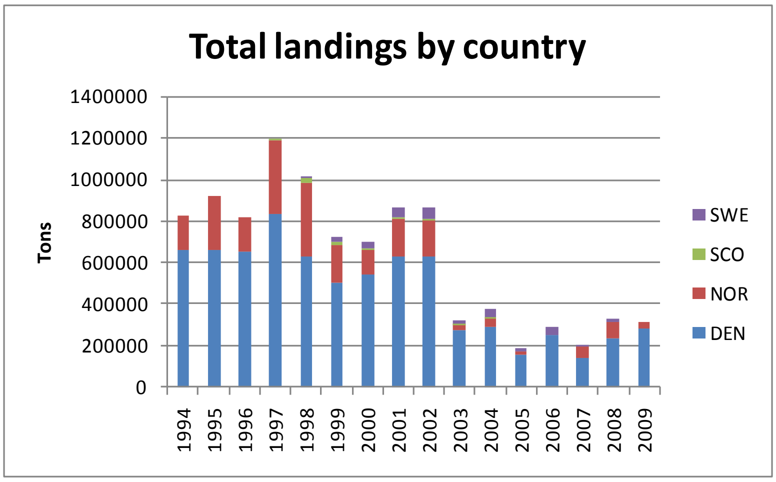


Figure 3.2.

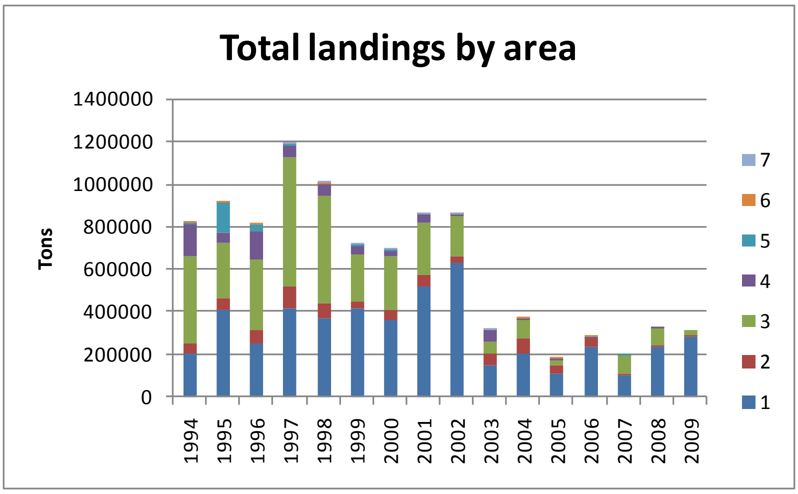


Figure 3.3.

The third most important area for the sandeel fishery is area 2. In the period 2003 to 2009 landings from this area contributed 12% of the total landings in average. The contribution of area 2 over the entire period is 9% in average.

Area 4 has contributed about 6% of the total landings since 1994 but there has been a few outstanding years with particular high landings (1994, 1996 and 2003 contributing 19, 17 and 20% of the total landings respectively). In the periods 1994 to 2002 and 2003 to 2009 the average contributions from area 4 was 8 and 3% respectively. There has been a moratorium on sandeel fisheries on Firth of Forth area along the U.K. coast since 2000.

The spatial distribution of sandeel landings is considered as a good representation of stock distribution, except for areas where severe restrictions on fishing effort is applied (i.e. the Firth of Forth, Shetland areas, and Norwegian EEZ in 2006 and 2009). Up to 2002 and particularly prior to 1998, most landings of sandeels in March were taken from the eastern North Sea banks whilst sandeel landings in April–June were mainly from the west Dogger Bank. In some years a relatively large part of the sandeel landings are taken from the central and eastern North Sea along the Danish west coast. From 1991, grounds off the Scottish east coast have been targeted particularly in June. However, since 2000 the banks in the Firth of Forth area have been closed to fishing.

In the Northern North Sea, mainly NEEZ, the change in the spatial pattern was significantly different from southern part. The highest landings from a single statistical square were taken in 1995 on the Vikingbank, the most northerly fishing ground for sandeel in the North Sea. However, in 1996 landings from the Vikingbank dropped substantially, and since 1997 have been close to nil. The marked reduction in landings around 2000 in NEEZ was accompanied by a marked contraction of the fishery to a small area in the southern part of NEEZ, the Vestbank area. In this area landings remained high in 2001 and 2002 due to the strong 2001 year class. However, the 2001 year-class was only abundant in the Vestbank area, which resulted in a highly concentrated fishery and the decimation of the year-class before it reached maturity in 2003. This may have led to the collapse of the sandeel fishery in NEEZ. In the EU EEZ any contraction of the fishery has been less apparent.

The sandeel fishing season was unusual short in both 2005 and 2006, starting later and ending earlier than in previous years. The late start of the fishery was partly because the Danish fishery first opened the 1st April, in accordance with a national regulation introduced in 2005. Further, weekly data on the oil content of sandeels in the commercial landings, provided by Danish fish meal factories, indicated a late onset of sandeels feeding season in both 2005 and 2006 and that sandeels therefore became available to the fishery later than usual. Landings in the second half year of both 2005 and 2006 were on a low level compared to previous years. Only 14 000 tonnes were recorded in 2005 and 17 000 tonnes in 2006.

There has been a significant reduction in fishing effort in the sandeel fishery in recent years (Figure 3.4 and 3.5).

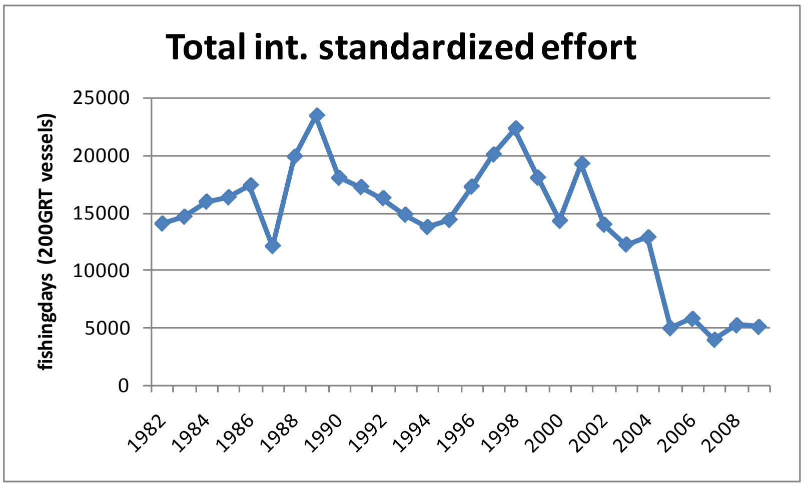


Figure 3.4.

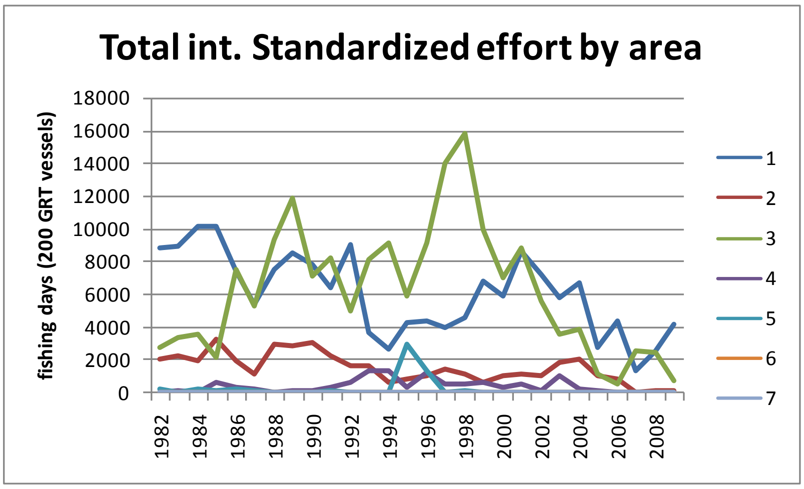


Figure 3.5.

The number of Danish vessels fishing sandeel declined about 50% (from 200 to 84 vessels) from 2004 to 2009. The introduction of an ITQ system in Denmark in 2007 is considered to have contributed to further reducing the fleet capacity and accelerating a change towards fewer and larger vessels. In addition, in 2008, when the TAC was not reached, high fuel prices and low prices of fish meal were claimed by the industry to have limited the fishery.

Also for the Norwegian fleet a drastic decline in number of vessels fishing sandeels has been observed in recent years. Of the 41 Norwegian vessels that fished sandeel in 2007, nine participated for the first time. Since 1998 25 of the 41 vessels entered the fishery during this ten year period, nine vessels were rebuilt (either extended or had larger engines installed) whereas only seven vessels remained unaltered. In addition, there is likely to be a continuous increase in efficiency due to improvement in fishing gear, instruments, etc.

Ecosystem aspects

Sandeels are small, short-lived, lipid-rich, shoaling fish. As such, they represent high quality food for many predatory fish, seabirds and marine mammals (Greenstreet *et al.*, 1997, 1998; Brown *et al.*, 2001; Stafford *et al.*, 2006; Macleod *et al.*, 2007; Daunt *et al.*, 2008). They are especially important in the diet of top predators during the summer, as sandeels then spend much time feeding during the day on zooplankton but burying in the sand at night (Freeman *et al.*, 2004; Engelhard *et al.*, 2008; Greenstreet *et al.*, 2010). At other times of year they mainly remain buried in the sand, where they are inaccessible to many predators such as surface-feeding seabirds, though they continue to be eaten by some predatory fish, seals, and diving seabirds which apparently can dig them out of the sand (Hammond *et al.*, 1994). Although the larvae drift with currents, and following metamorphosis may select on a local scale where to settle on the basis of sediment composition, they do not show extensive horizontal movements after that life-history stage (Gauld, 1990; Wright, 1996; Pedersen *et al.*, 1999; Christensen *et al.*, 2008, Jensen *et al.*, in press).

Top-down effects on sandeels

Demonstrating top-down effects of predators on sandeel stocks is difficult as it is not amenable to experimentation, but relies on detection of correlations; due to different spatial distributions of key predators it is also quite likely that the relative strength of top-down versus bottom-up control of sandeel abundance may vary between different parts of the North Sea (Frederiksen *et al*., 2007). However, we can assess the likelihood of such top-down effects from information on the amounts of sandeel consumed by different predators; it is unlikely that predators taking only small amounts of sandeel would exert significant top-down effects. Predation rates of seabirds and marine mammals on sandeels are trivial by comparison with predation rates by large fish, as shown by the MSVPA analysis. There is no evidence for depletion of sandeels by seabirds or marine mammals, even locally at major breeding colonies. However, some predatory fish consume very large amounts of sandeels. There is evidence that sandeel stocks increased in abundance in the North Sea following major reductions in the stocks of cod, haddock, whiting, herring, and mackerel, apparently a top-down effect resulting from reduced predation by these fish (Sherman *et al*., 1981).

Bottom-up effects on sandeels

There is strong evidence that sandeel stocks are affected by bottom-up processes involving climate and changing plankton stocks. A study of early larval survival suggested that the match between hatching and the onset of zooplankton production may be an important contributory factor to year-class variability in this species (Wright and Bailey, 1996). Frederiksen *et al*. (2005) used Continuous Plankton Recorder (CPR) data to develop an index of sandeel larval abundance for the Firth of Forth area. The sandeel larval index was strongly positively related to the abundance of phyto- and zooplankton, suggesting strong bottom-up control of sandeel larval survival (Frederiksen *et al*., 2005). Van Deurs *et al*. (2009) showed for the "North Sea sandeel" in ICES area IV 1983–2006 (with anomalous data from 1996 excluded) that a positive spawning stock–recruitment relationship is decoupled in years associated with high abundances of age-1 sandeels, and that survival success of early larvae depends on the abundance of *Calanus finmarchicus* but not *C. helgolandicus* or total Calanus density (again measured by CPR). They postulated that 0-group sandeels compete with older sandeels for copepods and so recruitment is reduced by the presence of high abundance of older (normally predominantly 1-group) sandeels. This conclusion contradicts an earlier finding by Arnott and Ruxton (2002) who studied the same sandeel area but for 1983–1999 only, and found a significant positive relationship between sandeel recruitment and total Calanus density over that time period. It is suggested by Van Deurs *et al.* (2009) that this changed pattern of correlation reflects coincidence of the switch in Calanus species at the same time as a run of poor recruitment years of sandeels after 1999. Van der Kooij *et al*. (2008) showed that sandeel distribution and abundance on the Dogger Bank was best explained by seabed substrate, temperature and salinity. However, contrary to the authors' expectation, their data showed that sandeel local abundance was not strongly related to zooplankton local density.

Top-down effects of sandeels on zooplankton

There appears to be no information on sandeels depleting zooplankton densities over their grounds.

Bottom-up effects of sandeels on higher predators: seabirds

Seabirds are long-lived animals with a low reproductive output. Life-history theory predicts that seabirds should buffer their adult survival rates against fluctuations in their food supply (Boyd *et al*., 2006), and since food-fish are short-lived animals with high but also variable recruitment rates (Jennings *et al*., 2001), it is inevitable that seabirds will experience large changes in the abundance of the food fish on which they depend. They must, therefore, have evolved the ability to cope with variation in food abundance. The literature indicates that, seabird breeding success does show a close correlation with food fish abundance (Furness and Tasker, 2000; Rindorf *et al*., 2000; Davis *et al*., 2005; Frederiksen *et al*., 2005), whereas breeding numbers and adult survival may not track these short-term fluctuations (Boyd *et al*., 2006). Nevertheless, several recent studies do show a trade-off between adult survival rate (Frederiksen *et al*., 2008b) and reproductive performance, as a result of adults increasing investment when food supply declines and so incurring costs (e.g. Davis *et al*., 2005). But variation in breeding success is much greater, and easier to measure, and so is likely to provide a much clearer signal of food shortage (Furness, 2002; Mitchell *et al*., 2004; Mavor *et al*., 2006).

Most species of seabirds in the North Sea suffered delayed breeding and widespread reproductive failures in 2003, 2004, 2005 and 2006 (Frederiksen *et al*., 2004; Mavor *et al*., 2005, 2006, 2007; Reed *et al*., 2006). The most severe problems, including total failures of some species, occurred in Shetland and Orkney in the northernmost part of the North Sea. Although bad weather during the chick-rearing period was partly to blame at some colonies, the main proximate cause of the breeding failures was a lack of high-quality food (Davis *et al*., 2005; Wanless *et al*., 2005). Most seabirds in the North Sea feed mainly on sandeels during the breeding season (Wanless *et al*., 1998; Furness and Tasker, 2000; Furness, 2002). Since the 1970s, sandeels have been the dominant mid-trophic pelagic fish in the North Sea, and around Shetland no other high-lipid prey fish occur in sufficient numbers to support successful breeding of most piscivorous seabirds (Furness and Tasker, 2000). There is thus little doubt that the observed seabird breeding failures were linked to low availability of sandeel prey (Frederiksen *et al*., 2004).

Furness and Tasker (2000) reviewed the ecological characteristics of seabirds in the North Sea and ranked species from highly sensitive (e.g. terns, kittiwake, Arctic skua) to insensitive (e.g. northern gannet) to reductions in sandeel abundance. They argued that the most sensitive seabirds would be those with high foraging costs, little ability to dive below the sea surface, little 'spare' time in their daily activity budget, short foraging range from the breeding site, and little ability to switch diet. This prediction was supported by empirical data from studies at Shetland (Furness and Tasker, 2000; Poloczanska *et al*., 2004) and at the Isle of May, east Scotland (Frederiksen *et al*., 2004). As one example, Figure 3.1a shows breeding success of kittiwakes on the Isle of May during years of sandeel fishing in the area and in years without sandeel fishing. Breeding success of kittiwakes in both periods varied with sea surface temperature, but was considerably lower when there was a sandeel fishery in the area where these birds were foraging. In Shetland, breeding success of kittiwakes and Arctic skuas (Figure 3.1b) shows very low success during periods of low Shetland sandeel stock biomass (late 1980s and 2000 onwards). Arctic skuas in Shetland feed almost exclusively on sandeels, although they obtain these by stealing them from terns, kittiwakes and auks, and so the link between their breeding success and sandeel stock size is indirect (Davis *et al*., 2005). We can estimate the amount of sandeels consumed by Arctic skuas from data on the numbers and energy requirements of these birds. The annual consumption of sandeels by Arctic skuas at Shetland in the period 1980–2000 is estimated to have been around 65 tonnes per year. This contrasts strongly with the observation that Arctic skua breeding success at Shetland fell to less than half of the level seen in years of high sandeel abundance when the sandeel stock biomass was below about 30 000 tonnes. The data indicate that Arctic skuas require a sandeel stock biomass about 460 times greater than the amount that they consume, in order to be able to gain energy at a rate sufficient to sustain a good level of breeding success. This seems to be the extreme case, with much lower ratios for kittiwake and even lower for guillemots. Throughout this period, breeding success of gannets remained consistently high in Shetland as those birds were able to switch to feed on adult herring and mackerel, fish too large to be caught (or swallowed) by kittiwakes or Arctic skuas.

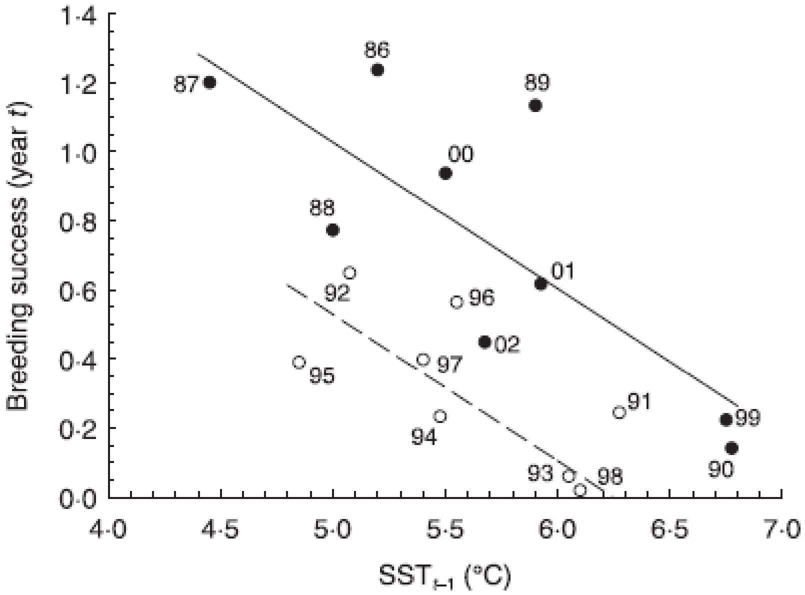


Figure 3.1a. Kittiwake breeding success as a function of local SST in February–March of the previous year and presence/absence of the Wee Bankie sandeel fishery. Data labels indicate current year. Regression lines estimated from weighted multiple regression. Filled circles and solid line, non-fishery years; open symbols and dashed line, fishery years. From Frederiksen *et al.*, 2004.

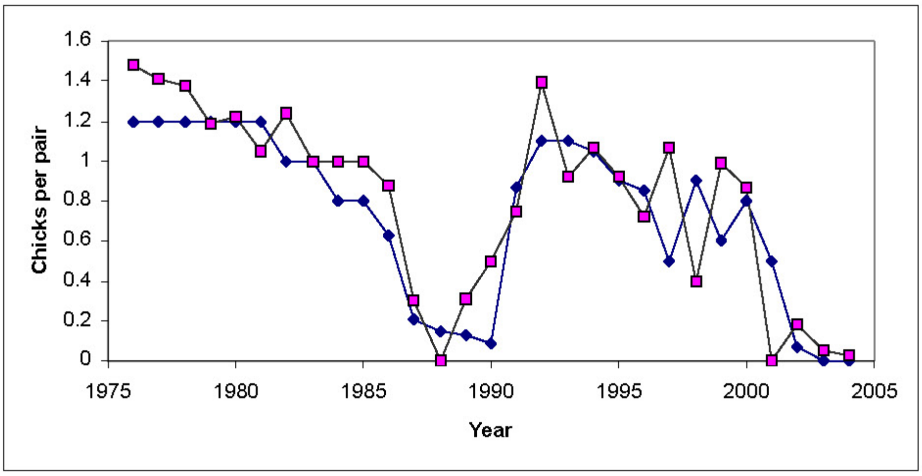


Figure 3.1b. Breeding success of black-legged kittiwakes (pink) and Arctic skuas (blue) at Foula, Shetland, during 1976–2004, showing a close correlation between the success of the two species in this time-series, and periods of particularly low success in 1987–1990 and in 2001–2004.

In 2004, breeding success was exceptionally low for most seabird species on the Isle of May, despite sandeel larvae being abundant in the spring of 2003 so this low breeding success was unexpected. Detailed studies showed that the energy content of both sandeels and sprat fed to seabird chicks in 2004 was extremely low, indicating poor food availability for the fish (Wanless *et al*., 2005). Data from chick-feeding puffins and CPR samples also indicate that the size-at-date of both larval, 0 group and older sandeels has declined substantially since 1973, although it is unclear what the cause of this decline might be (Wanless *et al*., 2004). There is thus evidence that both abundance and quality of seabird prey is under bottom-up control in this region, and this is likely to have affected seabird breeding success.

Bottom-up effects of sandeels on higher predators: fish

Sandeel is an important prey species for a range of natural predators (Hislop *et al*., 1991; WGSAM 2008). Of these, the species most likely to be affected are the species for which the sandeel make up a large proportion of the diet. In the North Sea, this would include whiting, haddock, mackerel, starry ray and grey gurnard (Figure 3.3b). These species all have a diet composition consisting of at least 10% sandeel. However, the proportion only exceeds 20% in the diets of western mackerel and starry ray. Of these two, the diet of western mackerel refers only to the time they spend in the North Sea, and hence the overall average percentage is likely to be lower.

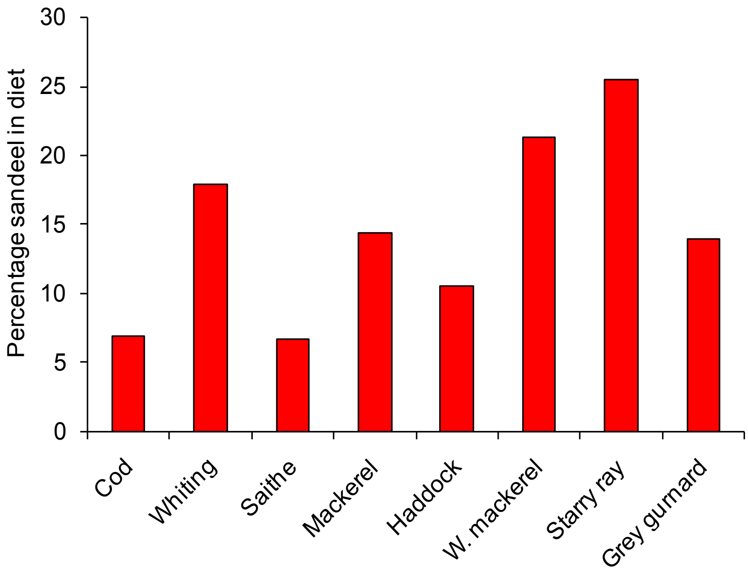


Figure 3.3b. Proportion of the diet consisting of sandeel for different predatory fish (ICES 1997).

Whiting might also be affected by a decline in sandeel availability. However they might also switch prey to consume greater quantities of herring and sprat, since populations of these species have increased in recent years, as has the apparent spatial overlap between whiting and sprat distributions. Two sources of recent data are available to test this hypothesis, from research carried out in the Firth of Forth region as part of the EU FP6 IMPRESS project (1997–2003), and from research carried out on western Dogger Bank ('MF0323' project; 2004–2006).

Three gadoid populations (cod haddock, whiting) were sampled at 19 evenly spaced stations in the Firth of Forth (including Wee Bankie and Marr Bank) on seven research cruises. The contribution of sandeels to the diet of the three gadoid predators varied markedly from year to year, although the importance of sandeels in particular years was consistent across all three species. No evidence of any beneficial effect of the local sandeel fishery closure in 2000 on the abundance or biomass of any of the three gadoid predators was apparent, however, there was evidence that fish condition was greater in years when the proportion of sandeel prey in the diet of each predator was higher (Figure 3.3c; see also Greenstreet 2006).

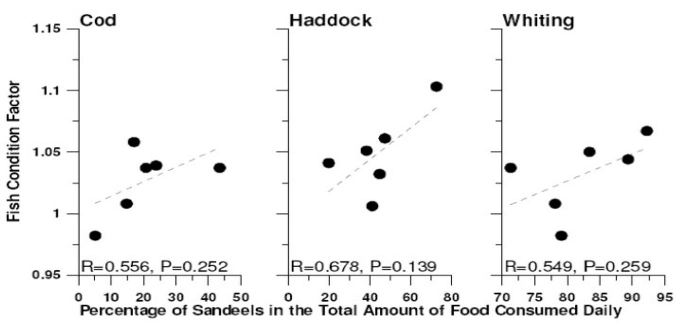


Figure 3.3c. Relationship between the body condition of gadoid predators in the Firth of Forth, and the quantity of sandeels consumed (from Greenstreet *et al.*, 2006).

Between 2004 and 2006, CEFAS conducted investigations into sandeels and their predators on the Dogger Bank ('MF0323' project). Two survey grids were sampled each containing 48 stations, the grids were separated by 28 km. The northernmost survey grid ('grid 1'), on an area known as the 'North-West Riff', was characterised as having high sandeel abundance and was an important area for the sandeel fishing fleet. The southernmost grid ('grid 2') on an area known as 'The Hills' was characterised by much lower sandeel abundance, and was less important to the sandeel fishery. Predator stomachs (mostly whiting, plaice, lesser weeverfish, grey gurnard, haddock, and mackerel) were sampled on six research cruises. The diets of all species were found to vary markedly and consistently between the two sampling grids (Pinnegar *et al*., 2006). Sandeels were much more important to predators (especially whiting and lesser weeverfish) at grid 1, and this coincides with the greater abundance of sandeels at grid 1, as determined by dredge survey during the night.

Clear seasonal differences were observed in predator diets for all species. Diets were much more diverse during autumn as compared to those in spring. Whiting ate substantially more crabs and sprat during the autumn period as well as hyperid amphipods, and much less sandeel at both sampling grids. Sandeels bury themselves in the sediment during autumn and winter months and are thus less accessible to predators, even though they were more abundant in real terms than was the case during the spring. Preliminary analyses (G. Engelhard, unpublished data) suggest that for some predators, most notably lesser weeverfish *Echiichthys vipera*, body 'condition' was slightly better at the high-sandeel site (grid 1) compared to the low-sandeel site (grid 2). An examination of interannual variability in fish body condition revealed that plaice and weever condition was better in sandeel-rich years and at the sandeel-rich survey grid. Whiting and haddock condition was better in sandeel-rich years, but no site difference was apparent in these mobile species which forage over a large area. Grey gurnard and greater sandeel (*Hyperoplus lanceolatus*) condition appeared not to be significantly linked to sandeel numbers, but positively linked to per-capita sandeel consumption (condition was better when more sandeels were observed to have been consumed). Thus it was concluded that various predatory fish species do have better condition in years/sites where sandeels are more abundant. In a parallel study carried out in August and October 2006, whiting were sampled aboard commercial fishing vessels all along the North East coast of England (from Flamborough to the Firth of Forth, including the Dogger Bank). It was noted by the crew that the fish caught over areas of hard ground with empty stomachs during the August survey were very thin and of poor condition (Stafford *et al*., 2006). Where stomachs were not empty, the main contents were small crustaceans in August and fish in October. Fish consumed were often non-commercial prey species such as pipefish or hagfish, although gadoids and clupeoids were also consumed. The data show changes from the 1981 and 1991 ICES 'year of the stomach' sampling exercises, when far more sandeel and clupeoids and far less crustaceans were consumed. The authors of this study (Stafford *et al*., 2006) speculate that the limited availability of sandeels in 2006 may have been responsible for the poor body condition of the fish in that year and the selection of nutritionally poor prey items such as snake pipefish.

Other impacts on sandeels

Hassel *et al*. (2004) showed that seismic shooting can kill sandeels, and may impact commercial catches on banks where seismic shooting is occurring. There are concerns that marine wind farms could possibly affect sandeels by altering sediment around turbines and possibly by noise/vibrations. Van Deurs *et al*. (2008) reported that they found no adverse effects of beam trawling on sandeels where beam trawling was carried out over sandeel grounds.

Implications for ecosystem-based management

Due to the stationary habit of post-settled sandeels, a patchy distribution of the sandeel habitat (Holland *et al.*, 2005), and a limited interchange of the planktonic stages between the spawning areas, the sandeel stock in IV consists of a number of sub-populations (Pedersen *et al.*, 1999; Christensen *et al.*, 2008). Within these sub-populations, fishing for sandeels may deplete numbers on particular banks. Recent evidence indicates that although closures can lead to rapid recovery of sandeel numbers in some cases (Greenstreet *et al.*, 2010), in others, banks may not be recolonised for some years. Although hydrographical features and the general distribution pattern of the sandeel spawning populations are responsible for most of the variation in recolonisation (Christensen *et al.*, 2008), possibly some of the variation in recolonisation of banks after depletion may reflect habitat preferences of sandeels that are seeking sites to settle, with optimal substrate being more attractive (Wright *et al.*, 2000). This pattern may also result from some local movement of settled sandeels between adjacent but especially within banks from poorer habitat to preferred habitat (Jensen *et al.*, in press). There was evidence for such relocation in Shetland, for example, where high fishery catches continued to be taken from Mousa even when all surrounding banks had become depleted, and breeding success of seabirds such as terns and kittiwakes had fallen close to zero due to shortages of sandeels around most of Shetland. Predators dependent on sandeels (such as kittiwakes) may therefore be adversely affected by local or regional depletion of sandeels. Serial depletion of banks in an area seems to be a particular risk. There is a need for sandeel stock assessment and management to take these risks into account. Exact local densities of sandeels needed to sustain healthy populations of predators are not known, and no doubt vary according to a range of ecological conditions and predator communities. But research has shown that certain top predators show particularly strong responses to depletion of sandeels. In particular, kittiwake breeding success tends to correlate strongly with abundance of sandeels over about a 50 km foraging radius around kittiwake colonies. In regions where kittiwakes feed predominantly on sandeels while breeding, which is the case in the North Sea, poor breeding success of these “indicator” seabirds can be used as evidence that the local stock of sandeels is depleted. Such evidence is less direct than can be obtained from dredge or acoustic surveys, but may help to identify problem areas where sandeel aggregations need to be allowed to recover. Sandeel stock assessments and subsequent management should also aim to avoid depletion of stocks to levels where damage to ecosystems becomes evident through its impact on dependent predators. Though the actual level at which these adverse effects occur is presently unknown in most cases, it is clear that a stock below the level where recruitment is impaired will significantly increase the probability of effects on top predators and is hence highly unlikely to be compatible with an ecosystem approach to fisheries.

Northeast UK closure

Due to their importance in North Sea food webs, ICES has advised that management should ensure that sandeel abundance be maintained high enough to provide food for a variety of predator species. During the early 1990s a sandeel fishery developed in Area 4, off the Firth of Forth. The landings from this fishery peaked at over 100 000 t in 1993 and then subsequently fell. The Firth of Forth area is important for breeding seabirds and the removal of such large quantities of sandeels within their foraging range soon became a matter of concern. In 1999, the UK called for a moratorium on sandeel fishing adjacent to seabird colonies along the UK coast and in response the EU requested advice from ICES. An ICES Study Group was convened in 1999 in response to this request with two terms of reference (ICES 1999):

a) assess whether removal of sandeel by fisheries has a measurable effect on sandeel predators such as seabirds, marine mammals, and other fish species;

b) assess whether establishment of closed areas and seasons for sandeel fisheries could ameliorate any effects. Identify possible seasons/areas as specifically as possible.

This study group noted that there was suggestion of a negative effect of the Firth of Forth fishery on the local sandeel abundance in 1993 which coincided with a particularly low breeding success of seabirds, especially kittiwakes. The study group concluded that there were two reasons for continued concern about this area that provided the basis for a precautionary closure:

1) sandeels supported a number of potentially sensitive seabird colonies (Lloyd *et al.*, 1991).

2) work on population structure indicated that sandeels in this region are reproductively isolated from the main fished aggregations in the North Sea (Wright *et al.*, 1998).

The ICES study group noted that, as sandeel assessments are only conducted for the North Sea, there was no reliable information on the state of the sandeel aggregations near the Firth of Forth, which forms part of area division 4 (see Figure 4). Given available information the study group proposed that kittiwake breeding success was the best practical indicator of sandeel availability at least to seabirds and threshold levels of the breeding success of this species should be used to guide futures decisions on re-opening. After ICES Advisory committees and STECF acceptance of the study group's advice, the EU advised that the fishery should be closed whilst maintaining a commercial monitoring. However, the EU did not accept the use of kittiwake breeding success as a harvest control threshold. A three year closure, from 2000 to 2002, was decided and the Commission was requested to produce annual reports to the Council on the effects of the restrictions in the sandeel fishery in the Firth of Forth area. On the basis of the second of these reports (Wright *et al.*, 2001) and uncertainty over the impact of the closure the commission proposed a further three year extension of the closure. The wording of the Act is stated in article 29a of: "Council Regulation (EC) no 850/98 of 30 March 1998 for the conservation of fishery resources through technical measures for the protection of juveniles of marine organisms". A further scientific review of the closure was made by STECF in 2007, together with other EU fishery closures. That group proposed that it would be prudent to wait for enhanced recruitment and productivity in the area before any re-opening is considered.

Evaluating changes in sandeel abundance in the region has been difficult due to the lack of a single reliable sampling method for assessing sandeel abundance. Nevertheless, the various research (acoustic, trawl and dredge) and commercial abundance indices suggested an initial increase in sandeel abundance during the period of the closure (Greenstreet *et al.*, 2006). This increase began with a relatively large recruitment in the first year of the closure, which would not have been related to any recovery in the spawning stock. Dredge surveys in 1999 and 2000 indicated a detectable decrease on total mortality on 1+ sandeels following the closure. A further indication that sandeel abundance increased in the region came from the observation that in 2003, when landings in the North Sea as whole had severely declined, 39 060 tonnes were taken in the ICES rectangle adjacent to the closed area near Marr and Berwick banks.

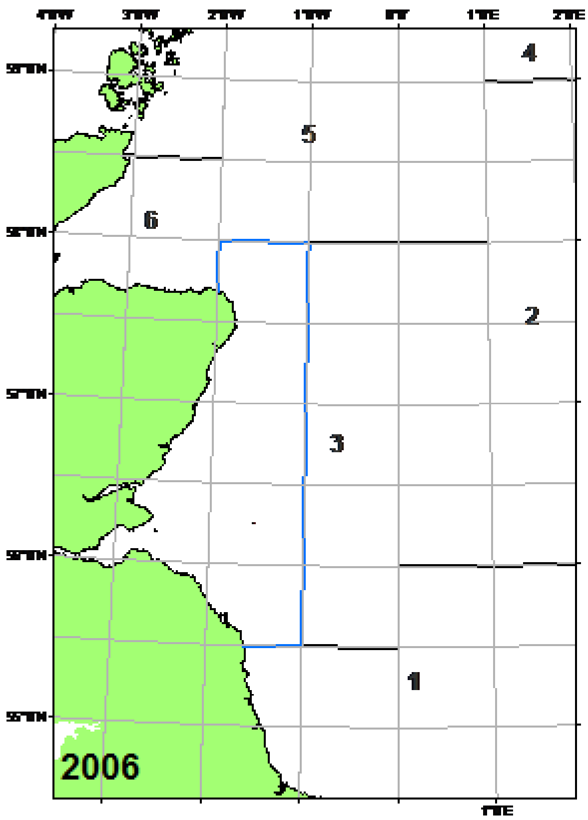


Figure 4. Chart showing the closed area (blue line).

