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

29 March–7 April 2016

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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

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Contents

This section is under preparation.

Executive Summary

The ICES herring assessment working group (HAWG) met for eight days in March 2016 to assess the state of five herring stocks and four sprat stocks/populations. HAWG also provided advice for seven sandeel stocks but reported on those prior to this meeting. The working group conducted update assessments for five of the herring stocks. An analytical assessment was performed for North Sea sprat and data limited assessments were conducted for English Channel sprat, Celtic Sea sprat and 3.a sprat.

The **North Sea autumn spawning herring** SSB in 2015 was estimated at 1.80 m tonnes while $F_{2–6}$ in 2015 was estimated at 0.24, below the target F_{2-6} of 0.26. Fishing mortality on juveniles, mean F_{0-1} is 0.05, just below the agreed ceiling. The estimate of 0-wr fish in 2016 (2015 year class) is estimated to be at approximately 23 billion and indicates a year class similar to those observed since 2003. Year classes since 2002 are estimated to be consistently week with year classes 2002 to 2007 to be among the weakest. ICES considers that the stock is still in a low productivity phase. The **Western Baltic spring spawning herring** assessment was updated. The SSB in 2015 has increased from last year and was estimated to be around 125 744 tonnes. Fishing mortality has been estimated at 0.24, and it is below the estimate of F_{msy} (0.32). After a minimum in 2008, recruitment is increasing although these should be considered with caution due to the uncertainty in the estimates. Under an historical perspective the estimates of SSB are considered still low, but give similar perception that the stock may have started to recover. The **Celtic Sea autumn and winter spawning stock** is estimated to be at a high level, although coming down in recent years. SSB is currently estimated at 101 382 tonnes in 2015, having rebuilt from 36 000 tonnes in 2004. Mean F (2–5 rings) was estimated at 0.19 in 2015, having increased from 0.06 in 2009. Overall there has been a substantial decrease in F from 0.41 in 2004. Recruitment has been good in recent years with several strong cohorts (2003, 2005, 2007, 2011, 2012) entering the fishery. The 2015 SSB estimate of **6.a/7.b, c** (the combined stock of 6.aN and 6.aS/7.b, c) was 250 296 tonnes, below at B_{pa}. Low recruitment has caused a decline of the stock while fishing mortality is low at 0.07 in recent years. Advice has been drafted to setup a monitoring fishery to ensure data relevant for the assessment and genetic studies are secured. **Irish Sea autumn spawning herring** assessment showed a decline in SSB in 2015 to 13 242 tonnes, and a continued high recruitment in recent years, with $F_{4–6}$ = 0.26 in 2015. 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}. Issues related to fish aging that could have affected the assessment were investigated and corrected for in 2015 and 2016. **North Sea sprat** is estimated to have come down from a high level in 2014 to 355 782 tonnes in 2015 with expected decline to 208 904 tonnes in 2016. Fishing mortality was estimated at 1.76 in 2015, above the F_{cap} of 0.7 that was estimated in 2015. Expected recruitment for 2016 is estimated to be well below the values observed in 2013–2015. **Sprat in Division 3.a** 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 3.a based on the ICES approach for data limited stocks (Category 3 / 4). The surveys indicate a substantial increase in the stock. Catch advice for **sprat in the English Channel (7.d, e)** was based on criteria for data limited stocks. Data available are landings and a short time series of acoustic biomass (2013–2015). The acoustic biomass indicates a decline in the stock. Quantitative advice was provided for **Sprat in the Celtic Sea (spr-irls)** based on criteria for data limited stocks where only data on landings are available.

The HAWG reviewed the assessments performed on seven sandeel stocks and the related advice of these stocks. Section 11 of this report contains the assessment of sandeel in Division 3.a and Subarea 4.

A special requests for a monitoring catch advice was dealt with at HAWG 2016 but will be issued as separate advice.

The working group commented on four Terms of Reference: bias in advice, the role of pelagic fish in the ecosystem, information from surveys relevant for HAWG and the potential effects of the landing obligation. Standard issues such as the quality and availability of data, estimating the amounts of discarded fish and the use of the data system InterCatch were discussed. The group also executed estimation of missing reference points as requested by the EU for some of the stocks.

1 Introduction

1.1 Participants

Valerio Bartolino	Sweden
Andrew Campbell	Ireland
Piera Carpi	UK
Lotte Worsøe Clausen	Denmark
Anne Cooper	ICES Secretariat
Maurice Clarke	Ireland
Cindy van Damme	The Netherlands
Sascha Fässler	The Netherlands
Tomas Gröhsler	Germany
Marc Hufnagel	Germany
Bastian Huwer	Denmark
Espen Johnsen	Norway
Michael O'Malley	UK/Scotland
Niels Hintzen	The Netherlands (Chair)
Cecilie Kvamme	Norway
Susan Mærsk Lusseau	UK/Scotland
Lars Mortensen	Denmark
Henrik Mosegaard	Denmark
Richard Nash	Norway
Martin Pastoors	The Netherlands
Claus Reedtz Sparrevohn	Denmark
Anna Rindorf	Denmark
Lisa Readdy	UK/England & Wales
Norbert Rohlf	Germany
Pieter-Jan Schön	UK/Northern Ireland

Contact details for each participant are given in Annex 1.

1.2 Terms of Reference

2015/2/ACOM07 The Herring Assessment Working Group for the Area South of 62ºN (HAWG), chaired by Niels Hintzen, NL will meet at ICES Headquarters, 29 March to 7 April 2015, and by correspondence in January and February to:

a) compile the catch data of North Sea and Western Baltic herring on 29–30 March
b) address generic ToRs for Regional and Species Working Groups 31 March–7 April
c) Prepare a list of the features and estimates derived from the existing surveys which are relevant to the interpretation of results and model fitting process and therefore need to be clearly presented in the surveys' group (WGIPS) report.
d) In preparation of the ecosystem approach for assessing and providing advice, evaluate total biomass of assessed and unassessed pelagic fish stocks and the structural diversity of the pelagic ecosystem in terms of the number of pelagic fish stocks comprising the majority of biomass

e) Evaluate the bias in advice when bi-annual advice would be given on SSB, F and recruitment for stocks with ages > 5 and having a category 1 analytical stock assessment
f) Examine where possible the effects of the landing obligation on TAC uptake, distribution of the fishing fleet and quality of the sampling

The assessments will be carried out on the basis of the Stock Annex. The assessments must be available for audit on the first day of the meeting.

Material and data relevant for the meeting must be available to the group no later than 15 March 2016 according to the Data Call 2016.

HAWG will report by 1 February 2016 (on sandeel), and by 14 April 2016 (all stocks except sandeel) for the attention of ACOM.

Fish Stock	Stock Name	Stock Coord.	Assesss. Coord. 1	Assess. Coord. 2	Advice	Review (SA)
san-nsea	Sandeel in Division 3.a and Subarea 4	Denmark	Denmark	Norway	Update	Germany
her-3a22	Herring in Division 3.a and Subdivisions 22–24 (Western Baltic Spring spawners)	Denmark	Germany/ Sweden	Denmark	Update	Denmark
her-47d3	Herring in Subarea 4 and Division 3.a and 7.d (North Sea Autumn spawners)	Germany	NL	UK (Scotland)	Update	Norway
her-irls	Herring in Division 7.a South of 52° 30′ N and 7.g-h and 7.j-k (Celtic Sea and South of Ireland)	Ireland	Ireland*		Update	UK (Scotland)
her-wis	Herring in Divisions 6.a and 7.b and 7.c	UK (Scotland) / Ireland	UK (Scotland)	Ireland	Update	Denmark
her-nirs	Herring in Division 7.a North of 52° 30′ N (Irish Sea)	UK (Northern Ireland)	UK (Northern Ireland)		Update	Ireland
spr-kask	Sprat in Division 3.a (Skagerrak - Kattegat)	Norway	Denmark	-	Update	Ireland
spr-nsea	Sprat in Subarea 4 (North Sea)	Denmark	Denmark	Norway	Update	NL
spr-celt (6 & 7)*	Sprat in the Celtic Seas	UK	UK		Update	Denmark

1.2.1 Generic ToRs for Regional and Species Working Groups

2015/2/ACOM05 The following ToRs apply to: AFWG, HAWG, NWWG, NIPAG, WGWIDE, WGBAST, WGBFAS, WGNSSK, WGCSE, WGDEEP, WGBIE, WGEEL, WGEF, WGHANSA and WGNAS.

The working group should focus on:

a) Consider and comment on ecosystem overviews where available;

b) For the fisheries relevant to the working group consider and comment on:

i) descriptions of ecosystem impacts of fisheries where available

ii) descriptions of developments and recent changes to the fisheries

iii) mixed fisheries overview, and

iv) emerging issues of relevance for the management of the fisheries;

c) Conduct an assessment to update advice on the stock(s) using the method (analytical, forecast or trends indicators) as described in the stock annex and produce a brief report of the work carried out regarding the stock, summarising where the item is relevant:

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

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

iii) For relevant stocks estimate the percentage of the total catch that has been taken in the NEAFC Regulatory Area by year in the recent three years.

iv) The developments in spawning stock biomass, total stock biomass, fishing mortality, catches (wanted and unwanted landings and discards) using the method described in the stock annex;

v) The state of the stocks against relevant reference points;

vi) Catch options for next year;

vii) Historical performance of the assessment and catch options and brief description of quality issues with these;

d) Produce a first draft of the advice on the fish stocks and fisheries under considerations according to ACOM guidelines.

The working group is furthermore requested to:

e) Consider and propose stocks to be benchmarked;

f) Review progress on benchmark processes of relevance to the expert group;

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

h) Prepare the data calls for the next year update assessment and for the planned data evaluation workshops;

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

i) Load fisheries data on effort and catches into the InterCatch database by fisheries/fleets;

ii) Abundance survey results;

iii) Environmental drivers.

j) Produce an overview of the sampling activities on a national basis based on the InterCatch database or, where relevant, the regional database.

k) Identify research needs of relevance for the expert group.

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

Stock	Addressed in Section
Herring in Subarea 4 and Division 3.a and 7.d (North Sea Autumn spawners)	Section 2
Herring in Division 3.a and subdivisions 22–24 (Western Baltic Spring spawners)	Section 3
Herring in Division 7.a South of 52° 30′ N and 7.g-h and 7.j-k (Celtic Sea and South of Ireland)	Section 4
Herring in Division 6.a assessment	Section 5
Herring in Division 6.a data	Section 6
Herring in Division 7.a North of 52° 30′ N (Irish Sea)	Section 7
Sprat in Subarea 4 (North Sea)	Section 8
Sprat in Division 3.a (Skagerrak - Kattegat)	Section 9
Sprat in the Celtic Seas	Section 10
Sprat in Division 7.d and 7.e	Section 10
Sandeel in Division 3.a and Subarea 4	Section 11
Stocks with limited data	Section 12

1.2.2 Prepare a list of the features and estimates derived from the existing surveys which are relevant to the interpretation of results and model fitting process and therefore need to be clearly presented in the surveys' group (WGIPS)

In the WGIPS report, presented estimates and tables fit well into the needs of the HAWG. However, to ensure proper documentation, consistently reported time-series and easy access to the relevant data to be included in calculation procedures and for comparison, the WGIPS report should present a kind of summary chapter for herring and sprat including tables with information on:

Acoustic surveys on herring

Stock	NSAS	WBSS	6.aN	Malin shelf	Irish Sea	Celtic Sea
Survey synonym	*HERAS*	*HERAS/GERAS*	*HERAS*	*HERAS*	*AC(7aN)*	*CSHAS*
Numbers at age	X	X	X	X	X	X
Biomass at age	X	X	X	X	X	X
Maturity at age	X	(X)	X	X	X	X
Weight at age	X	X	X	X	X	X
Length at age	X	X	X	X	X	X
Immature fish: numbers, biomass, mean length, mean weight	X	X	X	X	X	X
Mature fish: numbers, biomass, mean length, mean weight	X	X (3+ group)	X	X	X	X
Survey coverage	X	X	X	X	X	X
Track length per stratum (comparing last two years)	X	X	X	X	X	X
Number of fish aged per stratum and in total (comparing last two years)	X	X	X	X	X	X
Short description on survey quality, issues, CV (where possible)	X	X	X	X	X	X
Level of *Ichthyophonus* infection	X		X	X		

Acoustic surveys on sprat

Stock	NS	3.a
Survey synonym	*HERAS*	*HERAS*
Total numbers at age	X	X
Biomass at age	X	X
Maturity at age	X	X
Weight at age	X	X
Length at age	X	X
Immature: numbers, biomass, mean length, mean weight	X	X
Mature: numbers, biomass, mean length, mean weight	X	X
Survey coverage and nautical miles used in abundance estimates	X	X
Track length per stratum (comparing last two years)	X	X
Number of fish aged per stratum and in total (comparing last two years)	X	X
Short description on survey quality, issues, CV (where possible)	X	X

1.2.3 In preparation of the ecosystem approach for assessing and providing advice, evaluate total biomass of assessed and unassessed pelagic fish stocks and the structural diversity of the pelagic ecosystem in terms of the number of pelagic fish stocks comprising the majority of biomass

Pelagic fish communities are a key ecosystem component in marine food webs, representing one of the main pathways of the energy flow from zooplankton to the higher trophic levels. In many parts of the world, pelagic fish are targeted by large fisheries and they contribute substantially to the provision of protein for human and animal consumption. For instance, in the North Sea, pelagic fish represented a large part of the total fish catch in 2015. Hence, their management is a key aspect for an Ecosystem Approach to Fisheries Management.

In Europe, the Marine Strategy Framework Directive's (MSFD) ultimate objective is to achieve good environmental status (GES) by using an ecosystem approach which relies on indicators (including ecosystem indicators).

Ecosystem indicators that describe fish community structure and diversity may be appropriate across different parts of the food web, including the pelagic communities. Other indicators may have more restricted application and make sense only within specific communities. For instance, size based indicators are considered relevant to monitor and detect the effects of intense and prolonged size selective fishery on demersal fish communities, but tend to perform poorly in the case of pelagic fish communities where the size selection has a limited impact on the size structure of short living species.

Among the main difficulties of defining ecosystem indicators for pelagic fish communities are the wide geographical boundaries and the high temporal variability which often characterise pelagic ecosystems. Another challenge is the marked migratory behaviour of many pelagic fish populations. Pelagic species typically move across the boundaries of biogeographic areas and these populations may influence different communities during different seasons and throughout their life cycle. Among the stocks assessed by HAWG there are several examples; for instance, the Western Baltic Spring spawning herring perform seasonal feeding migration into the North Sea and link the energy flow between these ecoregions.

Given these considerations, and in preparation of the ecosystem approach for assessing and providing advice, HAWG has been asked to provide a preliminary evaluation of the total biomass of assessed and unassessed pelagic fish stocks and the structural diversity of the pelagic ecosystem in terms of the number of pelagic fish stocks comprising the majority of the biomass.

We considered two areas in our analyses:

- Greater North Sea ecoregion
- Celtic Sea ecoregion

Many pelagic species are widely distributed and therefore cannot be easily assigned to either ecoregion specifically. Species including Atlantic mackerel *Scomber scombrus* and blue whiting *Micromesistius poutassou* spend part of their life cycle in both ecoregions, and in geographical areas not considered here (e.g. Barents Sea and Norwegian Sea). There are other species including anchovy *Engraulis encrasicolus* and sardine *Sardina pilchardus* that may also enter these ecoregions during part of their life cycle, but these stocks are assessed as being distributed in the Bay of Biscay and Iberian Sea ecoregion.

We considered Total Stock Biomass (TSB) rather than Spawning Stock Biomass (SSB) as this reflects the whole population i.e. juveniles and adults. TSB is available from ICES for stocks in the North Sea and Celtic Seas ecoregions that have full analytical assessments (http://standardgraphs.ices.dk/stockList.aspx). Catch information is also available for stocks where trends based assessments are conducted. We considered the following species, focusing our analysis on species where TSB is available:

North Sea

TSB:-

Herring (*Clupea harengus*) in Subarea 4 and Divisions 3.a and 7.d (North Sea autumn spawners)

Sprat (*Sprattus sprattus*) in Subarea 4 (North Sea)

Sandeel (*Ammodytes* spp) in the Dogger Bank area (SA 1)

Sandeel in the South Eastern North Sea (SA 2)

Sandeel in the Central Eastern North Sea (SA 3)

Norway pout (*Trisopterus esmarkii*) in Subarea 4 (North Sea) and 3a (Skagerrak - Kattegat) - Autumn assessment

Catches:-

Sandeel in the Viking and Bergen Bank area (SA 5)

Sandeel in Division 3.a East (Kattegat, SA 6)

Sandeel in the Shetland area (SA 7)

Celtic Sea and West of Scotland

TSB:-

Herring in Divisions 6.a and 7.b and 7.c (West of Scotland, West of Ireland)

Herring in Division 7.a North of 52° 30′ N (Irish Sea)

Herring in Division 7.a South of 52° 30′ N and 7.g-h and 7.j-k (Celtic Sea and South of Ireland)

Catches:-

Sprat in Subarea 6 and divisions 7.a-c and f-k (Celtic Sea and West of Scotland)

Widely Distributed Stocks (distributed in both North Sea and Celtic Sea areas)

TSB:-

Mackerel in the Northeast Atlantic (combined Southern, Western and North Sea spawning components)

Blue whiting in subareas 1-9, 12 and 14 (Combined stock)

Horse mackerel (*Trachurus trachurus*) in divisions 2.a, 4.a, 5.b, 6.a, 7.a-c, e-k, 8 (Western stock)

Catches:-

Horse mackerel in divisions 3.a, 4.b and 4.c and 7.d (North Sea stock)

Boarfish (*Capros aper*) in subareas 6-8 (Celtic Seas and the English Channel, Bay of Biscay)

Other species considered:

Anchovy in Subarea 8 (Bay of Biscay)

Sardine in divisions 8.c and 9.a

To investigate changes in the pelagic fish community, we analysed both scientific survey data and assessment model output. Despite the bias against representative sampling of pelagic fish species in surveys using bottom trawling, most of pelagic species which occur in the North Sea and, to a minor extent, in the Celtic Sea ecoregion are represented in the bottom trawl surveys. Moreover, given the extensive temporal and spatial coverage and the availability of standardized biological data, the bottom trawl surveys conducted in these regions have been evaluated as a valuable source of information to address part of the ToR (http://www.ices.dk/marine-data/data-portals/Pages/DATRAS.aspx accessed on 5 April 2016). Data from the survey *NS-IBTS* was extracted for the North Sea, and the surveys *SWC-IBTS*, *NIGFS*, *IE-IGFS* and EVHOE for the Celtic Sea. Bottom trawl survey data were used to analyse the body condition of the pelagic fish community which could be related to changes in the availability and composition of the zooplankton community, in the ecosystem productivity and energy flow. In addition, total stock biomass estimated from the assessment of the HAWG stocks and for other pelagic fish stocks was retrieved and analysed to evaluate changes in the total biomass of the assessed stocks and in the diversity of the assessed pelagic community.

The following indicators have been calculated for each of the two ecoregions:

Indicator	Formulation	Data	MSFD
Total biomass estimated	$\sum(TSB_i)$ TSB_i is the estimated total biomass of the stock i	Assessment	D1
Unaccounted biomass	$BIOM^* - \sum(TSB_i)$ $BIOM^*$ is the pelagic fish biomass estimated by multispecies models	Assessment and multispecies model output	D1
Simpsons' diversity index	$1 - \sum n_i(n_i-1) / \sum n_i(\sum n_i-1)$ n_i is the abundance of species i	Assessment model output, survey	D1
Weight-at-age anomaly	$(waa_i\text{-avg}(waa)) / sd(waa)$	Survey	
Relative condition	W_i/W_r W_r is reference weight calculated by fitting a L-W relationship on the full time period	Survey	

Results

TSB

In the North Sea ecoregion, during the period from the 1980s to the present (Figure 1.2.4.1, left middle panel), the combined TSB of all assessed pelagic species was highest in 1986 (> 20 million t) and fell slightly to a relatively constant level between 1995 and 2013. 2014 was the second highest overall TSB on record.

In the Celtic Seas ecoregions, during the period from the 1980s to present (Figure 1.2.4.1, right middle panel), there was an obvious peak in combined TSB in 1985, followed by a steady annual decline until 1996. After 1996, combined TSB steadily rose again to an overall highest level in 2003 (> 17.5 million t). The TSB declined between 2003 and 2009, but has been steadily increasing in the most recent assessment years.

Simpson's Diversity Index

In the North Sea ecoregion, during the period from the 1980s to present (Figure 1.2.4.1, left bottom panel), there was a steady increase in diversity from the early 1980s, with the highest diversity index peaking in 1997 (0.86). After 1997, diversity decreased to its lowest overall level in 2003 (0.71). From 2003, diversity rose until 2010, but has declined in recent years, with 3 out of the 4 lowest diversities being recorded since 2010.

In the Celtic Seas ecoregion, during the period from the 1980s to present (Figure 1.2.4.1, right bottom panel), there was a slow but steady increase in diversity from the 1980s until about 1994 (0.72). After 1994, there was a relatively sharp decline in diversity, reaching its lowest level in 2003 (0.51). This lowest diversity in the Celtic Seas region coincides with highest overall TSB (Figure 1.2.4.1, right middle panel). Since 2003 there was a sharp increase in diversity until 2009 (0.67); the diversity has again declined in recent years.

Comparisons between the 2 ecoregions

There is overall higher TSB of pelagic species in the North Sea ecoregion compared to the Celtic Seas ecoregion. There is also higher diversity found in the North Sea ecoregion compared to the Celtic Seas ecoregion. The North Sea ecoregion is dominated by North Sea herring, mackerel and sprat (Figure 1.2.4.1, left top panel). The Celtic Seas ecoregion is dominated by two species in particular, mackerel and blue whiting (Figure 1.2.4.1, right top panel). The abundance of these species combined makes up the majority of the TSB in this ecoregion and subsequently diversity is reduced when their TSB is increased between 1995 and 2005.

Species not included in the analysis

Species were not included in the analysis if for instance their assessment was trends based and therefore only landings data were available (e.g. sandeels in management areas 5, 6 and 7 in the North Sea; sprat and boarfish in Celtic Seas ecoregion). These species may be a significant proportion of the pelagic biomass in any year. For instance, the boarfish assessment is currently in development, and therefore only relative TSB was available from the assessment. However, there has been an acoustic survey completed for the past 5 years in the Celtic Seas ecoregion and the TSB in 2015 was estimated at >230 000 t.

Species where no information was available, but could be a significant part of the overall pelagic biomass in the ecoregions include argentines *Argentina silus* and myctophids. However, there are undoubtedly a number of small species e.g. crystal gobies

(*Crystallogobius linearis* to name one) and the young juvenile stages of many species e.g. gadoids that contribute toward the pelagic biomass and its ecosystem dynamics of which we do not know the biomass.

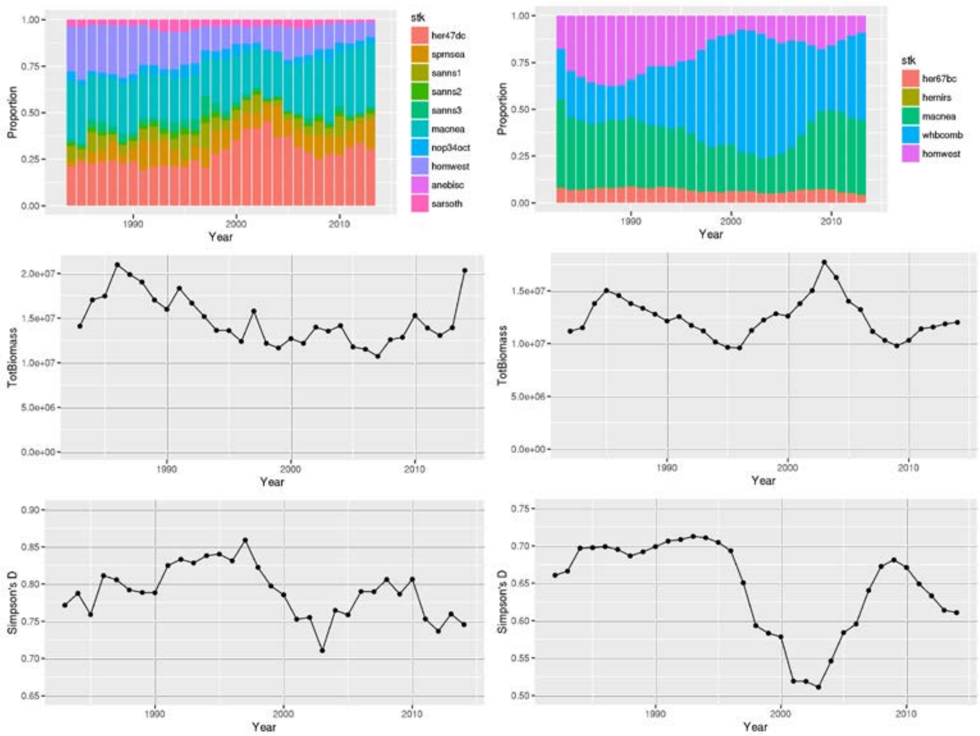


Figure 1.2.4.1. Top panels show the proportion of pelagic fish species from 1980s to present, central panels the total biomass of assessed pelagic stocks, and bottom panels the Simpson's index of species diversity for the same time period. Left panels refer to the Greater North Sea ecoregion and right panels to the Celtis Sea ecoregion.

Relative condition in Quarter 1 from the pelagic fish community represented in the North Sea samples shows a progressive increase for the period 2001–2009 followed by a drop in 2011 to relative condition close to the whole time period average during the last few years(Figure 1.2.4.2). This pattern is mostly shared by herring and Norway pout but not by sprat which shows lowest values around 2007. A similar increase in condition for 2003–2009 is observed in Quarter 3 and the drop estimated in 2010 Quarter 3 appears consistent with the 2011 Quarter 1 decrease (Figure 1.2.4.3).

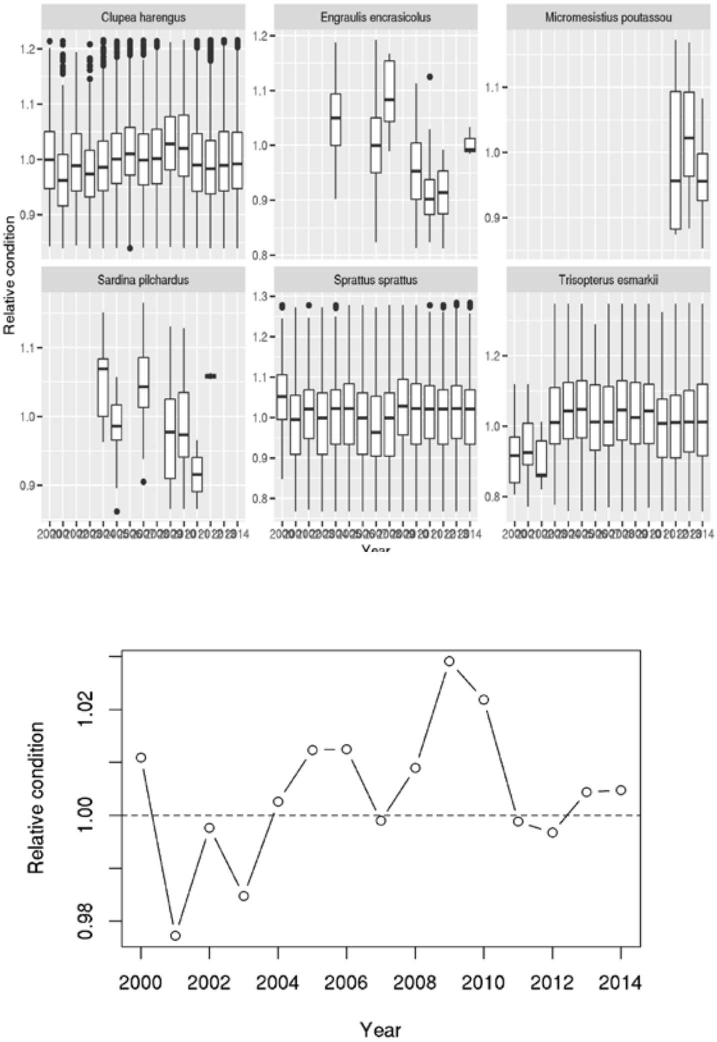


Figure 1.2.4.2. Time series (2000–2014) of relative condition in the North Sea from Quarter 1 by species (top panel) and averaged among the pelagic fish community (bottom panel).

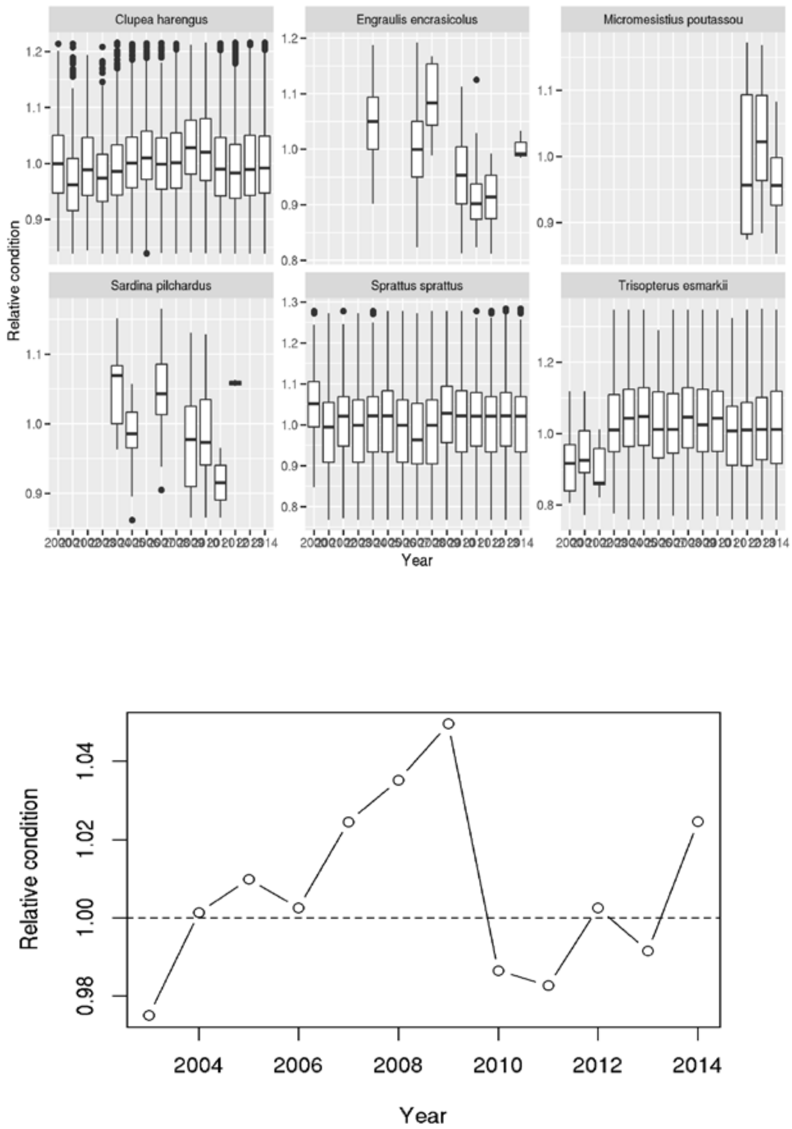


Figure 1.2.4.3. Time series (2003–2014) of relative condition in the North Sea from Quarter 3 by species (top panel) and averaged among the pelagic fish community (bottom panel).

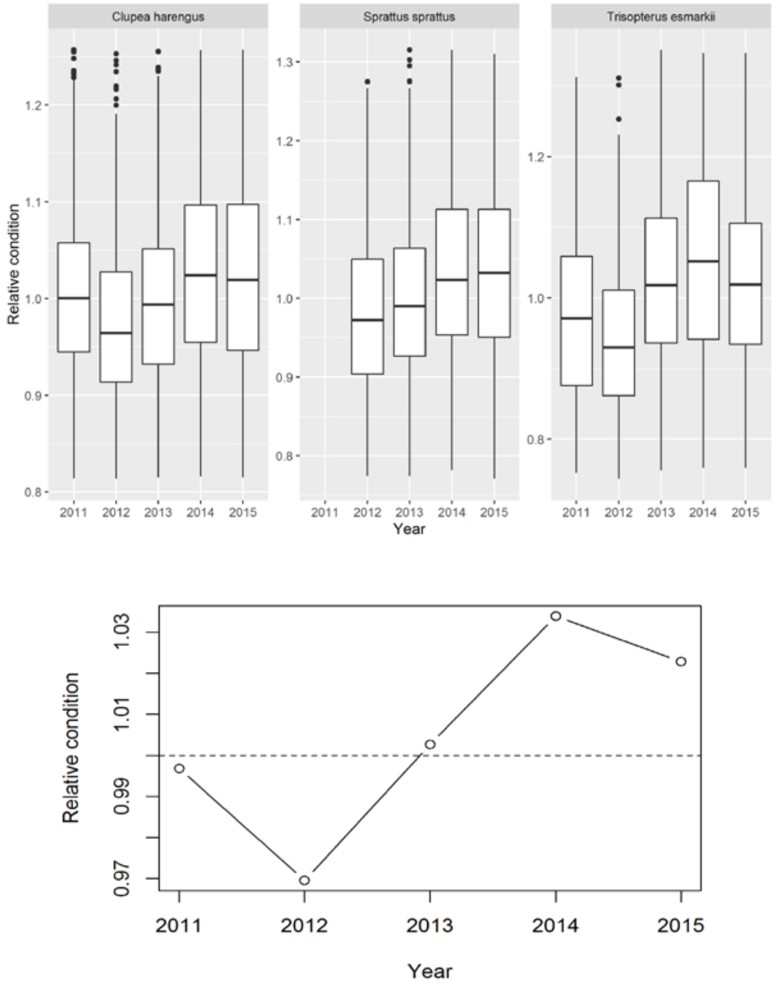


Figure 1.2.4.4. Time series (2011–2015) of relative condition in the Celtic Sea from Quarter 1 by species (top panel) and averaged among the pelagic fish community (bottom panel).

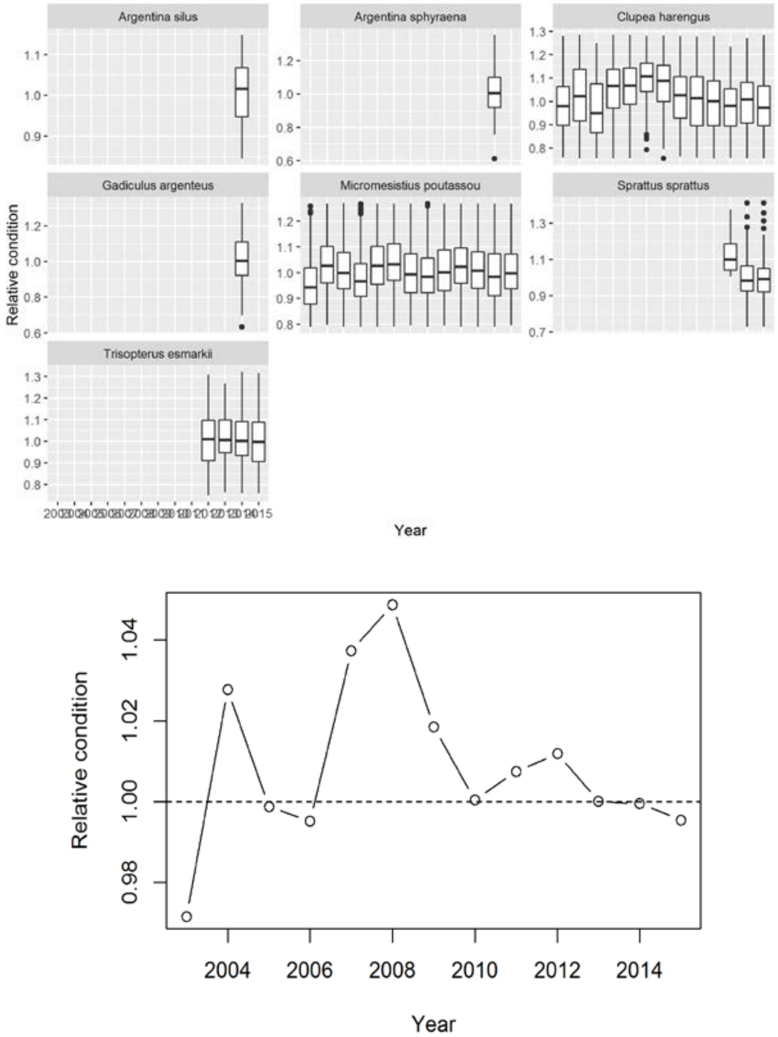
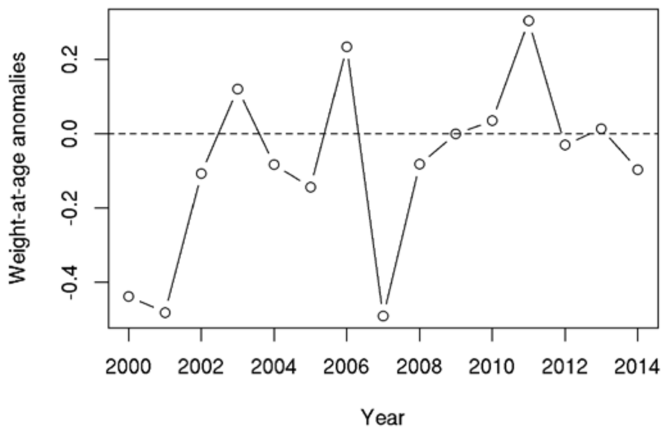


Figure 1.2.4.5. Time series (2003–2015) of relative condition in the Celtic Sea from Quarter 4 by species (top panel) and averaged among the pelagic fish community (bottom panel).

The main pelagic species represented in the Celtic Sea trawl surveys are herring, sprat and Norway pout in the first quarter of the year (Figure 1.2.4.4), herring and blue whiting, and to a lesser extent Norway pout and sprat and in the fourth quarter. Other pelagic species occur only occasionally (Figure 1.2.4.5).

The relative condition factor estimated for Quarter 1 shows a drop from 2011 to 2012, followed by an increase in 2013 and 2014 (Figuer 1.2.4.4). The values estimated for Quarter 4 display two positive deviations, one occurring in 2005, and the second from 2007 to 2010. For the last five years the values remain stable around 1 (Figure 1.2.4.5).

The trends described above resemble in a certain measure the results obtained for the North Sea ecoregion. In particular, in Quarter 1 an analogous drop to negative values is observed in both regions from 2011 to 2012, followed by an increase until 2013. Some analogies are visible also between Quarter 3 in the North Sea and Quarter 4 in the Celtic Sea, both showing two positive peaks in 2005 and betweem 2007 and 2008. The recent perspective on the other hand is different, with the condition factor in the North Sea that show a steep increase starting from 2010.



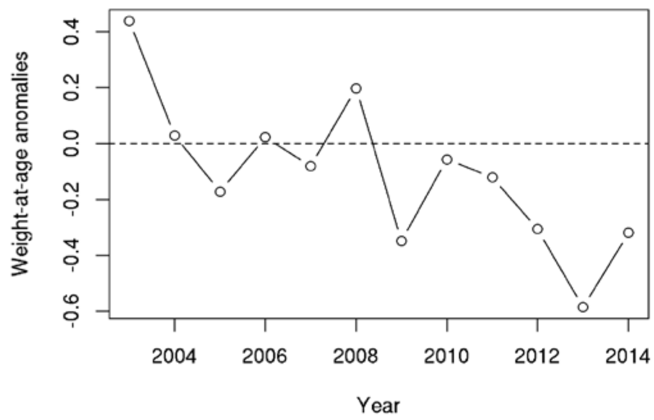


Figure 1.2.4.6. Time series of weight-at-age anomalies of the pelagic fish community from the North Sea in Quarter 1 (top) and Quarter 3 (bottom).

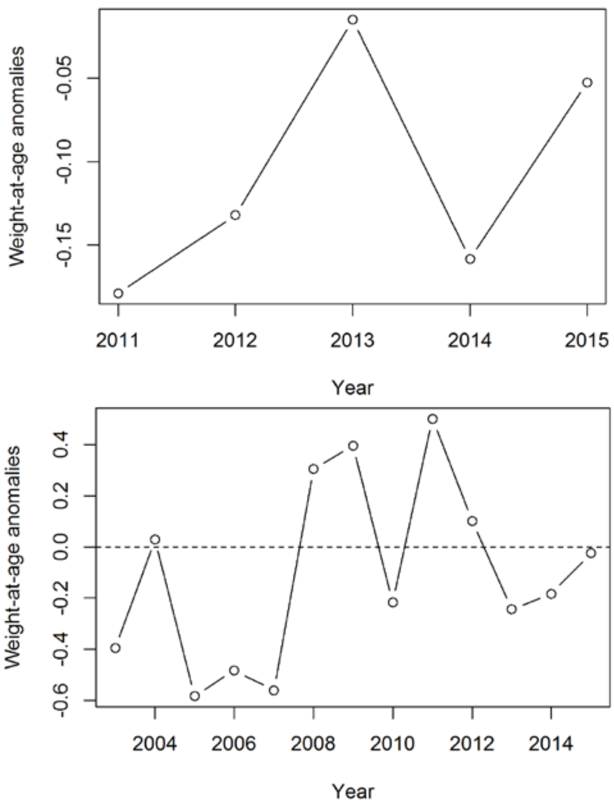


Figure 1.2.4.7. Time series of weight-at-age anomalies of the pelagic fish community (limited to herring, sprat and blue whiting) from the Celtic Sea in Quarter 1 (top) and Quarter 4 (bottom).

The weight-at-age anomalies for the North Sea in Quarter 1 show large fluctuations during 2000–2014 but not a trend over the analysed peagic community. On the contrary, weight-at-age anomalies for Quarter 3 show a marked decrease during the period investigated (Figure 1.2.4.6).

The weight at age anomalies are not really comparable with the condition index and no common trends between the North Sea and the Celtic Sea data are clear (figures 1.2.4.6–7).

A possible explanation to the lack of common signals may be due to the selectivity of the trawl survey. Because the trawl surveys are not designed to adequately sample pelagic species there is a possibility that not all age classes in the population are similarly well represented. In principle, the relative condition factor should be a more reliable index as this is not as dependent on the age structure in the samples.

In summary, there appear to be interannual variations in the mean relative condition of pelagic fishes and in measures of structural diversity in both ecoregions indicating the dynamic nature of the systems. However, whilst there were some similarities in the dynamics they were not identical. Therefore these ecoregions should not be considered in isolation nor should they be considered as one. This small study provides a starting point for examining the total pelagcic fish biomass in each of these reagions but there is still a considerable amount of further wok necessary to take account of the unassessed pelagic fish biomass. Likewise further work needs to be undertaken on evaluating the true structural diversity of these pelagic ecosystems.

1.2.4 Examine where possible the effects of the landing obligation on TAC uptake, distribution of the fishing fleet and quality of the sampling

HAWG was informed about changes in fishing pattern by work at national institutes as well as from the industry.

The implementation of the pelagic landing obligation is still in process, interpretations of rules are on-going, control methods for monitoring compliance are being developed and evaluated and exemptions are being established.

The sprat fishery in the North Sea in 2015 exhibited exceptionally low percentage by-catch of herring, the landing obligation thus does not appear to have affected the fishery this year. Neither were there any observed changes in fishing pattern for the only vessel operating in Channel sprat fishery.

Sprat fishery in 3.a usually takes herring as bycatch for which an annual by-catch ceiling has been set at 6659 t for a number of years. Usually the TAC utilisation of herring in this fishery is about 50% mainly restricted by limits on individual catch composition. Introduction of the landing obligation changed rules of 49% herring by-catch in landings from 3.a, to no specific percentage. However, in 2015 the Danish authorities have implemented national regulations. An initial by-catch ceiling of 1000 t herring in the sprat fishery in Kattegat and Skagerrak was enforced in the first quarter in 2015. The fishery control set a limit of 20% herring for individual landings. If exceeded the vessel would be grounded for a week. If exceeded twice the vessel would be grounded for another week with further penalties if the by-catch exceeded 40%. In the 3rd quarter the sprat fishery was reopened but apparently without catch composition limits. The effects were that 94% of the herring by-catch quota for 3.a in 2015 was utilised and that the sprat TAC as usual was not taken.

In general the herring fishery is considered very clean in relation to by-catch. The introduction of the landing obligation appears not to have had any major influence on TAC uptake or distribution of the fishing fleet. Quality of the catch sampling has not been affected and data on additional self-sampling is increasingly made available to science and by a higher coverage will probably increase overall quality of biological data.

In the Swedish herring fishery during autumn by-catch of saithe may occur, a project has been initiated aiming at finding a sorting grid to drastically reduce the by-catch of saithe. Experience to date with this grid is very good and people are hopeful that the project will lead to positive results.

Self-sampling of the Dutch pelagic freezer-trawler fishery has been carried out since 2015. In reports of 12 PFA observer trips and 8 for herring in 2015, no deviating behaviour was observed. There were zero discards and minimum by-catch. In the years 2013 and 2014 a few trips were also covered by the self-sampling programme, but only few vessels participated during those years. From the self-sampling, one can derive the catch composition per haul. Most of what used to be discarded in the pelagic freezer-trawler fishery was damaged or broken fish.

Under the landing obligation, the freezer-trawlers have an (informal) derogation to use the BMS landing category for broken or damaged fish of different species. As such, the category does not apply to the minimum landing size, but rather to a mixture of species. The herring fishery mostly takes place from July to August (in 6.a North and 4.a) and in December (in the Channel). From the self-sampling, we derived estimates of catch per species and catch in the BMS category, for trips that targeted herring. Results are shown below.

year	month	trips	her	oth	'BMS'	propBMS
2013	8	2	5,577	11	247	4.2%
2014	8	2	5,324	25	116	2.1%
2015	7	6	10,983	4,896	199	1.2%
2015	8	6	9,597	3,584	78	0.6%
2015	12	3	7,910	1,287	80	0.9%

Although the proportions BMS are lower in 2015 compared to 2014 and 2013, this cannot be taken as a direct proof that the landing obligation is leading to a change in the exploitation patterns. However, several of the skippers have indicated that the landing obligation has led them to be more careful in selecting when to fish and when not to fish. This may have led to apparent lower percentage of BMS by-catch in 2015.

Preliminary Dutch analyses do not show any indication of shifts in herring catch composition in the NS, for either small < 20 cm or large > 29 cm herring. A 10% BMS flexibility for herring allowed in landings – there are no apparent problems with this level of flexibility in the herring fishery.

The geographical distribution of the freezer trawler fleet in the Northern North Sea was compared to the distribution of herring in the acoustic survey. Preliminary results show no change in distribution or concentration after the landing obligation.

A Working document by IMARES to HAWG 2016 provides further background to this topic.

1.3 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.

1.3.1 Meeting of the Chairs of Assessment Related Expert Groups (WGCHAIRS)

HAWG was informed about the WGCHAIRS meeting in January 2015. 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:

Data call: ICES sends out one data call on all ICES assessment or related working groups. ICES members are requested to either upload the catch/landings data in InterCatch or send it to the ICES secretariat for registration purposes. BMS and logbook registered discard data was requested this year as well for 2015. HAWG reported very minor deviations from the data call and in general had access to all the data that was requested. Even members that didn't upload data last year did so this year. A discussion with ICES secretariat on how to improve the data call was held.

Advice format: Only minor changes were proposed to the advice format, relating to BMS and logbook registered catches.

Benchmark process: ICES is investigating if a new style of performing benchmarks will result in a less problems with assessments in the years in between benchmarks. They foresee a process of ~4 years where at a start a kick-off workshop is held with stakeholders, in the intermediate period intersessional work is executed, also at the expert group meetings, and a final benchmark session is held to present and discuss results.

Many of the HAWG members see this approach as an improvement of the current system.

Stock annex and report: Attention should be given to update the stock annex as also stock annexes are published at the ICES website. In addition, the WG reports could be shortened by moving standard sections in the WG report to the stock annex.

Reference points: Every stock coordinator is asked to provide all PA reference points (for most F_{lim}) for their stocks. In some cases this means running special software to estimate the reference point.

1.3.2 Working Group for International Pelagic Surveys [WGIPS]

The Working Group of International Pelagic Surveys (WGIPS) met in Dublin, Ireland on 18–22 January 2016. Among the core objectives of the Expert Group are combining and reviewing results of annual pelagic ecosystem surveys to provide indices for the stocks of herring, sprat, mackerel, boarfish, and blue whiting in the Northeast Atlantic, Norwegian Sea, North Sea, and Western Baltic; and to coordinate timing, coverage, and methodologies for the upcoming 2016 surveys.

Results of the 2015 surveys covered by WGIPS and coordination plans for the 2016 pelagic acoustic and larvae surveys are available from the WGIPS report (ICES CM 2016/SSGIEOM:05). The following text refers only to the surveys with relevance to HAWG.

Review of larvae surveys in 2015: Within the framework of the International Herring Larval Surveys in the North Sea, six survey metiers were covered in the **North Sea**. The herring larvae sampling was still in progress at the time of the WGIPS meeting, thus sample examination and larvae measurements had not yet been completed. The information necessary for the larvae abundance index calculation will be ready for, and presented at the HAWG meeting in March 2016.

The 2015 herring larvae survey in the **Irish Sea** was conducted in fair to good weather conditions. The spatial distribution of herring larvae was similar to previous years, with high abundances to the north of the Isle of Man and in the Douglas bank area. Evidence of a more southerly dispersal of larvae was provided by the relatively high abundances of larvae in the southern stations. A number of larvae were encountered in the vicinity of the Mourne spawning grounds off the Northern Irish coast. The point estimate of production in the north-eastern Irish Sea for 2015 was an increase from last year but still below the time series mean. The advanced stage of development of many of the larvae suggested earlier hatching and possible good growth rates of larvae. The index is used as an indicator of spawning-stock biomass in the assessment of Irish Sea herring.

North Sea, West of Scotland and Malin Shelf summer acoustic surveys in 2015: Six 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 2015 estimate of North Sea autumn spawning herring spawning stock biomass is slightly lower than previous year at 2.3 million tonnes but is comprised of a similar number of fish (2015: 14 222 mill. fish, 2014: 14 392 mill. fish).

The 2015 estimate of Western Baltic spring-spawning herring SSB is 207 000 tonnes and 1 447 million herring. This is nearly a doubling of the 2014 estimates of 128 000 tonnes and 791 million fish and brings the stock back in line with abundances observed in the period prior to 2009.

The West of Scotland estimate (6.aN) of SSB is 387 000 tonnes and 1 935 million herring, a considerable increase over the 2014 estimate of 272 000 tonnes and 1 400 million fish.

The SSB estimate for the Malin Shelf area (divisions 6.aN-S and 7.b and 7.c) is 430 000 tonnes and 2181 million herring. This is a significant increase on 2014 estimates of 285 000 tonnes and 1471 million fish.

Sprat in the North Sea and Division 3.a: The total abundance of North Sea sprat (Subarea 4) in 2015 was estimated at 58 745 million individuals and the biomass at 712 000 tonnes (Table 5.10). This is the fourth and second highest estimate observed in the time series, in terms of abundance and biomass, respectively. The stock is dominated by 1- and 2-year-old sprat.

In Division 3.a, the sprat abundance is estimated at 1394 million individuals and the biomass at 18 515 tonnes. This is below average both in terms of abundance and biomass. The stock is dominated by 1-year-old sprat.

Irish Sea Acoustic Survey: For this survey herring abundance for the Irish Sea and North Channel in August-September 2014 has been reported by Northern Ireland, UK. The estimate of herring SSB of 61 705 t for 2014 is slightly higher than the 2013 estimate, and the biomass estimate of 79 866 t for 1+ ringers is, also higher than the 2013 estimate. Whilst the biomass estimate is slightly higher than that 2013, it remains significantly lower than the 2010 and 2011 estimates, which are the highest in the time series. More than a third of the 1+ biomass estimate was to the north of the Isle of Man. This is an area of mixed size fish and the survey was mismatched with the migration of the main spawning biomass, as indicated by the high abundance of herring observed by the fishery on the Douglas Bank post survey. Results of a successive acoustic survey conducted later in September confirmed this. The evidence of higher abundance of spawning herring suggests poor reflection of the current age structure and abundance of the herring population in the Irish Sea.

Celtic Sea herring acoustic survey (CHAS): For this survey herring and sprat abundance for the Celtic Sea in October 2015 was reported by Ireland. For the core survey a total of three single herring echotraces were identified during routine 'on-track' observations. The echotraces occurred in a localised area within the Smalls offshore stratum and it was evident that they formed part of a much more substantial aggregation occurring off-track. The presence of aggregations occurring between survey transects initiated a fine spatial resolution survey approach in two key areas; the 'Trench' and 'Smalls'. Total herring biomass was calculated from two high resolution adaptive strata; the day-light survey of the Trench area and the combined day/night survey of the Smalls strata and were chosen as the best candidate surveys. Herring TSB (total stock biomass) and abundance (TSN) estimates were 24 710 t and 184 million individuals (CV 18.4%) respectively. No immature fish were encountered during the adaptive surveys. Herring distribution was limited to offshore strata. During the core survey herring were identified in low numbers from mixed catches from the eastern survey area and in the smalls stratum. No estimate of biomass was calculated from these echotraces due to the low numbers encountered.

The distribution of the stock observed during the survey was substantiated by the co-occurring fishery that was centred offshore. As a result it is not possible to say if the stock was contained within the survey area and may therefore not be a representative measure of abundance.

Pelagic ecosystem survey in Western Channel and eastern Celtic Sea (PELTIC): This survey was conducted by Cefas, UK, in the Western Channel and eastern Celtic Sea in

October 2015. The survey provides abundance data on pelagic species in the area such as herring, sardine, anchovy, mackerel and boarfish. Pending completion of the acoustic data processing, preliminary results suggested that numbers of sprat, sardine and anchovy were all up from previous two years. Mackerel quantities appeared more in line with 2012 not showing any of the large schools observed in 2013. High numbers of sardine eggs were found and larvae numbers were down suggesting that the survey took place earlier in the autumn spawning season. Despite the large temporal overlap with the 2013 survey physical conditions were different: top temperatures were higher and strong frontal features existed in several areas of the survey whilst chlorophyll values were lower than last year.

1.3.3 PGDATA, WGBIOP & WGCATCH

The Planning Group on Data Needs for Assessments and Advice (PGDATA) met in February 2016. This planning group is the umbrella for the newly formed WGBIOP, WGCATCH and WGREFS, which together embrace the responsibilities of PGCCDBS (Planning Group on Commercial Catches, Discards and Biological Sampling) and beyond in relation to data and sampling in general. This year the meeting focused on the upcoming cost-benefit workshop on survey sampling, outlining what should be included in such analyses. The WKCOSTBEN will take place at the ICES HQ, from 28 June – 1 July 2016**.**

Working Group on Biological Parameters (WGBIOP) coordinates the practical implementation of quality assured and statistically sound development of methods, standards and guidelines for the provision of accurate biological parameters for stock assessment purposes. However, the focus of such a group is not only on technical aspects of data collection and quality assurance but also on accuracy in life history parameter estimations to support stock assessment. WGBIOP review stock specific life history parameters and monitor potential changes in biological processes, such as growth rate, onset of maturity, maturity and fecundity at size/age, and related causal factors.

A main objective of WGBIOP is to support the development and quality assurance of regional and national provision of biological parameters as reliable input data to integrated ecosystem stock assessment and advice, while making the most efficient use of expert resources. As biological parameters are among the main input data for most stock assessment and mixed fishery modelling, these activities are considered to have a very high priority. The main link between stock-assessment working groups and WGBIOP is through the benchmark process. WGBIOP works in close association with the BSG (ICES benchmark steering group), reviewing all issue lists pointing to either missing issues in relation to specific stocks and guiding the process to get issues related to biological parameters resolved.

The ICES Working Group on Commercial Catches (WGCATCH) will continue to document national fishery sampling schemes, establish best practice and guidelines on sampling and estimation procedures, and provide advice on other uses of fishery data (e.g. developing relative abundance indices based on fishery catch rates). The group will also evaluate how new data collection regulations, or management measures (such as the landings obligation) will alter how data need to be collected and provide guidelines about biases and disruptions this may induce in time series of commercial data. WGCATCH will also continue to develop and promote the use of a range of indicators of fishery data quality for different types of end users. These include indicators to allow stock assessment and other ICES scientists to decide if data are of sufficient quality to be used, or how different data sets can be weighted in an assessment model according to their relative quality.

HAWG will report to PGDATA, WGBIOP and WGCATCH in terms of data needs using the table applied for PGCCDBS (Annex 2).

1.3.4 WGSAM

In 2014, WGSAM provided updated estimates of natural mortality for North Sea sprat and herring through a new SMS key run (WGSAM 2014). The estimated historical values differed substantially between this key run and the previous 2011 run used as a basis for the current North Sea herring management plan. These new values have been used in the benchmarks of herring in Celtic Sea to provide average natural mortalities by age and these natural mortalities used when estimating reference points. During the working group, it was discovered that there was an error in the SMS key run. Correcting this error led to historical estimates of natural mortalities that were close to the 2011 key run estimates.

In 2015, the corrections to the 2014 were further investigated by WGSAM and the corrected output was found to be of quality to be used in the assessments of HAWG. For the Celtic Sea stocks, that use time-invariant but age-varying M it was concluded that no updated time-series would be used as this would not match the perceived recent increase in predators while updated Ms were scaled downwards in the 2014 key-run compared to the 2014 key-run.

In 2016, the new multispecies key-run was used for North Sea herring. Main changes in the North Sea key run that affect the natural mortality of herring are the lower cod abundance (in numbers) and inclusion of hake into the multispecies model (Figure 1.3.4.1). Overall, this resulted in a lower overall natural mortality for herring in the order of 13% (over all ages). During the next benchmark of North Sea herring arrangements need to be made to define a process on how best to facilitate the availability of new key-run information, uptake and implementation into the assessment.

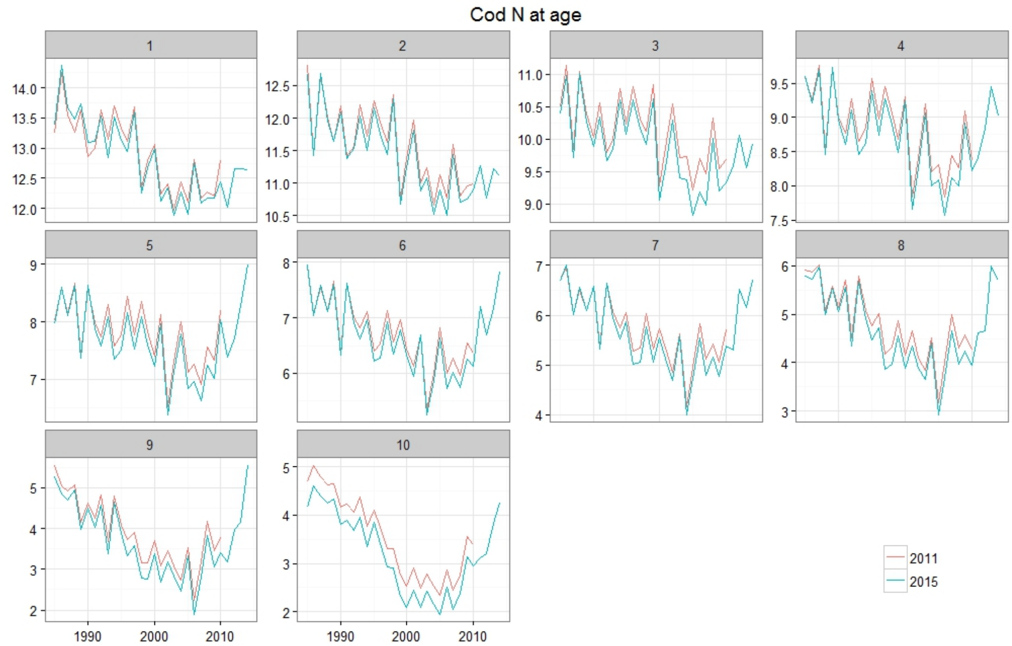


Figure 1.3.4.1 North Sea Herring. Natural mortality of herring is highly affected by abundance of cod which predates on herring. Shown here are the abundances (numbers at age) of cod as estimated in the North Sea key-run 2011 and 2015, showing the lower abundance of cod in the 2015 key-run.

WGSAM also responded to HAWG on their request for estimates of natural mortality in the Celtic Seas. A working document in annex 4 provides information on a comparison exercise executed by WGSAM, concluding that estimating M for the Celtic Seas is very difficult at this stage.

1.3.5 Other activities relevant for HAWG

An update on the work done at the University of Hamburg was given. Different scientists of the University of Hamburg have cooperated in the past with TI, IMARES, IMR and IFREMER to obtain micro- and mesozooplankton samples. These samples have been analyzed to focus on abundance, size- and biodiversity of zooplankton and to relate it to herring larval growth and survival. In line with these ongoing analysis the University of Hamburg got cruise time on the German research vessel Heincke to analyze in detail the winter prey situation in the southern bight. The strategy on how to and where to sample was discussed during HAWG to make the best use of the results for assessment and validation of the MIK and MLAI indices.

1.4 Commercial catch data collation, sampling, and terminology

1.4.1 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. 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, choosing the same (subjective) decisions currently made by the WG.

In 2016, ICES for the second time requested relevant countries within a data call to submit the national catches from 2015 into InterCatch or to accessions@ices (via the standard exchange files). National catch data submission was due by 16 March 2016. EU member states and Norway delivered their data in due time.

"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. Maximum discrepancies between the systems are presented in Table 1.5.1.

For Herring caught in the North Sea, these discrepancies were very small. The overall landings calculated by both procedures for North Sea autumn spawning herring were in close agreement. However, InterCatch does not provide the output as needed for the assessment of NSAS and WBSS.

InterCatch was used in conjunction with Salloc for herring in 6.aN for the first time in 2015 for comparison. There were some discrepancies particularly in the catch numbers between the Salloc format and InterCatch (Table 1.5.1). This will be investigated further, with the objective to move towards using InterCatch in the future. The standard Salloc methods were used to allocate samples to catch again in 2016.

More information on data handling transparency, data archiving and the current methods for compiling fisheries assessment data are given in the Stock Annex for each stock. Figure 1.5.1 shows the separation of areas applied to data in the archive.

1.4.2 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
4.a(E)	85 932	79 969	1 988	23
4.a(W)	280 600	247 868	5 820	21
4.b	72 495	56 465	1 303	18
4.c	744	0	0	0
7.d	40 324	30 024	518	13
7.a(N)	5 083	2 678	1 038	204
6.a(N)	21307	17413	1075	50
3.a	49 979	44 053	5 518	110
Celtic, 7.j	19 574	16 688	1 450	74
6.a(S), 7.b and 7.c	1073	744	438	589

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) and last amended in 2009 (Council regulations (EC) No 199/2008, No 665/2008). 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 (3.a (S) and 3.b-c)	1 sample of which	100 fish measured and	50 aged
Skagerrak (3.a (N))	1 sample	100 fish measured	100 aged
North Sea (4 and 7.d):	1 sample	50 fish measured	25 aged
NE Atlantic and Western Channel ICES subareas 2, 5, 6, 7 (excluding d) 8, 9, 10, 12, 14	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. Information and data exchange collected from samples from foreign vessels landing into different states became available to HAWG and improved the overall sampling level.