Kittiwake breeding success has tended to be higher since the fishery closure than in the preceding five years. However, poor breeding success in 2004 seen along the whole of the east U.K. coast appears partly related to environmental factors affecting the incoming year class of sandeels. Evidence from studies published since the ICES (1999) study group suggest that the breeding success of this species is not a reliable indicator of sandeel availability to some other coastal seabirds. For example, a downward trend in guillemot breeding success throughout the 1990s has not been reversed by fishery closure (but that species feeds extensively on sprats as well as sandeels in this area). After a series of very poor breeding seasons for seabirds since 2004 on the Isle of May, Firth of Forth, the 2009 season was the most successful in recent years, matching evidence of increased sandeel abundance from the dredge survey. Of six seabird species studied intensively, European shag had its highest productivity on record with only razorbill having productivity below average. All other species studied had their most productive season for at least four years. Sandeels remained the main food of young Atlantic puffins, razorbills and kittiwakes. Comparatively few 1+ group sandeels were present in food samples during the chick-rearing period in 2009, however 0-group appeared in large numbers and were substantially longer than in recent years, again matching dredge results. Kittiwakes had a good season with productivity (0.70 chicks per incubated nest) the highest since 2005 and well above the long-term average. The proportion of sandeel in kittiwake diet (89% by biomass) in 2009 was the highest since 2005.

However, the concern over a possible local impact of sandeel fishing expressed in 1999 has not fundamentally changed. On re-opening, the sandeel aggregations in the Northeast closure could be subject to significant depletion unless there were revised management controls. As originally agreed by the Commission, STECF would have to convene an international meeting of scientists to come up with a consensus on criteria for re-opening.

Data

Age composition and mean individual weight

Data available

Data available included Danish and Norwegian samples from harbour sampling and Danish samples taken by skippers on board vessels and frozen immediately (available from 1999 onwards). The Danish samples cover both age and length distributions whereas the Norwegian samples cover only length distribution prior to 1997 and both age and length samples after 1997. Sandeel measured for length distribution were weighed in the Danish samples whereas only aged sandeel were weighed from the Norwegian samples. To obtain weight-at-length for Norwegian samples, the parameters of the weight–length relationship.

$$W = aL^b$$

were estimated using the sandeel weighed in the Norwegian age samples after 1997 and Danish length–weight relationships before 1997 and weight-at-length estimated for sandeel which were not weighed. All data are combined in the analyses, corresponding to the assumption that the composition of catches taken in a given year and month did not differ between countries and that no differences in age reading existed.

Estimating age-length keys

Only age readings of *Ammodytes marinus* and unidentified sandeel Ammodytes spp. are used. The method suggested by Rindorf and Lewy (2001) is used to assure that the estimation is optimized when sampling is sparse. This method is used to estimate an age–length-key for each combination of year, time and area (Table 4.1.1). When the number of fish aged is too low to allow a reliable estimation on square level (confidence limits of the estimate exceeds +/-25%), higher aggregation levels are used (Table 1). When a given age is not observed in an age sample, this is assumed to reflect an absence of this age only if the number of fish sampled of this age or older exceeds ten. Otherwise, the absence of the particular age is assumed to be a result of low sampling efforts, and the probability of being of the particular age compared to the probability of being older taken from a higher aggregation level. The probability of being of a given age is set to zero at lengths outside the interval of lengths observed for this age +/-2 length groups (1 cm groups from 6 to 20 cm, 2 cm groups between 20 and 30 cm). Overdispersion (Rindorf and Lewy, 2001) was not estimated.

Estimating age distributions and mean weight-at-age

The number of *A. marinus* of each age (0 to 4+) per kg and the mean weight per individual of each age in each length distribution sample is estimated by combining the age–length key and the length distribution specific to square and period. The average number of sandeel per age per kg and their mean weight in a given rectangle in each month was estimated as the average of that recorded in individual samples when at least five samples were available. Mean weight was only estimated when the total catch of a given age in the square exceeded ten. If the total North Sea sampling resulted in less than ten sandeel of a particular age, the mean weight for the North Sea as a whole was used. When less than five length samples were taken, the next aggregation level (Table 4.1.2) was used. Hence, for each rectangle, month and year, the average number of *A. marinus* per age and kg caught was estimated and the level noted. No correction was made for differences in condition between on-board samples and harbour samples.

Estimating catch in ton per square per month

Before 1989, only logbook information stating the catch in directed Danish sandeel fishery is known. As the large majority of the catch in the sandeel fishery consists of sandeel, the distribution of catches in the directed sandeel fishery on squares and months were assumed to represent the distribution of sandeel catches. The total catch in tonnes was derived from the report of the working group on the assessment of Norway pout and sandeel (ICES, 1995) and distributed on squares and month in the particular year according to the distribution of catches derived from Danish logbooks. From **1989 to 1993**, the landings of sandeel per square and month from the Danish fishery are available at DTU-AQUA. These were used to distribute total landings to square and month. From **1994 to 1998**, international sandeel catches in ton per square per year are available. These catches were distributed to months according to the monthly distribution of Danish catches in the square in the given year. If no Danish catches were recorded from the square, the monthly distribution of the total catches in the ICES division was used. **After 1999**, international sandeel catches in ton per square per month and year are available.

All catches were scaled in order to sum to official ICES landing statistics.

Estimating catch in numbers and mean weight

The catch in numbers per age (1000s), month and square of sandeel is estimated as the product of sandeel catches in kg and the number-at-age of sandeel per kg in the particular square. The total number in a larger area and longer time period is estimated as the sum over individual squares and months in this area. The mean weight (kg) is estimated as the weighted average mean weight (weighted by catch in numbers of the age group in the square and month).

The text table below shows which country supplies which kind of data:

	Data				
Country	Caton (catch in weight, month square)	Length samples from catches	Weca (weight-at-age in the catch)	Matprop (proportion mature-by-age)	
Denmark	x	x	x	x	
Norway	x	x	x		
UK/Scotland	x				
Sweeden	x				
Farao Islands	x				

Biological

Both the proportion of natural mortality before spawning (M_{prop}) and the proportion of fishing mortality before spawning (F_{prop}) are set to 0.

The values of natural mortalities for sandeel used in the assessment are based on MSVPA model output, and have been kept constant since 1989 (ICES CM 1989/Asssess:13). However, the benchmark assessment group (ICES, 2010) considered that since there were updated estimates of half-yearly natural mortality available from WGSAM, these should be used in the assessment. The most recent estimate of natural mortality was done in 2008 by the Working Group on Multispecies Assessment Methods (WGSAM) in the so-called North Sea key-run (ICES, 2008). Compared to the MSVPA results used as basis for M in the assessment the WGSAM results are based on almost twice as many stomachs observations including both additional stomach samples for the main predators (cod, haddock, whiting, Saithe and mackerel) and additional predators (horse mackerel, grey gurnard, *Raja radiata*, and ten bird species). Figure 3.5 shows the partial predation mortality (M2) of sandeel by year as estimated by WGSAM. It is clear that there has been a significant increase in M since the late 1990s. The natural mortalities by age as estimated by WGSAM show almost equal values for the two half-years, while the M used by the assessment are much higher in the first half year. As the trends in natural mortality were only apparent in the end of the time period where the uncertainty is greatest, it was decided not to use annual estimates of M. Instead, the average over the period 1982 to 2007 for each age and half-year was used.

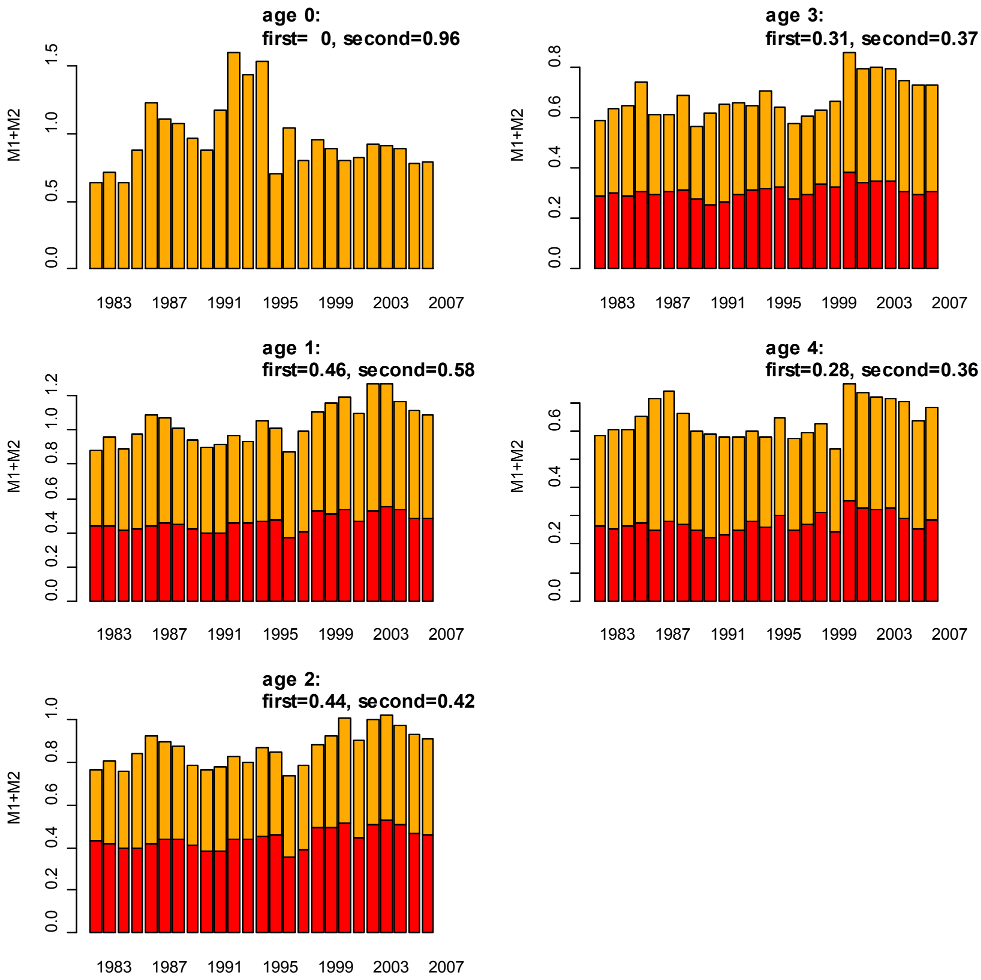


Figure 3.5. Natural mortalities of sandeel by half year. Mean values (1982–2007) for first and second half year are presented in the headings.

Past estimates of spawning stock size assumed a knife edge age-at-maturity, with all sandeels spawning at age 2. A model of maturity in relation to size, age and area found that this assumption did not hold for all sub-population areas (Boulcott *et al.*, 2007). The data used in this publication were collected during dredge surveys in 1999 and 2004. Data from 1999, indicated that a significant proportion of sandeels from area 3 were mature by age 1. In area 4, sandeels were found to mature at a smaller size than other areas but because of their low growth rate, the proportion mature by age 2 was still less than 1. Unpublished data for area 4 from 2000 were consistent with the published results. A time-series (2004–2009) of spatially resolved maturity data from the December dredge survey for areas 1–3 is held by the Danish institute. The working paper of Steen (WDA1 in Appendices) evaluates the assumption of knife edge maturity from these data. Whilst most sandeels from the time-series were mature at age 2, there was sufficient deviation from the knife edge age-at-maturity assumption for the benchmark group to decide that annual differences should be considered in area based assessments (see Section 5). For area 4, only the age maturity key of Boulcott *et al.* (2007) was applied, as there was no time-series of data available.

Surveys

Since 2004 DTU Aqua (formerly DIFRES) has carried out a survey with a modified scallop dredge to measure the relative abundance of sandeel in the seabed (REF). The

Danish dredge survey is conducted in late November–early December when the 0-group sandeel have been recruited to the settled population and the entire population is assumed to reside in the seabed.

Since 2004, in total 828 hauls have been at fixed positions on known sandeel habitats at known fishing banks in the North Sea from the little Fisher Bank in the Northeastern North Sea, to the Dogger Bank in the Southwestern North Sea (Figure 4.2.1.1). From 2006 additional positions were sampled in the Norwegian EEZ.

As a varying number of hauls have been made at the different positions over the years, calculation of the annual stratified average catch rates (total number caught by hour) for each area was done in a three step procedure: first, for each year, the average catch rate of each position was calculated as the average of the catch rates of all hauls (stations) made on this position, then the average catch rate of each ICES square was calculated as the average of the catch rates of its positions, and finally the average catch rate of each area was calculated as the average of the catch rates of its ICES squares. In other words, the annual average catch rate by area is calculated by:

(1) $$\overline{CPUE}_a = \frac{\sum_{sq} \overline{CPUE}_{a,sq}}{n_{a,sq}}$$

where

(2) $$\overline{CPUE}_{a,sq} = \frac{\sum_{pos} \overline{CPUE}_{a,sq,pos}}{n_{a,sq,pos}}$$

where

(3) $$\overline{CPUE}_{a,sq,pos} = \frac{\sum_{st} \overline{CPUE}_{a,sq,pos,st}}{n_{a,sq,pos,st}}$$

where n: number of hauls, a: area, sq: square, pos: position and st: station.

Descriptions of the survey and consistency analysis are given in WP on survey and ICES benchmark report.

Commercial cpue

Until 2009 the sandeel assessment was calibrated by the commercial cpue indices. With the introduction of the dredge survey from 2010 commercial cpue are no longer used for calibration.

Other relevant data

None.

Estimation of historical stock development

The Seasonal XSA (SXSA) developed by Skagen (1993) was up to 2001 used for stock assessment of sandeel in IV. Annual XSA was tried in 2002 WG where it was concluded that the two approaches gave similar results. For a standardization of methodology, it was decided to shift to XSA in 2003. From 2004 to 2009 SXSA was used again for the final assessment. In 2010 the SMS model was used as the assessment in 2009 indicated that the SXSA was sensitive to model settings and changes in effort distribution (ICES, 2009).

Previous whole-area assessments of Sandeel showed no consistent relationship between effort and F but, when moving towards a more biologically plausible assessment area, there is evidence that fishing effort may be used as a reasonable proxy for fishing mortality (Benchmark report, ICES 2010). This relationship has been used by the SMS model as the driver for estimating F. The SMS model has options to estimate rates for technical creeping and thereby take into account that the efficiency has increased in the sandeel fishing fleet. The results show that the new model fits to data in a reasonable way, and give results without retrospective bias. The model can be applied for assessment with just catch and effort, and for assessment where additional fisheries independent data are available.

Methodology

The SMS model, presently used for the ICES assessment of blue whiting (WGWIDE), and for the North Sea and Baltic Sea multispecies (WGSAM), was modified slightly to estimate fishing mortality from observed effort. In the original SMS version, fishing mortality, $F_{y,q,a}$ was modelled as an extended separable model including a seasonal, age and year effect. The new version substitutes the year effect by observed effort.

$F_{y,q,a}$ = SesonEffect(Y,A1) * AgeEffect(Y,A2,q) * YearEffect$_y$ (1, original version)

$F_{y,q,a}$ = SesonEffect(Y,A1) * AgeEffect(Y,A2,q) * Effort$_{y,q}$ (2, new version)

where

indices A*1* and *A2* are groups of ages, (e.g. ages 0, 1–2, 3–4) and *Y* is grouping of years (e.g. 1983–1998, 1999–2009). The SMS-effort defines that the years included in the model can be grouped into a number of period clusters (*Y*), for which the age selection and seasonal selection are assumed constant. Fishing mortality is assumed proportional to effort. The grouping of ages for age selection, *A1*, and season selection, *A1*, can be defined independently.

An example of parameterization with maximum annual effort at 1.0 is shown below. (Unique parameters in bold).

	Season effect A1=age 0 and age 1-4										
	First half year						Second half year				
YY	Age 0	Age 1	Age 2	Age 3	Age 4		Age 0	Age 1	Age 2	Age 3	Age 4
1983–1998	0.00*	0.426	0.426	0.426	0.426		1.0*	0.5*	0.5*	0.5*	0.5*
1999–2009	0.00*	0.337	0.337	0.337	0.337		1.0*	0.5*	0.5*	0.5*	0.5*

*** kept constant**

	Age effect A2=age 0, age 1, age2 and age 3-4										
	First half year						Second half year				
YY	Age 0	Age 1	Age 2	Age 3	Age 4		Age 0	Age 1	Age 2	Age 3	Age 4
1983–1998	0.00*	0.488	1.024	1.248	1.248		0.014	0.772	0.847	0.585	0.585
1999–2009	0.00*	0.772	0.857	0.585	0.585		0.010	0.176	0.195	0.133	0.133

"Catchability"-at-age, or more correctly the relation between effort and F by age group, is included in the AgeEffect parameter.

There are two additional options for the SMS-effort version, where technical creeping is taken into account.

$F_{y,q,a}$ = SesonEffect(Y,A1) * AgeEffect(Y,A2,q) * $\text{Effort}_{y,q}$ * (y-firstYear)$^{\text{commonCreep(Y)}}$ (3)
$F_{y,q,a}$ = SesonEffect(Y,A1) * AgeEffect(Y,A2,q) * $\text{Effort}_{y,q}$ * (y-firstYear)$^{\text{ageCreep(Y,A1)}}$ (4)

Equation (3) uses a common creeping exponent for all ages by one or more year clusters (Y), e.g. the efficient increase by 3.8% per year in the first year range, and 2.8% per year in the second. Equation (4) is more flexible as it allows an age dependent creeping exponent. If we assume that we only use one year cluster (the whole year range) an example could be that the technical creep for age 1 is 5.5% per year, while age 2 has a negative exponent, -2.7% (equivalent to parameter=0.973). As the product of effort and "technical creep" express both the fishing power and the directivity towards a specific age group, such an example indicates that there has been an overall increase in (standardised) fishing power, but the fishery has been less directed towards older sandeel in recent years.

SMS is a statistical model where three types of observations are considered: Total international catch-at-age; research survey cpue (and stomach content observations, which are not used here). For each type a stochastic model is formulated and the likelihood function is calculated. As the three types of observations are independent the total log likelihood is the sum of the contributions from three types of observations. A stock–recruitment (penalty) function is added as a fourth contribution.

Catch-at-age

Catch-at-age observations are considered stochastic variables subject to sampling and process variation. Catch-at-age is assumed to be lognormal distributed with log mean equal to log of the standard catch equation The variance is assumed to depend on age and season and to be constant over years. To reduce the number of parameters, ages and seasons can be grouped, e.g. assuming the same variance for age 3 and age 4 in one or all seasons. Thus, the likelihood function, L_C, associated with the catches is

$$L_{CATCH} = \prod_{a,y,q} \frac{1}{\sigma_{CATCH\,a,q}\sqrt{2\pi}} \exp\left(-\frac{(\log(C_{a,y,q}) - E(\log(C_{a,y,q})))^2}{2\sigma^2_{CATCH\,a,q}} \right)$$

Where

$$E(\log(C_{a,y,q})) = \log\left(\frac{F_{a,y,q}}{Z_{a,y,q}} N_{a,y,q} (1 - e^{-Z_{a,y,q}}) \right)$$

Leaving out the constant term, the negative log-likelihood of catches then becomes:

$$l_{CATCH} = -\log(L_{CATCH}) \propto NOY \sum_{a,q} \log(\sigma_{CATCH\,a,q}) + \sum_{a,y,q} (\log(C_{a,y,q}) - E(\log(C_{a,y,q})))^2 / (2\sigma^2_{CATCH\,a,q}))$$

Survey indices

Similarly, the survey indices, *cpue(survey,a,y,q)*, are assumed to be log-normally distributed with mean

$$E(\log(CPUE_{survey,a,y,q})) = \log(Q_{survey,a}\,\overline{N}_{SURVEY\,a,y,q})$$

where Q denotes catchability by survey and $\overline{N}_{SURVEY}$ mean stock number during the survey period. Catchability may depend on a single age or groups of ages. Similarly, the variance of log *cpue*, $\sigma(survey, a)$, may be estimated individually by age or by clusters of age groups. The negative log likelihood is on the same form as for catch observations:

$$l_{SURVEY} = -\log(L_{SURVEY}) \propto \sum_{survey,a} NOY_{survey} \sum_{survey,a} \log(\sigma_{SURVEY\,survey,a}) +$$
$$\sum_{survey,a,y} (\log(CPUE_{survey,a,y}) - E(\log(CPUE_{survey,a,y}))^2 / (2\sigma^2_{SURVEY\,survey,a}))$$

Stock–recruitment

In order to enable estimation of recruitment in the last year for cases where survey cpue and catch from the recruitment age is missing (e.g. saithe) a stock–recruitment relationship $R_y = R(SSB_y \mid \alpha, \beta)$ penalty function is included in the likelihood function. Assuming that recruitment takes place at the beginning of the third quarter of the year and that recruitment is lognormal distributed the parameters the log penalty contribution, l_{SR}, equals

$$l_{SR} = -\log(L_{SR}) \propto NOY\ \log(\sigma_{SR}) + \sum_{y} ((\log(N_{a=0,y,q=3}) - E(\log(R_y)))^2 / 2\sigma^2_{SR})$$

where

$E(\ln(R_y)) = \ln(\alpha\ SSB_y \exp(-\beta\ SSB_y))$ for the Ricker case. Other stock–recruitment relations (Beverton and Holt and "Hockey stick") and stock-independent geometric mean recruitment have also been implemented. As indicated in equation (26) recruitment-at-age zero in the beginning of the third quarter was considered.

Total likelihood function and parameterisation

The total negative log likelihood function, l_{TOTAL}, is found as the sum of the four terms:

$$l_{TOTAL} = l_{CATCH} + l_{SURVEY} + l_{STOM} + l_{SR}$$

Initial stock size, i.e. the stock numbers in the first year and recruitment over years are used as parameters in the model while the remaining stock sizes are considered as functions of the parameters.

The parameters are estimated using maximum likelihood (ML) i.e. by minimizing the negative log likelihood, l_{TOTAL}. The variance/covariance matrix is approximated by the inverse Hessian matrix. The variance of functions of the estimated parameters (such as biomass and mean fishing mortality) has been calculated using the delta method.

The SMS model was implemented using the AD Model Builder (ADMB Project 2009), freely available from ADMB Foundation (www.admb-project.org). ADMB is an efficient tool including automatic differentiation for Maximum likelihood estimation of many parameters in nonlinear models.

Settings of the SMS model is implicated in the Text Table 1 and the configuration file for Area 1 in Appendix AA.

Text Table 1. Settings of the SMS model.

Option	Area 1	Area 2	Area 3
Data first year	1983	1983	1983
Time step	Half-year	Half-year	Half-year
First age	Age 0	Age 0	Age 0
Last age	Age 4+	Age 4+	Age 4+
Spawning time	Start of 1st half-year	Start of 1st half-year	Start of 1st half-year
Recruitment time	Start of 2nd half-year	Start of 2nd half-year	Start of 2nd half-year
Age range for use of catch data in likelihood	Age 0 – age 4+	Age 0 – age 4+	Age 0 – age 4+
Last age with age dependent selection	Age 3	Age 3	Age 3
Objective function weighting (catch, survey, S/R)	1.0, 0.5, 0.01	1.0, 0.25, 0.01	1.0, 0.5, 0.01
Minimum CV of catch observations	0.2	0.2	0.2
Minimum CV of survey observations	0.2	0.2	0.2
Minimum CV of S/R relation	0.2	0.2	0.2
Catch observations: variance group	Age 0, ages 1 & 2 combined and ages 3 & 4 combined	Age 0, ages 1 & 2 combined and ages 3 & 4 combined	Age 0, ages 1 & 2 combined and ages 3 & 4 combined
Treatment of zero catch observations	Not used in likelihood	Not used in likelihood	Not used in likelihood
Year ranges for constant exploitation pattern	1983–1988, 1989–1998 & 1999-	1983–1998 & 1999-	1983–1988, 1989–1998 & 1999-
Ages for seasonal exploitation pattern	Age 0, and ages 1–4+ combined	Age 0, and ages 1–4+ combined	Age 0, and ages 1–4+ combined
Ages for calculation of mean F	Age 1 & age 2	Age 1 & age 2	Age 1 & age 2
Exclusion of catch data (no or very small catches are available)	2007 second half year	2007 second half year	2007 second half year
Catch Variance	Calculated within SMS	Calculated within SMS	Calculated within SMS
Survey variance	Free parameter	Free parameter	Free parameter
S/R variance	Calculated within SMS	Calculated within SMS	Calculated within SMS
Inflexion point (B_{lim})	160 000	70 000	100 000
Survey information			
Survey	Area 1: Dredge survey December 2004 Age 0 & age 1	Area 1 (copy) :Dredge survey December 2004 Age 0	Area 3:Dregde survey December 2004 Age 0 & age 1
Half year	2	2	2
Time: Alfa & beta	0.75, 1.0	0.75, 1.0	0.75, 1.0
Ages for separate	Age 0 and age 1	Age 0	Age 0 and age 1

Option	Area 1	Area 2	Area 3
variance estimate			
Power model	Not applied	Not applied	Not applied

Short-term projection

Analysis presented at the benchmark assessment (ICES, 2010) showed consistently large retrospective patterns in the assessments unless the dredge survey is included. Including the dredge survey largely removes this pattern, making it possible to produce unbiased estimate of terminal stock size. Further, the dredge survey shows high consistency both internally and externally in all areas, though the consistency in area 3 was somewhat lower than in the other areas. Though there is currently no coverage of area 2 in the dredge survey, recruitment in area 2 is highly correlated with that in area 1 and it is therefore possible to use the dredge catch rate in area 1 in the assessment of area 2. In area 3, the consistency of the survey is less and the CV of the SMS predictions is greater. Hence, producing an updated assessment following the December survey should provide reliable estimates of stock size in the areas where the relationship between the assessed stock size and dredge catch rate is tight (areas 1 and 2) but less reliable estimates for area 3. The dredge survey in area 4 cannot be used to produce pre-season assessments until the relationship between stock size and dredge catch in the area can be estimated from a longer time series than is presently available.

The benchmark assessment (ICES 2010) recommends that

- Two forecasts are provided. The assessment done in September does not include a reliable estimate of recruitment in the second half of the assessment year and forecast will be based on assumptions of recruitment as outlined Table 2a. Another forecast is provided in January of the TAC year when data from the dredge survey are processed and included in the updated assessment. An example of such forecast with known recruitment in the assessment year is shown in Table 2b;
- The forecast will be deterministic and be based on half yearly data;
- Proportion mature in TAC year is based on latest information from dredge survey;
- Proportion mature in year following TAC year is computed as the long-term average (unless a distinct or trend is suspected);
- WECA and WEST are computed as averages of last three years;
- Exploitation pattern as estimated by SMS for most recent year;
- Initial stock size start of TAC year is estimated by SMS assessment;
- 0-group in start of second half of the TAC year is obtained from long-term geometric mean.

Table 2a. Example of forecast provided in September, where recruitment in the assessment year is unknown. This forecast is based on the escapement strategy of reaching BMSY$_{escapement}$ (100 kt) in the year after the TAC year. (Please note that catch options are not based on real stock estimates).

Area-2 Sandeel						
Basis: Fsq=F(2010)=0.143; Yield(2010)=31; Recruitment(2011)= geometric mean = 2 billions; SSB(2011)=232						
F- multiplier	Basis: Recruitment(2010)	F(2011)	Landings(2011)	SSB(2012)	%SSB change	%TAC change
1.792	Geometric mean* 0	0.256	52	100	-57%	64%
2.326	Geometric mean* 0.2	0.332	68	100	-57%	115%
2.859	Geometric mean* 0.4	0.408	84	100	-57%	167%
3.389	Geometric mean* 0.6	0.484	100	100	-57%	219%
3.916	Geometric mean* 0.8	0.559	117	100	-57%	271%
4.437	Geometric mean* 1	0.633	134	100	-57%	325%

Table 2b. Example of forecast provided in January, where recruitment in the assessment is known. This forecast provides catch options for a range of F multipliers and for MSY (reaching BMSY$_{escapement}$ (100 kt) in the year after the TAC year). (Please note that catch options are not based on real stock estimates).

Area-2 Sandeel						
Basis: Fsq=F(2010)=0.143; Yield(2010)=31; Recruitment(2010)=2 billions; Recruitment(2011)= geometric mean = 2 billions; SSB(2011)=232						
F multiplier	Basis	F(2011)	Landings(2011)	SSB(2012)	%SSB change	%TAC change
0	F=0	0	0	141	-39%	-100%
0.25	Fsq*0.2	0.036	8	135	-42%	-74%
0.5	Fsq*0.5	0.071	16	129	-45%	-49%
0.75	Fsq*0.8	0.107	24	123	-47%	-25%
1	Fsq*1	0.143	31	117	-49%	-2%
1.25	Fsq*1.2	0.178	38	112	-52%	20%
1.5	Fsq*1.5	0.214	45	107	-54%	42%
1.886	MSY	0.269	55	100	-57%	73%

Medium-term projections

Not done.

Long-term projections

Not done.

Biological reference points

Inspection of the stock–recruitment plots from area 1, 2 and 3 revealed a decrease in recruitment at low SSB in all areas (Figure 6.4.1). However, no clear plateau was visible and this was reflected in a very flat surface of the likelihood when attempting to estimate an inflection point. Hence, the group considered that the relationship in all areas fell into the category where there is a relationship between R and SSB but no clear plateau. In this category, SGPRP advised that B_{lim} should be set after evaluation of historic patterns (SGPRP 2003, Figures. 6.4.2 to 6.4.4). The group did not consider the lack of plateau to have occurred through a consistent fishing down of the stock and hence did not think that there was evidence that B_{lim} was above the range of observed SSBs. It was also considered that a period of continuous low recruitment has only occurred around year 2000 and only in areas 2 and 3. After 2000, there has been a very low SSB in all areas but this followed the poor recruitment years rather than the opposite. For area 1 and 2, B_{lim} was therefore set as the median biomass in these years of low SSB (2000–2006) giving the values 160 000 tonnes for area 1 and 70 000 tonnes for area 2. In area 3, the drop in recruitment was also followed by a drop in SSB, but the level in the low period was more variable. For this area, B_{lim} was set at 100 000 tonnes, encompassing the lowest eight SSBs recorded. The level was set at the highest SSB observed in the period 2001–2007 (the period of low SSBs) rather than the median as there has been no really good recruitment years in the latter half of the period.

For short-lived species such as Sandeel, the ICES interpretation of the MSY concept uses B_{pa} estimates as the value for $B_{msy\text{-}trigger}$. This means that should advice follow the same escapement strategy as previously used the fishing opportunities for year y must be set at a level which ensures that B_{msy} is achieved in year y+1. No fishery should be allowed if this level of escapement can be achieved.

Table 3. Summary of Biomass reference points for areas 1–3.

Area	B_{lim}	SSB CV	B_{pa}
1	160 000	18%	215 000
2	70 000	23%	100 000
3	100 000	40%	195 000

The total of the B_{lim} estimates from areas 1, 2 and 3 is 330 kt and substantially below the historical level of 430 kt determined for the whole North Sea. This is partially due to not having areas 4 and 5 included. However, stock biomasses from these areas represent only a small fraction of the total their contribution to the combined total B_{lim} will be equally small. The difference is therefore mainly caused by two changes in the procedure used. Firstly, the new SMS assessments generate lower estimates of SSB compared to the old data and methodology and secondly, the revised maturity.

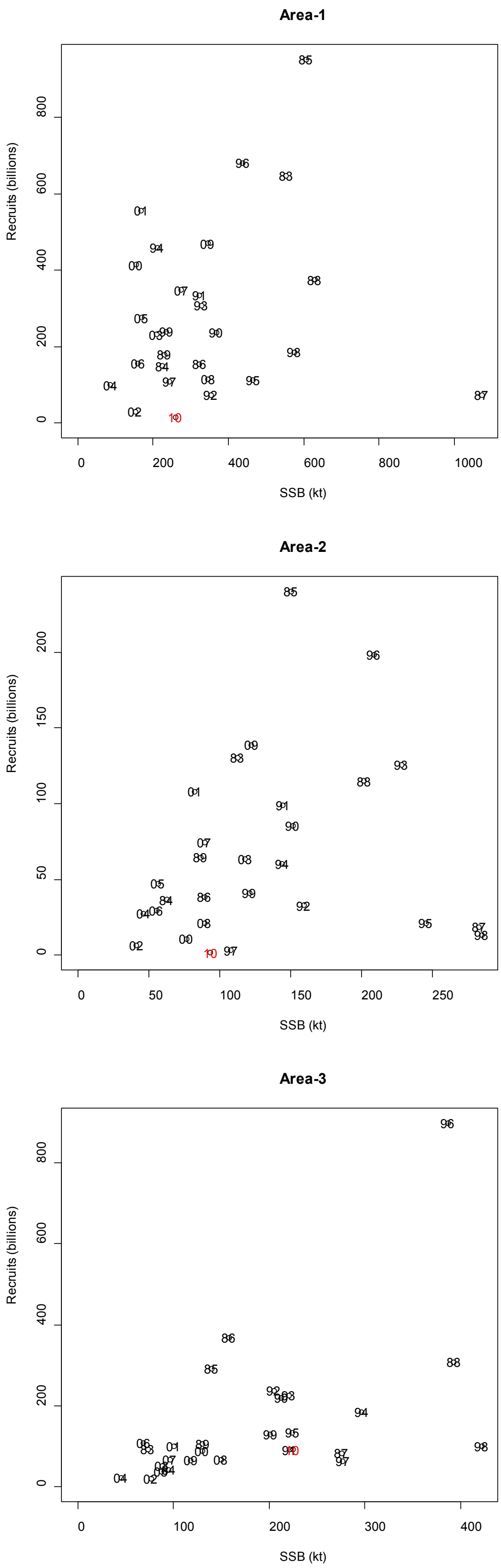


Figure 4. Stock–recruitment relationship in areas 1 to 3. Note that the recruit estimate for 2010 is based on very little input data and is therefore highly unreliable.

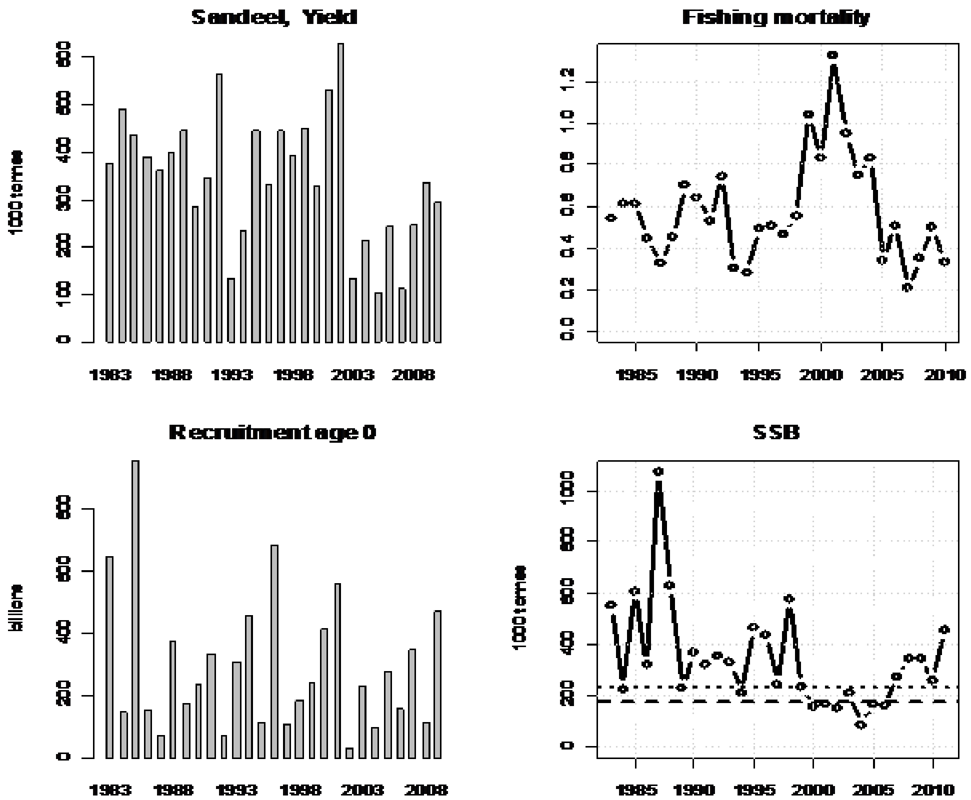


Figure 5. Stock summary for area 1.