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 and incorporated into the national InterCatch upload.

1.4.3 WD on German herring fisheries

In 2015 the total German herring landings from the Western Baltic Sea in subdivisions (SD) 22 and 24 amounted to 13 289 t, which represents an increase of 30% compared to the landings in 2014 (10 241 t). This increase was caused by an increase of the TAC/quota and some further quota transfer to other countries around the Baltic Sea (German quota for SDs 22 and 24 in 2016: 12 259 t + quota-transfer of 1216 t). The fishing activities in one of the main fishing areas, the Greifswald Bay (SD 24) could start earlier than in March due to mild winter conditions in January/February. The German fishery was forced to stop their activities in April due to quota restrictions.

As in previous years only some herring was caught in the Skagerrak/Kattegat area (Division 3.a; 2015: 128 t).

No logbook registered discards or BMS landings (both new catch categories in 2015) of herring have been reported in the German herring fisheries in 2015 (no discards have been reported before 2015).

The German herring fishing fleet in the Baltic Sea consists of two fleets where all catches are taken in a directed fishery:

(1) coastal fleet with undecked vessels boats (rowing/motor boats < = 10 m and engine power < = 100 HP)

(2) cutter fleet with decked vessels and total lengths between 12 m and 34 m.

The officially reported trawl landings (t) and the referring assessment input data were not corrected for the differences in species composition in the samples.

In the western Baltic, the distribution areas of two stocks, the Western Baltic Spring Spawning herring (WBSSH) and the Central Baltic herring (CBH) overlap. German autumn acoustic survey (GERAS) results indicated in the recent years 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 (ICES, 2013). Accordingly, a stock separation function (SF) based on growth parameters in 2005 to 2010 has been developed to quantify the proportion of CBH and WBSSH in the area (Gröhsler *et al*., 2013, Gröhsler *et al*., 2016). The application of the present SF to commercial catch data in 2015, lead to similar results compared to 2005–2014. German gillnet catches in SD 22 and 24, mostly sampled at the spawning ground, consist of 100% WBSSH. The amount of CBH in trapnet and trawl landings reached 5% in numbers and 3% or 2% in biomass, respectively. As in the years before it was decided not to exclude CBH when compiling the assessment input data.

1.4.4 Terminology

The WG noted that for herring the use of “age”, “winter rings”, “rings” and “ringers” still causes confusion outside the group (and sometimes even among WG members). The WG tries to avoid this by consequently using “rings”, “ringers”, “winter ringers” or “wr” instead of “age” throughout the report. However, if the word “age” is used it is qualified in brackets with one of the ring designations. It should be observed that, for autumn and winter spawning stocks, there is a difference of one year between “age” and “rings”. Further elaboration on the rationale behind this, specific to each stock, can be found in the individual Stock Annexes. It is the responsibility of any user of age based data for any of these herring stocks to consult the relevant annex and if in doubt consult a relevant member of the Working Group.

1.5 Methods Used

1.5.1 FLSAM

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. FLSAM was used to assess North Sea herring.

FLSAM is a wrapper for the SAM 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. Western Baltic, Celtic Sea and Irish Sea herring are assessed by means of SAM.

1.5.2 ASAP

The ASAP 3 (http://nft.nefsc.noaa.gov) model has been used for a selection of stocks at HAWG. ASAP (A Stock Assessment Program) is an age-structured stock assessment modelling program originally develop by Chris Legault and Victor Restrepo while they were at the Southeast Fisheries Science Center (Legault and Restrepo 1998). ASAP is a variant of a statistical catch-at-age model that can integrate annual catches and associated age compositions (by fleet), abundance indices and associated age compositions, annual maturity, fecundity, weight, and natural mortality at age. It is a forward projecting model that assumes separability of fishing mortality into year and age components, but allows specification of various selectivity time blocks. It is also possible to include a Beverton-Holt stock-recruit relationship and flexible enough to handle data poor stocks without age data (dynamic pool models) or with only new and post-recruit age or size groups.

1.5.3 SHORT TERM PREDICTIONS

FLR

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, 6.a herring, Celtic Sea herring and Irish Sea herring forecast used the standard projection routines developed under FLR package Flash (version 2.0.0 Tue Mar 24 09:11:58 2009). For sprat in the North Sea, a forecast using the FLR framework, is in use.

1.5.4 F_{MSY} management simulations

The eqsim software (https://github.com/wgmg/msy/) was used to estimate MSY reference points for herring stocks of HAWG. No updated reference points were estimated for the sprat stocks.

1.5.5 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 was moved from google code to github in 2016 and is now available as a branch of the ICES github site. https://github.com/ICES-dk/wg_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.

1.6 Ecosystem overview and considerations

An ecosystem overview and considerations relevant for herring stocks in the areas covered by the Herring Assessment Working Group for herring stocks south of 62°N (HAWG) are documented in the HAWG herring stocks annex (her-hawg-intro). This information was documented in ICES HAWG (2015). A number of topics are covered in this annex including the use of single species assessment and management, the use of ecosystem drivers, factors affecting early life history stages, the effects of gravel extraction, variability in the biology and ecology of species and populations (including biological and environmental drivers), and disease.

It should be pointed out that whist numerous studies have greatly improved our understanding on the effects of environmental forcing on the herring stock productivity and dynamics, 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.

1.7 Data coordination through PGDATA, WGBIOP and WGCATCH

During HAWG 2016, Lotte Worsøe Clausen (DTU Aqua) compiled all issues relevant for data input to the assessments. These are stated below and will be listed in the recommendation database as recommendations for PGDATA, WGBIOP or WGCATCH or other relevant bodies.

Stock	Data Problem	How to be addressed	By who – for recommendations
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.
Sprat in the North Sea and Division 3.a	Historic bycatch information in the official sprat catches must be estimated. Sprat is caught with bycatches of juvenile herring, norway pout, sandeel and other small pelagic fish. It appears that the official records of sprat catches are higher than the WG catches which indicates that these bycatches are included in the numbers.	Historic discard information may be inferred from the distribution of sampled catch composition specifically focusing on periods of change in regulations or from fishers' private logbooks.	National laboratories, RCM North Sea and RCM Baltic
Western Baltic herring	Increased sampling of stock affiliation in catches taken in Division 6.aE	An increasing part of the catch in the North Sea is taken in Division 6.aE in which parts of the WBSS mix with the NSAS. These catches are insufficiently sampled for the stock affiliation of the herring caught there. Given that it is the faster growing part of the WBSS stock, which is found in this area from late spring to early autumn, it is important to monitor the outtake of this particular part of the WBSS stock.	National laboratories (PGDATA)
Herring in Divisions 6.aN, 6.aS, 7.b and 7.c	Improvement of baseline for splitting of herring stocks in the Malin Shelf survey	UK and Ireland to cooperate with each other to secure samples of spawning fish in each spawning component.	National laboratories; RCM Celtic Sea (PGIPS, PGDATA)
Sprat in Division 7d-e	Only 3 years of acoustic survey and no CV estimation. LPUE for 2015 is based on only one vessel. No information on stock boundaries.	Develop robust biomass/abundance indicies. Stock identifictation studies through genetics and ad hoc survey.	Cefas
Sprat in Celtic Sea	No information on stock boundaries.	Stock identifictation studies through genetics and ad hoc survey.	National laboratories

1.8 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 fishery that seasonally targets herring 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 *Scomber scombrus*, horse mackerel *Trachurus trachurus* and blue whiting *Micromestistius poutasou*). In addition, Western Baltic Spring spawners are also caught in this fishery at certain time of the year in the northern North Sea to the west of the Norwegian coast. 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 by-catch of sea mammals and birds is also very low, i.e. undetectable using observer 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" fisheries in terms of by-catch, 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 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. Relatively major changes in wind patterns may affect the distribution of larvae and early stage of herring.

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 4.a and 4.b), the Skagerrak and Kattegat (Division 3.a) and Western Baltic (SD 22–24). The fishery for human consumption has mostly single-species catches, although in recent years some mackerel by catch can occurred in the trawl fishery for herring. In addition North Sea herring are also caught within the Skagerrak. The by-catch 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 3.a and hence a limited by catch of juvenile herring. The pelagic fisheries on herring claim to be some of the "cleanest" fisheries in terms of by catch, 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 7.j (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 6.a North (part of her-6.a):

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 by-catch 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, gravel extraction and the construction of wind farms. 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 6.aN herring stock has shown a marked decline in productivity during the late 1970s and has remained at a low level since then.

Herring in 6.a South and 7.b and 7.c (part of her-6.a):

Sea surface temperature**s** from Malin head on the North coast of Ireland since 1958 indicate that since 1990 sea surface temperatures have displayed a sustained increasing trend, with winter temperatures $> 6^{\circ}$ and higher summer temperatures. 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 by-catch 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 between these populations occurs at winterrings 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 wintering 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 of some fish species.

North Sea Sprat (spr-nsea):

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 into and out of adjacent management areas i.e. 3.a and the English Channel (7.d and 7.e) or how this may vary annually. Young herring as a by-catch is acknowledged for this fishery with by-catch regulations in force. The by-catch of marine mammals and birds is considered to be very low (undetectable using observer programs).

Sprat in 3.a (spr-kask):

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. Young herring as a by-catch is acknowledged for this fishery with by-catch 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.

Sprat in the English Channel (7.d and 7.e) (spr-ech):

The fishery considered here is primarily in Lyme Bay with small trawlers targeting sprat with very little to no by-catch of other species. The relationship of the sprat in this area to the sprat stock or population in the adjacent areas is unknown: sprat larvae are most likely drift away from the main spawning area in Lyme Bay, but to which extent they expand westward into the Celtic Sea or eastern deep into the Eastern English

Channel and the North Sea is under investigation. 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 (6 and 7 (excluding 7.d and 7.e)) (spr-celt):

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 by-catch. If a fishery was to be prosecuted in the Irish Sea then by-catch of young herring may become an issue due to the overlap in distribution between young herring and 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.

1.9 Stock overview

The WG was able to perform analytical assessment for 7 of the 10 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 2015 is estimated at 1.8 million tonnes. Recruitment in 2015 is estimated as the lowest value since 2002. The estimate of 0-wr fish in 2016 (2015 year class) is estimated to be at approximately 23 billion, being low but in line with recent recruitment. Mean F_{2-6} in 2015 is estimated at approximately 0.24, which is below the management agreement target F. From 2015 to 2016, SSB is expected to increase to ~2.0 million tonnes. Under all scenarios SSB is predicted to decrease in 2017 (between 1–22% according to the scenario) and a further decline in 2018 to approximately 1.5 million tonnes. SSB is expected to be above $B_{trigger}$, and therefore also B_{pa}, in 2016, 2017 and 2018.

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. The stock has decreased consistently during the second half of the 2000s. SSB was at a minimum of about 90 000 t in 2011 and recruitment had a minimum in 2009. Under a historical perspective the estimate of SSB of 125.744 tonnes in 2015 is considered still low, but gives perception that the stock may have started to recover. Fishing mortality (F_{3-6}) was drastically reduced in 2010 (0.35) and 2011 (0.29) followed by a minor increase. The estimate of F_{3-6} for 2015 is 0.26 which is below the recommended F_{MSY} (0.32). The expected overall catch of WBSS is 56 802 t in 2017, and that will result in an expected increase in SSB to around 150 000 t in 2017 and 2018.

Herring in the Celtic Sea and 7.j (her-irls): The herring fisheries to the south of Ireland in the Celtic Sea and in Division 7.j 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 was very low in the mid-2000s, with a historical minimum SSB of 36 467 t in 2004. The stock appears recovered from that low level, but this year assessment shows a significant downward revision of the perception of SSB and estimates an SSB around 101 382 t in 2015, which is above the B_{pa} reference of 54 000 t. Several strong cohorts (2004, 2008, 2009, 2010 and 2013) 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. This year assessment estimates a fishing mortality, $F_{2–5}$ of 0.19 in 2019 which is below the updated F_{MSY} (0.26). Short term projections under the long term management plan show a decrease in SSB to respectively 74 417 t and for 2017.

Herring in 6.a: 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; in recent years misreporting has remained relatively low. The assessment is a combination of two herring stocks, one residing in 6.aS, 7.b and 7.c, and one in 6.aN. It is currently not possible to separate the two stocks for assessment purposes and therefore stock size is estimated combined. SSB is at a recent low at 205 196 t in 2015, at B_{lim}. $F_{3–6}$ is estimated at 0.07 and fishing is likely not the cause of the low stock size. The lack of recruitment in recent years leads to expected SSB of 202 073t in 2017.

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 decline 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. In 2015, SSB and recruitment have been estimated at 13 243 t and 168 215 respectively, where SSB is showing a decline from recent years as so for recruits. $F_{4–6}$ is estimated at 0.26 in 2015. Under the MSY approach the stock is expected to remain stable around 12 788 t in 2017.

North Sea Sprat (spr-nsea) 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. 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 1 July to 30 June each year, and thus provide in-year advice. The sprat stock came down from a time-series high since the early '80, driven by high recruitment in 2014. The stock appears to be above B_{pa} (142 000 t) in 2015. Fishing mortality in the last years has been around 0.45–1.27. A recent management strategy evaluation (WKMSYREF2) suggested that the current manage strategy ($B_{escapement}$) is not precautionary. In the short term projections a provisional F_{cap} value of 0.7 was used. SSB is expected to go down to approximately 206 000 t with a change in TAC of ~54% coming from a high TAC in 2015.

Sprat in 3.a (spr-kask) 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 3.a is controlled by sprat TAC and herring by-catch quota. Various assessment methods have been explored for 3.a sprat without success, and no analytical assessment is available for this stock. Short term projections are based on the IBTSQ1 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 3.a based on the ICES data limited stock approach (Category 3/4). The surveys indicate a substantial changes in the stock since 2012–2015 and therefore an increase in TAC, applying an uncertainty cap of 20%, is advised.

Sprat in the English Channel (7.d and 7.e) (spr-ech) consists of a small midwater trawl fleet targeting sprat primarily in the vicinity of Lyme Bay, western English Channel. This year ICES has provided catch advice for sprat in divisions 7.d and 7.e (primarily in the vicinity of Lyme Bay) based on criteria for data limited stocks. Data available are catches, a time series of lpue (1988–2013) and one acoustic survey that has been carried out since 2013 in the area where the fishery occurs and further offshore, also including the waters north off the Cornish Peninsula. The advice provided was based on the biomass estimates from the acoustic survey. The stock identity of sprat in the English Channel relative to sprat in the North Sea and Celtic Sea is unknown. The advice is lower than last year and is smaller than the TAC.

Sprat in the Celtic Sea (spr-celt): The stock structure of sprat populations in this eco-region (subareas 6 and 7 (excluding 7.d and 7.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 fifth year ICES provides quantitative advice for sprat in this eco-region. The quality of information available for sprat is 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., 6.a and 7.a), while Irish acoustic surveys started in 1991, with some gaps in the time series provide sprat estimates but their validity to provide a reliable sprat index is questionable because they do not always cover the core of sprat distribution in the area. Acoustic estimates in the Irish Sea are more reliable. The state of the stock of sprat in the Celtic Seas ecoregion is uncertain.

Sandeel in 4 (san-nsea): Sandeels in the North Sea can be divided into a number of more or less reproductively isolated sub-populations. 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. Since 2010 this has been accounted for by dividing the North Sea into 7 management areas. Denmark and Norway are responsible for most of the fishery of sandeel in the North Sea. The catches are largely represented by age 1 fish. Analytical assessments are performed in three of the management areas (A1–3) where most of the fishery takes place and data are available.

A1: SSB above B_{pa} (215 000 t) in 2015 but remains below the B_{lim} level of 160 000 t in 2015 (191 471 t).

A2: SSB increased from 2002, had a number of distinct peaks in 2003, 2009 and 2011, and dropped in 2012 to B_{pa} and is just above to B_{lim} since 2013. F is relatively low (around 0.1) since 2007 but increased to 0.18 in 2015. SSB is below $B_{escapement}$ in 2015.

A3: The stock has increased from the record low SSB in 2004 at half of B_{lim} to above B_{pa} in 2015 up to 246 485 t. In 2016 SSB is expected at the highest level in the time-series since the '90 at 397 000 t.

1.10 Benchmark process

HAWG has made some strategic decisions regarding the future benchmarking of its stocks (Table 1.12). In 2016/2017, it is proposed to benchmark sandeel.

Stock	Ass status	Latest benchmark	Benchmark next year	Planning Year +2	Further planning	Comments
NSAS	Update	2012	No	2018		Consider mixing with 3.a in 2016
WBSS	Update	2013	No	2018		Consider mixing with North Sea in 2016
6.a	Update	2015	No	2018*	Splitting of Malin surveys	
Celtic Sea	Update	2015	No	No		
7.aN	Update	2012	2016/2017	No		Consider survey based approaches
Sprat NS	Update	2013	No	2019	Consider stock components	Need to evaluate stock identity
Sprat 3.a	Exploratory	2013	No	2019	Consider stock components	Need to evaluate stock identity
Sprat 7.d and 7.e	Exploratory	2013	No	2019	Consider stock components	Need to evaluate stock identity
Sprat Celtic	Exploratory	2013	No	2019	Consider stock components	Need to evaluate stock identity
Sandeel areas 1–4	Update	2010	2016	No	Improve survey indices, explore environmental indicators, explore sandeel area 4 as category 1 assessment	Prediction of recruitment of short-lived species must be explored

***Provisional, depending on progress in genetic studies**

1.10.1 Benchmark planning

There is a benchmarks on Irish Sea herring scheduled for 2016/2017 in addition to the on-going sandeel benchmark.

1.10.2 Ecosystem and long-term benchmark planning

HAWG is 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.

General

- Develop assessment tools that can take account of uncertainty estimates in surveys.

North Sea Autumn Spawning (NSAS) herring

- Splitting of catches, where possible, into autumn and winter-spawning components.
- Refinement of the IBTS0 index calculation to provide component-resolved information.
- Modification of the assessment model to account for reduced precision in catch statistics prior to the 1960s.

6.a 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.

Celtic Sea pelagic ecosystem

- Identify stock boundaries for the main pelagic species inhabiting the Celtic Sea ecoregion, with main focus on Sprat.

Future plans related to ecosystem integrated advice is considered in chapter 1.8.1.

1.11 Recommendations

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

Table 1.5.1: Comparison of CANUM and WECA-estimates from conventional systems and InterCatch, by stock and age-group (winter-rings).

North Sea (47d3)							
2015	CANUM	CANUM	Proportion	2014	WECA	WECA	%
wr	Salloc	IC	Match (%)	wr	Salloc	IC	Deviation
0	538228	538253	0.000	0	0.009	0.009	0.000
1	394878	394817	0.000	1	0.026	0.026	0.000
2	551802	554209	0.004	2	0.114	0.114	0.001
3	247555	246488	-0.004	3	0.154	0.154	0.000
4	282813	283540	0.003	4	0.188	0.188	0.000
5	461041	460446	-0.001	5	0.200	0.200	-0.001
6	432034	430137	-0.004	6	0.221	0.221	0.000
7	271280	270353	-0.003	7	0.217	0.217	0.000
8	167509	166368	-0.007	8	0.226	0.226	0.000
9+	170302	170313	0.000	9+	0.243	0.243	-0.001
Sum	3517441	3514923	-0.001				

Her 6.aN	Ring	Intercatch	Sallocl	% Deviation
CATON		18791	18801	0.05
CANUM	1	254.45	231.18	-9.14
CANUM	2	11117.85	10854.96	-2.36
CANUM	3	14065.75	13937.56	-0.91
CANUM	4	15431.88	15716.6	1.84
CANUM	5	20136.53	19386.7	-3.72
CANUM	6	21351.34	21621.33	1.26
CANUM	7	6177.65	6397.35	3.56
CANUM	8	1901.85	1932.73	1.62
CANUM	9	1240.71	1250.55	0.79
WECA	1	0.07748	0.0769	-0.75
WECA	2	0.13793	0.1425	3.31
WECA	3	0.17712	0.1795	1.34
WECA	4	0.20142	0.2059	2.22
WECA	5	0.21105	0.2136	1.21
WECA	6	0.22771	0.2307	1.31
WECA	7	0.23665	0.2386	0.82
WECA	8	0.24418	0.2454	0.50
WECA	9	0.27279	0.2685	-1.57

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			
6.aN herring			X				X
6.aS herring		X	X			X	X
7.aN herring					X		
Celtic Sea herring		X	X	X		X	X
North Sea sprat	X	X		X	X	X	
3.a sprat							

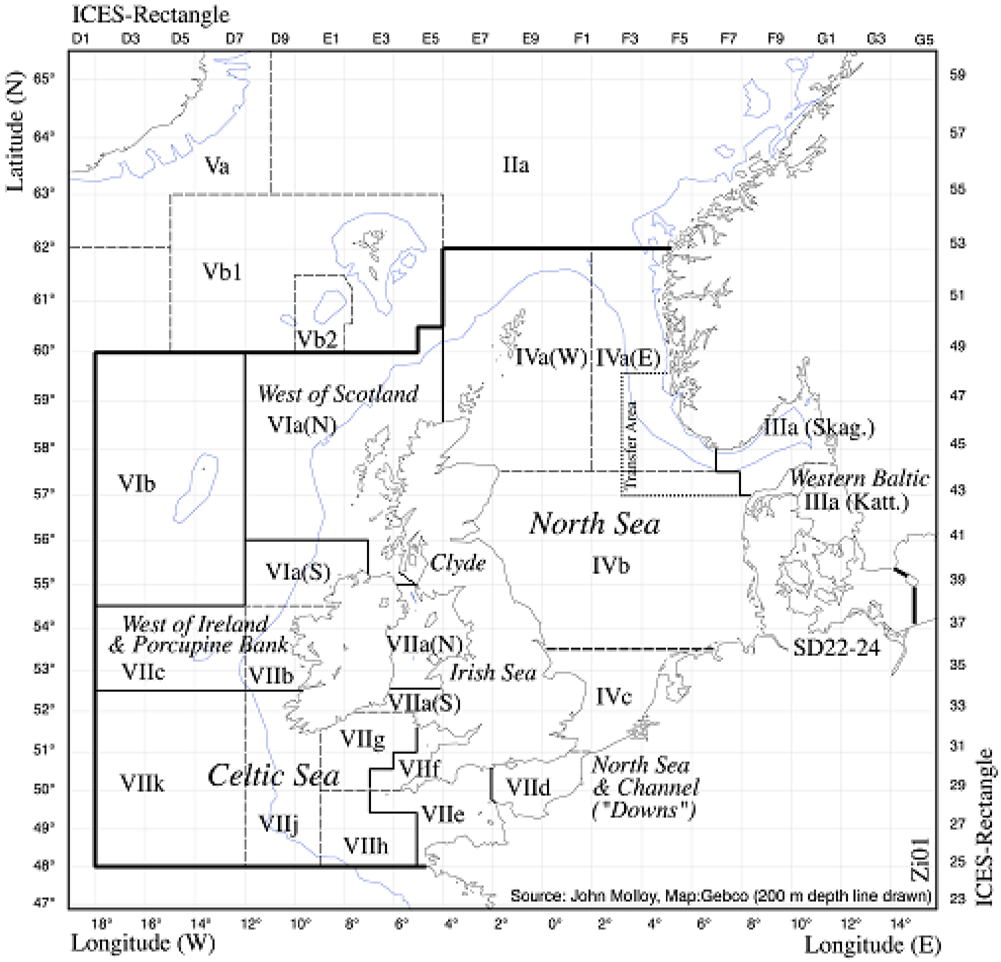


Figure 1.5.1 ICES areas as used for the assessment of herring stocks south of 62°N. Area names in italics indicate the area separation applied to the commercial catch and sampling data kept in long term storage. "Transfer area" refers to the transfer of Western Baltic Spring Spawners caught in the North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

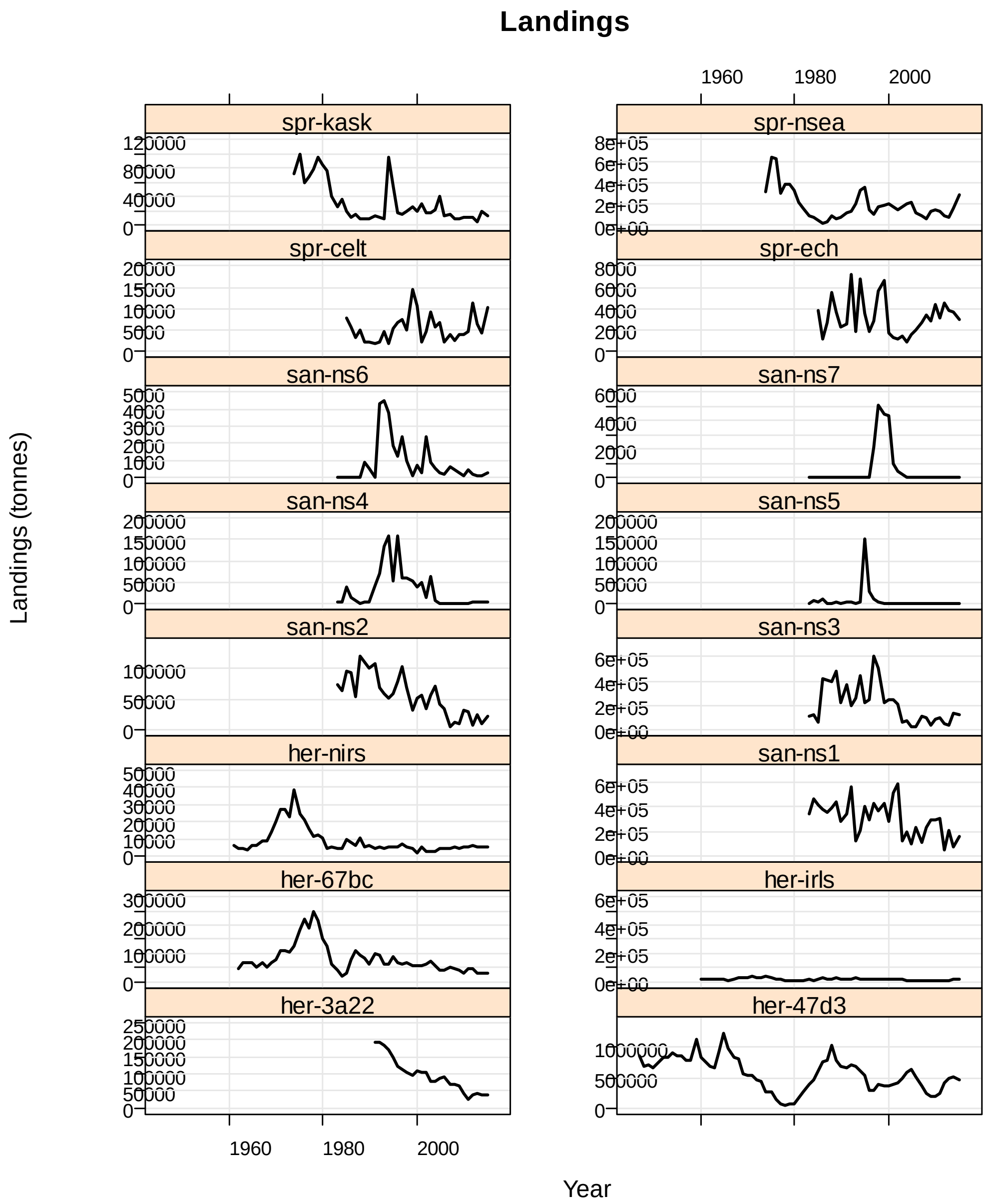


Figure 1.11.1 WG estimates of catch/landings (yield) of the herring and sprat stocks presented in HAWG 2016.

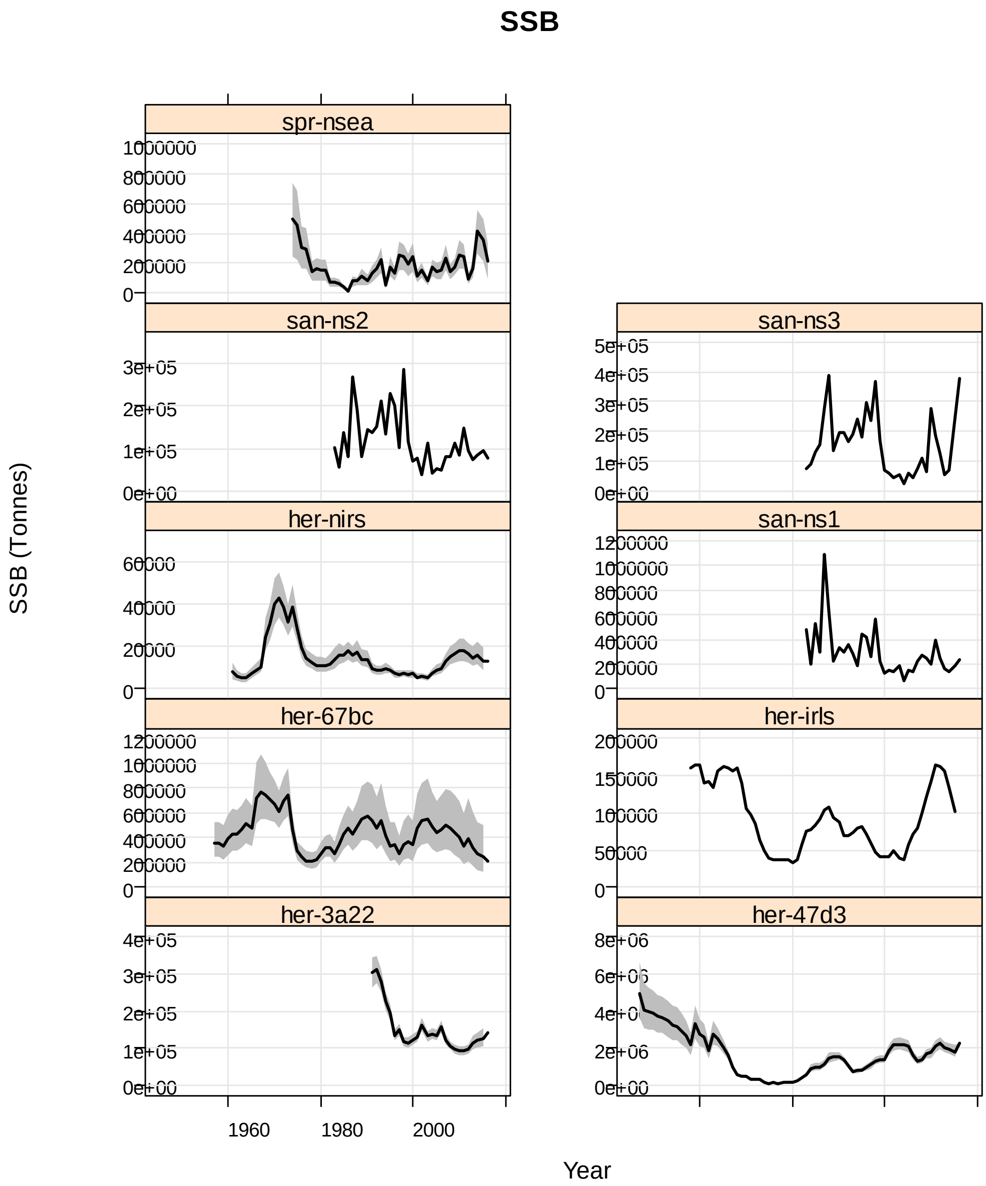


Figure 1.11.2 Spawning stock biomass estimates for the sprat and herring stocks under analytical assessment presented in HAWG 2015.

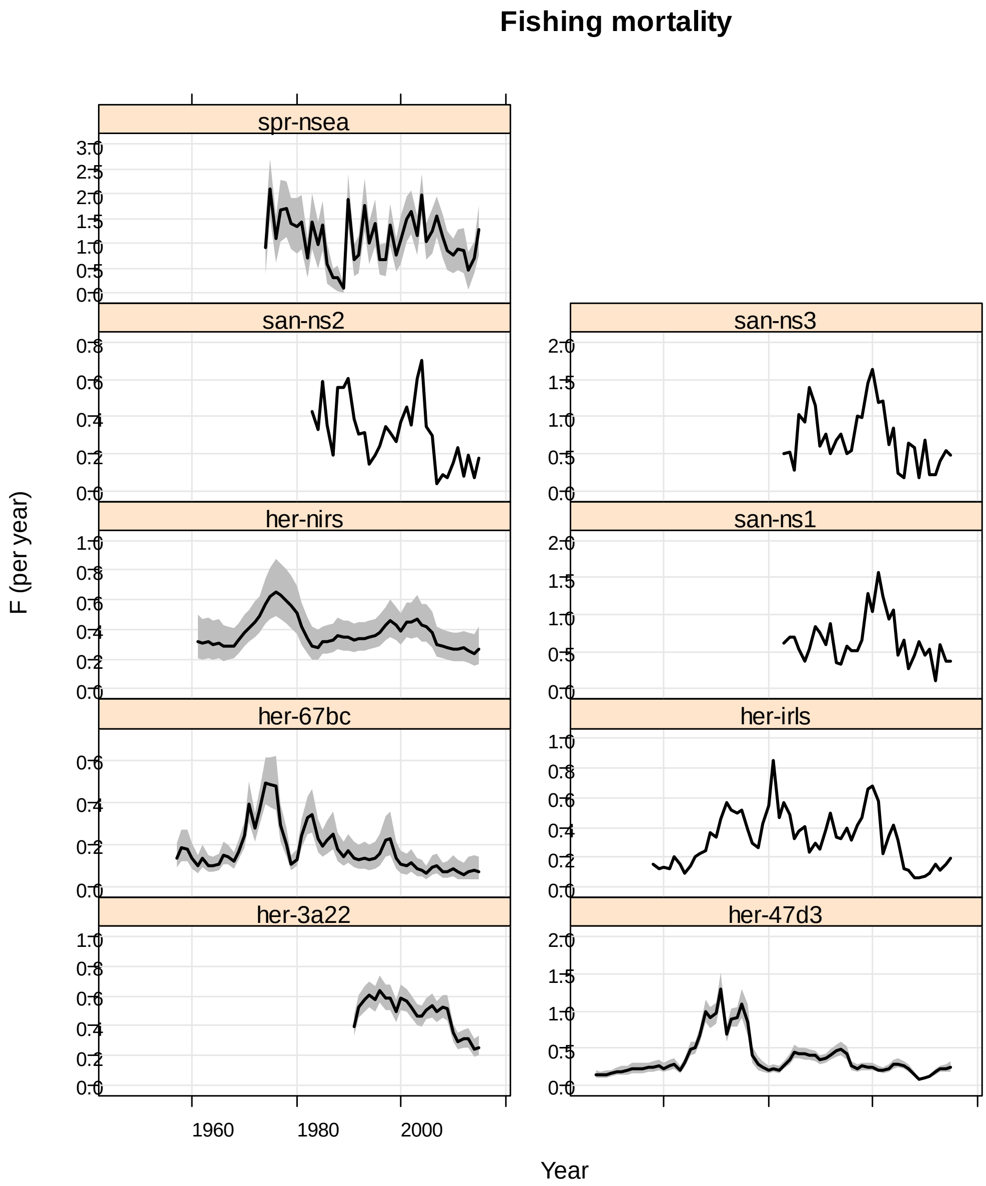


Figure 1.11.3 Estimates of mean F for the sprat stock and herring stocks under analytical assessment presented in HAWG 2015.

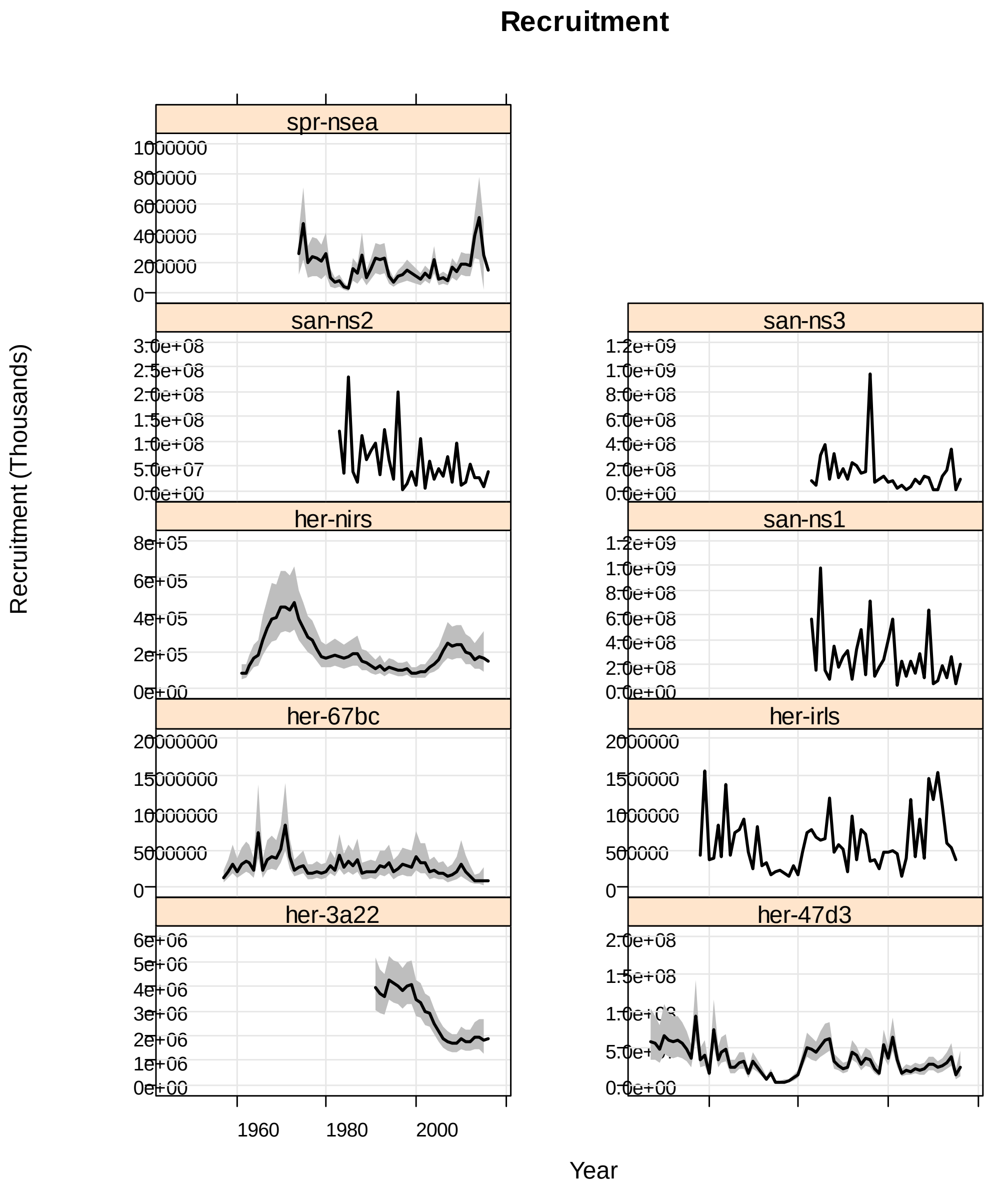


Figure 1.11.4 Estimates of recruitment for the sprat stock and herring stocks under analytical assessment presented in HAWG 2016.

2 North Sea Herring

The WG noted that the use of “age”, “winter rings”, “rings” and “ringers” still causes confusion outside the group (and sometimes even among WG members). The WG tries to avoid this by consequently using “rings”, “ringers”, “winter ringers” or “wr” instead of “age” throughout this section. However, if the word “age” is used it is qualified in brackets with one of the ring designations. It should be observed that, for autumn and winter spawning stocks, there is a difference of one year between “age” and “rings”, which is not the case for the spring spawners. Further elaboration on the rationale behind this, specific to the North Sea autumn spawners, Western Baltic Spring Spawners and the mixed stock catches, can be found in the Stock Annexes. It is the responsibility of any user of age based data for any of these herring stocks to consult the relevant annex and if in doubt consult a relevant member of the Working Group.

2.1 The Fishery

2.1.1 ICES advice and management applicable to 2015 and 2016

According to the management plan agreed between the EU and Norway, adopted in December 1997 and amended in November 2007, every effort should be made to maintain a minimum level of spawning stock biomass (SSB) of North Sea Autumn Spawning herring greater than 800 000 tonnes. The management plan is given in Stock Annex 3.

The final TAC adopted by the management bodies for 2015 was 461 073 t for Area 4 and Division 7.d, where no more than 48 986 t should be caught in Division 4.c and 7.d. For 2016, the total TAC was increased by 15% to 531 624 t (518 242 t for the A-Fleet), including a TAC of 57 0076 t for Division 4.c and 7.d.

The by-catch TAC for the B-Fleet in the North Sea (and Division 2.a) was 15 744 t in 2015 and has decreased by 15% to 13 328 t for 2016. As North Sea autumn spawners are also caught in Division 3.a, 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 2015

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.

The total WG catch of all herring caught in the North Sea amounted to 481 611 t in 2015. Official catches by the human consumption fishery were 472 168 t, corresponding to a slight overshoot of 6% of the TAC for the human consumption fishery (445 329 t). As in previous years, the vast majority of catches are taken in the 3rd quarter in Division 4.a(W).

In the southern North Sea and the eastern Channel, the total catch sums to 41 068 t. The separate TAC for this area was 48 968 t, so 16% of the TAC remains in Division 4.c and 7.d (but due to catch regulations, 50% of the TAC could have been taken in Division 4.b). The reduced catch continues to relieve the fishing pressure on the Downs stock component, as observed since 2012.

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 decreased considerably by 43% to 7 909 t in 2015 (Table 2.1.6). The by-catch ceiling for the B-Fleet was 15 744 t. Since the introduction of yearly by-catch ceilings in 1996, these ceilings have only fully been taken in 2014.

The total North Sea TAC and catch estimates for the years 2010 to 2015 are shown in the table below (adapted from Table 2.1.6).

Year	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
TAC HC (‘000 t)	164	200	405	478	470	445
“Official” landings HC (‘000 t) *	166	209	414	490	490	472
Working Group catch HC (‘000 t)	166	209	414	490	493	474
Excess of landings over TAC HC (‘000 t)	1	9	9	12	23	28
By-catch ceiling (‘000 t) **	14	17	18	14	13	16
Reported by-catches (‘000 t) ***	9	9	11	8	14	8
Working Group catch North Sea (‘000 t)	175	218	425	498	507	482

HC = human consumption fishery

*** 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.**

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

***** 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 6.aN was relaxed. The minimal amount of target species in the EU industrial fisheries in 3.a has been reduced to 50% (for sprat, blue whiting and Norway pout).

In 2016, half of the EU quota for Division 3.a can be taken in the North Sea (4); based on correspondence with the Pelagic RAC, HAWG notes that this transfer will be in the same order of magnitude as in 2015 (46%). Norway can take up to 50% of its quota for Division 3.a in the North Sea (4).

In the North Sea, Norway can take up to 50 000 t of its quota in EU-waters in Divisions 4.a and 4.b. 50 000 t of the EU-quota can be taken within Norwegian waters south of 62°N.

Half of the EU quota for Division 6.c and 7.d can be taken in Division 4.b. However, no information on the occurrence of such transfer is available to the HAWG.

In 2014, an agreed record between EU and Norway was applied, enabling an inter-annual quota flexibility of 10% of the TAC. Each party could transfer non-utilised quota of up to 10% of its quota into the next year, where it is added to the quota allocated to the party concerned in the following year (or borrow 10% of the TAC, to be subtracted the following year). This inter-annual flexibility has changed in 2015 so that 25 % of the TAC can be transferred into the next year, while up to 10 % can be borrowed.

HAWG has not applied this record to national catches, e.g. to what extent or which party may have used this annual quota flexibility.

Since 2015, a landing obligation is in place for pelagic fleets operating in the North Sea and the Baltic. All catches have to be landed into port.

2.1.4 Changes in fishing technology and fishing patterns.

There have been no major changes to fishing technology of the fleets that target North Sea herring.

The fishery concentrated in the north-western part of the North Sea, around the Fladen Ground area (Fig 2.1.1 a-e). Some rectangles yielded higher catches compared to the previous year, especially rectangle 49F2 (from 8 500 to 46 500 t). The majority of catches is still taken in Subdivision 4.aW, in the order of 60% of the total. After a drop in Subdivision 4.aE down to 9% in 2014, catches re-increased to 18% of the total North Sea catch. (2013: 16%).

After a sharp reduction in the catches taken in Division 4.b in 2010, the proportion of catches in this area have increased again and contributed roughly 20-25% to the total catches since 2011. In 2015, this area yielded 15% of the catches. The utilisation of catches in Divisions 4.c and 7.d has decreased since 2010. As in 2014, the southern North Sea contributed only 8% to the catch, while they were in the range of 15% for the period before 2010. The TAC in this Division is not fully taken since 2012. Catches in Division 4.c were only 744 t in 2015.

As in former years, most of the catches in the B-Fleet are taken in Division 4.b (> 80%). The by-catch ceiling for this fleet has not been not fully taken in 2015.

After a substantial decline in misreporting since 2009, misreporting was regarded as a minor problem in the herring fishery. However, misreporting did occur in 2015, but the quantities (1 500 t) are still much lower than it had been prior to 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 4.aE), and for the total NSAS stock, including catches in Division 3.a.

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

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 1999-2014 (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 3.a
- 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 2004-2014.

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

The total number of herring taken in the North Sea is 3.2 billion fish and NSAS amounts to 3.5 billion fish in 2015. The proportion of 0- and 1-ringers of herring taken in the North Sea is 23% of the total catch in numbers in 2015 (Table 2.2.5), compared to 36% in 2014. Most of these young herring are still taken in the B-Fleet in Division 4.b. Here, 0- and 1-ringers amount to 62% of the total catch in numbers.

The proportion of 3+ winterring herring has increased to 63% of the total catch in numbers taken in the North Sea (compared to 56% in 2014).

Western Baltic (WBSS) and local Division 3.a spring-spawners are taken in the eastern North Sea during the summer feeding migration (see Stock Annex 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 3.a/Western Baltic in 2000-2015. After splitting the herring caught in the North Sea and 3.a between stocks, the total catch of North Sea Autumn spawners amounts to 494 089 tonnes.

Area	Allocated	Unallocated	Discards	Total
4.a West	280 600	1939	-	282 539
4.a East	85 932	-423	-	85 509
4.b	72 495	-	-	72 495
4.c/7.d	41 068	-	-	41 068
	Total catch in the North Sea			481 611
	Autumn spawners caught in Division 3.a (SOP)			14 692
	Baltic spring spawners caught in the North Sea (SOP)			-2 204
	Blackwater spring spawning herring			-10
	Other spring spawners			0
	Total catch NSAS used for the assessment			494 089

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 4.a (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 reduction in biomass of these spring spawning herring in most recent years, the catches have decreased to 2 191 t in 2015.

Blackwater herring are caught in the Thames estuary under a separate quota and included in the catch figure for England & Wales. In 2015, catches were in the range of 10 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

In the recent years, some nations provided information on misreported and unallocated catches of herring in the North Sea and adjacent areas. Misreporting did occur between Subdivision 6.aN-4.a(W) and 4.a(E)-4.a(W), but in general 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 almost in the same order of magnitude as the official catch.

Since 2015, a landing obligation is in place for pelagic fleets operating in the North Sea and the Baltic. All catches have to be landed into port. Two nations reported catches in the BMS category (below minimum landing size, including any fishes lost or damaged during processing procedures), while some countries stated these to be zero, and other countries have not reported catches in this category. The BMS catches in the North Sea in 2015 sums to 334 t. This is less than 0.1 % of the total catch. The reported BMS catches are included in the national catch figures. In accordance with the landing obligation, no discards were reported in the 2015 North Sea herring fishery.

The sampling of commercial landings covers 86% of the total catch (2014: 83%). The number of herring aged is higher than in 2014 (+9%), and those measured have increased considerably by almost 74% (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 107 different reported metiers, only 34 were sampled in 2015. The recommended sampling level of more than 1 sample per 1 000 t catch has been met for 19 metiers. With regards to age readings, 21 metiers appear to be sampled sufficiently (recommended level >25 fish aged per 1 000 t catch).

However, some of the metiers yielded very little catch. In 61 metiers the catch is below 1 000 t. The total catch in these metiers sums to 9 883 t, so the remaining 46 metiers represent 471 725 t of the working group catch (98%). Of these 46 metiers 29 were sampled. Only 14 fulfil the recommended level of more than 1 sample per 1 000 t catch; additionally 16 fulfil the criteria of 25 age readings per 1 000 t catch.

According to the DCF regulations, some catches of UK(England & Wales) and France 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 6.a(N) and the Malin Shelf area (MSHAS) in June–July 2015

Six 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 around 200 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 2015/SSGIEOM:05). 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 strata and distributions of mean weight- and proportion mature-at-age.

The estimate of North Sea autumn spawning herring spawning stock biomass is slightly lower than previous year at 2.3 million tonnes but is comprised of a similar number of fish.

The abundance of mature fish of 14 222 million in 2015 is comparable to the 2014 estimate of 14 392 million (Table 2.3.1.2). The drop in SSB is caused by a significant decrease in the mean weight of the mature fish from 181.4 g in 2015 to 160.3 g this year. This is due to a combination of two factors. The mean weight is decreased for all ages apart from 1 winter ringers this year compared to last year. In addition the stock has seen a large increase in 2 winter ring fish and a small decrease in abundance of all older ages in effect shifting the abundance to a larger amount of smaller fish. The large increase in 2 winter ringers confirms the strength of this large 2013 year class.

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

The spatial distribution of herring from the survey is shown in figures 2.3.1.2. The distribution of adult herring in the North Sea is still concentrated in the areas east and north of Scotland. Similarly to last year the distribution is stretching south in the western North Sea.

Immature herring was largely distributed in the central North Sea and less abundant along the Danish west coast.

The 2007 year class (6-winter rings this year) continues to grow very slow and mean weight is still lower than the one year younger fish (Table 2.3.1.3).

Quality considerations

Changing analysis tool

The global estimates for 2015 were for the first time calculated based on disaggregated acoustic and biological data in the StoX software.

The effect of changing from one analysis method to another was thoroughly investigated. It was shown that the effect of changing the calculation method to StoX had very little effect on the resulting indices carried forward to the stock assessment process. WGIPS was therefore confident that the latest index at age for North Sea herring is comparable to the existing time series (WGIPS, ICES 2016).

Stock splitting methods

At the present two different methods are used within the survey to assign herring in the splitting area to the North Sea autumn spawning stock or the Western Baltic spring spawning stock. These methods have been developed independently within national laboratories, but have not been calibrated against each other so far. To ensure resilience in the consistency over the time series the two methods should be calibrated against each other. And ideally, the method should be standardised across the surveys to use one common method for all splitting between the two stocks. HAWG is planning a workshop in 2017 to address this issue.

Maturity

This year, immature fish > age 4 were reported. In the past, fish 5 wr or older were all assumed mature by definition in the result reported by WGIPS. This is a decision that should be made in the assessment working group for each assessment, and the underlying data should be collected and reported as actually observed. This will be the case in the future also.

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

Six survey areas were covered within the framework of the International Herring Larval Surveys in the North Sea during the sampling period 2015/2016. They monitored the abundance and distribution of newly hatched herring larvae in the Orkney/Shetland area, Buchan and the central North Sea in the second half of September and in the southern North Sea in the second half of December 2015 as well as in the first and second half of January 2016. The survey in December could only sample half of the planned stations. Unfavourable weather conditions causes winch problems, thus the survey had to be stopped earlier than expected. However, the main spawning area seems to be covered.

Compared to the previous year, the total number of newly hatched larvae in the Orkney/Shetland region is quite substantial, but not at the record highs as seen in 2012 and 2013. Buchan and Central North Sea indicate successful hatching of larger quantities of herring larvae. The estimate for the central North Sea has increased compared to 2014, but this area is known to be very variable.

The abundance of newly hatched larvae in the southern North Sea is strikingly low in the most recent sampling period. While the overall distribution of larvae and thus the spawning area used by herring is not obviously different from preceding years, the abundance of larvae is much lower than expected and more comparable to the situation in the mid-1990s and before. Larger quantities of foraging larvae which may have been hatched in the English Channel were found during the 1st quarter IBTS (MIK survey), but at the moment it is not possible to trace their origin reliably down to the spawning area.

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 is lower compared to 2014, reflecting the decrease in larvae abundance in the southern North Sea (Tab. 2.3.2.1). The corresponding SSB is found to be around 1.6 million tonnes.

During the most recent benchmark of the North Sea herring assessment (ICES, WKPELA 2012), it was decided to replace the MLAI model by the Spawning Component Abundance Index (SCAI) model (Payne 2010). This index also monitors dynamics on a component level in addition to the total stock dynamics. The most recent SCAI index has decreased as compared to 2014 and 2013 (Tab. 2.3.2.1). More details on the SCAI are given in section 2.11.

2.3.3 International Bottom Trawl Survey (IBTS-Q1)

The International Bottom Trawl Survey (IBTS) provides the time series for 1-ringer herring abundance index in the North Sea from GOV catches carried out during day-time. In addition, night time catches with a fine meshed 2 m ring trawl provide abundance estimates for large herring larvae (0-ringers) of the autumn spawning stock components. For more details on the times series, the reader is referred to the previous reports of the working group.

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, 661 depth-integrated hauls were completed with the MIK-net. The coverage of the survey area was very good with at least 2 hauls in most of ICES rectangles in the North Sea as well as in Kattegat and Skagerrak. Few rectangles rectangles were only sampled once while there were no rectangles that couldn't be sampled at all. Index values are calculated as described in detail in the Stock Annex. This year, there were 66 hauls from the area south of 54° N with mean larval length <20mm which had to be excluded from the index calculation as specified in the calculation procedure. The index is, thus, calculated from the results of 595 hauls, and 4 rectangles, 30F0, 34F4, 36F4 and 36F6, in the Southern Bight and southern North Sea 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 stations from the index should provide that the Downs component is not accounted for in the IBTS0 index.

Larvae measured between 7 and 39 mm standard length (SL). Contrasting to the previous years, the smallest larvae < 10 mm were much less numerous, while large numbers of medium sized larvae around 18 mm SL were caught (Fig. 2.3.3.1). The smallest larvae were chiefly caught in 7.d and in the Southern Bight. The medium sized larvae appeared chiefly and in large quantities in a band stretching along the Dutch, German and Danish coasts as far North as north of 56°N. This resulted in a large number of stations with mean larval sizes < 20 mm SL north of 54°N that had, thus, to be kept in the index calculation. These small larvae can be assumed to represent the Downs larvae. Larger larvae were comparatively rare and much less abundant.

The time series of IBTS0 estimates according to the standard index calculation algorithms is shown in Table 2.3.3.1. The new index value of 0-ringer abundance of the 2015 year class is estimated at 99.8.

This index is much larger than last year's estimate for the 2014 year class. It is 92.5 % of the long term mean, and would indicate at the second highest recruitment since the year class of 2001. Overall, the larval herring abundance was low. Larvae were predominantly found in the more coastal areas in the North Sea, while the central North Sea, but also Kattegat and Skagerrak were almost devoid of larvae. Only in a few rectangles of the Southern Bight and in the German Bight mean abundance was exceptionally high. Only six of the rectangles in those areas (35F4, 39F6, 38F6, 38F7, 34F3, and 37F6) with most of the larvae around or less than 20 mm SL contributed to more than 65 % of the total index. (Figure 2.3.3.2). It is obvious that similarly to the high index in 2014, this year's 0-ringer index has to be treated with some care (see above).

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

The 1-ringer recruitment estimate (IBTS-1 index) is based on GOV catches in the entire survey area. The time series for year classes 1977 to 2014 is shown in Table 2.3.3.2. This year's 1-ringer index for the 2014 year class is only about the fifth of the index for the 2013 year class from last year's survey. The index from the 2016 survey of 779 is at 39.4 % of the long term mean and is the lowest on record since the 1997 yearclass and the second lowest since the 1979 yearclass. Figure 2.3.3.3 illustrates the spatial distribution of 1-ringers as estimated by trawling in January/February 2014, 2015 and 2016. In previous years, the main areas of 1-ringer distribution are in the German Bight and south of Dogger Bank. For the 2013 year class, however, the majority of the 1-ringers were distributed in the central part of the southern North Sea and the Kattegat. This year, 1-ringer herring were only found in the southeastern North-Sea and in the Kattegat at mostly very low abundances. In the Kattegat, abundances were the highest, and there was one rectangle, 36F7, in the German Bight that showed the single highest abundance. It appears noteworthy, that the two recent 1-ringer abundances correspond very well to their 2 respective 0-ringer indices, despite their apparently biased nature.

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 4 and 3.a from the North Sea acoustic survey (HERAS) as well as the mean weights-at-age in the catch from 1996 to 2015 for comparison. The data for 2015 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.

The mean weights in the acoustic survey in 2015 were lighter for all groups from 2-wr onwards compared to those in the catch (Figure 2.4.1.1).

In 2015, not all age groups had similar mean weights-at-age compared to 2014. A general trend towards smaller mean weight at age can be observed in the acoustic survey, while no such tendency is obvious in the mean weight-at-age in the catches. Here, the mean weight of 6-wr fish has increased compared to 2014. The mean weight-at-age of the 7-wr were lower than the 6-wr in both the survey and catch. This cohort (2007 year class) seems to have been growing slower throughout the years and was also the year class exhibiting greatly reduced maturity as 2-wr in 2010 and 3-wr in 2011.

2.4.2 Maturity ogive

The percentages at age of North Sea autumn spawning herring that were considered mature in 2015 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). Maturity at age of 2-and 3-wr herring was lower as in 2014, and even 4-wr fish were not fully mature. However, maturity estimates were still in the range of those found in previous years and not strikingly low. While 5+ group herring were considered fully mature in the period prior to 2015, WGIPS reported maturity stage for all groups up to 7+ separately this year.

2.4.3 Natural mortality

One of the improvements of the latest benchmark of the North Sea herring stock (ICES, WKPELA 2012) was 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. Natural mortality in years outside the time-period covered by the model are filled and estimated for each age as a five year running mean in the forward direction and in the reverse direction for years prior. 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. The time series of M adopted at the benchmark in 2012 was from the 2011 keyrun of the SMS model covering the period 1963 – 2010 (WGSAM 2011). Detailed explanation regarding the natural mortality estimates used to 2015 can be found in the Stock Annex.

A new time-series from WGSAM 2014 was made available to HAWG for use in the assessment in 2015. However, during HAWG 2015 the chair of WGSAM reported an error in the new estimates of natural mortality for herring in the North Sea. Thus this time-series was not used and the 2015 assessment incorporated the SMS run as obtained in 2011 (Figure 2.4.3.1 (left panel).

The natural mortality time series has now been revised following the new SMS model North Sea 2015 key run (WGSAM 2015). This new key run was adopted by HAWG 2016 for the assessment of North Sea herring in 2016. Main changes in the North Sea key run that particularly affected the natural mortality of herring are the truncation of the time series to 1974 – 2014, lower cod abundance, lower whiting abundance and inclusion of hake into the multispecies model. Overall, this resulted in a lower overall natural mortality for herring in the order of 13% (over all ages, Figure 2.4.3.1, right panel).

2.4.3.1 Comparison between the 2015 and 2011 multispecies key run natural mortalities for herring

The changes introduced from 2011 to 2015 in the WGSAM reviewed North Sea SMS key run include lower historical cod catches, higher biomass of medium-large grey gurnards and large starry rays, inclusion of hake, revision of mackerel assessment, revision of the haddock stock definition and the division of sandeel into two stocks. Together, these changes resulted in lower cod biomass and hence predation by cod, higher predation by grey gurnards and starry ray and increasing predation by hake.

Lower cod biomass occurred as a result of the revision of historical catches to a lower level of unallocated mortality and as a result, the main prey of cod were predicted to have a lower natural mortality. In some species, this effect was counteracted by the increased estimated biomass of grey gurnards, starry ray and, in the later years, hake. However, these predators did not have a substantial effect on the natural mortality of large (3+) herring, and hence the estimated natural mortality of these were reduced as a result of the lower cod biomass following the lower historic cod catches (Figure Figure 2.4.3.1.1). With the decrease in biomass of large cod M of 2+herring has decreased over time, but here the effect is counteracted in later years as the biomass of large hake and grey gurnard have increased.

WGSAM discussed these features of the results in detail and concluded that (WGSAM 2014, 2015):

- The 2015 key run time series is seen as more accurate than the previous time series as the change in historic catches by WGNSSK is based on the best available knowledge
- The increased cod biomass in the last two years is uncertain and hence smoothing the values at least in the last years of the period is recommended

WGSAM does not recommend updating existing data series of natural mortality by simply adding the latest three new years. The time series as a whole shows patterns which are not retained by this procedure. For example, herring shows an increased natural mortality over the past decade, but adding only the latest three years will give the impression that natural mortality has decreased over the last five years.

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 have deviated between the two indices. However, with the 2013 year class there was once again good agreement between the two indices. In 2014 it was recorded as the largest 0-ringer abundance since 2002, and the strength of this year class was confirmed in 2015 with one of the largest 1-ringer abundances. This is the first strong year class observed since 2002. The 2015 IBTS0 index indicated that the 2014 year class is another poor year class and this was also confirmed in the IBTS-1 index this year (Figure 2.5.2).

2.6 Assessment of North Sea herring

2.6.1 Data exploration and preliminary results

The last benchmark (2012) decided on revised input data sources and assessment methods which are described in the WKPELA report (ICES, WKPELA 2012) and in the Stock Annex. 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 library (Kell *et al.* 2007).

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 scrutinised to check for potential problems.

Natural mortality has been revised following the new North Sea key run (WGSAM 2015, also see section 1.3.4 and 2.4.3). Overall, this resulted in a lower overall natural mortality for herring in the order of 13% (over all ages).

The proportion mature of 2, 3 and 4-wr in 2015 was average (0.70, 0.90 and 0.96 respectively) and lower than last year (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.

Survey indices are shown in Figure 2.6.1.4. The SCAI estimate for 2015 is still high (2.7 times the average from the survey), although the index is somewhat lower than the highest values of 2013.

The latest observations from the IBTS0 index show a strong 2013 yearclass, a very weak 2014 yearclass and an around average 2015 yearclass.

The pattern of the IBTS-Q1 1-wr confirms the strong 2013 yearclass and the weak 2014 yearclass.

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 and 2.6.1.4b). 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 2.6.1.27). 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 (Figure 2.6.1.26). This likely indicates a trade-off in model fit to either the age 7 or age 8+ catch information. There is a methodological need however to link age 7 and age 8+ together in the stock assessment model. The residuals are very small and are not considered an issue for the performance of the assessment.

The SCAI survey fit shows a clear residual pattern (Figure 2.16.1.15), 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.

The acoustic survey residuals show a negative year effect in 2007 and a positive year effect in 2010 (Figure 2.6.1.27).

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 2.6.1.28). 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 IBTS0 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 2.6.1.29). However, the CVs do not indicate a lack of convergence of the assessment model.

The analytical retrospective pattern shows a very similar perception in F for the years 2009—2014 (Figure 2.6.1.30).

Figure 2.6.1.31 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 2.6.1.32).

2.6.2 Exploratory Assessment for NS herring

By way of exploratory assessment, the working group carried out a comparison between the fishing mortality estimated in the SAM model and the F-proxy ('harvest rate') derived by dividing the catch number at age by the acoustic index at age (i.e. the acoustic index was treated as a measure of stock size). In order to compare the fishing mortality from the SAM model with the F_{proxy}, both series were scaled to the mean for each age separately. Results show that, apart from age (wr) 0, the two series are very consistent. This indicates that the F pattern in the assessment is to a large extend derived from the catch data and the acoustic survey data (Figure 2.6.2.1).

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.

Overall, the revision of the natural mortality in the 2016 assessment has resulted in a downward revision of SSB (-16%) and an upward revision of fishing mortality (+14%) compared to using the old natural mortality time series, for the period 1985-2015 (Figure 2.6.3.3)

The spawning stock at spawning time in 2015 is estimated at approximately 1.8 million tonnes, which is substantially lower than the 2015 intermediate year estimate of 2.2 million tonnes. This is partly due to the new natural mortality values being used and due to the decline in the stock.

The abundance of 0-wr fish in 2016 (2015 year class) is estimated to be at approximately 23 billion, which is 17% below the long term geometric mean (see Table 2.6.3.14).

Mean $F_{2\text{-}6}$ in 2015 is estimated at approximately 0.24, which is below the management agreement target F. The mean $F_{0\text{-}1}$ is 0.045, which is just below the agreed ceiling.

2.6.4 State of the Stock

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. Fishing mortality is below the estimated F_{MSY} (0.27) and the management plan target (0.26).

The SSB in autumn 2015 was estimated at 1.8 million t, which is above B_{pa} (1.0 million t) and the biomass trigger in the management plan (1.5 million t).

The 2015 year class is estimated to be 17% lower than the long term geometric mean recruitment.

A remarkable feature of the assessment this year is the high fishing mortality on older ages in recent year. According to the assessment, the fishing mortality at age 7 is around 0.67, which is substantially higher than mean fishing mortality. The same signal is observed when using only the acoustic survey and the catch data. Apparently, the catches at the older ages are relatively high compared to the estimated stock size at those ages (figures 2.6.1.2 and 2.6.1.4b).

2.7 Short term predictions

Short term predictions for the years 2016, 2017 and 2018 were done with code developed in R software. In HAWG 2015, a modification to the code had to be made to allow for the estimation of the C-fleet outtake. Because of the 2015 EU-Norway management rule, the C-fleet no longer takes a fixed catch outtake, but the outtake is calculated as 5.7% of the sum of the A fleet TAC in the forecast year and 41% of the Western Baltic Spring Spawning TAC both multiplied with the proportion of NSAS in the catch.

In the short term predictions, recruitment is assumed constant for the years 2017 and 2018 following the same recruitment regime since 2002 (geometric mean of 2004 to 2014 year classes). The recruitment estimate of the 2015 year class, obtained from the assessment served as the estimate for 2016.

For the intermediate year (2016), no overshoot for the A fleet was assumed, as there was minimal deviation from the TAC in 2015. Negotiations between the EU and Norway resulted in the allowance of 50% of the C-fleet TAC in the Kattegat-Skagerrak area to be taken in the North Sea. In 2015, the pelagic AC was requested to estimate the percentage of the 3a herring TAC that would be taken in the North Sea under this regulation. The pelagic AC estimated it at 46%. The same proportion has been used in this forecast.

The expected catches of Western Baltic Spring Spawning herring caught under the North Sea TAC are deducted from the expected A fleet catches (amounting to 2 205t).

For the B-fleet, 60% of the agreed by-catch ceiling in 2015 has been used.

For the C and D fleets, the fraction of North Sea Autumn Spawning (NSAS) herring caught in 3a is used to derive C and D fleet NSAS catches, based on projected TACs in 3a for these fleets. See Table 2.7.1—2.7.11 for other inputs.

Since the current management plan(s) only stipulates overall fishing mortalities for juveniles and adults, making fleet-wise predictions for four fleets that are more or less independent, could potentially result in many different options for 2017. The seven scenarios presented (Table 2.7.12) are based on an interpretation of the harvest control rule or other options and are only illustrative. **All predictions are for North Sea autumn spawning herring only.**

1 Management plan (0% transfer in C fleet)

2 Fmsy

3 No fishing

4 No change in TAC

5 TAC increase of 15%

6 TAC reduction of 15%

7 As 1, with 50% transfer in C fleet

For 2016, the C and D fleets are assumed to have a North Sea autumn spawner catch of 11.6 and 4.7 thousand tonnes respectively. In 2017 and 2018 the D-fleet is assumed to have a North Sea autumn spawner catch of 4.7 thousand tonnes. The C-fleet catch depends on the A & B fleet outtakes. The results are presented in Table 2.7.12.

2.7.1 Comments on the short-term projections

From 2016 to 2017, SSB is expected to decrease due to the weak 2014 yearclass. Under all scenarios SSB is predicted to decrease in 2017. In the management plan scenario (1), the SSB is expected to remain just above $B_{trigger}$ in 2018. This corresponds to a reduction in the A-fleet catch of 16%. If a lower reduction in A-fleet catches is applied, SSB in 2018 is expected to be lower than $B_{trigger}$.

The predicted catch according to the management plan for 2016 implies an decrease in TAC of 16%, above the 15% inter annual variation limit implemented in the plan. This because the 10% maximum F_{target} deviation trumps the TAC variation cap.

2.7.2 Exploratory short-term projections

No exploratory short-term projections were considered.

2.8 Medium term predictions and HCR simulations

No medium term prediction or HCR simulations were carried out during the Working Group. The most recent HCR evaluation of the 2014 North Sea herring management plan and the 2014 management rule for 3a fisheries is in the 2015 WKHERTAC report (ICES CM 2015/ACOM:47).

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) implied that the reference points had shifted under the new perception of the stock assessment which was driven by the inclusion of dynamic natural mortality on herring. 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 precautionary management plan designs (WKHELP, ICES CM 2012/ACOM:72). The derivation of reference points and the history of the reference points for North Sea herring are further described in the Stock Annex.

The 2016 assessment of North Sea herring has been revised due to a new time series of the natural mortality. This has resulted in a downward revision of SSB over most of the time series (-16%) and an upward revision of fishing mortality (+14%) compared to using the old natural mortality time series. Because the shift applied to the whole time series, the working group explored the consequences for the biological reference points.

Similar to WKMSYREF III (ICES CM 2014 / ACOM:64), the EqSim software (msy package 0.1.16) was used to analyse the differences that were generated by the inclusion of the new natural mortality time series. This was compared to the reference points estimated using the old M values (as used in the 2015 assessment).

SRR estimation was, similar to WKHELP, carried out on the years since 2002, the onset of the low recruitment phase.

FIT <- eqsr_fit_shift(NSH, nsamp = 1000, models = c("Bevholt","Ricker"), rshift=1, remove.years=c(1947:2001))

The MSY calculation was carried out using the following settings:

bio.years	c(2004, 2015)
bio.const	FALSE

sel.years	c(2004, 2015)
sel.const	FALSE
recruitment.trim	c(3, -3)
Fcv *	0.24
Fphi *	0.50
Btrigger **	1 500 000
Blim	800 000
Bpa	1 000 000
Fscan	seq(0,0.80,len=40)
Extreme.trim	c(0.01,0.99)

*** set to 0 for calculation of F_{lim}**

**** not used when calculating F_{msy}**

Results are presented in figures 2.9.1 and 2.9.2.

F_{msy}

F_{msy} was previously estimated at 0.27 (WKHELP 2012). Using the updated assessment with new natural mortality estimates and using the SRR pairs since 2002 (low productivity period), results in a new estimate of F_{msy} = 0.33 with ranges of 0.24 – 0.40. F_{cv} and F_{phi} were calculated from historic assessment results and amounted to 0.27 and 0.5 respectively. The Bevholt and Ricker curves were used in estimating the SR-relationship, in agreement with WKHELP 2012. In addition, a retrospective analysis was carried out on the F reference points, which showed that the estimate of F_{msy} was sensitive to the inclusion of the last data year. Removing the last data year would have resulted in an F_{msy} = 0.30. This type of sensitivity is to be expected when using a short time series for recruitment. The WG considered that the F_{msy} = 0.33 is the most appropriate value to be used. Given that F_{pa} is estimated above F_{msy}, the F_{msy} value did not have to be re-adjusted.

F_{pa}

F_{pa} was removed from the ICES advice in 2013. On request of ACOM, HAWG 2016 has re-estimated F_{pa} from F_{lim}, following the guidelines by ICES stipulating that the sigma of the log-transformed F in the terminal year is to be used to calculate F_{pa}. Here, a 10-year retrospective was used to estimate with more precision the uncertainty in terminal F, similar to the approach taken by WKHELP 2012 where B_{pa} was derived from B_{lim} following a similar equation and where SSB uncertainty over the past 10 years was used as well. . Average SD was estimated at 0.079 which results in an F_{pa} value of 0.34.

F_{lim}

F_{lim} has never been estimated for North Sea herring. On request of ACOM, HAWG 2016 has estimated F_{lim} using the updated assessment with new natural mortality estimates and using the SRR pairs since 2002. Given the short time-series, it was considered inappropriate to apply the segmented regression for estimation of F_{lim} as the breakpoint used for the B_{lim} calculation would be outside the range of observed SSBs in this time-series. Neither was it considered appropriate to apply the longer time-series used for the estimation of B_{lim} as this would no longer be in line with the recent low productivity of the stock. It was therefore that the same recruitment models were used as in the calculation of F_{msy}. F_{cv}, F_{phi} and $B_{trigger}$ were all set to 0 according to the ICES guidelines. This resulted in an estimated F_{lim} value of 0.39..

B_{lim}

B_{lim} was previously estimated at 800 000 tonnes (WKHELP 2012). Using the updated assessment with new natural mortality estimates and using the SRR pairs since 1985 did not change the breakpoint of 800 000 tonnes. The North Sea herring stock has gone through two major collapses from which the breakpoint, at which impaired recruitment can be expected, can be estimated reasonably well. A longer time-series was used, in agreement with WKHELP (2012) for estimation of B_{lim} to ensure that variability in population dynamics and state were covered.

B_{pa}

B_{pa} was estimated at 1 000 000 tonnes (WKHERTAC 2015) and has not been revised during HAWG 2016. The uncertainty in terminal SSB did not changed since WKHERTAC 2015. There was no need to update B_{pa} since B_{lim} did not change.

B_{msy}trigger

Bmsytrigger has never been estimated for North Sea herring. The current NSAS management plan stipulates that F should decrease below 1.5mt to ensure sustainable exploitation. The EQsim software was used, with identical settings as the F_{msy} calculation, though now including a value for $B_{trigger}$ to scan at what level Fp0.5 > F_{msy}. This value was estimated at 1.5mt, similar to the setting in the NSAS management plan.

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) and these are described in the North Sea Herring Stock Annex (a list of links to the Stock Annexes can be found in Annex 4). The 2016 assessment was classified as an update assessment and was carried out following these procedures and settings.

During the benchmark in 2012, dynamic natural mortality values for herring were introduced, based on the 2011 North Sea key-run. The North Sea herring Stock Annex, that was written at the end of the benchmark, concluded that: “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.” The working group concluded that the intention had been to update natural mortality estimates when they become available, even when the inclusion of the new natural mortality estimates (WGSAM 2015) did change the overall level of the stock and the fishing mortality. The current perception of SSB, F_{2-6} and recruitment over the past three years has changed in comparison to last year’s assessment even though the retrospective assessment does not show substantial model revisions. (Figure 2.10.1).

Because of the fluctuations introduced by the inclusion of new natural mortality time series, the historical consistency of the assessment (Figure 2.10.1) is lower than suggested by the internal consistency and the diagnostics of the current model formulation.

The 2016 assessment has lowered the estimates of the 2013-2015 recruitments by around 30% compared to the 2015 assessment. The SSB has been lowered by around 13% for these year and the fishing mortality is estimated higher by around 13% (see text table below).

2015 Assessment					2016 Assessment				%change 2016/2015			
Year	Rec	SSB	Catch	F2-6	Rec	SSB	Catch	F2-6	Rec	SSB	Catch	F2-6
2013	38340	2285	483	0.194	30280	2027	482	0.218	-21%	-11%	0%	+12%

2014	68889	2220	506	0.203	38340	1947	505	0.227	-44%	-12%	0%	+12%
2015	17176	2194*	492*	0.21*	13524	1803	475	0.242	-21%	-18%	-3%	+15%

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

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). Monitoring and maintaining the diversity of local populations is widely viewed as critical to the successful management of marine fish stocks.

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 model analysis shows that the Downs component appears to have a different set of dynamics from the other three components (Figure 2.11.1). The earlier dynamics of the components are documented in the stock annex. In recent times, the Downs component has increased consistently to a point where it is the largest component in the stock.

The SCAI indices also indicate 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 was represented by the Orkney–Shetland component. However, the relative contribution of the Downs component to the total stock has increased systematically since. 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.

The most recent estimate of the SCAI in the Downs component has been impacted by missing LAI observations in two sampling unit of the IHLS in the English Channel. Therefore, the rapid reduction in the Downs component seen in Figure 2.11.2 is not thought to be credible. In addition, the most recent years also suggest rapid increases in the Orkney/Shetland and Buchan components. While the precision of the terminal year estimate in the SCAI index is reduced there are now several years of data (2010—2014) to support this overall trend.

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). As in the 2013 survey, concentrations of smaller larvae which are thought to be of the Downs component were found in 2016. Nevertheless, these small larvae (separated as < 20 mm) have until now been excluded from the standard estimation of 0-ringer recruitment (IBTS0 index).

2.11.3 Component considerations

The Downs TAC was 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 4.c-7.d TAC be maintained at 11% of the total North Sea TAC (as recommended by ICES). 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.

2.12 Ecosystem considerations

There has been no recent updates to the ecosystem considerations. The status as of 2015 can be found in ICES HAWG (2015) and the stock annex.

2.13 Changes in the environment

This stock has, since 2002, produced a series of below average year classes, a situation which has not been observed previously (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 continues the trend of relatively poor survival.

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) with continued poor survival.

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

Table 2.1.1: Herring caught in the North Sea. Catch in tonnes by country, 2006—2015. These figures do not in all cases correspond to the official statistics and cannot be used for legal purposes.

Country	2006	2007	2008	2009	2010
Belgium	3	1	-	-	-
Denmark *	102322	84697	62864	46238	45869
Faroe Islands	1785	2891	2014	1803	3014
France	49475	24909	30347	18114	17745
Germany	40414	14893	8095	5368	7670
Netherlands	76315	66393	23122	24552	23872
Norway	135361	100050	59321	50445	46816
Lithuania	-	-	-	-	90
Sweden	10529	15448	13840	5299	4395
Ireland	-	-	-	-	-
UK (England)	22198	15993	11717	652	10770
UK (Scotland)	48428	35115	16021	14006	14373
UK (N.Ireland)	3531	638	331	-	-
Unallocated landings	18764	26641	17151	-726	-
Total landings	509125	387669	244823	165751	174614
Discards	1492	93	224	91	13
Total catch	**510617**	**387762**	**245047**	**165842**	**174627**
Parts of the catches which have been allocated to spring spawning stocks					
WBSS	10954	1070	124	3941	774
Thames estuary **	65	2	7	48	85
Norw. Spring Spawners ***	626	685	2721	44560	56900

Country	2011	2012	2013	2014	2015
Belgium	4	3	14	27	18
Denmark *	58726	105707	117367	124423	113481
Faroe Islands	-	-	-	118	981
France	16693	23819	30122	29679	30269
Germany	9427	24515	46922	36767	44377
Netherlands	34708	72344	80462	74647	70076
Norway	60705	119253	143718	142002	134349
Lithuania	-	-	-	9830	-
Sweden	8086	14092	15615	15583	13184
Ireland	-	-	221	68	183
UK (England)	11468	25346	19079	19287	18897
UK (Scotland)	18564	34414	39243	45119	48332
UK (N.Ireland)	17	4794	5738	6612	5948
Unallocated landings	-	321	-	3292	1516
Total landings	218398	424608	498501	507454	481611
Discards	-	-	-	31	-
Total catch	**218398**	**424608**	**498501**	**507485**	**481611**
Estimates of the parts of the catches which have been allocated to spring spawning stocks					
WBSS	308	2095	452	2953	2204
Thames estuary **	2	63	20	10	10
Norw. Spring Spawners ***	12178	9619	3150	2307	2191

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

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

***** 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.**

Table 2.1.2: Herring caught in the North Sea. Catch in tonnes in Division 4.a West. These figures do not in all cases correspond to the official statistics and cannot be used for legal purposes.

Country	2006	2007	2008	2009	2010
Denmark *	60462	45948	28426	16550	25092
Faroe Islands	580	1118	2	288	1110
France	18453	8570	13068	7067	6412
Germany	18605	4985	498	-	505
Netherlands	39209	42622	11634	11017	13593
Norway	38363	40279	40304	25926	38897
Lithuania	-	-	-	-	90
Sweden	4957	7658	7025	1435	2310
Ireland	-	-	-	-	-
UK (England)	12031	11833	8355	578	7384
UK (Scotland)	47368	35115	14727	10249	13567
UK (N. Ireland)	3531	638	331	-	-
Unallocated landings **	10981	22215	14952	-977	0
Total Landings	253048	220981	139322	72133	108960
Discards	1492	93	194	91	13
Total catch	**254540**	**221074**	**139516**	**72224**	**108973**

Country	2011	2012	2013	2014	2015
Denmark *	26523	42867	80874	74719	68017
Faroe Islands	-	-	-	118	981
France	7885	11131	9750	12620	13401
Germany	2642	13060	19323	23245	32253
Netherlands	15202	46654	18418	37380	44309
Norway	45200	72581	49517	89974	47010
Lithuania	-	-	-	8129	-
Sweden	5121	6065	12280	7760	10388
Ireland	-	-	221	68	183
UK (England)	4555	18289	10874	10085	12249
UK (Scotland)	17909	33352	37889	41844	46931
UK (N. Ireland)	17	4794	5738	6021	4878
Unallocated landings **	0	-3416	0	3292	1939
Total Landings	125054	245377	244884	315255	282539
Discards	-	-	-	31	-
Total catch	**125054**	**245377**	**244884**	**315286**	**282539**

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

**** May include misreported catch from 6.aN and discards. Negative unallocated catches due to misreporting into other areas.**

Table 2.1.3: Herring caught in the North Sea. Catch in tonnes in Division 4.a East. These figures do not in all cases correspond to the official statistics and cannot be used for legal purposes.

Country	2006	2007	2008	2009	2010
Denmark *	8614	2646	1587	499	-
Faroe Islands	975	577	400	700	719
France	-	-	-	-	-
Germany	34	-	-	-	-
Netherlands	-	263	-	-	-
Norway	90065	54424	17474	6981	7362
UK (Scotland)	83	-	-	-	-
Sweden	2857	640	-	1735	1505
Unallocated landings **	0	-96	0	0	0
Total landings	102628	58454	19461	9915	9586
Discards	-	-	-	-	-
Total catch	**102628**	**58454**	**19461**	**9915**	**9586**
Norw. Spring Spawners 4	626	685	2721	44560	56900

Country	2011	2012	2013	2014	2015
Denmark *	1590	1822	1162	-	16739
Faroe Islands	-	-	-	-	-
France	-	-	-	30	-
Germany	-	-	15	-	-
Netherlands	-	-	-	-	-
Norway	12922	32714	76894	44060	67254
UK (Scotland)	167	-	-	124	1369
Sweden	150	815	865	940	570
Unallocated landings	0	0	0	0	-423
Total landings	14829	35351	78936	45154	85509
Discards	-	-	-	-	-
Total catch	**14829**	**35351**	**78936**	**45154**	**85509**
Norw. Spring Spawners ***	12178	9619	3150	2307	2191

*** Including any bycatches in the industrial fishery.**

**** Negative unallocated catches due to misreporting into other areas.**

***** 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 4.b. These figures do not in all cases correspond to the official statistics and cannot be used for legal purposes.

Country	2006	2007	2008	2009	2010
Denmark*	32277	35990	32230	29164	19671
Faroe Islands	200	1196	1612	815	1185
France	17385	8421	9687	4316	2349
Germany	14222	2205	2415	1061	1994
Netherlands	13363	8550	904	3164	830
Norway	6933	5347	1543	17538	557
Sweden	2715	7150	6815	2129	580
UK (England)	4924	577	833	2	1577
UK (Scotland)	977	-	1293	3757	805
Unallocated landings**	2364	-203	-904	-166	0
Total landings	95360	69233	56428	61780	29548
Discards	-	-	30	-	-
Total catch	**95360**	**69233**	**56458**	**61780**	**29548**

Country	2011	2012	2013	2014	2015
Denmark*	30498	60503	34707	49118	28551
Faroe Islands	-	-	-	-	-
France	1687	3898	8728	7839	6342
Germany	1778	4187	17701	4424	107
Lithuania	-	-	-	1701	-
Netherlands	7314	9202	43339	22628	10606
UK (N. Ireland)	-	-	-	591	1070
Norway	2537	13958	17307	7968	20077
Sweden	2815	7212	2470	6883	2226
UK (England)	4748	3045	4391	4498	3484
UK (Scotland)	488	1062	1312	3151	32
Unallocated landings**	0	411	42	0	0
Total landings	51865	103478	129955	108801	72495
Discards	-	-	-	-	-
Total catch	**51865**	**103478**	**129997**	**108801**	**72495**

*** Including any bycatches in the industrial fishery**

**** Negative unallocated catches due to misreporting into other areas.**

Table 2.1.5: Herring caught in the North Sea. Catch in tonnes in Division 4.c and 7.d. These figures do not in all cases correspond to the official statistics and cannot be used for legal purposes.

Country	2006	2007	2008	2009	2010
Belgium	3	1	-	-	-
Denmark*	969	113	621	25	1106
Faroe Islands	30	-	-	-	-
France	13637	7918	7592	6731	8984
Germany	7553	7703	5182	4307	5171
Netherlands	23743	14958	10584	10371	9449
UK (England)	5243	3583	2529	72	1809
UK (Scotland)	-	-	1	-	1
Unallocated landings	5419	4725	3103	417	0
Total landings	56597	39001	29612	21923	26520
Discards	-	-	-	-	-
Total catch	**56597**	**39001**	**29612**	**21923**	**26520**
Coastal spring spawners	65	2	7	48	85
included above**					

Country	2011	2012	2013	2014	2015
Belgium	4	3	14	27	18
Denmark*	115	515	624	586	174
France	7121	8790	11644	9190	10526
Germany	5007	7268	9883	9098	12017
Netherlands	12192	16488	18705	14639	15161
Norway	46	-	-	-	8
UK (England)	2165	4012	3814	4704	3164
UK (Scotland)	-	-	42	-	-
Unallocated landings***	0	3326	-42	0	0
Total landings	26650	40402	44684	38244	41068
Discards	-	-	-	-	-
Total catch	**26650**	**40402**	**44684**	**38244**	**41068**
Coastal spring spawners	2	63	20	10	10
included above**					

*** Including any bycatches in the industrial fishery**

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

***** Negative unallocated catches due to misreporting into other areas.**

Table 2.1.6 ("The Wonderful Table"): Herring caught in the North Sea. Catch in thousand tonnes in Subarea 4, Division 7.d and Division 3.a.

YEAR	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Sub-Area 4 and Division 7.d: TAC (4 and 7.d)												
Agreed Divisions 4.a,b	460.7	404.7	303.5	174.6	147.4	149.0	173.5	360.4	427.7	418.3	396.3	461.2
Agreed Div. 4.c, 7.d	74.3	50.0	37.5	26.7	23.6	15.3	26.5	44.6	50.3	51.7	49.0	57.0
Bycatch ceiling in the small mesh fishery *	50.0	42.5	31.9	18.8	16.0	13.6	16.5	17.9	14.4	13.1	15.7	13.4
CATCH (4 and 7.d)												
National catch Divisions 4.a,b **	502.3	439.2	326.8	201.2	145.0	148.1	191.7	387.2	453.8	465.9	439	
Unallocated catch Divisions 4.a,b	49.6	13.3	21.9	14.0	-1.1	0.0	0.0	-3.0	0.0	3.3	1.5	
Discard/slipping Divisions 4.a,b ***	12.8	1.5	0.1	0.2	0.1	0.0	-	-	-	0.0	-	
Total catch Divisions 4.a,b #	564.6	454.0	348.8	215.4	143.9	148.1	191.7	384.2	453.9	469.2	440.5	
National catch Divisions 4.c, 7.d **	66.1	51.2	34.3	26.5	21.5	26.5	26.7	37.1	44.7	38.2	41.1	
Unallocated catch Divisions 4.c,7.d	8.2	5.4	4.7	3.1	0.4	0.0	0.0	3.3	0.0	0.0	0.0	
Discard/slipping Divisions 4.c, 7.d ***	-	-	-	-	-	-	-	-	-	-	-	
Total catch Divisions 4.c, 7.d	74.3	56.6	39.0	29.6	21.9	26.5	26.7	40.4	44.7	38.2	41.1	
Total catch 4 and 7.d as used by ICES #	638.9	510.6	387.8	245.0	165.8	174.6	218.4	424.6	498.5	507.5	481.6	
CATCH BY FLEET/STOCK (4 and 7.d) ##												
North Sea autumn spawners directed fisheries (Fleet A)	610.0	487.1	379.6	236.3	152.1	164.8	209.2	411.8	489.9	490.5	471.5	
North Sea autumn spawners industrial (Fleet B)	21.8	11.9	7.1	8.6	9.8	9.1	8.9	10.6	8.1	14.0	7.9	
North Sea autumn spawners in 4 and 7.d total	631.9	499.0	386.7	244.9	161.9	173.9	218.1	422.5	498.1	504.5	479.4	
Baltic-3.a-type spring spawners in 4	7.0	11.0	1.1	0.1	3.9	0.8	0.3	2.1	0.5	3.0	2.2	
Coastal-type spring spawners	0.1	0.1	0.0	0.0	0.0	0.1	0.0	0.1	0.0	0.0	0.0	
Norw. Spring Spawners caught under a separate quota in 4 ###	0.4	0.6	0.7	2.7	44.6	56.9	12.2	9.6	3.2	2.3	2.2	
Division 3.a: TAC (3.a)												
Agreed herring TAC	96.0	81.6	69.4	51.7	37.7	33.9	30.0	45.0	55.0	46.8	43.6	51.1
Bycatch ceiling in the small mesh fishery	24.2	20.5	15.4	11.5	8.4	7.5	6.7	6.7	6.7	6.7	6.7	6.7
CATCH (3.a)												
National catch	90.8	88.9	47.3	38.2	38.8	37.3	20.0	27.7	31.2	28.9	27.8	
Catch as used by ICES	69.6	51.2	47.4	38.2	38.8	37.3	20.0	27.7	31.2	28.9	27.8	
CATCH BY FLEET/STOCK (3.a) ##												
Autumn spawners human consumption (Fleet C)	22.9	11.6	16.4	9.2	5.1	12.0	6.6	7.8	11.8	9.5	10.2	
Autumn spawners mixed clupeoid (Fleet D)	9.0	3.4	3.4	3.7	1.5	1.8	1.8	4.4	1.6	3.3	4.4	
Autumn spawners in 3.a total	31.9	15.0	19.8	12.9	6.5	13.8	8.4	12.2	13.4	12.8	14.7	
Spring spawners human consumption (Fleet C)	32.5	30.2	25.3	23.0	29.4	23.0	10.8	14.5	16.6	15.4	11.3	
Spring spawners mixed clupeoid (Fleet D)	5.1	5.9	2.3	2.2	2.9	0.5	0.8	1.0	1.3	0.6	1.8	
Spring spawners in 3.a total	37.6	36.1	27.6	25.2	32.3	23.5	11.6	15.5	17.9	16.1	13.1	
North Sea autumn spawners Total as used by ICES	663.8	514.6	406.5	257.9	168.4	187.6	226.5	434.6	511.4	517.3	494.1	

Table 2.2.1: North Sea autumn spawning herring (NSAS), and western Baltic spring spawners (WBSS) caught in the North Sea and Division 3.a in 2015. 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	**30.7**	**0.0**	**0.0**	**0.0**	**117.1**	**383.3**	**7.1**	**0.0**	**500.4**	**7.1**	**538.2**	**507.5**
1	**169.6**	**0.9**	**0.0**	**0.9**	**24.0**	**185.0**	**10.1**	**5.3**	**209.9**	**15.4**	**394.9**	**225.3**
2	**97.6**	**38.1**	**0.1**	**38.0**	**172.2**	**82.1**	**0.8**	**161.2**	**292.2**	**162.0**	**551.8**	**454.3**
3	**7.0**	**47.8**	**0.9**	**47.0**	**136.0**	**39.5**	**0.2**	**17.9**	**222.5**	**18.1**	**247.6**	**241.5**
4	**1.3**	**54.1**	**1.4**	**52.7**	**180.9**	**36.0**	**0.3**	**11.7**	**269.5**	**12.0**	**282.8**	**283.0**
5	**4.9**	**86.4**	**3.9**	**82.5**	**272.2**	**75.0**	**0.6**	**25.7**	**429.8**	**26.3**	**461.0**	**460.0**
6	**1.1**	**78.7**	**1.8**	**76.9**	**296.6**	**42.3**	**0.3**	**14.7**	**415.9**	**15.1**	**432.0**	**432.8**
7	**1.2**	**71.0**	**1.4**	**69.6**	**144.9**	**25.9**	**0.7**	**28.9**	**240.5**	**29.6**	**271.3**	**271.5**
8	**0.4**	**49.2**	**0.9**	**48.2**	**84.6**	**19.8**	**0.3**	**14.2**	**152.6**	**14.5**	**167.5**	**168.1**
9+	**0.0**	**42.1**	**1.2**	**40.9**	**90.1**	**27.7**	**0.3**	**11.4**	**158.7**	**11.6**	**170.3**	**171.5**
Sum	**313.6**	**468.4**	**11.7**	**456.7**	**1518.6**	**916.7**	**20.7**	**291.1**	**2892.0**	**311.8**	**3517.4**	**3215.5**
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	31.5	0.1	0.0	0.1	0.0	28.1	9.5	0.0	28.2	9.5	**69.3**	**37.8**
2	81.6	8.7	0.0	8.7	10.4	2.3	0.0	0.0	21.4	0.0	**102.9**	**21.4**
3	2.1	15.1	0.5	14.6	16.6	3.8	0.0	0.0	35.0	0.0	**37.1**	**35.5**
4	0.2	19.4	0.8	18.5	16.4	3.7	0.1	1.4	38.7	1.5	**40.3**	**41.0**
5	0.2	23.6	0.9	22.6	30.3	6.8	0.2	3.3	59.8	3.5	**63.5**	**64.2**
6	0.0	31.9	0.7	31.2	27.5	6.3	0.1	1.4	64.9	1.5	**66.5**	**67.1**
7	0.0	9.1	0.4	8.6	3.5	0.6	0.2	2.8	12.7	3.0	**15.7**	**16.2**
8	0.0	6.8	0.5	6.3	1.8	0.2	0.1	1.4	8.3	1.5	**9.8**	**10.3**
9+	0.0	10.6	0.8	9.9	6.7	1.5	0.1	1.4	18.1	1.5	**19.6**	**20.4**
Sum	**115.6**	**125.2**	**4.7**	**120.5**	**113.2**	**53.3**	**10.4**	**11.7**	**287.0**	**22.1**	**424.7**	**313.8**
Quarter: 2												
0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.5	0.0	**0.5**	**0.5**
1	1.9	0.6	0.0	0.6	7.2	129.6	0.2	0.0	137.4	0.2	**139.5**	**137.6**
2	2.0	24.9	0.0	24.9	48.2	1.5	0.0	0.0	74.6	0.0	**76.6**	**74.6**
3	0.0	27.0	0.0	27.0	16.8	1.3	0.0	0.0	45.1	0.0	**45.1**	**45.1**
4	0.0	27.3	0.0	27.3	12.3	1.4	0.0	0.0	41.0	0.0	**41.1**	**41.1**
5	0.0	50.4	2.0	48.3	21.6	3.9	0.0	0.1	73.8	0.1	**73.9**	**75.9**
6	0.0	34.3	0.0	34.3	14.8	1.1	0.0	0.0	50.1	0.0	**50.2**	**50.2**
7	0.0	52.2	0.5	51.7	19.9	0.8	0.0	0.0	72.4	0.0	**72.4**	**72.9**
8	0.0	35.1	0.0	35.1	13.7	0.7	0.0	0.0	49.5	0.0	**49.5**	**49.5**
9+	0.0	24.7	0.0	24.7	9.0	1.2	0.0	0.0	34.9	0.0	**34.9**	**34.9**
Sum	**3.9**	**276.5**	**2.6**	**273.9**	**163.5**	**142.0**	**0.3**	**0.2**	**579.4**	**0.5**	**583.7**	**582.4**
Quarter: 3												
0	3.9	0.0	0.0	0.0	64.0	157.4	0.2	0.0	221.4	0.2	**225.5**	**221.6**
1	50.5	0.1	0.0	0.1	10.4	16.5	0.0	0.0	27.1	0.0	**77.6**	**27.1**
2	12.5	3.2	0.1	3.1	75.8	65.5	0.0	0.0	144.5	0.0	**157.0**	**144.6**
3	4.6	4.4	0.4	0.0	73.7	26.0	0.0	0.0	99.7	0.0	**104.3**	**104.1**
4	0.9	5.6	0.5	0.0	121.3	19.4	0.0	0.0	140.7	0.0	**141.6**	**146.3**
5	4.7	9.2	0.9	0.0	171.0	44.5	0.0	0.0	215.5	0.0	**220.3**	**224.8**
6	1.1	9.1	0.8	0.0	188.5	14.4	0.0	0.0	202.9	0.0	**204.0**	**212.0**
7	1.2	7.0	0.5	0.0	85.9	6.2	0.0	0.0	92.1	0.0	**93.3**	**99.0**
8	0.3	5.6	0.2	0.0	46.5	5.9	0.0	0.0	52.4	0.0	**52.8**	**58.0**
9+	0.0	4.8	0.2	0.0	43.7	11.8	0.0	0.0	55.5	0.0	**55.5**	**60.3**
Sum	**79.8**	**49.1**	**3.6**	**3.3**	**881.0**	**367.4**	**0.4**	**0.0**	**1251.7**	**0.4**	**1331.9**	**1297.9**
Quarter: 4												
0	26.8	0.0	0.0	0.0	53.1	225.4	6.8	0.0	278.5	6.8	**312.2**	**285.4**
1	85.7	0.1	0.0	0.1	6.4	10.7	0.3	5.3	17.2	5.7	**108.5**	**22.8**
2	1.6	1.3	0.0	1.3	37.8	12.7	0.7	161.2	51.8	162.0	**215.3**	**213.7**
3	0.2	1.3	0.0	1.3	28.8	8.5	0.2	17.9	38.6	18.1	**56.9**	**56.7**
4	0.2	1.8	0.0	1.8	30.9	11.5	0.2	10.3	44.1	10.5	**54.7**	**54.6**
5	0.0	3.2	0.0	3.2	49.3	19.8	0.4	22.4	72.3	22.8	**95.1**	**95.1**
6	0.0	3.4	0.3	3.1	65.9	20.6	0.2	13.3	89.6	13.5	**103.2**	**103.4**
7	0.0	2.8	0.0	2.8	35.6	18.4	0.5	26.1	56.8	26.5	**83.4**	**83.4**
8	0.0	1.8	0.2	1.5	22.5	13.0	0.2	12.8	37.1	13.0	**50.1**	**50.3**
9+	0.0	2.0	0.3	1.7	30.6	13.2	0.2	9.9	45.6	10.1	**55.7**	**55.9**
Sum	**114.4**	**17.7**	**0.8**	**16.8**	**360.8**	**353.9**	**9.8**	**279.2**	**731.6**	**288.9**	**1135.0**	**1021.4**

Table 2.2.2: North Sea autumn spawning herring (NSAS), and western Baltic spring spawners (WBSS) caught in the North Sea and Division 3.a in 2015. Mean weight-at-age (kg) in the catch (WECA), by quarter and division.

Quarters: 1-4

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
0	**0.016**	**0.000**	**0.000**	**0.008**	**0.008**	**0.010**	**0.000**	**0.008**	**0.010**	**0.009**	**0.008**
1	**0.030**	**0.114**	**0.115**	**0.054**	**0.019**	**0.010**	**0.054**	**0.023**	**0.025**	**0.026**	**0.023**
2	**0.068**	**0.127**	**0.137**	**0.124**	**0.140**	**0.118**	**0.114**	**0.129**	**0.114**	**0.114**	**0.123**
3	**0.133**	**0.148**	**0.144**	**0.158**	**0.162**	**0.129**	**0.127**	**0.157**	**0.127**	**0.154**	**0.154**
4	**0.157**	**0.163**	**0.162**	**0.198**	**0.189**	**0.151**	**0.154**	**0.190**	**0.154**	**0.188**	**0.188**
5	**0.180**	**0.178**	**0.181**	**0.211**	**0.203**	**0.152**	**0.157**	**0.203**	**0.157**	**0.200**	**0.200**
6	**0.196**	**0.191**	**0.203**	**0.233**	**0.208**	**0.182**	**0.183**	**0.223**	**0.183**	**0.221**	**0.221**
7	**0.197**	**0.203**	**0.204**	**0.228**	**0.216**	**0.188**	**0.197**	**0.219**	**0.197**	**0.217**	**0.217**
8	**0.215**	**0.212**	**0.211**	**0.239**	**0.227**	**0.197**	**0.204**	**0.228**	**0.204**	**0.226**	**0.226**
9+	**0.000**	**0.227**	**0.220**	**0.252**	**0.250**	**0.199**	**0.210**	**0.245**	**0.210**	**0.243**	**0.243**

Quarter: 1

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
0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	**0.000**	**0.000**
1	0.014	0.107	0.107	0.117	0.009	0.009	0.000	0.009	0.009	**0.011**	**0.009**
2	0.062	0.088	0.088	0.081	0.078	0.000	0.000	0.083	0.000	**0.066**	**0.083**
3	0.102	0.127	0.127	0.121	0.120	0.000	0.000	0.123	0.000	**0.122**	**0.124**
4	0.119	0.144	0.144	0.139	0.138	0.130	0.130	0.141	0.130	**0.141**	**0.141**
5	0.161	0.159	0.159	0.153	0.152	0.128	0.128	0.155	0.128	**0.154**	**0.154**
6	0.158	0.178	0.178	0.176	0.175	0.171	0.171	0.176	0.171	**0.176**	**0.176**
7	0.184	0.194	0.194	0.189	0.183	0.154	0.154	0.192	0.154	**0.185**	**0.185**
8	0.160	0.201	0.201	0.204	0.199	0.171	0.171	0.201	0.171	**0.197**	**0.197**
9+	0.000	0.210	0.210	0.215	0.214	0.166	0.166	0.212	0.166	**0.208**	**0.209**

Quarter: 2

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
0	0.000	0.000	0.000	0.004	0.004	0.004	0.000	0.004	0.004	**0.004**	**0.004**
1	0.015	0.116	0.116	0.047	0.018	0.018	0.000	0.020	0.018	**0.020**	**0.020**
2	0.047	0.138	0.138	0.120	0.138	0.144	0.000	0.126	0.144	**0.124**	**0.126**
3	0.000	0.156	0.156	0.151	0.164	0.170	0.000	0.154	0.170	**0.154**	**0.154**
4	0.000	0.170	0.170	0.170	0.198	0.197	0.130	0.171	0.145	**0.171**	**0.171**
5	0.000	0.182	0.182	0.179	0.211	0.214	0.128	0.182	0.139	**0.182**	**0.182**
6	0.000	0.193	0.193	0.192	0.211	0.230	0.171	0.193	0.180	**0.193**	**0.193**
7	0.000	0.202	0.202	0.200	0.223	0.238	0.154	0.202	0.157	**0.202**	**0.202**
8	0.000	0.211	0.211	0.209	0.230	0.258	0.171	0.211	0.174	**0.211**	**0.211**
9+	0.000	0.229	0.229	0.227	0.262	0.247	0.166	0.230	0.169	**0.230**	**0.230**

Quarter: 3

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
0	0.017	0.000	0.000	0.006	0.006	0.006	0.000	0.006	0.006	**0.006**	**0.006**
1	0.031	0.104	0.104	0.046	0.028	0.023	0.000	0.036	0.023	**0.033**	**0.036**
2	0.107	0.137	0.137	0.132	0.142	0.149	0.115	0.136	0.144	**0.134**	**0.136**
3	0.148	0.166	0.166	0.170	0.168	0.170	0.126	0.169	0.164	**0.168**	**0.169**
4	0.162	0.192	0.192	0.214	0.205	0.206	0.154	0.212	0.201	**0.212**	**0.212**
5	0.181	0.202	0.202	0.232	0.216	0.231	0.162	0.227	0.217	**0.227**	**0.227**
6	0.196	0.225	0.225	0.256	0.236	0.248	0.184	0.253	0.232	**0.253**	**0.253**
7	0.197	0.216	0.216	0.246	0.241	0.238	0.204	0.244	0.220	**0.243**	**0.244**
8	0.215	0.229	0.229	0.260	0.243	0.258	0.209	0.255	0.230	**0.255**	**0.255**
9+	0.000	0.250	0.250	0.280	0.271	0.247	0.214	0.276	0.232	**0.276**	**0.276**

Quarter: 4

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
0	0.016	0.000	0.000	0.010	0.010	0.010	0.000	0.010	0.010	**0.011**	**0.010**
1	0.035	0.130	0.130	0.073	0.041	0.037	0.054	0.053	0.053	**0.039**	**0.053**
2	0.089	0.149	0.149	0.126	0.139	0.115	0.114	0.130	0.114	**0.117**	**0.118**
3	0.109	0.164	0.164	0.154	0.164	0.126	0.127	0.156	0.127	**0.147**	**0.147**
4	0.165	0.177	0.177	0.178	0.178	0.157	0.158	0.178	0.157	**0.174**	**0.174**
5	0.000	0.188	0.188	0.188	0.188	0.161	0.161	0.188	0.161	**0.182**	**0.182**
6	0.000	0.198	0.198	0.201	0.199	0.184	0.184	0.200	0.184	**0.198**	**0.198**
7	0.000	0.207	0.207	0.206	0.209	0.202	0.202	0.207	0.202	**0.205**	**0.205**
8	0.000	0.216	0.216	0.215	0.220	0.208	0.208	0.217	0.208	**0.214**	**0.215**
9+	0.000	0.233	0.233	0.228	0.234	0.217	0.217	0.230	0.217	**0.228**	**0.228**

Table 2.2.3: North Sea autumn spawning herring (NSAS), and western Baltic spring spawners (WBSS) caught in the North Sea in 2015. 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	Herring caught in the North Sea
Quarters: 1-4										
0	**n.d.**	**0.0**	**n.d.**	**10.8**	**11.0**	**11.6**	**0.0**	**11.0**	**11.6**	**11.0**
1	**n.d.**	**23.0**	**n.d.**	**18.6**	**14.0**	**12.2**	**19.8**	**14.6**	**14.8**	**14.6**
2	**n.d.**	**24.2**	**n.d.**	**24.4**	**25.2**	**24.4**	**24.2**	**24.6**	**24.2**	**24.4**
3	**n.d.**	**25.9**	**n.d.**	**26.3**	**26.5**	**25.3**	**25.3**	**26.3**	**25.3**	**26.2**
4	**n.d.**	**26.9**	**n.d.**	**28.1**	**27.9**	**27.1**	**27.1**	**27.8**	**27.1**	**27.8**
5	**n.d.**	**27.5**	**n.d.**	**28.8**	**28.6**	**27.0**	**27.1**	**28.5**	**27.1**	**28.4**
6	**n.d.**	**28.5**	**n.d.**	**29.8**	**29.0**	**28.4**	**28.4**	**29.4**	**28.4**	**29.4**
7	**n.d.**	**28.6**	**n.d.**	**29.3**	**29.2**	**28.9**	**29.0**	**29.1**	**29.0**	**29.1**
8	**n.d.**	**29.0**	**n.d.**	**29.8**	**29.7**	**29.5**	**29.4**	**29.6**	**29.4**	**29.5**
9+	**n.d.**	**30.0**	**n.d.**	**30.7**	**30.7**	**29.6**	**29.7**	**30.5**	**29.7**	**30.5**
Quarter: 1										
0	n.d.	0.0	n.d.	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
1	n.d.	23.1	n.d.	23.1	12.0	12.0	0.0	12.0	12.0	**12.0**
2	n.d.	22.8	n.d.	22.3	22.2	0.0	0.0	22.5	0.0	**22.5**
3	n.d.	26.0	n.d.	25.8	25.8	0.0	0.0	25.9	0.0	**25.9**
4	n.d.	27.1	n.d.	27.2	27.2	27.1	27.1	27.2	27.1	**27.2**
5	n.d.	28.0	n.d.	28.1	28.1	26.5	26.5	28.0	26.5	**27.9**
6	n.d.	29.1	n.d.	29.5	29.5	28.1	28.1	29.3	28.1	**29.3**
7	n.d.	29.7	n.d.	29.4	29.9	28.6	28.6	29.6	28.6	**29.4**
8	n.d.	30.1	n.d.	30.0	30.8	29.9	29.9	30.1	29.9	**30.1**
9+	n.d.	30.7	n.d.	31.2	31.3	29.1	29.1	30.9	29.1	**30.8**
Quarter: 2										
0	n.d.	0.0	n.d.	9.0	9.0	9.0	0.0	9.0	9.0	**9.0**
1	n.d.	23.0	n.d.	17.2	13.9	13.9	0.0	14.1	13.9	**14.1**
2	n.d.	24.5	n.d.	23.9	25.1	25.2	0.0	24.1	25.2	**24.1**
3	n.d.	25.7	n.d.	25.7	26.6	26.7	0.0	25.7	26.7	**25.7**
4	n.d.	26.5	n.d.	26.7	28.3	27.7	27.1	26.6	27.2	**26.6**
5	n.d.	27.2	n.d.	27.2	29.0	28.7	26.5	27.3	26.8	**27.3**
6	n.d.	27.8	n.d.	27.9	28.9	29.6	28.1	27.9	28.3	**27.9**
7	n.d.	28.3	n.d.	28.4	29.3	29.8	28.6	28.3	28.6	**28.3**
8	n.d.	28.7	n.d.	28.8	29.8	30.9	29.9	28.7	29.9	**28.7**
9+	n.d.	29.6	n.d.	29.6	31.2	31.4	29.1	29.6	29.2	**29.6**
Quarter: 3										
0	n.d.	0.0	n.d.	10.2	10.2	10.2	0.0	10.2	10.2	**10.2**
1	n.d.	22.4	n.d.	18.1	16.2	15.7	0.0	16.9	15.7	**16.9**
2	n.d.	24.7	n.d.	24.6	25.3	25.6	24.5	24.9	25.4	**24.9**
3	n.d.	26.3	n.d.	26.5	26.7	26.7	25.4	26.5	26.5	**26.5**
4	n.d.	27.5	n.d.	28.5	28.4	28.3	27.1	28.5	28.2	**28.5**
5	n.d.	28.0	n.d.	29.3	29.0	29.2	27.4	29.2	28.8	**29.2**
6	n.d.	29.1	n.d.	30.2	29.6	30.0	28.5	30.1	29.6	**30.1**
7	n.d.	28.8	n.d.	29.7	30.2	29.8	29.2	29.7	29.5	**29.7**
8	n.d.	29.4	n.d.	30.4	30.5	30.9	29.5	30.3	30.1	**30.3**
9+	n.d.	30.4	n.d.	31.1	31.4	31.4	29.9	31.1	30.7	**31.1**
Quarter: 4										
0	n.d.	0.0	n.d.	11.6	11.6	11.6	0.0	11.6	11.6	**11.6**
1	n.d.	24.1	n.d.	20.8	17.7	17.4	19.8	18.9	19.7	**19.1**
2	n.d.	25.4	n.d.	25.3	25.1	24.3	24.2	25.2	24.2	**24.4**
3	n.d.	26.4	n.d.	26.6	26.4	25.2	25.3	26.6	25.3	**26.2**
4	n.d.	27.1	n.d.	27.7	27.2	27.0	27.0	27.5	27.0	**27.4**
5	n.d.	27.7	n.d.	28.1	27.7	27.2	27.2	28.0	27.2	**27.8**
6	n.d.	28.3	n.d.	29.0	28.3	28.4	28.4	28.9	28.4	**28.8**
7	n.d.	28.8	n.d.	29.0	28.9	29.0	29.0	28.9	29.0	**29.0**
8	n.d.	29.2	n.d.	29.4	29.3	29.4	29.4	29.4	29.4	**29.4**
9+	n.d.	30.0	n.d.	30.3	30.0	29.8	29.8	30.2	29.8	**30.1**

Table 2.2.4: North Sea autumn spawning herring (NSAS), and western Baltic spring spawners (WBSS) caught in the North Sea and Division 3.a in 2015. 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	Herring caught in the North Sea
Quarters: 1-4												
0	**0.5**	**0.0**	**0.0**	**0.0**	**0.9**	**3.2**	**0.1**	**0.0**	**4.1**	**0.1**	**4.7**	**4.2**
1	**5.0**	**0.1**	**0.0**	**0.1**	**1.3**	**3.5**	**0.1**	**0.3**	**4.9**	**0.4**	**10.3**	**5.3**
2	**6.6**	**4.8**	**0.0**	**4.8**	**21.3**	**11.5**	**0.1**	**18.3**	**37.6**	**18.4**	**62.6**	**56.0**
3	**0.9**	**7.1**	**0.1**	**6.9**	**21.5**	**6.4**	**0.0**	**2.3**	**34.9**	**2.3**	**38.1**	**37.3**
4	**0.2**	**8.8**	**0.2**	**8.6**	**35.8**	**6.8**	**0.0**	**1.8**	**51.2**	**1.9**	**53.3**	**53.3**
5	**0.9**	**15.4**	**0.7**	**14.7**	**57.4**	**15.2**	**0.1**	**4.0**	**87.2**	**4.1**	**92.3**	**92.1**
6	**0.2**	**15.0**	**0.4**	**14.6**	**69.1**	**8.8**	**0.1**	**2.7**	**92.6**	**2.8**	**95.6**	**95.7**
7	**0.2**	**14.4**	**0.3**	**14.1**	**33.1**	**5.6**	**0.1**	**5.7**	**52.8**	**5.8**	**58.9**	**58.9**
8	**0.1**	**10.4**	**0.2**	**10.2**	**20.2**	**4.5**	**0.1**	**2.9**	**34.9**	**3.0**	**37.9**	**38.1**
9+	**0.0**	**9.5**	**0.3**	**9.3**	**22.7**	**6.9**	**0.1**	**2.4**	**38.9**	**2.4**	**41.4**	**41.6**
Sum	**14.7**	**85.5**	**2.2**	**83.3**	**283.4**	**72.4**	**0.7**	**40.4**	**439.2**	**41.1**	**495.0**	**482.5**
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	0.4	0.0	0.0	0.0	0.0	0.3	0.1	0.0	0.3	0.1	**0.8**	**0.4**
2	5.1	0.8	0.0	0.8	0.8	0.2	0.0	0.0	1.8	0.0	**6.8**	**1.8**
3	0.2	1.9	0.1	1.9	2.0	0.5	0.0	0.0	4.3	0.0	**4.5**	**4.4**
4	0.0	2.8	0.1	2.7	2.3	0.5	0.0	0.2	5.5	0.2	**5.7**	**5.8**
5	0.0	3.7	0.1	3.6	4.6	1.0	0.0	0.4	9.3	0.4	**9.7**	**9.9**
6	0.0	5.7	0.1	5.5	4.8	1.1	0.0	0.2	11.5	0.3	**11.7**	**11.8**
7	0.0	1.8	0.1	1.7	0.7	0.1	0.0	0.4	2.4	0.5	**2.9**	**3.0**
8	0.0	1.4	0.1	1.3	0.4	0.0	0.0	0.2	1.7	0.3	**1.9**	**2.0**
9+	0.0	2.2	0.2	2.1	1.5	0.3	0.0	0.2	3.8	0.2	**4.1**	**4.2**
Sum	**5.8**	**20.2**	**0.8**	**19.4**	**17.1**	**4.0**	**0.2**	**1.8**	**40.5**	**2.0**	**48.2**	**43.3**
Quarter: 2												
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	0.0	0.1	0.0	0.1	0.3	2.3	0.0	0.0	2.7	0.0	**2.8**	**2.7**
2	0.1	3.4	0.0	3.4	5.8	0.2	0.0	0.0	9.4	0.0	**9.5**	**9.4**
3	0.0	4.2	0.0	4.2	2.5	0.2	0.0	0.0	7.0	0.0	**7.0**	**7.0**
4	0.0	4.6	0.0	4.6	2.1	0.3	0.0	0.0	7.0	0.0	**7.0**	**7.0**
5	0.0	9.2	0.4	8.8	3.9	0.8	0.0	0.0	13.5	0.0	**13.5**	**13.8**
6	0.0	6.6	0.0	6.6	2.8	0.2	0.0	0.0	9.7	0.0	**9.7**	**9.7**
7	0.0	10.5	0.1	10.4	4.0	0.2	0.0	0.0	14.6	0.0	**14.6**	**14.7**
8	0.0	7.4	0.0	7.4	2.9	0.2	0.0	0.0	10.4	0.0	**10.4**	**10.4**
9+	0.0	5.6	0.0	5.6	2.0	0.3	0.0	0.0	8.0	0.0	**8.0**	**8.0**
Sum	**0.1**	**51.7**	**0.5**	**51.2**	**26.3**	**4.7**	**0.0**	**0.0**	**82.3**	**0.0**	**82.4**	**82.8**
Quarter: 3												
0	0.1	0.0	0.0	0.0	0.4	0.9	0.0	0.0	1.3	0.0	**1.4**	**1.3**
1	1.6	0.0	0.0	0.0	0.5	0.5	0.0	0.0	1.0	0.0	**2.5**	**1.0**
2	1.3	0.4	0.0	0.4	10.0	9.3	0.0	0.0	19.7	0.0	**21.1**	**19.7**
3	0.7	0.7	0.1	0.7	12.5	4.4	0.0	0.0	17.5	0.0	**18.2**	**17.6**
4	0.2	1.1	0.1	0.0	26.0	4.0	0.0	0.0	29.9	0.0	**31.1**	**31.0**
5	0.9	1.9	0.2	1.7	39.6	9.6	0.0	0.0	50.9	0.0	**51.8**	**51.1**
6	0.2	2.1	0.2	0.0	48.3	3.4	0.0	0.0	51.6	0.0	**53.7**	**53.7**
7	0.2	1.5	0.1	1.4	21.1	1.5	0.0	0.0	24.0	0.0	**24.3**	**24.1**
8	0.1	1.3	0.0	1.2	12.1	1.4	0.0	0.0	14.8	0.0	**14.8**	**14.8**
9+	0.0	1.2	0.0	1.2	12.3	3.2	0.0	0.0	16.6	0.0	**16.6**	**16.6**
Sum	**5.2**	**10.2**	**0.7**	**6.6**	**182.7**	**38.2**	**0.0**	**0.0**	**227.4**	**0.0**	**235.5**	**231.0**
Quarter: 4												
0	0.4	0.0	0.0	0.0	0.5	2.3	0.1	0.0	2.8	0.1	**3.3**	**2.9**
1	3.0	0.0	0.0	0.0	0.5	0.4	0.0	0.3	0.9	0.3	**4.2**	**1.2**
2	0.1	0.2	0.0	0.2	4.8	1.8	0.1	18.3	6.7	18.4	**25.2**	**25.1**
3	0.0	0.2	0.0	0.2	4.4	1.4	0.0	2.3	6.0	2.3	**8.3**	**8.3**
4	0.0	0.3	0.0	0.3	5.5	2.0	0.0	1.6	7.8	1.6	**9.5**	**9.5**
5	0.0	0.6	0.0	0.6	9.3	3.7	0.1	3.6	13.6	3.7	**17.3**	**17.3**
6	0.0	0.7	0.1	0.6	13.2	4.1	0.0	2.4	17.9	2.5	**20.4**	**20.5**
7	0.0	0.6	0.0	0.6	7.3	3.8	0.1	5.3	11.8	5.4	**17.1**	**17.1**
8	0.0	0.4	0.1	0.3	4.8	2.9	0.0	2.7	8.0	2.7	**10.7**	**10.8**
9+	0.0	0.5	0.1	0.4	7.0	3.1	0.0	2.2	10.5	2.2	**12.7**	**12.7**
Sum	**3.6**	**3.4**	**0.2**	**3.3**	**57.3**	**25.5**	**0.5**	**38.6**	**86.1**	**39.1**	**128.8**	**125.4**

Table 2.2.5: North Sea autumn spawning herring (NSAS), and western Baltic spring spawners (WBSS) caught in the North Sea in 2015. 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	Herring caught in the North Sea
Quarters: 1-4												
0	9.8%	0.0%	0.0%	0.0%	7.7%	41.8%	34.1%	0.0%	17.3%	2.3%	15.3%	15.8%
1	54.1%	0.2%	0.2%	0.2%	1.6%	20.2%	48.7%	1.8%	7.3%	5.0%	11.2%	7.0%
2	31.1%	8.1%	0.8%	8.3%	11.3%	9.0%	3.9%	55.4%	10.1%	52.0%	15.7%	14.1%
3	2.2%	10.2%	7.4%	10.3%	9.0%	4.3%	1.2%	6.1%	7.7%	5.8%	7.0%	7.5%
4	0.4%	11.5%	12.0%	11.5%	11.9%	3.9%	1.4%	4.0%	9.3%	3.9%	8.0%	8.8%
5	1.6%	18.4%	33.1%	18.1%	17.9%	8.2%	3.1%	8.8%	14.9%	8.4%	13.1%	14.3%
6	0.4%	16.8%	15.7%	16.8%	19.5%	4.6%	1.6%	5.1%	14.4%	4.8%	12.3%	13.5%
7	0.4%	15.2%	12.3%	15.2%	9.5%	2.8%	3.2%	9.9%	8.3%	9.5%	7.7%	8.4%
8	0.1%	10.5%	8.0%	10.6%	5.6%	2.2%	1.5%	4.9%	5.3%	4.7%	4.8%	5.2%
9+	0.0%	9.0%	10.5%	9.0%	5.9%	3.0%	1.3%	3.9%	5.5%	3.7%	4.8%	5.3%
Sum 3+	5.0%	91.7%	99.0%	91.5%	79.4%	29.1%	13.3%	42.8%	65.3%	40.8%	57.8%	63.1%
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	27.3%	0.1%	0.0%	0.1%	0.0%	52.7%	92.2%	0.0%	9.8%	43.3%	16.3%	12.0%
2	70.6%	6.9%	0.0%	7.2%	9.2%	4.3%	0.0%	0.0%	7.4%	0.0%	24.2%	6.8%
3	1.8%	12.1%	10.5%	12.1%	14.7%	7.1%	0.0%	0.0%	12.2%	0.0%	8.7%	11.3%
4	0.1%	15.5%	18.0%	15.4%	14.5%	7.0%	0.9%	12.0%	13.5%	6.8%	9.5%	13.1%
5	0.2%	18.8%	19.7%	18.8%	26.7%	12.8%	2.2%	28.0%	20.8%	15.9%	14.9%	20.5%
6	0.0%	25.5%	14.8%	25.9%	24.3%	11.7%	0.9%	12.0%	22.6%	6.8%	15.6%	21.4%
7	0.0%	7.2%	9.5%	7.1%	3.1%	1.1%	1.9%	24.0%	4.4%	13.6%	3.7%	5.2%
8	0.0%	5.4%	10.7%	5.2%	1.6%	0.5%	0.9%	12.0%	2.9%	6.8%	2.3%	3.3%
9+	0.0%	8.5%	16.7%	8.2%	6.0%	2.7%	0.9%	12.0%	6.3%	6.8%	4.6%	6.5%
Sum 3+	2.1%	93.0%	100.0%	92.7%	90.8%	42.9%	7.8%	100.0%	82.7%	56.7%	59.4%	81.2%
Quarter: 2												
0	0.0%	0.0%	0.0%	0.0%	0.0%	0.3%	0.3%	0.0%	0.1%	0.2%	0.1%	0.1%
1	48.4%	0.2%	0.7%	0.2%	4.4%	91.3%	78.8%	0.0%	23.7%	46.9%	23.9%	23.6%
2	51.6%	9.0%	0.0%	9.1%	29.5%	1.1%	11.2%	0.0%	12.9%	6.7%	13.1%	12.8%
3	0.0%	9.8%	0.0%	9.9%	10.3%	0.9%	2.1%	0.0%	7.8%	1.3%	7.7%	7.7%
4	0.0%	9.9%	0.0%	10.0%	7.5%	1.0%	2.3%	12.0%	7.1%	6.2%	7.0%	7.1%
5	0.0%	18.2%	78.9%	17.7%	13.2%	2.7%	2.7%	28.0%	12.7%	12.9%	12.7%	13.0%
6	0.0%	12.4%	0.0%	12.5%	9.0%	0.8%	1.4%	12.0%	8.7%	5.7%	8.6%	8.6%
7	0.0%	18.9%	20.4%	18.9%	12.2%	0.5%	0.6%	24.0%	12.5%	10.1%	12.4%	12.5%
8	0.0%	12.7%	0.0%	12.8%	8.4%	0.5%	0.3%	12.0%	8.5%	5.0%	8.5%	8.5%
9+	0.0%	8.9%	0.0%	9.0%	5.5%	0.9%	0.3%	12.0%	6.0%	5.0%	6.0%	6.0%
Sum 3+	0.0%	90.8%	99.3%	90.7%	66.1%	7.3%	9.7%	100.0%	63.3%	46.2%	62.9%	63.5%
Quarter: 3												
0	4.9%	0.0%	0.0%	0.0%	7.3%	42.8%	67.1%	0.0%	17.7%	62.7%	16.9%	17.1%
1	63.3%	0.3%	0.1%	4.5%	1.2%	4.5%	6.3%	0.0%	2.2%	5.9%	5.8%	2.1%
2	15.6%	6.6%	2.7%	95.5%	8.6%	17.8%	10.1%	25.9%	11.5%	11.2%	11.8%	11.1%
3	5.8%	9.0%	10.4%	0.0%	8.4%	7.1%	3.9%	9.6%	8.0%	4.3%	7.8%	8.0%
4	1.2%	11.4%	14.5%	0.0%	13.8%	5.3%	3.9%	6.2%	11.2%	4.0%	10.6%	11.3%
5	5.9%	18.8%	25.0%	0.0%	19.4%	12.1%	4.5%	15.6%	17.2%	5.2%	16.5%	17.3%
6	1.4%	18.6%	23.5%	0.0%	21.4%	3.9%	2.1%	9.7%	16.2%	2.6%	15.3%	16.3%
7	1.5%	14.2%	13.1%	0.0%	9.7%	1.7%	1.1%	17.1%	7.4%	2.1%	7.0%	7.6%
8	0.4%	11.3%	5.8%	0.0%	5.3%	1.6%	0.5%	9.5%	4.2%	1.1%	4.0%	4.5%
9+	0.0%	9.8%	5.0%	0.0%	5.0%	3.2%	0.5%	6.5%	4.4%	0.9%	4.2%	4.6%
Sum 3+	16.2%	93.1%	97.3%	0.0%	82.9%	34.8%	16.5%	74.1%	68.6%	20.2%	65.5%	69.7%
Quarter: 4												
0	23.4%	0.0%	0.0%	0.0%	14.7%	63.7%	70.1%	0.0%	38.1%	2.4%	27.5%	27.9%
1	74.9%	0.4%	0.0%	0.4%	1.8%	3.0%	3.2%	1.9%	2.3%	2.0%	9.6%	2.2%
2	1.4%	7.2%	0.0%	7.5%	10.5%	3.6%	7.5%	57.8%	7.1%	56.1%	19.0%	20.9%
3	0.2%	7.4%	0.0%	7.8%	8.0%	2.4%	2.3%	6.4%	5.3%	6.3%	5.0%	5.6%
4	0.1%	10.2%	4.5%	10.5%	8.6%	3.2%	1.9%	3.7%	6.0%	3.6%	4.8%	5.3%
5	0.0%	18.2%	0.0%	19.1%	13.7%	5.6%	4.0%	8.0%	9.9%	7.9%	8.4%	9.3%
6	0.0%	19.3%	35.8%	18.5%	18.3%	5.8%	2.4%	4.8%	12.2%	4.7%	9.1%	10.1%
7	0.0%	15.8%	0.0%	16.6%	9.9%	5.2%	4.7%	9.3%	7.8%	9.2%	7.3%	8.2%
8	0.0%	10.1%	28.1%	9.2%	6.2%	3.7%	2.3%	4.6%	5.1%	4.5%	4.4%	4.9%
9+	0.0%	11.3%	31.6%	10.3%	8.5%	3.7%	1.8%	3.6%	6.2%	3.5%	4.9%	5.5%
Sum 3+	0.3%	92.4%	100.0%	92.0%	73.0%	29.7%	19.2%	40.3%	52.5%	39.6%	44.0%	48.9%

Table 2.2.6: Total catch of herring caught in the North Sea and Division 3.a: 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.