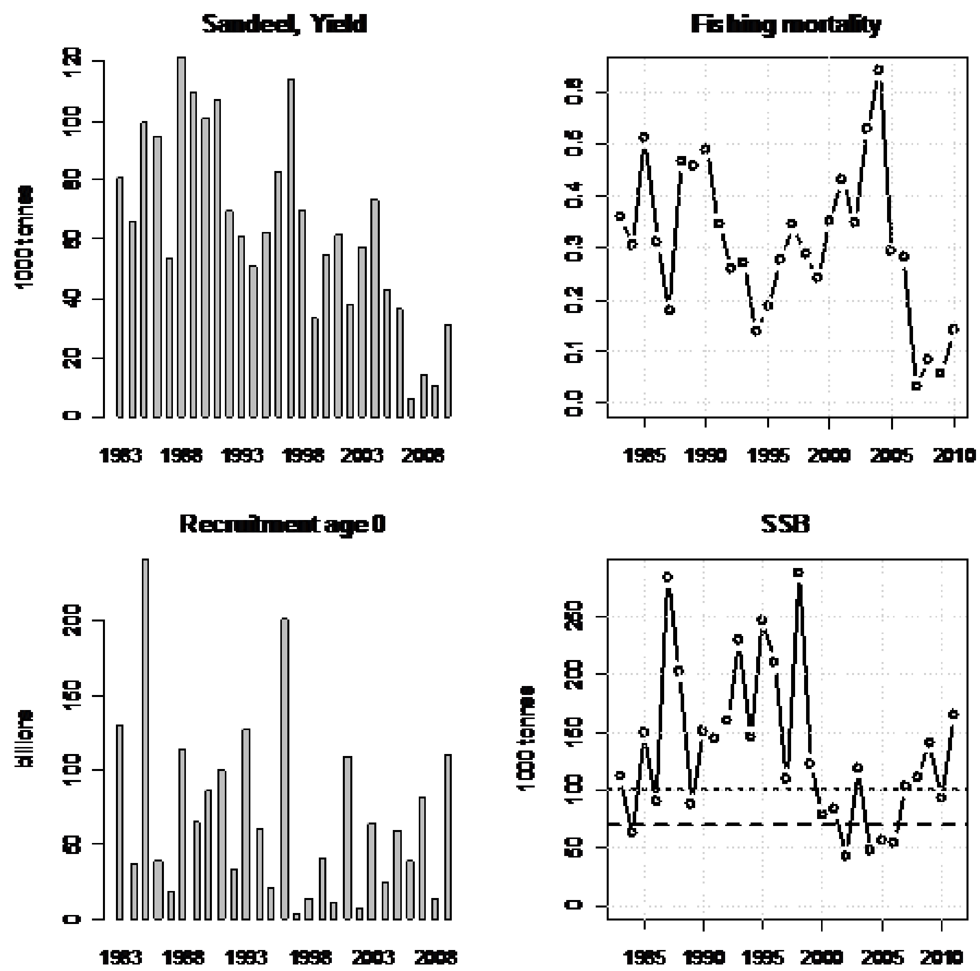


Figure 6. Stock summary for area 2.

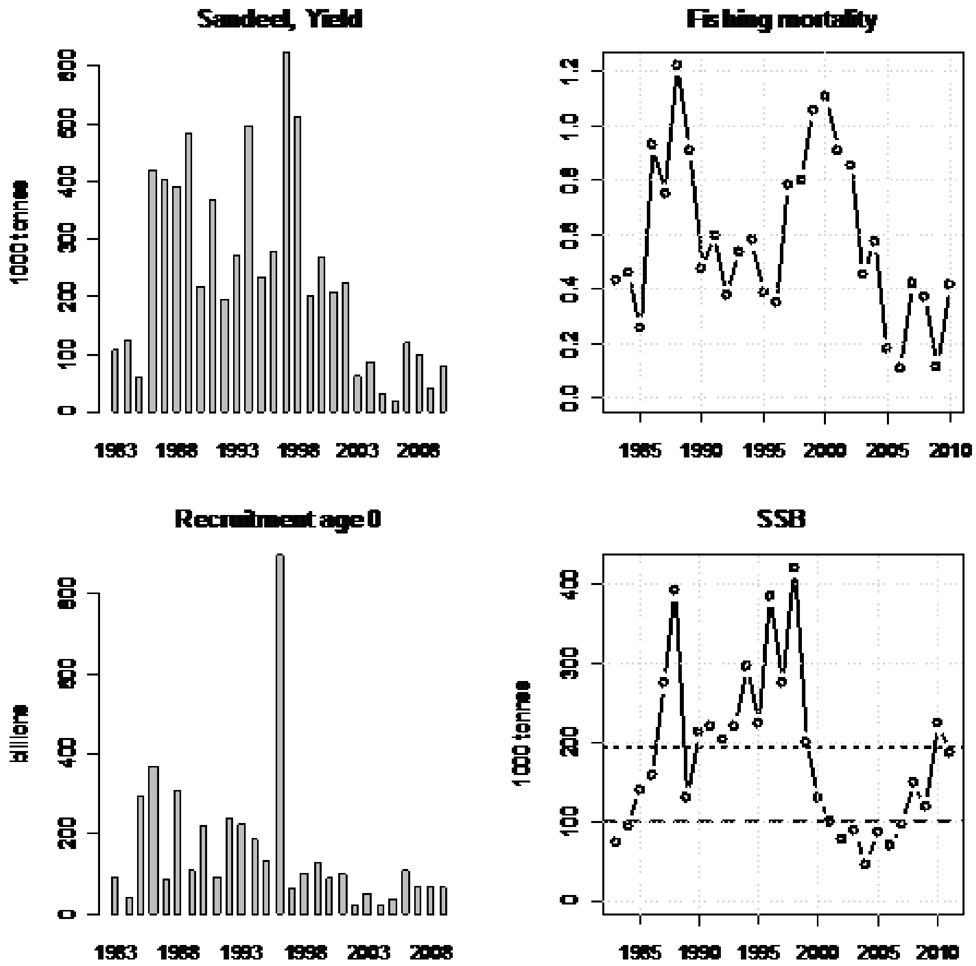


Figure 7. Stock summary for area 3.

The total of the B_{lim} estimates from areas 1, 2 and 3 is 330 kt and substantially below the historical level of 430 kt determined for the whole North Sea. This is partially due to not having areas 4 and 5 included. However, stock biomasses from these areas represent only a small fraction of the total their contribution to the combined total B_{lim} will be equally small. The difference is therefore mainly caused by two changes in the procedure used. Firstly, the new SMS assessments generate lower estimates of SSB compared to the old data and methodology and secondly, the revised maturity estimates provide lower SSBs at the same biomass of 2+-year olds. Further, the previous B_{lim} level was set in 1998 at the lowest observed spawning–stock since there was no indication of a relationship between SSB and recruitment at the time. Since then the stocks have been through a period of lower SSB, some of which have still produced reasonable recruitments, and it is these observations which now inform the selection of reference points.

In-season monitoring of sandeel

The sandeel fishery and stock are in most years dominated by 1-group sandeel for which very little information exists before the fishery is opened. Commercial cpue is a poor predictor of 0-group recruitment and reliable indices from surveys were not available until 2010 when the Danish dredge survey data from area 1 and 3 was applied. Since 2004, therefore, information on the 1-group abundance has been obtained from in-season monitoring of the fishery in the start of the fishery (1 April to around 5 May).

The methodology for in-season monitoring has been unchanged since 2007 and is described in detail in ICES CM 2007/ACFM:38.

The benchmark meeting (WKSAN 2010) considered that the rise in importance and reliability of the dredge survey has potential area specific implications for the in-season monitoring programme:

Area 1

Statistics show that the dredge survey is sufficiently robust to provide an estimate of the incoming 1-group such that the fishing opportunities for the coming year can be established in January. Although this relationship appears to be robust it may be prudent to continue some level of real-time monitoring in years where the dredge survey result is outside the bounds of the current observations particularly at the lower bound. There will be regular samples passed to DTU-Aqua as part of the standard monitoring process every year, but the requirement for real-time monitoring would only occur when the dredge survey is beyond historically observed bounds.

Area 2

There appears to be a sufficiently robust relationship between the recruitments in areas 1 and 2 to be able to use the same data sources and procedures from area 1 for the estimation of the incoming year class. There should, however, be an increase in the sampling coverage within this area.

Area 3

Pre-season estimates of the incoming year class appears less robust for this area and it is therefore appropriate that in-season monitoring (e.g. acoustic monitoring and age-based commercial cpue) to continue in area 3. The internal and external consistency of the acoustic survey is yet unknown and the consistency of commercial and dredge data is less in area 3 than in the other areas.

Area 4

Whilst it is important to continue the Scottish dredge survey the overlap between this and the commercial time-series is too short to provide robust estimates of incoming 1-group strength. There has been little or no information for this area from the in-year monitoring system in recent years due to the low commercial effort level expended in the area.

The dredge survey information is sufficient to provide TAC advice in Areas 1 and 2, without requiring the in-season processing and incorporation of in-season monitoring in most cases. Increasing the coverage and time-series length of dredge surveys in other areas may lead to a similar reduction or elimination of the need for in-year processing in those areas.

Other issues

Recent investigations (Greenstreet *et al*., 2006) showed the biomass of age 1+ sandeels increased sharply in the Firth of Forth area in the first year of the closure and remained higher in all four of the closure years analysed, than in any of the preceding three years, when the fishery was operating. Further, the biomass of 0-group sandeels in three of the four closure years exceeded the biomass present in the three years of commercial fishing. The closure appears to have coincided with a period of enhanced recruit production.

References

Arnott, S.A., Ruxton, G.D. 2002. Sandeel recruitment in the North Sea: demographic, climatic and trophic effects. Marine Ecology Progress Series 238:199–210.

Boulcott P., Wright P.J., Gibb F., Jensen H. and Gibb I. 2006. Regional variation in the maturation of sandeels in the North Sea. ICES Journal of Marine Science. 64: 369–376.

Boyd, I.L., Wanless, S., and Camphuysen, C.J. eds. 2006. *Top predators in marine ecosystems: their role in monitoring and management.* Cambridge University Press, Cambridge.

Brown, E. G., Pierce, G. J., Hislop, J. R. G., Santos, M. B. 2001. Inter-annual variation in the summer diets of harbour seals *Phoca vitulina* at Mousa, Shetland (UK). Journal of the Marine Biological Association of the UK, 81: 325–337.

Christensen A., Hochbaum U., Jensen H, Mosegaard H, St. John M., and Schrum C. Hydrodynamic backtracking of fish larvae by individual-based modelling. Accpeted by MEPS.

Christensen A., Jensen H., Mosegaard H., St. John M., and Schrum C. Sandeel larval transport patterns in North Sea from an individual-based hydrodynamic egg and larval model. Submitted.

Christensen, A., Jensen, H., Mosegaard, H., St John, M., Schrum, C. 2008. Sandeel (*Ammodytes marinus*) larval transport patterns in the North Sea from an individual-based hydrodynamic egg and larval model. Canadian Journal of Fisheries and Aquatic Sciences, 65: 1498–1511.

Daunt, F., Wanless, S., Greenstreet, S. P. R., Jensen, H., Hamer, K. C., Harris, M. P. 2008. The impact of the sandeel fishery closure on seabird food consumption, distribution and productivity in the northwestern North Sea. Canadian Journal of Fisheries and Aquatic Sciences, 65: 362–381.

Daunt F., Wanless S, Greenstreet S.P.R., Jensen H., Hamer K.C. Hamer and Harris P.H. The impact of fishery closure on seabird food consumption, distribution and productivity in the northwestern North Sea. Submitted.

Davis, S.E., Nager, R.G., Furness, R.W. 2005. Food availability affects adult survival as well as breeding success of parasitic jaegers. Ecology, 86, 1047–1056.

Engelhard, G.H., van der Kooij, J., Bell, E.D., Pinnegar, J.K., Blanchard, J.L., Mackinson, S., Righton, D.A. 2008. Fishing mortality versus natural predation on diurnally migrating sandeels *Ammodytes marinus.* Marine Ecology Progress Series 369: 213–227.

Frederiksen, M., Wanless, S., Harris, M.P., Rothery, P., Wilson, L.J. 2004. The role of industrial fisheries and oceanographic change in the decline of North Sea black-legged kittiwakes. Journal of Applied Ecology, 41, 1129–1139.

Frederiksen, M., Wright, P.J., Heubeck, M., Harris, M.P., Mavor, R.A., Wanless, S. 2005. Regional patterns of kittiwake *Rissa tridactyla* breeding success are related to variability in sandeel recruitment. Marine Ecology Progress Series 300:201–211.

Frederiksen, M., Furness, R.W., Wanless, S. 2007. Regional variation in the role of bottom-up and top-down processes in controlling sandeel abundance in the North Sea. Mar. Ecol. Prog. Ser. 337, 279–286.

Frederiksen, M., Jensen, H., Duant, F., Mavor, D.R. Wanless, S. 2008. Differential effects of a local industrial sand lance fishery on seabird breeding performance. Ecological Applications, 18: 701–710.

Frederiksen M., Jensen. H., Daunt F., Mavor R.A., and Wanless S. Differential effects of a local industrial sand lance fishery on seabird breeding performance. Submitted.

Freeman, S., Mackinson, S., Flatt, R. 2004. Diel patterns in the habitat utilisation of sandeels revealed using integrated acoustic surveys. Journal of Experimental Marine Biology and Ecology 305: 141–154.

Furness, R.W. 2002. Management implications of interactions between fisheries and sandeel-dependent seabirds and seals in the North Sea. ICES Journal of Marine Science 59:261–269.

Furness, R. W., Tasker, M. L. 2000. Seabird–fishery interactions: quantifying the sensitivity of seabirds to reductions in sandeel abundance, and identification of key areas for sensitive seabirds in the North Sea. Marine Ecology Progress Series, 202: 253–264.

Gauld, J. A. 1990. Spawning and fecundity in the lesser sandeel, *Ammodytes marinus* (Raitt), in the north-western North Sea. Journal of Fish Biology, 36: 611–613.

Gauld A. 1990. Movements of lesser sandeels (*Ammodytes marinus* Raitt) tagged in the north-western North Sea. J. Cons. int. Explor. Mer. 46: 229–231.

Greenstreet, S. P. R. 2006. Does the prohibition of industrial fishing for sandeel have any impact on local gadoid populations? In Management of Marine Ecosystems, pp. 223–235. Ed. by I. L. Boyd, S. Wanless, and C. J. Camphuysen. Cambridge University Press, Cambridge, UK.

Greenstreet, S. P. R., Armstrong, E., Mosegaard, H., Jensen, H., Gibb, I. M., Fraser, H. M., Scott, B., *et al*. 2006. Variation in the abundance of sandeels *Ammodytes marinus* off southeast Scotland: an evaluation of area-closure fisheries management and stock abundance assessment methods. ICES Journal of Marine Science, 63: 1530–1550.

Greenstreet, S. P. R., Bryant, A. D., Broekhuizen, N., Hall, S. J., Heath, M. R. 1997. Seasonal variation in the consumption of food by fish in the North Sea and implications for foodweb dynamics. ICES Journal of Marine Science, 54: 243–266.

Greenstreet, S. P. R., McMillan, J. A., Armstrong, F. 1998. Seasonal variation in the importance of pelagic fish in the diet of piscivorous fish in the Moray Firth, NE Scotland: a response to variation in prey abundance? ICES Journal of Marine Science, 55: 121–133.

Greenstreet, S.P.R., Holland, G.J., Guirey, E.J., Armstrong, E., Fraser, H.M., Gibb, I.M. 2010. Combining hydroacoustic seabed survey and grab sampling techniques to assess "local" sandeel population abundance. ICES Journal of Marine Science 67: 971–984.

Hammond, P. S., Hall, A. J., Prime, J. H. 1994. The diets of grey seals around Orkney and other island and mainland sites in north-eastern Scotland. Journal of Applied Ecology 31: 340–350.

Hassel, A., Knutsen, T., Dalen, J., Skaar, K., Løkkeborg, S., Misund, O. A., Østensen, Ø., Fonn, M., Haugland, E. K. 2004. Influence of seismic shooting on the lesser sandeel (*Ammodytes marinus*). ICES Journal of Marine Science 61: 1165–1173.

Hislop, J. R. G., Robb, A. P., Bell, M. A., Armstrong, D. W. 1991. The diet and food consumption of whiting (*Merlangius merlangus*) in the North Sea. ICES Journal of Marine Science, 48: 139–156.

Holland, G. J., Greenstreet, S. P. R., Gibb, I. M., Fraser, H. M., Robertson, M. R. 2005. Identifying sandeel *Ammodytes marinus* sediment habitat preferences in the marine environment. Marine Ecology Progress Series, 303: 269–282.

ICES 1986. Report of the Industrial Fisheries Working Group. ICES C.M. 1986/Assess:15.

ICES 1987. Report of the Industrial Fisheries Working Group. ICES C.M. 1987/Assess:17.

ICES 1988. Report of the Industrial Fisheries Working Group. ICES C.M. 1988/Assess:15.

ICES 1989. Report of the Industrial Fisheries Working Group. ICES C.M. 1989/Assess:13.

ICES 1990. Report of the Industrial Fisheries Working Group. ICES C.M. 1990/Assess:13.

ICES 1991. Report of the Industrial Fisheries Working Group. ICES C.M. 1991/Assess:14.

ICES 1992. Report of the Industrial Fisheries Working Group. ICES C.M. 1992/Assess:9.

ICES 1994. Report of the Working Group on the Assessment of Norway Pout and Sandeel. ICES C.M. 1994/Assess:7.

ICES 1995. Report of the Working Group on the Assessment of Norway Pout and Sandeel. ICES C.M. 1995/Assess:5.

ICES 1999. Report of the Study group on effects of sandeel fishing. ICES 1999/ACFM:19.

ICES-ACFM 2005. Report of the ICES Advisory Committee on Fishery Management, Advi-sory Committee on the Marine Environment and Advisory Commit tee on Ecosystems, 2005. ICES ADVICE 2005 AVIS DU CIEM Volumes IV.

ICES-AGSAN 2007. Report of the Ad Hoc Group on Sandeel. ICES CM 2007/ACFM:38.

ICES WGECO 2004. Report of the Working Group on the Ecosystem Effects of Fishing Activities. ICES C.M. 2004/ACE:0*, Ref. D,E,G.

ICES WGNSSK 1996. Report of the Working Group on the Assessment of the Demersal Stocks in the North Sea and Skagerrak. Part 1 to 3. ICES C.M. 1996/Assess:6.

ICES WGNSSK 1997. Report of the Working Group on the Assessment of the Demersal Stocks in the North Sea and Skagerrak. Part 1 and 3. ICES C.M. 1997/Assess:6.

ICES WGNSSK 1998. Report of the Working Group on the Assessment of the Demersal Stocks in the North Sea and Skagerrak. Part 1 and 3. ICES C.M. 1998/Assess:7.

ICES WGNSSK 1999. Report of the Working Group on the Assessment of the Demersal Stocks in the North Sea and Skagerrak. Part 1 to 3. ICES C.M. 1999/ACFM:8.

ICES WGNSSK 2000. Report of the Working Group on the Assessment of the Demersal Stocks in the North Sea and Skagerrak. Part 1 to 3. ICES C.M. 2000/ACFM:7.

ICES WGNSSK 2001. Report of the Working Group on the Assessment of the Demersal Stocks in the North Sea and Skagerrak. Part 1 to 2. ICES C.M. 2001/ACFM:7.

ICES-WGNSSK 2003. Report of the Working Group on the Assessment of the Demersal Stocks in the North Sea and Skagerrak. Part 1 to 3. ICES C.M. 2003/ACFM:2.

ICES-WGNSSK 2005. Report of the Working Group on the Assessment of the Demersal Stocks in the North Sea and Skagerrak. ICES CM 2005/ACFM:07.

ICES-WGNSSK 2006. Report of the Working Group on the Assessment of the Demersal Stocks in the North Sea and Skagerrak. ICES CM 2006/ACFM:09.

ICES WGNSSK 2007. Report of the Working Group on the Assessment of the Demersal Stocks in the North Sea and Skagerrak.ICES CM 2007/ACFM:35.

ICES-SGMSNS 2005. Report of the Study Group on Multispecies Assessments in the North Sea (SGMSNS). ICES CM 2005/D:06.

ICES-SGRECVAP 2006. Report of the Study Group on Recruitment Variability in North Sea Planktivorous Fish (SGRECVAP). ICES CM 2006/LRC:03.

Jensen H.; Rindorf A.; Horsten M.B.; Mosegaard H.; Brogaard P.; Lewy P.; Wright P.J.; Kennedy F.M.; Gibb I.M.; Ruxton G.; Arnott S.A. and Leth J.O. 2001. Modelling the population dynamics of sandeel (Ammodytes marinus) populations in the North Sea on a spatial resolved level. DG XIV no. 98/025.

Jensen H., Mosegaard H., Rindorf A., Dalskov J. and Brogaard P. 2002. Indsamling af detaljerede oplysninger om tobisfiskeriet i Nordsøen. DFU rapport no. 97-02.

Jensen and Vinther. 2003. Estimation of fishing effort for the Danish sandeel fishery in the North Sea based on catch per unit effort data. Working document for the 2003 ICES WGNSSK meeting in Bolougne.

Jensen H. and Rolev A.M. 2004. The Sandeel fishing grounds in the North Sea. Information about the foraging areas of the lesser sandeel Ammodytes marinus in the North Sea. Working document prepared for the BECAUSE project, November 2004.

Jensen, H., Rindorf, A., Wright P. J., Mosegaard, H. Inferring the location and scale of mixing between habitat areas of lesser sandeel through information from the fishery. ICES Journal of Marine Science. (in press).

Jennings, S., Kaiser, M.J., Reynolds, J.D. 2001. *Marine fisheries ecology*. Blackwell, Oxford.

Lewy, P. and M. Vinther. 2004. A stochastic age–length-structured multispecies model applied to North Sea stocks. ICES CM 2004/FF:20.

Macleod, C.D., Santos, M.B., Reid, R.J., Scott, B.E., Pierce, G.J. 2007. Linking sandeel consumption and the likelihood of starvation in harbour porpoises in the Scottish North Sea: could climate change mean more starving porpoises? Biology Letters 3: 185–188.

Mavor, R.A., Parsons, M., Heubeck, M., Schmitt, S. 2005. *Seabird numbers and breeding success in Britain and Ireland, 2004.* UK Nature Conservation Report. Joint Nature Conservation Committee, Peterborough.

Mavor, R.A., Parsons, M., Heubeck, M., Schmitt, S. 2006. *Seabird numbers and breeding success in Britain and Ireland, 2005.* UK Nature Conservation Report. Joint Nature Conservation Committee, Peterborough.

Mavor, R.A., Parsons, M., Heubeck, M., Schmitt, S. 2007. *Seabird numbers and breeding success in Britain and Ireland, 2006.* UK Nature Conservation Report. Joint Nature Conservation Committee, Peterborough.

Mitchell, P.I., Newton, S.F., Ratcliffe, N., Dunn, T.E. 2004. Seabird populations of Britain and Ireland. T and AD Poyser, London.

Pedersen, S. A., Lewy, P., Wright, P. 1999. Assessments of the lesser sandeel (*Ammodytes marinus*) in the North Sea based on revised stock divisions. Fisheries Research, 41: 221–241.

Pinnegar, J.K., van der Kooij, J., Engelhard, G.H., Blanchard, J.L., Warr, K.J., Righton, D. 2006. Small-scale variability in fish diet and whether or not this reflects local patterns of prey availability. ICES CM 2006/F:07.

Poloczanska, ES, Cook, RM, Ruxton, GD and Wright, PJ. 2004. *Fishing vs. natural recruitment variation in sandeels as a cause of seabird breeding failure at Shetland: a modelling approach.* Ices Journal Of Marine Science, 61. pp. 788–797.

Pope, J. G. 1980. Some consequences for fisheries management of aspects of the behaviour of pelagic fish. Rapp. P.-v. Reun. Cons. Explor. Mer 177, 466–476.

Proctor, R., Wright, P.J. and Everitt, A. 1998. Modelling the transport of larval sandeels on the north west European shelf. Fisheries Oceanography.7, 347–354.

Reed, T.E., Wanless, S., Harris, M.P., Frederiksen, M., Kruuk, L.E.B., Cunningham, E.J.A. 2006. Responding to environmental change: plastic responses vary little in a synchronous breeder. Proceedings of the Royal Society Series B, 273, 2713–2719.

Rindorf, A., Wanless, S., Harris, M. P. 2000. Effects of changes in sandeel availability on the reproductive output of seabirds. Marine Ecology Progress Series, 202: 241–252.

Sherman, K., Jones, C., Sullivan, L., Smith, W., Berrien, P., Ejsymont, L. 1981. Congruent shifts in sandeel abundance in western and eastern North Atlantic ecosystems. Nature, 291: 486–489.

Stafford, R., Whittaker, C., Velterop, R., Wade, O., Pinnegar, J. 2006. Final Report, Programme 13: North Sea Whiting Stomach Contents. *Fisheries Science Partnership: 2006/07.* 25pp.

STECF 2004. Report of the Scientific, Technical and Economic Committee For Fisheries. Evaluation of the report of the Ad Hoc Working Group on Sandeel Fisheries "Estimate of the Abundance of the 2003 Year-class of North Sea Sandeel".

STECF 2005a. Report of the Scientific, Technical and Economic Committee For Fisheries. Evaluation of the report of the Ad Hoc Working Group on Sandeel Fisheries "Estimate of the Abundance of the 2004 Year-class of North Sea Sandeel".

STECF 2005b. REPORT of the STECF Ad-Hoc Working Group on Sandeel Fisheries. November 7th–9th 2005, Charlottenlund. Denmark.

STECF 2006. Report of the Scientific, Technical and Economic Committee For Fisheries. Evaluation of the report of the Ad Hoc Working Group on Sandeel Fisheries "Estimate of the Abundance of the 2005 Year-class of North Sea Sandeel".

Ulltang, Ø. 1980. Factors affecting the reaction of pelagic fish stocks to exploitation and requiring a new approach Rapp. P.-v. Reun. Cons. Explor. Mer 177, 489–504.

Van der Kooij, J., Scott, B.E., Mackinson, S. 2008. The effects of environmental factors on daytime sandeel distribution and abundance on the Dogger Bank. Journal of Sea Research 60: 201–209.

Van Deurs, M., van Hal, R., Jensen, H., Tomczak, M.T., Dolmer, P. 2008. A spatially and temporally explicit analysis of beam-trawling on sandeel fishing grounds in the North Sea. Working Document to ICES AGSAN2.

Van Deurs, M., van Hal, R., Tomczak, M.T., Jónasdóttir, S.H., Dolmer, P. 2009. Recruitment of lesser sandeel *Ammodytes marinus* in relation to density dependence and zooplankton composition. Marine Ecology Progress Series 381: 249–258.

Wanless, S., Harris, M. P., Greenstreet, S. P. R. 1998. Summer sandeel consumption by seabirds breeding in the Firth of Forth, south-east Scotland. ICES Journal of Marine Science, 55: 1141–1151.

Wanless, S., Wright, P.J., Harris, M.P., Elston, D.A. 2004. Evidence for decrease in size of lesser sandeels *Ammodytes marinus* in a North Sea aggregation over a 30-yr period. Marine Ecology Progress Series, 279, 237–246.

Wanless, S., Harris, M.P., Redman, P., Speakman, J. 2005. Low energy values of fish as a probable cause of a major seabird breeding failure in the North Sea. Marine Ecology Progress Series, 294, 1–8.

Wright, P. J. 1996. Is there a conflict between sandeel fisheries and seabirds? In:, Aquatic predators and their prey, pp. 154–165. Ed. by S. P. R. Greenstreet and M. L. Tasker. Fishing News Books, Blackwell Science, Oxford. 191 pp.

Wright, P.J. and Bailey, M.C. 1996. Timing of hatching in *Ammodytes marinus* from Shetland waters and its significance to early growth and survivorship. Marine Biology 126, 143–152.

Wright, P. J., Jensen, H., Tuck, I. 2000. The influence of sediment type on the distribution of the lesser sandeel, *Ammodytes marinus*. Journal of Sea Research, 44: 243–256.

Wright P., Verspoor E., Andersen C., Donald L., Kennedy F., Mitchell A., Munk P., Pedersen S.A., Jensen H., Gislason H. and Lewy P. 1998. Population structure in the lesser sandeel (*Ammodytes marinus*) and its implications for fishery-predator interactions. DG XIV no. 94/071.

Wright P.J., Jensen H., Mosegaard H., Dalskov J. and Wanless S., 2002. European Commission's annual report on the impact of the Northeast sandeel fishery closure and status report on the monitoring fishery in 2000 and 2001.

Appendix A. Configuration file for Area 1

```
# SMS.dat option file
# the character "#" is used as comment character, such that all text
and numbers after # are skipped by the SMS program
#
########################################
# Produce test output (option test.output)
#  0 no test output
#  1 output file SMS.dat and  file fleet.info.dat as read in
#  2 output all single species input files as read in
#  3 output all multi species input files as read in
#  4 output option overview
#
# 11 output between phases output
# 12 output iteration (obj function) output
# 13 output stomach parameters
# 19 Both 11, 12 and 13
#
# Forecast options
# 51 output HCR_option.dat file as read in
# 52 output prediction output summary
# 53 output prediction output detailed
0
########################################
# Single/Multispecies mode (option VPA.mode)
# 0=single species mode
# 1=multi species mode, but Z=F+M (used for initial food suitability
parameter estimation)
# 2=multi species mode, Z=F+M1+M2
0
########################################
## first year of input data (option first.year)
1983
########################################
## last year of input data (option last.year)
2010
########################################
## last year used in the model (option last.year.model)
2010
########################################
##  number of seasons (option last.season). Use 1 for annual data
2
########################################
## last season last year (option last.season.last.year). Use 1 for
annual data
2
########################################
## number of species (option no.species)
1
########################################
# Species names, for information only. See file species_names.in
########################################
## first age all species (option first.age)
0
########################################
## recruitment season (option rec.season). Use 1 for annual data
2
########################################
## maximum age for any species(max.age.all)
4
########################################
## various information by species
# 1. last age
# 2. first age where catch data are used (else F=0 assumed)
# 3. last age with age dependent fishing selection
```

```
# 4. Last age included in the catch at age likelihood (normally last
age)
# 5. plus group, 0=no plus group, 1=plus group
# 6. predator species, 0=no, 1=VPA predator, 2=Other predator
# 7. prey species, 0=no, 1=yes
# 8. Stock Recruit relation, 1=Ricker, 2=Beverton & Holt, 3=Geom mean,
#                            4= Hockey stick, 5=hockey stick with
smoother,
#                            >100= hockey stick with known breakpoint
(given as input)
##
4 0 3 4 1 0 0  170000
########################################
## adjustment factor to bring the beta parameter close to one (option
beta.cor)
         1e+08
########################################
## year range for data included to fit the R-SSB relation (option
SSB.R.year.range)
# first (option SSB.R.year.first) and last (option SSB.R.year.last)
year to consider.
# the value -1 indicates the use of the first (and last) available
year in time series
# first year by species
            -1
# last year by species
            2009
########################################
## Objective function weighting by species (option objec-
tive.function.weight) (default=1)
# first=catch observations,
# second=CPUE observations,
# third=SSB/R relations
# fourth=stomach observations SPECIAL SANDEEL -1=Creep by year, -
2=Creep by age-group
##
1 0.5 0.01 0
########################################
## parameter estimation phases for single species parameters
# phase.rec (stock numbers, first age) (default=1)
1
# phase.rec.older (stock numbers, first year and all ages) (default=1)
1
# phase.F.y (year effect in F model) (default=1)
1
# phase.F.q (season effect in F model) (default=1)
1
# phase.F.a (age effect in F model) (default=1)
1
# phase.catchability (survey catchability) (default=1)
1
# phase.SSB.R.alfa (alfa parameter in SSB-recruitment relation) (de-
fault=1)
1
# phase.SSB.R.beta (beta parameter in SSB-recruitment relation) (de-
fault=1)
-1
########################################
## minimum CV of catch observation used in ML-estimation (option
min.catch.CV) (default=0.2)
0.20
########################################
## minimum CV of catch SSB-recruitment relation used in ML-estimation
(option min.SR.CV) (default=0.2)
0.2
########################################
## use seasonal or annual catches in the objective function (option
combined.catches)
```

```
# do not change this options from default=0, without looking in the
manual
#    0=annual catches with annual time steps or seasonal catches with
seasonal time steps
#    1=annual catches with seasonal time steps, read seasonal relative
F from file F_q_ini.in (default=0)
0
########################################
## use seasonal or common combined variances for catch observation
(option seasonal.combined.catch.s2)
# seasonal=0, common=1 (use 1 for annual data)
    0
########################################
##
# catch observations: number of separate catch variance groups by spe-
cies
   3
#  first age group in each catch variance group
0 1 3 #  Sandeel
########################################
##
# catch observations: number of separate catch seasonal component
groups by species
    2
#  first ages in each seasonal component group by species
0 1    #  Sandeel
########################################
## first and last age in calculation of average F by species (option
avg.F.ages)
1 2
########################################
## minimum 'observed' catch, (option min.catch). You cannot log zero
catch at age!
#
# value 0 = Ignore data point in likelihood
# negative value gives percentage (e.g. -10 ~ 10%) of average catch in
age-group for
# input catch=0
# negative value less than -100 substitute all catches by the op-
tion/100 /100 *average
# catch in the age group for catches less than (average catch*-
option/10000
#
# if option>0 then will zero catches be replaced by catch=option
#
# else if option<0 and option >-100 and catch=0 then catches will be
replaced by catch=average(catch at age)*(-option)/100
# else if option<-100  and catch < average(catch at age)*(-
option)/10000 then catches will be replaced by catch=average(catch at
age)*(-option)/10000
#  Sandeel
0
########################################
##
# catch observations: number of year groups with the same age and sea-
sonal selection
       3
#  first year in each group
1983 1989 1999
########################################
## year season combinations with zero catch (F=0) (option ze-
ro.catch.year.season)
# 0=no, all year-seasons have catchs, 1=yes there are year-season com-
binations with no catch. Read from file zero_catch_seasons_ages.in
# default=0
1
########################################
```

```
## season age combinations with zero catch (F=0) (option ze-
ro.catch.season.ages)
# 0=no, all seasons have catchs, 1=yes there is seasons with no catch.
Read from file zero_catch_seasons_ages.in
# default=0
1
########################################
## Factor for fixing last season effect in F-model (default=1)
(fix.F.factor))
             1
########################################
## Uncertanties for catch, CPUE and SSB-R observations (option
calc.est.sigma)
#  values: 0=estimate sigma as a parameter (the right way of doing it)
#          1=Calculate sigma and truncate if lower limit is reached
#          2=Calculate sigma and use a penalty function to avoid lower
limit
#  catch-observation, CPUE-obs, Stock/recruit
        2               0       2
########################################
# Read HCR_option file (option=read.HCR) default=0
#  0=no  1=yes
0

#
```

13 Appendices

A1. Working Paper WKSAN2010-Results from the Danish dredge survey

Steen Christensen, DTU Aqua

Background

Since 2004 DIFRES has used a modified scallop dredge to measure the relative abundance of sandeels in the seabed. The survey is conducted in November/December when the 0-group sandeels have been recruited to the adult population and the whole population is assumed to reside in the seabed.