2013	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	460.7	0.008	0.9	0.034	0.0	0.000	**461.6**	**0.008**
1	220.3	0.046	106.5	0.026	64.3	0.091	21.9	0.031	**413.0**	**0.047**
2	218.4	0.140	20.6	0.040	68.5	0.080	17.3	0.053	**324.9**	**0.116**
3	481.8	0.156	0.6	0.156	2.3	0.135	0.1	0.105	**484.8**	**0.156**
4	569.3	0.198	1.5	0.198	0.3	0.161	0.0	0.138	**571.1**	**0.198**
5	421.5	0.198	0.5	0.288	0.3	0.200	0.0	0.000	**422.3**	**0.198**
6	326.2	0.215	0.7	0.215	0.0	0.000	0.0	0.000	**326.9**	**0.215**
7	144.9	0.233	0.3	0.233	0.0	0.000	0.0	0.000	**145.3**	**0.233**
8	151.8	0.234	0.9	0.234	0.0	0.000	0.0	0.000	**152.6**	**0.234**
9+	160.4	0.241	0.0	0.000	0.0	0.000	0.0	0.000	**160.4**	**0.241**
TOTAL	2'694.6		592.2		136.7		39.3		3'462.7	
SOP catch	**490.2**		**8.1**		**11.8**		**1.6**		**511.7**	

Figures for A fleet include 3 509 t unsampled bycatch in the industrial fishery

2014	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	51.8	0.018	1051.9	0.007	0.3	0.014	284.5	0.009	**1'388.5**	**0.007**
1	123.5	0.084	185.5	0.030	50.3	0.065	10.8	0.022	**370.1**	**0.052**
2	301.3	0.137	0.4	0.147	60.1	0.090	20.1	0.024	**381.9**	**0.124**
3	378.0	0.173	0.9	0.170	5.0	0.117	0.9	0.064	**384.8**	**0.172**
4	612.2	0.186	1.6	0.188	0.5	0.162	0.0	0.000	**614.4**	**0.186**
5	482.9	0.215	2.4	0.214	0.5	0.191	0.0	0.000	**485.8**	**0.215**
6	282.5	0.212	0.8	0.206	0.2	0.209	0.0	0.000	**283.5**	**0.212**
7	190.2	0.226	0.8	0.227	0.0	0.221	0.0	0.000	**191.0**	**0.226**
8	91.0	0.244	0.3	0.238	0.1	0.228	0.0	0.000	**91.4**	**0.244**
9+	121.5	0.242	0.9	0.222	0.0	0.000	0.0	0.000	**122.4**	**0.241**
TOTAL	2'635.0		1'245.6		116.9		316.4		4'313.9	
SOP catch	**490.2**		**14.0**		**9.5**		**3.3**		**517.0**	

Figures for A fleet include unsampled bycatch in the industrial fishery

2015	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	507.5	0.008	2.0	0.015	28.7	0.016	**538.2**	**0.009**
1	22.1	0.075	203.2	0.018	50.7	0.042	118.9	0.024	**394.9**	**0.026**
2	454.2	0.123	0.0	0.000	77.9	0.071	19.6	0.055	**551.8**	**0.113**
3	240.6	0.154	0.0	0.000	6.9	0.133	0.1	0.095	**247.6**	**0.154**
4	281.6	0.188	0.0	0.000	1.3	0.157	0.0	0.000	**282.8**	**0.188**
5	456.1	0.200	0.0	0.000	4.9	0.180	0.0	0.147	**461.0**	**0.200**
6	430.9	0.221	0.0	0.000	1.1	0.196	0.0	0.000	**432.0**	**0.221**
7	270.1	0.217	0.0	0.000	1.2	0.197	0.0	0.000	**271.3**	**0.217**
8	167.2	0.226	0.0	0.000	0.4	0.215	0.0	0.000	**167.5**	**0.226**
9+	170.3	0.243	0.0	0.000	0.0	0.000	0.0	0.000	**170.3**	**0.243**
TOTAL	2'493.1		710.7		146.3		167.3		3'517.4	
SOP catch	**472.4**		**7.8**		**10.2**		**4.4**		**494.8**	

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, 2000-2015.

YEAR/RINGS	0	1	2	3	4	5	6	7	8	9+	TOTAL
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
2013	461	327	239	482	571	422	327	145	153	160	3287
2014	1104	309	303	380	616	487	284	192	92	123	3890
2015	508	225	454	241	282	456	431	270	167	170	3204

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 3.a, 2000-2015.

YEAR/RINGS	0	1	2	3	4	5	6	7	8	9+	TOTAL
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
2013	0.0	0.0	0.1	0.4	0.2	0.5	0.3	0.1	0.2	0.5	2.2
2014	0.0	0.0	2.5	3.4	5.4	0.8	2.1	1.0	0.5	1.1	16.8
2015	0.0	0.0	0.1	0.9	1.4	3.9	1.8	1.4	0.9	1.2	11.7

Table 2.2.9: Catch at age (numbers in millions) of NSAS taken in 3.a, and transferred to the assessment of NSAS, 2000-2015.

Year/rings	0	1	2	3	4	5	6	7	8+	Total
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
2013	1	86	86	2	0	0	0	0	0	176
2014	285	61	80	6	1	0	0	0	0	433
2015	31	170	98	7	1	5	1	1	0	314

Table 2.2.10: Catch at age (numbers in millions) of the total NSAS stock 2000–2015.

Year/rings	0	1	2	3	4	5	6	7	8	9+	Total
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
2013	462	413	325	484	571	422	327	145	152	160	3461
2014	1389	371	383	386	617	488	285	192	92	123	4323
2015	538	395	552	248	283	461	432	271	168	170	3517

Table 2.2.11: Comparison of mean weight (kg) at age (rings) in the catch of adult North Sea herring (by Division) and NSAS caught in Division 3.a in 2005–2015.

		Age (Rings)							
Division	Year	2	3	4	5	6	7	8	9+
3.a	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	-
	2013	0.075	0.134	0.160	0.201	0.000	0.000	0.000	-
	2014	0.074	0.109	0.162	0.191	0.209	0.221	0.228	-
	2015	0.068	0.133	0.157	0.180	0.196	0.197	0.215	-
4.a(E)	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
	2013	0.129	0.147	0.184	0.191	0.205	0.215	0.215	0.228
	2014	0.146	0.161	0.167	0.195	0.200	0.216	0.227	0.224
	2015	0.127	0.148	0.163	0.178	0.191	0.203	0.212	0.227
4.a(W)	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
	2013	0.139	0.158	0.201	0.197	0.218	0.234	0.234	0.251
	2014	0.143	0.172	0.184	0.215	0.212	0.227	0.246	0.242
	2015	0.124	0.158	0.198	0.211	0.233	0.228	0.239	0.252
4.b	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
	2013	0.125	0.162	0.205	0.206	0.228	0.251	0.261	0.246
	2014	0.133	0.187	0.208	0.233	0.240	0.249	0.256	0.277
	2015	0.140	0.162	0.189	0.203	0.208	0.216	0.227	0.250

Table 2.2.11 continued: Comparison of mean weight (kg) at age (rings) in the catch of adult North Sea herring (by Division) and NSAS caught in Division 3.a in 2005–2015.

		AGE (RINGS)							
Division	Year	2	3	4	5	6	7	8	9+
4.a & 4.b	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
	2013	0.132	0.158	0.198	0.198	0.217	0.234	0.235	0.244
	2014	0.138	0.174	0.187	0.216	0.213	0.227	0.246	0.243
	2015	0.129	0.157	0.190	0.203	0.223	0.219	0.228	0.245
4.c & 7.d	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
	2013	0.126	0.144	0.180	0.196	0.206	0.216	0.218	0.226
	2014	0.119	0.148	0.166	0.183	0.208	0.222	0.227	0.233
	2015	0.114	0.127	0.154	0.157	0.183	0.197	0.204	0.210
Total	2005	0.099	0.153	0.166	0.208	0.223	0.240	0.257	0.278
North Sea	2006	0.122	0.145	0.172	0.181	0.220	0.237	0.235	0.262
Catch	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
	2013	0.131	0.156	0.198	0.198	0.215	0.233	0.234	0.241
	2014	0.137	0.173	0.186	0.215	0.212	0.226	0.244	0.241
	2015	0.123	0.154	0.188	0.200	0.221	0.217	0.226	0.243

Table 2.2.12: Sampling of commercial landings of North Sea herring (Division 4 and 7.d) in 2015 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 meters	Metiers sampled	Sampled Catch %	Official landings	No. of samples	No. fish aged	No. fish measured	>1 sample per 1 kt catch
Belgium	1	2	0	0%	6	0	0	0	n
	2	2	0	0%	3	0	0	0	n
	3	2	0	0%	0	0	0	0	n
	4	2	0	0%	9	0	0	0	n
total		**8**	**0**	**0%**	**18**	**0**	**0**	**0**	**n**
Denmark (A)	1	3	2	88%	32423	22	580	3146	n
	2	3	1	55%	5375	6	156	815	y
	3	3	2	93%	50059	23	571	2538	n
	4	2	2	100%	17714	12	294	1513	n
total		**11**	**7**	**91%**	**105571**	**63**	**1601**	**8012**	**n**
Denmark (B)	1	2	1	75%	354	4	22	22	y
	2	3	1	98%	2442	2	11	11	n
	3	3	1	71%	1862	100	100	823	y
	4	3	1	79%	3252	19	149	162	y
total		**11**	**4**	**83%**	**7909**	**125**	**282**	**1018**	**y**
England and Wales	1	3	0	0%	75	0	0	0	n
	2	4	2	99%	1014	6	150	4680	y
	3	4	2	100%	14299	32	795	18862	y
	4	4	1	83%	3509	5	125	1938	y
total		**15**	**5**	**96%**	**18897**	**43**	**1070**	**25480**	**y**
France	1	2	0	0%	1447	0	0	0	n
	2	4	1	99%	2507	11	275	2368	y
	3	4	0	0%	15036	0	0	0	n
	4	4	0	0%	11278	0	0	0	n
total		**14**	**1**	**8%**	**30268**	**11**	**275**	**2368**	**n**
Germany	2	2	0	0%	23	0	0	0	n
	3	1	1	100%	29139	74	304	29585	n
	4	4	2	99%	15215	54	442	16480	y
total		**7**	**3**	**100%**	**44377**	**128**	**746**	**46065**	**n**
Ireland	4	1	0	0%	183	0	0	0	n
total		**1**	**0**	**0%**	**183**	**0**	**0**	**0**	**n**
Netherlands	1	1	1	100%	332	1	25	157	y
	2	1	0	0%	0	0	0	0	n
	3	2	2	100%	53712	54	1350	6596	y
	4	4	2	95%	16031	2	50	450	n
total		**8**	**5**	**98%**	**70076**	**57**	**1425**	**7203**	**n**
Northern Ireland	3	2	0	0%	5941	0	0	0	n
	4	1	0	0%	7	0	0	0	n
total		**3**	**0**	**0%**	**5948**	**0**	**0**	**0**	**n**
Norway	1	4	1	97%	7739	8	399	519	y
	2	3	2	99%	64756	26	1151	1855	n
	3	3	1	78%	6994	4	199	382	y
	4	3	3	100%	54861	22	757	1478	n
total		**13**	**7**	**98%**	**134349**	**60**	**2506**	**4234**	**n**
Scotland	2	1	1	100%	2420	5	258	888	y
	3	3	3	100%	41906	31	1230	4246	n
	4	1	0	0%	67	0	0	0	n
total		**6**	**4**	**100%**	**45118**	**36**	**1488**	**5134**	**n**
Sweden	1	**1**	**0**	**0%**	**900**	**0**	**0**	**0**	**n**
	2	3	0	0%	4202	0	0	0	n
	3	3	0	0%	6545	0	0	0	n
	4	2	0	0%	1537	0	0	0	n
total		**9**	**0**	**0%**	**13184**	**0**	**0**	**0**	**n**
Faroese	3	1	0	0%	30	0	0	0	n
	4	1	0	0%	951	0	0	0	n
total		**2**	**0**	**0%**	**981**	**0**	**0**	**0**	**n**
grand total		**107**	**34**	**86%**	**480093**	**526**	**9629**	**99748**	**n**
Period total	**1**	18	5	85%	43276	35	1026	3844	n
Period total	**2**	26	8	91%	82878	57	2009	10774	n
Period total	**3**	31	10	85%	228296	320	4777	63109	n
Period total	**4**	32	11	86%	125642	114	1817	22021	n
Total for stock 2014		**107**	**34**	**86%**	**480093**	**526**	**9629**	**99748**	**n**
Human Cons. only		96	30	86%	472184	401	9347	98730	n
Total for stock 2013		92	42	85%	498501	385	8236	67118	n
Total for stock 2014		97	35	83%	504190	369	8794	57454	n
Human Cons. only 2014		88	33	84%	490207	352	8628	56951	n

Table 2.3.1.1. North Sea herring. Acoustic Surveys in the North Sea (HERAS) in June-July 2014. Vessels, areas and cruise dates.

Vessel	Period	Area	Rectangles
Celtic Explorer (IRL)	24 June – 14 July	53°30′-58°30′N ,12°-4°W	36D8-D9, 37D9-E1, 38D9-E1, 39E0-E2, 40E0-E2,41E0-E3, 42E0-E3, 43E0-E3, 44E0-E3, 45E0-E4, 46E2-E5, 47E3-E6, 48E4-E5, 49E5
Scotia (SCO)	25 June – 14 July	58°30′-62°N, 4°W-2°E	46E6-F1, 47E6-F1, 48E6-F1, 49E6-F1, 50E7-F1, 51E8-F1
Johan Hjort (NOR)	25 June – 15 July	56°30′-62°N, 2°-6°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)	22 June – 17 July	54°25′– 58°24′N, 3° W–5°E	37E9-F1, 38E8-F1, 39E8-F1, 40E8-F4, 41E7-F4, 42E7-F1, 43E7-F1, 44E6-F1, 45E6-F1
Solea (GER) DBFH	26 June – 16 July	52°-56.5°N, Eng to Den/Ger coasts	33F1-F4, 34F2-F4, 35F2-F4, 36F2-F7, 37F2-F8, 38F2-F7, 39F2-F7, 40F6-F7, 41F5
Dana (DEN) OXBH	25 June – 8 July	Kattegat and North of 56°N, east of 6°E	41F6-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 2015. 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	386	2	0.00	4.0	8.1
1	6 714	331	0.00	49.3	18.2
2	9 495	1 148	0.70	120.9	24.0
3	2 831	414	0.90	146.4	25.6
4	1 591	292	0.96	183.5	27.5
5	1 549	309	0.98	199.6	28.1
6	926	204	0.99	220.1	29.0
7	520	107	1.00	205.4	28.9
8	275	58	1.00	210.0	29.3
9+	221	51	1.00	229.1	30.2
Immature	**10 285**	**635**		**61.7**	**19.1**
Mature	**14 222**	**2 280**		**160.3**	**26.2**
Total	**24 508**	**2 915**	**0.58**	**119.0**	**23.2**

Table 2.3.1.3. Estimates of North Sea autumn spawners (millions) at age from acoustic surveys, 1986—2015. For 1986 the estimates are the sum of those from the Division 4.a summer survey, the Division 4.b autumn survey, and the Divisions 4.c, 7.d winter survey. The 1987 to 2015 estimates are from summer surveys in Divisions 4.a, b, c, and 3.a excluding estimates of Western Baltic spring spawners. For 1999 and 2000 the Kattegat was excluded from the results because it was not surveyed. Total numbers include 0-ringers from 2008 onwards.

Years / Age (rings)	1	2	3	4	5	6	7	8	9+	Total	SSB ('000t)
1986	1639	3206	1637	833	135	36	24	6	8	7542	942
1987	13736	4303	955	657	368	77	38	11	20	20165	817
1988	6431	4202	1732	528	349	174	43	23	14	13496	897
1989	6333	3726	3751	1612	488	281	120	44	22	16377	1637
1990	6249	2971	3530	3370	1349	395	211	134	43	18262	2174
1991	3182	2834	1501	2102	1984	748	262	112	56	12781	1874
1992	6351	4179	1633	1397	1510	1311	474	155	163	17173	1545
1993	10399	3710	1855	909	795	788	546	178	116	19326	1216
1994	3646	3280	957	429	363	321	238	220	132	13003	1035
1995	4202	3799	2056	656	272	175	135	110	84	11220	1082
1996	6198	4557	2824	1087	311	99	83	133	206	18786	1446
1997	9416	6363	3287	1696	692	259	79	78	158	22028	1780
1998	4449	5747	2520	1625	982	445	170	45	121	16104	1792
1999	5087	3078	4725	1116	506	314	139	54	87	15107	1534
2000	24735	2922	2156	3139	1006	483	266	120	97	34928	1833
2001	6837	12290	3083	1462	1676	450	170	98	59	26124	2622
2002	23055	4875	8220	1390	795	1031	244	121	150	39881	2948
2003	9829	18949	3081	4189	675	495	568	146	178	38110	2999
2004	5183	3415	9191	2167	2590	317	328	342	186	23722	2584
2005	3113	1890	3436	5609	1211	1172	140	127	107	16805	1868
2006	6823	3772	1997	2098	4175	618	562	84	70	20199	2130
2007	6261	2750	1848	898	806	1323	243	152	65	14346	1203
2008	3714	2853	1709	1485	809	712	1749	185	270	20355	1784
2009	4655	5632	2553	1023	1077	674	638	1142	578	31526	2591
2010	14577	4237	4216	2453	1246	1332	688	1110	1619	43705	3027
2011	10119	4166	2534	2173	1016	651	688	440	1207	25524	2431
2012	7437	4718	4067	1738	1209	593	247	218	478	23641	2269
2013	6388	2683	3031	2895	1546	849	464	250	592	36484	2261
2014	11634	4918	2827	2939	1791	1236	669	211	250	61339	2610
2015	6714	9495	2831	1591	1549	926	520	275	221	24508	2280

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/ Year	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			3312
1973	2029	822	3	4	492	830	1213			1	13.1	3253
1974	758	421	101	284	81		1184		10		7.6	2201
1975	371	50	312			90	77	1	2		2.9	1380
1976	545	81		1	64	108			3		2.5	1230
1977	1133	221	124	32	520	262	89	1			6.2	1632
1978	3047	50		162	1406	81	269	33	3		7.4	2133
1979	2882	2362	197	10	662	131	507		111	89	13.7	3202
1980	3534	720	21	1	317	188	9	247	129	40	9.3	3492
1981	3667	277	3	12	903	235	119	1456		70	13.7	3951
1982	2353	1116	340	257	86	64	1077	710	275	54	19.8	5020
1983	2579	812	3647	768	1459	281	63	71	243	58	24.9	7737
1984	1795	1912	2327	1853	688	2404	824	523	185	39	45.5	12098
1985	5632	3432	2521	1812	130	13039	1794	1851	407	38	69.7	15119
1986	3529	1842	3278	341	1611	6112	188	780	123	18	36.3	14563
1987	7409	1848	2551	670	799	4927	1992	934	297	146	64.1	18390
1988	7538	8832	6812	5248	5533	3808	1960	1679	162	112	128.0	25923
1989	11477	5725	5879	692	1442	5010	2364	1514	2120	512	127.7	21850
1990		10144	4590	2045	19955	1239	975	2552	1204		165.9	20306
1991	1021	2397		2032	4823	2110	1249	4400	873		87.8	13913
1992	189	4917		822	10	165	163	176	1616		40.0	7457
1993		66		174		685	85	1358	1103		29.3	5051
1994	26	1179				1464	44	537	595		20.1	4438
1995		8688					43	74	230	164	20.3	5557
1996		809		184		564		337	675	691	40.0	7010
1997		3611		23				9374	918	355	51.5	9839
1998		8528		1490	205	66		1522	953	170	64.4	13106
1999		4064		185		134	181	804	1260	344	55.0	14234
2000		3352	28	83		376		7346	338	106	37.3	16328
2001		11918		164		1604		971	5531	909	125.1	21505
2002		6669		1038			3291	2008	260	925	102.3	25973
2003		3199		2263		12018	3277	12048	3109	1116	246.9	33257
2004		7055		3884		5545		7055	2052	4175	306.9	36518
2005		3380		1364		5614		498	3999	4822	183.9	31917
2006	6311	2312		280		2259		10858	2700	2106	112.0	29525
2007		1753		1304		291		4443	2439	3854	159.6	30703
2008	4978	6875		533		11201		8426	2317	4008	178.2	37390
2009		7543		4629		4219		15295	14712	1689	458.0	46676
2010		2362		1493		2317		7493	13230	8073	375.4	47224
2011		3831		2839		17766		5461	6160	1215	309.9	49874
2012		19552		5856		517		22768	11103	3285	650.9	58610
2013		21282		8618		7354		5	9314	2957	310.7	61593
2014		6604		5033		1149				1851	285.8	59947
2015		9631		3496		3424		2011	1200	645	149.0	53163

Table 2.3.3.1 North Sea herring. Density and abundance estimates of 0-ringers caught in February during the IBTS. Values given for the 1995 to 2015 year classes by areas are density estimates in numbers per square metre. Total abundance is found by multiplying density by area and summing up. Data for the period 1976 to 1994 are recorded in the stock annex.

Area	North west	North east	Central west	Central east	South west	South east	Division 3.a	South'Bight	IBTS–0 index
Area m2 x 109	83	34	86	102	37	93	31	31	
Year class									no. in 109
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
2013	0.132	0.151	0.240	0.254	0.389	0.678	0.037	0.759	164.5
2014	0.010	0.006	0.150	0.047	0.038	0.002	0.009	0.007	20.8
2015	0.015	0.015	0.137	0.088	0.083	0.712	0.006	0.259	99.8

Table 2.3.3.2. North Sea herring. Indices of 1-ringers from the IBTS 1st Quarter for the 1995 to 2014 year classes (the data for the 1977 to 1994 year classes can be found in the stock annex). Estimation of the small sized component (possibly Downs herring) in different areas. " North Sea" = total area of sampling minus 3.a.

Year class	Year of sampling	All 1-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 3.a vs small in total area
1995	1997	4403	1356	0.31	1089	0.25	0.25
1996	1998	2276	1322	0.58	1399	0.61	0.02
1997	1999	753	152	0.2	149	0.20	0.09
1998	2000	3304	1068	0.32	939	0.28	0.18
1999	2001	2499	328	0.13	307	0.12	0.13
2000	2002	3881	1520	0.39	1436	0.37	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	1015	341	0.34	357	0.35	0.02
2004	2006	900	115	0.13	121	0.13	0.02
2005	2007	1322	303	0.23	304	0.23	0.07
2006	2008	1792	417	0.23	444	0.25	0.01
2007	2009	2339	734	0.31	623	0.27	0.21
2008	2010	1206	279	0.23	286	0.24	0.05
2009	2011	2939	1331	0.45	1407	0.48	0.02
2010	2012	1353	279	0.21	288	0.21	0.04
2011	2013	1665	747	0.45	796	0.48	0.01
2012	2014	2615	1297	0.5	1245	0.48	0.11
2013	2015	3918	1808	0.46	1105	0.28	0.43
2014	2016	779	366	0.47	362	0.47	0.08

Table 2.4.1.1. North Sea herring. Mean stock weight-at-age (wr) in the third quarter, in divisions 4.a, 4.b and 3.a. Mean catch weight-at-age for the same quarter and area is included for comparison. 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
2013	38	48	131	149	161	170	221	217	210	207	236	222	257	252	249	254	252	265
2014	44	49	130	142	177	191	195	208	225	239	218	233	225	243	250	264	246	266
2015	49	33	121	134	146	168	183	212	200	226	220	253	205	243	210	255	229	276

Table 2.4.2.1. North Sea herring. Percentage maturity at 2, 3, 4, 5, 6 and 7+ ring for autumn spawning herring in the North Sea. The values are derived from the acoustic survey for 1988 to 2015. In the period 1988-2014, maturity of age 5+ were set to 100%.

Year \ Ring	2	3	4	5	6	7+
1988	65.6	87.7	100	100	100	100
1989	78.7	93.9	100	100	100	100
1990	72.6	97.0	100	100	100	100
1991	63.8	98.0	100	100	100	100
1992	51.3	100	100	100	100	100
1993	47.1	62.9	100	100	100	100
1994	72.1	85.8	100	100	100	100
1995	72.6	95.4	100	100	100	100
1996	60.5	97.5	100	100	100	100
1997	64.0	94.2	100	100	100	100
1998	64.0	89.0	100	100	100	100
1999	81.0	91.0	100	100	100	100
2000	66.0	96.0	100	100	100	100
2001	77.0	92.0	100	100	100	100
2002	86.0	97.0	100	100	100	100
2003	43.0	93.0	100	100	100	100
2004	69.8	64.9	100	100	100	100
2005	76.0	97.0	96.0	100	100	100
2006	66.0	88.0	98.0	100	100	100
2007	71.0	92.0	93.0	100	100	100
2008	86.0	98.0	99.0	100	100	100
2009	89.0	100	100	100	100	100
2010	45.0	90.0	100	100	100	100
2011	87.0	84.0	99.0	100	100	100
2012	91.0	99.0	100	100	100	100
2013	83.0	96.0	98.0	100	100	100
2014	85.0	100	100	100	100	100
2015	70.0	90.0	96.0	98.0	99.0	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	1972-2015	1973-2015
IBTS 1st Quarter (Trawl survey)	1-wr	1971-2016	1984-2016
Acoustic (+trawl)	1wr	1995-2015	1997-2015
	2-9+wr	1984-2015	1989-2015
IBTS0	0wr	1977-2016	1992-2016

Table 2.6.3.1 North Sea Herring. Catch in numbers.

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

Table 2.6.3.1 (continued). North Sea Herring. Catch in numbers.

age \ year	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
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	2013	2014	2015
0	773241	461571	1388685	538228
1	284906	413000	370590	394878
2	455259	324920	382990	551802
3	673465	485185	386131	247555
4	404265	571269	616563	282813
5	306234	422765	487582	461041
6	152577	327213	284562	432034
7	104461	145330	191729	271280
8	205427	313638	214513	337811

Table 2.6.3.2 North Sea Herring. Weight 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

Table 2.6.3.2 (continued). North Sea Herring. Weight at age in the catch.

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
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

age \ year	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

age \ year	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

age \ year	2010	2011	2012	2013	2014	2015
0	0.0075000	0.008000	0.0106000	0.0077000	0.0075000	0.0087000
1	0.0571000	0.041300	0.0463000	0.0468000	0.0522000	0.0261000
2	0.1292000	0.131700	0.1243000	0.1162000	0.1240000	0.1135000
3	0.1669000	0.159300	0.1706000	0.1563000	0.1719000	0.1538000
4	0.1912000	0.183100	0.1854000	0.1977000	0.1861000	0.1883000
5	0.2203000	0.197000	0.2058000	0.1980000	0.2148000	0.2001000
6	0.2193000	0.216700	0.2215000	0.2154000	0.2118000	0.2212000
7	0.2160000	0.221100	0.2387000	0.2334000	0.2264000	0.2170000
8	0.2383892	0.231918	0.2427213	0.2378432	0.2426541	0.2347182

Table 2.6.3.3 North Sea Herring. Weights at age in the stock.

Units : kg

age \ year	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

age \ year	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

Table 2.6.3.3 (continued). North Sea Herring. Weights at age in the stock.

age \ year	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
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

Table 2.6.3.3 (continued). North Sea Herring. Weights at age in the stock.

age	2004	2005	2006	2007	2008	2009
0	0.006666667	0.005666667	0.006666667	0.00600000	0.00800000	0.007333333
1	0.042000000	0.041333333	0.041000000	0.05133333	0.05766667	0.061333333
2	0.119333333	0.118000000	0.125666667	0.12800000	0.13033333	0.137333333
3	0.165333333	0.164333333	0.155333333	0.16066667	0.16433333	0.181000000
4	0.202666667	0.198000000	0.191000000	0.17966667	0.18066667	0.196666667
5	0.223000000	0.224666667	0.216000000	0.20700000	0.19533333	0.210000000
6	0.247666667	0.248000000	0.242000000	0.22366667	0.21766667	0.222666667
7	0.267666667	0.265000000	0.252333333	0.23800000	0.22600000	0.233666667
8	0.280490193	0.284851772	0.270150625	0.25639104	0.25556215	0.255734029

age	2010	2011	2012	2013	2014	2015
0	0.007333333	0.006666667	0.00600000	0.00600000	0.005666667	0.005333333
1	0.052000000	0.043000000	0.04033333	0.04033333	0.043333333	0.043666667
2	0.142333333	0.145666667	0.13800000	0.13566667	0.128666667	0.127333333
3	0.190333333	0.187333333	0.18200000	0.17466667	0.176666667	0.161333333
4	0.216000000	0.225000000	0.21133333	0.20866667	0.203666667	0.200000000
5	0.223666667	0.239666667	0.23300000	0.22133333	0.215666667	0.211666667
6	0.234333333	0.243666667	0.24100000	0.24200000	0.228666667	0.224666667
7	0.240000000	0.250666667	0.24266667	0.24933333	0.241333333	0.229000000
8	0.260650879	0.257270953	0.25251076	0.25179433	0.246572539	0.239358137

Table 2.6.3.4 North Sea Herring. Natural mortality.

Units : NA

age	1947	1948	1949	1950	1951	1952	1953
0	0.8965553	0.8965550	0.8965542	0.8965543	0.8965558	0.8965573	0.8965533
1	0.7070241	0.7070248	0.7070258	0.7070253	0.7070229	0.7070215	0.7070284
2	0.3970898	0.3970897	0.3970895	0.3970895	0.3970899	0.3970903	0.3970892
3	0.3663949	0.3663947	0.3663943	0.3663943	0.3663951	0.3663958	0.3663938
4	0.3420698	0.3420698	0.3420697	0.3420696	0.3420698	0.3420701	0.3420697
5	0.3223452	0.3223451	0.3223448	0.3223448	0.3223454	0.3223460	0.3223446
6	0.3162028	0.3162026	0.3162021	0.3162022	0.3162031	0.3162038	0.3162016
7	0.2932376	0.2932372	0.2932365	0.2932367	0.2932381	0.2932393	0.2932354
8	0.2932376	0.2932372	0.2932365	0.2932367	0.2932381	0.2932393	0.2932354

age	1954	1955	1956	1957	1958	1959	1960
0	0.8965504	0.8965545	0.8965637	0.8965647	0.8965329	0.8965360	0.8965754
1	0.7070310	0.7070227	0.7070106	0.7070149	0.7070629	0.7070442	0.7069807
2	0.3970884	0.3970896	0.3970921	0.3970924	0.3970835	0.3970845	0.3970956
3	0.3663924	0.3663946	0.3663990	0.3663993	0.3663837	0.3663857	0.3664052
4	0.3420691	0.3420693	0.3420707	0.3420717	0.3420678	0.3420661	0.3420704
5	0.3223434	0.3223449	0.3223482	0.3223488	0.3223374	0.3223379	0.3223519
6	0.3162001	0.3162025	0.3162074	0.3162076	0.3161902	0.3161927	0.3162145
7	0.2932332	0.2932374	0.2932453	0.2932450	0.2932163	0.2932221	0.2932585
8	0.2932332	0.2932374	0.2932453	0.2932450	0.2932163	0.2932221	0.2932585

age	1961	1962	1963	1964	1965	1966	1967
0	0.8966096	0.8965699	0.8963736	0.8965513	0.8967726	0.8967804	0.8963717
1	0.7069505	0.7070365	0.7073024	0.7069507	0.7066631	0.7067997	0.7074668
2	0.3971048	0.3970935	0.3970389	0.3970896	0.3971512	0.3971511	0.3970366
3	0.3664211	0.3664007	0.3663057	0.3663958	0.3665027	0.3665005	0.3662989
4	0.3420776	0.3420767	0.3420481	0.3420576	0.3420918	0.3421140	0.3420721
5	0.3223650	0.3223519	0.3222802	0.3223405	0.3224219	0.3224306	0.3222865
6	0.3162320	0.3162087	0.3161029	0.3162052	0.3163239	0.3163192	0.3160925
7	0.2932848	0.2932433	0.2930726	0.2932510	0.2934409	0.2934161	0.2930360
8	0.2932848	0.2932433	0.2930726	0.2932510	0.2934409	0.2934161	0.2930360

age	1968	1969	1970	1971	1972	1973	1974
0	0.8953919	0.8974399	0.8978791	0.8968196	0.8943280	0.8904932	0.9076796
1	0.7086315	0.7051925	0.7052250	0.7074827	0.7108020	0.7144553	0.6879976
2	0.3967659	0.3973430	0.3974597	0.3971501	0.3964641	0.3954128	0.4002281
3	0.3658305	0.3668467	0.3670369	0.3664894	0.3652910	0.3634884	0.3719278
4	0.3419049	0.3421051	0.3422629	0.3422248	0.3418628	0.3410691	0.3431060
5	0.3219214	0.3226419	0.3228293	0.3224741	0.3215656	0.3200960	0.3262446
6	0.3155738	0.3167169	0.3169171	0.3162956	0.3149591	0.3129801	0.3224328
7	0.2922189	0.2941433	0.2943901	0.2932921	0.2911356	0.2881336	0.3037649
8	0.2922189	0.2941433	0.2943901	0.2932921	0.2911356	0.2881336	0.3037649

Table 2.6.3.4 (continued). North Sea Herring. Natural mortality.

age \ year	1975	1976	1977	1978	1979	1980	1981
0	0.9000750	0.8915222	0.8818698	0.8713194	0.8593691	0.8461517	0.8327639
1	0.7053876	0.7187712	0.7273984	0.7327215	0.7341041	0.7315335	0.7273459
2	0.3980433	0.3956023	0.3930341	0.3901562	0.3869195	0.3833439	0.3792957
3	0.3679878	0.3637520	0.3592993	0.3544751	0.3492394	0.3436118	0.3375233
4	0.3430515	0.3420346	0.3400528	0.3371008	0.3331128	0.3280894	0.3221419
5	0.3237665	0.3206980	0.3170229	0.3127479	0.3078709	0.3023749	0.2962876
6	0.3179179	0.3131880	0.3082766	0.3030852	0.2976821	0.2920477	0.2860090
7	0.2956242	0.2878022	0.2803530	0.2731239	0.2662211	0.2596270	0.2530696
8	0.2956242	0.2878022	0.2803530	0.2731239	0.2662211	0.2596270	0.2530696

age \ year	1982	1983	1984	1985	1986	1987	1988
0	0.8187654	0.8043777	0.7889868	0.7723920	0.7573031	0.7414107	0.7265873
1	0.7153238	0.7010988	0.6937230	0.6872393	0.6792442	0.6718757	0.6638450
2	0.3747833	0.3699339	0.3650458	0.3600685	0.3545250	0.3445140	0.3345718
3	0.3312715	0.3246117	0.3159265	0.3059541	0.2973456	0.2860972	0.2759717
4	0.3148039	0.3065211	0.2961347	0.2839697	0.2737314	0.2612509	0.2501418
5	0.2893166	0.2817134	0.2723778	0.2616976	0.2527487	0.2427375	0.2338307
6	0.2799124	0.2734042	0.2647060	0.2546756	0.2460435	0.2361377	0.2271801
7	0.2474062	0.2417752	0.2337646	0.2246438	0.2170837	0.2093401	0.2025478
8	0.2474062	0.2417752	0.2337646	0.2246438	0.2170837	0.2093401	0.2025478

age \ year	1989	1990	1991	1992	1993	1994	1995
0	0.7172914	0.7110829	0.7065958	0.7025892	0.7000766	0.6976706	0.6956149
1	0.6515736	0.6377937	0.6244281	0.6039680	0.5840028	0.5697455	0.5553106
2	0.3277575	0.3209044	0.3168527	0.3177469	0.3197250	0.3208557	0.3233006
3	0.2721084	0.2703141	0.2708915	0.2776747	0.2856419	0.2912902	0.2983756
4	0.2465746	0.2457930	0.2467850	0.2535637	0.2613654	0.2662117	0.2721848
5	0.2300761	0.2283638	0.2284738	0.2333929	0.2393742	0.2434319	0.2484810
6	0.2227627	0.2199929	0.2192156	0.2233030	0.2284693	0.2317960	0.2360766
7	0.1996415	0.1985368	0.1986948	0.2023900	0.2068624	0.2092900	0.2120814
8	0.1996415	0.1985368	0.1986948	0.2023900	0.2068624	0.2092900	0.2120814

age \ year	1996	1997	1998	1999	2000	2001	2002
0	0.6983717	0.7094121	0.7234486	0.7431392	0.7687325	0.7879394	0.8017320
1	0.5486203	0.5533680	0.5629294	0.5828287	0.6120658	0.6332999	0.6533508
2	0.3270289	0.3299493	0.3345761	0.3460554	0.3609426	0.3732300	0.3886273
3	0.3048050	0.3089526	0.3135255	0.3202844	0.3274834	0.3342691	0.3449506
4	0.2771983	0.2785695	0.2803052	0.2845230	0.2886973	0.2938106	0.3044885
5	0.2530521	0.2552715	0.2581317	0.2634449	0.2692526	0.2757281	0.2866804
6	0.2402370	0.2428323	0.2462119	0.2521491	0.2588869	0.2657467	0.2762943
7	0.2149922	0.2157750	0.2175890	0.2235415	0.2308219	0.2384173	0.2502256
8	0.2149922	0.2157750	0.2175890	0.2235415	0.2308219	0.2384173	0.2502256

age \ year	2003	2004	2005	2006	2007	2008	2009
0	0.8129805	0.8162740	0.8158639	0.8168008	0.8192047	0.8204193	0.8204422
1	0.6696337	0.6671653	0.6576203	0.6495382	0.6424365	0.6334179	0.6237293
2	0.4021713	0.4056177	0.4061169	0.4047458	0.4012439	0.3954705	0.3877396
3	0.3544945	0.3577122	0.3593065	0.3592480	0.3574352	0.3540455	0.3491904
4	0.3148123	0.3203738	0.3254766	0.3283538	0.3289307	0.3279876	0.3253955
5	0.2972330	0.3038143	0.3100614	0.3139323	0.3154262	0.3153612	0.3135234
6	0.2863114	0.2920184	0.2970697	0.3002624	0.3015723	0.3015044	0.2999452
7	0.2616882	0.2689091	0.2757679	0.2802310	0.2823417	0.2828278	0.2814051
8	0.2616882	0.2689091	0.2757679	0.2802310	0.2823417	0.2828278	0.2814051

age \ year	2010	2011	2012	2013	2014	2015
0	0.8191635	0.8173077	0.8156684	0.8137161	0.8172596	0.8164639
1	0.6120449	0.5994214	0.5871932	0.5745417	0.5993861	0.5933003
2	0.3776919	0.3655729	0.3518383	0.3363089	0.3638303	0.3578530
3	0.3427256	0.3346570	0.3251469	0.3142024	0.3331844	0.3291830
4	0.3212505	0.3154057	0.3078469	0.2987052	0.3137208	0.3108021
5	0.3100955	0.3048594	0.2977150	0.2888504	0.3030087	0.3003801
6	0.2969777	0.2924872	0.2864755	0.2790475	0.2909866	0.2887470
7	0.2783231	0.2733752	0.2664683	0.2577845	0.2714712	0.2689877
8	0.2783231	0.2733752	0.2664683	0.2577845	0.2714712	0.2689877

Table 2.6.3.5 North Sea Herring. Proportion mature.

Units : NA

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

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

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

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

age	2007	2008	2009	2010	2011	2012	2013	2014	2015
0	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
2	0.71	0.86	0.89	0.45	0.87	0.91	0.83	0.85	0.70
3	0.92	0.98	1.00	0.90	0.84	0.99	0.96	1.00	0.90
4	0.93	0.99	1.00	1.00	1.00	1.00	0.98	1.00	0.96
5	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
7	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

Table 2.6.3.6 North Sea Herring. Fraction of harvest before spawning.

Units : NA

age \ year	1947	1948	1949	………………..									2013	2014	2015
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

Table 2.6.3.7 North Sea Herring. Fraction of natural mortality before spawning.

Units : NA

age \ year	1947	1948	1949	………………..									2013	2014	2015
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

Table 2.6.3.8 North Sea Herring. Survey indices.

SCAI - Configuration

Spawning component abundance index

min	max	plusgroup	minyear	maxyear	startf	endf
NA	NA	NA	1972	2015	NA	NA

Index type : biomass

SCAI - Index Values

Units : NA

age \ year	1972	1973	1974	1975	1976	1977	1978	1979
all	3298.997	3235.13	2198.14	1385.457	1235.196	1634.164	2131.976	3196.972

age \ year	1980	1981	1982	1983	1984	1985	1986	1987
all	3497.043	3971.085	5033.55	7725.54	12063.05	15082.29	14550.95	18357.46

age \ year	1988	1989	1990	1991	1992	1993	1994	1995
all	25795.03	21847.43	20305.77	13948.55	7480.141	5083.119	4437.796	5523.62

age \ year	1996	1997	1998	1999	2000	2001	2002	2003
all	7002.36	9861.96	13054.13	14179.77	16260.25	21433.49	25819.53	33197.98

age \ year	2004	2005	2006	2007	2008	2009	2010	2011
all	36489.91	31851.42	29581.25	30736.25	37425.11	46831.33	47387.3	49456.26

age \ year	2012	2013	2014	2015
all	57434.95	58965.15	54184.84	53163.48

HERAS - Configuration

Herring in Sub-area 4, Divisions 7.d & 3.a (autumn-spawners) . Imported from VPA file.

min	max	plusgroup	minyear	maxyear	startf	endf
1.00	8.00	8.00	1989.00	2015.00	0.54	0.56

Index type : number

Table 2.6.3.8 (continued). North Sea Herring. Survey indices.

HERAS - Index Values

Units : NA

age \ year	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

age \ year	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

age \ year	2007	2008	2009	2010	2011	2012	2013	2014	2015
1	6261000	3714000	4655000	14577000	10119000	7437000	6388000	11634000	6714000
2	2750000	2853000	5632000	4237000	4166000	4719000	2683000	4918000	9495000
3	1848000	1709000	2553000	4216000	2534000	4067000	3031000	2827000	2831000
4	898000	1485000	1023000	2453000	2173000	1738000	2895000	2939000	1591000
5	806000	809000	1077000	1246000	1016000	1209000	1546000	1791000	1549000
6	1323000	712000	674000	1332000	651000	593000	849000	1236000	926000
7	243000	1749000	638000	688000	688000	247000	464000	669000	520000
8	217000	455000	1720000	2729000	1737000	696000	842000	461000	496000

IBTS-Q1 - Configuration

Herring in Sub-area 4, Divisions 7.d & 3.a (autumn-spawners) . Imported from VPA file.

min	max	plusgroup	minyear	maxyear	startf	endf
1.00	1.00	NA	1984.00	2016.00	0.08	0.17

Index type : number

IBTS-Q1 - Index Values

Units : NA

age \ year	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

age \ year	1992	1993	1994	1995	1996	1997	1998	1999
1	1268.145	2794.007	1752.053	1312.789	1888.992	4410.411	2275.845	752.862

age \ year	2000	2001	2002	2003	2004	2005	2006	2007
1	3721.308	2499.353	3881.426	2969.874	933.926	1006.134	903.6	1322.346

age \ year	2008	2009	2010	2011	2012	2013	2014	2015
1	1761.476	2339.203	1206.327	2943.202	1357.438	1665.726	2615.018	3917.632

age \ year	2016
1	778.844

IBTS0 - Configuration

Herring in Sub-area 4, Divisions 7.d & 3.a (autumn-spawners) . Imported from VPA file.

min	max	plusgroup	minyear	maxyear	startf	endf
0.00	0.00	NA	1992.00	2016.00	0.08	0.17

Index type : number

IBTS0 - Index Values

Units : NA

age \ year	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  2014 2015 2016
  0 61.3 83.1 37.2 27.8 95.8 77.1   77   68 50.4 164.5 20.9 99.8
```

Table 2.6.3.9 North Sea Herring. Stock object configuration.

```
min       max plusgroup   minyear   maxyear   minfbar   maxfbar
  0         8         8      1947      2015         2         6
```

Table 2.6.3.10 North Sea Herring. sam Configuration settings.