Four different dredges have been used in the survey: DK1: standard dredge; DK2: modified standard dredge with video camera; DK3: modified standard dredge with additional net roof; DF1: modified standard dredge with additional net. As the DF1 dredge was used at an experimental basis only and analysis indicated that and the DK3 dredge had catch rates significantly different from the DK1 and DK2, in the present analysis only data from DK 1 and DK 2 was used. These two dredges obtained similar catch rates and therefore their data was aggregated in the analysis.

Since 2004 in total 828 hauls were made with the four different dredges of which 790 were made with DK1 and DK2 (Table 1). As indicated in Table 1 and Figures 1 and 2, the dredge survey covers Areas 1 and 3 only except for seven hauls taken in Area 2 in 2005. The data from Area 2 are not included in the present analysis.

Sampling is carried out at fixed positions on known sandeel habitats at some of the most important fishing banks in the North Sea from the Little Fisher Bank in the North Eastern North Sea, to the Dogger Bank area in the southwestern North Sea (Figure 1). In 2006 additional positions were sampled in the Norwegian EEZ.

Methods

A varying number of hauls have been made at the different positions over the years (Table 2). Therefore, calculation of the annual stratified average catch rates (total number caught by hour) for each area was done in a three step procedure: first, for each year, the average catch rate of each position was calculated as the average of the catch rates of all hauls (stations) made on this position, then the average catch rate of each ICES square was calculated as the average of the catch rates of its positions, and finally the average catch rate of each area was calculated as the average of the catch rates of its ICES squares. In other words, the annual average catch rate by area is calculated by:

(1) $$\overline{CPUE}_a = \frac{\sum_{sq} \overline{CPUE}_{a,sq}}{n_{a,sq}}$$

where

(2) $$\overline{CPUE}_{a,sq} = \frac{\sum_{pos} \overline{CPUE}_{a,sq,pos}}{n_{a,sq,pos}}$$

where

(3) $$\overline{CPUE}_{a,sq,pos} = \frac{\sum_{st} \overline{CPUE}_{a,sq,pos,st}}{n_{a,sq,pos,st}}$$

where n: number of hauls, a: area, sq: square, pos: position and st: station.

Results

The total number of hauls made with DK1 and DK2 by year, area and square are indicated in Table 3 and the associated stratified average catch rates in Table 4 and Figure 3. For each area, the stratified catch rates by age are indicated in Table 5.

The internal consistency, i.e. the ability of the survey to follow cohorts, was evaluated for each area by plotting catch rates of an age group in a given year versus the catch rates of the next age group in the following year. The analysis indicated that the internal consistency of the dredge survey is acceptable for both areas (R^2 varying between 0.541 and 0.755) using the unweighted catch rate indices (Figure 4).

Exploratory analysis indicated that the internal consistency did not improve by standardization to the square means (Figure 5) or by weighting by total commercial catches by square (Figure 6) or by the size of the sandeel distribution area (Figure 7) of the catch rate indices.

The external consistency, i.e. the consistency of catch rates at age between areas, was evaluated for each age group by plotting the catch rates of the two areas against each other. As indicated in Figure 8 the external consistency was absent for age groups 0 and 1, whereas R^2 was 0.63 for age group 2.

Table 1. Total number of hauls by type of dredge (DF1, DK1, DK2, DK3) and area (1, 2 and 3) in the period 2004–2009.

Dredge	Area	2004	2005	2006	2007	2008	2009	Total
DF1					**10**	**3**		**13**
	1				6	3		9
	3				4			4
DK1		**134**	**155**	**63**	**95**	**105**		**552**
	1	114	135	43	58	59		409
	2		7					7
	3	20	13	20	37	46		136
DK2				**111**	**28**	**4**	**95**	**238**
	1			83	25	4	58	170
	3			28	3		37	68
DK3				**5**	**10**	**10**		**25**
	1			3		1		4
	3			2	10	9		21
	Total	**134**	**155**	**179**	**143**	**122**	**95**	**828**

Table 2. Number of stations (hauls) by area, square and position made by dredges DK1 and DK 2.

			Year						
Area	Square	Position	2004	2005	2006	2007	2008	2009	Total
1			**114**	**135**	**126**	**83**	**63**	**58**	**579**
	37F0		**0**	**15**	**14**	**7**	**7**	**8**	**51**
		3760.01					1		**1**
		3760.03		5					**5**
		3760.04		5	5	3	1	3	**17**
		3760.05		5	4	4	2	3	**18**
		3760.06			5		3	2	**10**
	37F1		**11**	**24**	**15**	**6**	**3**	**3**	**62**
		3761.03	6	10	5				**21**
		3761.04	5	9	5	3	3	2	**27**
		3761.08		5	5	3		1	**14**
	37F2		**5**	**5**	**4**	**3**	**4**	**5**	**26**
		3762.01					3	3	**6**
		3762.02	5	5	4	3	1	2	**20**
	38F1		**20**	**30**	**27**	**27**	**13**	**10**	**127**
		3861.02		5			2		**7**
		3861.14	5	5	4	3	1	2	**20**
		3861.19	5	5	5	5	2	2	**24**
		3861.22	5	5	5	6	3	2	**26**
		3861.23		5	5	6	1	2	**19**
		3861.32	5	5	8	7	4	2	**31**
	39F1		**15**	**13**	**13**	**3**	**6**	**5**	**55**
		3961.01		2					**2**
		3961.02					1		**1**
		3961.22		1					**1**
		3961.28	10	5	6		2	3	**26**
		3961.29	5	5	7	3	3	2	**25**
	39F3		**19**	**9**	**11**	**14**	**9**	**7**	**69**
		3963.01	10	4	6	6	3	2	**31**
		3963.04	9	5	5	4	3	3	**29**
		3963.07				4			**4**
		3963.08					3	2	**5**
	39F4		**25**	**14**	**15**	**8**	**10**	**8**	**80**
		3964.01	10	9	10		1	3	**33**
		3964.02	10	5		4	3	2	**24**
		3964.03	5		5	4	6	3	**23**
	40F5		**10**	**15**	**17**	**7**	**7**	**7**	**63**
		4065.01	5	5	5	7	3	2	**27**
		4065.02	5	5	5		3	3	**21**

			Year						
Area	**Square**	**Position**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**Total**
		4065.03			2				**2**
		4065.04		5	5		1	2	**13**
	41F5		**9**	**10**	**10**	**8**	**4**	**5**	**46**
		4165.01	5	5	5		3	2	**20**
		4165.02	4	5	5	8	1	3	**26**
2			**0**	**7**	**0**	**0**	**0**	**0**	**7**
	38F6		**0**	**4**	**0**	**0**	**0**	**0**	**4**
		3866.01		4					**4**
	39F7			**3**					**3**
		3967.02		3					**3**
3			**20**	**13**	**48**	**40**	**46**	**37**	**204**
	42F3		**0**	**1**	**5**	**3**		**1**	**10**
		4263.02		1	5	3		1	**10**
	42F4		**0**	**0**	**1**	**5**	**6**	**0**	**12**
		4264.01					2		**2**
		4264.03				3	1		**4**
		4264.05			1	2	3		**6**
	42F7		**15**	**10**	**10**	**4**	**7**	**9**	**55**
		4267.08	1						**1**
		4267.12	10	5			2	3	**20**
		4267.25	4	5	5	4	2	3	**23**
		4267.27			5		3	3	**11**
	43F4		**0**	**0**	**0**	**0**	**7**	**4**	**11**
		4364.01					3		**3**
		4364.05					2	1	**3**
		4364.07					2	3	**5**
	43F5		**0**	**0**	**16**	**9**	**6**	**8**	**39**
		4365.04			6	3		2	**11**
		4365.08			5	3	3	3	**14**
		4365.1			5	3	3	3	**14**
	43F6		**0**	**0**	**6**	**3**	**3**	**3**	**15**
		4366.06			6	3	3	3	**15**
	43F7		**5**	**2**	**10**	**10**	**11**	**12**	**50**
		4367.02			5	4	3	3	**15**
		4367.06					3	3	**6**
		4367.16		2		4	3	3	**12**
		4367.23	5		5	2	2	3	**17**
	44F4		**0**	**0**	**0**	**6**	**6**	**0**	**12**
		4464.04				3	3		**6**
		4464.05				3	3		**6**
Grand Total			**134**	**155**	**174**	**123**	**109**	**95**	**790**

Table 3. Danish dredge survey. Number of hauls made with DK1 and DK2 by area and square.

NUMBER OF HAULS								
		year(year)						
Area	**square**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**Total**
1	**37F0**	0	15	14	7	7	8	51
	37F1	11	24	15	6	3	3	62
	37F2	5	5	4	3	4	5	26
	38F1	20	30	27	27	13	10	127
	39F1	15	13	13	3	6	5	55
	39F3	19	9	11	14	9	7	69
	39F4	25	14	15	8	10	8	80
	40F5	10	15	17	7	7	7	63
	41F5	9	10	10	8	4	5	46
Total area 1		114	135	126	83	63	58	579
2	**38F6**	0	4	0	0	0	0	4
	39F7	0	3	0	0	0	0	3
Total area 2		0	7	0	0	0	0	7
3	**42F3**	0	1	5	3	0	1	10
	42F4	0	0	1	5	6	0	12
	42F7	15	10	10	4	7	9	55
	43F4	0	0	0	0	7	4	11
	43F5	0	0	16	9	6	8	39
	43F6	0	0	6	3	3	3	15
	43F7	5	2	10	10	11	12	50
	44F4	0	0	0	6	6	0	12
Total area 3		20	13	48	40	46	37	204
Total all areas		134	155	174	123	109	95	790

Table 4. Danish dredge survey. Stratified CPUE (number per 60min) per square and area.

		Stratified CPUE					
Area	Square	2004	2005	2006	2007	2008	2009
1	37F0		950	1727	297	585	378
	37F1	1356	1482	993	2609	3029	6458
	37F2	301	2493	4256	3626	757	1613
	38F1	409	2723	3149	2258	1445	6538
	39F1	1720	3518	2044	136	812	7998
	39F3	342	1786	92	1931	189	1111
	39F4	3372	4049	1853	6638	166	3639
	40F5	523	1062	248	3834	263	4695
	41F5	827	2491	1048	7877	1799	5755
Average area 1		1106	2284	1712	3245	1005	4243
2	38F6		34				
	39F7		29				
Average area 2			32				
3	42F3		1030	871	2894		6523
	42F4			12	26	3582	
	42F7	93	333	637	512	221	245
	43F4					127	140
	43F5			1438	890	879	1700
	43F6			1974	498	1197	550
	43F7	117	240	882	768	89	174
	44F4				307	68	
Average area 3		105	534	969	842	880	1556

Table 5. Danish Dredge survey. Stratified cpue (number per hour) by age for area 1, 3 and for area 1 and 3 combined.

Area 1			
	Age		
Year	0	1	2
2004	928.12	166.52	11.61
2005	2242.27	35.68	5.78
2006	1485.45	244.36	0.34
2007	3121.29	176.40	31.64
2008	522.75	568.58	26.32
2009	4116.66	96.11	30.01
Area 3			
	Age		
Year	0	1	2
2004	85.85	13.39	5.76
2005	486.66	46.70	1.00
2006	906.10	62.28	0.57
2007	547.78	321.20	9.53
2008	643.75	183.70	52.90
2009	454.97	902.71	197.86

Area 1 and 3 combined			
	age		
year	0	1	2
2004	759.66	135.89	10.44
2005	1803.37	38.44	4.58
2006	1253.71	171.53	0.43
2007	1995.38	239.75	21.97
2008	575.69	400.19	37.95
2009	2651.98	418.75	97.15

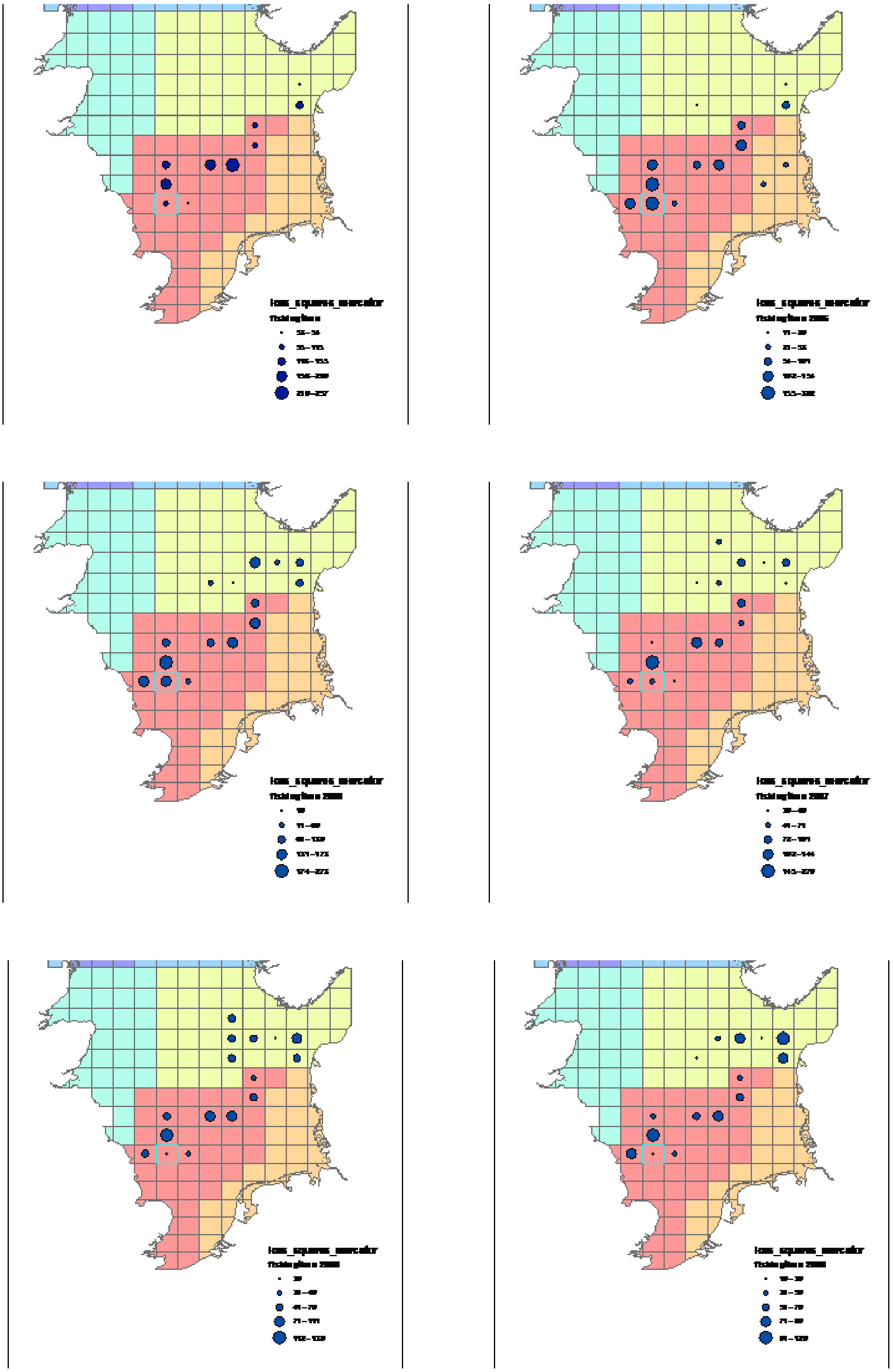


Figure 1. Danish dredge survey. Distribution of effort 2004–2009.

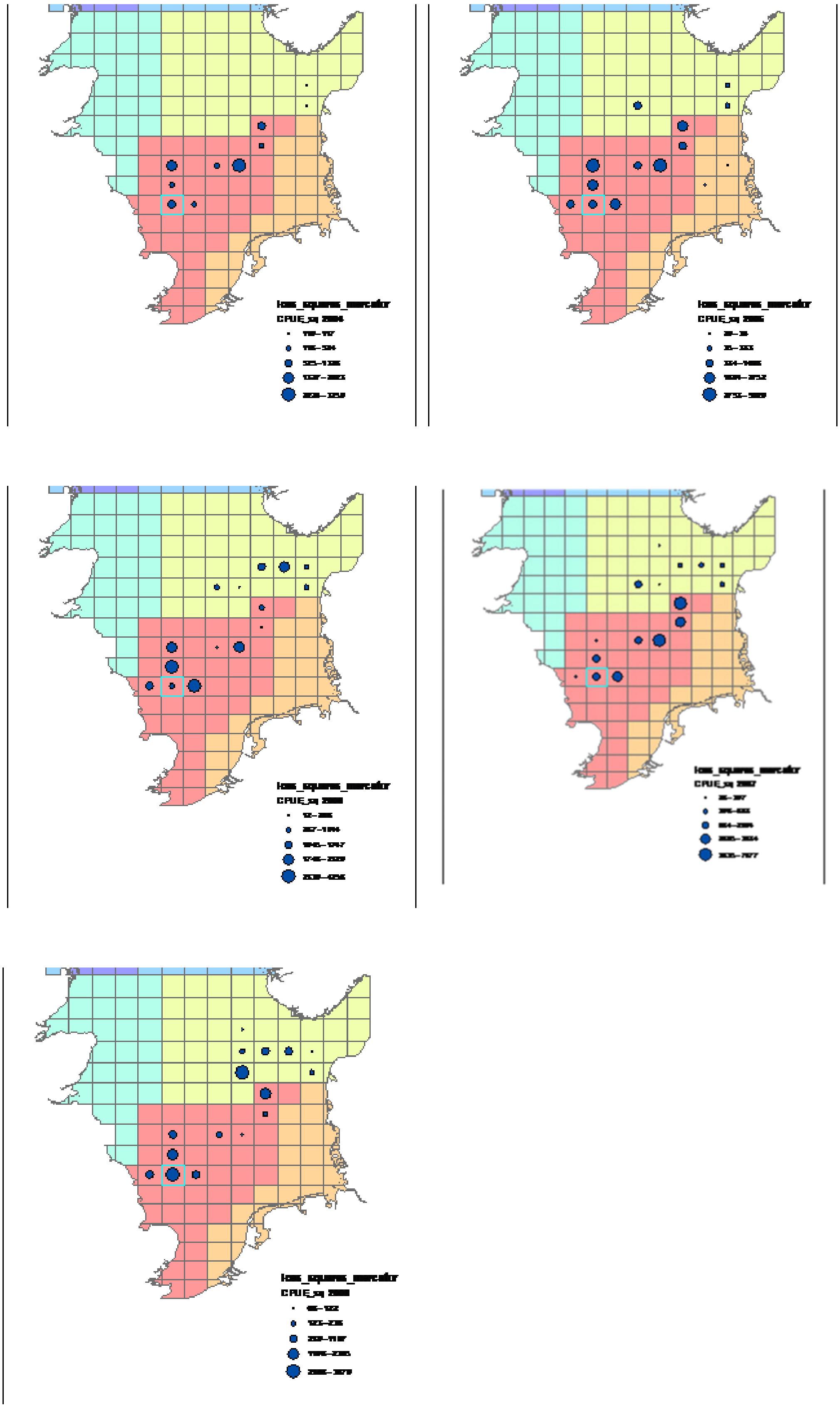


Figure 2. Danish dredge survey. Cpue 2004–2009.

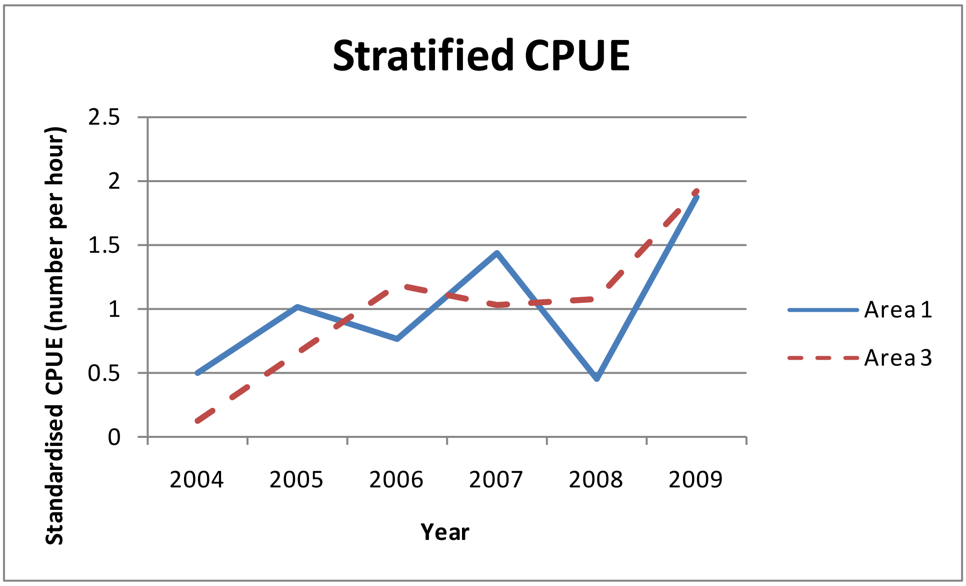


Figure 3. Danish dredge survey. Stratified average catch rate indices by area (number per hour standardized to their means).

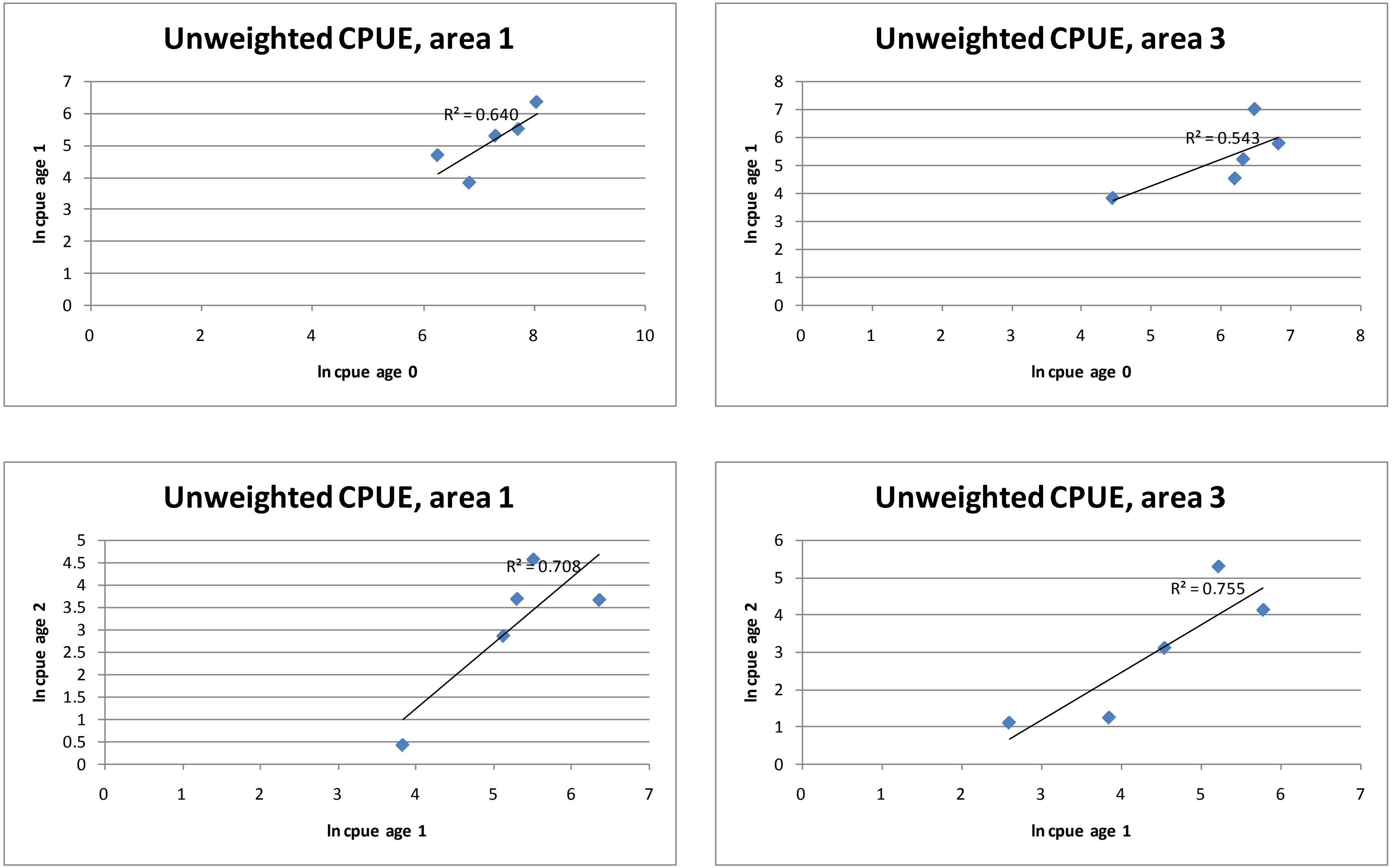


Figure 4. Dredge survey. Internal consistency plot. Raw data.

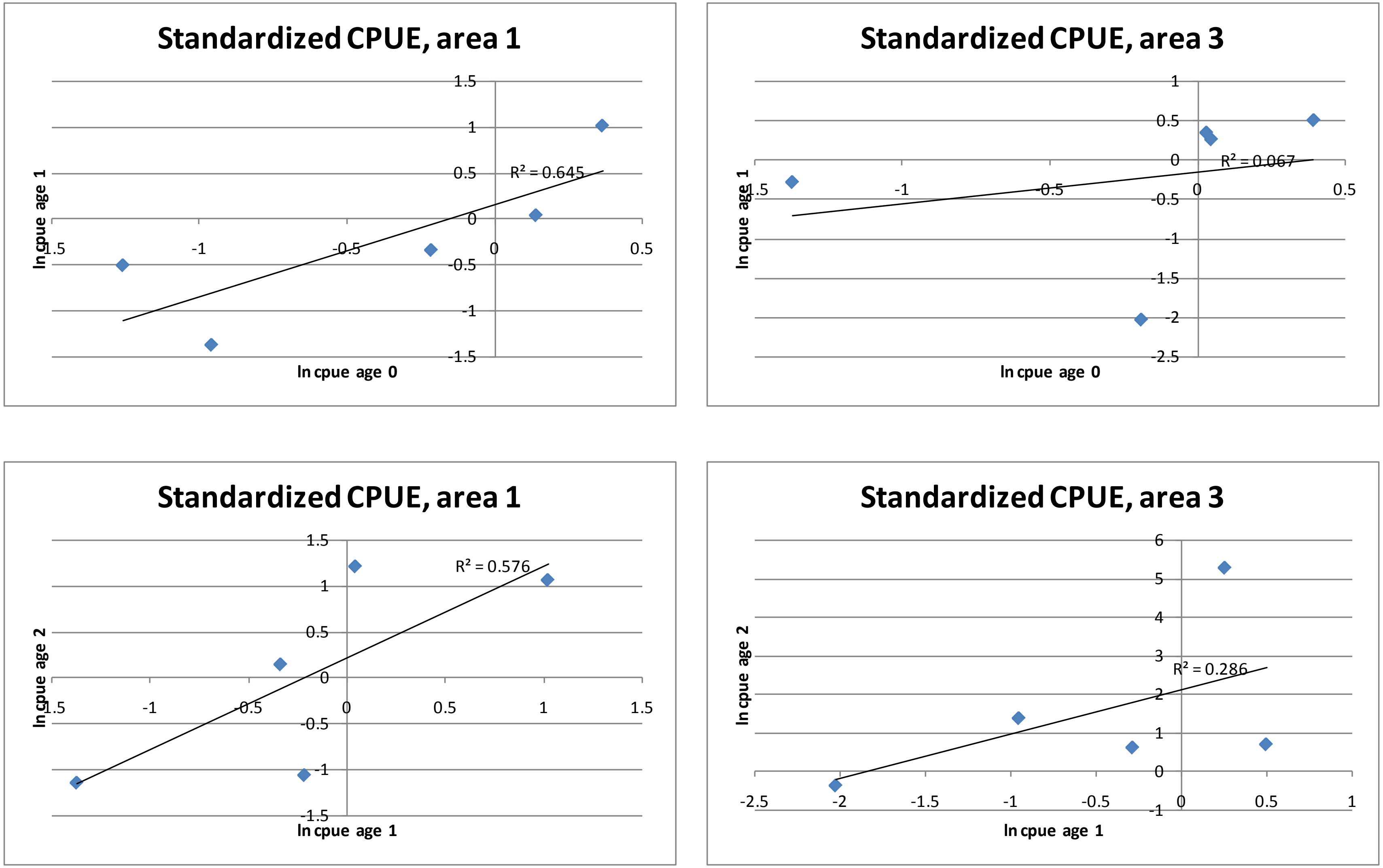


Figure 5. Dredge survey. Internal consistency plot: average of indices standardized by square means.

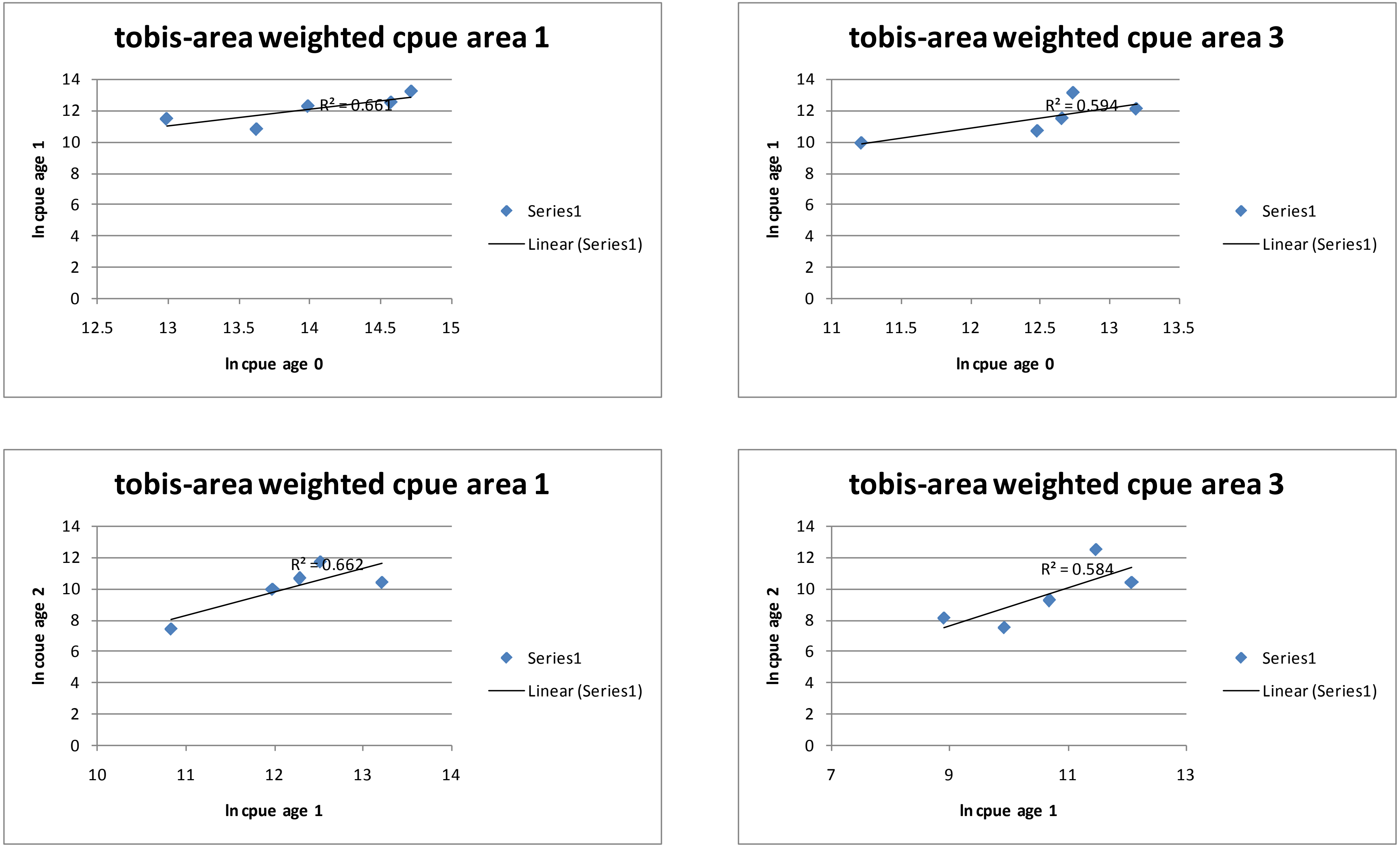


Figure 6. Dredge survey. Internal consistency plot. Average of standardized indices weighted by tobis area by square.

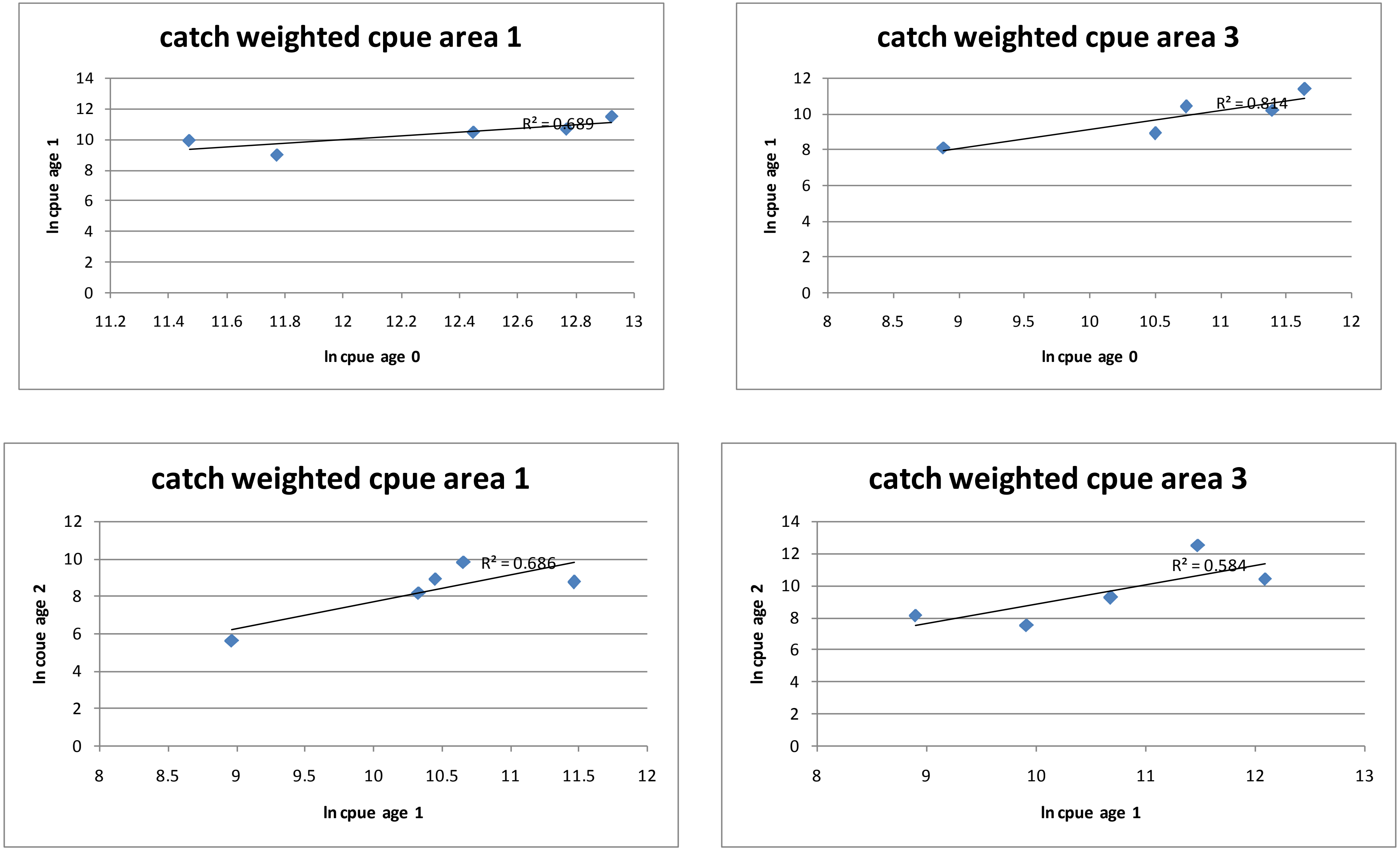


Figure 7. Dredge survey. Internal consistency plot. Average of raw indices weighted by the total catch of tobis by square.