```
name           : Final Assessment
desc           :
range          :       min       max plusgroup   minyear   maxyear   minfbar
maxfbar
range          :         0         8         8      1947      2016         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
sam.binary     : character()
```

Table 2.6.3.11 North Sea Herring. FLR, R Software versions.

FLSAM.version	0.99-99
FLCore.version	2.4
R.version	R version 2.13.2 (2011-09-30)
platform	i386-pc-mingw32
run.date	2016-03-31 10:13:23

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	59233629	8718868	6606908	0.1929	581760	1.4609
1948	55895811	7740679	5465368	0.1855	502100	1.3326
1949	49229323	7496899	5287870	0.2013	508500	1.4502
1950	67524429	7452052	5128294	0.2079	491700	1.3073
1951	60008693	7572244	4816415	0.2452	600400	1.3238
1952	58235169	7370529	4813293	0.2544	664400	1.2720
1953	60430228	7102803	4553468	0.2675	698500	1.1979
1954	56344771	6892883	4285090	0.3003	762900	1.2509
1955	48690768	6491473	4183642	0.2954	806400	1.0598
1956	35855230	5856133	3851326	0.2946	675200	1.2712
1957	92711215	6004381	3495024	0.3119	682900	1.1575
1958	34483793	5914988	2867491	0.3212	670500	1.1674
1959	39467969	6343873	4267681	0.3420	784500	1.5186
1960	16014418	5219958	3565304	0.2967	696200	1.1830
1961	75300701	5341409	3314789	0.3338	696700	1.1348
1962	35180412	4975319	2365706	0.3686	627800	1.1705
1963	44678368	5526139	3489199	0.2616	716000	0.8602
1964	47870021	5531668	3077887	0.3587	871200	1.0656
1965	23700341	4911058	2388769	0.5829	1168800	1.1496
1966	23724053	3696881	1861499	0.5934	895500	1.0707
1967	31046604	2899358	1174912	0.7768	695500	1.1757
1968	31484314	2475616	639915	1.1588	717800	1.2551
1969	15556669	1901208	593052	1.0576	546700	0.9674
1970	31832553	1863562	563575	1.1131	563100	0.9657
1971	24618285	1741052	388221	1.5154	520100	1.0747
1972	16869199	1518145	391398	0.8165	497500	0.9197
1973	8418986	1179971	335585	1.0343	484000	0.9575
1974	15855072	875018	223639	1.0580	275100	0.9680
1975	3392237	695927	130393	1.3006	312800	0.9343
1976	4210113	484562	193974	1.0895	174800	0.9530
1977	4723214	339422	141797	0.5284	46000	1.1979
1978	4985279	387705	174968	0.3929	11000	1.2152
1979	9426166	500318	209827	0.3198	25100	1.0056
1980	14461493	684881	226887	0.2610	70764	1.0936
1981	32443154	1206218	335226	0.2854	174879	1.0081
1982	51084925	1813919	465395	0.2574	275079	0.9786
1983	47583661	2438759	700607	0.3165	387202	1.0771
1984	43618852	3075568	1127935	0.4140	428631	1.0543
1985	52169052	3485075	1176486	0.5352	613780	1.0419
1986	60068732	3933342	1189074	0.5142	671488	1.1373
1987	61898097	3941217	1379390	0.5031	792058	1.0173
1988	31610503	3941217	1752797	0.4882	887686	1.1641
1989	26376921	3321742	1766344	0.4667	787899	1.0335
1990	21638831	3217129	1812616	0.3961	645229	1.0515
1991	23324153	2990646	1570034	0.4299	658008	1.0197
1992	45262978	3002633	1213926	0.4817	716799	0.9950
1993	39586551	2780107	869432	0.5545	671397	1.0231
1994	28036001	2450984	921695	0.5793	568234	1.0498
1995	36433528	2385693	977517	0.5201	579371	1.0084
1996	33264456	2502999	1118315	0.3183	275098	0.9987
1997	22953936	2676445	1288433	0.2775	264313	1.0006
1998	16751527	2882014	1532269	0.3094	391628	1.0018
1999	53865459	2925570	1601859	0.2926	363163	1.0000
2000	37132383	3685807	1599949	0.2934	388157	1.0004
2001	65136785	4164055	2192088	0.2578	374065	0.9901
2002	34346133	4867057	2518886	0.2407	394709	0.9974
2003	16518640	5272420	2565590	0.2727	482281	1.0153
2004	19638451	4474924	2525892	0.3339	587698	0.9985
2005	18201235	3771563	2407568	0.3554	663813	1.0033
2006	21189154	3128299	1884011	0.3161	514597	0.9950

2007	20542367	2657775	1507253	0.2759	406482	1.0056
2008	21295365	2695246	1579044	0.1768	257870	1.0040
2009	27896171	3106477	1953101	0.1066	168443	1.0023
2010	27180218	3609212	2041223	0.1106	187611	1.0034
2011	23324153	3689494	2404222	0.1425	226478	0.9938
2012	25597366	3767793	2619185	0.2218	434710	1.0109
2013	30280061	3641841	2342149	0.2666	511416	1.0014
2014	38339835	3813279	2267215	0.2797	517356	1.0029
2015	13524319	3836227	2160125	0.3234	494099	1.0017
2016	23394231					

Table 2.6.3.13 North Sea Herring. Estimated fishing mortality.

Units : f

age \ year	1947	1948	1949	1950	1951	1952
0	0.0039802924	0.0039810885	0.0039830796	0.003977905	0.003979894	0.003980292
1	0.0001910835	0.0001910835	0.0009252006	0.004480144	0.021651079	0.041681412
2	0.0481516439	0.0353661546	0.0443164207	0.060048663	0.090211353	0.127607006
3	0.1015605608	0.1164841578	0.1169861181	0.132324241	0.158595237	0.145337014
4	0.1094267394	0.1198876769	0.1282851190	0.158151792	0.215003709	0.190691183
5	0.1481248174	0.1569073147	0.1639489795	0.163082349	0.216969172	0.210388386
6	0.2605657631	0.2340782074	0.2679915041	0.246325856	0.234335835	0.271389560
7	0.2711454191	0.2615577967	0.3334707912	0.263764136	0.235816811	0.325269893
8	0.2711454191	0.2615577967	0.3334707912	0.263764136	0.235816811	0.325269893

age \ year	1953	1954	1955	1956	1957	1958
0	0.003979894	0.00549784	0.005038232	0.004237847	0.004537859	0.004737243
1	0.061920746	0.08340058	0.133720965	0.127990402	0.163261838	0.145904935
2	0.153938824	0.18264699	0.215822277	0.271036983	0.257998889	0.280410690
3	0.180215846	0.22700119	0.230293660	0.236170802	0.241955852	0.271769771
4	0.185277607	0.19082471	0.193941250	0.204538307	0.211993429	0.203457122
5	0.206036900	0.22135224	0.195812052	0.186001601	0.234171857	0.259421792
6	0.266068895	0.28430718	0.257457660	0.207359765	0.225395194	0.201311866
7	0.311891471	0.35904771	0.200167653	0.223375738	0.230224583	0.147651576
8	0.311891471	0.35904771	0.200167653	0.223375738	0.230224583	0.147651576

age \ year	1959	1960	1961	1962	1963	1964
0	0.009002977	0.01727318	0.02094616	0.007971361	0.01389536	0.01496562
1	0.180630820	0.19891056	0.10063049	0.096154404	0.12851624	0.25433576
2	0.303492008	0.30807870	0.34099073	0.210178103	0.24561255	0.32413344
3	0.267589818	0.22738742	0.25748341	0.338815353	0.24329028	0.32462000
4	0.239165380	0.19774044	0.24669562	0.289992563	0.19779977	0.29475818
5	0.236619953	0.17737307	0.22512488	0.274144483	0.17994573	0.27706587
6	0.252410134	0.23059324	0.24433868	0.329032088	0.16597800	0.25988917
7	0.255482849	0.27518821	0.21651401	0.288777149	0.16972089	0.21318392
8	0.255482849	0.27518821	0.21651401	0.288777149	0.16972089	0.21318392

age \ year	1965	1966	1967	1968	1969	1970
0	0.01178415	0.02275205	0.03084749	0.03466586	0.01492526	0.03788879
1	0.24718951	0.22355451	0.29311214	0.31273472	0.32827618	0.30727874
2	0.50790544	0.49177696	0.48887424	0.94248809	0.73746990	0.79988285
3	0.51052790	0.54256358	0.70675585	1.34848265	0.84416273	1.01309095
4	0.49583107	0.48622199	0.67711104	0.81055182	0.78617175	0.98504791
5	0.47449699	0.60835298	0.70662158	0.89357054	0.85496906	0.85718630
6	0.44039202	0.39033888	0.73545200	0.96448307	1.29507680	1.15696477
7	0.47543743	0.57372218	0.97408374	1.18930607	1.05078552	0.99824085
8	0.47543743	0.57372218	0.97408374	1.18930607	1.05078552	0.99824085

age \ year	1971	1972	1973	1974	1975	1976	1977
0	0.04438295	0.06398542	0.05901285	0.09284721	0.1184221	0.09192337	0.08869072
1	0.59668258	0.60823133	0.67336348	0.48902581	0.5868888	0.19657721	0.13559266
2	0.76175523	0.74377999	0.86174145	0.90760139	1.0176459	0.69826960	0.19551855
3	0.94817518	0.74904217	1.01351856	0.86874990	1.1215481	0.97994189	0.53606492
4	0.96528006	0.70602121	0.79845234	0.83558767	1.0001377	0.91591382	0.34362649
5	0.77085114	0.57775811	0.78598309	1.00971913	1.3205918	0.96706652	0.51918760
6	3.07867713	0.67742258	1.03148035	0.95707646	0.9845998	0.69415500	0.37621669
7	1.42857865	0.37191126	0.61706556	0.83474416	1.5843750	1.09333647	0.48266618
8	1.42857865	0.37191126	0.61706556	0.83474416	1.5843750	1.09333647	0.48266618

Table 2.6.3.13 (continued). North Sea Herring. Estimated fishing mortality.

age	1978	1979	1980	1981	1982	1983	1984
0	0.1116150	0.1313881	0.15907174	0.4368742	0.4035278	0.4475129	0.2561736
1	0.1251553	0.1200797	0.10721705	0.2347345	0.2010503	0.2363835	0.2171428
2	0.2047020	0.2213522	0.24326595	0.2243608	0.2039460	0.2240245	0.2507999
3	0.3466291	0.3052269	0.27845467	0.2299715	0.2986150	0.2646889	0.3257582
4	0.2782320	0.2155634	0.20002758	0.2216845	0.2195007	0.2859896	0.3925348
5	0.3758219	0.3137057	0.24770915	0.2561736	0.1678474	0.2534978	0.3944827
6	0.2221283	0.1198637	0.07262835	0.2171428	0.1521635	0.2679379	0.3480532
7	0.4043478	0.2849903	0.15815179	0.4605794	0.2232194	0.3861189	0.5465989
8	0.4043478	0.2849903	0.15815179	0.4605794	0.2232194	0.3861189	0.5465989

age	1985	1986	1987	1988	1989	1990	1991
0	0.1314669	0.1046849	0.1793888	0.1567191	0.1612983	0.1025505	0.1623014
1	0.3404115	0.3471841	0.4079217	0.5462164	0.4160374	0.4491672	0.3315091
2	0.3113617	0.3363174	0.3385783	0.3110194	0.3155936	0.3064196	0.4117784
3	0.4467661	0.3988619	0.3662643	0.3336709	0.3219046	0.2867341	0.3293942
4	0.4964661	0.4386866	0.4348170	0.4242637	0.4300000	0.3469412	0.3430428
5	0.4653991	0.4310462	0.4613354	0.4747533	0.4507015	0.3890723	0.3584378
6	0.4842616	0.5277355	0.4999636	0.5020126	0.4497425	0.3361829	0.3736447
7	0.5851541	0.6046896	0.4685558	0.5081442	0.4704385	0.3784997	0.3012545
8	0.5851541	0.6046896	0.4685558	0.5081442	0.4704385	0.3784997	0.3012545

age	1992	1993	1994	1995	1996	1997	1998
0	0.3360484	0.4073225	0.2752983	0.2720689	0.09828341	0.03128239	0.02487978
1	0.3736970	0.3793599	0.2206671	0.2277288	0.16388341	0.04811314	0.11697442
2	0.4313653	0.4709422	0.4615523	0.3419468	0.19040536	0.16009306	0.17808399
3	0.3654960	0.4657669	0.4876682	0.4501925	0.27063073	0.22659296	0.23990794
4	0.3873913	0.4895396	0.6380427	0.4455303	0.24583370	0.24875172	0.25446296
5	0.3952092	0.4246330	0.4132924	0.4911970	0.26955037	0.24825471	0.27656760
6	0.4493919	0.4776677	0.4337704	0.4122398	0.29352279	0.23985997	0.31167322
7	0.4272782	0.5210184	0.4236744	0.3759384	0.14291575	0.18583427	0.16873936
8	0.4272782	0.5210184	0.4236744	0.3759384	0.14291575	0.18583427	0.16873936

age	1999	2000	2001	2002	2003	2004
0	0.03913258	0.04271522	0.04012322	0.03291259	0.03534848	0.05369690
1	0.05752130	0.06203230	0.05630342	0.03941929	0.05795433	0.04572089
2	0.17185572	0.16022119	0.09286579	0.10051986	0.08851352	0.09787149
3	0.24855280	0.22987950	0.20775412	0.16092771	0.16186381	0.15763075
4	0.25286488	0.26113964	0.24453423	0.23950045	0.23154061	0.25892936
5	0.27117254	0.29130047	0.25009861	0.23993194	0.35625803	0.36589825
6	0.25947368	0.26780398	0.25882581	0.24531799	0.28659076	0.48104714
7	0.15310980	0.15777268	0.17361762	0.22215054	0.25172955	0.37696988
8	0.15310980	0.15777268	0.17361762	0.22215054	0.25172955	0.37696988

age	2005	2006	2007	2008	2009	2010
0	0.07699614	0.06191455	0.04755349	0.05166369	0.03631589	0.03360434
1	0.10531494	0.04600064	0.03775641	0.03331325	0.02554279	0.02987002
2	0.12324266	0.10997524	0.08700410	0.09022037	0.06199510	0.06837828
3	0.16162119	0.17481972	0.17915570	0.11176017	0.06067036	0.07608532
4	0.24783304	0.25619920	0.24387487	0.15223955	0.09895402	0.09046430
5	0.40406077	0.32229113	0.30023193	0.19280037	0.11220811	0.11723205
6	0.51633990	0.42891351	0.31154858	0.17877987	0.09267097	0.09801841
7	0.69065835	0.61543250	0.49302273	0.23356380	0.12420771	0.09482710
8	0.69065835	0.61543250	0.49302273	0.23356380	0.12420771	0.09482710

age	2011	2012	2013	2014	2015	2016
0	0.04656528	0.04228597	0.02690078	0.04981197	0.05832059	0.05808197
1	0.01881878	0.03990315	0.04946450	0.03298178	0.03241610	0.03246476
2	0.07079266	0.08342561	0.08671746	0.08228224	0.07212172	0.07212172
3	0.10275580	0.15343166	0.14288717	0.14410688	0.10073117	0.10073117
4	0.11665902	0.18941782	0.21770812	0.23952440	0.20301001	0.20301001
5	0.15167731	0.23398459	0.29588039	0.32020304	0.34483129	0.34483129
6	0.14183370	0.24820506	0.34496925	0.34784441	0.49088274	0.49088274
7	0.12760701	0.29772055	0.43706647	0.45426252	0.66878008	0.66878008
8	0.12760701	0.29772055	0.43706647	0.45426252	0.66878008	0.66878008

Table 2.6.3.14 North Sea Herring. Estimated population abundance.

Units : NA

age	1947	1948	1949	1950	1951	1952	1953	1954
0	59233629	55895811	49229323	67524429	60008693.4	58235168.5	60430228	56344771
1	19346073	24179120	22839453	19326736	28374459.9	24227526.4	23535018	25368023
2	11983006	9539961	13483806	11319076	9165894.2	13216809.2	11172880	10777811
3	5251372	7145548	7018078	9939229	7377902.9	5378929.9	7311800	6274473
4	7370529	3392237	4012801	4965378	6892883.1	4218541.5	3315105	4016816
5	4501855	4794596	2184724	2385693	3464226.7	3996781.6	2455891	2028891
6	3719129	2847637	3014667	1353223	1504543.4	2109581.2	2376169	1468864
7	2076096	2069878	1694672	1669442	777625.2	898965.6	1194215	1349170
8	6287034	4742144	3968902	3005637	2679122.8	2128653.1	1677810	1647880

age	1955	1956	1957	1958	1959	1960	1961
0	48690767.9	35855230	92711215	34483792.9	39467969.4	16014418.0	75300700.8
1	22297831.7	19875532	13456866	43706177.0	13429978.9	17296245.3	5142243.4
2	12019008.5	9074692	8841791	5142243.4	21660480.9	5293551.8	7088611.2
3	5974434.5	6824298	4201701	4818629.0	2433886.7	11863772.7	2579226.2
4	3242969.6	3269017	3878659	2152197.6	2566362.3	1185885.1	7534477.2
5	2249008.5	1812106	1874776	2258022.5	1241710.0	1338419.5	707151.4
6	1161241.2	1310606	1116825	1037163.4	1222000.7	677388.3	861990.9
7	802911.7	641138	782305	652130.5	618467.5	657368.5	382697.4
8	1542631.1	1503040	1298863	1205011.9	1284654.0	1116824.6	952647.3

age	1962	1963	1964	1965	1966	1967
0	35180411.7	44678367.8	47870021.0	23700341.1	23724053.3	31046604.4
1	32900552.2	14768395.3	17575211.0	19935248.4	9684139.5	9029431.8
2	1963030.5	16387018.1	6803855.5	6299620.8	7857664.6	3957013.0
3	3041921.7	1081651.9	9597373.3	3576874.7	2240030.4	3295274.4
4	1409858.6	1231815.9	675359.2	5378929.9	1451343.2	868914.5
5	4606597.2	677388.3	727231.4	406768.7	2244515.0	668639.3
6	412916.2	2388079.4	456799.6	412091.2	187962.9	851708.8
7	527023.3	201189.0	1550363.5	280969.1	187775.1	100007.5
8	788588.6	712831.3	563543.6	1370930.1	809360.7	435826.7

age	1968	1969	1970	1971	1972	1973
0	31484313.6	15556669.32	31832552.89	24618284.57	16869199.4612	8418986.409
1	12347942.4	12212859.35	6401225.41	12685878.45	9840331.9184	6407629.835
2	3162900.4	4461519.67	4256679.69	2480572.65	3348422.8436	2679122.839
3	1886059.0	708567.07	1516627.99	1247934.07	806129.7591	1110143.673
4	1213476.6	306508.27	218600.25	375494.84	322868.3713	296262.155
5	299239.6	382697.45	98715.77	56556.76	96374.7966	120330.813
6	248948.2	83199.78	118657.92	29732.62	18153.1613	42616.637
7	285215.4	70474.06	15951.37	28969.53	925.6535	7528.115
8	154662.4	97635.85	43870.61	16595.72	7610.6206	4624.391

age	1974	1975	1976	1977	1978	1979
0	15855071.887	3392236.51	4210112.806	4723213.726	4985279.360	9426166.027
1	3072493.485	6702559.32	1047587.019	1612022.242	1832148.720	1783342.553
2	1556577.408	940343.02	1854266.949	387317.481	707858.858	794922.576
3	764517.351	423792.83	212564.340	559612.579	266199.152	403124.207
4	267266.081	237755.95	90853.173	50614.835	220135.820	162917.628
5	98814.536	82536.84	61267.206	21995.650	28085.255	114005.275
6	40619.357	26476.16	14760.353	16068.241	9167.318	15487.678
7	11124.443	11465.53	7087.585	5095.943	7874.618	5212.944
8	5292.786	5557.48	2513.672	2313.461	3411.816	5499.431

age	1980	1981	1982	1983	1984	1985
0	14461492.715	32443153.74	51084924.90	47583660.81	43618851.99	52169051.82
1	3555477.749	5465684.92	8692750.84	15634647.45	13085299.73	14991590.97
2	725778.391	1662777.58	2010713.11	3416065.47	6212040.61	5632139.81
3	434955.932	356111.80	962221.55	1141666.96	1872902.64	3485074.57
4	213629.824	227294.09	207523.53	494845.07	685565.96	1003495.54
5	115266.256	132190.59	125869.38	132190.59	269952.15	357896.82
6	58454.269	82371.93	71467.64	92595.89	83116.62	129702.68
7	11193.628	44936.25	52208.47	47762.69	58923.78	47619.61
8	5690.765	13002.54	29114.74	60054.03	64796.05	62692.68

Table 2.6.3.14 (continued). North Sea Herring. Estimated population abundance.

age	1986	1987	1988	1989	1990	1991
0	60068732.13	61898097.37	31610503.10	26376921.50	21638831.2	23324153.2
1	21856305.08	26990621.18	24642915.17	12787772.51	10617349.9	10049164.0
2	5193923.80	8435841.23	9781466.70	6837960.00	4235449.4	3704282.0
3	2925570.32	2505502.82	4381930.77	5416714.45	3700579.5	2226630.5
4	1541089.20	1480662.23	1262999.49	2438759.34	3355126.4	2165149.6
5	433219.58	741922.45	741180.90	632857.15	1333076.5	1897409.3
6	168720.71	216425.14	359331.27	359690.78	336717.6	726504.5
7	58395.84	75962.87	103362.76	169396.94	187399.9	193881.0
8	53423.18	48825.11	63703.83	81226.76	139246.4	169566.4

age	1992	1993	1994	1995	1996	1997
0	45262978.3	39586551.1	28036001.2	36433527.7	33264456.08	22953936.39
1	9587780.7	15572233.8	12188458.0	10303559.7	13085299.73	15172573.79
2	4239687.0	3620055.8	5411300.4	5509585.8	4694959.29	5838590.66
3	1698065.1	1861698.9	1436902.1	2431454.0	2744199.58	2697942.49
4	1279525.7	906186.1	765282.3	700115.1	1031990.48	1492555.04
5	1217122.5	688313.7	385385.7	305895.9	307429.17	584785.27
6	1104606.8	659343.6	324162.4	186838.5	117594.79	185720.85
7	417483.4	541446.7	299239.6	154507.8	86595.23	62504.89
8	217510.0	331041.8	379268.6	308970.2	235861.49	197797.69

age	1998	1999	2000	2001	2002	2003
0	16751527.4	53865459.2	37132382.9	65136784.9	34346133.2	16518640.0
1	10564395.6	7474441.8	25648611.6	14931744.4	30706963.2	14504942.3
2	8469652.2	4629687.8	4479401.5	12839026.0	7032128.6	18146713.0
3	2993638.2	5411300.4	2631330.1	2928497.4	8088873.2	4155735.6
4	1438339.7	1530339.2	3166064.8	1497039.4	1595982.4	4818629.0
5	822414.7	675359.2	921723.0	1708284.1	824061.1	879404.3
6	350109.1	397519.8	397917.5	476870.4	983625.0	516587.5
7	115036.0	174730.5	226386.7	218163.5	264871.5	569776.8
8	151751.6	141775.5	180232.0	207731.2	264342.3	302549.4

age	2004	2005	2006	2007	2008	2009
0	19638451.2	18201234.9	21189153.9	20542367.1	21295365.0	27896171.1
1	6756394.9	8684062.4	6976096.0	8640750.5	9559060.4	9616587.2
2	5998380.1	3450397.5	4528946.9	3361843.4	4290869.7	5671703.1
3	11161713.0	3870909.3	2244515.0	2725057.3	2016754.3	2525627.2
4	2649814.0	7011063.8	2354879.2	1391649.1	1652830.8	1235516.9
5	2847636.8	1542631.1	4252425.1	1271871.5	876770.0	1052838.1
6	449998.7	1489572.9	773746.8	2333780.4	767581.5	584785.3
7	313639.7	211292.8	667303.3	385385.7	1486596.7	527023.3
8	474492.0	370274.5	223016.3	373995.9	433219.6	1401424.8

age	2010	2011	2012	2013	2014	2015	2016
0	27180218.3	23324153.2	25597365.7	30280061.0	38339835	13524318.6	23394230.7
1	12225078.3	12261808.6	9313728.0	10799387.7	15463609	16419824.9	5493081.8
2	5256626.3	6543612.9	6569839.8	4519898.1	5700133	9606975.4	8788898.9
3	3859314.0	3351772.9	4960415.2	4260938.5	3134562	3259225.0	6249424.9
4	1824834.8	2424170.6	2470670.2	3298571.3	3131429	1848712.5	2120155.5
5	913464.7	1112366.2	1602379.1	1767364.5	2026863	1788700.6	1106818.2
6	807743.6	583033.5	724328.3	1056001.3	1113479	1125795.0	938464.2
7	445966.9	544160.8	364397.3	449998.7	622812	613539.5	516587.5
8	1522706.6	1306679.8	1065548.2	869783.8	639857	648878.0	494350.5

Table 2.6.3.15 North Sea Herring. Predicted catch numbers at age.

Units : NA

age	1947	1948	1949	1950	1951	1952	1953
0	465561.741	659937.2	283565.9	337695.5	490754.9	158577.7	204045.8
1	425789.342	325591.9	612007.6	608103.3	710838.1	1017236.3	1463000.5
2	649397.312	597912.7	420079.8	436219.1	1311654.7	1321925.6	1494347.2
3	531787.898	512881.4	982936.7	654155.3	611824.0	1015000.8	1074214.2
4	736599.792	415692.0	545522.9	910182.1	623435.1	477347.5	593979.4
5	430068.596	951695.1	1035608.8	1136200.1	651934.9	393092.4	346348.2
6	1302505.141	483110.2	618158.4	581287.1	432959.7	479021.1	313984.8
7	3310.485	650892.6	308229.5	271034.1	218054.4	279483.9	355791.4
8	273894.973	410692.5	254944.2	142457.6	516535.9	392738.8	434782.0

Table 2.6.3.15 (continued). North Sea Herring. Predicted catch numbers at age.

age \ year	1954	1955	1956	1957	1958	1959	1960
0	161571.0	100167.6	277367.9	107645.6	1607514.9	2263448.3	355009.56
1	2016149.4	1724590.2	1467396.1	4288724.8	4725103.4	1169983.3	1709309.42
2	1938645.3	1793895.4	1674123.0	1047377.5	482337.8	2034376.6	493806.98
3	1035815.9	1210809.9	761465.4	967721.9	465561.7	181262.2	1404651.80
4	486941.9	514885.6	631277.0	337358.0	225010.0	186801.2	122602.17
5	343794.7	264130.9	336616.6	444097.8	235272.6	120354.9	161296.57
6	227544.2	211567.6	194385.8	162982.8	121613.1	137929.8	64919.28
7	126918.4	111814.9	140266.6	77823.6	252533.7	234497.5	161571.01
8	243726.0	262157.3	232722.0	143932.5	181262.2	1032609.9	184480.68

age \ year	1961	1962	1963	1964	1965	1966	1967
0	2175349.7	1286582.45	2871083.38	3176212.48	1408731.20	1672115.25	2420053.00
1	309248.4	2968003.31	1570806.91	2104313.83	2561234.69	1282985.06	1642122.22
2	739700.0	196988.38	2249458.32	1216149.16	798507.79	1427878.02	1216757.39
3	303094.5	188376.90	147251.90	1805232.59	479932.14	368943.94	583733.60
4	950839.0	95817.44	151493.80	133026.02	888420.10	294990.96	154786.19
5	100077.5	314581.98	90228.44	127325.24	52585.73	387549.94	135442.16
6	115335.4	27326.17	259263.45	93209.04	72041.67	55243.17	176839.89
7	172594.5	96867.56	94277.70	454566.73	310363.66	240602.15	95932.49
8	407542.3	470005.65	183505.51	352956.47	624308.55	710340.70	152344.55

age \ year	1968	1969	1970	1971	1972	1973
0	2497997.58	1236876.737	4226986.98	3323403.6117	2332847.075	882928.939
1	1966960.47	1985735.634	1118948.54	1486448.0902	1313754.991	787879.155
2	346902.83	832925.932	658355.28	364069.4773	611212.519	380598.389
3	144422.74	119193.083	202177.24	141209.5166	141181.278	131124.168
4	192163.14	49667.198	26505.30	36731.8682	57233.805	55033.645
5	53524.78	71797.146	26058.52	7798.2919	24170.786	21931.078
6	40696.61	8936.238	19731.47	251.6829	3056.330	5543.825
7	56392.98	24582.744	11308.27	2069.2262	1877.413	2637.614
8	783009.42	707717.301	694189.32	320712.3839	930148.937	252029.141

age \ year	1974	1975	1976	1977	1980	1981
0	2207122.083	134887.989	146414.9511	258047.7695	823731.577	1144410.254
1	511754.348	787327.832	57210.9161	131124.1679	279987.433	311358.419
2	247038.630	114611.107	198193.6773	90219.4216	62486.137	213096.416
3	130796.767	47334.751	12600.9817	33193.1896	38870.854	35277.477
4	53476.629	33329.561	7738.8626	21969.4911	26019.460	16950.286
5	14571.459	6456.547	4377.1802	3556.4922	14056.216	8831.764
6	8187.796	4200.799	1720.4824	1447.0322	14792.861	9292.473
7	3969.082	1489.864	781.1288	735.6614	4280.906	5185.233
8	246471.094	268015.475	1451488.2974	8026025.4440	11898227.531	12141015.631

age \ year	1982	1983	1984	1985	1986	1987
0	2399569.73	1865052.95	3187986.23	4742144.42	6732788.81	7805194.25
1	577289.99	1163566.02	1276969.18	1261610.96	2069463.60	2240478.46
2	228410.56	450178.75	1093615.79	840876.43	673807.67	1094709.95
3	106819.95	194580.26	345967.46	483593.52	463981.52	389804.26
4	25941.52	77699.18	118326.14	135252.68	245683.65	252205.62
5	19149.27	21626.83	44418.00	62006.84	76557.70	128027.45
6	13694.78	22354.88	19106.23	24079.11	25835.38	37597.77
7	17225.74	24585.20	25139.61	22037.48	16622.46	23169.68
8	6932284.70	4514928.91	4212218.39	7256440.66	3289019.32	2832300.96

age \ year	1988	1989	1990	1991	1992	1993	1994
0	3269998.22	2906906.46	2144678.04	2285282.03	3792742.8	1859652.13	1627083.98
1	1590883.37	963569.60	1082734.13	1287740.90	1178555.4	1732541.56	1375461.68
2	1314937.90	813336.34	551391.30	457576.79	609869.3	486795.79	770349.82
3	761922.41	878437.46	560957.26	365857.80	312106.6	321515.17	222570.68
4	206922.58	387123.87	514628.21	357253.18	213587.1	116716.13	106212.81
5	117735.99	86838.04	204863.67	361276.91	225776.3	102693.08	56664.32
6	58081.36	53911.55	45944.99	132309.61	200385.8	93938.91	43914.51
7	27847.54	40050.64	40179.01	68940.56	122491.9	119062.04	87851.22
8	1519056.54	2529165.59	9459215.41	9751191.10	4932714.5	6350854.95	2252835.04

Table 2.6.3.15 (continued). North Sea Herring. Predicted catch numbers at age.

age	1995	1996	1997	1998	1999	2000	2001
0	1533709.70	548421.812	896631.28	317489.49	1157994.28	607252.52	873095.31
1	697738.73	739182.408	1180442.59	621008.47	559556.62	952837.83	559053.25
2	564615.36	473165.263	551722.23	1025919.66	463656.85	469535.88	1021619.84
3	197501.21	288456.623	283452.55	299509.08	636029.36	283084.30	294814.02
4	64569.67	114096.516	176222.03	141789.66	205499.73	332268.95	153737.21
5	26747.60	35323.368	83641.91	80708.57	82875.93	96047.68	188038.12
6	10398.74	9567.814	16105.24	22287.92	29596.16	31048.32	46896.58
7	28325.00	30284.763	21229.35	18081.24	23559.87	29557.71	46812.24
8	507017.10	293343.630	1462854.18	1086747.66	1776756.38	766814.35	393682.49

age	2002	2003	2004	2005	2006	2007	2008
0	597076.19	220819.3	639473.21	231260.49	236735.8	232349.97	180592.79
1	1268949.56	461482.8	330116.20	389453.60	231491.9	306753.57	283055.99
2	525392.04	1375186.6	487770.36	303883.60	377905.7	180177.90	125693.29
3	859838.62	520788.9	1322851.25	457028.03	258383.4	199845.53	99677.97
4	229923.06	759412.2	445699.39	1013682.20	285072.8	132561.24	96211.10
5	112724.27	150738.2	526233.34	235531.51	543671.2	108945.17	44837.49
6	112173.27	87055.4	93582.62	271359.56	132190.6	271142.56	53809.21
7	59593.39	131768.3	163865.30	90689.78	128258.1	78991.85	143028.62
8	704046.72	926713.7	873357.27	653566.78	733806.0	680239.35	614460.55

age	2009	2010	2011	2012	2013	2014	2015
0	269574.48	172111.88	276150.14	397519.8	378094.7	395774.5	425789.342
1	289844.54	375457.29	444186.59	319751.7	378548.7	563205.6	649397.312
2	240001.39	279065.00	605070.34	488649.1	359079.8	266838.8	531787.898
3	135279.73	229532.52	368648.91	560845.1	576021.3	293637.1	736599.792
4	87125.07	135388.00	290802.61	395893.3	482917.0	454566.7	430068.596
5	65427.63	67043.71	139190.67	270925.7	286101.0	383924.0	1302505.141
6	35284.53	57199.48	82892.51	141747.1	201189.0	266199.2	3310.485
7	120559.66	137406.64	242486.18	273949.8	206695.1	281587.9	273894.973
8	727231.40	726940.57	550895.27	1277096.9	525865.1	465561.7	659937.228

Table 2.6.3.16 North Sea Herring. Catch at age residuals.

Units : NA

age	1947	1948	1949	1950	1951	1952
0	0.41196100	0.1258110	0.0832612	-0.0744350	-0.364471000	-0.232233000
1	-0.17795600	0.0514049	0.2355460	-0.0685275	0.108174000	0.039306500
2	-0.12263900	0.0357597	0.3542030	0.3984030	0.179287000	0.000228514
3	-0.07588530	-0.1926510	0.1991420	0.0615856	-0.418905000	-0.082581100
4	0.09688090	-0.1431810	-0.1350780	0.3627590	-0.151437000	-0.048531200
5	0.00803435	-0.1383730	0.0225546	0.6903440	0.000460292	-0.126680000
6	0.02433180	-0.0737944	-0.0129414	0.5589740	0.257906000	-0.047274700
7	-0.68379400	-0.0739201	-0.4231290	-0.1263430	0.294256000	-0.019956000
8	-0.71798600	-0.2528850	-0.0138712	-0.0119389	0.260621000	-0.007110170

age	1953	1954	1955	1956	1957	1958
0	0.29529300	0.0621706	-0.1774880	0.0246782	-0.4347050	0.0066121
1	-0.05721490	0.1899550	-0.1120270	0.0733138	-0.0157957	0.3000530
2	-0.00650027	-0.0273415	0.2512880	-0.1260010	-0.1228850	0.0813079
3	0.23372900	-0.0259581	0.0581426	-0.2361390	0.2211280	0.4534800
4	-0.03516000	-0.1143100	0.0153593	0.1388730	-0.3237270	0.2420280
5	0.28773000	-0.1387530	-0.4093050	0.1505250	0.2593620	0.2110430
6	0.18537300	0.0723088	-0.3225520	0.2339940	-0.3843950	-0.0498918
7	0.23518300	-0.2086920	-0.2698980	0.1746080	-0.2383520	0.6535130
8	0.60133900	-0.4668300	0.4013460	0.3111440	-0.7396250	0.2965100

age	1959	1960	1961	1962	1963	1964	1965
0	0.385328	-0.3819860	-0.0911214	-0.1330700	0.2394720	0.0716326	-0.1276620
1	-0.166128	0.6952590	-0.9530190	-0.0156725	-0.1041120	0.3642400	0.0229812
2	-0.234784	-0.1984890	0.5216060	-0.7348450	-0.0199880	0.5933420	-0.5167750
3	-0.615257	0.2486010	0.6972640	-1.2075400	0.0536984	0.8467810	-0.4455520
4	-0.749031	0.0784051	0.8962800	-1.2007800	-0.1150360	0.6030720	0.0111117
5	-0.238004	-0.0791728	0.8841410	-1.1706600	0.1919320	0.6571330	-0.5551890
6	-0.342661	-0.2074740	0.8546740	-0.7398970	-0.0426435	0.8652340	-0.3943620
7	0.533132	-0.4415770	0.0107753	-0.1515850	-0.4296530	0.2901380	0.2487270
8	0.861275	-1.0983200	0.3462640	0.2323260	-0.6484600	0.2471440	0.1387050

Table 2.6.3.16 (continued). North Sea Herring. Catch at age residuals.

age \ year	1966	1967	1968	1969	1970	1971	1972
0	0.00914097	0.014111	0.0146342	-0.2322960	0.2446210	0.0358002	0.103713
1	-0.63086500	0.618553	-0.3026400	0.0594693	0.1707580	-0.2177140	0.159033
2	-0.31417600	1.426700	-1.0945100	0.4099120	0.0436647	-0.3980670	0.525124
3	0.04804920	0.434394	-0.5665520	0.3412080	0.2074530	-0.5423820	0.430141
4	0.06581900	0.103123	-0.0497227	0.0877225	0.1026610	-0.7652350	0.246241
5	0.05291690	0.253989	-0.2609820	-0.6067640	0.5857980	-1.6546300	0.877988
6	0.76796700	-0.294338	0.1787260	-0.4588260	1.1398700	-0.8556880	0.711503
7	0.20771600	0.353828	-0.2662950	-0.0584742	0.3729950	-1.1976400	0.235463
8	0.69643300	-1.284190	0.5725570	-0.1421300	0.3251820	-0.4286900	0.285781

age \ year	1973	1974	1975	1976	1977	1980	1981
0	-0.2955610	0.754475	-0.440206	-0.100726	-0.3571520	0.3955360	-0.171893
1	-0.1360420	0.394821	0.940193	-1.713560	0.1503710	0.1063770	-0.271702
2	-0.3480840	0.344573	0.160912	-0.426215	0.1204020	-0.6504880	0.533037
3	-0.2768620	0.497038	0.652835	-1.070900	-0.2108920	0.1117480	-0.317985
4	0.1333170	0.467361	0.239574	-0.696776	-0.0857073	0.6320120	-1.132160
5	0.0620867	0.371377	-0.211460	-0.243550	-1.6226200	1.7843100	-0.973265
6	-0.3843470	0.393238	0.172486	-0.510520	-0.1229950	0.8725330	-0.651798
7	0.6013150	0.707607	-0.231595	-0.408222	-1.4376000	1.6116100	-0.365753
8	0.1904400	-0.142293	-0.178560	-0.581554	0.7126460	0.0206374	0.379687

age \ year	1982	1983	1984	1985	1986	1987
0	0.1404060	-0.175633	0.1400700	0.086033000	0.10575400	0.05502810
1	-0.0419078	-0.104444	0.2630630	0.028295100	0.22356200	-0.02493250
2	-0.3747770	-0.136628	0.5423340	-0.000872539	-0.06095250	-0.02573300
3	-0.1125100	0.242790	0.4380610	-0.258863000	0.04656400	-0.10934800
4	0.0690342	0.297391	0.3531540	-0.285769000	0.00363159	0.09815260
5	0.6495940	0.163847	-0.0691499	0.005403390	-0.09150910	0.00201143
6	-0.2515400	0.446156	0.2072220	-0.598976000	-0.30565100	0.03966430
7	1.0923500	0.703746	0.5572630	0.944075000	-0.09581870	0.10002900
8	0.0245586	-0.290983	-0.5135010	0.525175000	-0.16092600	0.31991000

age \ year	1988	1989	1990	1991	1992	1993
0	-0.2689480	0.26481700	-0.01876550	0.0538004	0.06236370	-0.2838640
1	0.0124448	-0.47946000	0.31382800	-0.0152488	-0.01304590	0.2003390
2	0.2531480	-0.29838000	0.06666220	-0.2293520	-0.00967378	0.0328770
3	0.4186650	-0.13901400	-0.15057600	-0.0830944	-0.14862000	0.5414220
4	0.1619900	0.00701675	-0.18387200	0.0631171	0.06511500	-0.4749100
5	0.1840280	-0.29595100	0.00786936	0.1447760	0.00368737	-0.4175700
6	0.1823740	0.03351700	-0.58155800	0.5263290	-0.23745600	-0.7692670
7	0.0468304	0.05996140	-0.14927700	-0.3649980	0.19260500	-0.0778362
8	-0.6411230	-0.24221700	0.36821000	0.2146630	-0.38421900	0.6599760

age \ year	1994	1995	1996	1997	1998	1999	2000
0	0.159391	0.321357	-0.929401	0.6007960	-0.3123910	0.08186980	0.0817921
1	0.337998	-0.576989	-0.499156	0.2292790	-0.0523666	0.74387200	-0.8533750
2	0.405983	-0.496834	-0.396507	-0.1755060	0.2186850	-0.00722226	0.2338890
3	0.281776	-0.955978	-0.085725	-0.1763750	-0.1270830	0.11663200	-0.1040130
4	0.761962	-0.794523	-0.305797	-0.0159855	-0.3075750	0.26438500	-0.2232710
5	-0.102272	-0.637979	-0.439624	0.2279710	-0.5674730	-0.01796620	-0.2041470
6	-0.218521	-0.430149	0.790709	-0.2075250	0.8490610	0.69879100	0.7766300
7	0.414593	-1.088640	-0.794155	-0.1210850	-1.4561300	-1.19583000	-1.3437900
8	0.106684	-0.676267	-0.511262	0.2855640	0.0698826	0.12922200	-0.2037850

age \ year	2001	2002	2003	2004	2005	2006	2007
0	-0.2885060	0.2281580	-0.4605870	0.7808060	-0.280024	-0.035114	0.0794264
1	0.2502010	-0.2616730	-0.2071480	0.5131700	0.204314	-0.381425	0.5445120
2	-0.3562260	0.0525278	-0.0456832	-0.0291389	0.151988	0.690743	0.1747330
3	-0.0616714	-0.1991000	0.2948460	-0.0223022	0.114105	0.698787	-0.0268350
4	-0.6155240	0.4348380	-0.0566060	0.5145310	-0.109860	0.569585	0.2555370
5	-0.2765350	-0.1678130	0.4328820	0.3375770	0.253773	0.543673	0.3081330
6	0.1563940	0.3516690	0.6956060	0.7740350	-0.349582	0.416406	-0.8544900
7	-0.2885490	-0.9064810	-1.1349600	-0.4093010	0.595329	0.746727	1.4705100
8	-0.2694620	0.0680946	0.3819730	0.0250166	-0.213240	0.351498	-0.1894410

Table 2.6.3.16 (continued). North Sea Herring. Catch at age residuals.

age	2008	2009	2010	2011	2012	2013	2014	2015
0	-0.18159300	0.2812810	-0.527972	0.217048	0.2651120	-0.1389710	-0.0160065	-0.17795600
1	-0.60486400	0.0960237	-0.142608	0.170879	0.1114960	0.0812826	-0.1422920	-0.12263900
2	-1.13537000	-0.0928781	-0.101720	0.743541	-0.0497395	0.5042010	-0.5205250	-0.07588530
3	-0.45734200	-0.4802200	-0.335410	0.640656	0.1277510	0.4722510	-0.2605220	0.09688090
4	-0.76792600	-0.2625780	-0.275181	0.359230	0.4559750	0.0670677	0.0979845	0.00803435
5	-0.62072800	-0.2280240	-0.235267	0.341904	0.7025590	-0.0202181	0.4394770	0.02433180
6	-0.04715570	-0.2148490	-0.348991	0.860792	0.0930576	-0.1791580	0.0703795	-0.68379400
7	0.00270493	-0.2188480	-0.330656	-0.617585	0.5035450	0.1382310	0.6778140	-0.71798600
8	-0.27770100	0.2868310	0.257783	-0.738682	0.3498020	0.0968430	0.4119610	0.12581100

Table 2.6.3.17 North Sea Herring. Predicted index at age SCAI.

Units : NA

age	1972	1973	1974	1975	1976	1977	1978	1979
all	4507.96	3922.757	2634.793	1511.896	2063.585	1467.081	1849.295	2300.243

age	1980	1981	1982	1983	1984	1985	1986	1987
all	2562.58	3784.39	5294.215	7989.792	12863.64	13654.44	13918.58	16126.19

age	1988	1989	1990	1991	1992	1993	1994	1995
all	20553.98	21271.85	21946.87	19065.58	14653.73	10372.78	11049.94	11597.56

age	1996	1997	1998	1999	2000	2001	2002	2003
all	13239.63	15271.29	18394.19	19202.58	19212.38	26217.96	30260.55	31045.22

age	2004	2005	2006	2007	2008	2009	2010	2011
all	30546.34	28943.47	22638.34	18071.66	18999.54	23442.36	24328.41	29155.53

age	2012	2013	2014	2015
all	31713.57	28353.34	27247.04	25205.06

Table 2.6.3.19 North Sea Herring. Index at age residuals SCAI.

Units : NA

age	1972	1973	1974	1975	1976	1977	1978
all	-0.715356	-0.441567	-0.415133	-0.200103	-1.17585	0.247124	0.325903

age	1979	1980	1981	1982	1983	1984	1985
all	0.754224	0.712332	0.110341	-0.11567	-0.0770573	-0.147233	0.227868

age	1986	1987	1988	1989	1990	1991	1992
all	0.101807	0.296916	0.520374	0.0611682	-0.178074	-0.716015	-1.54067

age	1993	1994	1995	1996	1997	1998	1999
all	-1.63418	-2.09014	-1.69948	-1.45938	-1.00191	-0.785703	-0.694749

age	2000	2001	2002	2003	2004	2005	2006	2007
all	-0.382228	-0.461732	-0.363628	0.153649	0.407283	0.219417	0.612952	1.21682

age	2008	2009	2010	2011	2012	2013	2014	2015
all	1.55324	1.58544	1.52756	1.21065	1.36083	1.67764	1.57509	1.70985

Table 2.6.3.20 North Sea Herring. Predicted index at age IBTS-Q1.

Units : NA

age \ year	1984	1985	1986	1987	1988	1989	1990	1991
1	1960.549	2212.791	3226.199	3959.052	3555.425	1878.746	1555.543	1496.718

age \ year	1992	1993	1994	1995	1996	1997	1998	1999
1	1423.922	2317.977	1854.258	1568.429	2009.518	2361.849	1629.03	1158.244

age \ year	2000	2001	2002	2003	2004	2005	2006	2007
1	3959.686	2299.185	4726.499	2222.882	1037.2	1324.645	1073.661	1332.67

age \ year	2008	2009	2010	2011	2012	2013	2014	2015
1	1476.043	1487.854	1894.897	1905.539	1445.933	1677.483	2399.414	2549.927

age \ year	2016
1	852.736

Table 2.6.3.21 North Sea Herring. Index at age residuals IBTS-Q1.

Units : NA

age \ year	1984	1985	1986	1987	1988	1989	1990
1	-0.880025	-0.183312	-0.656169	-0.237863	0.724144	0.738256	-1.30629

age \ year	1991	1992	1993	1994	1995	1996	1997	1998
1	-0.516783	-0.39612	0.638607	-0.193841	-0.608302	-0.211476	2.1352	1.14318

age \ year	1999	2000	2001	2002	2003	2004	2005	2006
1	-1.47281	-0.212281	0.285403	-0.67348	0.990527	-0.358584	-0.940324	-0.589559

age \ year	2007	2008	2009	2010	2011	2012	2013	2014
1	-0.0265773	0.604412	1.54699	-1.54395	1.48633	-0.215923	-0.0240627	0.294199

age \ year	2015	2016
1	1.46818	-0.309881

Table 2.6.3.22 North Sea Herring. Predicted index at age HERAS.

Units : NA

age \ year	1989	1990	1991	1992	1993	1994	1995
1	NA	NA	NA	NA	NA	NA	NA
2	4802273.45	3001131.7	2482309.7	2811981.6	2345947.7	3522212.8	3823206.4
3	4585914.05	3195966.2	1877966.3	1398345.1	1445693.9	1098658.0	1889834.8
4	1972475.68	2842799.9	1836367.5	1055156.9	703976.3	546451.0	553656.6
5	568809.01	1240841.1	1796229.0	1126020.2	624308.6	350774.9	266225.8
6	324616.58	324097.6	685497.4	996894.3	584025.5	293813.4	170894.2
7	153154.12	178367.3	192374.6	385694.2	474112.5	276094.9	146107.8
8	73423.55	132495.0	168232.1	200967.8	289815.6	349934.1	292289.5

age \ year	1996	1997	1998	1999	2000	2001	2002
1	NA	10905742.0	7275332.0	5260307.3	17727009.6	10225549.5	20993008.3
2	3534208.75	4465090.3	6396746.1	3485423.1	3367563.4	9943205.4	5378929.9
3	2346182.27	2357706.8	2591895.5	4644991.0	2272520.2	2549990.0	7187830.9
4	908091.12	1310212.6	1257706.0	1336948.1	2746121.2	1306679.8	1388590.8
5	301492.37	579545.8	801147.2	657434.2	884785.0	1671613.7	806291.0
6	114576.73	186036.8	336684.0	391954.1	389414.7	467007.2	964919.5
7	92901.96	65506.2	121588.8	185590.9	238899.9	227316.8	266918.9
8	253039.28	207336.8	160267.6	150557.4	190175.0	216403.5	266465.5

Table 2.6.3.22 (continued). North Sea Herring. Predicted index at age HERAS.

age \ year	2003	2004	2005	2006	2007	2008	2009
1	9727816.3	4567607.0	5710402.1	4763055.8	5950584.5	6628572.3	6731442.4
2	13861142.8	4553924.7	2581032.3	3416407.1	2573300.8	3289019.3	4430841.2
3	3671093.0	9867923.5	3411968.7	1962834.2	2381402.1	1831965.5	2365736.6
4	4188277.0	2261186.0	6004981.9	2004489.6	1191948.6	1489721.9	1148652.4
5	801948.8	2574587.8	1361775.6	3915290.2	1184462.9	866658.2	1088705.6
6	492721.8	384308.2	1244071.5	676846.6	2177526.2	770041.7	616060.2
7	561406.2	287190.2	162332.2	533012.4	328765.5	1462122.9	550950.4
8	298253.8	434695.0	284247.3	178117.7	318985.2	425959.7	1464610.7

age \ year	2010	2011	2012	2013	2014	2015
1	8600234.3	8735449.9	6604091.9	7671325.7	10934133.9	11653300.5
2	4114796.8	5153053.5	5173706.9	3586904.0	4465983.4	7591957.3
3	3598400.5	3093457.6	4475819.4	3888756.5	2828621.4	3019192.6
4	1707088.8	2242271.6	2204916.1	2913600.0	2710652.7	1636221.2
5	943451.3	1130307.2	1563128.8	1674290.4	1879657.2	1639496.9
6	849752.2	599769.1	705103.6	978817.0	1023562.8	958572.0
7	474492.0	570346.9	349095.2	401193.8	546068.7	478590.2
8	1621237.0	1370107.8	1021211.3	775450.9	561013.4	506257.1

Table 2.6.3.23 North Sea Herring. Index at age residuals HERAS.

Units : NA

age \ year	1989	1990	1991	1992	1993	1994	1995
1	NA	NA	NA	NA	NA	NA	NA
2	-0.818785	0.493490	0.302254	1.4461900	1.226460	-0.513362000	0.0341936
3	-0.822372	0.494088	-0.507805	-0.0748800	0.633785	-1.375040000	0.3923530
4	-0.963088	0.933625	0.329372	0.4253950	1.263910	-1.603390000	0.9877970
5	-0.739854	0.489848	0.147575	0.0358308	0.873716	0.421244000	0.5922420
6	-0.541036	0.749681	-0.246172	0.8792180	1.125340	0.348892000	0.6788420
7	-0.961580	0.643767	0.669663	0.0938579	0.592631	0.655137000	-0.2250610
8	-0.420312	1.119240	-0.585968	0.3206240	0.083223	0.000754303	-1.2662000

age \ year	1996	1997	1998	1999	2000	2001	2002
1	NA	-0.418189	-1.346870	-0.0917462	0.912457	-1.1025100	0.25661000
2	1.228240	1.472720	-0.546179	-0.6337250	-0.721869	1.0806400	-0.50163400
3	0.945165	1.116880	-0.143204	0.0869340	-0.268351	0.9678120	0.68443100
4	0.916827	0.485202	1.306720	-0.9210840	0.683351	0.5725370	0.00505609
5	0.158144	0.185543	1.037870	-1.3349300	0.659727	0.0131101	-0.07431060
6	-0.575890	0.570203	1.099490	-0.8740780	0.849190	-0.1461950	0.26129300
7	-0.444166	-1.393340	1.321180	-1.1395500	0.423596	-1.1454300	-0.34755200
8	1.152780	0.527145	0.138348	-0.2586000	0.520067	-1.2649900	0.05937430

age \ year	2003	2004	2005	2006	2007	2008	2009
1	0.0284092	0.3465810	-1.660790	0.9842610	0.139169	-1.5866600	-1.0102800
2	1.5942700	-1.4661900	-1.161690	0.5050550	0.338762	-0.7251440	1.2230500
3	-0.8936390	-0.3619150	0.341639	0.0885572	-1.292800	-0.3541850	0.3886710
4	0.0006845	-0.2163240	-0.186107	0.2312340	-1.443770	-0.0159965	-0.5907970
5	-0.8778860	0.0318043	-0.590219	0.3276820	-1.963020	-0.3508130	-0.0550796
6	0.0166975	-0.7579060	-0.225678	-0.3572350	-1.964220	-0.3090040	0.3544120
7	0.0480176	0.5189480	-0.586125	0.2096500	-1.191460	0.7061840	0.5781730
8	0.3166380	0.7640600	-0.780267	-0.5556290	-1.518740	0.2600010	0.6338210

age \ year	2010	2011	2012	2013	2014	2015
1	1.445170	0.402537	0.325376	-0.5014800	0.1699130	-1.5100800
2	0.149036	-1.084060	-0.468960	-1.4803200	0.4913900	1.1405000
3	0.807523	-1.017380	-0.488434	-1.2708500	-0.0027831	-0.3283650
4	1.848620	-0.160149	-1.213470	-0.0327739	0.4123690	-0.1429640
5	1.418160	-0.543692	-1.309710	-0.4064180	-0.2465000	-0.2894230
6	1.772010	0.323221	-0.682444	-0.5610700	0.7432930	-0.1361800
7	1.464660	0.739348	-1.363760	0.5731600	0.8004040	0.3270190
8	2.052780	0.935201	-1.511330	0.3245240	-0.7741250	-0.0806694

Table 2.6.3.24 North Sea Herring. Predicted index at age IBTS0.

Units : NA

age	1992	1993	1994	1995	1996	1997	1998	1999
0	141.6586	122.8741	88.44934	115.055	107.2873	74.54329	54.36008	174.1906

age	2000	2001	2002	2003	2004	2005	2006	2007
0	119.6248	209.294	110.3305	52.95963	62.75887	58.01433	67.70229	65.72176

age	2008	2009	2010	2011	2012	2013	2014	2015
0	68.03757	89.30255	87.0724	74.61861	81.99432	97.15717	122.6151	43.22547

age	2016
0	74.76052

Table 2.6.3.25 North Sea Herring. Index at age residuals IBTS0.

Units : NA

age	1992	1993	1994	1995	1996	1997	1998	1999
0	0.84469	1.05803	0.33845	0.2395	-0.0178457	1.66445	-0.0568654	0.81712

age	2000	2001	2002	2003	2004	2005	2006	2007
0	0.330582	0.062969	0.928316	0.0650539	-0.68564	0.133557	0.496838	-1.37985

age	2008	2009	2010	2011	2012	2013	2014	2015
0	-2.17001	0.170272	-0.294909	0.0761581	-0.453728	-1.5913	0.712484	-1.76187

age	2016
0	0.700384

Table 2.6.3.27 North Sea Herring. Fit paramteres.

	name	value	std.dev
1	logFpar	-8.69230000	0.069042
2	logFpar	-12.54500000	0.102630
3	logFpar	0.00092141	0.061250
4	logFpar	0.16004000	0.058048
5	logFpar	0.26759000	0.077588
6	logSdLogFsta	-0.55104000	0.095180
7	logSdLogFsta	-1.12610000	0.123250
8	logSdLogFsta	-1.14540000	0.115940
9	logSdLogFsta	-0.67317000	0.105310
10	logSdLogN	-0.56565000	0.116440
11	logSdLogN	-1.84230000	0.125940
12	logSdLogObs	-1.22930000	0.156860
13	logSdLogObs	-0.88564000	0.174990
14	logSdLogObs	-1.42900000	0.480720
15	logSdLogObs	-1.93780000	0.314210
16	logSdLogObs	-1.31450000	0.172650
17	logSdLogObs	-1.00750000	0.192840
18	logSdLogObs	-1.62910000	0.108670
19	logSdLogObs	-1.37170000	0.123250
20	logScaleSSB	-4.26970000	0.077958
21	logSdSSB	-0.82885000	0.111990

Table 2.6.3.28 North Sea Herring. Negative likelihood.

658.557

Table 2.7.1 North Sea herring. Weights at age in the catch.

Units : kg

, , unit = A

year						
age	2013	2014	2015	2016	2017	2018
0	0.0077000	0.0075000	0.0087000	0.01800000	0.01800000	0.01800000
1	0.0468000	0.0522000	0.0261000	0.06033608	0.06033608	0.06033608
2	0.1162000	0.1240000	0.1135000	0.13109869	0.13109869	0.13109869
3	0.1563000	0.1719000	0.1538000	0.16157764	0.16157764	0.16157764
4	0.1977000	0.1861000	0.1883000	0.19093740	0.19093740	0.19093740
5	0.1980000	0.2148000	0.2001000	0.20467341	0.20467341	0.20467341
6	0.2154000	0.2118000	0.2212000	0.21679716	0.21679716	0.21679716
7	0.2334000	0.2264000	0.2170000	0.22375527	0.22375527	0.22375527
8	0.2378432	0.2426541	0.2347182	0.23780326	0.23780326	0.23780326

, , unit = B

year						
age	2013	2014	2015	2016	2017	2018
0	0.0077000	0.0075000	0.0087000	0.007479276	0.007479276	0.007479276
1	0.0468000	0.0522000	0.0261000	0.024215668	0.024215668	0.024215668
2	0.1162000	0.1240000	0.1135000	0.042033620	0.042033620	0.042033620
3	0.1563000	0.1719000	0.1538000	0.164368090	0.164368090	0.164368090
4	0.1977000	0.1861000	0.1883000	0.192764518	0.192764518	0.192764518
5	0.1980000	0.2148000	0.2001000	0.226033614	0.226033614	0.226033614
6	0.2154000	0.2118000	0.2212000	0.210080690	0.210080690	0.210080690
7	0.2334000	0.2264000	0.2170000	0.228824671	0.228824671	0.228824671
8	0.2378432	0.2426541	0.2347182	0.229347124	0.229347124	0.229347124

, , unit = C

year						
age	2013	2014	2015	2016	2017	2018
0	0.0077000	0.0075000	0.0087000	0.02025000	0.02025000	0.02025000
1	0.0468000	0.0522000	0.0261000	0.06806484	0.06806484	0.06806484
2	0.1162000	0.1240000	0.1135000	0.07951530	0.07951530	0.07951530
3	0.1563000	0.1719000	0.1538000	0.12767983	0.12767983	0.12767983
4	0.1977000	0.1861000	0.1883000	0.15880374	0.15880374	0.15880374
5	0.1980000	0.2148000	0.2001000	0.18195423	0.18195423	0.18195423
6	0.2154000	0.2118000	0.2212000	0.19800000	0.19800000	0.19800000
7	0.2334000	0.2264000	0.2170000	0.19700000	0.19700000	0.19700000
8	0.2378432	0.2426541	0.2347182	0.21760000	0.21760000	0.21760000

, , unit = D

year						
age	2013	2014	2015	2016	2017	2018
0	0.0077000	0.0075000	0.0087000	0.009641443	0.009641443	0.009641443
1	0.0468000	0.0522000	0.0261000	0.024866711	0.024866711	0.024866711
2	0.1162000	0.1240000	0.1135000	0.043461404	0.043461404	0.043461404
3	0.1563000	0.1719000	0.1538000	0.070855856	0.070855856	0.070855856
4	0.1977000	0.1861000	0.1883000	0.138000000	0.138000000	0.138000000
5	0.1980000	0.2148000	0.2001000	0.000000000	0.000000000	0.000000000
6	0.2154000	0.2118000	0.2212000	0.000000000	0.000000000	0.000000000
7	0.2334000	0.2264000	0.2170000	0.000000000	0.000000000	0.000000000
8	0.2378432	0.2426541	0.2347182	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	2013	2014	2015	2016	2017	2018
0	0.00600000	0.005666667	0.005333333	0.005333333	0.005333333	0.005333333
1	0.04033333	0.043333333	0.043666667	0.043666667	0.043666667	0.043666667
2	0.13566667	0.128666667	0.127333333	0.127333333	0.127333333	0.127333333
3	0.17466667	0.176666667	0.161333333	0.161333333	0.161333333	0.161333333
4	0.20866667	0.203666667	0.200000000	0.200000000	0.200000000	0.200000000
5	0.22133333	0.215666667	0.211666667	0.211666667	0.211666667	0.211666667
6	0.24200000	0.228666667	0.224666667	0.224666667	0.224666667	0.224666667
7	0.24933333	0.241333333	0.229000000	0.229000000	0.229000000	0.229000000
8	0.25179433	0.246572539	0.239358137	0.239358137	0.239358137	0.239358137

, , unit = B

age \ year	2013	2014	2015	2016	2017	2018
0	0.00600000	0.005666667	0.005333333	0.005333333	0.005333333	0.005333333
1	0.04033333	0.043333333	0.043666667	0.043666667	0.043666667	0.043666667
2	0.13566667	0.128666667	0.127333333	0.127333333	0.127333333	0.127333333
3	0.17466667	0.176666667	0.161333333	0.161333333	0.161333333	0.161333333
4	0.20866667	0.203666667	0.200000000	0.200000000	0.200000000	0.200000000
5	0.22133333	0.215666667	0.211666667	0.211666667	0.211666667	0.211666667
6	0.24200000	0.228666667	0.224666667	0.224666667	0.224666667	0.224666667
7	0.24933333	0.241333333	0.229000000	0.229000000	0.229000000	0.229000000
8	0.25179433	0.246572539	0.239358137	0.239358137	0.239358137	0.239358137

, , unit = C

age \ year	2013	2014	2015	2016	2017	2018
0	0.00600000	0.005666667	0.005333333	0.005333333	0.005333333	0.005333333
1	0.04033333	0.043333333	0.043666667	0.043666667	0.043666667	0.043666667
2	0.13566667	0.128666667	0.127333333	0.127333333	0.127333333	0.127333333
3	0.17466667	0.176666667	0.161333333	0.161333333	0.161333333	0.161333333
4	0.20866667	0.203666667	0.200000000	0.200000000	0.200000000	0.200000000
5	0.22133333	0.215666667	0.211666667	0.211666667	0.211666667	0.211666667
6	0.24200000	0.228666667	0.224666667	0.224666667	0.224666667	0.224666667
7	0.24933333	0.241333333	0.229000000	0.229000000	0.229000000	0.229000000
8	0.25179433	0.246572539	0.239358137	0.239358137	0.239358137	0.239358137

, , unit = D

age \ year	2013	2014	2015	2016	2017	2018
0	0.00600000	0.005666667	0.005333333	0.005333333	0.005333333	0.005333333
1	0.04033333	0.043333333	0.043666667	0.043666667	0.043666667	0.043666667
2	0.13566667	0.128666667	0.127333333	0.127333333	0.127333333	0.127333333
3	0.17466667	0.176666667	0.161333333	0.161333333	0.161333333	0.161333333
4	0.20866667	0.203666667	0.200000000	0.200000000	0.200000000	0.200000000
5	0.22133333	0.215666667	0.211666667	0.211666667	0.211666667	0.211666667
6	0.24200000	0.228666667	0.224666667	0.224666667	0.224666667	0.224666667
7	0.24933333	0.241333333	0.229000000	0.229000000	0.229000000	0.229000000
8	0.25179433	0.246572539	0.239358137	0.239358137	0.239358137	0.239358137

Table 2.7.3 North Sea herring. Stock in number.

Units : NA

, , unit = A

age	2013	2014	2015	2016	2017
0	30280060.9678263	38339835.3077486	13524318.5911913	23394230.7316497	
1	10799387.7427352	15463608.7677547	16419824.9310812	5493081.77860885	
2	4519898.06697536	5700132.62455565	9606975.43116766	8788898.94864226	
3	4260938.50363776	3134561.97062997	3259225.01623332	6249424.89075802	
4	3298571.32210884	3131428.97541803	1848712.4836837	2120155.51480952	
5	1767364.47903503	2026863.33325246	1788700.61355759	1106818.23258289	
6	1056001.32713058	1113479.10461187	1125794.98793598	938464.210976747	
7	449998.712215916	622812.008358702	613539.545562319	516587.519278738	
8	869783.840009212	639857.004562195	648878.002267521	494350.470954973	

, , unit = B

age	2013	2014	2015	2016	2017
0	30280060.9678263	38339835.3077486	13524318.5911913	23394230.7316497	
1	10799387.7427352	15463608.7677547	16419824.9310812	5493081.77860885	
2	4519898.06697536	5700132.62455565	9606975.43116766	8788898.94864226	
3	4260938.50363776	3134561.97062997	3259225.01623332	6249424.89075802	
4	3298571.32210884	3131428.97541803	1848712.4836837	2120155.51480952	
5	1767364.47903503	2026863.33325246	1788700.61355759	1106818.23258289	
6	1056001.32713058	1113479.10461187	1125794.98793598	938464.210976747	
7	449998.712215916	622812.008358702	613539.545562319	516587.519278738	
8	869783.840009212	639857.004562195	648878.002267521	494350.470954973	

, , unit = C

age	2013	2014	2015	2016	2017
0	30280060.9678263	38339835.3077486	13524318.5911913	23394230.7316497	
1	10799387.7427352	15463608.7677547	16419824.9310812	5493081.77860885	
2	4519898.06697536	5700132.62455565	9606975.43116766	8788898.94864226	
3	4260938.50363776	3134561.97062997	3259225.01623332	6249424.89075802	
4	3298571.32210884	3131428.97541803	1848712.4836837	2120155.51480952	
5	1767364.47903503	2026863.33325246	1788700.61355759	1106818.23258289	
6	1056001.32713058	1113479.10461187	1125794.98793598	938464.210976747	
7	449998.712215916	622812.008358702	613539.545562319	516587.519278738	
8	869783.840009212	639857.004562195	648878.002267521	494350.470954973	

, , unit = D

age	2013	2014	2015	2016	2017
0	30280060.9678263	38339835.3077486	13524318.5911913	23394230.7316497	
1	10799387.7427352	15463608.7677547	16419824.9310812	5493081.77860885	
2	4519898.06697536	5700132.62455565	9606975.43116766	8788898.94864226	
3	4260938.50363776	3134561.97062997	3259225.01623332	6249424.89075802	
4	3298571.32210884	3131428.97541803	1848712.4836837	2120155.51480952	
5	1767364.47903503	2026863.33325246	1788700.61355759	1106818.23258289	
6	1056001.32713058	1113479.10461187	1125794.98793598	938464.210976747	
7	449998.712215916	622812.008358702	613539.545562319	516587.519278738	
8	869783.840009212	639857.004562195	648878.002267521	494350.470954973	

Table 2.7.4 North Sea herring. Fishing mortality at age in the stock.

```
Units  :  f
, , unit = A

age               2013               2014               2015
  0 0.0269007799061755 0.0498119681264688 0.0583205943585794
  1 0.0494645019001947 0.0329817797098534 0.0324161021402496
  2 0.0867174627218572 0.0822822392146296 0.0721217222928278
  3  0.142887167305453  0.144106884682697  0.100731169384133
  4  0.217708122699985   0.23952439722297  0.203010008134589
  5  0.295880388272474  0.320203035004315  0.344831288637955
  6  0.344969248743592  0.347844408917087  0.490882739237474
  7  0.437066465712475  0.454262524620047  0.668780081567763
  8  0.437066465712475  0.454262524620047  0.668780081567763
   year
age                2016 2017 2018
  0                   0
  1 0.00239809328009348
  2  0.0784892854297882
  3   0.129392468544276
  4   0.267126695468131
  5   0.450989002930932
  6   0.647247898049495
  7     0.8801531759222
  8   0.883016980895749

, , unit = B

   year
age               2013               2014               2015               2016
  0 0.0269007799061755 0.0498119681264688 0.0583205943585794 0.0548644924552734
  1 0.0494645019001947 0.0329817797098534 0.0324161021402496 0.0166408089067518
  2 0.0867174627218572 0.0822822392146296 0.0721217222928278                  0
  3  0.142887167305453  0.144106884682697  0.100731169384133                  0
  4  0.217708122699985   0.23952439722297  0.203010008134589                  0
  5  0.295880388272474  0.320203035004315  0.344831288637955                  0
  6  0.344969248743592  0.347844408917087  0.490882739237474                  0
  7  0.437066465712475  0.454262524620047  0.668780081567763                  0
  8  0.437066465712475  0.454262524620047  0.668780081567763                  0
   year
age 2017 2018
  0
  1
  2
  3
  4
  5
  6
  7
  8

, , unit = C
   year
age               2013               2014               2015
  0 0.0269007799061755 0.0498119681264688 0.0583205943585794
  1 0.0494645019001947 0.0329817797098534 0.0324161021402496
  2 0.0867174627218572 0.0822822392146296 0.0721217222928278
  3  0.142887167305453  0.144106884682697  0.100731169384133
  4  0.217708122699985   0.23952439722297  0.203010008134589
  5  0.295880388272474  0.320203035004315  0.344831288637955
  6  0.344969248743592  0.347844408917087  0.490882739237474
  7  0.437066465712475  0.454262524620047  0.668780081567763
  8  0.437066465712475  0.454262524620047  0.668780081567763
```

Table 2.7.4 (continued). North Sea herring. Fishing mortality at age in the stock.

```
   year
age                 2016 2017 2018
  0 0.000254102852168599
  1  0.00487958529591865
  2   0.0119399321599641
  3  0.00329127084213483
  4  0.00109377791403223
  5  0.00429737364439904
  6    0.001465507333375
  7  0.00346829538843613
  8 0.000928231763719762

, , unit = D

   year
age               2013               2014               2015
  0 0.0269007799061755 0.0498119681264688 0.0583205943585794
  1 0.0494645019001947 0.0329817797098534 0.0324161021402496
  2 0.0867174627218572 0.0822822392146296 0.0721217222928278
  3  0.142887167305453  0.144106884682697  0.100731169384133
  4  0.217708122699985   0.23952439722297  0.203010008134589
  5  0.295880388272474  0.320203035004315  0.344831288637955
  6  0.344969248743592  0.347844408917087  0.490882739237474
  7  0.437066465712475  0.454262524620047  0.668780081567763
  8  0.437066465712475  0.454262524620047  0.668780081567763
   year
age                  2016 2017 2018
  0   0.00642520641467693
  1    0.0201642676138303
  2   0.00529353899072648
  3 0.0000840504755489708
  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      2013      2014      2015      2016      2017      2018
  0 0.8137161 0.8172596 0.8164639 0.8160831 0.8160831 0.8160831
  1 0.5745417 0.5993861 0.5933003 0.5907685 0.5907685 0.5907685
  2 0.3363089 0.3638303 0.3578530 0.3550807 0.3550807 0.3550807
  3 0.3142024 0.3331844 0.3291830 0.3272747 0.3272747 0.3272747
  4 0.2987052 0.3137208 0.3108021 0.3092961 0.3092961 0.3092961
  5 0.2888504 0.3030087 0.3003801 0.2989627 0.2989627 0.2989627
  6 0.2790475 0.2909866 0.2887470 0.2875487 0.2875487 0.2875487
  7 0.2577845 0.2714712 0.2689877 0.2676174 0.2676174 0.2676174
  8 0.2577845 0.2714712 0.2689877 0.2676174 0.2676174 0.2676174

, , unit = B

   year
age      2013      2014      2015      2016      2017      2018
  0 0.8137161 0.8172596 0.8164639 0.8160831 0.8160831 0.8160831
  1 0.5745417 0.5993861 0.5933003 0.5907685 0.5907685 0.5907685
  2 0.3363089 0.3638303 0.3578530 0.3550807 0.3550807 0.3550807
  3 0.3142024 0.3331844 0.3291830 0.3272747 0.3272747 0.3272747
  4 0.2987052 0.3137208 0.3108021 0.3092961 0.3092961 0.3092961
  5 0.2888504 0.3030087 0.3003801 0.2989627 0.2989627 0.2989627
  6 0.2790475 0.2909866 0.2887470 0.2875487 0.2875487 0.2875487
  7 0.2577845 0.2714712 0.2689877 0.2676174 0.2676174 0.2676174
  8 0.2577845 0.2714712 0.2689877 0.2676174 0.2676174 0.2676174

, , unit = C
```

Table 2.7.5 (continued). North Sea herring. Natural mortality.

year

age	2013	2014	2015	2016	2017	2018
0	0.8137161	0.8172596	0.8164639	0.8160831	0.8160831	0.8160831
1	0.5745417	0.5993861	0.5933003	0.5907685	0.5907685	0.5907685
2	0.3363089	0.3638303	0.3578530	0.3550807	0.3550807	0.3550807
3	0.3142024	0.3331844	0.3291830	0.3272747	0.3272747	0.3272747
4	0.2987052	0.3137208	0.3108021	0.3092961	0.3092961	0.3092961
5	0.2888504	0.3030087	0.3003801	0.2989627	0.2989627	0.2989627
6	0.2790475	0.2909866	0.2887470	0.2875487	0.2875487	0.2875487
7	0.2577845	0.2714712	0.2689877	0.2676174	0.2676174	0.2676174
8	0.2577845	0.2714712	0.2689877	0.2676174	0.2676174	0.2676174

, , unit = D

year

age	2013	2014	2015	2016	2017	2018
0	0.8137161	0.8172596	0.8164639	0.8160831	0.8160831	0.8160831
1	0.5745417	0.5993861	0.5933003	0.5907685	0.5907685	0.5907685
2	0.3363089	0.3638303	0.3578530	0.3550807	0.3550807	0.3550807
3	0.3142024	0.3331844	0.3291830	0.3272747	0.3272747	0.3272747
4	0.2987052	0.3137208	0.3108021	0.3092961	0.3092961	0.3092961
5	0.2888504	0.3030087	0.3003801	0.2989627	0.2989627	0.2989627
6	0.2790475	0.2909866	0.2887470	0.2875487	0.2875487	0.2875487
7	0.2577845	0.2714712	0.2689877	0.2676174	0.2676174	0.2676174
8	0.2577845	0.2714712	0.2689877	0.2676174	0.2676174	0.2676174

Table 2.7.6 North Sea herring. Proportion mature.

year

age	2013	2014	2015	2016	2017	2018
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	0.83	0.85	0.70	0.7933333	0.7933333	0.7933333
3	0.96	1.00	0.90	0.9533333	0.9533333	0.9533333
4	0.98	1.00	0.96	0.9800000	0.9800000	0.9800000
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	2013	2014	2015	2016	2017	2018
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	0.83	0.85	0.70	0.7933333	0.7933333	0.7933333
3	0.96	1.00	0.90	0.9533333	0.9533333	0.9533333
4	0.98	1.00	0.96	0.9800000	0.9800000	0.9800000
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	2013	2014	2015	2016	2017	2018
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	0.83	0.85	0.70	0.7933333	0.7933333	0.7933333
3	0.96	1.00	0.90	0.9533333	0.9533333	0.9533333
4	0.98	1.00	0.96	0.9800000	0.9800000	0.9800000
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

Table 2.7.6 (continued). North Sea herring. Proportion mature.

age \ year	2013	2014	2015	2016	2017	2018
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	0.83	0.85	0.70	0.7933333	0.7933333	0.7933333
3	0.96	1.00	0.90	0.9533333	0.9533333	0.9533333
4	0.98	1.00	0.96	0.9800000	0.9800000	0.9800000
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 \ year	2013	2014	2015	2016	2017	2018
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	2013	2014	2015	2016	2017	2018
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	2013	2014	2015	2016	2017	2018
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	2013	2014	2015	2016	2017	2018
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 2013 2014 2015 2016 2017 2018
  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 2013 2014 2015 2016 2017 2018
  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 2013 2014 2015 2016 2017 2018
  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 2013 2014 2015 2016 2017 2018
  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 2016.

```
23644739
```

Table 2.7.10. North Sea herring. Recruitment in 2017.

```
23644739
```

Table 2.7.11. North Sea herring. FLR, R software versions.