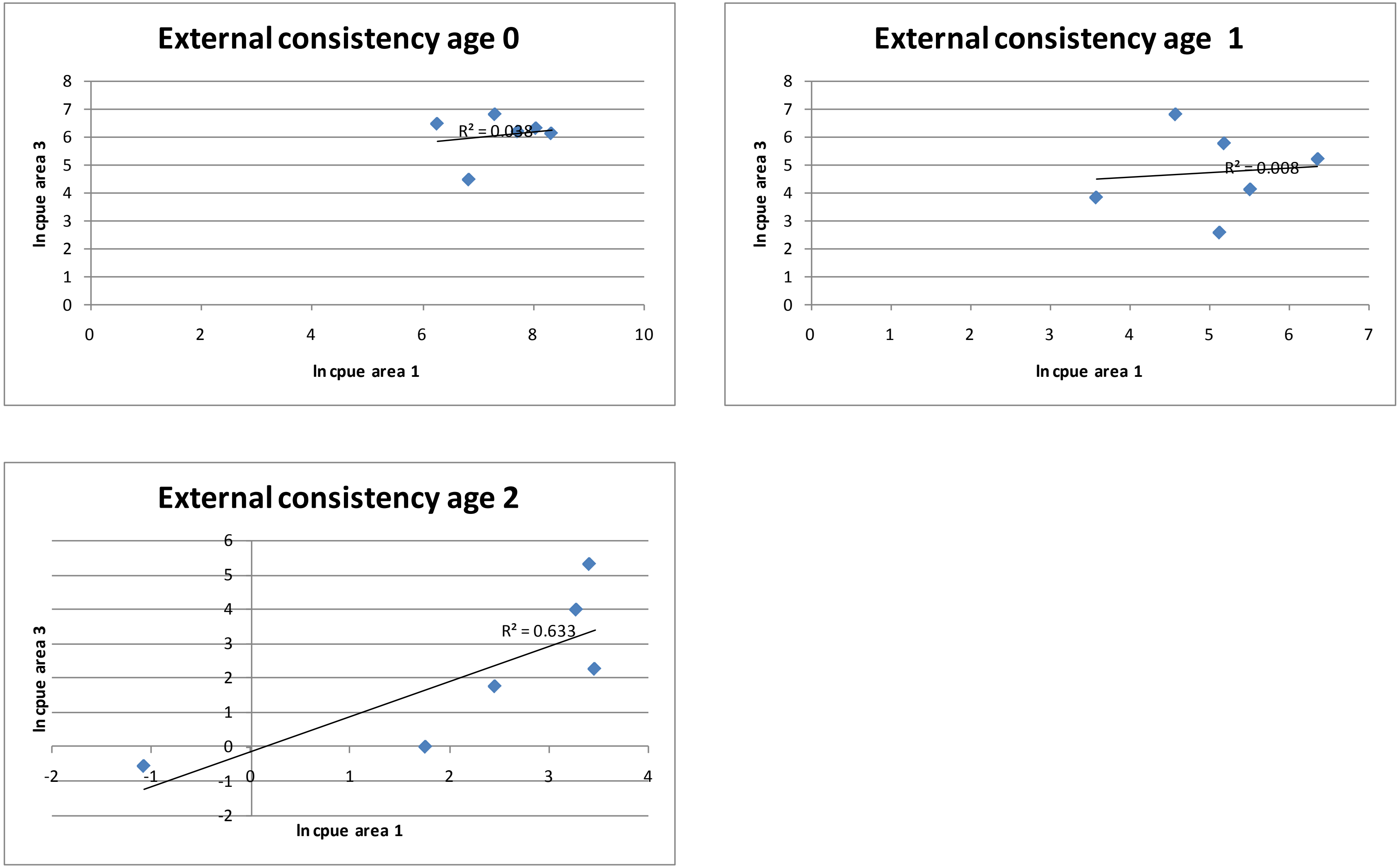


Figure 8. Dredge survey. External consistency plot. Unweighted catch rate indices.

A2. Working Document 2/9/10–Marine Scotland Science sandeel dredge survey indices for Area 4 (Firth of Forth)

P.J. Wright and R. Watret

Introduction

There are several reasons why it is difficult to design a survey to estimate sandeel abundance. Once settled, sandeels exhibit a diel emergence pattern and can occur in the sediment, near the bottom or throughout the water column during the day. Sandeels also overwinter in the sand and their period of emergence differs with age and condition. For example, 1-group sandeels may emerge from March/April to July whilst older age-classes may emerge later (Reeves, 1994). 0-group sandeels tend to metamorphose into juveniles capable of burrowing in May to June (Wright and Bailey, 1996). Many seabirds and fish predators begin to feed on 0-group during this period of metamorphosis (Lewis *et al*., 2001). However, 0-group may not settle to some fishing grounds until July (Jensen, 2001). These young sandeels tend to remain active in the water column until August or September, before beginning an overwintering phase in the sand. Sandeel distribution is limited by the patchiness of suitable sand for burrowing (Wright *et al*., 2000). Because of the age related differences in emergence and settlement, sampling of the water column at any one time will generally only provide reliable estimates of one or two age classes. Surveys of buried sandeels have been used to overcome this problem.

MSS research in the North Sea has focussed on sandeel availability to predators near the Firth of Forth. Many types of sampling approaches have been applied to consider sandeel abundance and accessibility to surface feeding seabirds and fish predators. An attempt to estimate changes in age specific biomass using a combination of acoustics, trawling, dredge and grabs and information on primary productivity has also been made (see Greenstreet *et al*., 2006). Until 2007, the sampling times and mix of approaches used were not designed with the specific aim of producing a year-class index. However, in order to complement the Danish dredge survey a dedicated sampling programme was begun in 2008 with the aim of producing a year-class index for area 4, off the northeast UK coast. The survey is targeted at banks off the Firth of Forth and around Turbot bank and takes place in November–December, coinciding with the Danish sampling. This report presents the results from this survey for just the Firth of Forth banks and compares with similar data collected in October–November between 1999 and 2003.

Methods

The Scottish surveys used a video dredge system developed in 1999 that enabled estimates of the time spent on sediments suitable for sandeels to be made (see Figure 1). This corresponds to the gear DK2 described in the Danish survey (Christensen WDA1). Catch rates of the Scottish and Danish gears were found to be highly correlated in a previous gear trial (Jensen, unpubl. data). Dredge hauls encompassing the major sandeel banks were taken at eight stations in 1999–2003 and 2008–2009; three stations on the Wee Bankie, three on Marr Bank and two on Berwick bank. At each station 1–6 tows over the same ground were made and each haul comprised a 10–15 minute tow. All sandeels were measured and a length stratified sample was aged. Numbers caught were converted to numbers per area swept and then raised to numbers per hour based on the average area swept in one hour. Average cpue for area 4

(Firth of Forth) was calculated using the same averaging used in the Danish surveys (Christensen, WDA1) in order to enable comparison.

Results

The total number of hauls are given in Table 1. Due to the different requirements of surveys, sample sizes were low prior to the establishment of a dedicated recruit survey in 2008. Based on a catch curve for 2009, only sandeels ≥8.5 cm appear to be fully selected by the gear (Figure 2). As 0-group ranged from 4.5–11.5 cm, the gear appears unsuitable for estimating absolute numbers of 0-group. Nevertheless, the proportion of very small 0-group is likely to be small since grab samples from the same region only recorded 0-group ≥7 cm. The bias against small 0-group sizes resulted in higher catches for age 1 compared to age 0 for a given year-class. Nevertheless, there was a consistency in catch rates between age 0 and 1 as well as between age 1 and 2, based on the limited comparisons that could be made (Figure 3).

Estimated average cpue indicated that the 2009 year class was the largest year class recorded (Table 2). The 1999 and 2000 year classes were larger than those in 2001–2003 and 2008. Large year classes were characterised by high densities at most stations.

References

Christensen. 2010. Working Document to ICES Benchmark Workshop on Sandeel.

Greenstreet SPR, Armstrong, E., Fraser, H., Holland, G. and Gibb, I. 2006. Sandeels and clupeids in the Wee Bankie/Marr Bank region. IMPRESS Final report Q5RS-2000-30864.

Jensen H. 2001. Settlement dynamics in the lesser sandeel *Ammodytes marinus* in the North Sea. Aberdeen University.

Lewis S, Wanless S, Wright PJ, Harris J, Bull J, Elston DA. 2001. Diet and breeding performance of black-legged kittiwakes, *Rissa tridactyla,* at a North Sea colony. Marine Ecology Progress Series 221: 277–284.

Reeves SA. 1994. Seasonal and annual variation in catchability of Sandeels at Shetland. . ICES CM 1994/D:19.

Wright PJ, Bailey MC. 1996. Timing of hatching in *Ammodytes marinus* from Shetland waters and its significance to early growth and survivorship. Marine Biology 126: 143–152.

Wright PJ, Jensen H, Tuck ID. 2000. The influence of sediment type on the distribution of the lesser sandeel, *Ammodytes marinus*. Journal of Sea Research 44: 243–256.

Table 1. Scottish dredge survey. Number of hauls by ICES rectangle and year.

Rectangle	Year						
	1999	2000	2001	2002	2003	2008	2009
41E7	3	4	3	3	3	18	15
41E8	4	5	3	3	3	8	8
40E8	2	5	0	2	2	6	8

Table 2. Average cpue by age for area 4, Firth of Forth.

		Age		
Year	0	1	2	3
1999	169.8943	142.9584	116.1867	54.96475
2000	251.44	504.8271	135.828	58.39198
2001	48.48734	329.096	250.5868	32.34407
2002	88.0291	114.231	179.1284	77.85894
2003	135.4006	NA	NA	NA
2008	68.25798	24.37893	23.85956	15.55977
2009	982.8225	164.2795	50.21453	19.33099

Figure 1. The video dredge system developed by Marine Scotland Science.

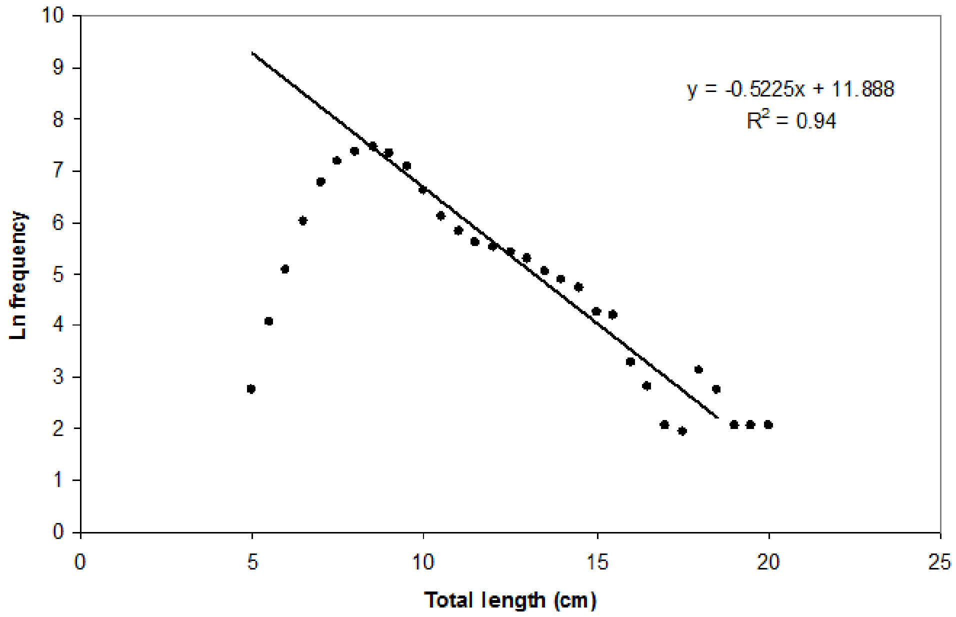


Figure 2. Log transformed frequency by total length of *A. marinus* from the 2009 Firth of Forth stations.

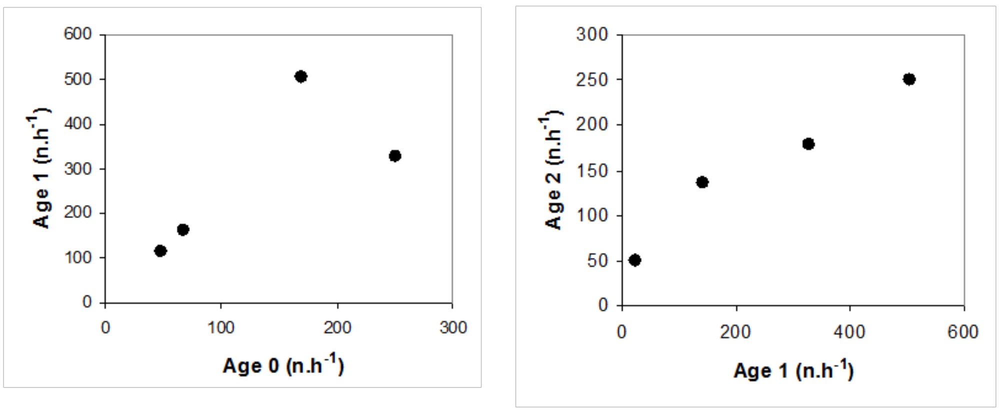


Figure 3. Internal consistency plot. Average cpue of consecutive ages from the same year class.

A3. Statistical catch-at-age model for sandeel with temporally explicit fishing mortality

A4. Proposal for a future North Sea sandeel management

A5. Management proposal on sandeel in the North Sea from the Norwegian Fishermen's Association

1) TAC should be set separately for each zone/area 1–7 based upon the best available sources of information.

2) Proposal for TAC to ICES in zone 3 (NEEZ + part of EEZ in Skagerrak included in zone 3) should be set in cooperation between the Norwegian and Danish authorities in due time before 23rd April. This requires a close cooperation between DTU Aqua and IMR.

3) Proposal for TAC to ICES in area 5 should be set by ???

4) Proposal for TAC to ICES in zone 1, 2 and 6 should be set by ??? in due time before 1st April.

5) Proposal for TAC to ICES in area 4 and 7 should be set by ????

6) There should be a close cooperation between IMR, DTU Aqua and other relevant institutes in EU on sandeel research in all zones.

7) We acknowledge that IMR uses acoustic survey as their tool to measure the sandeelstock in zone 3. IMR should also consider using the results from the Danish dredge surveys.

8) The season in zone 3 should be from 23rd April to 23rd June.

9) There should be a quota in zone 3 set by the 23rd April which should be revised no later than the 15th May. Methods used in the revision of the quota could be another in-season acoustic survey, real-time monitoring and/or sampling of catches delivered ashore.

10) The Norwegian management plan launched in 2010 for area 3 continues in 2011 with an evaluation in August 2011 with participants from both Norwegian and Danish fishermen as well as scientists and representatives from the authorities in both countries.

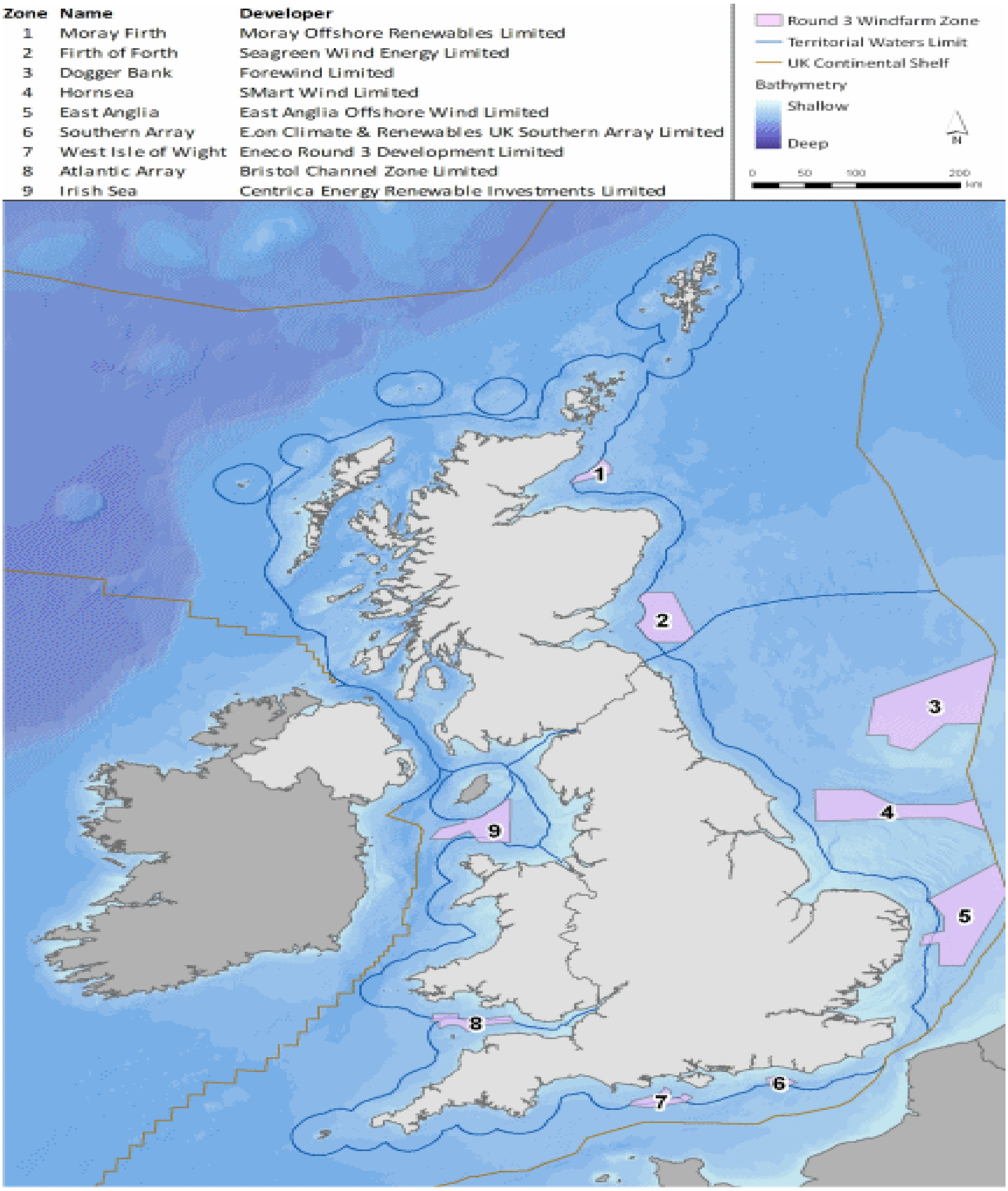
sign.

Harald Oestensjoe

Copenhagen, 8th September 2010

A6. Windmills in the North Sea-existing and planned plants

The United Kingdom Crown Estate round three of possible areas for developing windmill parks in the North Sea where some areas will have big effects on the sandeel fisheries and habitats.



Area 3 is on the Dogger Bank and is going to be developed by The Forewind Consortium.

These areas are further detailed in an interactive map which can be found at http://www.thecrownestate.co.uk/our_portfolio/marine/offshore_wind_energy/round3/70-interactive-maps-r3.htm.

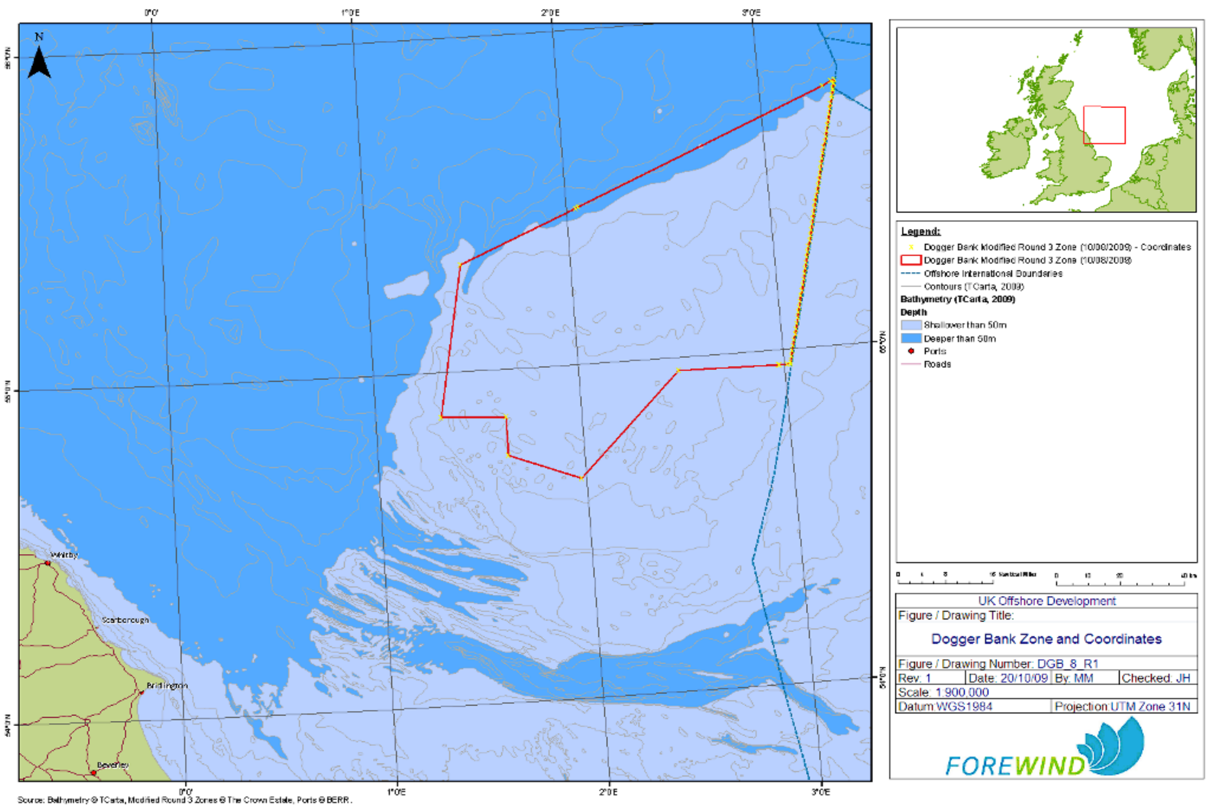
Area 2, 4 and 5 is also within the sandeel fishing areas.

Operational offshore wind farms in Europe at the end of 2009 you are given in Annex 9.

Annex 10 contains a datasheet with amended windmill projects at sea in Europe updated in 2009.

There is an official Norwegian initiative for finding suitable sites for windmills in the North Sea, and two of the areas they so far have found are in the southern part of NEZ nearby the sandeel banks. However, they are for the time being outside the banks.

The Forewind project on Dogger Bank is clearly the biggest threat for the sandeel fisheries.

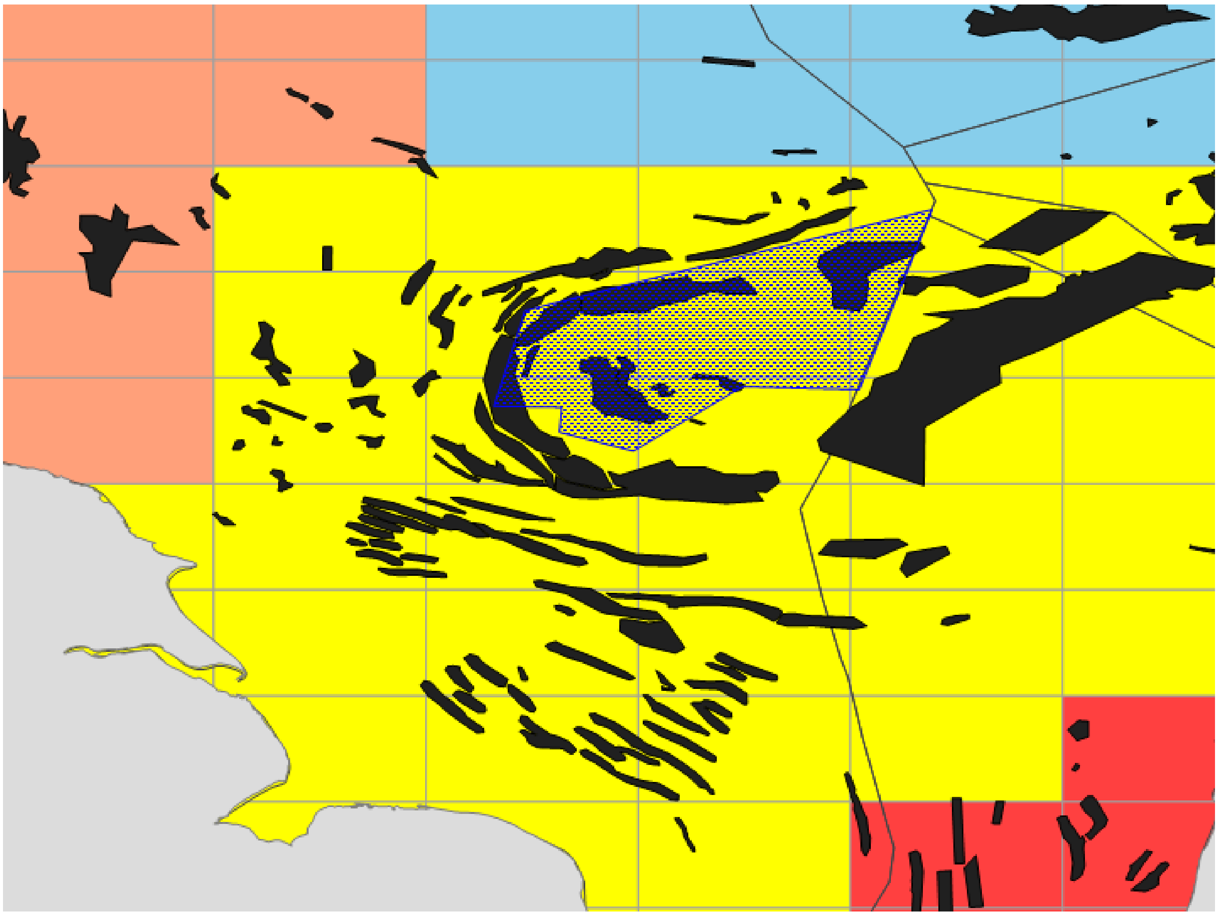


At 8660 square kilometres, the Dogger Bank zone is not only the largest of the proposed offshore sites; it is also the farthest from shore (between 125 and 195 kilometres), presenting a number of significant technical challenges.

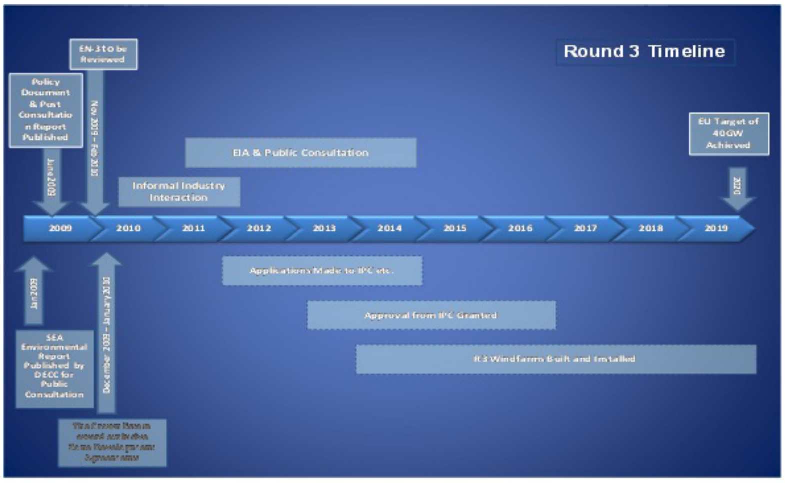
- Water depth 18–63 meters (59 to 206 feet).
- Forewind has agreed with The Crown Estate a target installed capacity of 9 GW, though the zone has a potential for approximately 13 GW, which equates to around 10 per cent of total UK electricity requirements. If developed it is likely to be the world's largest offshore wind project.

- The UK target is to have a total of 33 GW of installed offshore wind energy by 2020.
- Investments estimated to 300 billion NOK.
- 2–3000 windmills, really big ones.

Here you can see how the Dogger Bank project (in blue) covers the sandeel fisheries (in black):



The timeline for the development of Dogger Bank:



We are concerned about the consequences for:

- habitats (sandeels, plaice, turbots)?
- the biology on the sea bottom?
- the spread of sandeels?
- other species eating sandeels?
- the fisheries?
- the land industry?

There are mainly three kinds of fisheries on the Dogger Bank:

Gillnetters;

Danish seines;

Sandeel trawlers from both Denmark and Norway and other countries.

Main fish species are:

Turbot;

Plaice;

Sandeel.

Danish landings from Dogger Bank (2008):

Catch	150 000 tons of sandeels;
	1000 tons of plaice;
	100 tons of turbot.
Value	23 million Euro to the fishermen (6.6 % of the total value from Danish landings)

The Norwegian sandeel fishery on Dogger Bank is dependent on size of quota in EU waters.

In 2009 and 2010 it was 27 500 tons with an approx. value of 40 million NOK in 2009 and 55 million NOK in 2010. In earlier years the Norwegians fished much more with a relatively high quota.

The area of the southern North Sea including the Dogger Bank is, beside for the Norwegian and Danish sandeel fishers, very important for a number of other commercial fisheries for the Dutch, German and British fishing fleet. It includes fisheries for cod, haddock, plaice, sole, dab and lemon sole.

The Dogger Bank has also been identified as an important spawning ground for herring, and an important feeding ground for fulmars, particularly in autumn and winter, when high densities have been reported in the area. Other species known to feed on the Dogger Bank include gannets, kittiwake, guillemot, razorbill and gulls.

A7. Draft Working Paper–Sandeel maturity estimates based on data from DTU Aqua dredge survey

Steen Christensen, DTU AQUA.

Background

Based on data from the DTU Aqua dredge survey from 2004 to 2009 the present working paper evaluates the assumption of knife edge maturity curve applied in the sandeel assessment.

Data

Two sets of data from the DTU Aqua dredge survey (2004–2009) were used to estimate the maturity ogives: Dataset 1 giving age, length and maturity (Table 1) of subsamples of the catches and dataset 2 giving the total number by length group (Table 2, Figure 1) of the total catches (or of representative samples of the catches).

For various reasons (broken otholits, unidentifiable gonads, etc.) some records in dataset 1 did not include information about age and/or maturity. Provided that these fish were less than 100 mm they were assumed to belong to the age group 0. Fish larger than 100 mm were not included in the analysis if age information was missing (Table 1).

The Macer Index (1–6) was used to measure the maturity condition. In the present analysis fish with Macer Index 1 was considered juvenile and with Macer Index >1 mature. Fish without information about maturity was not included in the analysis.

Method

Age–length keys (giving the age distribution of each length group) and the maturity percentage by length and age was estimated from dataset 1.

Three age–length keys were estimated:

ALKEY1 giving the age distribution by year, area and length group

ALKEY2 giving the age distribution by area and length group

ALKEY3 giving the age distribution by length group

Three maturity percentages were estimated:

MATKEY1 giving the maturity percentages by year, area and length group

MATKEY2 giving the maturity percentages by area and length group

MATKEY3 giving the maturity percentages by length group.

The total number of fish by length group (Dataset 2) was distributed into age groups by applying the age–length keys. Records in the length distribution data not covered by ALKEY1 were distributed into age groups by applying ALKEY2. The few records not covered by ALKEY2 either was distributed into age groups by applying ALKEY3. The average age distribution over the years and areas (ALKEY3) are indicated in Figure 2 (upper panel) and the total number of fish by length and age group estimated from Dataset 2 by applying ALKEY3 in Figure 2 (middle panel).

The total number of mature fish by length and age group was estimated from the age distributed length groups by applying the maturity keys. The maturity distribution of records in the age distributed length group data that were not covered by MATKEY1 was estimated by applying MAKEY2. The maturity of the few records not covered by MATKEY2 either was estimated by applying MATKEY3.

Results

As indicated in Table 3 and Figure 3 the maturity ogives for age group 0 has been less than 5% in both areas since 2005. Age group 2 usually has maturity ogives above 80% and age group 2+ close to 100%. In area 1 the maturity ogive for age group 1 was above 90% until 2008. In contrast in 2008 and 2009 it declined to 60%. In area 3 the age group 1 maturity ogive declined from 90% in 2004 to 50% in 2008. However, in 2009 the maturity percentage was back to 90%.

Conclusion

Taking into consideration that the dredge survey is implemented in December, the age group 1 will appear in the fishery the following year as age group 2. Therefore the analysis gave no reason to change the assumption applied in the sandeel assessment with regard to the knife edge maturity curve and it is suggested to keep the maturity ogives for age 0, 1, 2+ at 0, 0 and 1 respectively.

Table 1. Summary of data from DTU dredge survey. A & M: Total number of fish with age, length and maturity. NULL: age and/or maturity not available. Maturity Index 1: juvenile, 2+: mature. Raw data given by ICES square.

		maturityIndex							
		1	2	3	4	5	6	NULL	A & M
		Number Sum	Number Sum	Number Sum	Number Sum	Number Sum	Number Sum	Number Sum	Sum
year	age								
2004	0	1436	176	265	36	.	.	18	1913
	1	24	138	844	273	.	.	1	1279
	2	.	.	13	7	.	.	.	20
	3	.	1	10	5	.	.	.	16
	4	.	.	3	.	.	.	.	3
	NULL	7	5	8	4	.	.	.	
Total 2004		1467	320	1143	325	0	0	19	3231
2005	0	483	28	7	.	.	.	374	518
	1	6	56	46	.	.	.	50	108
	2	.	6	8	1	.	.	.	15
	3	.	1	1	.	.	.	.	2
	4	.	.	1	.	.	.	.	1
	5	.	1	.	.	.	.	.	1
	NULL	9	1	1	.	.	.	220	
Total 2005		498	93	64	1	0	0	644	645
2006	0	255	5	3	1	.	.	376	264
	1	15	155	163	41	.	.	65	374
	2	.	4	.	3	.	.	1	7
	3	.	.	.	1	.	.	.	1
	NULL	.	1	2	.	.	.	.	
Total 2006		270	165	168	46	0	0	442	646
2007	0	291	32	11	1	.	.	186	335
	1	79	125	273	111	23	15	89	626
	2	8	19	32	10	8	7	10	84
	3	.	1	4	2	1	.	2	8
	4	.	.	2	.	.	.	1	2
	5	.	.	.	.	.	.	2	0
	NULL	37	2	37	9	.	.	26	
Total 2007		415	179	359	133	32	22	316	1055
2008	0	269	4	.	.	1	.	210	274
	1	196	75	202	35	1	21	101	530
	2	7	.	26	8	7	28	7	76
	3	.	1	5	1	.	.	1	7
	4	.	.	1	.	.	1	.	2
	7	.	.	.	1	.	.	.	1
	NULL	16	1	.	.	.	.	5	
Total 2008		488	81	234	45	9	50	324	890
2009	0	1989	30	38	1	.	.	42	2058
	1	47	37	84	20	.	.	5	188
	2	3	8	30	11	.	.	.	52
	3	.	.	9	8	.	.	.	17
	4	.	.	1	3	.	.	.	4
	NULL	3	.	.	.	.	.	39	
Total 2009		2042	75	162	43	0	0	86	2319
Overall total		5180	913	2130	593	41	72	1831	8786

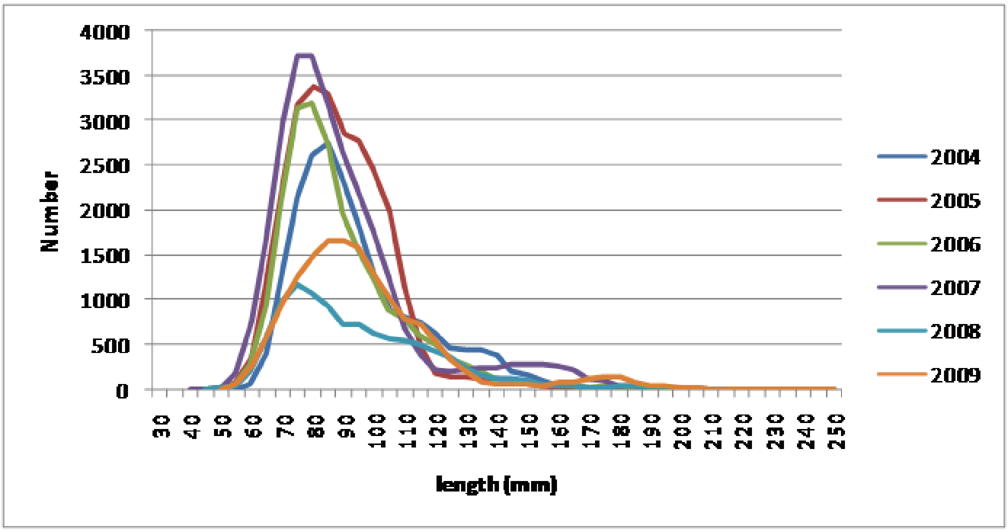
Table 2. Number by length group (5 mm). Raw data were given by square.

Sum of number	Column Labels						
Row Labels	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**Grand Total**
30					1		1
35	3						3
40				1			1
45			4	3	6		13
50		11	23	14	13	5	66
55	9	82	56	174	39	58	418
60	69	368	274	768	204	266	1949
65	411	1213	954	1690	587	576	5431
70	1242	2295	2084	2978	972	962	10533
75	2144	3182	3127	3716	1179	1246	14594
80	2615	3380	3187	3710	1071	1491	15454
85	2753	3303	2716	3168	942	1650	14532
90	2339	2850	1964	2650	741	1645	12189
95	1830	2768	1565	2188	727	1566	10644
100	1291	2442	1234	1765	637	1282	8651
105	892	1983	880	1204	564	1013	6536
110	814	1148	778	696	552	779	4767
115	752	486	606	378	508	717	3447
120	623	176	515	214	431	551	2510
125	475	142	352	200	370	321	1860
130	439	139	277	216	242	193	1506
135	444	133	205	237	161	88	1268
140	389	131	129	243	121	68	1081
145	204	106	99	286	121	53	869
150	159	70	74	283	102	55	743
155	96	39	49	291	68	49	592
160	51	19	47	256	41	76	490
165	44	9	34	215	43	87	432
170	23	5	27	131	23	124	333
175	22	5	33	94	28	133	315
180	7	2	44	42	35	134	264
185	16	3	24	32	39	84	198
190	7		12	16	30	52	117
195	1		11	15	12	44	83
200			3	10	7	25	45
205			2	12	8	14	36
210			1	8	1	10	20
215			2	4	4	6	16
220				4	1	7	12
225				3	3	6	12
230				1		3	4
235				1		5	6
240						5	5
245					1	5	6
250					1	2	3
Grand Total	**20164**	**26490**	**21392**	**27917**	**10636**	**15456**	**122055**

Table 3. Maturity ogives (percent) for area 1 and 3. Data from DTU-Aqua dredge survey.

Area 1						
Sum of MatOgive	**Column Labels**					
Row Labels	**0**	**1**	**2**	**3**	**4**	**7**
2004	6	98	100	100	100	
2005	1	90	100	100	100	
2006	1	94	78	100		
2007	2	97	89	100		
2008	0	61	73	100	100	100
2009	1	56	85	100	100	

Area 3					
Sum of MatOgive	**Column Labels**				
Row Labels	**0**	**1**	**2**	**3**	**4**
2004	12	96	100	100	
2005	8	78	98	100	
2006	2	80	100	100	
2007	3	69	77	100	100
2008	1	48	95	100	100
2009	4	92	100	100	100



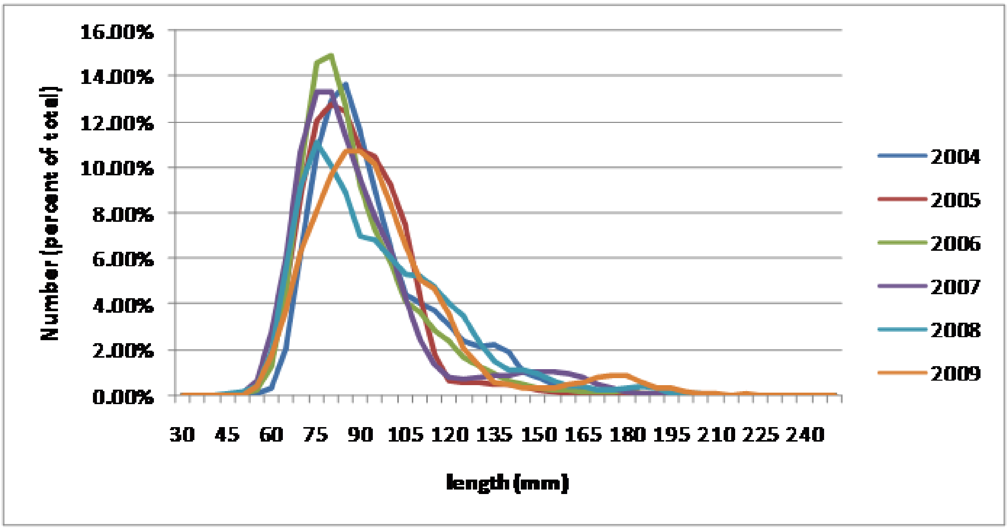


Figure 1. Length distribution. Average over year and area.

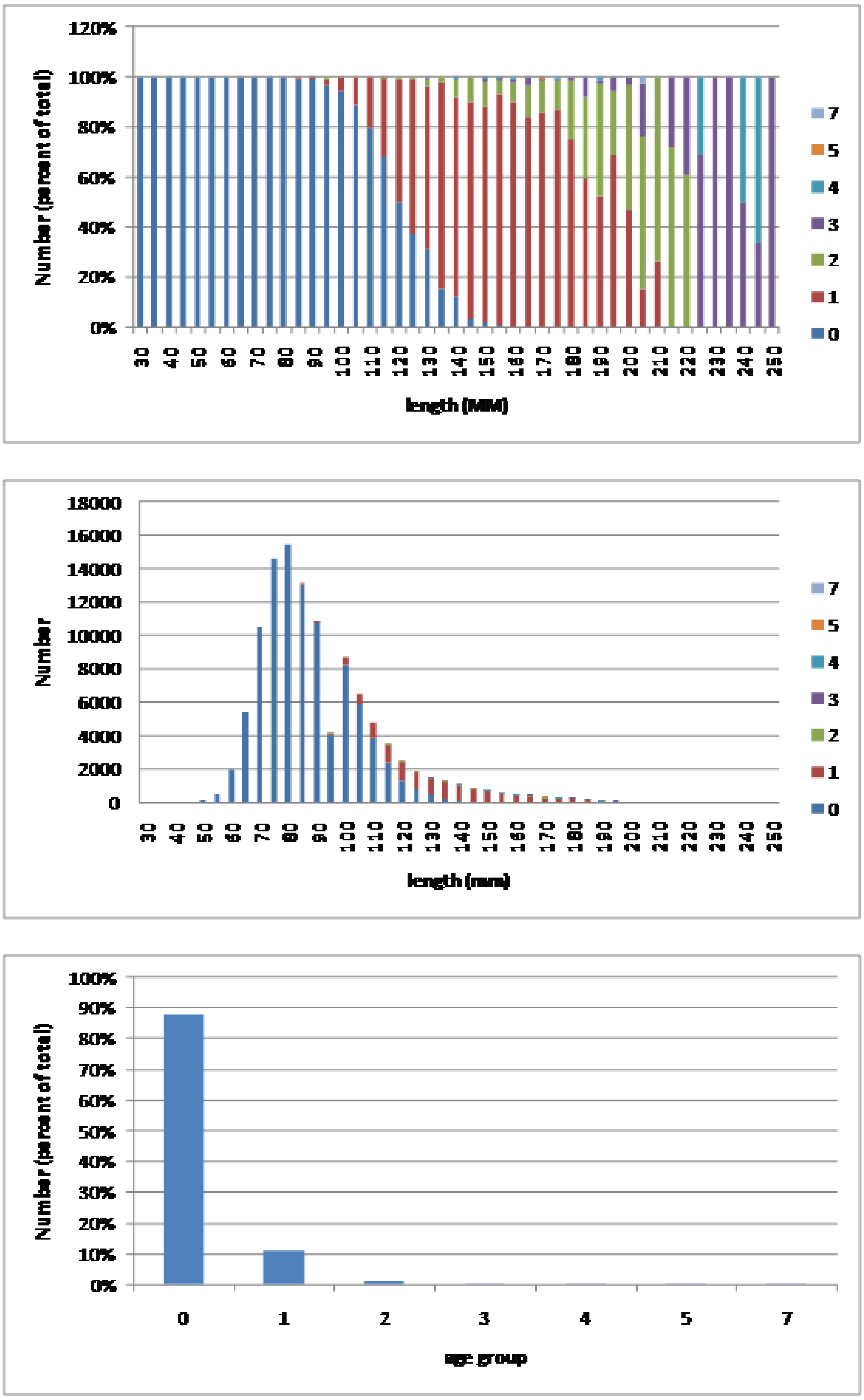


Figure 2. Average age and length distributions of dredge survey data from 2004–2009.

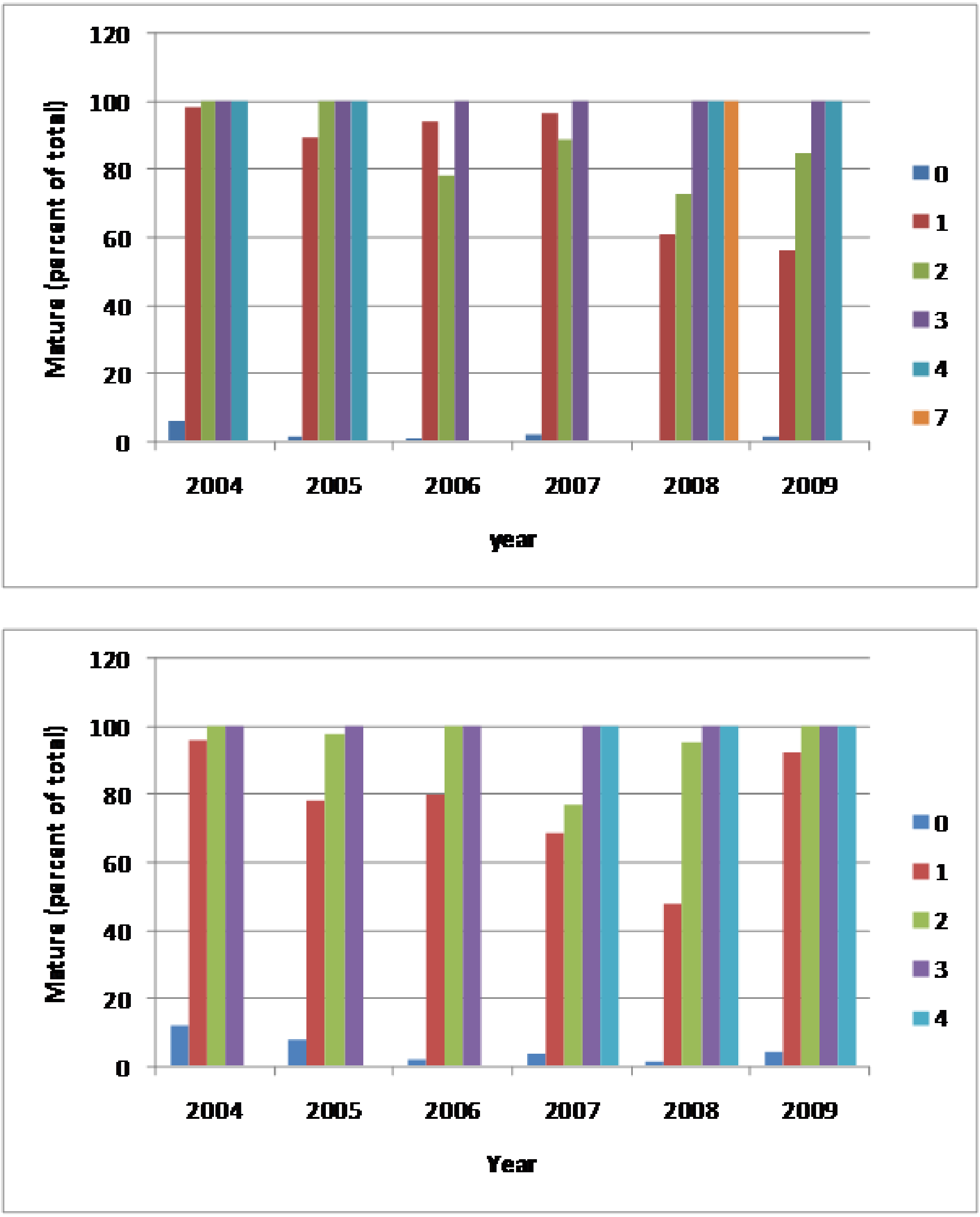


Figure 3. Maturity ogives (percent) for area 1 (upper) and area 3 (lower).

A8 Amended wind-farm database for BDC 2010

ID No	Country	Name	Location	Distance from coast	Operator	No of wind turbines	Current Status	Capacity in MW	Foundation type	Water depth (m)	Height (m)	EIA	Remarks
Be01	Belgium	Seanergy		11/12,5 *	Electrabel-Jan De Nul	50	refused	100	monopile	less than 10 m	118	yes	authorisation withdrawal
Be02	Belgium	C-Power Wenduinebank		6	C-Power	50	refused	100	monopile	4-11 m	98	yes	
Be03	Belgium	C-power II	(Block10) 2.89796,51.54472 2.92499,51.55248 2.95435,51.53946 2.92741,51.53167 (Block 2) 2.95576,51.56077 2.99146,51.57988 3.01841,51.56483 2.98264,51.54558	27	C-power	60	authorised	216-300	gravity-based	10 to 25 m	130	yes	Authorisation for project layout in 2 blocks, groundsurvey finished in September 2004. Prework ecological monitoring finished in June 2006.
Be04	Belgium	SPE Zeebrugge		0-15	SPE Power Company	14	refused	28	monopile	o-less than 5	116	yes	project situated half on the harbour/half in the sea, permit refused
Be05	Belgium	Eldepasco	2.872406;51,59558 2.904308,51.60846 2.906422,51.60719 2.923025,51.6139 2.930356,51.61757 2.94461,51.62589 2.926872,51.63656 2.912725,51.6283 2.905525,51.62469 2.888622,51.61788 2.892,51.61585 2.860097,51.60298	37	Electrawinds-Depret-Aspiravi-We power	36	authorised	216	other	15-20 m	130	yes	Foundation type not decided yet, depending on results groundsurvey. Area concession granted in June 2006.
Be06	Belgium	Belwind	2.800711, 51.712290 2.867403,51.672295 2.801326, 51.620236 2.791981,51.636446 2.763609,51.649857	46	Belwind nv, Ecocem	66 (5 MW) or 110 (3 MW)	authorised	330	other	25-50 m	126	yes	Foundation type not decided yet, depending on results groundsurvey. Area concession granted in June 2007. Permit granted in February 2008.
Be07	Belgium	Rentel	Area A 2.889653,51.591950 2.902606,51.597183 2.904719,51.595919 2.931389,51.606697 2.939722,51.610864 2.950603,51.617231 3.001992,51.588136 2.991944,51.587606 2.964722,51.587275 2.939756,51.585422 2.932856,51.584294 2.919122,51.581247 2.912286,51.579164 Area B 2.918033,51.575914 2.921928,51.577094 2.934983,51.579997 2.941058,51.580992 2.965289,51.582789 2.972908,51.582936 2.963950,51.578672 2.956928,51.573975 2.950250,51.569278 2.941975,51.564464 2.920633,51.574442	31	Rent-a-port	48	application	288	other				Foundation type not decided yet, depending on results groundsurvey. Area concession granted in June 2009.
~~Dk01~~	~~Denmark~~	~~Unknown~~	~~Unknown~~	~~Unknown~~	~~Unknown~~	~~Unknown~~	~~Tender~~	~~400~~	~~unknown~~	~~unknown~~	~~unknown~~	~~yes~~	~~In tender. Operational by the end of 2012.~~
Dk02	Denmark	Horns Rev	7.79511,55.50134 7.87488,55.50210 7.88344,55.46721 7.80374,55.46646	14-17	Vattenfall	80	operational	160	monopile	less than 15	120	yes	
Dk03	Denmark	Frederikshavn	10.56588,57.44570 10.56560,57.44370 10.56534,57.44199	1	Dong Energy	1	operational	2.5	monopile	0-less than 5	123	yes	
Dk04	Denmark	Roenland	8.21489,56.66853 8.21900,56.66000 8.22416,56.65132	1	Vindenergi Aps	8	operational	17	monopile	less than 5	120	yes	

Dk05	Denmark	Horns Rev 2	7.57690,55.63457 7.58466,55.64142 7.59320,55.64797 7.59999,55.64494 7.60679,55.64191 7.61359,55.63887 7.62038,55.63584 7.62719,55.63281 7.63399,55.62977 7.62744,55.62476 7.62148,55.61951 7.61615,55.61406 7.61144,55.60842 7.60737,55.60262 7.60400,55.59669 7.60129,55.59065 7.59929,55.58451 7.59799,55.57833 7.59738,55.57210 7.59751,55.56586 7.59834,55.55965 7.58974,55.55912 7.58115,55.55859 7.57256,55.55807 7.56397,55.55754 7.55538,55.55702 7.54679,55.55648	30	Dong Energy	91	operational	209	monopile	9 - 17 m	up to 132 m	yes	
De01	Germany	alpha ventus	6.62333,54.00000 6.59000,54.00000 6.58833,54.02667 6.62167,54.02667	45	Stiftung Offshore Windenergie	12	operational	60	monopile / tripod / gravity-based / other	25 to 50 m	118 to 150	yes	
De02	Germany	DanTysk	7.24083,55.06694 7.17778,55.06333 7.17725,55.06392 7.17083,55.07111 7.16962,55.10983 7.16806,55.15972 7.18417,55.16111 7.16639,55.22806 7.16639,55.22806 7.17000,55.23500 7.20111,55.23056 7.20889,55.22278 7.24694,55.07417	50	GEO mbH	80	authorised	max. 400	tripod	10 to 25 m / 25 to 50 m	130	yes	
De03	Germany	Borkum Riffgrund West	6.28753,54.06033 6.28937,54.02250 6.28931,54.02251 6.18087,54.03448 6.17903,54.07215	40	Energiekontor AG	80	authorised	max. 280	monopile / tripod / other	25 to 50 m	120	yes	
De04	Germany	Borkum Riffgrund	6.61694,53.94028 6.54833,53.94028 6.49139,53.97389 6.49111,53.99444 6.56000,53.99444 6.61694,53.96083	34	PNE2 Riff I GmbH	77	authorised	max. 230	tripod / other	10 to 25 m / 25 to 50 m	115	yes	
De05	Germany	Amrumbank West	7.77694,54.50639 7.64056,54.50639 7.64056,54.53889 7.77694,54.53889	35	Amrumbank West GmbH	80	authorised	max. 400	other	10 to 25 m	130	yes	
De06	Germany	Nordsee Ost	7.72639,54.43417 7.64028,54.40083 7.64056,54.47083 7.73917,54.47194 7.73972,54.46111	30	Essent Wind Nordsee Ost Planungs- und Betriebsgesellschaft mbH	80	authorised	400	monopile / tripod	10 to 25 m	140	yes	
De07	Germany	Meerwind Ost	7.71667,54.37488 7.70500,54.37052 7.69615,54.39333 7.69333,54.41077 7.75262,54.43383 7.76202,54.42500 7.76667,54.38590	22	Meerwind Südost GmbH & Co Rand KG	40	authorised	max. 200	monopile / tripod	10 to 25 m / 25 to 50 m	110	yes	

De08	Germany	Butendiek	7.80000,54.96667 7.78435,54.96667 7.73750,55.01054 7.73751,55.04124 7.78446,55.06762 7.80000,55.06762	34	Butendiek Offshore Windpark GmbH & Co. KG	80	authorised	240	monopile	10 to 25 m	130	yes	
De09	Germany	GlobalTech I	6.41582,54.54083 6.38867,54.45392 6.38867,54.45392 6.31813,54.49900 6.31817,54.54087 6.31817,54.54087 6.36702,54.54085 6.41582,54.54083	100	Nordsee Windpower GmbH & Co. KG	80	authorised	360	tripod	25 to 50 m	150	yes	
De10	Germany	OWP Delta Nordsee 1	6.78417,54.00617 6.74767,54.00617 6.74767,54.06917 6.78417,54.06920 6.78417,54.06917	40	OWP Delta Nordsee GmbH	48	authorised	max. 240	monopile / tripod / other	25 to 50 m	130	yes	
De11	Germany	Hochsee Windpark Nordsee	6.38540,54.44178 6.36852,54.38922 6.25915,54.45992 6.30933,54.48943	90	EnBW Nordsee Offshore GmbH	80	authorised	360	tripod	25 to 50 m	110	yes	
De12	Germany	Sandbank 24	6.90953,55.11842 6.87861,55.11425 6.85975,55.12133 6.80039,55.27983 6.81294,55.29053 6.84386,55.29414	100	Sandbank Power GmbH & Co. KG	80	authorised	max. 420	tripod / monopile	25 to 50 m	100	yes	
De13	Germany	Gode Wind	7.04694,53.99944 7.03083,53.99944 6.94167,54.05167 6.94167,54.07083 7.02278,54.07083 7.04694,54.05667	45	Plambeck Neue Energien AG	80	authorised	320	monopile / tripod	25 to 50 m	125	yes	
De14	Germany	Weiße Bank	6.97083,54.84167 6.87917,54.77500 6.84167,54.80417 6.83750,54.83750 6.86667,54.87917 6.89583,54.88167	83	Energiekontor	170	application	320	other	25 to 50 m	150	no	
De15	Germany	Ventotec Nord 1	5.97616,54.69571 5.99829,54.68191 6.00887,54.68331 6.05983,54.65146 6.06351,54.64916 6.01608,54.62507 6.00832,54.62113 6.00732,54.62175 5.99662,54.62842 5.94577,54.66015 5.90745,54.68405 5.95793,54.70708	130	GHF GmbH	80	application	150	tripod	25 to 50 m	80	no	
De16	Germany	Ventotec Nord 2	6.10515,54.57112 6.09514,54.56567 6.02123,54.61290 6.08904,54.64912 6.10531,54.63870 6.11997,54.62930 6.16231,54.60217 6.11984,54.57910	112	GHF GmbH	80	application	150	tripod	25 to 50 m	80	no	
De17	Germany	Nördlicher Grund	6.97222,55.09833 6.99750,55.02722 6.88833,55.03028 6.86306,55.10139	84	Konsortium Nördlicher Grund (ABB, GEO, GREP)	80	authorised	360	monopile / tripod	10 to 25 m / 25 to 50 m	100	yes	
De18	Germany	Hochsee Windpark He dreiht	6.22222,54.37778 6.29167,54.32917 6.13333,54.32917 6.13333,54.37778	85	EnBW Nordsee Offshore GmbH	80	authorised	360	tripod	25 to 50 m	110	yes	

De19	Germany	Nordergründe	8.18028,53.82361 8.16806,53.82194 8.14917,53.84139 8.18361,53.83917 8.18361,53.82722	11	Energiekontor GmbH	max. 25	application	max. 125	monopile / tripod	less than 10 m / 10 to 25 m	150	yes	
De20	Germany	Riffgat	6.51433,53.69233 6.44083,53.68200 6.43667,53.69250 6.51000,53.70283	14.5	ENOVA Offshore Projektentwicklungs-GmbH & Co.KG	max. 44	application	max. 220	monopile / tripod	10 to 25 m	140 to 180	yes	
De21	Germany	H2-20	4.19389,55.77889 4.19361,55.61778 4.07806,55.66000 4.07806,55.79806	200	GEO	800	application	400	tripod	25 to 50 m	150	no	Hydrogen production. Planned start of construction in 2020
De22	Germany	BARD Offshore 1	6.01889,54.30639 5.93833,54.30222 5.93861,54.38750 6.01917,54.42333	87	Bard Engineering GmbH	80	authorised	max. 400	other	25 to 50 m	110	yes	
De23	Germany	Deutsche Bucht	5.82750,54.27475 5.81000,54.27473 5.74255,54.30411 5.82869,54.34169	87	Eolic Power GmbH	50	application	250	gravity-based	25 to 50 m	110	no	
De24	Germany	Austerngrund	5.79978,54.41466 5.63713,54.34979 5.79927,54.51827	87	Global Wind Support GmbH	80	application	400	gravity-based	25 to 50 m	110	no	
De25	Germany	MEG Offshore I	6.57924,54.00036 6.50476,54.00003 6.50317,54.02977 6.54044,54.07377 6.53955,54.08908 6.55967,54.08931 6.61882,54.04351 6.61877,54.03067 6.57827,54.03053	45	Multibrid Entwicklungsgesellschaft mbH	80	authorised	400	tripod	25 to 50 m	150	no	
De26	Germany	Borkum West II	6.48957,54.00003 6.42066,54.00003 6.41560,54.08756 6.52456,54.08892 6.52558,54.07132 6.51280,54.05355 6.48782,54.03142	40	Trianel Windkraftwerk Borkum GmbH & Co. KG	80	authorised	400	tripod	10 to 25 m / 25 to 50 m	150	yes	
De27	Germany	Innogy Nordsee 1	6.93400,54.09250 6.93400,53.97933 6.74767,53.95233 6.74767,53.99983 6.79417,53.99983 6.79433,54.07767 6.79433,54.07767 6.74767,54.07767 6.74767,54.09250	40	Innogy Nordsee 1 GmbH	163	application	815	monopile / tripod	25 to 50 m	150	no	
De28	Germany	OWP Delta Nordsee 2	6.79433,54.07767 6.79417,53.99983 6.74767,53.99983 6.74767,54.00617 6.78417,54.00617 6.78417,54.06917 6.74767,54.06917 6.74767,54.07767 6.79433,54.07777	40	OWP Delta Nordsee GmbH	32	authorised	192	monopile / tripod	25 to 50 m	160	yes	
De29	Germany	Borkum Riffgrund II	Area 1: 6.47984,53.97409 6.54848,53.93371 6.60558,53.93371 6.51424,53.92021 6.49141,53.92019 6.45752,53.94057 6.42272,53.96728 6.42261,53.99427 6.47979,53.99433 Area 2: 6.61703,53.99436 6.61701,53.96741 6.57128,53.99436	26	Plambeck Neue Energien AG	96	application	480	monopile / tripod	25 to 50 m	150	no	

De30	Germany	OWP West	6.29785,54.02123 6.29817,54.01645 6.10693,54.01665 6.10260,54.02267 6.15435,54.05770 6.17967,54.05860 6.17967,54.05859 6.18087,54.03448 6.28933,54.02220	58	LCO Nature	42	application	240 to 480	monopile / tripod	25 to 50 m	120 to 150	no	
De31	Germany	Borkum Riffgrund West 2	6.29460,54.08675 6.29817,54.01645 6.29785,54.02123 6.28937,54.02123 6.28933,54.02220 6.28931,54.02251 6.28753,54.06033 6.17903,54.07215 6.17969,54.05859 6.17967,54.05859 6.15435,54.05770 6.10260,54.02267 6.07140,54.06920	52	Energiekontor	83	application	415	tripod / other	25 to 50 m	160	no	
De32	Germany	Hochsee Testfeld Helgoland	7.75306,54.48667 7.64056,54.48667 7.64056,54.49278 7.75306,54.49278	35	Hochsee Testfeld Helgoland GmbH	19	application	95	monopile / tripod	10 to 25 m	130	no	
De33	Germany	Gode Wind II	6.99790,53.98903 6.94190,53.98033 6.94179,54.02483 6.94682,54.03612 7.01592,53.99240 6.99790,53.98903 7.07007,54.09312 7.10465,54.07609 7.11524,54.06985 7.11516,54.03249 7.06226,54.00137 7.05959,54.06191 7.00519,54.07988 6.94165,54.07984 6.94162,54.09229	34	Plambeck Neue Energien Gode Wind II GmbH	80	authorised	400	monopile / tripod	25 to 50 m	150	no	
De34	Germany	Sandbank extension	Area 1: 6.87861,55.11425 6.86317,55.11258 6.84478,55.11936 6.78883,55.26914 6.80039,55.27983 6.85975,55.12133 6.87861,55.11425 Area 2: 6.91867,55.13786 6.90953,55.11842 6.84386,55.29414 6.85933,55.29608 6.91867,55.13786	90	Sandbank Power Extension GmbH	40	application	200	monopile / tripod	25 to 50 m	100	no	
De35	Germany	Veja Mate	5.82750,54.27475 5.82870,54.34169 5.90961,54.37686 5.91037,54.27485	89	Cuxhaven Steel Construction GmbH	80	authorised	400	other	25 to 50 m	110	no	
De36	Germany	Kaskasi	7.79883,54.39074 7.78183,54.38816 7.77738,54.42562 7.75888,54.43997 7.75507,54.47211 7.78834,54.47253	23	Essent Wind Nordsee Ost Planungs- und Betriebsgesellschaft mbH	40	application	max. 320	monopile / tripod / gravity-based / other	10 to 25 m	160	no	
De37	Germany	Meerwind Süd	7.70500,54.37052 7.64125,54.34662 7.64125,54.39230 7.65513,54.39590 7.69333,54.41077 7.69615,54.39333	22	Meerwind Südost GmbH & Co Föhn KG	40	authorised	max. 200	monopile / tripod	10 to 25 m / 25 to 50 m	110	yes	

De38	Germany	Albatros	6.30972,54.49472 6.25306,54.46139 6.18472,54.50611 6.32368,54.56203 6.35201,54.57343 6.36833,54.58000 6.38998,54.56370 6.41667,54.54361 6.31817,54.54361 6.31026,54.54361 6.30972,54.54361 6.30972,54.49615	105	LCO Nature	80	application	400	tripod / other	25 to 50 m	165	no	
De39	Germany	Kaikas	6.27712,54.61348 6.13241,54.55533 6.11980,54.56339 6.11984,54.57910 6.11997,54.62930 6.12007,54.66689	88	Eos Kaikas GmbH	88	application	528	other	25 to 50 m	153	no	
De40	Germany	Notos	6.28881,54.50096 6.24003,54.47238 6.20634,54.49410 6.19676,54.50028 6.27362,54.53308 6.28727,54.53891	88	EOS Offshore Notos GmbH	50	application	300	other	25 to 50 m	153	no	
De41	Germany	Aiolos	Area 1: 6.27039,54.73590 6.27588,54.68538 6.19018,54.71471 Area 2: 6.47131,54.69099 6.37326,54.65193 6.35100,54.65958 6.29891,54.67748 6.29201,54.67985 6.28552,54.73988 6.28222,54.77017 6.28188,54.77332 6.28283,54.77332 6.30542,54.77327 6.49510,54.77285 6.49416,54.76961	88	Eos Aiolos GmbH	310	application	1550	other	25 to 50 m	153	no	
De42	Germany	Sea Wind I	6.44985,54.54836 6.41496,54.43699 6.38867,54.45392 6.38867,54.45392 6.41582,54.54083 6.41582,54.54083 6.36702,54.54085 6.31817,54.54087 6.31817,54.54087 6.31817,54.54361 6.31817,54.55883 6.32368,54.56203 6.34600,54.57497 6.35201,54.57343 6.38998,54.56370	90	Northern Energy SeaWind I GmbH	44	application	400	tripod / other	25 to 50 m	150	yes	
De43	Germany	Sea Wind II	6.30972,54.49615 6.25370,54.46317 6.20578,54.49378 6.20634,54.49410 6.27362,54.53308 6.31025,54.55430 6.31026,54.54361 6.31032,54.49650	90	Northern Energy SeaWind II GmbH	60	application	300	tripod / other	25 to 50 m	150	yes	
De44	Germany	Sea Storm I	6.03226,54.59056 5.94254,54.56125 5.87572,54.59507 5.93368,54.65322	110	Northern Energy SeaStorm I GmbH	80	application	400	tripod / other	25 to 50 m	150	yes	
De45	Germany	He dreiht II	6.30465,54.32075 6.13334,54.31231 6.13340,54.32897 6.29180,54.32901	110	EOS Offshore AG	28	application	168	other	25 to 50 m	153	no	

De46	Germany	Diamant	5.35661,54.68574 5.20674,54.53569 5.18394,54.54555 5.18131,54.68475	113	Bard Schiffsbetriebs GmbH & Co. Natalie KG	160	application	800	monopile / tripod / gravity-based / other	25 to 50 m	151	no	
De47	Germany	Bernstein	6.00742,54.50501 5.80711,54.42430 5.80649,54.50486	108	Bard Schiffsbetriebs GmbH & Co. Natalie KG	80	application	400	monopile / tripod / gravity-based / other	25 to 50 m	151	no	
De48	Germany	Citrin	6.01687,54.50950 5.80648,54.50935 5.80644,54.51577 5.87329,54.58441	111	Bard Schiffsbetriebs GmbH & Co. Natalie KG	80	application	400	monopile / tripod / gravity-based / other	25 to 50 m	151	no	
De49	Germany	Aquamarin	6.01903,54.22797 5.92853,54.22280 5.82013,54.27026 5.91811,54.27036 5.91789,54.29658 6.01887,54.30202	83	Bard Schiffsbetriebs GmbH & Co. Natalie KG	80	application	400	monopile / tripod / gravity-based / other	25 to 50 m	151	no	
De50	Germany	SeaWind IV	5.99662,54.62842 5.99477,54.62775 5.94555,54.65900 5.94577,54.66015 5.94701,54.66656 5.97616,54.69571 5.99133,54.71088 6.10823,54.67141 6.07389,54.65658 6.05983,54.65146	110	Northern Energy SeaWind IV GmbH i. Grdg.	80	application	400	gravity-based	25 to 50 m	150	no	
De51	Germany	GAIA II	6.24534,54.80559 6.23441,54.79982 6.12081,54.83956 6.15458,54.87304 6.20460,54.82307	100	Northern Energy GAIA II GmbH	80	application	400	tripod / other	25 to 50 m	150	no	
De52	Germany	GAIA III	6.13795,54.74702 6.12124,54.73785 6.04469,54.76394 6.11311,54.83172 6.22226,54.79334 6.18058,54.77044	90	Northern Energy GAIA III GmbH i. Grdg.	80	application	400	tripod / other	25 to 50 m	150	no	
De53	Germany	GAIA IV	6.27029,54.74526 6.17454,54.72008 6.13775,54.73263 6.13521,54.73349 6.13778,54.73488 6.20327,54.77038 6.25359,54.79766 6.26495,54.79479 6.26760,54.77021	90	Northern Energy GAIA IV GmbH i. Grdg.	80	application	400	tripod / other	25 to 50 m	150	no	
De54	Germany	Skua	6.68885,54.46937 6.48382,54.40312 6.51997,54.52636	85	OPG Projekt GmbH	80	application	400	tripod	25 to 50 m	165	no	
De55	Germany	Horizont II	6.34986,54.84123 6.27595,54.83955 6.26934,54.89798 6.26085,54.97302 6.35079,54.89771 6.37405,54.87824 6.41645,54.84274	125	Germany Mainstream Renewable Power Developments GmbH	76	application	380	monopile / tripod / gravity-based / other	25 to 50 m	165	no	
De56	Germany	Nordpassage	7.17778,55.06333 7.16056,55.06306 7.03722,55.26056 7.17000,55.23500 7.16639,55.22806 7.16639,55.22806 7.18417,55.16111 7.16806,55.15972 7.16962,55.10983 7.17083,55.07111 7.17725,55.06392	75	Vattenfall	80	application	480	monopile / tripod / gravity-based / other	10 to 25 m / 25 to 50 m	160	no	