```
R version 2.14.2 (2012-02-29)

Package  : FLSAM
Version  : 0.99-99
Packaged :
Built    : R 2.13.2; ; 2013-03-17 22:10:20 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  : 2.4
Packaged :
Built    : R 2.14.0; i386-pc-mingw32; 2012-02-10 08:15:33 UTC; windows
```

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

Outlook assuming a TAC constraint for fleet A in 2016, proportion of 2015 by-catch ceiling taken applied to 2016 for fleet B

Basis: Intermediate year (2016) with catch constraint

F fleet A	F fleet B	F fleet C	F fleet D	F2–6	F0–1	Catch fleet A	Catch fleet B	Catch Fleet C	Catch fleet D	SSB 2016
0.31	0.036	0.003	0.013	0.32	0.05	539574	8029	11586	4661	2008169

[1]Includes a transfer of 46% of 3.a TAC from the C-fleet to the A-fleet

Scenarios for prediction year (2017). Weights in tonnes.

F-values by fleet and total							NSAS Catches by fleet				Biomass			
scenario	fleet A	fleet B	fleet C	fleet D	F0-1	F2-6	fleet A	fleet B	fleet C	fleet D	SSB 2017[(1)]	SSB 2018	%SSB change[(2)]	%TAC change fleet A[(3)]
1	0.27	0.031	0.006	0.012	0.29	0.05	426259	8020	19986	4661	1694363	1510120	-16	-18
2	0.26	0.031	0.006	0.012	0.27	0.05	405468	8020	19488	4661	1709020	1537157	-15	-22
3	0.00	0.000	0.000	0.000	0.00	0.00	0	0	0	0	1989011	2169415	-1	-100
4	0.35	0.031	0.007	0.012	0.36	0.05	518242	8020	21455	4661	1629197	1395540	-19	0
5	0.41	0.031	0.008	0.012	0.43	0.05	595978	8020	24674	4661	1572050	1300616	-22	+15
6	0.28	0.031	0.006	0.012	0.30	0.05	440506	8020	18237	4661	1685469	1494984	-16	-15
7	0.29	0.031	0.003	0.012	0.30	0.05	450052	8020	9993	4661	1683503	1495750	-16	-13

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 (2017) relative to SSB (2016). 3) Calculated catches (2017) relative to TAC 2016 for the A fleet.

Scenarios

1 Management plan (0% transfer in C fleet)

2 Fmsy

3 No fishing

4 No change in TAC

5 TAC increase of 15%

6 TAC reduction of 15%

7 As 1, with 50% transfer in C fleet

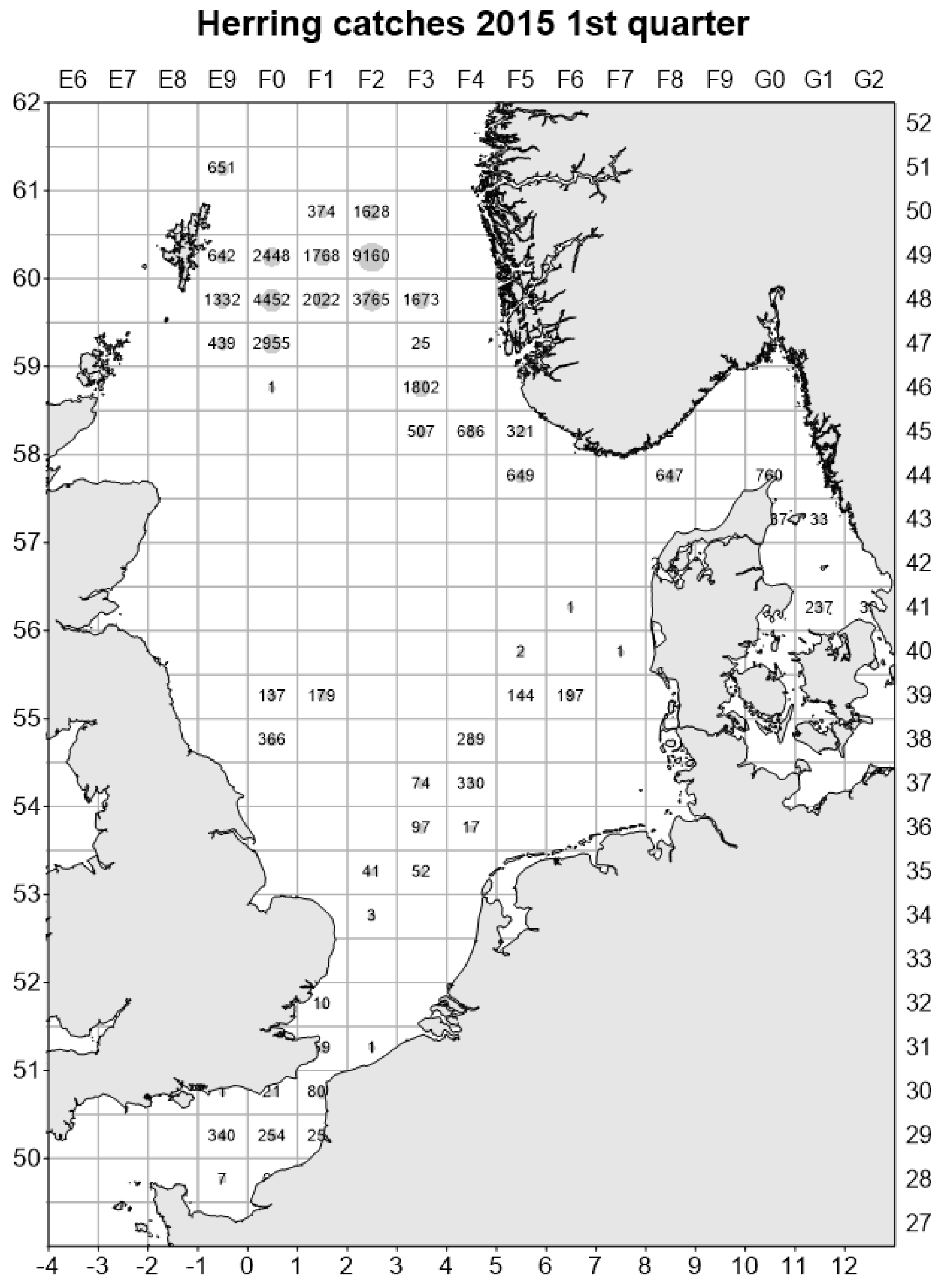


Figure 2.1.1a: Herring catches in the North Sea in the 1st quarter of 2015 (in tonnes) by statistical rectangle.

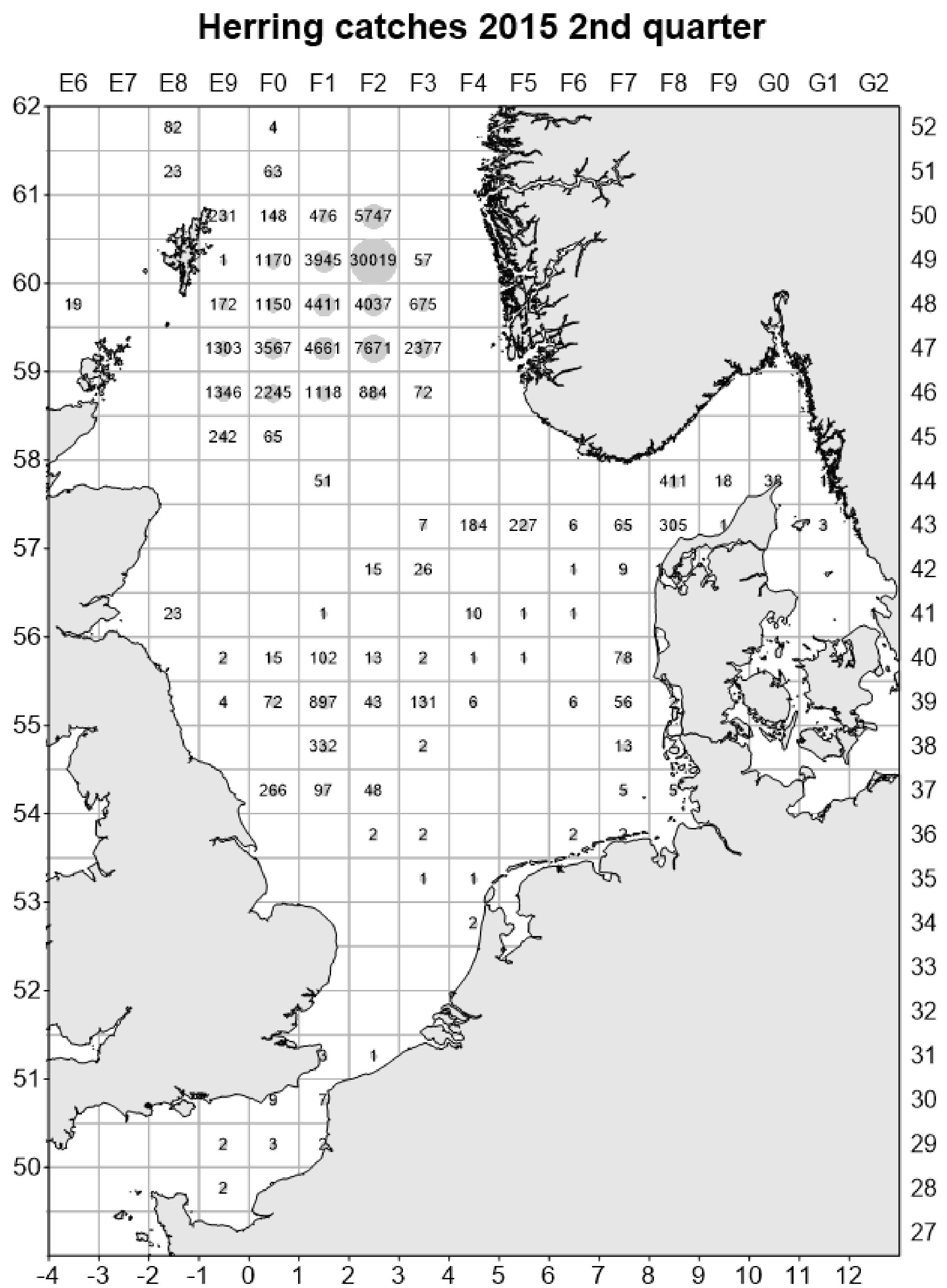


Figure 2.1.1b: Herring catches in the North Sea in the 2nd quarter of 2015 (in tonnes) by statistical rectangle.

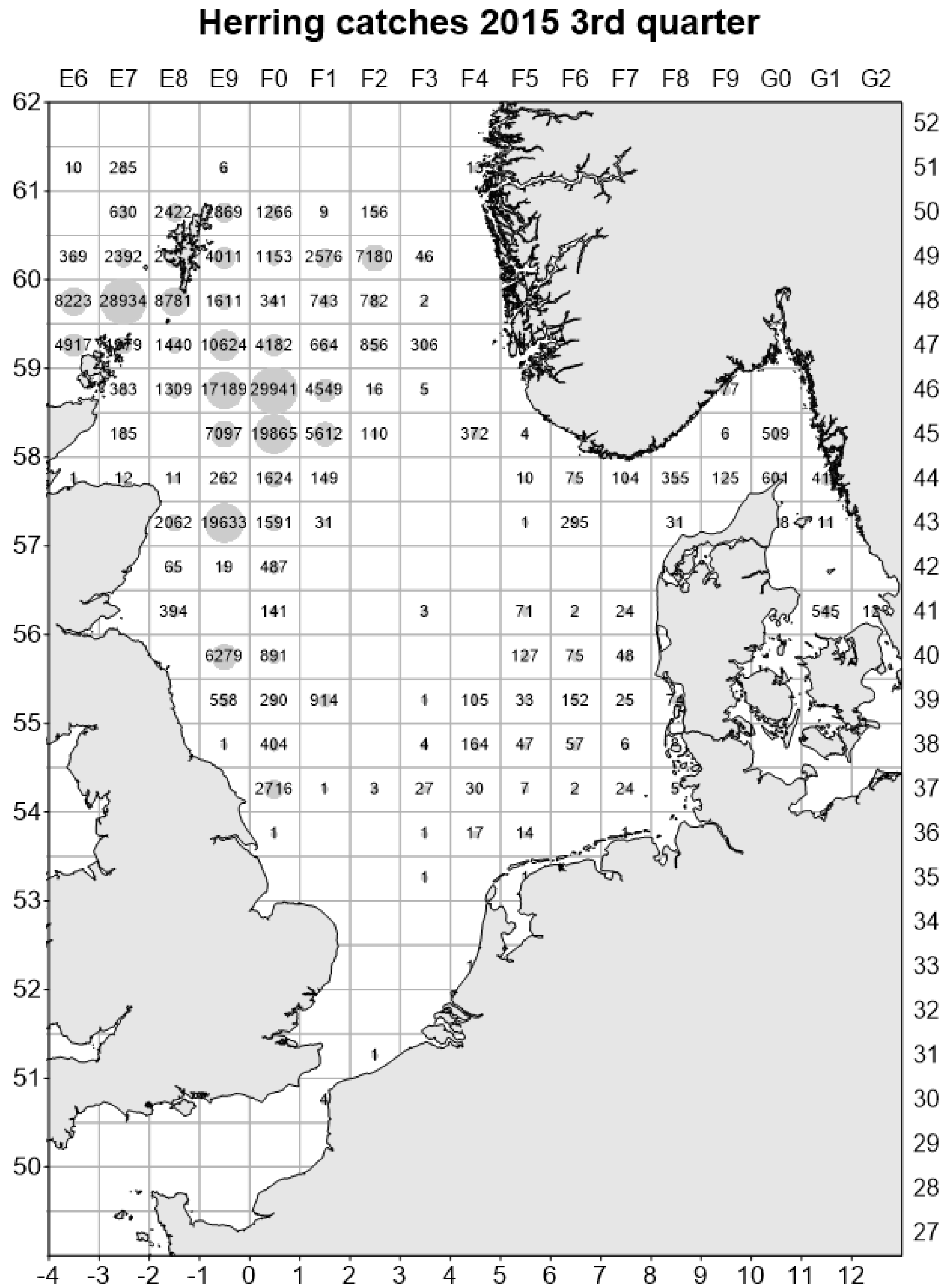


Figure 2.1.1c: Herring catches in the North Sea in the 3rd quarter of 2015 (in tonnes) by statistical rectangle.

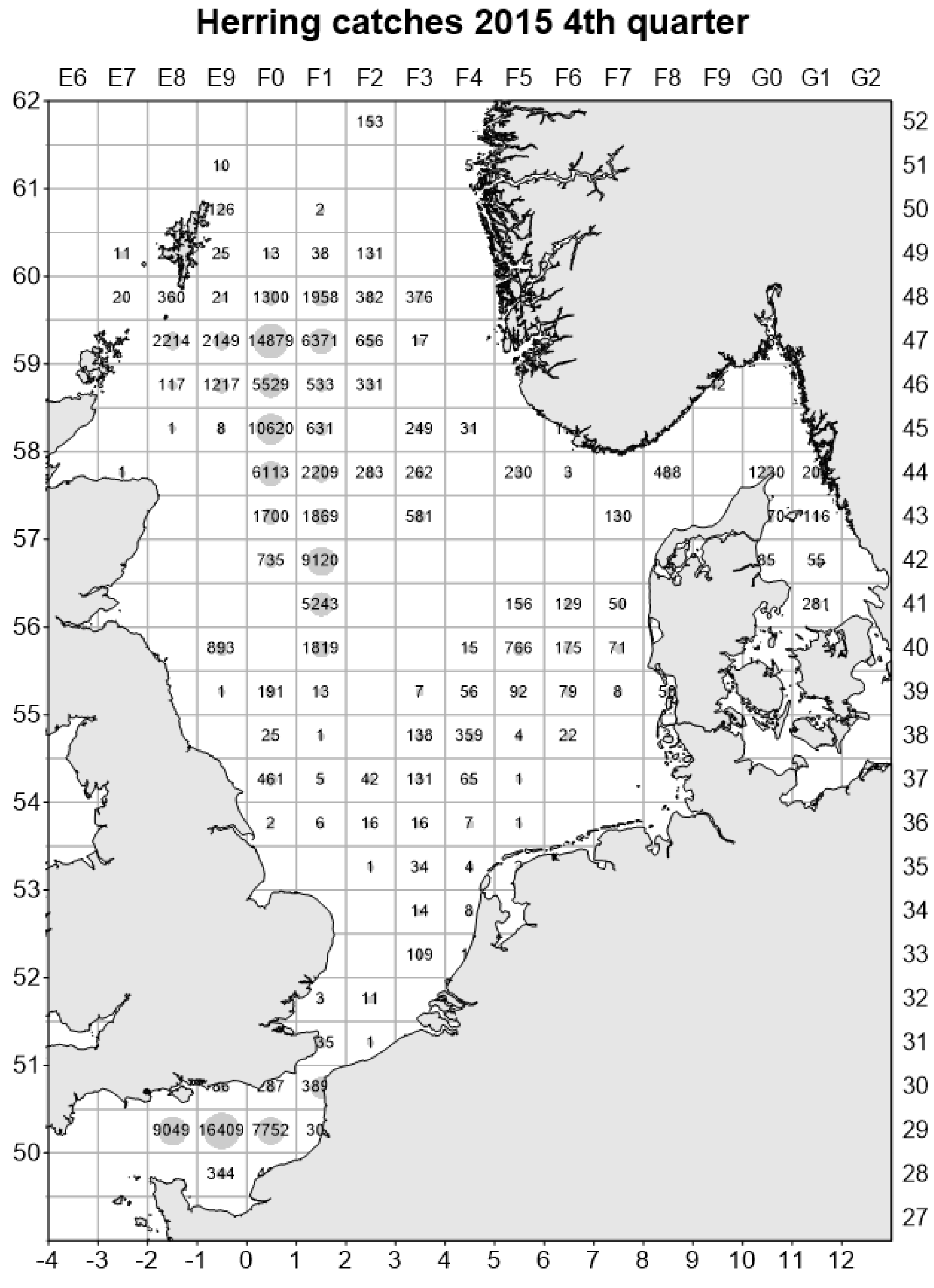


Figure 2.1.1d: Herring catches in the North Sea in the 4th quarter of 2015 (in tonnes) by statistical rectangle.

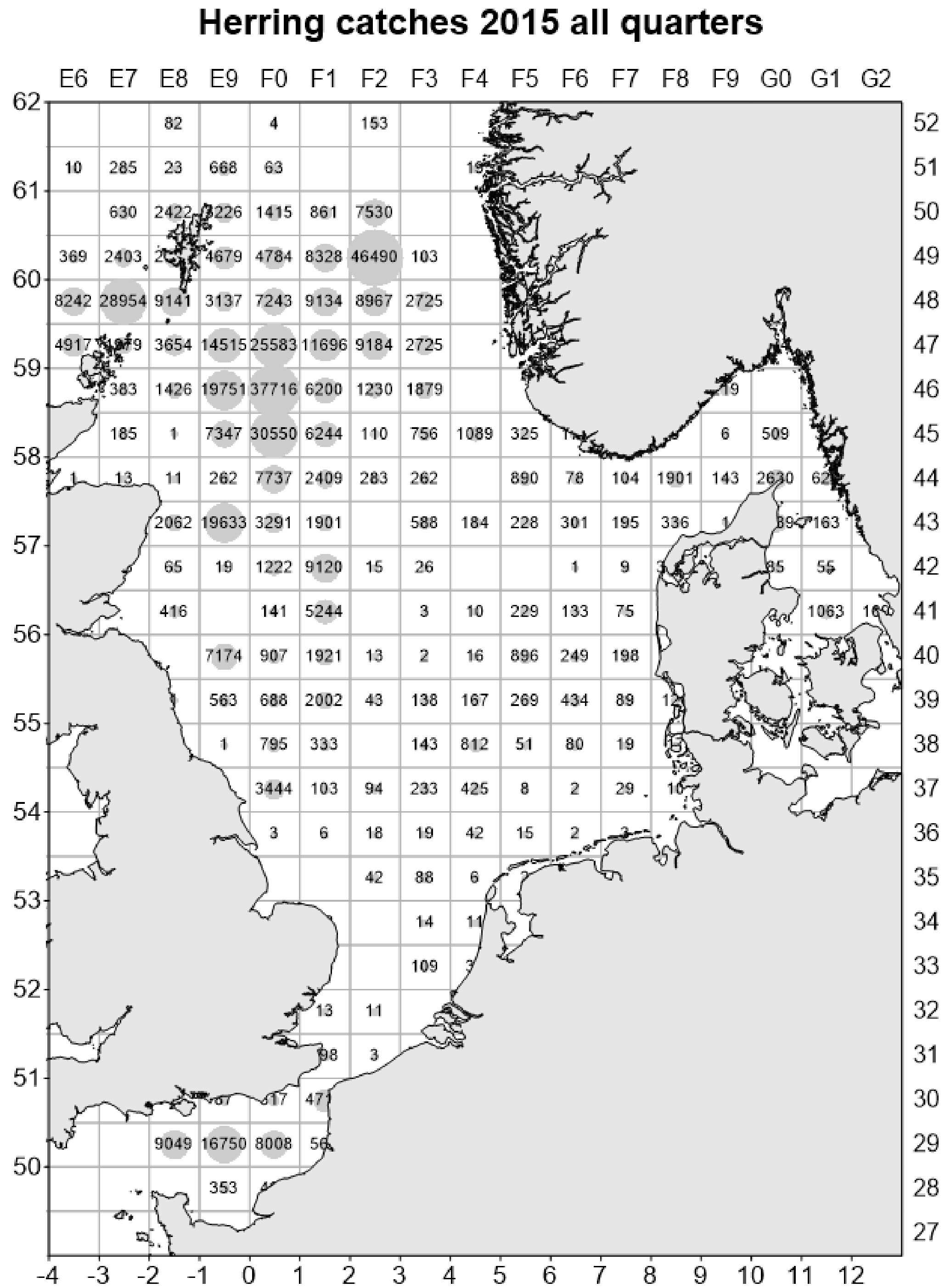


Figure 2.1.1e: Herring catches in the North Sea in all quarters of 2015 (in tonnes) by statistical rectangle.

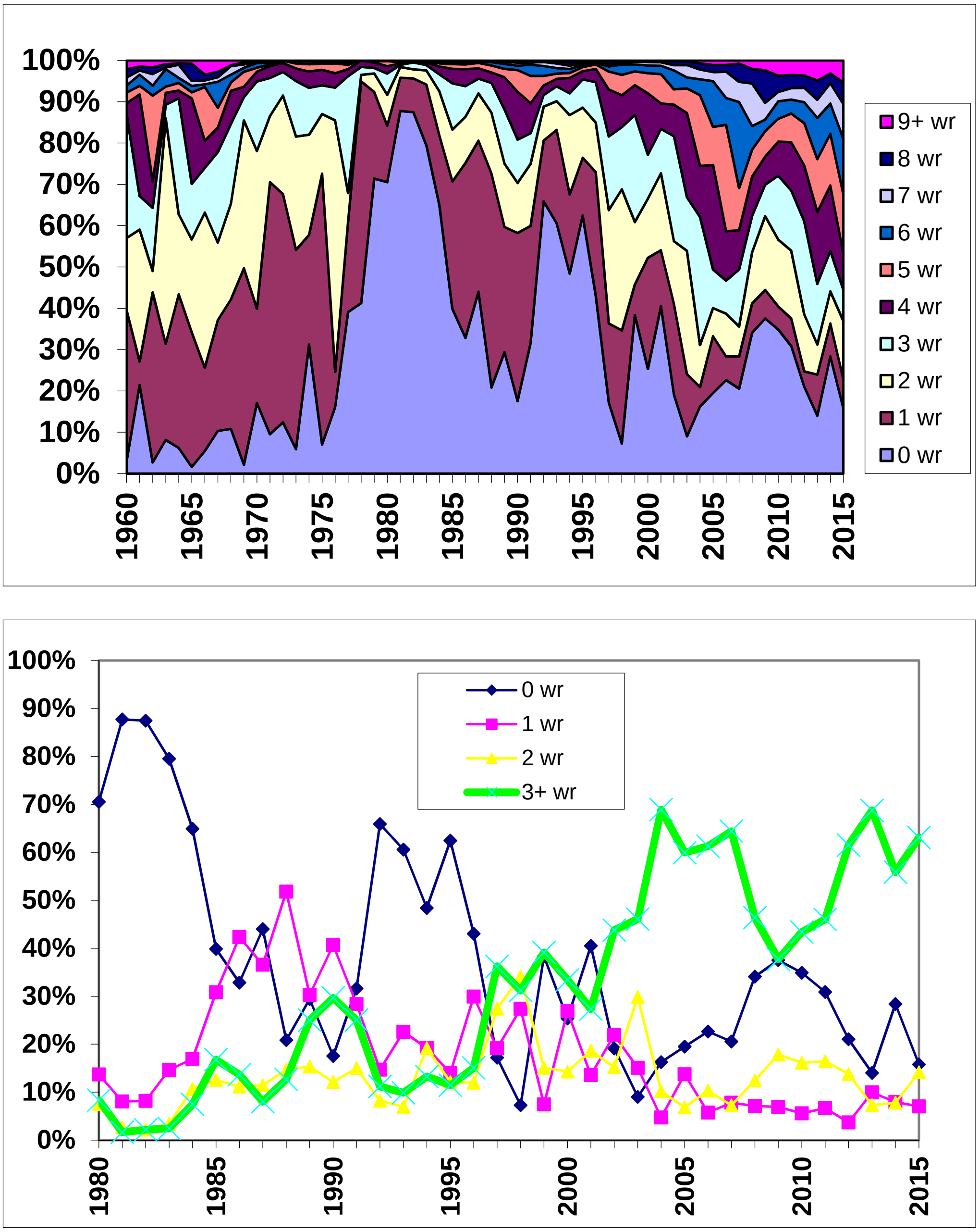


Figure 2.2.1: Proportions of age groups (numbers) in the total catch of herring caught in the North Sea (upper, 1960–2015, and lower panel, 1980–2015).

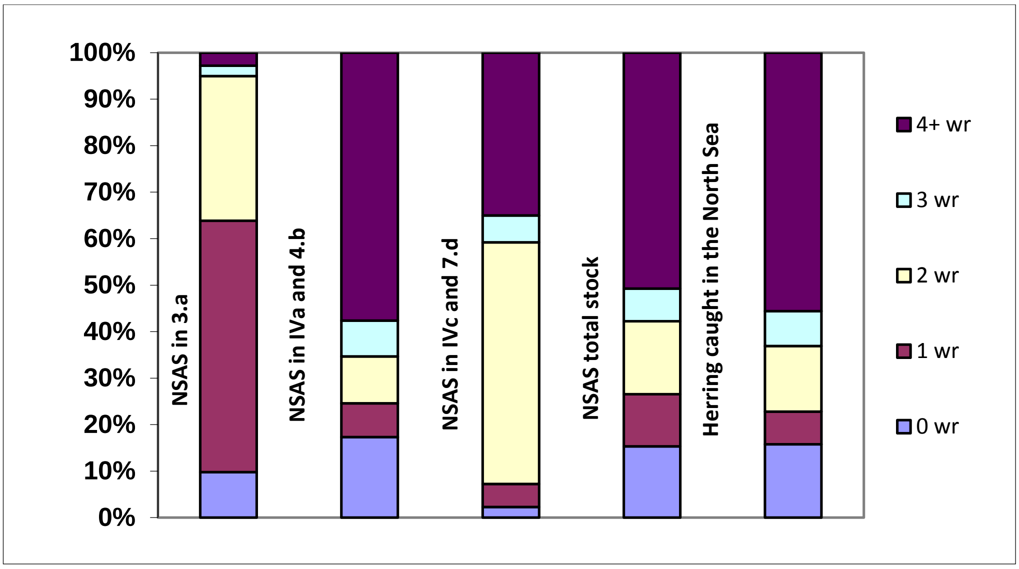


Figure 2.2.2: Proportion of age groups (numbers) in the total catch of NSAS and herring caught in the North Sea in 2015.

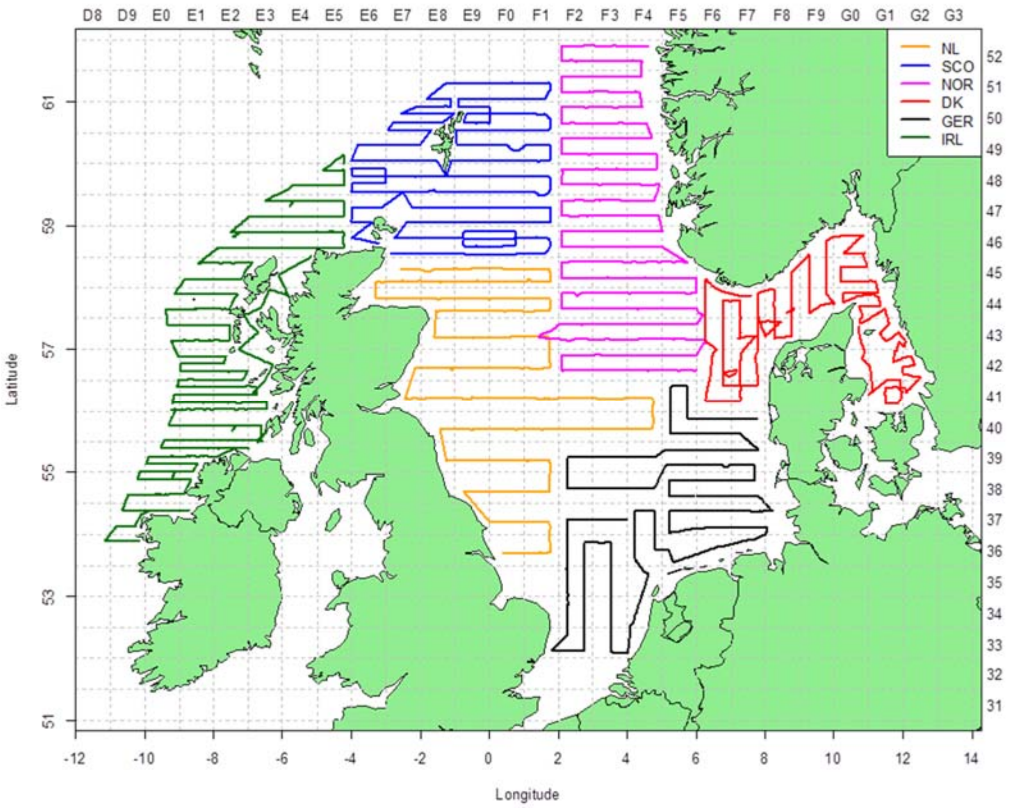


Figure 2.3.1.1. Cruise tracks and survey area coverage in the HERAS acoustic surveys in 2015 by nation.

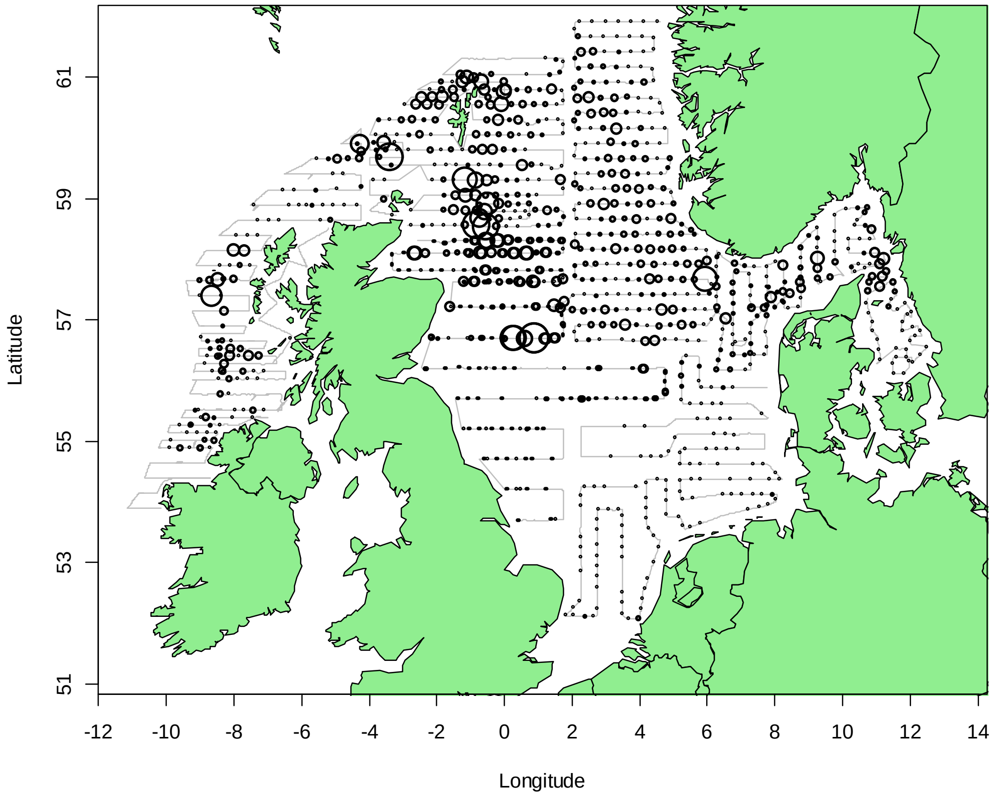


Figure 2.3.1.2. Distribution of NASC attributed to herring in HERAS 2015. Cruise tracks are outlined in light grey with circles representing size and location of herring aggregations. NASC values are resampled at 15 nm intervals along the cruise track. Distribution displayed here is for all herring encountered in the HERAS survey regardless of stock identity.

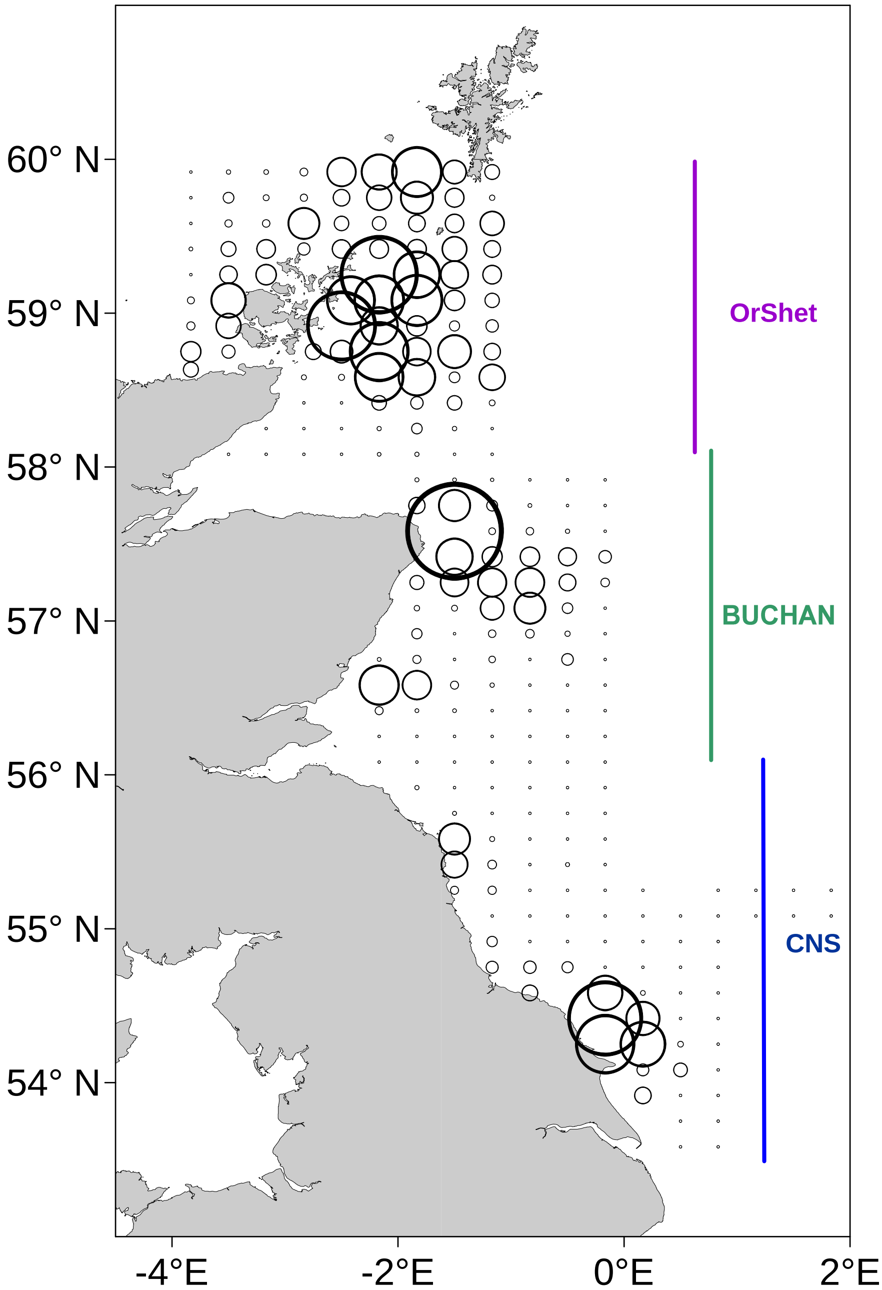


Figure 2.3.2.1: North Sea herring - Abundance of larvae < 10 mm (n/m²) in the Orkney, Buchan and Central North Sea as obtained from the International Herring Larvae Surveys in the second half of September 2015 (maximum circle size = 5 300 n/m²).

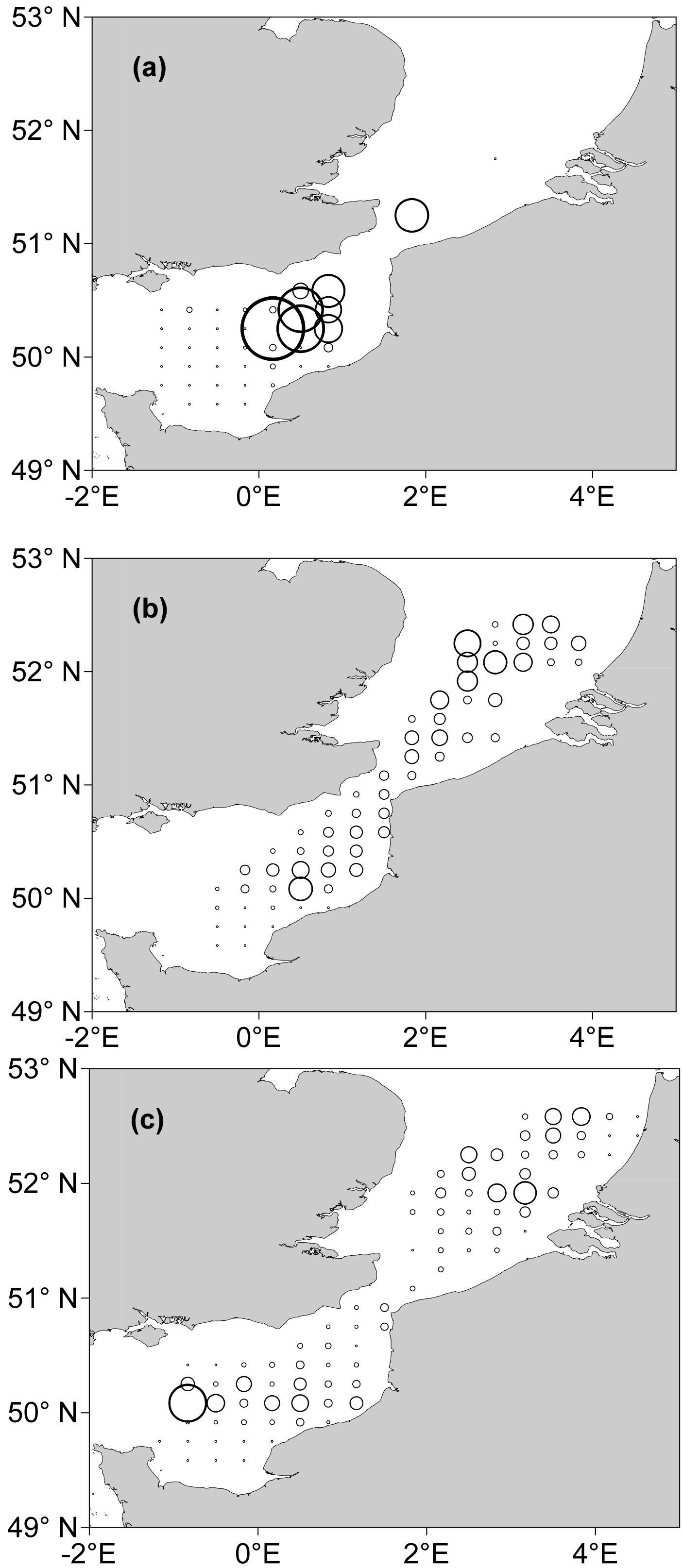


Figure 2.3.2.2 a-c: North Sea herring - Abundance of larvae < 11 mm (n/m²) in the southern North Sea as obtained from the International Herring Larvae Survey in the second half of December 2015 (a) and in the first (b) and the second half (c) of January 2016 (maximum circle size = 1 600 n/m²).

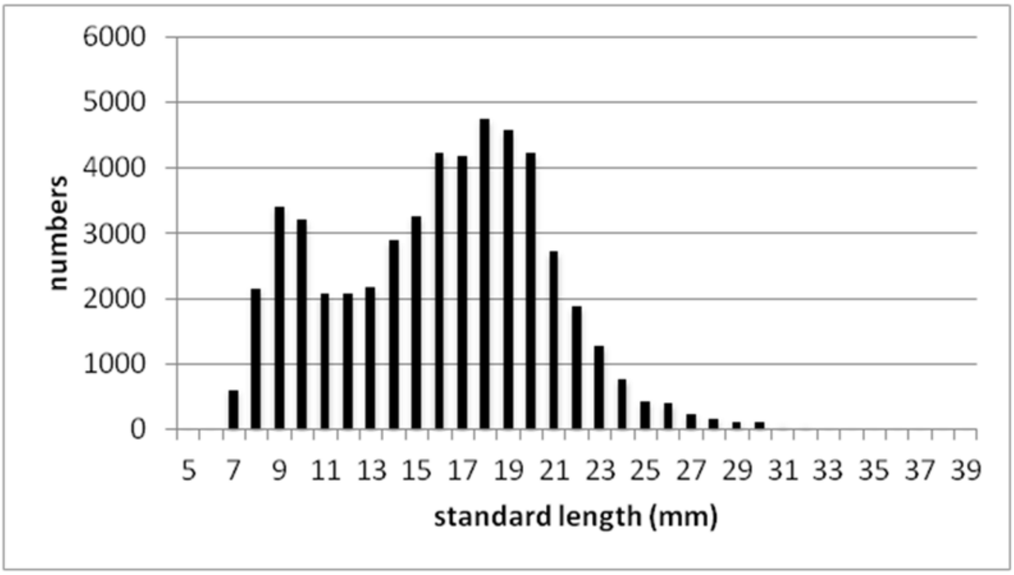


Figure 2.3.3.1. North Sea herring. Length distribution of all herring larvae caught during the 2016 Q1 IBTS.

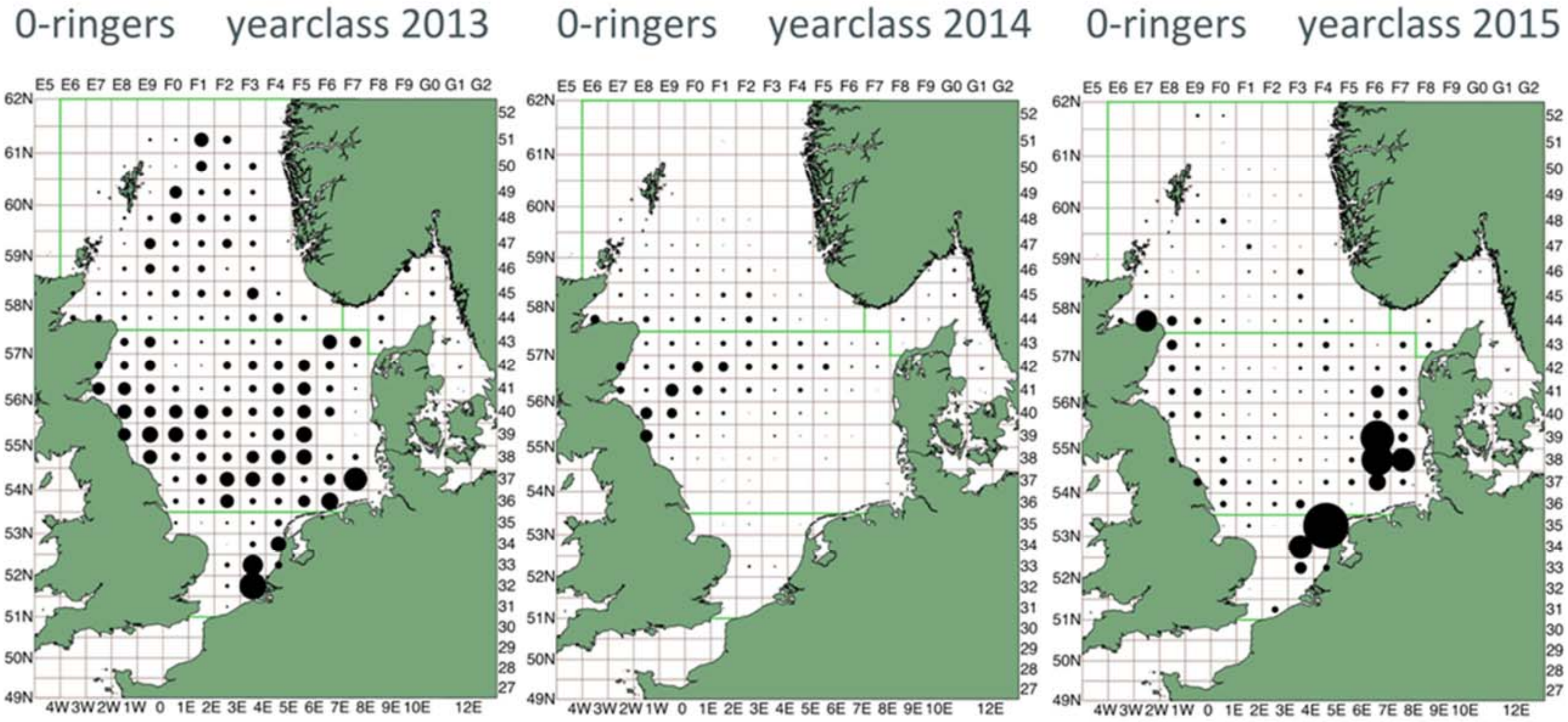


Figure 2.3.3.2. North Sea herring. Distribution of 0-ringer herring, year classes 2013-2015. Density estimates of 0-ringers within each statistical rectangle are based on MIK catches during IBTS in January/February 2014-2016. Areas of filled circles illustrate densities in no m^{-2}, the area of the largest circle represents a density of 7.59 m^{-2}. All circles are scaled to the same order of magnitude of the square root transformed densities.

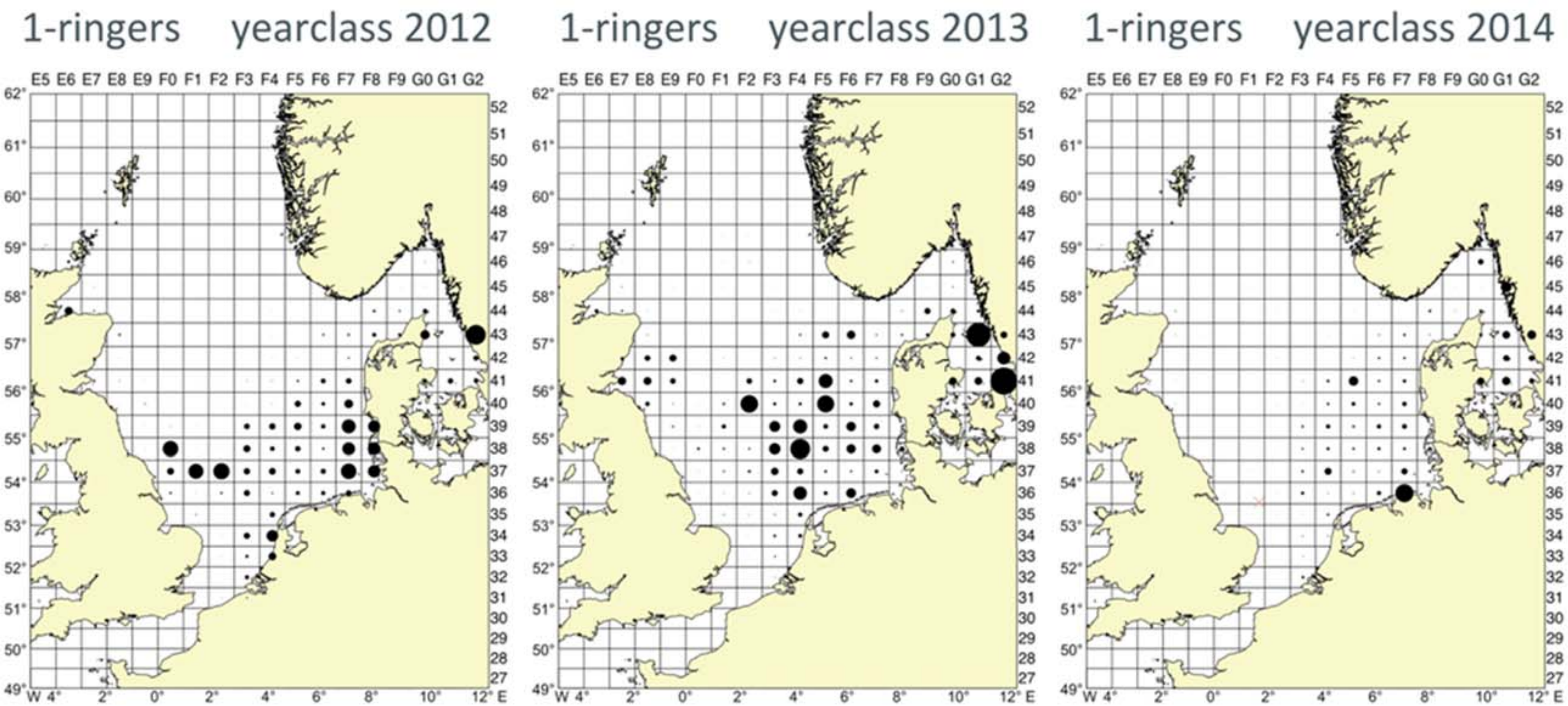
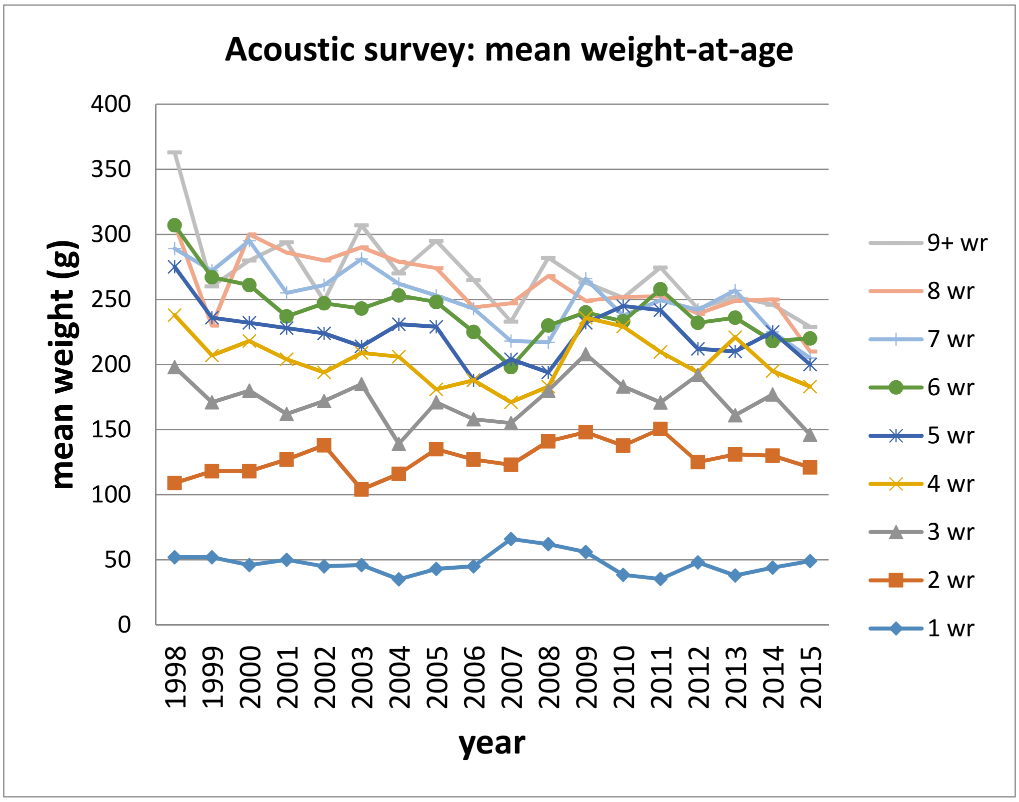


Figure 2.3.3.3. North Sea herring. Distribution of 1-ringer herring, year classes 2012-2014. Density estimates of 1-ringers within each statistical rectangle are based on GOV catches during IBTS in January/February 2014-2016. Areas of filled circles illustrate numbers per hour, scaled proportionally to the square root transformed CPUE data, the area of a circle extending to the border of a rectangle represents 45000 h^{-1}.



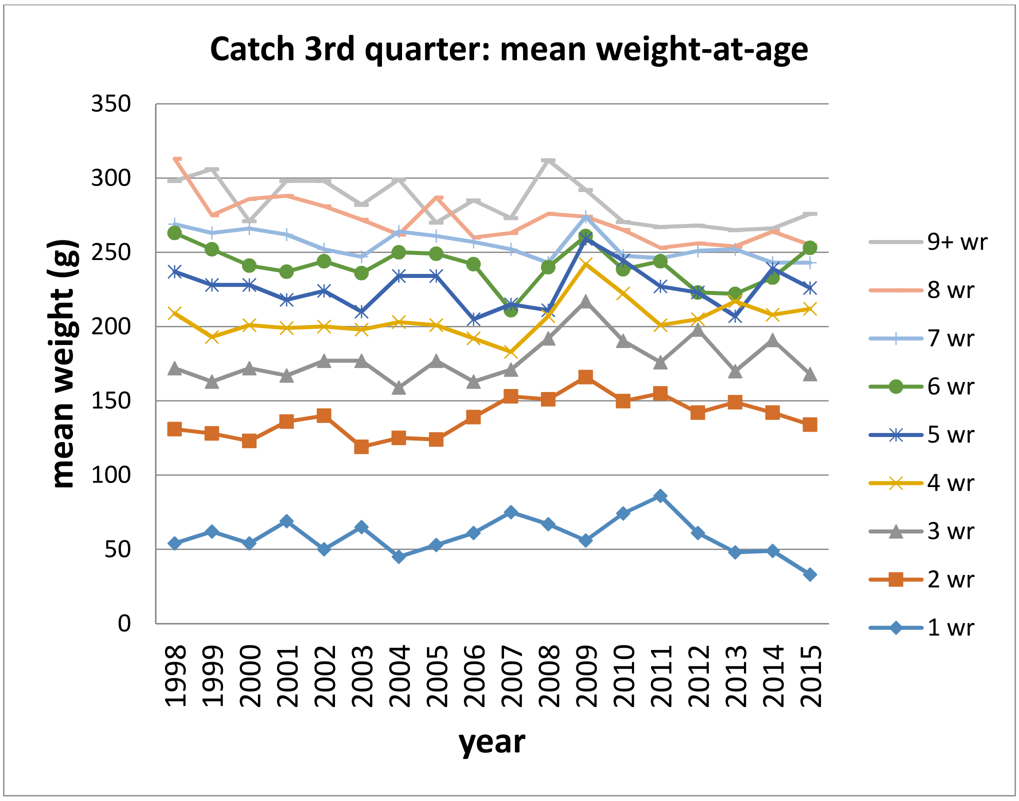


Figure 2.4.1.1. North Sea Herring. Mean weights-at-age for the 3rd quarter in Divisions 4 and 3.a from the acoustic survey (upper panel) and mean weights-in-the-catch (lower panel) for comparison.

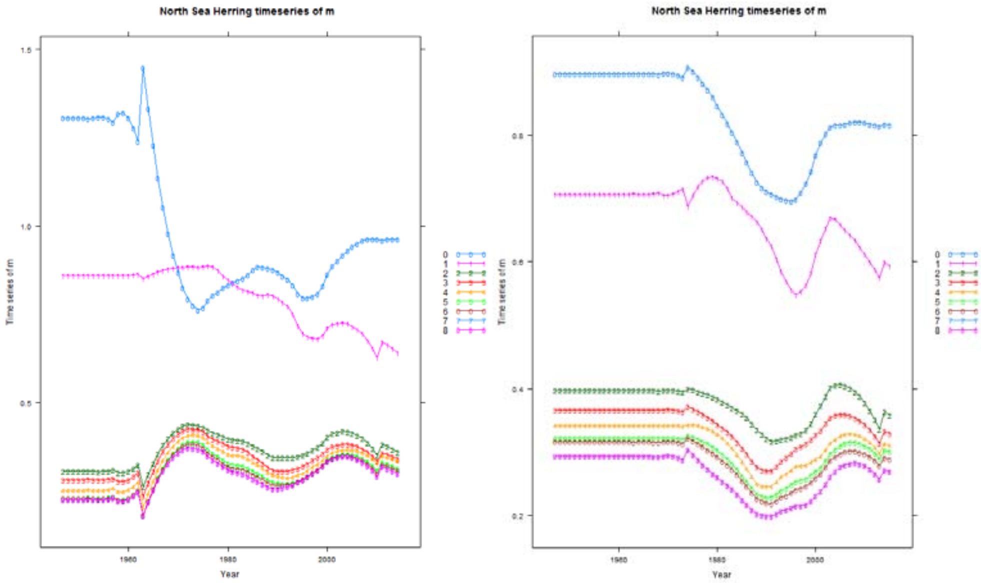


Figure 2.4.3.1. North Sea Herring. Time series of smoothed time varying absolute natural mortality values at age 0-8+ as used in the North Sea herring assessments. Left panel: Smoothed time varying natural mortality estimates at age for North Sea herring derived from the SMS model 2011 North Sea key-run for the time period 1963–2010 as used in the assessment up to 2015 (WGSAM 2011). Right panel: Natural mortality values based on the 2015 North Sea key-run for the time period 1974–2014 as used in the assessment in 2016 (WGSAM 2015). Note differing scale between the two panels.