De57	Germany	Horizont III	6.42658,54.83397 6.49361,54.78268 6.31183,54.78307 6.28177,54.78314 6.28116,54.78314 6.27822,54.81070 6.27611,54.83056 6.34389,54.83210	121	Germany Mainstream Renewable Power Developments GmbH	71	application	355	monopile / tripod / gravity-based / other	25 to 50 m	165	no	
De58	Germany	Horizont I	6.26324,54.81074 6.26364,54.80714 6.21607,54.83069 6.16374,54.88326 6.24742,54.95577 6.25382,54.89712 6.26134,54.82820 6.26152,54.82658	131	Germany Mainstream Renewable Power Developments GmbH	65	application	325	monopile / tripod / gravity-based / other	25 to 50 m	165	no	
De59	Germany	GlobalTech II	6.22205,54.26639 6.13309,54.26008 6.13309,54.26008 6.13336,54.28574 6.18156,54.30571 6.21928,54.30757 6.22450,54.30783 6.25705,54.30943 6.26142,54.26919 6.22725,54.26676	70	Northern Energy GlobalTech II GmbH i. Grdg.	76	application	380	gravity-based	25 to 50 m	150	no	
De60	Germany	GlobalTech III	6.27663,54.27016 6.27663,54.27016 6.27235,54.30971 6.27230,54.31018 6.31659,54.31234 6.31680,54.31040 6.32072,54.27323	70	Northern Energy GlobalTech III GmbH i. Grdg.	21	application	105	gravity-based	25 to 50 m	150	no	
De61	Germany	GAIA I	6.42549,55.00444 6.30168,54.95481 6.26688,54.98383 6.34353,55.05900 6.34501,55.05802 6.42030,55.00790	145	Northern Energy GAIA I GmbH	80	application	400	tripod / other	25 to 50 m	150	no	
De62	Germany	SeaStorm II	6.10347,54.54512 6.03140,54.51595 5.95398,54.55524 6.04265,54.58394	110	Northern Energy SeaStorm II GmbH	38	application	190	tripod / other	25 to 50 m	150	no	
De63	Germany	SeaWind III	6.10515,54.57112 6.10512,54.55743 6.00541,54.62102 6.00732,54.62175 6.01608,54.62507 6.10535,54.65898 6.10531,54.63870	110	Northern Energy SeaWind III GmbH	80	application	400	tripod / other	25 to 50 m	150	no	
De64	Germany	Bight Power I	6.22432,54.23275 6.12052,54.23052 6.11559,54.30622 6.21919,54.30896 6.21928,54.30757 6.22205,54.26639	74	Airtricity Germany Developments GmbH	80	application	400	monopile / tripod / gravity-based / other	25 to 50 m	163	no	
De65	Germany	Bight Power II	6.35036,54.24180 6.22910,54.23926 6.22725,54.26676 6.22450,54.30783 6.22442,54.30897 6.27235,54.30971 6.31680,54.31040 6.33090,54.31062 6.34624,54.30104	74	Airtricity Germany Developments GmbH	80	application	400	monopile / tripod / gravity-based / other	25 to 50 m	163	no	
De66	Germany	AreaC I	6.65828,54.25760 6.64003,54.24639 6.59466,54.24995 6.46756,54.33227 6.47033,54.37027 6.48969,54.37958 6.64160,54.27965	66	Airtricity Germany Developments GmbH	80	application	400	monopile / tripod / gravity-based / other	25 to 50 m	163	no	

De67	Germany	AreaC II	6.81390,54.25209 6.67094,54.24924 6.63634,54.29528 6.63544,54.30591 6.75542,54.30820 6.75493,54.31729 6.80891,54.31846	66	Airtricity Germany Developments GmbH	80	application	400	monopile / tripod / gravity-based / other	25 to 50 m	163	no	
De68	Germany	AreaC III	6.95550,54.30990 6.95722,54.27531 7.02972,54.27551 7.03080,54.25290 6.84166,54.24999 6.82352,54.25982 6.82070,54.31852 6.87444,54.31981 6.87495,54.31000	66	Airtricity Germany Developments GmbH	80	application	400	monopile / tripod / gravity-based / other	25 to 50 m	163	no	
De69	Germany	Euklas	5.17336,54.68554 5.17614,54.54892 5.00572,54.62236 5.00536,54.68424	143	BARD Foundation GmbH	160	application	1040	monopile / tripod / gravity-based / other	25 to 50 m	151	no	
De70	Germany	Witte Bank	6.53592,55.03743 6.45988,55.00720 6.42030,55.00790 6.29653,55.01007 6.34501,55.05802 6.43793,55.14994	120	Projekt Ökovest GmbH	171	application	855	other	25 to 50 m	163	no	
De71	Germany	ENOVA Offshore NSWP 4	4.97450,55.31133 5.14650,55.24483 5.19067,55.24483 5.09067,55.19113 4.97450,55.26217	205	ENOVA Energieanlagen GmbH	81	application	486	monopile / tripod / gravity-based / other	25 to 50 m	163	no	
De72	Germany	ENOVA Offshore NSWP 5	5.29783,55.20133 5.17850,55.13767 5.10133,55.18483 5.21383,55.24483 5.22667,55.24483	158	ENOVA Energieanlagen GmbH	85	application	486	monopile / tripod / gravity-based / other	25 to 50 m	163	no	
De73	Germany	ENOVA Offshore NSWP 6	5.32406,55.12563 5.25650,55.08967 5.18917,55.13100 5.32350,55.20267 5.39083,55.16117 5.35035,55.13962	190	ENOVA Energieanlagen GmbH	84	application	504	monopile / tripod / gravity-based / other	25 to 50 m	163	no	
De74	Germany	ENOVA Offshore NSWP 7	5.24500,55.08350 5.20017,55.05950 4.97450,55.20250 4.97450,55.24900	190	ENOVA Energieanlagen GmbH	95	application	570	monopile / tripod / gravity-based / other	25 to 50 m	163	no	
De75	Germany	Gode Wind III	7.13751,54.00790 7.06809,53.99858 7.11853,54.02825 7.11861,54.06451 7.11525,54.07579 7.07372,54.09649 7.11013,54.09676	34	Plambeck Neue Energien AG	15	application	75	monopile / tripod	25 to 50 m	150	no	
De76	Germany	He dreiht	6.13313,54.43780 6.21601,54.38269 6.14279,54.38274 6.13588,54.38734 6.12892,54.42851	85	EnBW Nordsee Offshore GmbH	39	application	195	tripod	25 to 50 m	110	no	
De77	Germany	Jules Verne I	5.51821,55.09372 5.40793,54.98510 5.23847,55.04094 5.32406,55.12563 5.33597,55.13741 5.35035,55.13962 5.36994,55.14263	170	PNE Wind AG	120	application	600	monopile / tripod / gravity-based / other	25 to 50 m	158	no	
De78	Germany	Jules Verne II	5.40793,54.98510 5.51821,55.09372 5.67400,55.04200 5.56343,54.93352	170	PNE Wind AG	120	application	600	monopile / tripod / gravity-based / other	25 to 50 m	158	no	

FR01	France	Cote d'Albatre	0.58133, 49.91275 0.54714, 49.94981 0.62622, 49.91322 0.59206, 49.95031	7 km	Enertrag	21	authorized, but court case in process	105	tripod	25	160	yes	
IE01	Ireland	Arklow Bank	-5.9975,52.78269 -5.96417,52.67472 -5.8975,52.91445 -5.93417,52.91805	10	Arklow Energy subleased from Sure Partners	200	operational	520	monopile	5 to 30	125 m	yes	currently 7 x 3.6 MW turbines are in place. It is intended that the final output will be 520MV with all turbines with the area specified.
IE02	Ireland	Codling Bank	-5.82917,53.07167 -5.71667,53.07167 -5.71667,53.10883 -5.78333,53.14333 -5.84350,53.14333	13 km	Codling Wind Park Ltd	220	authorised	1100	Not yet determined. Monopile or tripod proposed.	5 to 20	160 (max)	yes	Phased development over the period 2009 to 2016.Foreshore Lease granted (copy available at http://www.dcmnr.gov.ie/NR/rdonlyres/665CD3AA-C74D-4FBE-9329-70186FC44F3E/0/MS538LForeshoreLease.pdf)
IE03	Ireland	Oriel Wind Farm	-6.09230,53.94789 -6.04121,53.94664 -6.02737,53.92036 -6.04839,53.88695 -6.09030,53.88798 -6.10840,53.92226	7	Oriel Wind Farm Ltd	55	application	max 330	Not yet determined. Concrete Caisson gravity foundation proposed	15 to 30	160m (max)	yes	Formal application submitted with EIS
IE04	Ireland	Sceirde Rocks	-9.96766,53.29433 -10.03150,53.26617 -10.02000,53.25000 -9.95000 ,53.23333 -9.91833,53.26833	5 km	Fuinneamh Sceirde Teoranta	20	application	100	Not yet determined. Monopile proposed.	5 to 35	140 (max)	yes	Formal application submitted with EIS
NL01	Netherlands	Prinses Amaliapark (new name; was Q7 WP)	4.24033, 52.60778 4.19544, 52.60536 4.18436, 52.57669 4.24814, 52.56897 4.26447, 52.58514	23	Eneco (new operator)	60	operational	120	monopile	10 to 25	97	yes	coordinates in WGS 84
NL02	Netherlands	Offshore Windpark Egmond aan Zee (new name; was Near Shore Windpark (demonstration park))	4.49472, 52.60461 4.48756, 52.57381 4.43097, 52.57411 4.35183, 52.63117 4.37986, 52.63514 4.39453, 52.62575 4.41819, 52.63944	11	Noordzeewind	36	operational	108	monopile	10 to 25	112	yes	coordinates in WGS 84. .
NL04	Netherlands	Beaufort (new name; was Katwijk)	3.94290,52.24997 3.97587,52.24998 3.99473,52.31075 3.98288,52.31023 3.97645,52.31150 3.96235,52.30830 3.95070,52.30982 4.00623,52.34767 3.99713,52.34647 3.95555,52.34677 3.96077,52.38650 4.01887,52.38812	24	NUON (was WEOM)	100	authorized	300	monopile	20 to 28	115	yes	coordinates in WGS 84
NL07	Netherlands	Scheveningen Buiten	3.70638,52.19427 3.71780,52.20632 3.85905,52.20740 3.85927,52.20055 3.74393,52.17750 3.70638,52.19427	30	Evelop	89	authorised	320	monopile	19 to 30	137 to 165	yes	coordinates in WGS 84.
NL08	Netherlands	Q4-WP	4.25427,52.64785 4.23800,52.65657 4.23542,52.65883 4.24295,52.66692 4.24095,52.71680 4.26968,52.67880 4.28607,52.64965	24	E-connection	40	authorised	120	monopile	±25	109	yes	coordinates in WGS 84.

NL10	Netherlands	West Rijn	3.63703,52.32000 3.68537,52.31168 3.67762,52.30542 3.69815,52.30010 3.62375,52.21683 3.58458,52.23398	40	Airtricity	72	authorised	260	monopile	19 top21	130	yes	coordinates in WGS 84
NL13	Netherlands	Breeveertien II	3.51617,52.54848 3.56745,52.58857 3.60608,52.61867 3.60712,52.61932 3.62725,52.60532 3.63395,52.60065 3.64067,52.59597 3.65818,52.58357 3.66592,52.57627 3.67048,52.56443 3.65210,52.54880 3.64135,52.54208 3.54115,52.54718	65	Airtricity	79	authorised	285	monopile	19-25	130	yes	coordinates in WGS 84.
~~NL14~~	~~Netherlands~~	~~Helmveld~~	~~4.02069, 52.50383 4.04514, 52.53364 4.09327, 52.49131 4.06203, 52.47176 4.05389, 52.47189~~	~~34~~	~~Evelop/Eneco~~	~~137~~	~~application & negative draft decision~~	~~493~~	~~monopile~~	~~23-28~~	~~142~~	~~yes~~	~~coordinates in WGS 84. Final decision before end 2009.~~
~~NL15~~	~~Netherlands~~	~~Rijnveld Noord/Oost~~	~~3.52541, 52.22397 3.52533, 52.21190 3.52148, 52.20388 3.49427, 52.20393 3.51187, 52.22199 3.47552, 52.18485 3.47345, 52.18289 3.49248, 52.17449 3.49420, 52.17241 3.50199, 52.17228 3.50543, 52.16413 3.51494, 52.16192 3.52066, 52.15584 3.52274, 52.16180 3.52381, 52.18188 3.52210, 52.18396~~	~~35~~	~~E-Connection~~	~~72~~	~~application & negative draft decision~~	~~216~~	~~monopile~~	~~20-30~~	~~110~~	~~yes~~	~~final decision before end 2009~~
~~NL17~~	~~Netherlands~~	~~Rijnveld West~~	~~534.683, 5.796.089 532.302, 5.791.647 532.682, 5.791.035 533.401, 5.791.058 534.161, 5.789.834 535.521, 5.792.373 535.141, 5.792.985 536.841, 5.796.158~~	~~45~~	~~E-Connection~~	~~41~~	~~application & negative draft decision~~	~~123~~	~~monopile~~	~~30~~	~~110~~	~~yes~~	~~coordinates in UTM zone 31 ED50.~~
NL18	Netherlands	Brown Ridge Oost	3.43795,52.75877 3.43673,52.66168 3.44598,52.66487 3.46468,52.68420 3.47395,52.68738 3.49268,52.70672 3.50195,52.70990 3.51132,52.71957 3.52060,52.72275 3.52078,52.73570 3.48402,52.74883 3.46553,52.74892 3.43795,52.75877	74	E-Connection	94	authorized	282	monopile	30	142	yes	coordinates in WGS 84

~~NL19~~	~~Netherlands~~	~~Callantsoog Noord~~	~~575000, 5865848~~ ~~575263, 5868178~~ ~~575600, 5868388~~ ~~575859, 5868629~~ ~~576106, 5868962~~ ~~576319, 5869525~~ ~~576349, 5870244~~ ~~576231, 5870694~~ ~~577131, 5871467~~ ~~581170, 5870943~~ ~~577994, 5866594~~ ~~577569, 5866688~~ ~~577173, 5866694~~ ~~576759, 5866616~~ ~~576336, 5866440~~ ~~575938, 5866128~~ ~~575652, 5865776~~ ~~575459, 5865398~~ ~~575227, 5865663~~ ~~579248, 5865271~~ ~~582978, 5870679~~ ~~584073, 5870476~~ ~~581545, 5863665~~ ~~579324, 5864569~~ ~~579325, 5864829~~ ~~579306, 5865055~~	~~30~~	~~Eneco~~	~~101~~	~~application & negative draft decision~~	~~303~~	~~monopile~~	~~24-36~~	~~115~~	~~yes~~	~~coordinates in UTM zone 31 ED50. Final decision before end 2009.~~
NL20	Netherlands	Den Helder I	3.60188,52.90002 3.65790,52.93892 3.74602,52.90107 3.68715,52.85975 3.67095,52.86100 3.61182,52.88512	63	Airtricity	78	authorised	468	monopile	23	160	yes	Coordinates in WGS 84. Final decision before end 2009.
~~NL21~~	~~Netherlands~~	~~Rotterdam NW~~	~~3.69770,52.20615~~ ~~3.85905,52.20740~~ ~~3.85927,52.20055~~ ~~3.81612,52.19192~~ ~~3.68363,52.19193~~	~~30~~	~~Evelop/Eneco~~	~~50~~	~~Application & negative draft decision~~	~~180~~	~~monopile~~	~~20-30~~	~~137 to 165~~	~~yes~~	~~Coordinates in WGS 84.~~
NL22	Netherlands	BARD Offshore NL1	6.05458,54.07498 5.98863,54.07013 6.09532,54.00383 6.02677,54.00420	56	Bard Engineering GmbH	60	authorised	300	tripile	29-33	150	yes	coordinates in WGS 84
NL23	Netherlands	EP Offshore NL 1	5.98103,54.06953 5.91532,54.06417 6.01870,54.00425 5.95015,54.00455	56	Eolic Power GmbH	55	authorised	275	tripile	29-33	150	yes	coordinates in WGS 84
NL24	Netherlands	GWS Offshore NL1	5.90777,54.06402 5.81385,54.05625 5.94208,54.00458 5.87755,54.00485	56	Global Wind Support GmbH	60	authorised	300	tripile	29-33	150	yes	coordinates in WGS 84
NL25	Netherlands	Tromp Binnen	3.60797,52.80467 3.61278,52.80307 3.61827,52.80282 3.62343,52.80393 3.62738,52.80625 3.63980,52.80117 3.61368,52.78040 3.49928,52.82705 3.42825,52.85587 3.42663,52.87767 3.42722,52.87813 3.51837,52.84115	75	RWE	59	authorised	295	gravity based	20-33	152	yes	coordinates in WGS 84.
NO1	Norway	Karmøy	5.01786, 59.08406		StatoilHydro ASA	1	authorised	3	floating prototype			yes	

NO2	Norway	Havsul I	6.22179,62.78594 6.23994,62.77237 6.20353,62.78659 6.26712,62.82155 6.38935,62.85867 6.47046,62.83154 6.45481,62.82605 6.43562,62.82874 6.38096,62.81429 6.38320,62,78919 6.35700,62,77721 6.27331,62.79956 6.22179,62.78594	6 km	Havgul AS	78	authorised	350	Other	5 - 35	160	yes	The turbine's specific information is based upon the most likely turbines to be used
NO3	Norway	Havsul II	5.95625,62.67455 6.08520,62.62281 6.05914,62.61214 6.04730,62.61189 6.03228,62.60729 6.03850,62.60695 5.91653,62,55916 5.89581,62.57011 5.88834,62.64148 5.95625,62.67455 6.08520,62.62281 5.95610,62.67461 5.98920,62.69023 6.03297,62.71042 6.07096,62.70713 6.14195,62.69041 6.12738,62.65740 6.08520,62.62281	2	Havgul AS	178	refused	800	other	5 - 35	160	yes	The turbine's specific information is based upon the most likely turbines to be used
NO4	Norway	Havsul IV	7.16936,63.12408 7.25626,63.12408 7.30304,63.11913 7.30410,63.09548 7.26448,63.07001 7.23404,63.07001 7.16884,63.10164 7.16936,63.12408 7.32153,63.07872 7.32112,63.08726 7.36300,63.09253 7.36336,63.08414 7.32153,63.07872 7.33012,63.05623 7.32313,63.05628 7.32281,63.06337 7.36818,63.07930 7.38051,63.07934 7.38074,63.07386 7.33012,63.05623	3	Havsul IV AS	78	refused	350	other	5 - 35	160	yes	The turbine's specific information is based upon the most likely turbines to be used
~~NO5~~	~~Norway~~	~~Steinshamn Offshore Vindpark~~	~~7.00, 63.00 (approx)~~	~~3~~	~~Offshore Vindenergi AS~~	~~21 - 30~~	~~notification~~	~~105~~	~~not decided~~	~~10 to 25~~	~~140 - 150 m~~	~~yes~~	~~notification. EIA work ongoing.~~
~~NO6~~	~~Norway~~	~~Fosen Offshore Vindpark~~	~~10.20, 64.20 (approx)~~	~~3~~	~~Offshore Vindenergi AS~~	~~120 - 170~~	~~notification~~	~~600~~	~~not decided~~	~~10 to 25~~	~~140 - 150 m~~	~~yes~~	~~notification. Waiting for EIA programme from NVE~~
~~NO7~~	~~Norway~~	~~Selvær offshore vindkraftverk~~	~~12.31593, 66.62242~~ ~~12.31258, 66.65330~~ ~~12.25126, 66.67323~~ ~~12.21214, 66.67254~~ ~~12.09709, 66.62153~~ ~~12.09912, 66.60422~~ ~~12.28173, 66.60749~~ ~~12.28297, 66.59623~~ ~~12.23058, 66.56640~~ ~~12.23116, 66.56115~~ ~~12.30881, 66.56236~~ ~~12.30373, 66.60922~~ ~~12.31593, 66.62242~~	~~30~~	~~Nord-Norsk Vindkraft AS~~	~~100~~	~~notification~~	~~450~~	~~not decided~~	~~5 to 30~~	~~130-180~~	~~yes~~	~~notification. Waiting for EIA programme from NVE.~~ ~~Within the wind farm there are significant areas with depths 30 to 80 meters, which during the planning prosess will be taken into consideration for possible utilization. Hence the number of wind turbines may increase.~~
~~NO8~~	~~Norway~~	~~Gimsøy~~	~~14.08530, 68.22140 (centre)~~	~~1~~	~~Lofokraft Vind AS~~	~~45 - 85~~	~~notification~~	~~250~~	~~not decided~~	~~10 to 25~~	~~130 - 185~~	~~yes~~	~~notification. Waiting for EIA-program form NVE.~~
~~NO9~~	~~Norway~~	~~Lofoten Havkraftverk~~	~~14.19500, 68.25300 (centre)~~	~~2.5~~	~~Lofotkraft Vind~~	~~125 - 250~~	~~notification~~	~~500 - 750~~	~~not decided~~	~~25 to 50~~	~~130 - 185~~	~~yes~~	~~notification March 2008~~

~~NO10~~	~~Norway~~	~~Utsira~~	~~4.555785, 59.155593~~ ~~4.565769, 59.155780~~ ~~4.57210, 59.152071~~ ~~4.55245, 59.151697~~ ~~4.55168, 59.152342~~	~~15~~	~~Lyse Produksjon AS~~	~~5~~	~~notification~~	~~25~~	~~floating~~	~~150~~	~~150~~	~~yes~~	~~notification. Proposed EIA programme been on public hearing, awaiting final EIA programme from NVE~~
~~NO11~~	~~Norway~~	~~Utsira~~	~~4.28246, 59.193657~~ ~~4.344612, 59.195046~~ ~~4.283421, 59.153809~~ ~~4.351709, 59.155194~~	~~30~~	~~Lyse Produksjon AS~~	~~56~~	~~notification~~	~~280~~	~~floating~~	~~270~~	~~150~~	~~yes~~	~~notification. Waiting for EIA programme from NVE~~
~~NO12~~	~~Norway~~	~~South of North Sea~~	~~5.492, 56.571~~ ~~6.543, 57.159~~ ~~6.1055, 56.572~~ ~~5.5431, 56.523~~	~~130~~	~~Lyse Produksjon AS~~	~~200~~	~~notification~~	~~1000~~	~~steel jacket (but not decided)~~	~~45 to 60~~	~~150~~	~~yes~~	~~notification. Waiting for EIA programme from NVE~~
NO13	Norway	Siragrunnen	6.225, 58.272 6.340, 58.282 6.288, 58.238 6.406, 58.248	1	Siragrunnen AS	40	application	200	gravitation (concrete)	15 to 40	150	yes	
~~NO14~~	~~Norway~~	~~Stadtvind~~	~~4.30665, 62.14932~~ ~~4.11766, 62.12665~~ ~~3.56653, 62.35516~~ ~~4.15601, 62.27705~~	~~33~~	~~Vestavind Kraft AS~~	~~216~~	~~notification~~	~~1080~~	~~floating prototype~~	~~160 to 200~~		~~yes~~	~~notification. Waiting for EIA programme from NVE~~
~~NO15~~	~~Norway~~	~~Idunn energy park~~	~~3.537654, 56.587294~~ ~~3.660098, 56.616607~~ ~~3.795923, 56.258281~~ ~~3.921266, 56.291654~~	~~250~~	~~Fred. Olsen Renawables~~	~~200~~	~~notification~~	~~1200~~	~~not decided~~	~~60 to 70~~	~~Not decided~~	~~yes~~	~~notification April 2008. Wave and wind~~
~~NO16~~	~~Norway~~	~~Aegir energy park~~	~~7.748879, 65.166771~~ ~~7.894365, 65.208441~~ ~~8.197564, 64.857656~~ ~~8.347250, 64.899128~~	~~120~~	~~Fred. Olsen Renawables~~	~~200~~	~~notification~~	~~1200~~	~~not decided~~	~~200 to 250~~	~~Not decided~~	~~yes~~	~~notification April 2008. Wave and wind~~
SE1	Sweden	Fladen		25	Göteborg En-y	60	refused	Total 300 MW	gravity-based	10 to 25	120	yes	Application dismissed because Fladen is a Natura 2000 site.
SE2	Sweden	Stora Middlegrund	12.03532, 56.65295 12.06134, 56.65899 12.08176, 56.65979 12.08910, 56.66148 12.11229, 56.63124 12.12933, 56.62739 12.14440, 56.60751 12.16143, 56.60366 12.18202, 56.57647 12.17501, 56.56708 12.18003, 56.56045 12.16554, 56.54098 12.14155, 56.53544 12.13546, 56.52624 12.13797, 56.52292 12.13499, 56.52223	35	Universal Wind	110	aplication	800	not decided	0-30	200	yes	near the Danish border
SE3	Sweden	Risholmen - Arendal	11.81423, 57.68374 11.82048, 57.68547 11.80816, 57.70327	0-0,02	Göteborg Energi	3	aplication	9	concrete	0-12	150	yes	
SE4	Sweden	Lövstaviken	12.46977, 56.88748	0-1	Falkenberg Energi	5	authorised	10	both monopile and gravity	0-10	100	yes	wind-farm consist of 6 wind turbines of which 5 are located on land
UK01	UK	Scroby Sands	1.77340, 52.62715 1.77378, 52.66197 1.80750, 52.66172 1.80711, 52.62692	2km	E.on	30	operational	60	monopile	less than 10m	100	yes	operational since 2004.
UK02	UK	North Hoyle	-3.47420, 53.40333 -3.41518, 53.41029 -3.42208, 53.43121 -3.48134, 53.42491	8km	Npower Renewables	30	operational	60	monopile	less than 10m	130	yes	operational since 2003
UK03	UK	Rhyl Flats	-3.65395, 53.39262 -3.60799, 53.38226 -3.61995, 53.36333 -3.69251, 53.37971 -3.68711, 53.39030 -3.65937, 53.38404	8km	Npower Renewables	30	authorised	100	monopile	less than 10m	130	yes	
UK04	UK	Barrow	-3.33136, 53.99518 -3.30577, 54.01186 -3.26065, 53.98774 -3.28598, 53.97107	10km	DONG/Centrica	30	operational	90	monopile	10 to 25 m	125	yes	operational since 2006.

UK05	UK	Robin Rigg	-3.73993, 54.76293 -3.70173, 54.75223 -3.70505, 54.74815 -3.69013, 54.74431 -3.67755, 54.75220 -3.66930, 54.77274 -3.68454, 54.78279	9.5km	E.on	60	authorised	216	monopile	less than 10m	130	yes	
UK06	UK	Kentish Flats	1.05383, 51.46850 1.10700, 51.47383 1.13400, 51.45233 1.08083, 51.44700	8.5km	Elsam	30	operational	90	monopile	less than 10m	140	yes	operational since 2005.
UK07	UK	Burbo Bank	-3.22000, 53.50283 -3.18665, 53.50319 -3.14751, 53.48185 -3.17905, 53.47023 -3.22399, 53.49471	6.4km	Elsam	25	operational	90	monopile	less than 10m	130	yes	under construction
UK08	UK	Lynn	0.42914, 53.14750 0.48896, 53.14747 0.48766, 53.12503 0.42787, 53.12505	5.2km	Centrica	30	operational	108	monopile	less than 10m	150	yes	under construction
UK09	UK	Inner Dowsing	0.43320, 53.21332 0.46313, 53.21334 0.46319, 53.16841 0.43329, 53.16840	5km	Centrica	30	operational	120	monopile	less than 10m	145	yes	under construction
~~UK10~~	~~UK~~	~~Cromer~~	~~1.35633, 53.03216~~ ~~1.37950, 53.03366~~ ~~1.39200, 52.97866~~ ~~1.36916, 52.97666~~	~~7.5km~~		~~30~~	~~application withdrawn~~	~~108~~	~~monopile~~	~~10 to 25 metres~~	~~140~~	~~yes~~	~~not being persued~~
UK11	UK	Gunfleet Sands	1.18153, 51.72783 1.24281, 51.75173 1.25820, 51.73651 1.19693, 51.71261	6 km	GE Wind Energy	30	operational	108	monopile	less than 10m	150	yes	
~~UK12~~	~~UK~~	~~Shell Flat 1~~	~~-3.354453, 53.85739~~ ~~-3.16334, 53.85519~~ ~~-3.16390, 53.84819~~ ~~-3.35552, 53.85029~~	~~7.1km~~	~~Shell Wind Energy Ltd~~	~~30~~	~~application withdrawn~~	~~324~~	~~monopile/gravity based~~	~~less than 10m/10 to 25 metres~~	~~160~~	~~yes~~	~~Application on hold - new application submitted in revised location. See Cirrus Shell Flat Array~~
UK13	UK	Scarweather Sands	-3.88839, 51.48594 -3.86649, 51.49613 -3.83030, 51.49819 -3.82410, 51.48448 -3.81685, 51.47589 -3.83136, 51.47449 -3.85691, 51.47411 -3.88371, 51.47569	9.5	E.on	30	application	108	monopile/gravity based	less than 10m	130	yes	
UK14	UK	Blyth	-1.48965,55.13503 -1.49083,55.13725	1km	Blyth Offshore Wind Ltd	2	operational	4	drilled monopile	less than 10m	91	yes	Operational since 2000
UK15	UK	Teesside	-1.08900,54.63100 -1.05200,54.64000 -1.11100,54.66800 -1.13300,54.65200	1.5 km	EDF	30	authorised	90	drilled monopile	10 to 25	130	yes	
UK16	UK	Ormonde	-3.44468,54.10850 -3.40135,54.08350 -3.42802,54.06850 -3.47301,54.09183	10 km	Ormonde Energy	30	authorised	108	monopile	10 to 25	130	yes	combined wind farm/gas field
UK17	UK	London Array	1.34924, 51.60440 1.44748, 51.66220 1.50193, 51.70240 1.56083, 51.76010 1.63268, 51.75040 1.55491, 51.70046 1.66583, 51.70030 1.66583, 51.65520 1.57156, 51.56820 1.38756, 51.58130	21 km	London Array	271	authorised	1000	monopile/gravity based	0 to 25	140	yes	

UK18	UK	Greater Gabbard	Inner Gabbard 1.93400, 51.97850 2.00000, 51.97850 2.00000, 51.88750 1.86950, 51.85130 1.84460, 51.87180 1.87280, 51.95580 1.88750, 51.96120 1.89350, 51.95910 1.89680, 51.96470 The Galloper 2.00000, 51.81100 2.00000, 51.75400 1.93850, 51.73300 1.91640, 51.76600 1.93400, 51.79600	23 km	Greater Gabbard Offshore Wind Ltd	140	authorised	300	monopile/gravity based	20 to 50	170	yes	
UK19	UK	Thanet	1.56957, 51.44295 1.60120, 51.46080 1.63535, 51.46078 1.68790, 51.42435 1.68779, 51.40085 1.62770, 51.40269	11km	Thanet Offshore Wind Ltd	100	authorised	500	monopile/gravity based	0 to 30	150	yes	
UK20	UK	Gwynt y Mor	-3.767098,53.495198 -3.692035,53.501690 -3.544143,53.501813 -3.456768,53.451828 -3.458598,53.451475 -3.481888,53.447800 -3.500255,53.445453 -3.515118,53.444418 -3.532743,53.441228 -3.548947,53.438053 -3.560877,53.434508 -3.569970,53.431002 -3.580478,53.427473 -3.593065,53.422647 -3.605617,53.416972 -3.616683,53.409620 -3.628345,53.417933 -3.642153,53.426642 -3.650775,53.429488 -3.663107,53.436518 -3.674602,53.440170 -3.681102,53.443045 -3.692582,53.446272 -3.707662,53.450717 -3.716968,53.452702 -3.735548,53.455822 -3.759840,53.459703 -3.765670,53.459617	13km	Gwynt y Mor Offshore Wind Farm Ltd	250	authorised	750	monopile/multipile/ gravity based/ suction caisson	13	165	yes	
UK21	UK	Walney	-3.63156, 54.12671 -3.44433, 54.02959 -3.52591, 54.01227 -3.53295, 54.01900 -3.54755, 54.02967 -3.56460, 54.03899 -3.58468, 54.04670 -3.60174, 54.05214 -3.62464, 54.05734 -3.64297, 54.05952 -3.65569, 54.07402 -3.66950, 54.09328	14km	Dong Walney Ltd	152	authorised	600	monopile/tripod/gravity base	18 to 30	157	yes	
UK22	UK	West of Duddon	-3.55859, 54.00255 -3.44334, 54.02872 -3.37940, 53.97193 -3.42159, 53.94403 -3.42159, 53.94530	13km	Scottish Power/Elsam/Euros Energy	139	authorised	500	monopile/tropod/gravity base/suction caisson	18 to 23	183	yes	
UK23	UK	Sherringham Shoal	1.07777, 53.17464 1.18243, 53.14968 1.21717, 53.09644 1.11248, 53.12152	17km	Scira Offshore Energy	108	application	315	monopile/tripod/gravity base/suction caisson	15 to 22	172	yes	

UK24	UK	Shell Flat 2	-3.33898, 53.86579 -3.27128, 53.86499 -3.27084, 53.87049 -3.24391, 53.87019 -3.24243, 53.87649 -3.16148, 53.87559 -3.16339, 53.86229 -3.33894, 53.86429	7.1km	CeltPower Ltd	30	application	324	monopile/gravity based	less than 10m/10 to 25 metres	160	yes	Application on hold - new application submitted in revised location. See Cirrus Shell Flat Array
UK25	UK	Shell Flat 3	-3.33963, 53.84309 -3.16417, 53.84129 -3.16289, 53.82789 -3.23038, 53.82869 -3.23132, 53.83509 -3.28544, 53.83559 -3.28560, 53.84109 -3.33958, 53.84169	7.1km	Elsam A/S	30	application	324	monopile/gravity based	less than 10m/10 to 25 metres	160	yes	Application on hold - new application submitted in revised location. See Cirrus Shell Flat Array
UK26	UK	Gunfleet Sands 2	1.19777, 51.7129 1.27995, 51.754 1.28568, 51.73933 1.20350, 51.70723	8.5km	DONG Energy	20	application	48 - 64	monopile/gravity based	7 to 24	135	yes	
UK27	UK	Lincs	0.45769, 53.24188 0.50127, 53.24845 0.51897, 53.20635 0.51896, 53.15115 0.48786, 53.12513 0.48920, 53.14771 0.47315, 53.14776 0.47560, 53.19937	8km	Centrica	120	application	190 - 250	monopile/gravity based	8 to 20	170	yes	
UK28	UK	Cirrus Shell Flat Array	-3.16139, 53.9214 -3.15641, 53.9162 -3.12553, 53.9265 -3.12516, 53.9088 -3.25500, 53.8654 -3.26009, 53.8705 -3.27935, 53.8640 -3.28441, 53.8692 -3.29408, 53.8660 -3.30207, 53.8743	5km	CeltPower Ltd/Shell Wind Energy/Dong Energy	90	application	284	gravity/pile/tripod/bucket/jacket	2 to 21	177	yes	
UK29	UK	Docking Shoal	0.721000, 53.230000 0.765000, 53.204000 0.785000, 53.198000 0.831000, 53.175000 0.891000, 53.134000 0.742000, 53.142000 0.719000, 53.143000 0.639000, 53.157000	14km	Centrica	83 - 166	application	500		3 to 14	180	Yes	
UK30	UK	Dudgeon East	1.324068, 53.298047 1.459595, 53.235157 1.456812, 53.201668 1.321383, 53.264553	32km	Warwick Energy	168	application	560				Yes	
UK31	UK	Humber Gateway	0.246866, 53.668410 0.331365, 53.683891 0.331409, 53.633651 0.281592, 53.597121 0.270673, 53.587944 0.271334, 53.613033	8km	E-on	42 to 83	application	300	monopile/jack-up vessel			Yes	
UK32	UK	Triton Knoll	0.724000, 53.523000 0.893000, 53.509000 0.994000, 53.409000 0.933000, 53.409000 0.700000, 53.484000		Npower Renewables	83	application	1200					
UK33	UK	Westermost Rough	0.087247, 53.812037 0.160250, 53.842923 0.212387, 53.799705 0.139417, 53.768852	9km	Dong Energy	65	application	234					

A9 Operational offshore farms 2009

Annex 1: List of participants

NAME	ADDRESS	PHONE/FAX	EMAIL
Michael Andersen	Danish Fishermen's Association Fredericia Nordensvej 3 Taulov 7000 Fredericia Denmark	Phone +45 70 10 9645 Cell: +45 4026 5040	ma@dkfisk.dk
Ewen Bell ICES Coordinator	Centre for Environment, Fisheries and Aquaculture Science Lowestoft Laboratory Pakefield Road NR33 0HT Lowestoft Suffolk United Kingdom	Phone +44 1 502 524 238 Fax +44 1 502 562 244	ewen.bell@cefas.co.uk
Jim Berkson Chair	National Marine Fisheries Services NMFS RTR Unit at Virginia Tech 114 Cheatham Hall Blacksburg VA 24061-0321 United States	Phone +1 540 231-5910 Fax +1 540 231-7580	Jim.berkson@noaa.gov
Steen Christensen	DTU Aqua - National Institute of Aquatic Resources Section for Fisheries Advice Charlottenlund Slot Jægersborg Alle 1 DK-2920 Charlottenlund Denmark	Phone +45 35 88 33 52 Fax +45 33 96 33 33	sc@aqua.dtu.dk
Bob Furness External Expert	University of Glasgow Graham Kerr Building G12 8QQ Glasgow United Kingdom	Phone + 44 141 330 3560 Fax + 44 141 330 5971	r.furness@bio.gla.ac.uk
Tore Johannessen	Institute of Marine Research Flødevigen Marine Research Station N-4817 His Norway	Phone +47 37 05 90 21 Fax +47 37 05 90 01	torejo@imr.no
Espen Johnsen	Institute of Marine Research P.O. Box 1870 N-5817 Bergen Norway	Phone +47 55 23 53 55 Fax +47 55 23 86 87	espen.johnsen@imr.no
Jesper Juul Larsen	Danish Fishermen's Association Esbjerg Auktionsgade 2 DK-6700 Esbjerg Denmark	Phone +45 7515 5619 Cell +45 4018 5619	jjl@esbjerg-fiskeriforening.dk

Name	Address	Phone/Fax	Email
Henrik S. Lund	Danish Fishermen's Association Nordensvej 3 Taulov DK-7000 Fredericia Denmark	Phone +45 7610 9652 Cell +45 2924 5565 Fax +45	hl@dkfisk.dk
Henrik Mosegaard	DTU Aqua - National Institute of Aquatic Resources Section for Fisheries Advice Charlottenlund Slot Jægersborg Alle 1 DK-2920 Charlottenlund Denmark	Phone +45 35 88 34 61 Fax +45 33 96 33 33	hm@aqua.dtu.dk
Anders Nielsen	DTU Aqua - National Institute of Aquatic Resources Jægersborg Allé 1 DK-2920 Charlottenlund Denmark	Phone +45 35 88 33 75 Fax +45	an@aqua.dtu.dk
Anna Rindorf	DTU Aqua - National Institute of Aquatic Resources Jægersborg Allé 1 DK-2920 Charlottenlund Denmark	Phone +45 35 88 33 78 Fax +45 35 88 33 33	ar@aqua.dtu.dk
Esben Sverdrup-Jensen	Danish Ministry of Food, Agriculture and Fisheries Slotsholmsgade 12 DK-1216 Copenhagen K Denmark	Phone +45 Fax +45	esje@fvm.dk
Morten Vinther	National Institute of Aquatic Resources Section for Fisheries Advice Charlottenlund Slot Jægersborg Alle 1 DK-2920 Charlottenlund Denmark	Phone +45 35 88 33 50 Fax +45 33 96 33 33	mv@aqua.dtu.dk
Peter Wright	Marine Scotland Marine Laboratory Aberdeen P.O. Box 101 AB11 9DB Aberdeen United Kingdom	Phone +44 1224 295436 Fax +44 1224 295511	wrightp@marlab.ac.uk

NAME	ADDRESS	PHONE/FAX	EMAIL
Harald Østensjø	Fiskebåtredernes Forbund and Sør-Norges Trålerlag Sørhauggt. 128 5527 Haugesund Norway	Phone + 47 52 86 69 80 Fax + 47 52 73 32 0147 Cell +47 91 55 55 62	post@tralerlaget.no

Annex 13 Benchmark Information

Stock	Celtic Sea herring			
Stock coordinator	Name: Afra Egan	Email: afra.egan@marine.ie		
Stock assessor	Name: Afra Egan	Email: afra.egan@marine.ie		
Data contact	Name: Afra Egan	Email: afra.egan@marine.ie		
Issue	Problem/Aim	Work needed / possible direction of solution	Data needed to be able to do this: are these available / where should these come from?	External expertise needed at benchmark type of expertise / proposed names
Tuning series	Celtic Sea Herring Acoustic survey: are there issues with double counting?	Need to look at survey design The impact of transect spacing Possible revision of data series	MI, WGIPS	
Data	Investigate foreign landings data over time.	Collate and map all landings data VMS of freezer trawler fleets	HAWG, Member States' authorities	
Discards	Discard information currently not available for the assessment	Need to quantify discards in recent years and provide estimates for the assessment	Industry and University input	

Stock	Celtic Sea herring			
Stock coordinator	Name: Afra Egan	Email: afra.egan@marine.ie		
Stock assessor	Name: Afra Egan	Email: afra.egan@marine.ie		
Data contact	Name: Afra Egan	Email: afra.egan@marine.ie		
Issue	Problem/Aim	Work needed / possible direction of solution	Data needed to be able to do this: are these available / where should these come from?	External expertise needed at benchmark type of expertise / proposed names
Biological Parameters	Irish Sea Mixing Precision in ageing Maturity Ogive – survey and sampling data Natural mortality	Can we make progress on accounting for the mixing of juveniles with Irish Sea? Evaluate if precision is acceptable Is the existing assumption of 50% mature at 1-ring valid? In view of developments in NS and IS herring, is there a basis to change the time invariant M@age currently in use	Splitting work underway in Northern Ireland Perhaps use averages of NS Multi-Species work?	`````

Stock	Celtic Sea herring			
Stock coordinator	Name: Afra Egan	Email: afra.egan@marine.ie		
Stock assessor	Name: Afra Egan	Email: afra.egan@marine.ie		
Data contact	Name: Afra Egan	Email: afra.egan@marine.ie		
Issue	Problem/Aim	Work needed / possible direction of solution	Data needed to be able to do this: are these available / where should these come from?	External expertise needed at benchmark type of expertise / proposed names
Assessment method	1 Current assessment model is not and cannot be maintained 2Large year classes now a significant component of the plus group 3 Investigate cause of year effects in the survey data 4. Analysis of any retrospective bias 5. Ages in the tuning series	1a Implement the assessment using the SAM model 1b. Comparison of available stock assessment models and assumptions. 2.Examine the impact of changing the plus group on the assessment diagnostics 3. Model bias in the survey 4. Perform sensitivity runs with different model input data configurations 5. Analyse performance of different ages in the assessment model	HAWG	

Stock	Celtic Sea herring			
Stock coordinator	Name: Afra Egan	Email: afra.egan@marine.ie		
Stock assessor	Name: Afra Egan	Email: afra.egan@marine.ie		
Data contact	Name: Afra Egan	Email: afra.egan@marine.ie		
Issue	Problem/Aim	Work needed / possible direction of solution	Data needed to be able to do this: are these available / where should these come from?	External expertise needed at benchmark type of expertise / proposed names
Biological Reference Points	1. Investigate reference points under benchmarked assessment outcomes and in relation to the management plan 2. Investigate alternative reference points	1. Calculate new reference points based on assessment results, with main focus on Fmsy and Blim/Btrigger. 2. Literature / other assessment work review	HAWG, WKFRAME and literature	

Annex 14 – Appendix of Audit Reports

Audit of Herring in Division IIIa and Subdivisions 22–24

Date 9 April 2013

Reviewer: Mark R Payne, DTU Aqua

General

This assessment has been substantially revised from that presented in the WKPELA 2013 benchmark assessment performed earlier in the year. The benchmark review process appears to have overlooked a number of key indicators that suggest that the model had not converged to a "valid" solution. This outcome may have arisen due to a possible over-parameterization of the model, and indicated the existence of multiple optima in the objective function. However, the changes made to the assessment procedure here appear to have rectified this problem, and the resulting model appears to have greatly improved its stability and consistency. Concerns about the model still remain – particular with regards to the "unnatural" smoothness of the recruitment time-series and the choice of parameter bindings – but the current assessment model, and updated stock annex, now appear to form a valid basis for advice. The changes below the surface of the model do not appear to have greatly changed the perception of the stock.

For single stock summary sheet advice:

1) **Assessment type: update**
2) **Assessment**: analytical
3) **Forecast**: presented
4) **Assessment model**: SAM
5) Data issues: data is as described in stock annex
6) **Consistency**: Major revision from previous benchmark assessment
7) **Stock status**: B>Blim, F>Fmsy, R systematically low
8) **Man. Plan.**: Under development

General comments

Documentation of the exploratory runs performed within the working group to resolve key stability issues is unfortunately limited.

Limited information regarding the ecosystem and environmental influences on this stock is provided. However, this is a reflection of the current state of scientific understanding, rather than the work of the working group.

Technical comments

The "as-benchmarked" model, and associated stock.annex, presented to the working group showed several flaws. In particular, the most important of these was related to the use of correlated random walks to represent the fishing mortality. The correlation parameter estimated by the model for these processes took a value of 0.99, which is the upper bound hard-coded within the SAM model itself, thereby suggesting that the model had converged to a solution up against the artificially imposed bounds of optimization space. Furthermore, switching this option off, and representing the fishing mortality with independent random walks, resulted in a substantially different solution and a different perception of the stock. Ideally these two models should give the same result, as the correlated random-walk model is can easily be represented by independent random walks – the fact that they did not is cause for concern..

This situation has been seen before in several assessments using the SAM model, most notably in the Irish Sea herring stock during the WKPELA 2012 benchmark. However, the implications of this outcome are not understood, and there is no documentation associated with the SAM model to support or guide the decision making process in this eventuality. The opinion held within the HAWG working group, and shared by this author, is that this is indicative of an over-parameterized model, with too much flexibility and insufficient information to inform it.

Modifications were therefore made to the model to attempt to constrain it more. In particular, attention was focused on the binding of the fishing mortality random walks on the plus-group ages. These changes provided immediate dividends, with the model settling into a stable solution where all parameters were unconstrained by bounds, and where there was consistency between the solutions fitted with and without a correlated fishing mortality random walk.

The modified model appears to fit the observations in a satisfactory manner. There are few signs to indicate that the model assumptions are violated. The parameter estimates appear largely independent of each other. The results obtained are also consistent with *a priori* understanding of the data, the stock and the fishery, and with previous assessments. The assessment model therefore appears to be a valid model.

Several issues remain and require further exploration, however. In particular, the choice of parameter bindings, particularly on the survey catchabilities has not been explored thoroughly or statistically, and there are clear suggestions (e.g. the similarity of coefficients at different ages in Figure 3.6.4.48) that several of these parameters could be bound together. The model also places an extremely low weight (high observation CV) on some of the tuning series, indicating that they contribute little information. In theory this should not be a problem, as they are essentially "downweighted" out of the assessment: however, their presence could contribute extra parameters that may impact model stability. Further exploration of these facets is required.

Finally, the recruitment time series produced by the model appears "unnaturally" smooth. Previous assessments of this stock have indicated large inter-annual variability in recruitment: however, the current assessment does not support this, and produces a relatively smooth time series. This is most likely due to a combination of the inherent structure of the SAM model, and the presence of weak recruitment signals in the data. Great caution must therefore be taken in the interpretation and application of this time series, as it has a fundamentally different meaning to "traditional" recruitment estimates.

Conclusions

The assessment as presented forms a valid basis for generating advice.

However, further work is clearly required to refine this assessment, and resolve some of the outstanding issues. I do not believe that the issues are severe enough to warrant a new benchmark, and it is likely that the model will continue to perform well "as-is". Furthermore, the developments required need to come from the wider community, with improved understanding and furthermore development of the assessment model: another benchmark will not necessarily resolve these issues. Nevertheless, close attention should be paid to this assessment in the meantime.

Audit of Sprat in Division IIIa

Date

Reviewer: Sascha Fässler & Yves Verin

General

- Advice is given correctly following the ICES Approach to Data Limited Stocks.
- No analytical assessment has been presented since the mid1980s. The stock is assessed by examining trends in surveys (Bottom trawl survey IBTS Q1 and Q3 and acoustic survey HERAS).

For single stock summary sheet advice:

1) **Assessment type:** first time, data limited
2) **Assessment**: trends in the survey
3) **Forecast**: not presented
4) **Assessment model**: Trial assessments using the SMS model did not produce any results. Four survey indices (IBTSQ1 age 1, IBTSQ1 age 2, IBTSQ3 age 1, and HERAS age 1) are used as information about stock trends.
5) Data were available as described in the stock annex, however, there was a distinct lack of consistency between survey indices resulting in no valid analytical assessment.
6) **Consistency**: The assessment of Sprat in Division IIIa was benchmarked this year. No analytical assessment has been presented for this stock since the mid-1980s, and it is still not possible due to inconsistencies between the surveys. During the benchmark it was decided to use the combined survey indices as indicator of the incoming year classes to produce in-year advice based on the ICES Data Limited Stock approach.
7) **Stock status**: next year's TAC is estimated based on method 3.2 for Data Limited Stocks using the average catch over the last three years, and is equal to 6 787 t. This is well below the historical minimum catch of 8 700 t. However, sprat catches are mainly limited by herring bycatch rules and do not reflect sprat stock size. No biological reference points are defined for this stock.
8) **Man. Plan.**: No specific management plan is in place for this stock. However, a TAC of 41 600 t was agreed in the 'Skagerrak-Kattegat Agreement' for 2013. This is substantially above the TAC advice given by ICES.

General comments

The section is well structured and easy to follow. Given the lack of possibilities for an analytical assessment, the text is consequently kept short and concise.

Technical comments

- *It is initially not clear where the TAC of 41 600 t is coming from or whether this is even the official ICES advice on TAC.*
- *The stock annex was changed/amended during HAWG 2013 and now contains results of the 2013 assessment. Including these was presumably due to a copy/paste error. They are usually not part of the stock annex and should be removed.*

Conclusions

- Advice is given correctly following the ICES Approach to Data Limited Stocks.
- Lack of usable survey indices for an analytical assessment is the main issue. This problem should be investigated prior to a future benchmark.
- The IIIa sprat stock is presented as one stock unit with a genetic differentiation in samples of sprat from Kattegat compared to adjacent waters (North sea, Baltic sea). It is mentioned that more research is required on sprat in the Skagerrak and in the Swedish and Norwegian fjords. This should be investigated prior to a future benchmark.
- The last sentence in the section (i.e. the fact that IIIa sprat should derive from migrations of fish from the North Sea) refutes more or less the stock definition.

Audit of (Herring in the Celtic Sea)

Date: April 5th 2013

Reviewer: Emma Hatfield

General

The Celtic Sea assessment this year had to contend with a survey index that contained the highest abundance on record. There were concerns about the veracity of the survey result that could not easily be addressed during the WG. The survey design and implementation needs to be addressed and examined in a benchmark. The stock has increased in size and expanded its distribution since the original survey was designed so the current design may no longer be appropriate.

The new management plan with 30% constraint will ensure that any quota increase resulting from the increased perception of stock size is constrained.

For single stock summary sheet advice:

1) **Assessment type:** update assessment with catch data and survey index for 2012 included (benchmark planned for 2014)
2) **Assessment**: analytical
3) **Forecast**: a deterministic short term forecast using MFDP was presented
4) **Assessment model**: FLICA + tuning by 1 acoustic survey (CSHAS)
5) **Data issues:** the data used in the assessment was consistent with the description in the stock annex. The following issues were highlighted:
    a. the catch estimates for 2012 available to the WG are not as reliable as for previous years. It is known that a relaxation of controls during the fourth quarter of 2012 was accompanied by an expansion of extra-quota fishing. Controls were tightened again in response to this, and the problem is thought to have been eliminated. No estimate of this additional catch was available, but is likely to be less than 10% of the catch during those weeks, and consequently a much lower percentage of the catch for the entire season
    b. it should also be noted that the reported landings of sprat in VIIaS were much higher than in previous years. Though there was a substantial increase in sprat catches in this area, it is known that a certain amount of misreporting of herring as sprat occurs. Another concern is that sprat catches may contain an unknown component of juvenile herring
    c. 50% of 1-ringers are considered mature in the assessment. Sampling data from the Celtic Sea catches suggest that greater than 50% of 1-ringers are mature
    d. assessment outputs are sensitive to discarding which is difficult to quantify but understood to have taken place in 2010 and 2011 and to a lesser extent in 2012

e. these issues are all highlighted to be examined for the benchmark in 2014

6) **Consistency**:

a. a significant upward revision of the perception of SSB is a feature of the 2013 assessment. This is associated with the significant increase in the 2012 acoustic survey biomass estimate and increased catches

b. the 2011 SSB has been adjusted upwards by 87% from the 2012 assessment. The 2011 F has been adjusted downwards by 28%

c. there has been retrospective overestimation of F in recent years

7) **Stock status**:

a. SSB in 2012 (159 776 t) is well above B_{pa} (44 000 t)

b. Fbar (ages 2-5) in 2012 (0.15) is below $F_{0.1}$ (0.17) and F_{MSY} (0.25)

c. there are three recent strong year classes (2003/4, 2005/6, and 2007/8) in the fishery

8) **Man. Plan.**: A plan was agreed by the Irish industry in 2011 and was evaluated by ICES in 2012 and found to be consistent with the precautionary approach. It was also found to deliver long term sustainable yield, at the expense of maximising yield in any one year. The proposed target F is 0.23 and the trigger biomass point is 61 000 t. The plan was adopted as the basis for the 2013 TAC.

General comments

This WG report was well written, concise and documented the assessment well. The input data were clearly described as were various data issues and their possible effects. Ecosystem aspects were included in the stock annex.

Technical comments

The input data and assessment model settings have been used as specified in the stock annex.

Conclusions

There are no concerns for using this assessment as the basis for management advice. There is good evidence to show that the stock has increased substantially in recent years and is at a high level. The rebuilding plan which was in place until 2011 can be considered to be successful because the stock has been shown to be above B_{pa} for three consecutive years. The stock should now be managed according to a long term management plan.

Audit of Herring in Division VIIa North (Irish Sea)

Date 21 March 2013

Reviewer: Susan Mærsk Lusseau

1) **Assessment type:** Update, commercial catch data and survey indices for 2012 included
2) **Assessment**: Analytical
3) **Forecast**: A deterministic short term forecast using MFDP was presented
4) **Assessment model**: FLSAM tuned to 2 indices – an acoustic survey, AC(VIIaN), and a larvae survey (NINEL)
5) **Data issues**: The data used in the assessment was consistent with the description in the stock annex.
6) **Consistency**:
    a. Model was applied as per stock annex
    b. Low retrospective bias
    c. The influence on the assessment of the strong year effect in the 2011 survey has been reduced with the addition of the 2012 data.
7) **Stock status**:
    a. SSB and recruitment increasing trend in recent years, associated with downward trend in F.
    b. SSB in 2012 (21 544t) is well above B_{pa} (9 500t)
    c. Fbar (ages 4-6) in 2012 (0.2527) is below F_{msy} (0.26).
8) **Man. Plan.**: There is no management plan in place for this stock, the WG supports the development of a long term management plan for this stock.

General comments

The WG report was well written, concise and documented the assessment well. The input data was clearly described as was the fisheries and regulations affecting them. Ecosystem aspects were included in the stock annex. Stock mixing (especially at younger ages) is a main issue in this assessment, but the possible effects on the assessment are well described and taken into consideration in the interpretation of the assessment.

Technical comments

The input data and assessment model settings had been applied as described in the stock annex. There were no notable technical issues with the reporting or the assessment as presented. It is impressive though that Northern Ireland has already managed to carry out a herring larvae survey in November 2013….

Conclusions

This assessment was carried out in accordance with the stock annex and no major issues were highlighted by the retrospective pattern or the model diagnostics. There are no apparent concerns for using this assessment as a basis for management advice.

Audit of Herring in Divisions VIa (South) and VIIb,c

Date 5 April 2013

Reviewer: Henrik Mosegaard, DTU-Aqua, Denmark

General

- Data lack long survey time series and is influenced by changing fishing patterns and unknown mixing of stock components.
- Assessment follows to some degree the protocol outlined in the stock annex taking into account the development in availability of a now 5 years acoustic survey time series. However the stock annex is incomplete and settings have not all been updated recently.
- Exploratory analytical assessments are presented and compared. A separable VPA testing different terminal F based on catches and FLICA supplemented by a 5 years acoustic tuning series are compared. No conclusive assessment is presented.

For single stock summary sheet advice:

1) **Assessment type: update**
2) **Assessment**: comparisons of exploratory analytical assessments
3) **Forecast**: exploratory forecast is presented, based on FLICA output and assumptions about catch/TAC uncertainty.
4) **Assessment model**: Separable VPA and FLICA tuned by 1 acoustic survey
5) **Data issues:** The stock complex is composed of several sub-stocks with different spawning time and migration behaviour. Methods for stock splitting are under development but not applied yet. Lower recent quotas have reduced effort leading to a shorter fishing season which may have an effect on both the age selectivity and the proportions of spawning types caught.
6) **Consistency**: There appears to have been changes in recent FLICA settings. However no major jumps in perception of the stock are apparent. F and R are highly variable.
7) **Stock status**: B is considered to be below Blim (81 000 t) which is reasonable given the range of CL of the FLICA. Each exploratory assessment affects F to a high degree, and thus F in 2012 appears very uncertain in relation to the estimated $F_{0.1}$ (0.2) and F_{MSY} (0.25). R is highly uncertain with no recruitment index available.
8) **Man. Plan.**: No management plan has been established, but a rebuilding plan was proposed by the Pelagic RAC in 2011. STECF evaluated this plan in 2012, but further evaluation is needed. The plan includes the following harvest rule: When SSB is below B_{pa} then F is calculated using the equation $F=SSB*(F_{0.1}/B_{pa})$. The plan has not been evaluated by ICES.

General comments

The WG report is well written and is generally in line with what can be found in the stock annex. However the stock annex needs a full update.

The reasoning behind the modelling decisions is well described in the WG report and the choice of the FLICA as the most reliable of the exploratory assessments appears justified. Due to lack of a consistent long time series of fishery independent data the assessment is rightfully considered uncertain and it is reasonable to present a conclusion with only a relative state of the stock.

There are however caveats since no updated description of the ICA settings in recent years is given, only a reference to ICA exploratory runs in 2006 and 2007. It is therefore difficult to judge if input data and assessment model settings have been applied consistently in recent years. For example the reference age in these older ICA runs is set to age 3 and the plus group is 9+ whereas the present WG report uses age 4 and 7+ respectively.

Seasonal fishing pattern has changed between years and a table of model settings reflecting these changes is needed. Further there is no indication of how to deal with mean weight in the stock when catch samples only contain one quarter as in 2012. There is neither any specific protocol for weighting autumn, winter and spring spawner components and this also has potential influence on calculation of the maturity ogive where 2+ ringers are considered to be 100% mature

It appears that a part of the stock annex was updated in 2013 to account for the availability of a 5 years' time series of the Malin Shelf acoustic survey (MSHAS 2008-2012). According to the stock annex there appears to be more candidate surveys to be explored.

It should however be noted that a change in fishing pattern has been observed, with all catches taken in the fourth quarter in 2012. This may question the separable assumptions of both model types explored. These and similar questions should be addressed during a coming benchmark.

Technical comments

When comparing proportions-at-age in the catch and survey data the period in the text 2010-2012 is different from the period in the figure 6.3.1.2 legend (2008-2012).

The stock annex lacks a reference to the Lowestoft separable VPA software (Darby and Flatman 1994) used for exploratory assessments, whereas the WG report contains this reference.

Conclusions

The assessment has been performed in a sensible way given the lack of full guidance from the stock annex.

The changing fishing pattern affecting both age selectivity and proportions of different stock components, gives rise to concern.

An assessment model that does not have an obligate separable assumption and makes better use of additional available survey information should be adopted.

A robust identification and separation of stock components should be explored.

Audit of HER-VIAN

[HAWG Section 5: Herring in Division VIa (North)])

Date 27.03.2013

Reviewer: Norbert Rohlf (TI-SF), Tomas Gröhsler (TI-OF), Germany

1) **Assessment type:** Update with commercial catch and survey data 2012/ SALY
2) **Assessment**: Analytical
3) **Forecast**: A deterministic short-term projection using average Fbar (ages 3-6) over the last three years and geometric mean recruitment since 1989 (corresponding to period of low productivity) was presented.
4) **Assessment model**: FLICA tuned to the MSHAS_N acoustic survey from 1991-2012.
5) **Data issues**: The data are consistent with the description in the stock annex. Minimum sampling requirements have been met only in quarter four in 2012. Sampling in the other quarters was not adequate and does not represent the major fishery in the area. Survey and catch show different pattern in proportions of 1-ringers.
6) **Consistency**: The assessment follows the procedures set out in the stock annex. The settings were last explored in 2009. The assessment is known to be noisy, with annual revisions of SSB and F. Analytical retrospective perceive the assessment more stable in the last five years. Most variability is associated with mixing of three separate stocks.
7) **Stock status**: The stock is slightly below average of the last 20 years. SSB in 2012 (102 000 t) is twice the Blim (50 000 t). Fishing mortality has fluctuated around F_{MSY} in recent years, $F(2013)_{3-6} = 0.16$ and below F_{MSY} (0.25) (as defined by HAWG in 2010). The current recruitment is lower than in the historical period.
8) **Man. Plan.**: The EU management plan (Council Regulation (EC) 1300/2008) is based on the following rule(ICES has evaluated the plan and concluded it as precautionary):

SSB in the year of the TAC	Fishing mortality	Maxim. TAC variation
SSB > 75 000 t	F = 0.25	20%
SSB < 75 000 t	F = 0.2	20%
SSB < 62 500 t	F = 0.2	25%
SSB < 50 000 t (B_{lim})	F = 0	-

General comments

The WG report is well written and consistent with the stock annex. The reasoning behind the modelling decisions is well described in the stock annex.

As stated by the WG and also by the RG last year, the assessment is is fairly noisy due to the reliance on a variable acoustic survey. The continual temporal and spatial contraction of effort into northern areas in quarter three should be monitored. There is concern that this contraction could indicate a decrease in stock abundance. If this is the case, the damage caused will be multiplied if the fish being harvested from this area represent a single spawning population, which is being progressively fished down.

There are no specific recruitment indices for this stock. The first reliable appearance of a cohort appears at 2-ring in both the catch and the stock.

Technical comments

The input data and assessment model settings had been applied as described in the stock annex. There were no notable technical issues with the reporting or the assessment as presented.

The RG in 2012 commented that the value for F_{MSY} was higher than estimates of $F_{0.1}$ and $F_{35\%}$. As an exploration, yield-per-recruit and MSY reference points and their associated uncertainties were estimated by means of the "plotMSY" software in 2003. The estimation of of FMSY was based on the three common stock recruit relationships: Ricker, Beverton and Holt and Hockey stick. Weighting the estimates by likelihood gives an combined estimate of F_{MSY} around 0.19, lower than the currently defined value for F_{MSY} of F=0.25. However, the currently defined value for F_{MSY} (F=0.25) is in accordance with the maximum F in the VIaN management plan which was recommended to give an increased probability of allowing expansion of the stock and is considered to be consistent with the MSY approach.

Conclusions

There are no concerns for using this assessment/forecast as a basis for advice.

Audit of Sprat in Subarea VI and Divisions VIIa-c and f-k (Celtic Sea and West of Scotland) (spr-celt)

Date: 6th of April 2013

Reviewer: Cecilie Kvamme, Institute of Marine Research

General

ICES gives advice based on the methods for data limited stocks (DLS), but it is not stated by which category. The method for giving TAC advice for spr-celt is not described in Section 10 (only for spr-ech). It would be clearer if the method was briefly explained, also by stating the category number and referring to the DLS Guidance report 2012, in Section 10, the stock annex and the advice.

For single stock summary sheet advice:

1) **Assessment type: update**
2) **Assessment**: no assessment
3) **Forecast**: no forecast
4) **Assessment model**: TAC advice is based on the methods for DLS stocks, but the category is not given.
5) **Data issues:** are the data available as described in stock annex? Yes
6) **Consistency**: It seems like the method for giving TAC advice is the same as last year, but it is not completely clear as the category is not given.
7) **Stock status**: No reference points
8) **Man. Plan**: No management plan

Conclusions

Section 10 and the stock annex describes the fishery, landings and the different surveys available (but currently not usable for giving advice, since they only cover parts of the stock) clearly. It would, however, be nice if also a description of the method for TAC advice could be given (with the category number for DLS methods, and a reference to the manual).

Audit of sprat in Division VIIde (spr-ech)

Date: 4th of April 2013

Reviewer: Cecilie Kvamme, Institute of Marine Research, Norway

For single stock summary sheet advice:

Short description of the assessment:

1) **Assessment type: update**
2) **Assessment**: Method 3.2 for DLS. The advice is based on an abundance index from landings per unit effort (lpue) used as an indicator of stock size. The index is computed from August to March of the following year.
3) **Forecast**: not presented
4) **Assessment model**: Input Data: Time-series of midwater trawl lpue, landings statistics
5) **Data issues**: are the data available as described in stock annex? Yes
6) **Consistency**: Last year's assessment was also based on the methods for DLS, but the type of method is not given. It is, however, stated in the advice that "The advice is based on a precautionary reduction of catches because of missing or non representative data. The methods applied to derive quantitative advice for data limited stocks are expected to evolve as they are further developed and validated."
7) **Stock status**: No reference points.
8) **Man. Plan.**: No management plan. An annual TAC is set.
9) **General comments**

General

This was mainly a well documented and considered section.

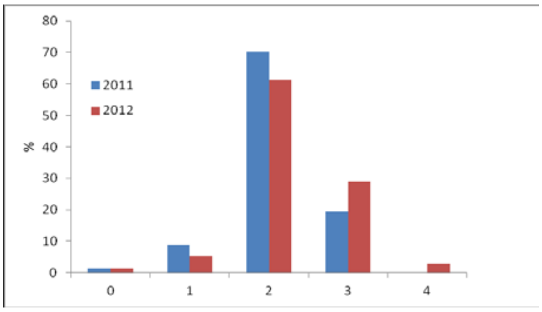
<u>Lpue time series as tuning series</u>

Concerning the assessment, the use of an lpue time series as the most important tuning series is, in my opinion, of concern, as shown in Ulltang (1980). This is also mentioned in the section: "Concerns were expressed about using lpue as an index of abundance for sprat. However, the lpue series presented is the best data set available to assess sprat trends in the area." (10.6.1)

From the description of the fisheries in this section, it also seems like the lpue also could be affected by environmental changes: "The UK has a history of taking the quota, but sprat is found by sonar search and sometimes the shoals are found too far offshore for sensible economic exploitation. Skippers then go back to other trawling activity. This offshore/ near shore shift may be related to environmental changes such as temperature and/ or salinity."

Acoustic survey

The age distribution from the acoustic survey (2011-2012), presented in the stock annex and below, suggests that the survey only partly covers the 0-1 year-old sprat.



Technical comments

Assessment versus stock annex

Neither the explorative assessment model (surplus production dynamic model) nor the method for giving TAC advice was described in the stock annex given on the share point. The stock annex should be updated. From section 10.6.1, it is not clear whether lpue or predicted lpue is used for giving TAC advice.

10.1.2 Landings – Divisions VIIde (English Channel)

The figure reference in the first reference is missing.

In the text it's said that "Sprat landings prior to 1985 in VIId,e were extracted from FishBase, from 1985 onwards they are WG estimates".

There is no reference to a table here, but Table 10.1.4 presents landings data from 1985 till now. There is no data presented prior to 1985. Are these presented somewhere else, then please give the reference.

Are the data really extracted from FishBase (www.fishbase.org), or is it FishStat+, i.e. official catches. (also see Stock annex)

The text also states that "Since 1985 sprat catch has been taken mainly by UK, England and Wales." Until 2000, however, also Denmark has high catches.

10.6 Stock assessment

The sentence "An analytical assessment was carried out for sprat in the English Channel." should be changed to "An **explorative** analytical assessment was carried out for sprat in the English Channel."

10.6.1 Data exploration

§1, Line 3-4: Figure 10.5.1 should be 10.6.1

Page 561, §5, line 9: "Figs. 5.6.8-9" should be corrected to the right figure references.

Figure 10.6.1 – figure legend: "... observed lpue and ..." should be changed into "... observed lpue (green squares) and ...". Also the green line of the modelled estimate of biomass should be explained in the figure legend. An explanation of how the model biomass estimates were estimated prior to 1988 (without data) should be given. Lpue

should be explained, and lpue consequently used (not a mixture of cpue and lpue). The last comment also applies to Figure 10.6.2.

The text says: "A preliminary run where the model had no constrains, was scaled by the landings, resulting in low biomass well below the acoustic estimates." It would be nice if this run could be presented in a figure.

In page 561, last sentence, it is said: "This reveals a noisy series and a model fit suggesting an increasing trend in lpue." In my opinion, after studying the figure, this should be changed to e.g. "This reveals a noisy series and a model fit suggesting an increasing trend in lpue from 1988-2007, stabilizing after 2007."

10.11 Management considerations

The presentation of how the TAC advice was estimated is clear and well-documented, especially with the presentation of the underlying data in a table. The meaning of Unc Cap + / - is, however, a bit unclear, and could benefit from more thorough explanations, e.g. in a table legend or foot note.

It should also be explained shortly how the **uncertainty cap** and the **precautionary buffer** is used.

Tables 10.1.1-7

It is impossible to read the headers of some of these tables, since parts of them are missing. In addition, there are lots of green and red triangles that should be removed.

Table 10.3.2

The column %sprat is duplicated.

Figures 10.2.1-8

The figure legends should only include the nations with catches in the figure. Figure 10.2.2 has a nation called Series 2 (probably Ireland).

Conclusions

The explorative assessment has been performed as it was explained in the benchmark (WKSPRAT) and HAWG. However, the stock annex have no description of the explorative assessment, and should be updated.

Also the a description of the method for giving TAC advice is missing.

In my opinion, the use of an lpue as the most important index for a pelagic stock is of concern, but the recently started acoustic survey will probably improve the quality of the assessment in a couple of years.

Reference

Ulltang Ø 1980. Factors affecting the reaction of pelagic fish stocks to exploitation and requiring new approach to assessment and management. Rapports et Procès-verbaux des Réunions Conseil International pour I'Exploration de la Mer 177:489.