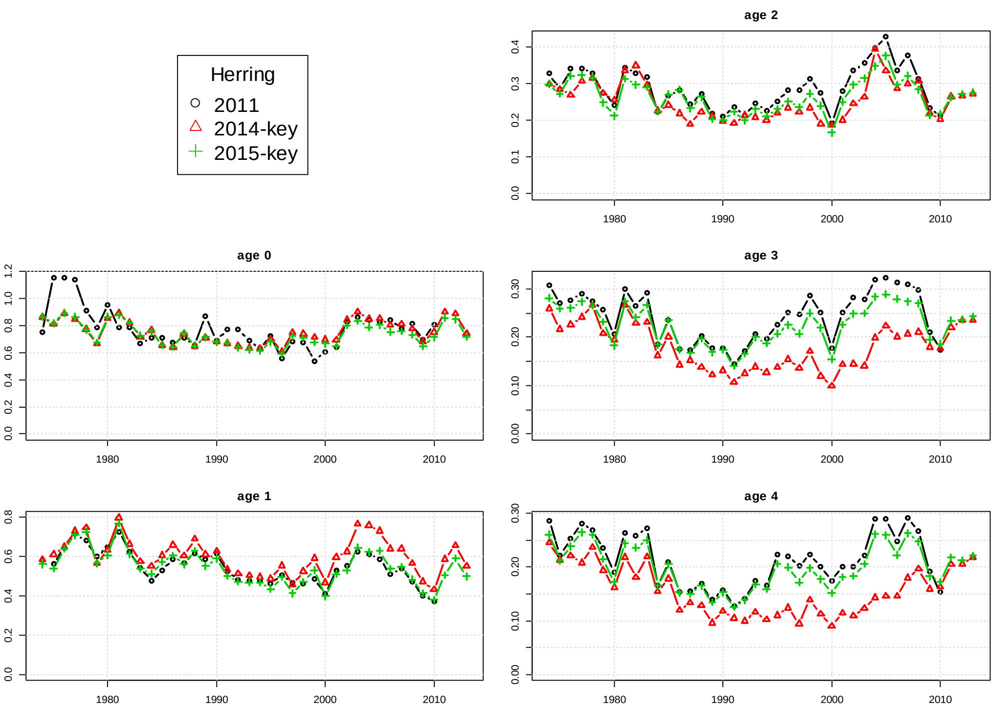


Figure 2.4.3.1.1 North Sea Herring. Comparison of 2011, 2014 and 2015 SMS North Sea key runs for herring natural mortalities (WGSAM 2014, 2015). The 2014 key run has not been used in North Sea herring assessments as an error was discovered by WGSAM before its inclusion in assessments.

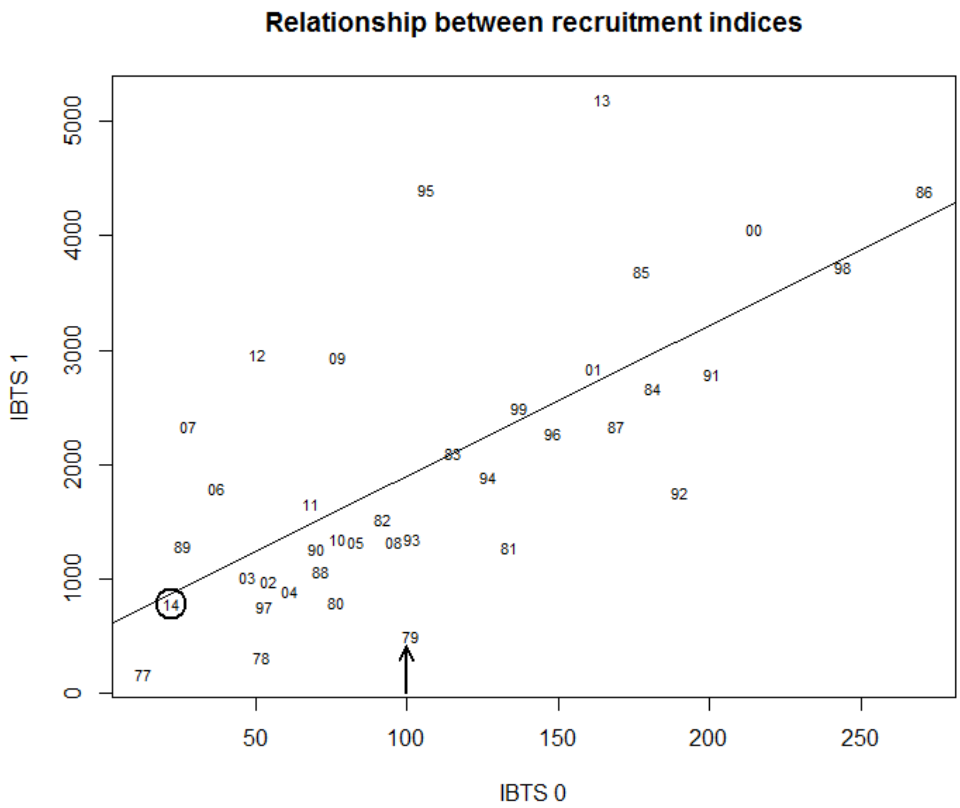


Figure 2.5.1. North Sea herring. Relationship between indices of 0-ringers and 1-ringers for year classes 1977 to 2015. The 2014 year class relation is circled; the present 0-ringer index for year class 2015 is indicated by an arrow.

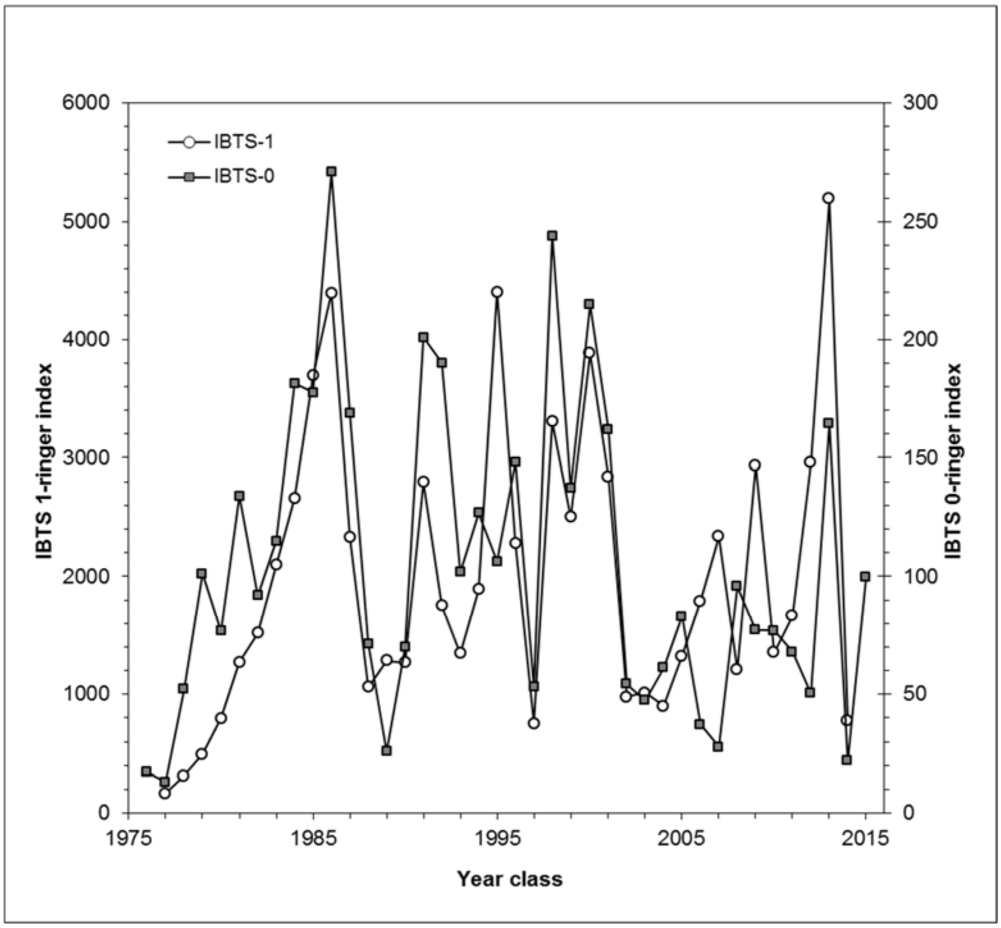


Figure 2.5.2 North Sea herring. Time series of 0-ringer and 1-ringer indices. Year classes 1976 to 2015 for 0-ringers, year classes 1977-2014 for 1-ringers.

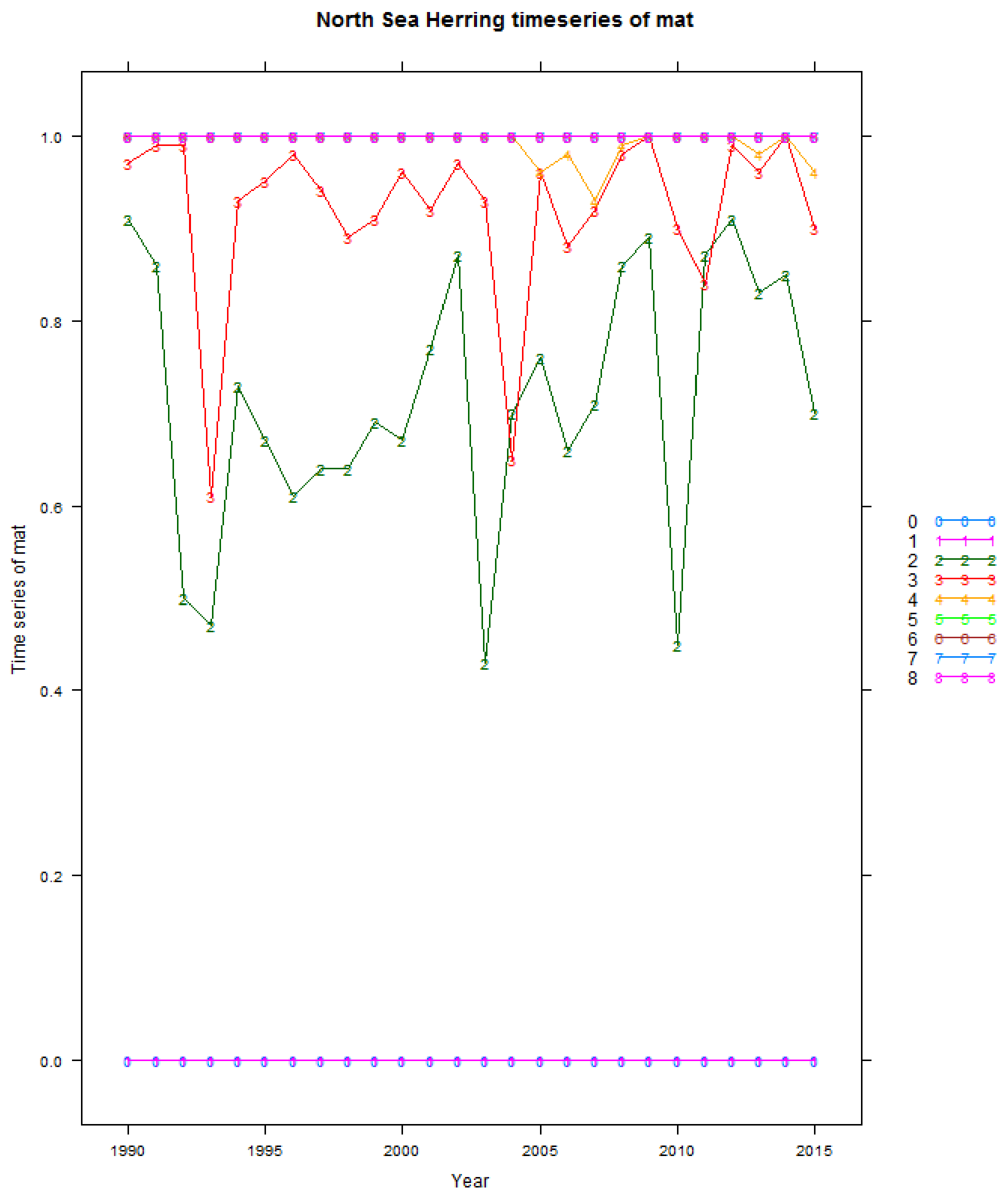


Figure 2.6.1.1 North Sea Herring. Time series of proportion mature at ages 0 to 8+ as used in the North Sea herring assessment.

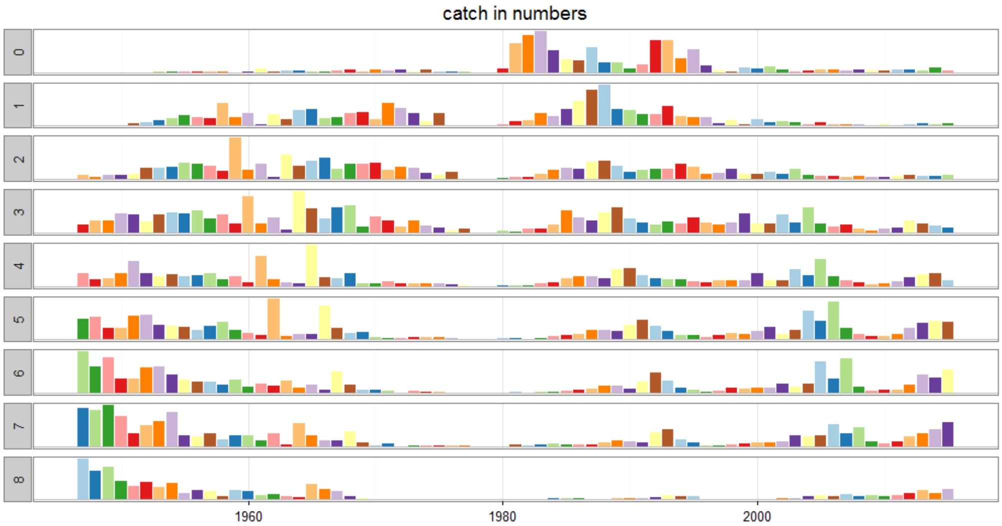


Figure 2.6.1.2. North Sea Herring. Time series of catch-at-age proportion at ages 0-8+ as used in the North Sea herring assessment. Colours indicate year-classes. All ages are scaled independently and cannot be compared between ages.

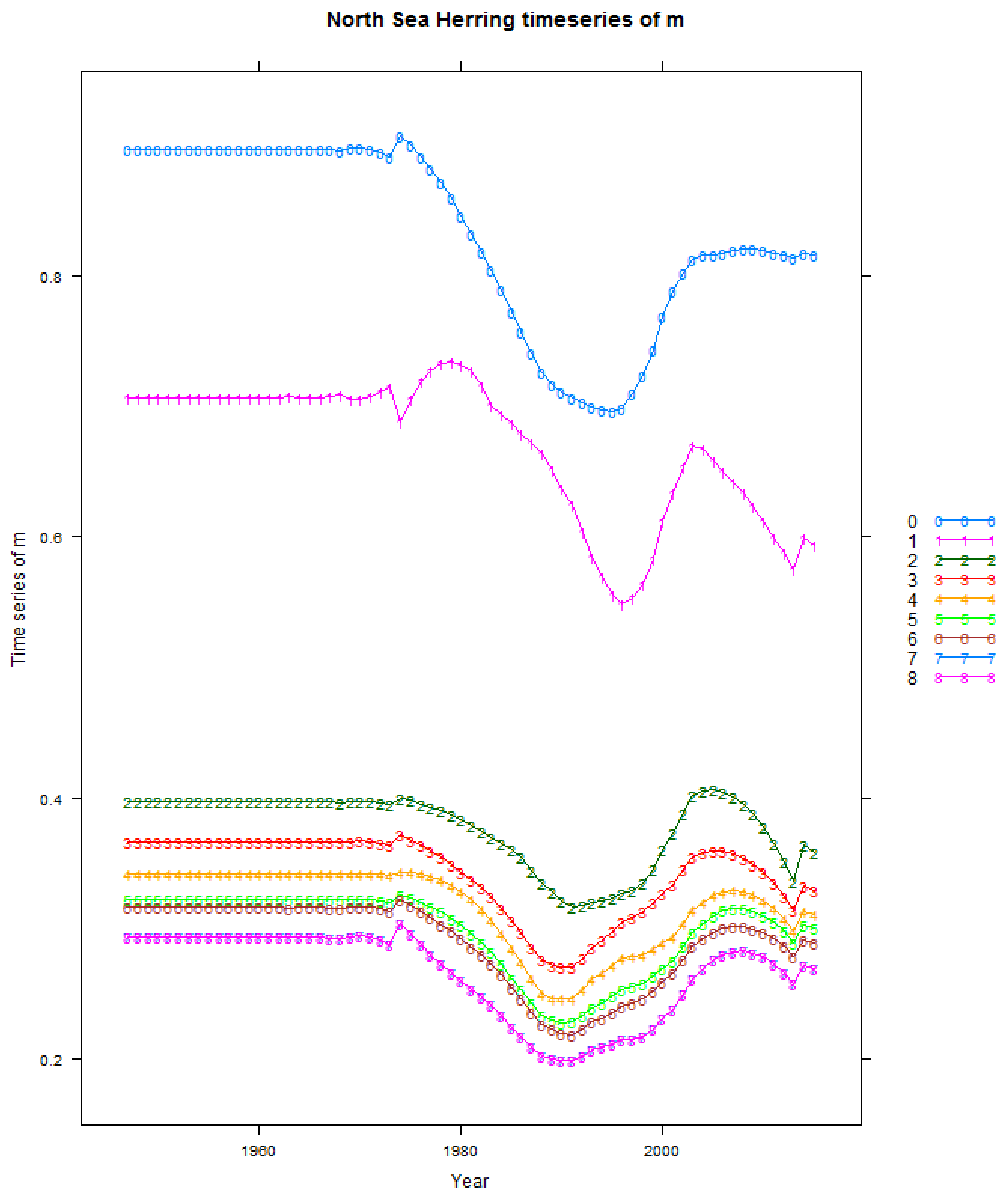


Figure 2.6.1.3. North Sea Herring. Time series of absolute natural mortality values at age 0-8+ as used in the North Sea herring assessment. Natural mortality values are based on the 2015 North Sea key-run (WGSAM 2015).

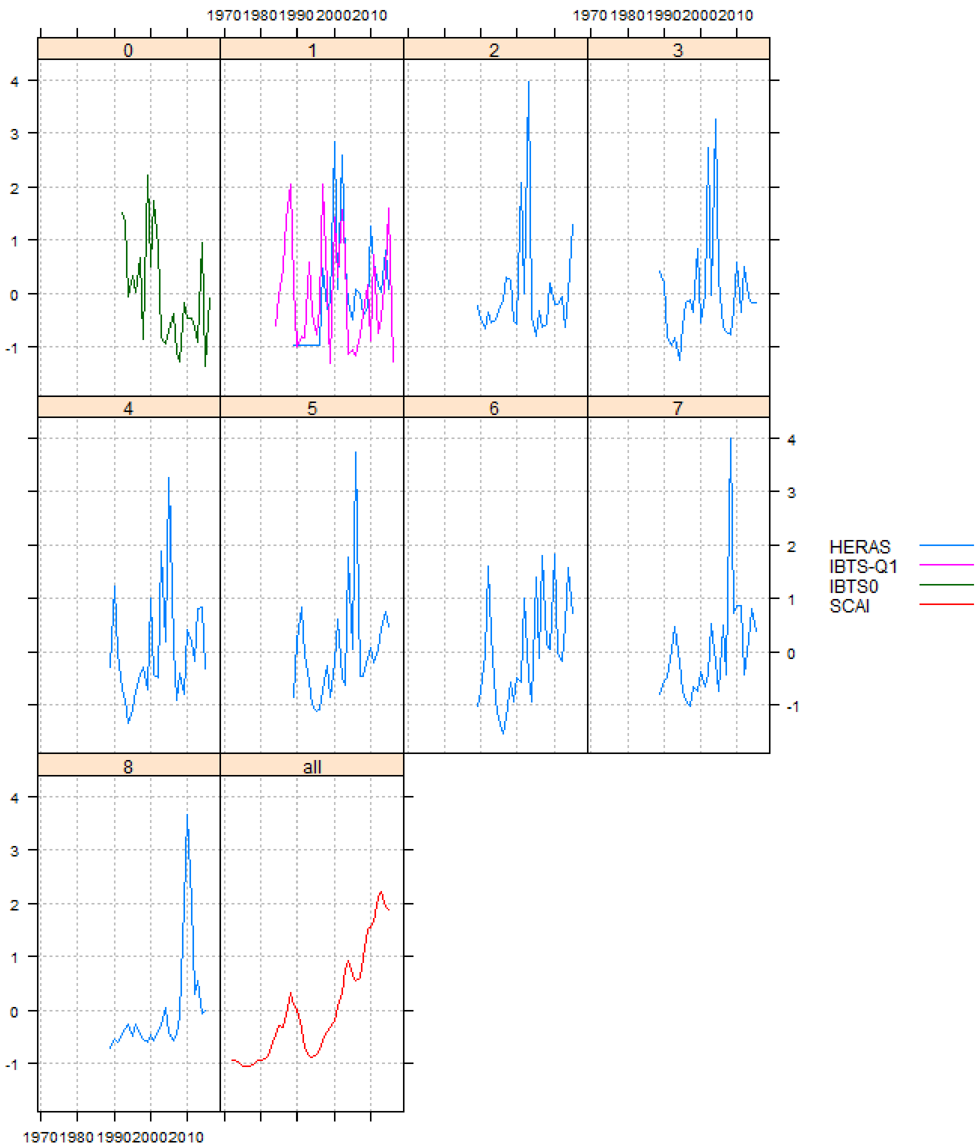


Figure 2.6.1.4. North Sea Herring. Time series of the standardized tuning series by ages 0-8+ (Acoustic survey: HERAS, IBTS quarter 1 survey: IBTS-Q1 and IBTS MIK net survey in quarter 1: IBTS0) and SSB tuning series (IHLS survey: SCAI).

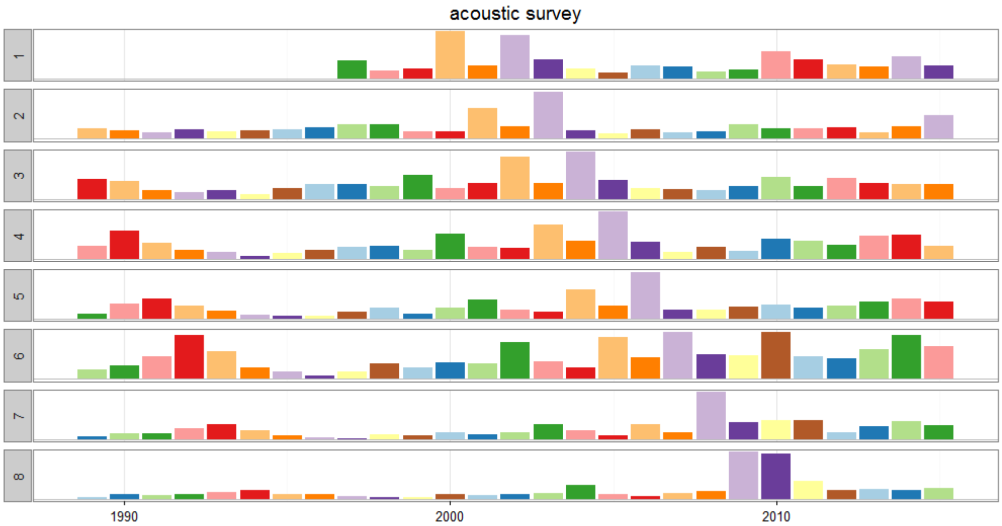


Figure 2.6.1.4b. North Sea Herring. Time series of the HERAS acoustic index by age 0-8+. Colours indicate year-classes. All ages are scaled independently and cannot be compared between ages.

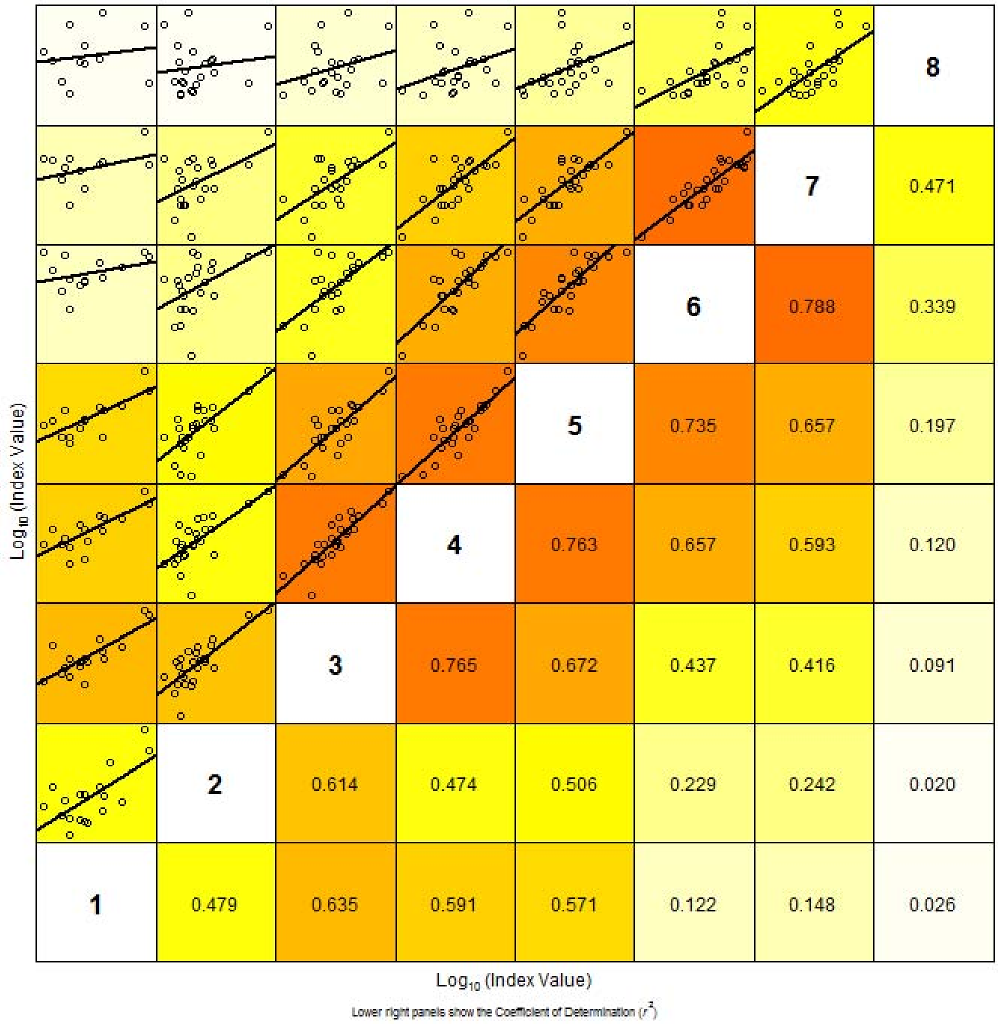


Figure 2.6.1.5. North Sea herring. Internal consistency plot of the acoustic survey (HERAS). Above the diagonal the linear regression is shown including the observations (in points) while under the diagonal the r^2 value that is associated with the linear regression is given.

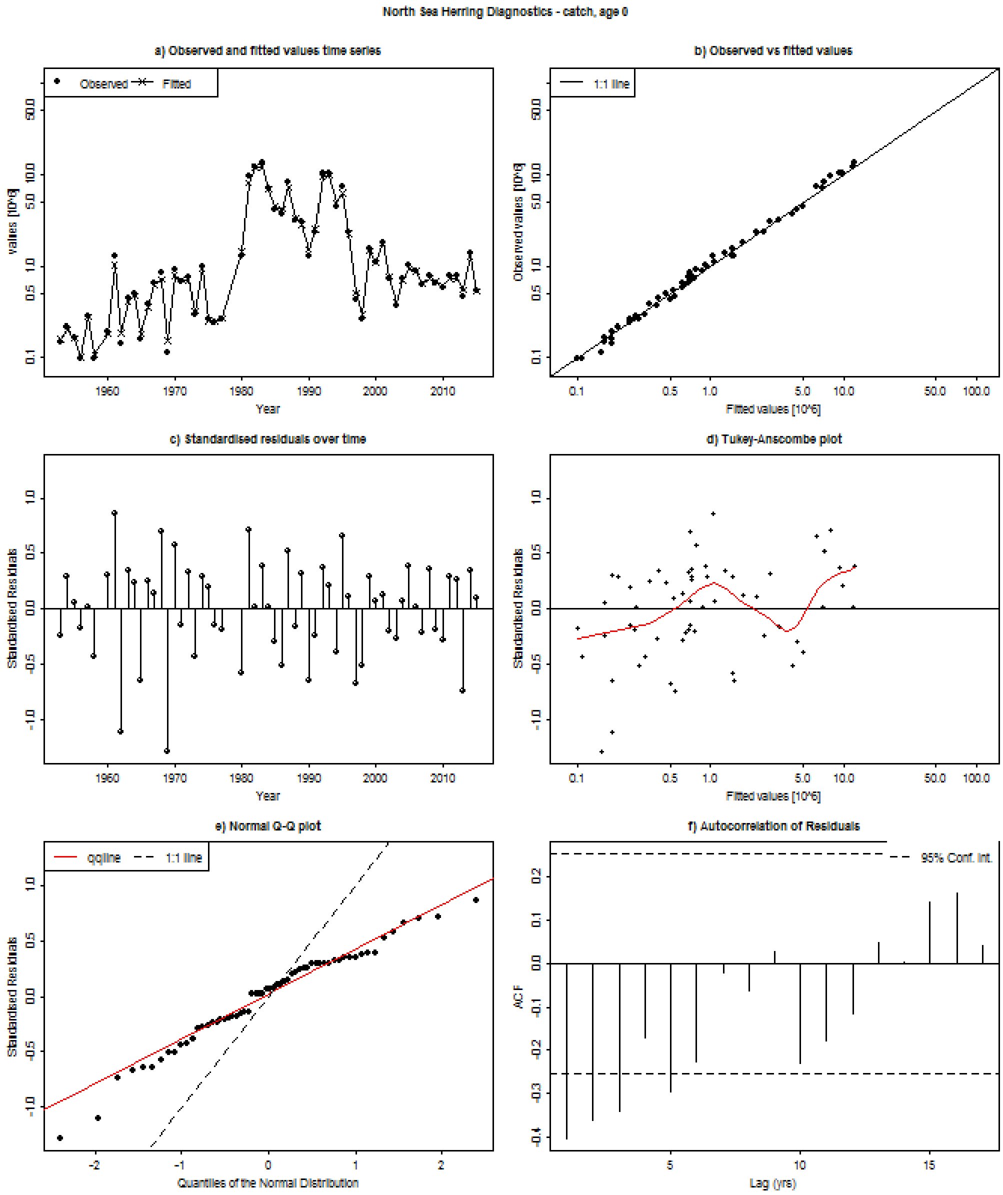


Figure 2.6.1.6 North Sea herring. Diagnostics of the assessment model fit to the catch at age 0 time series. Top left: Estimates of numbers at 0 wr (line) and numbers predicted from catch abundance at 0 wr. Top right: scatterplot of catch observations versus assessment model estimates of numbers at 0 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.

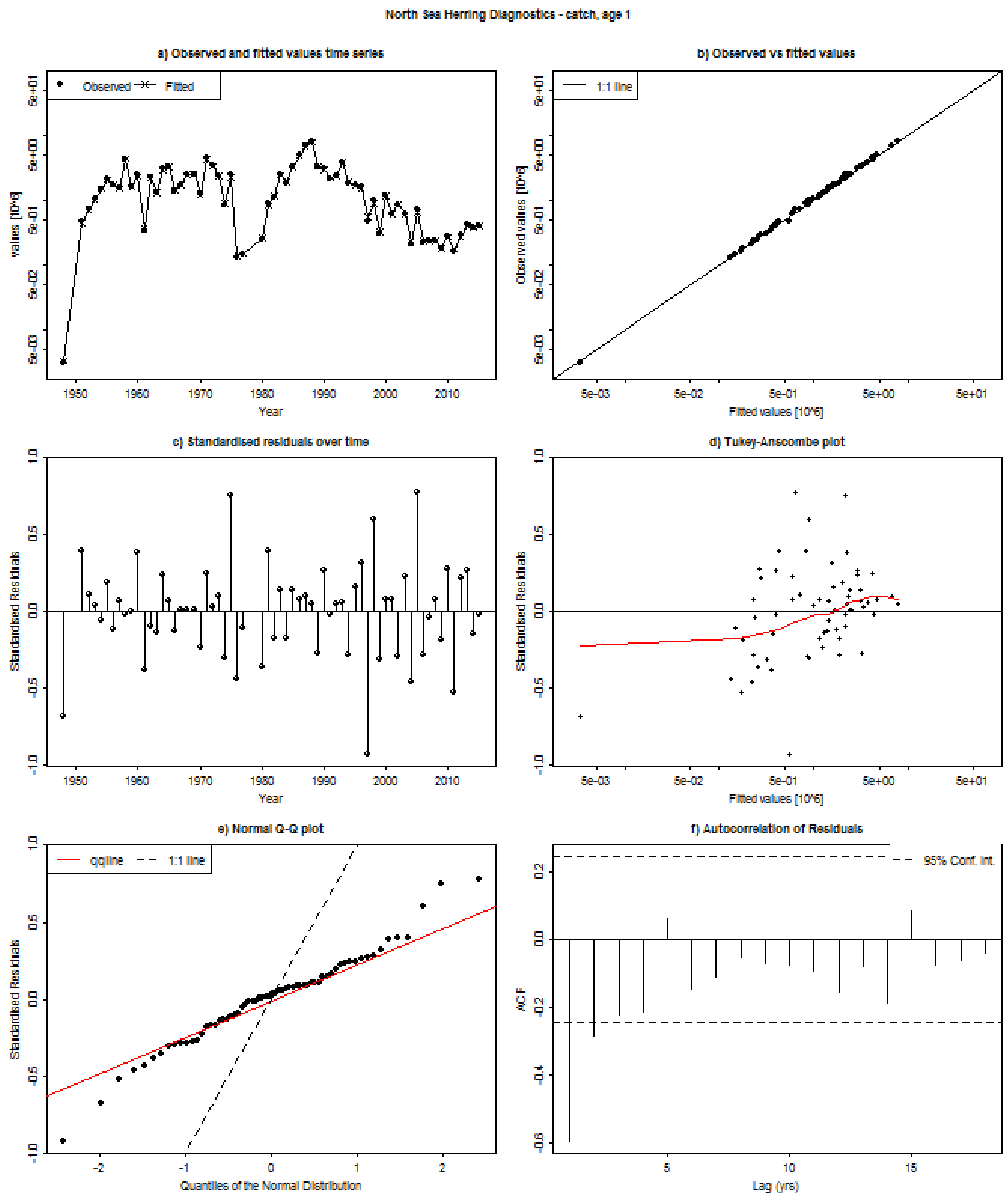


Figure 2.6.1.7 North Sea herring. Diagnostics of the assessment model fit to the catch at age 1 time series. Top left: Estimates of numbers at 1 wr (line) and numbers predicted from catch abundance at 1 wr. Top right: scatterplot of catch observations versus assessment model estimates of numbers at 1 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.

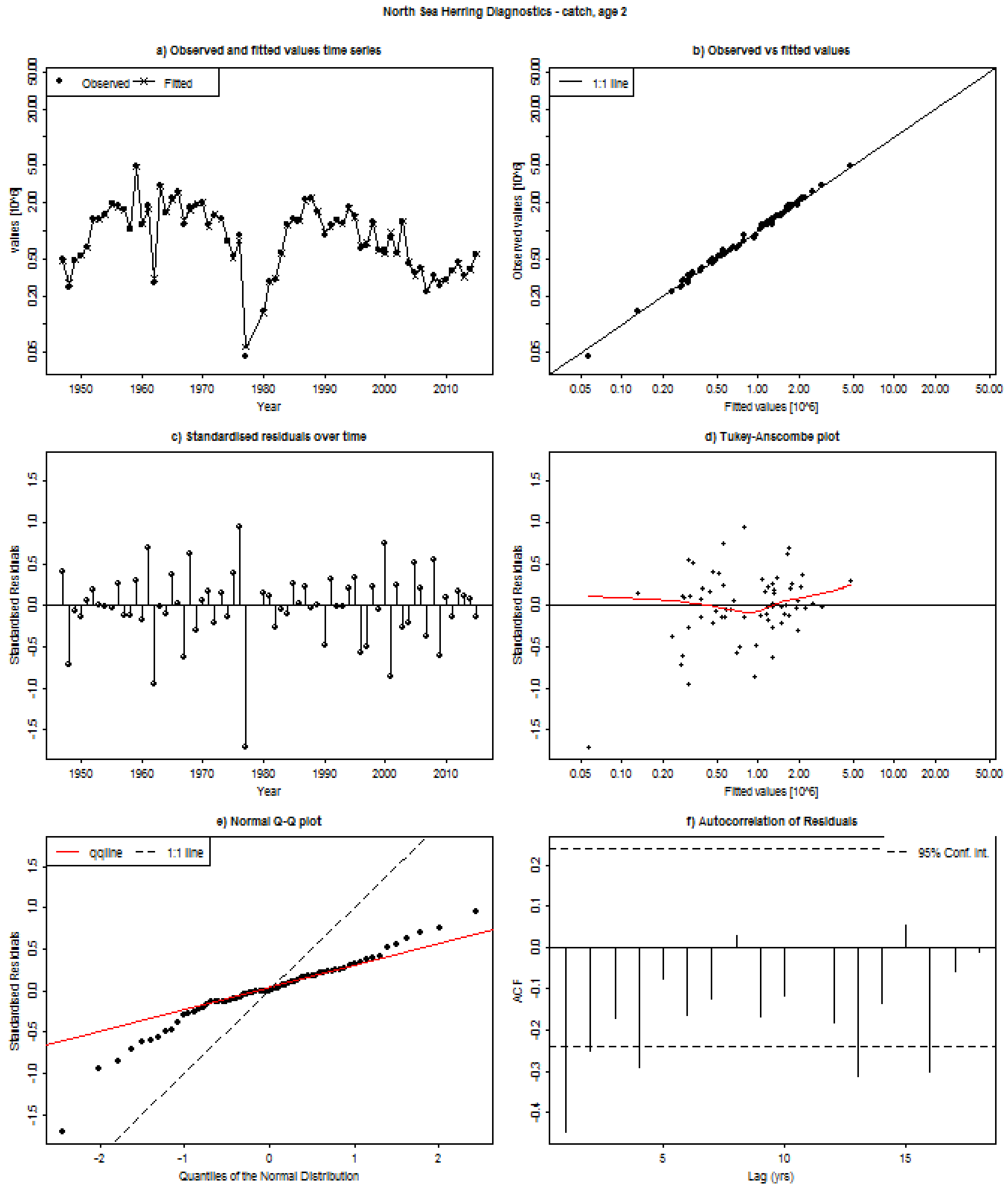


Figure 2.6.1.8 North Sea herring. Diagnostics of the assessment model fit to the catch at age 2 time series. Top left: Estimates of numbers at 2 wr (line) and numbers predicted from catch abundance at 2 wr. Top right: scatterplot of catch observations versus assessment model estimates of numbers at 2 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.

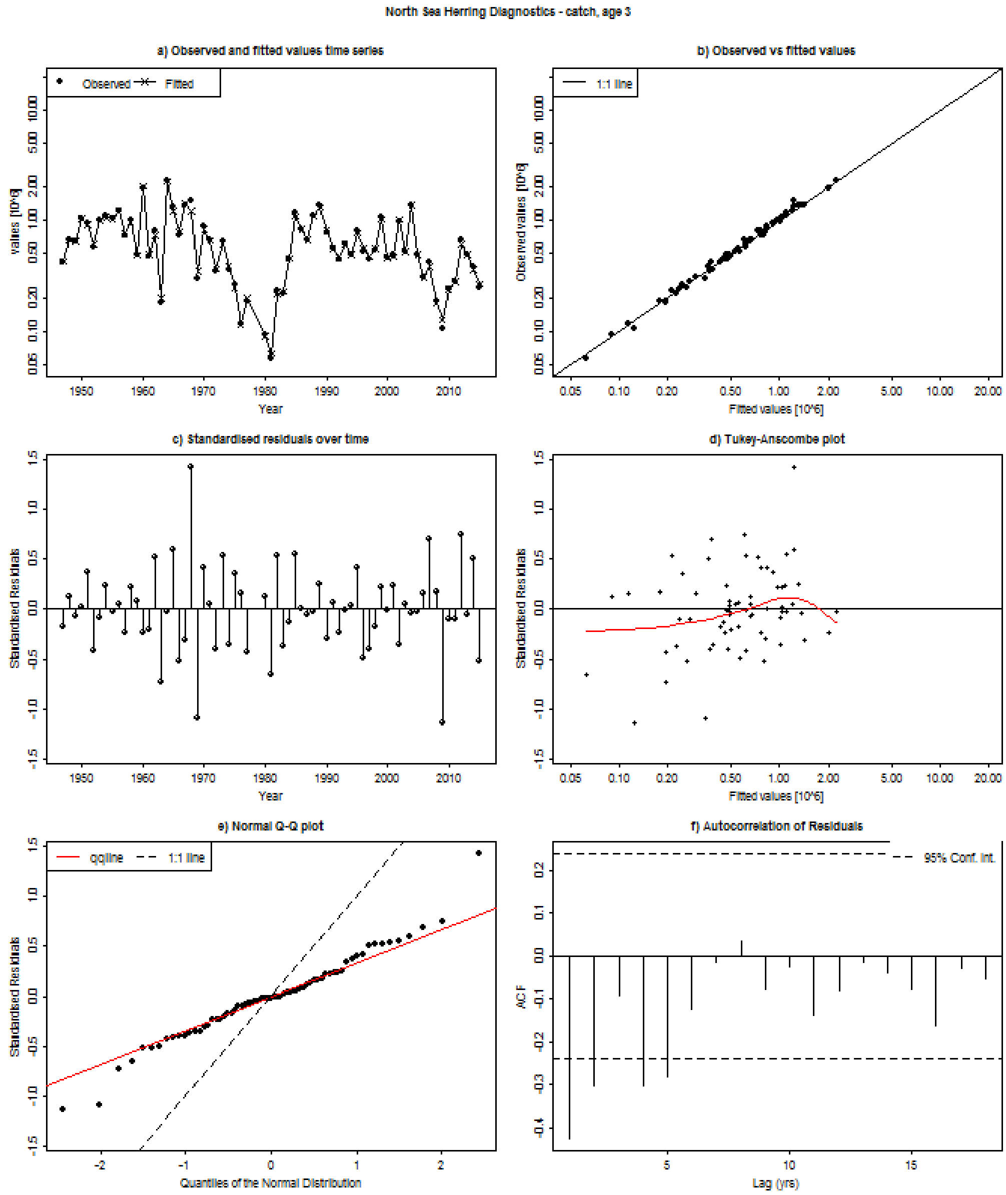


Figure 2.6.1.9 North Sea herring. Diagnostics of the assessment model fit to the catch at age 3 time series. Top left: Estimates of numbers at 3 wr (line) and numbers predicted from catch abundance at 3 wr. Top right: scatterplot of catch observations versus assessment model estimates of numbers at 3 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.

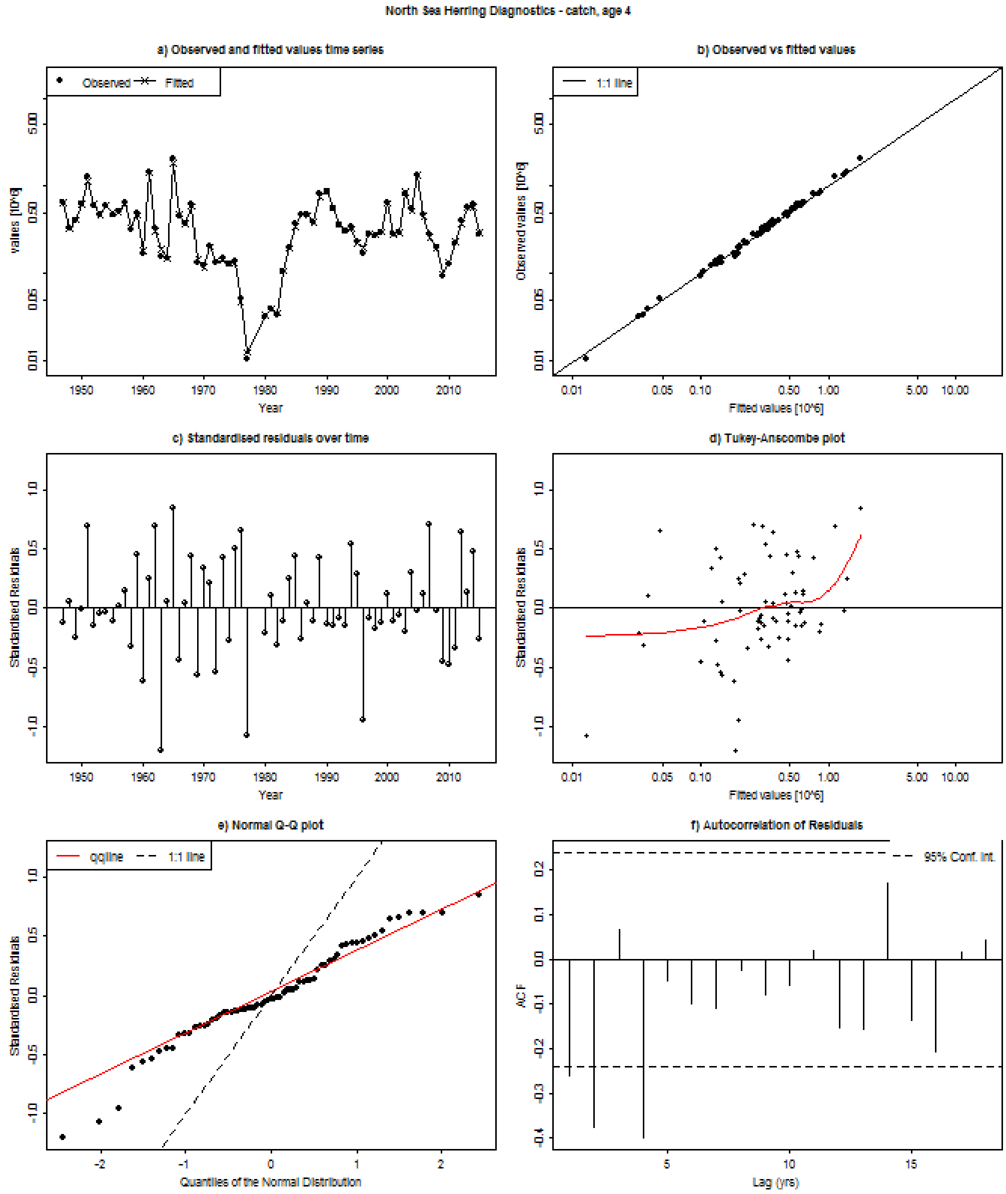


Figure 2.6.1.10 North Sea herring. Diagnostics of the assessment model fit to the catch at age 4 time series. Top left: Estimates of numbers at 4 wr (line) and numbers predicted from catch abundance at 4 wr. Top right: scatterplot of catch observations versus assessment model estimates of numbers at 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.

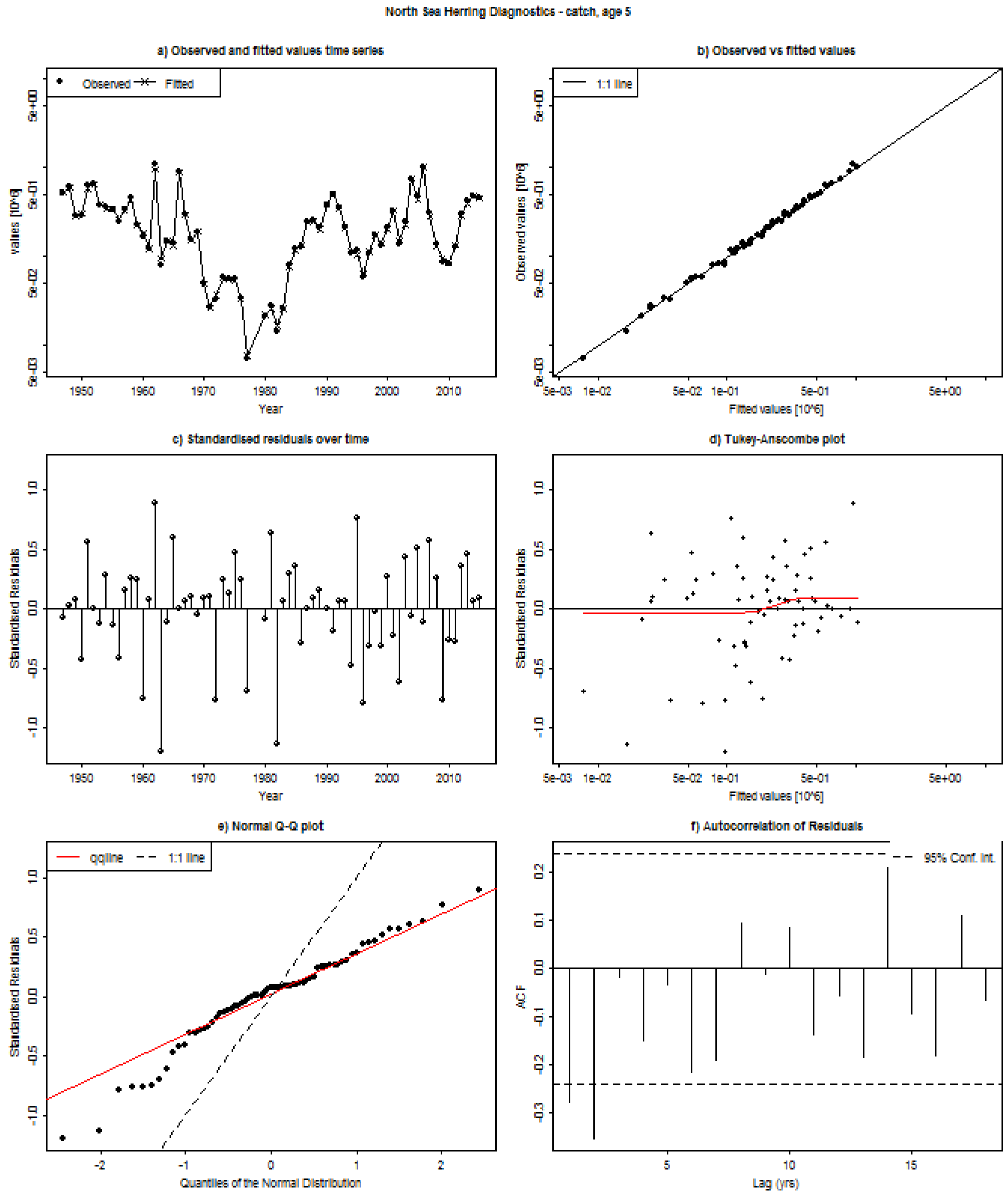


Figure 2.6.1.11 North Sea herring. Diagnostics of the assessment model fit to the catch at age 5 time series. Top left: Estimates of numbers at 5 wr (line) and numbers predicted from catch abundance at 5 wr. Top right: scatterplot of catch observations versus assessment model estimates of numbers at 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.

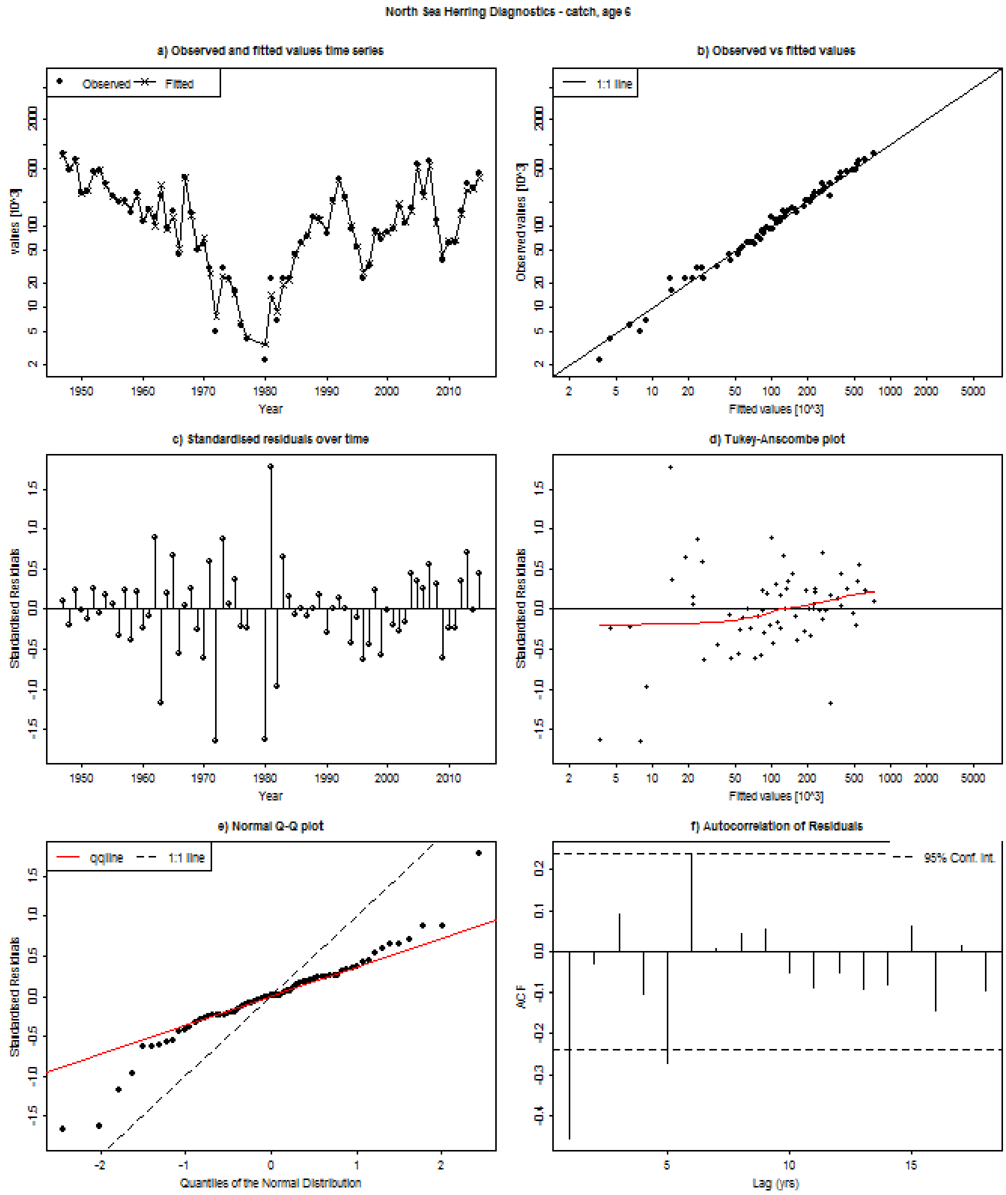


Figure 2.6.1.12 North Sea herring. Diagnostics of the assessment model fit to the catch at age 6 time series. Top left: Estimates of numbers at 6 wr (line) and numbers predicted from catch abundance at 6 wr. Top right: scatterplot of catch observations versus assessment model estimates of numbers at 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.

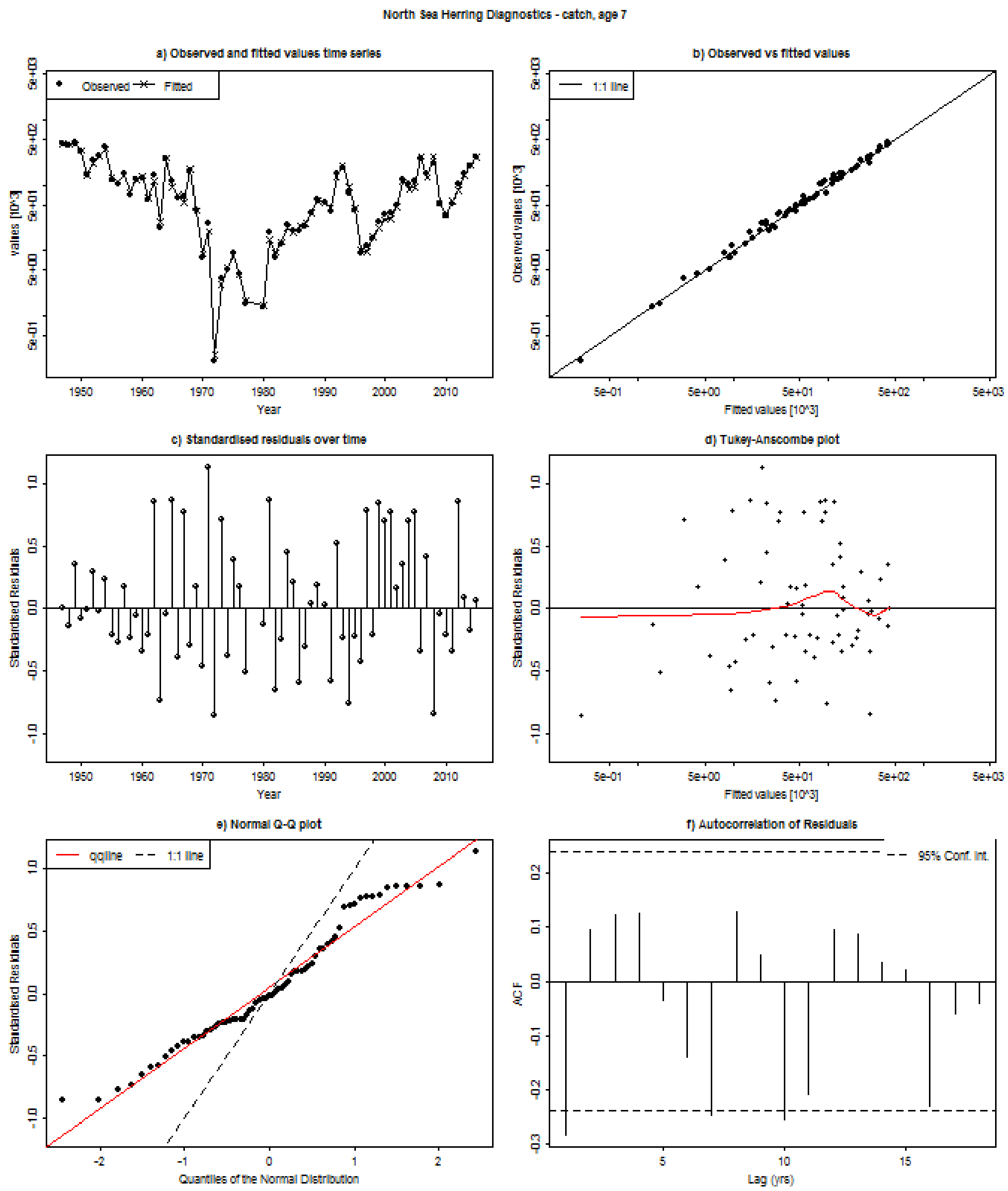


Figure 2.6.1.13 North Sea herring. Diagnostics of the assessment model fit to the catch at age 7 time series. Top left: Estimates of numbers at 7 wr (line) and numbers predicted from catch abundance at 7 wr. Top right: scatterplot of catch observations versus assessment model estimates of numbers at 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.

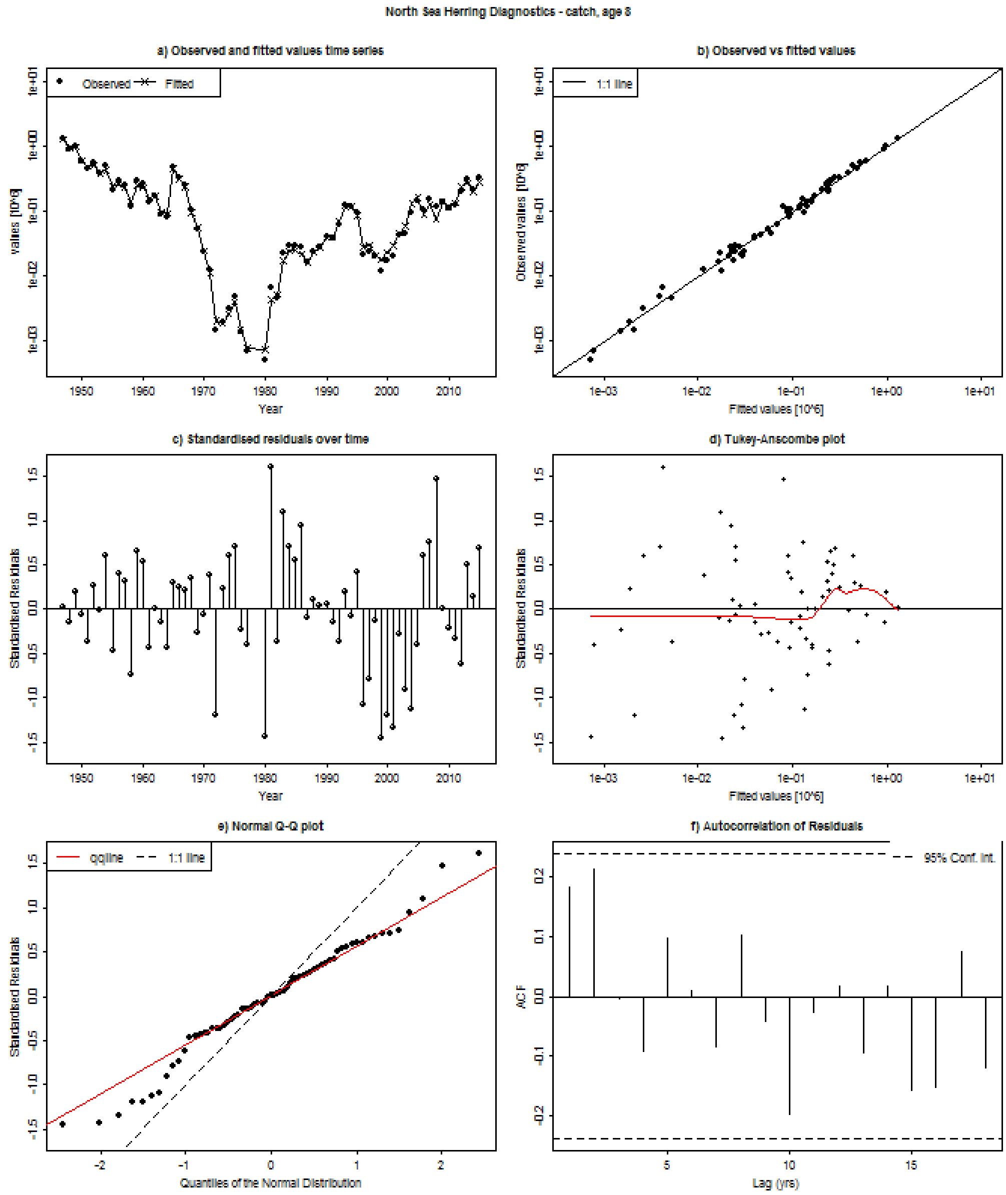


Figure 2.6.1.14. North Sea herring. Diagnostics of the assessment model fit to the catch at age 8+ time series. Top left: Estimates of numbers at 8+ wr (line) and numbers predicted from catch abundance at 8+ wr. Top right: scatterplot of catch observations versus assessment model estimates of numbers 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.

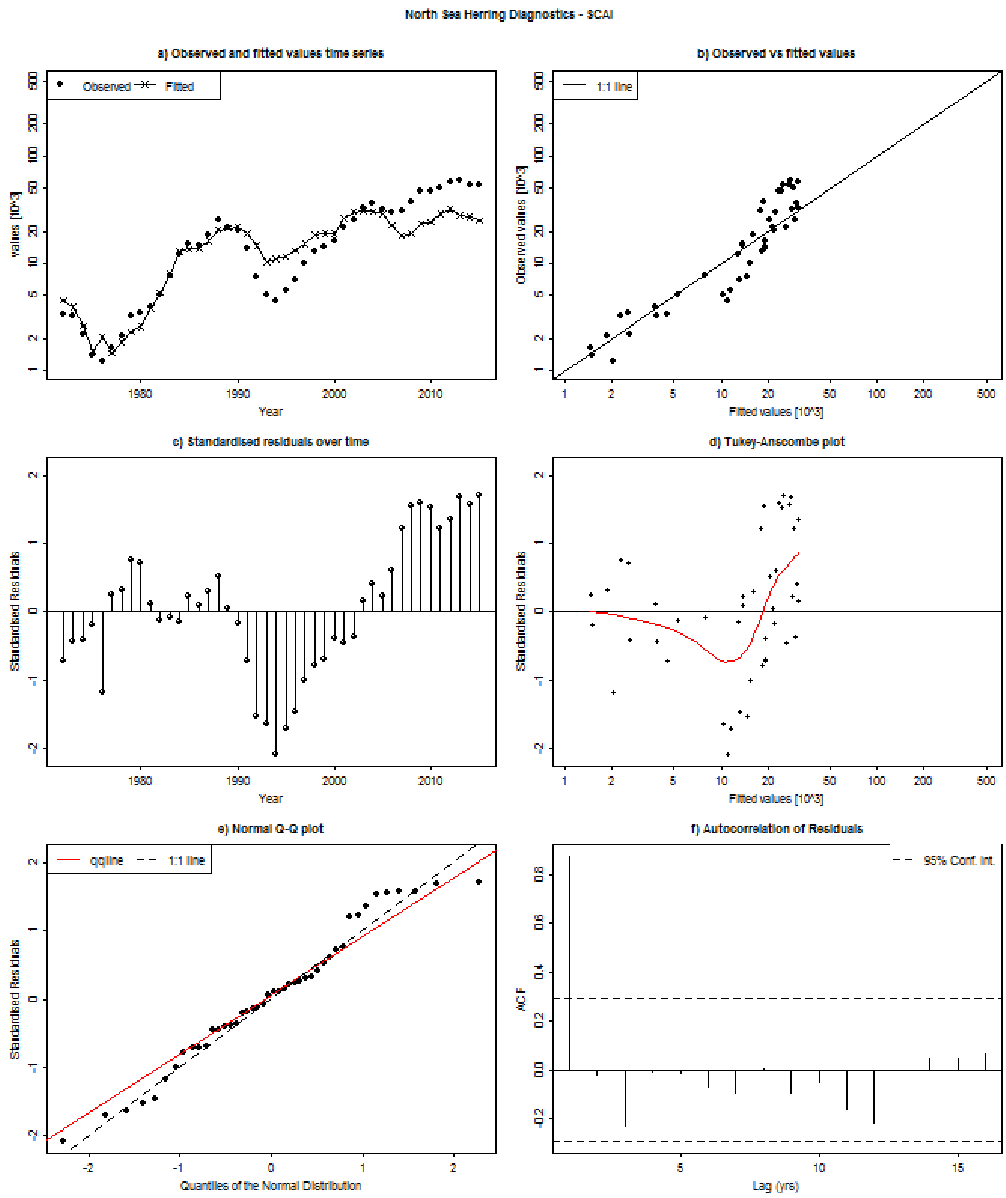


Figure 2.6.1.15. North Sea herring. Diagnostics of the assessment model fit to the SCAI SSB index time series. Top left: Estimates of SSB (line) and SSB predicted from assessment model. Top right: scatterplot of SSB observations versus assessment model estimates with the best-fit catchability model (linear 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.

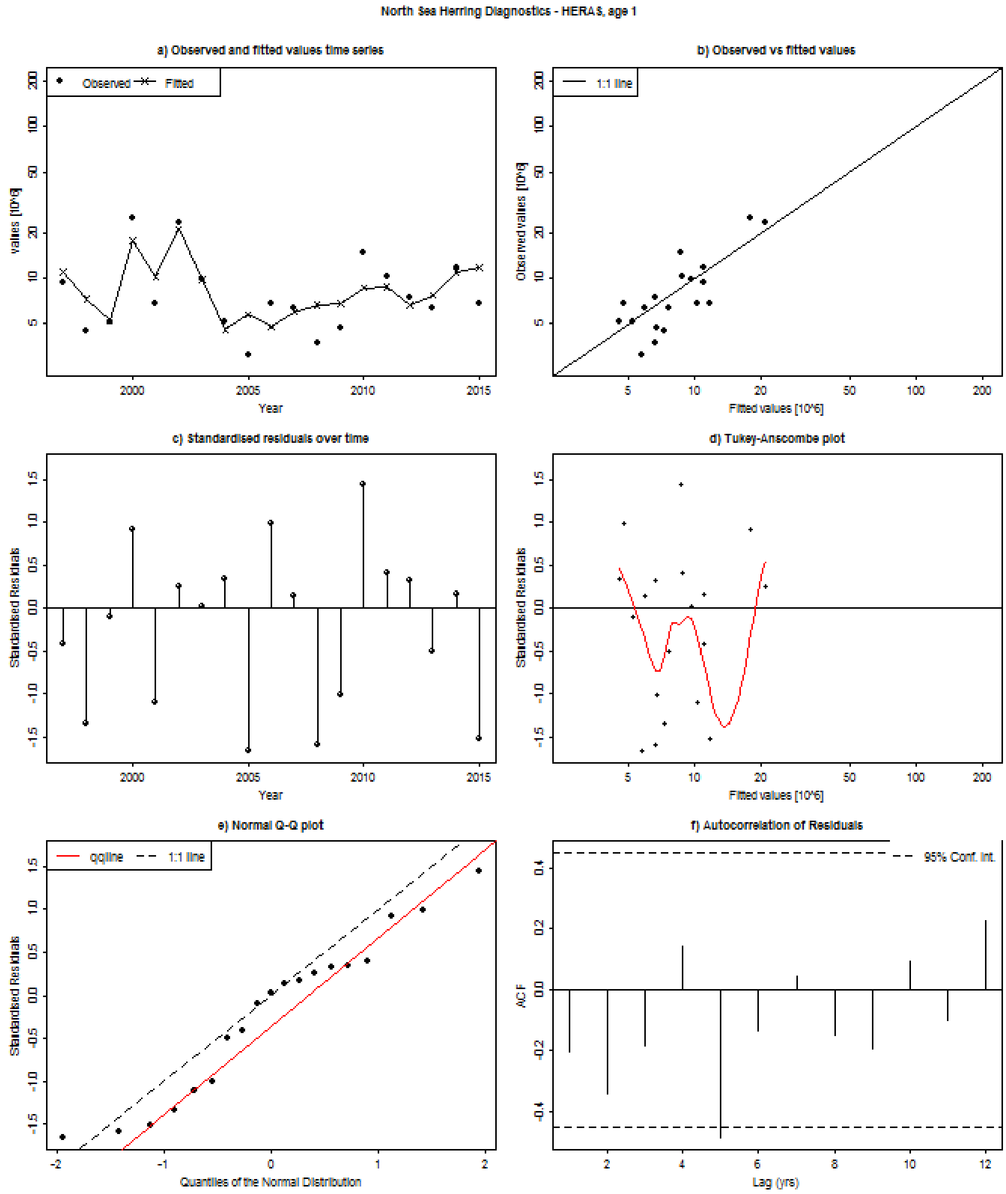


Figure 2.6.1.16. North Sea herring. Diagnostics of the assessment model fit to the HERAS index at age 1 wr time series. Top left: Estimates of numbers at 1 wr (line) and numbers predicted from index abundance at 1 wr. Top right: scatterplot of index observations versus assessment model estimates of numbers 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.

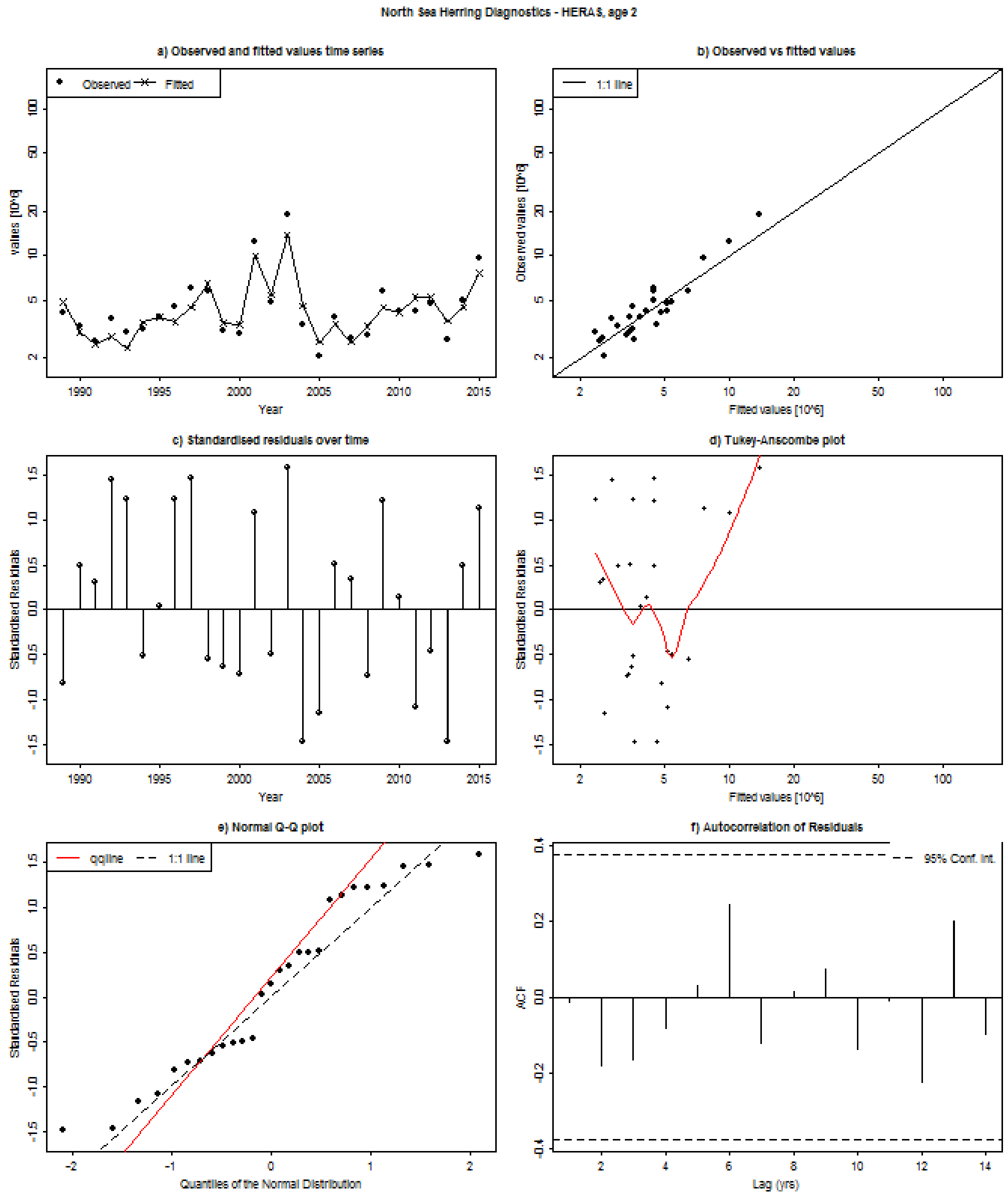


Figure 2.6.1.17. North Sea herring. Diagnostics of the assessment model fit to the HERAS index at age 2 wr time series. Top left: Estimates of numbers at 2 wr (line) and numbers predicted from index abundance at 2 wr. Top right: scatterplot of index observations versus assessment model estimates of numbers 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.

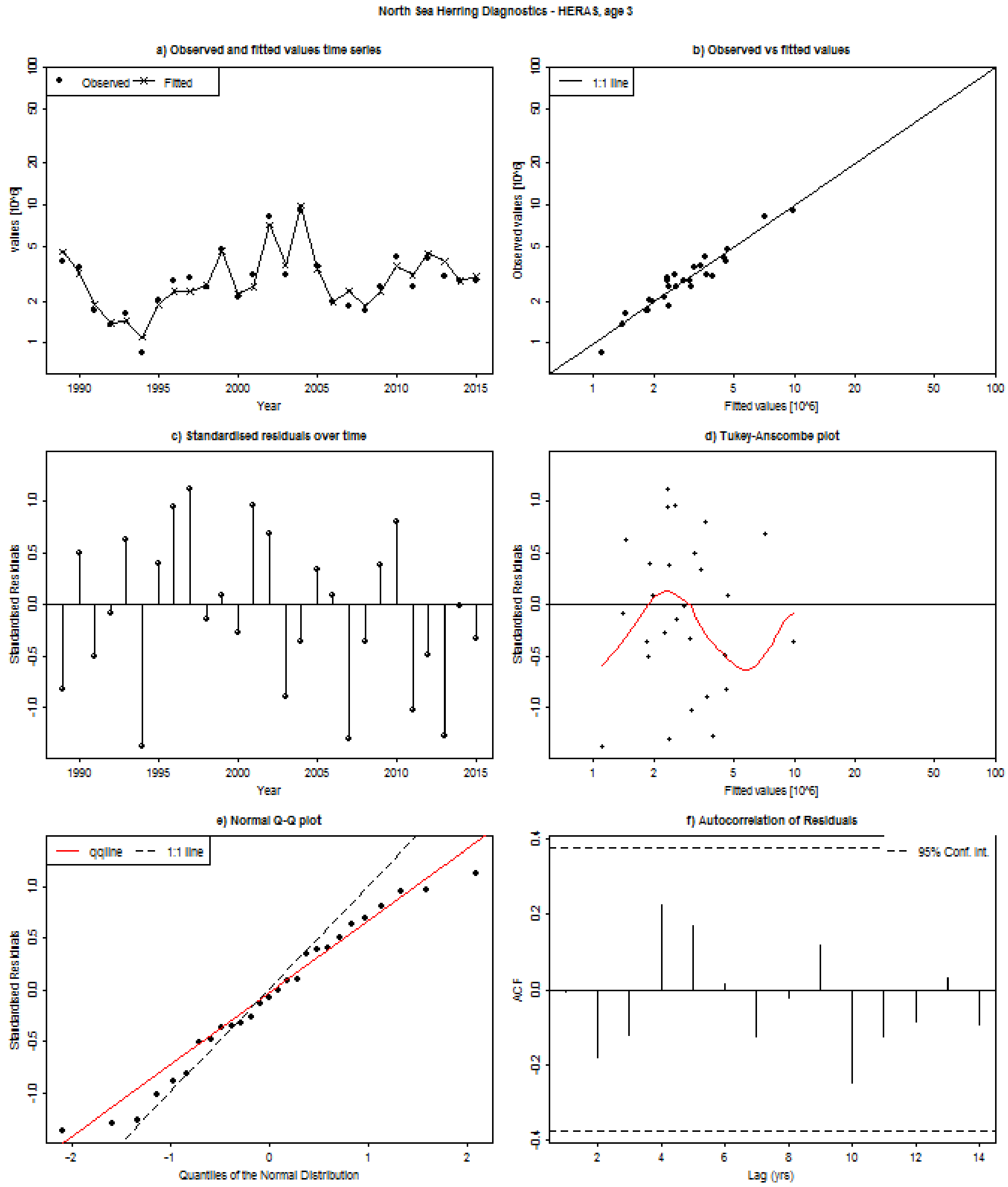


Figure 2.6.1.18. North Sea herring. Diagnostics of the assessment model fit to the HERAS index at age 3 wr time series. Top left: Estimates of numbers at 3 wr (line) and numbers predicted from index abundance at 3 wr. Top right: scatterplot of index observations versus assessment model estimates of numbers 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.

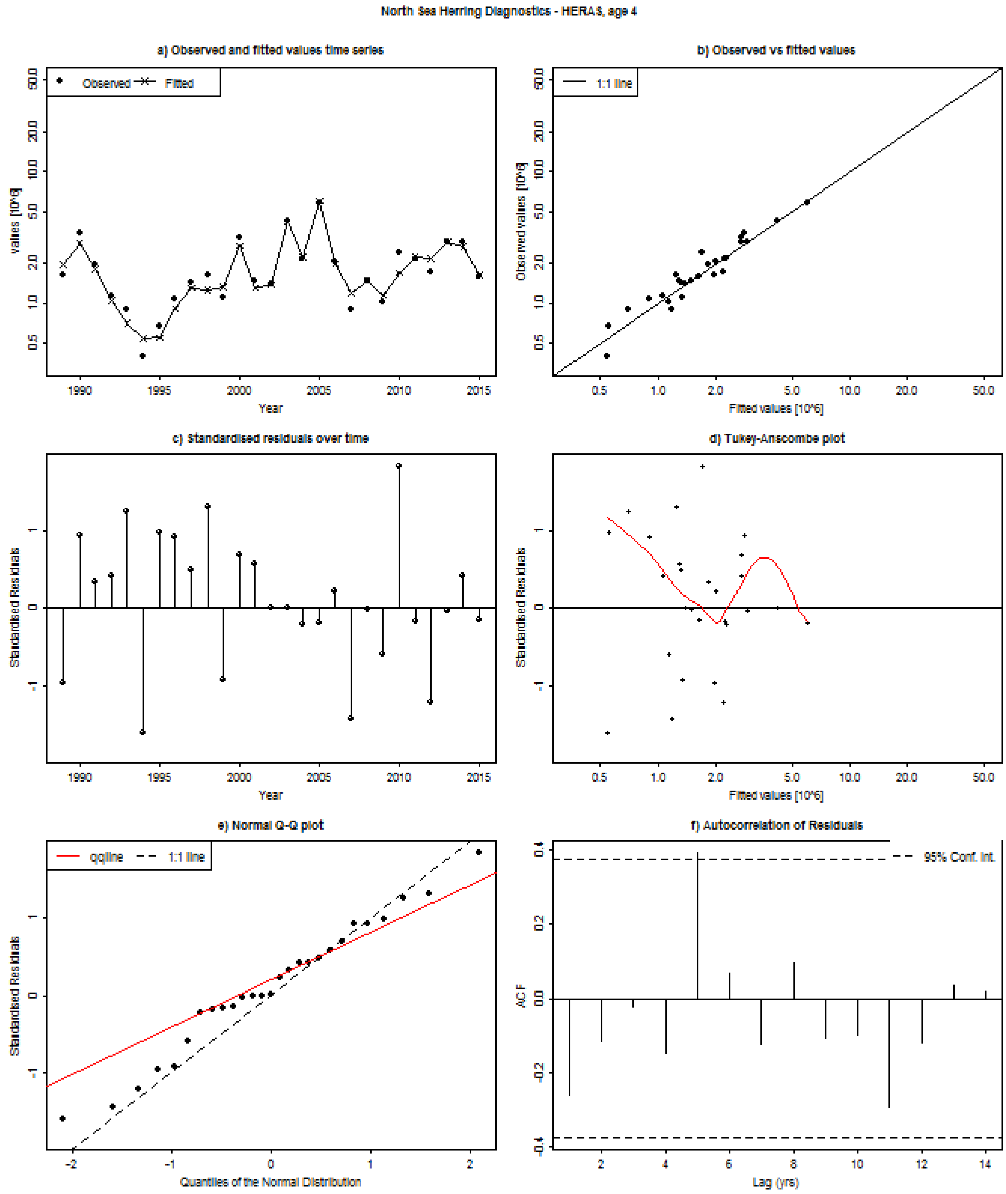


Figure 2.6.1.19. North Sea herring. Diagnostics of the assessment model fit to the HERAS index at age 4 wr time series. Top left: Estimates of numbers at 4 wr (line) and numbers predicted from index abundance at 4 wr. Top right: scatterplot of index observations versus assessment model estimates of numbers 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.

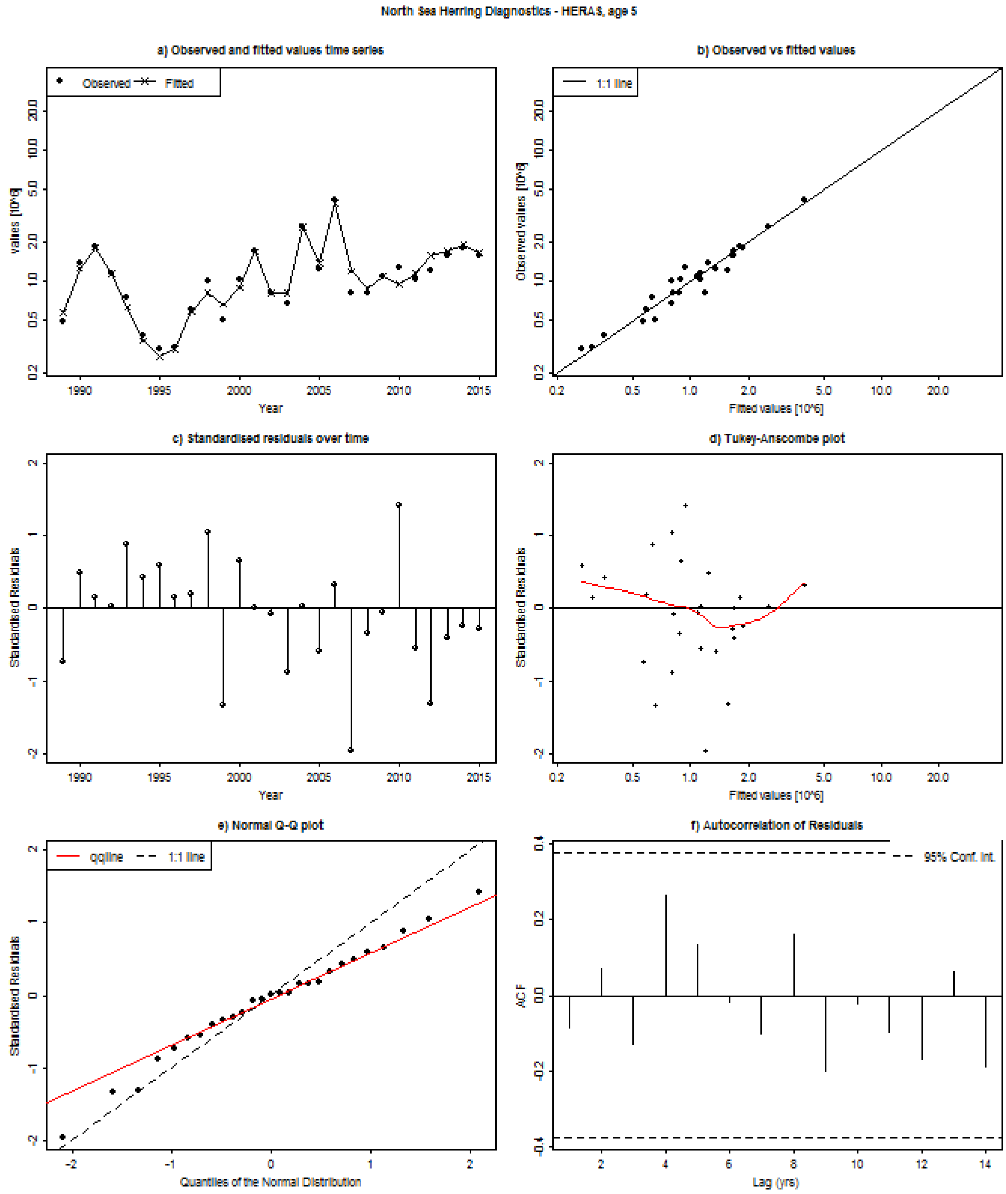


Figure 2.6.1.20. North Sea herring. Diagnostics of the assessment model fit to the HERAS index at age 5 wr time series. Top left: Estimates of numbers at 5 wr (line) and numbers predicted from index abundance at 5 wr. Top right: scatterplot of index observations versus assessment model estimates of numbers 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.

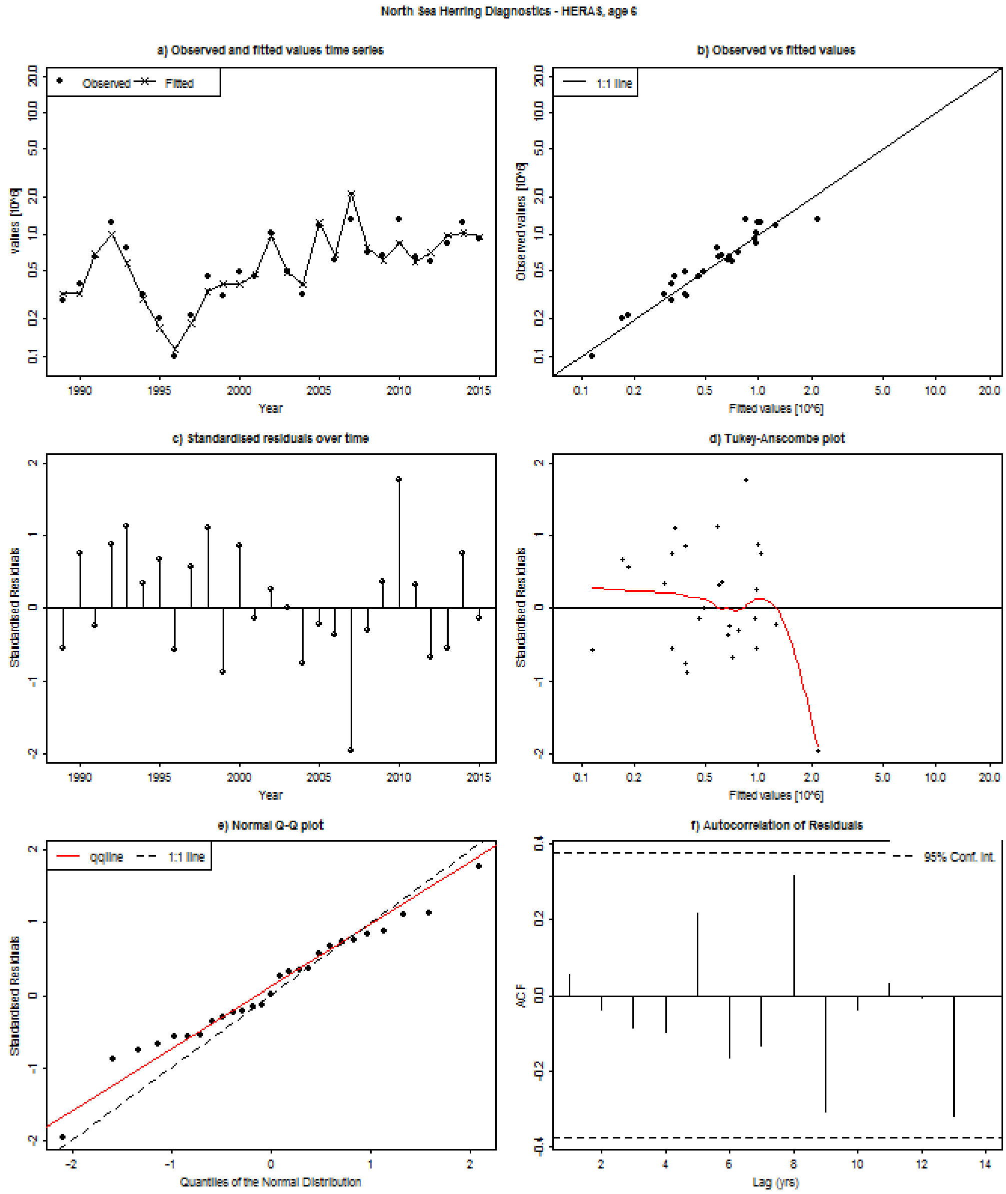


Figure 2.6.1.21. North Sea herring. Diagnostics of the assessment model fit to the HERAS index at age 6 wr time series. Top left: Estimates of numbers at 6 wr (line) and numbers predicted from index abundance at 6 wr. Top right: scatterplot of index observations versus assessment model estimates of numbers 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.

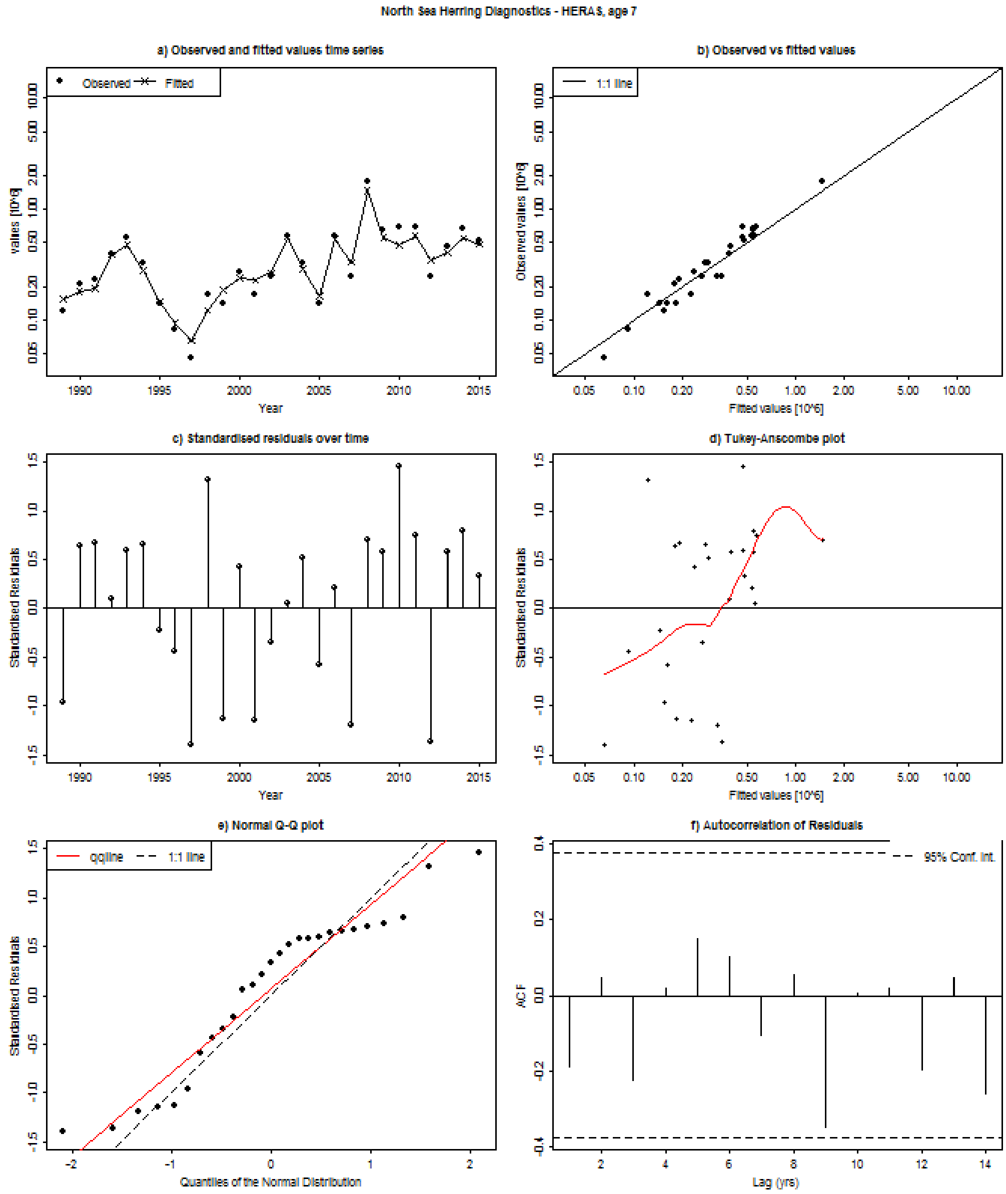


Figure 2.6.1.22. North Sea herring. Diagnostics of the assessment model fit to the HERAS index at age 7 wr time series. Top left: Estimates of numbers at 7 wr (line) and numbers predicted from index abundance at 7 wr. Top right: scatterplot of index observations versus assessment model estimates of numbers 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.

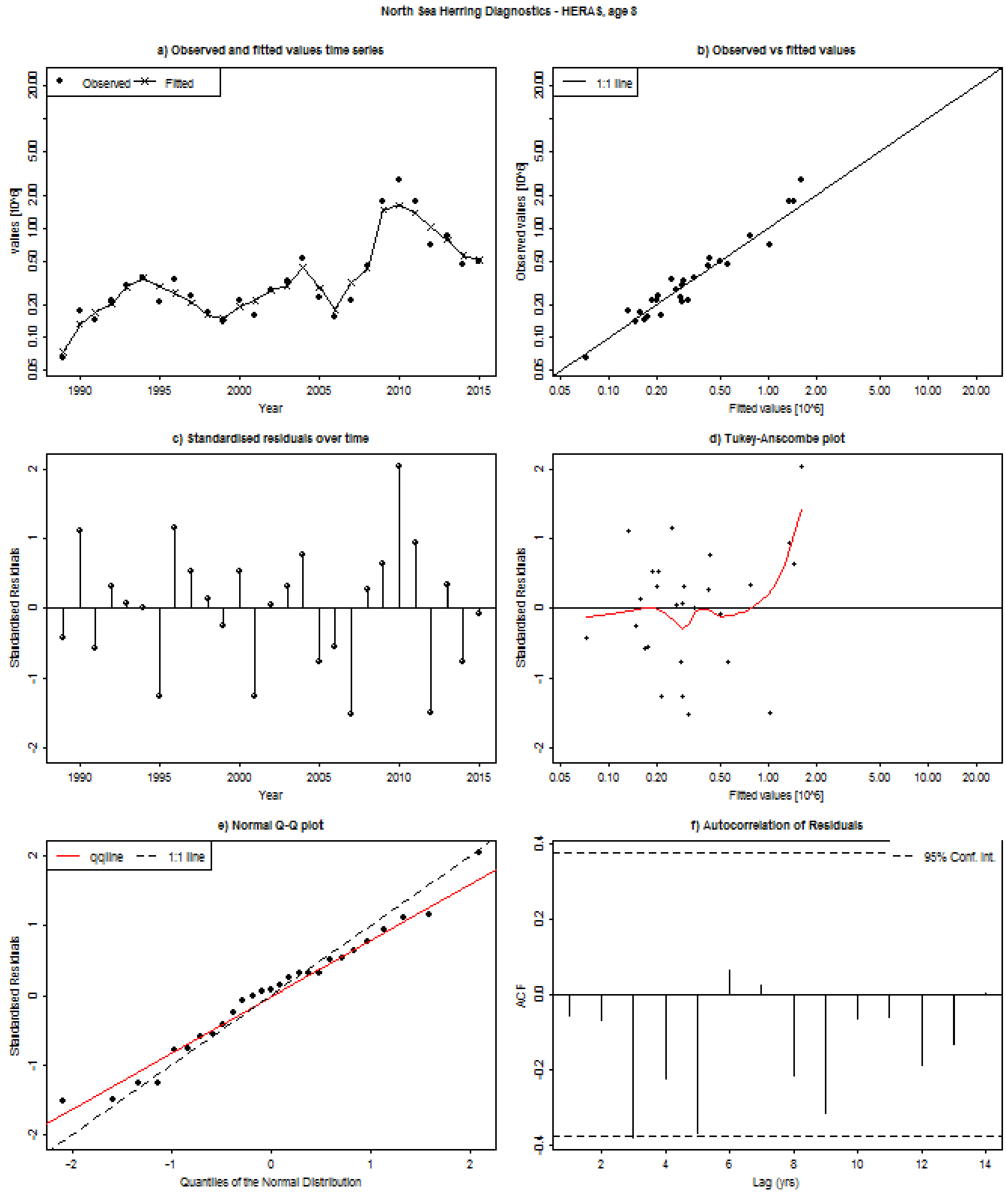


Figure 2.6.1.23. North Sea herring. Diagnostics of the assessment model fit to the HERAS index at age 8+ wr time series. Top left: Estimates of numbers at 8+ wr (line) and numbers predicted from index abundance at 8+ wr. Top right: scatterplot of index observations versus assessment model estimates of 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.

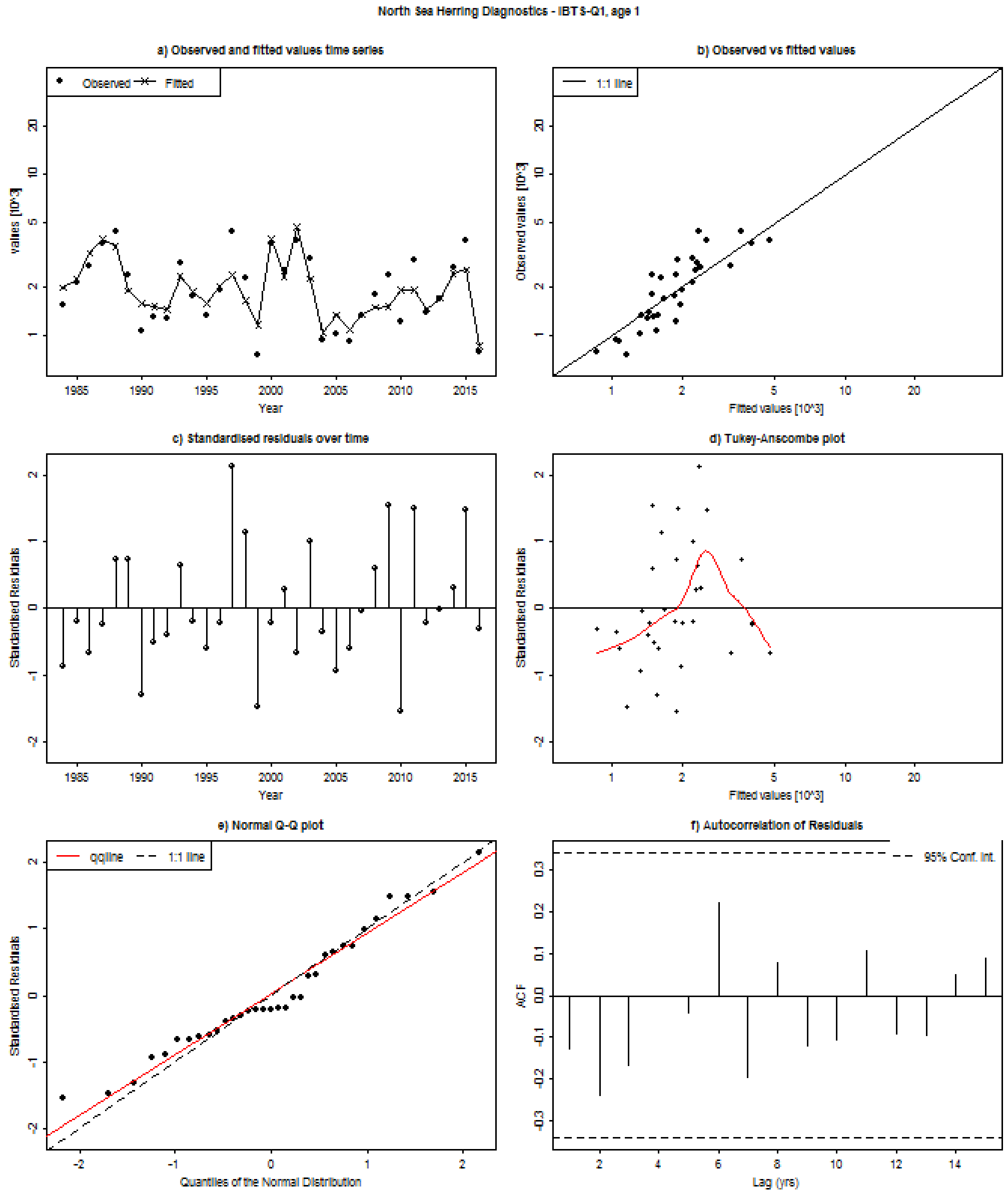


Figure 2.6.1.24. North Sea herring. Diagnostics of the assessment model fit to the IBTS-Q1 index at age 1 wr time series. Top left: Estimates of numbers at 1 wr (line) and numbers predicted from index abundance at 1 wr. Top right: scatterplot of index observations versus assessment model estimates of 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.

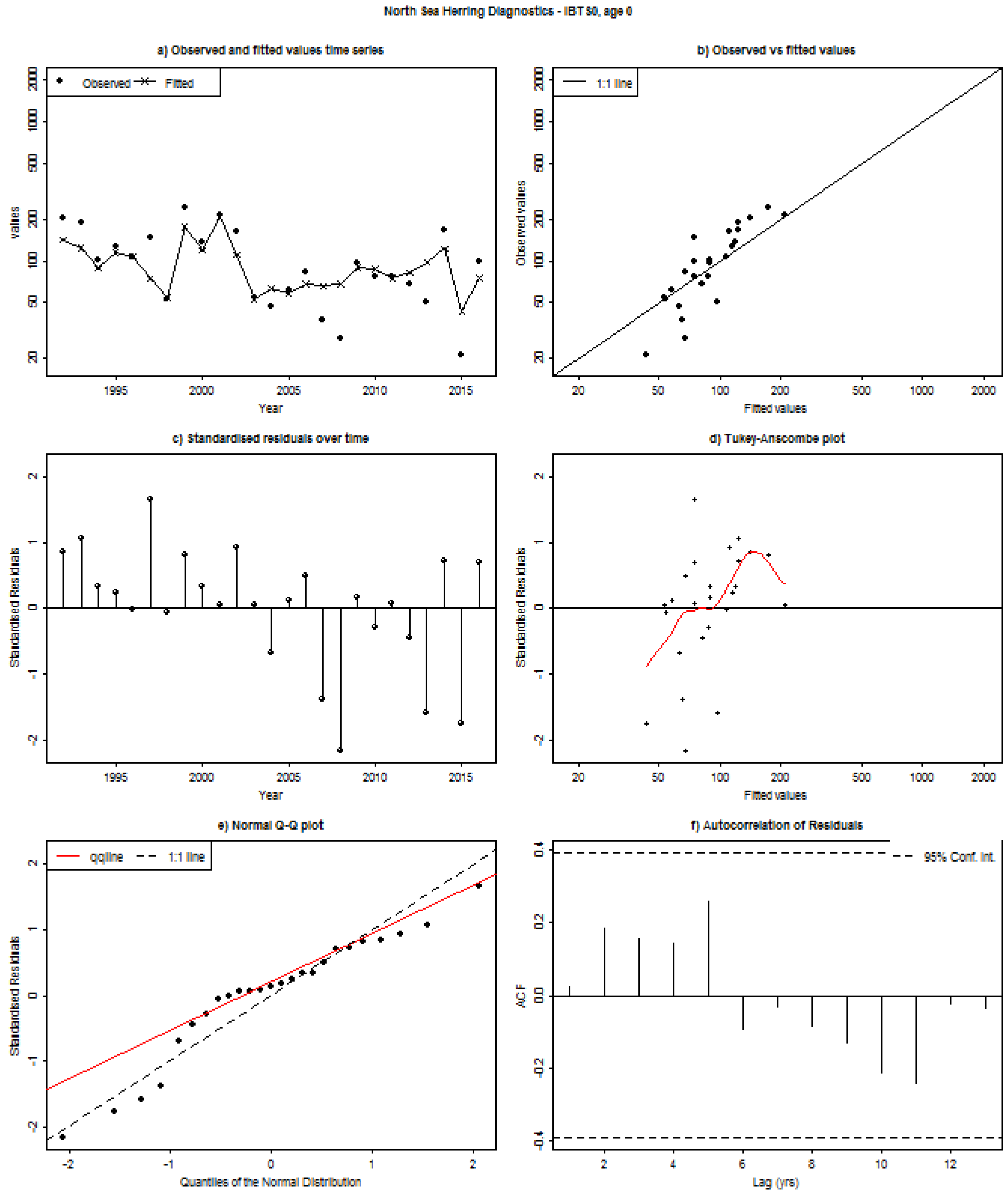


Figure 2.6.1.25. North Sea herring. Diagnostics of the assessment model fit to the IBTS0 index at age 0 wr time series. Top left: Estimates of numbers at 0 wr (line) and numbers predicted from index abundance at 0 wr. Top right: scatterplot of index observations versus assessment model estimates of numbers 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.

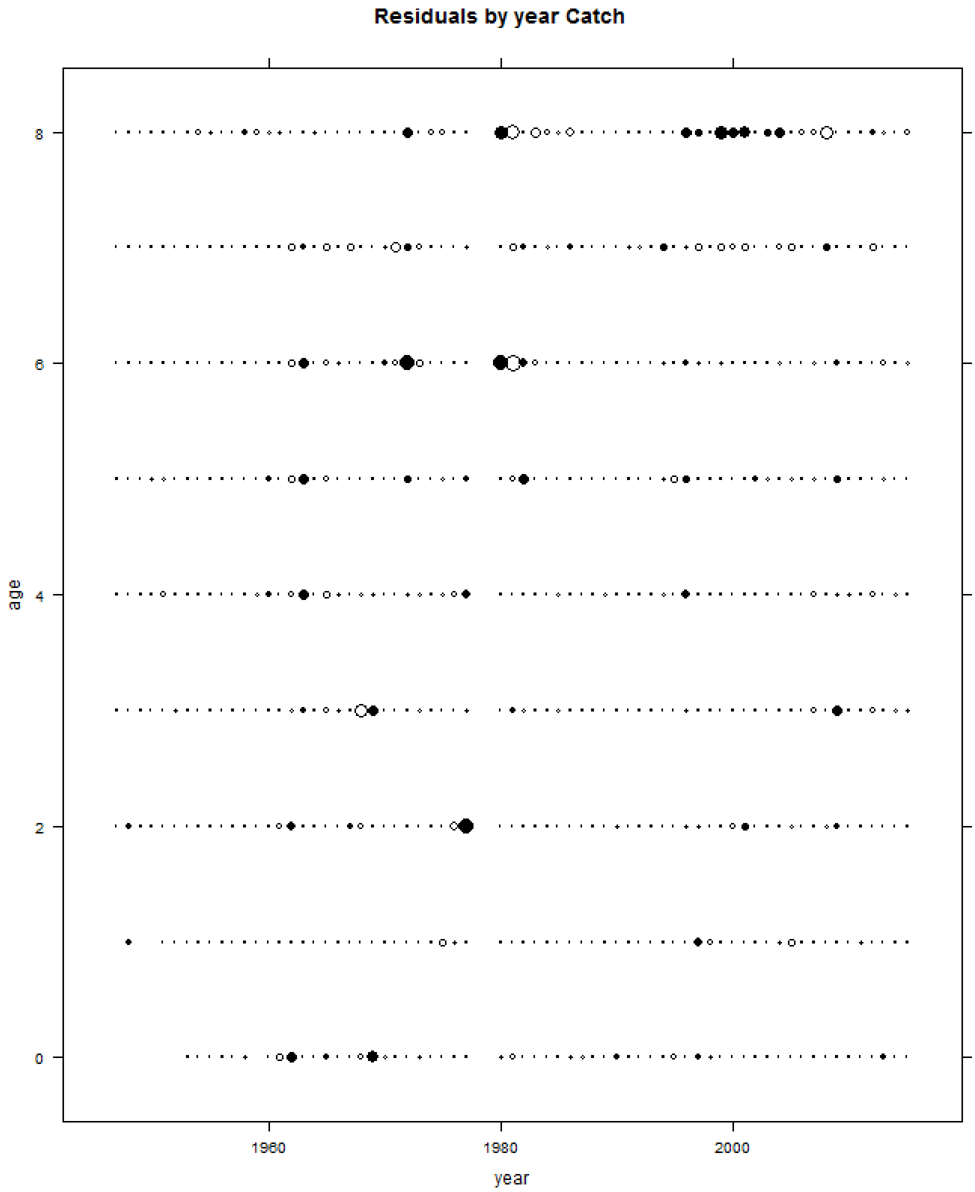


Figure 2.6.1.26. North Sea herring. Bubble plot of standardised catch residual.

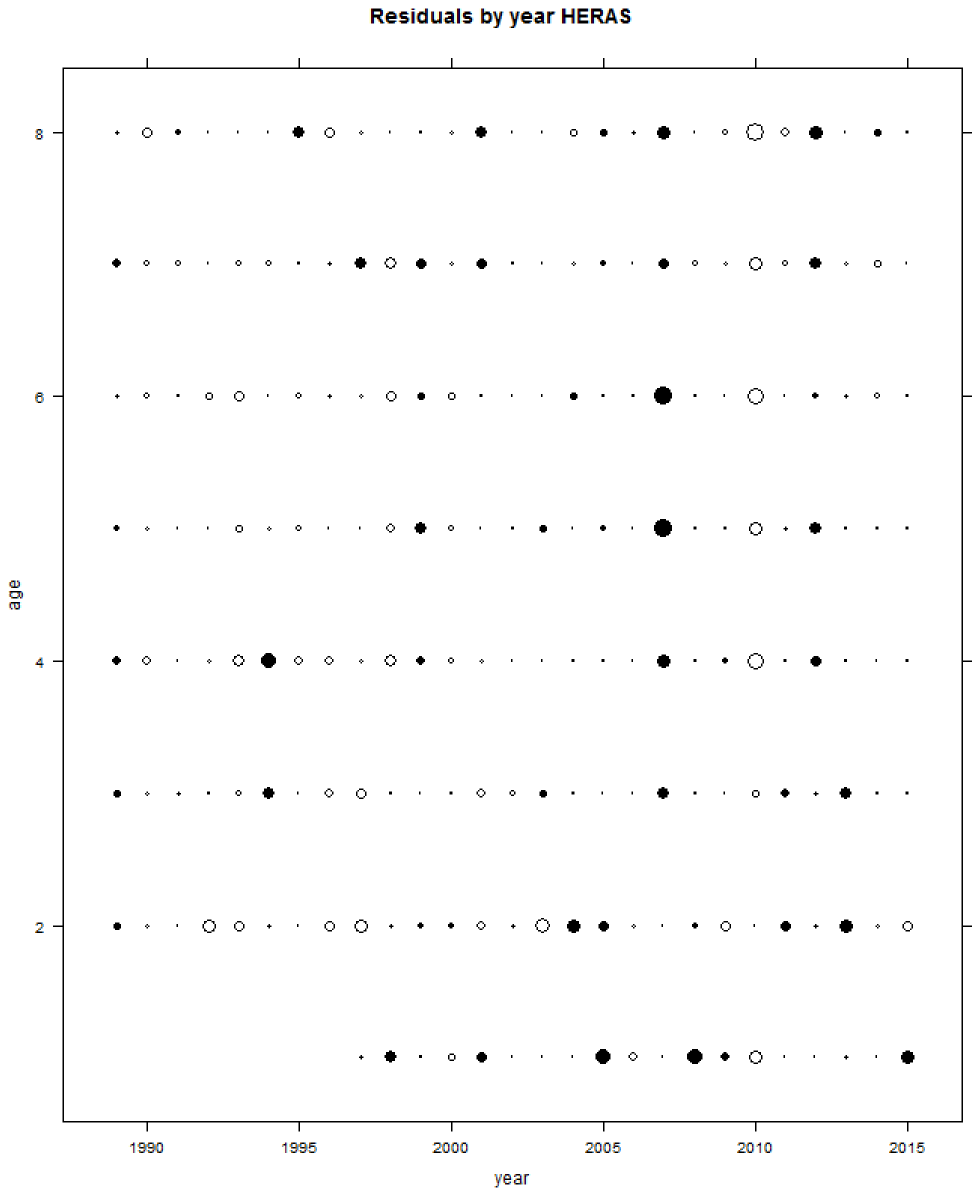


Figure 2.6.1.27. North Sea herring. Bubble plot of standardised acoustic survey residuals.

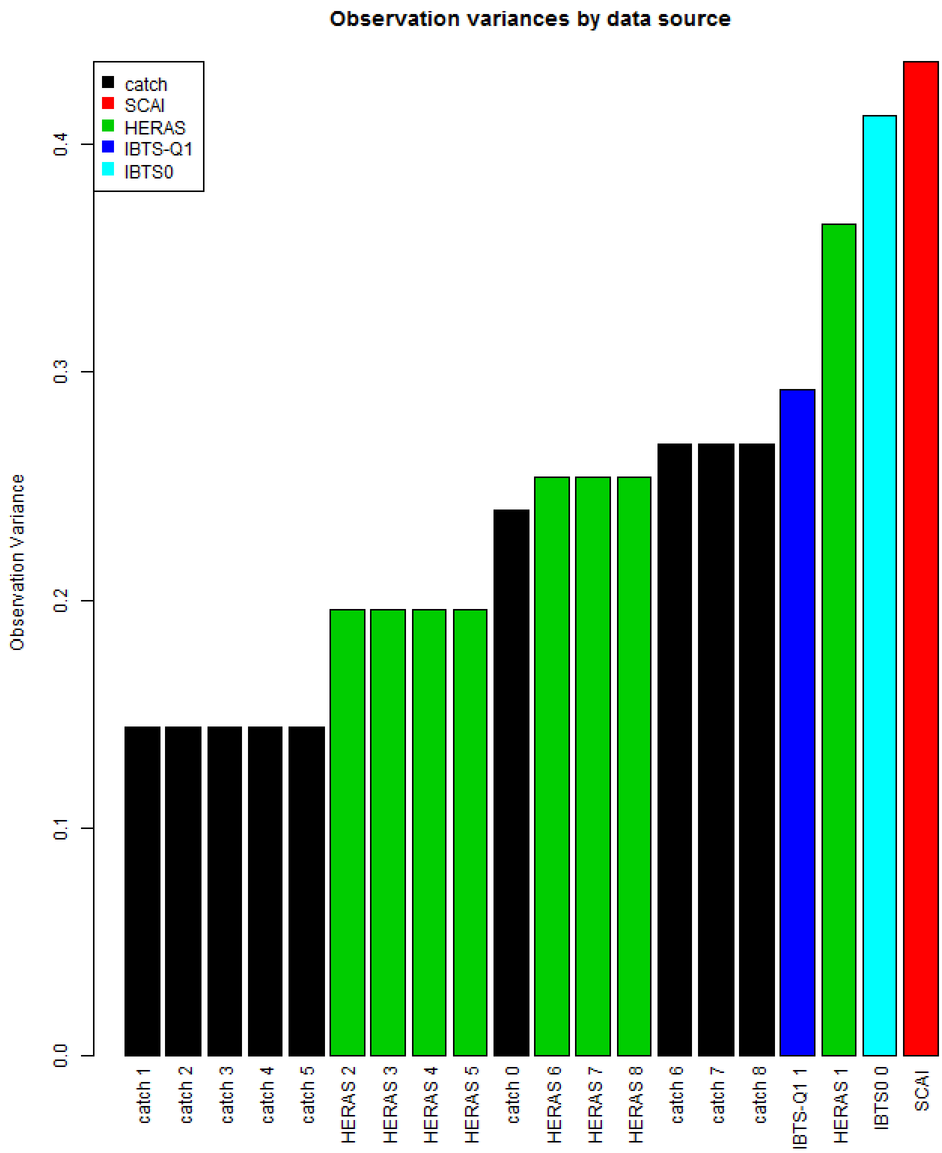


Figure 2.6.1.28. North Sea herring. Observation variance by data source as estimated by the assessment model. Observation variance is ordered from least (left) to most (right). Colours indicate the different data sources. Observation variance is not individually estimated for each data source individually thereby reducing the parameters needed to be estimated in the assessment model. In these cases of parameter bindings, observation variances have equal values.

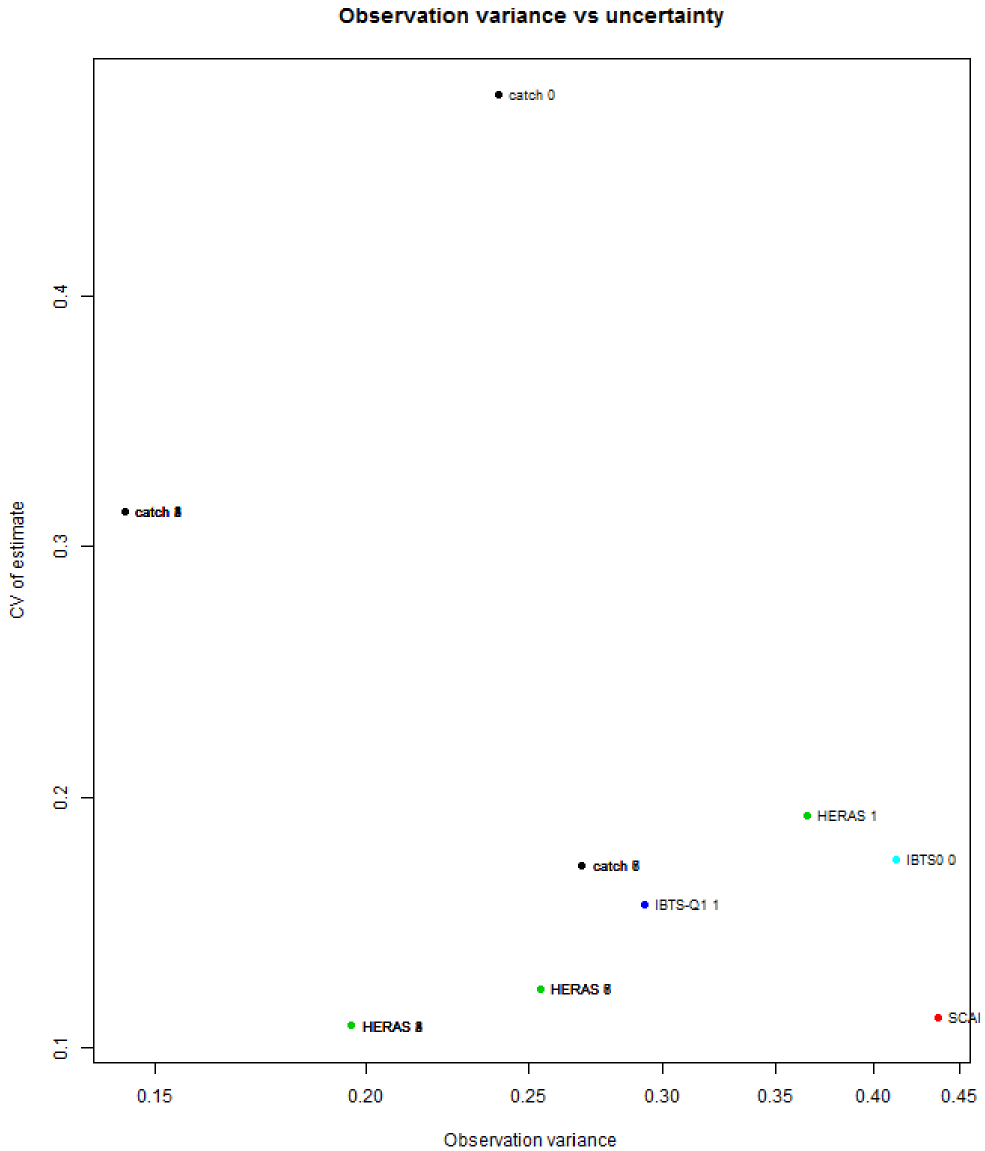


Figure 2.6.1.29. North Sea herring. Observation variance by data source as estimated by the assessment model plotted against the CV estimate of the observation variance parameter.

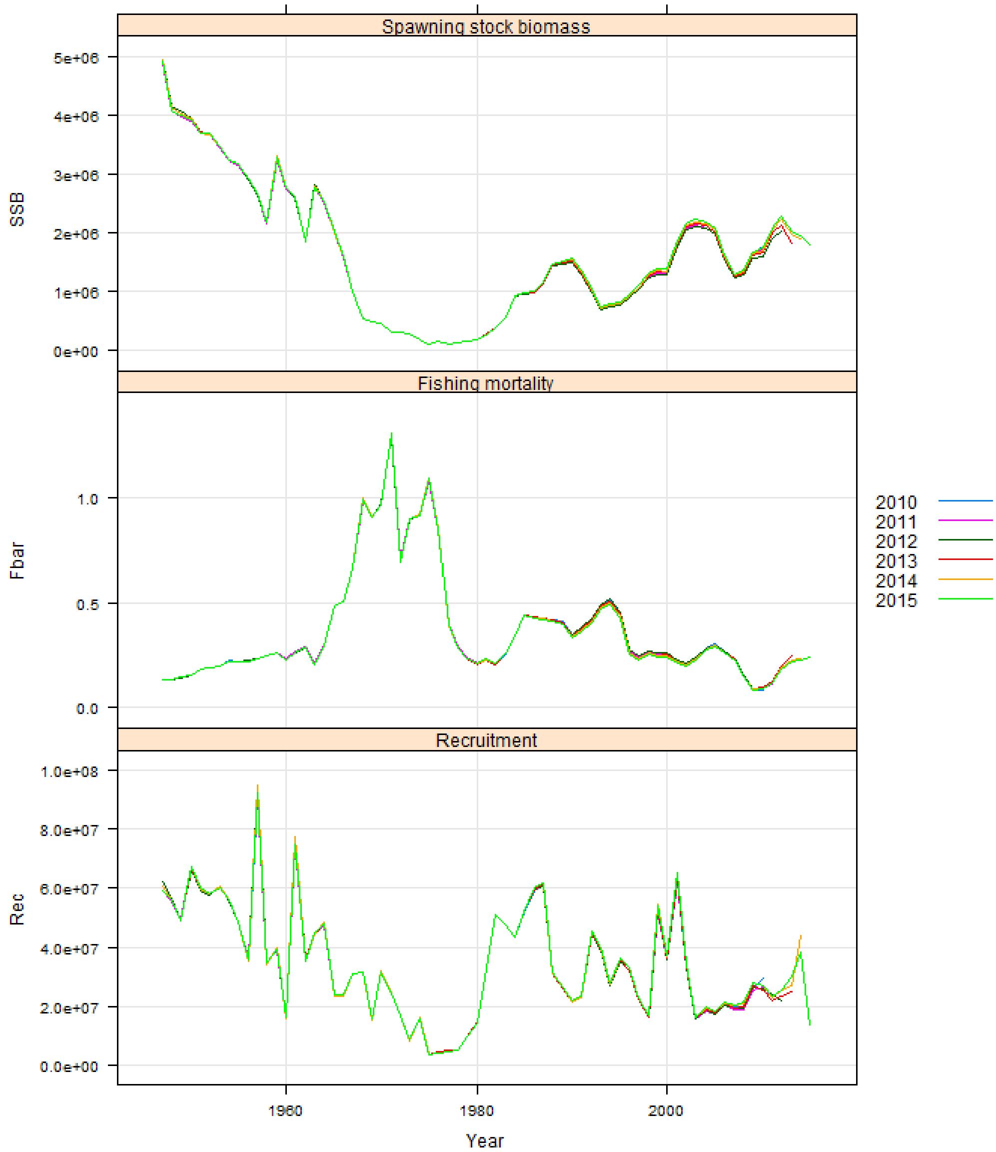


Figure 2.6.1.30. North Sea herring. Retrospective pattern of SSB (top panel) F (middle panel) and recruitment (bottom panel) for the assessments with respectively terminal years in 2013 to 2003.

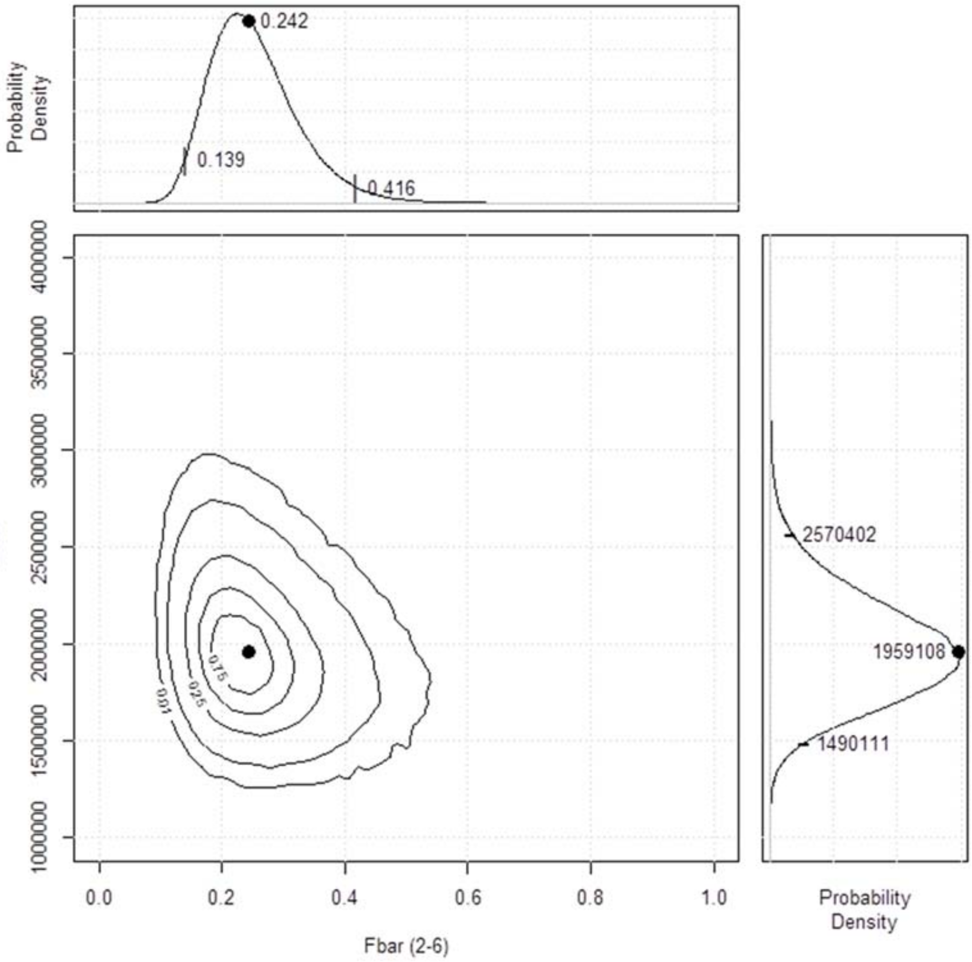


Figure 2.6.1.31. North Sea herring. Model uncertainty; distribution and quantiles of estimated SSB and $F_{2\text{-}6}$ in the terminal year of the assessment. Estimates of precision are based on a parametric bootstrap from the FLSAM estimated variance / covariance estimates from the model.

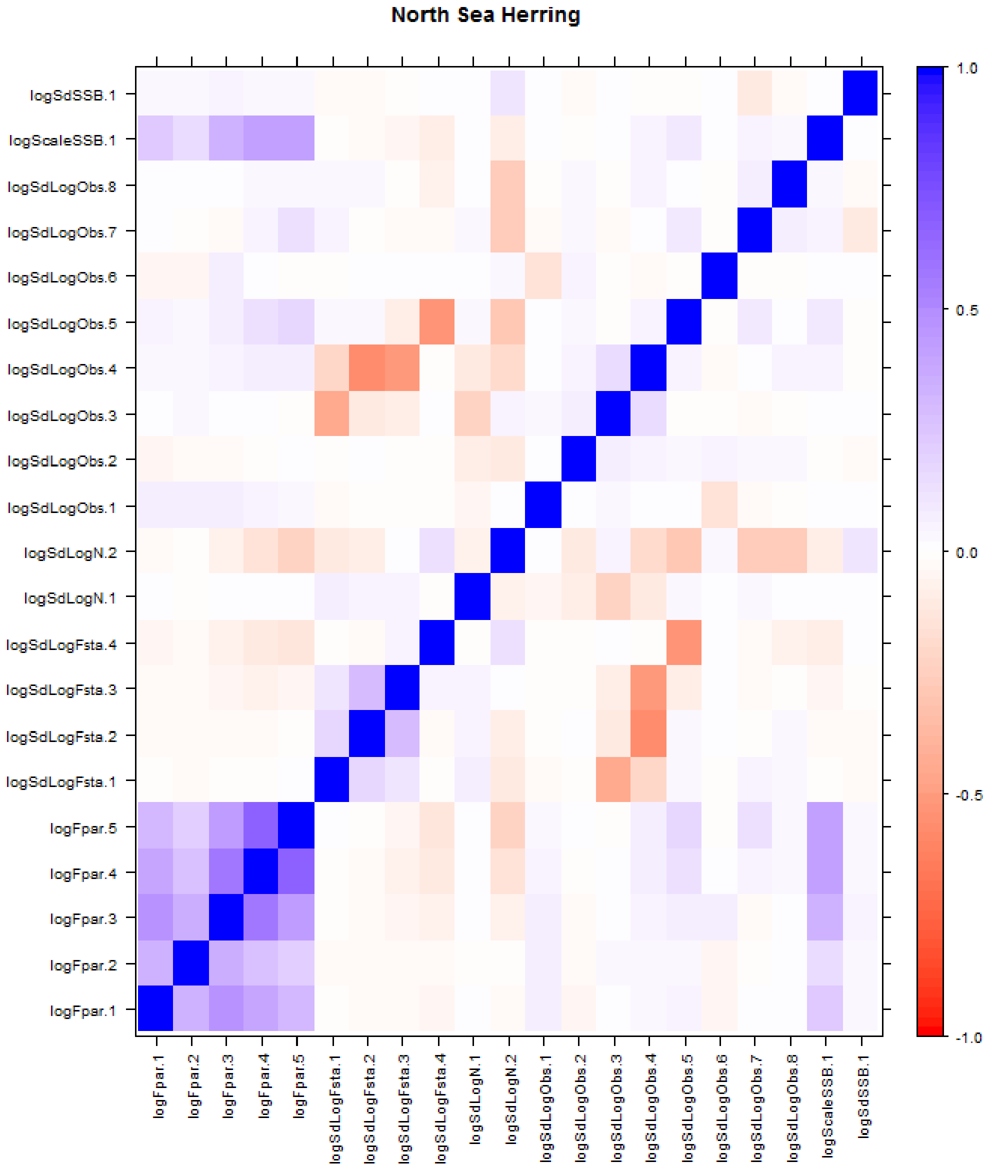


Figure 2.6.1.32. North Sea herring. Correlation plot of the FLSAM assessment model with the final set of parameters estimated in the model. The diagonal represents the correlation with the data source itself.

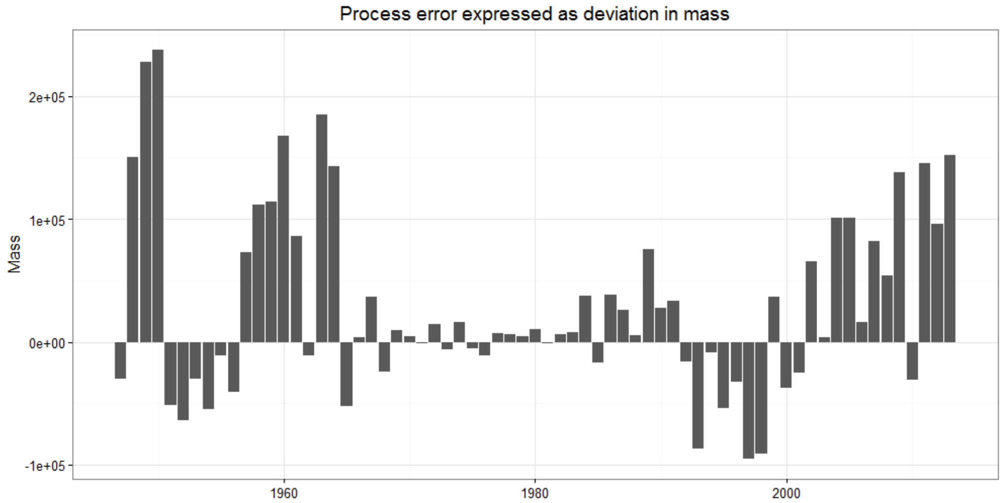


Figure 2.6.1.33. North Sea herring. Process error estimated from the 2016 SAM assessment. Top: Process error expressed as deviations in total mortality. Bottom: Process error in stock biomass.

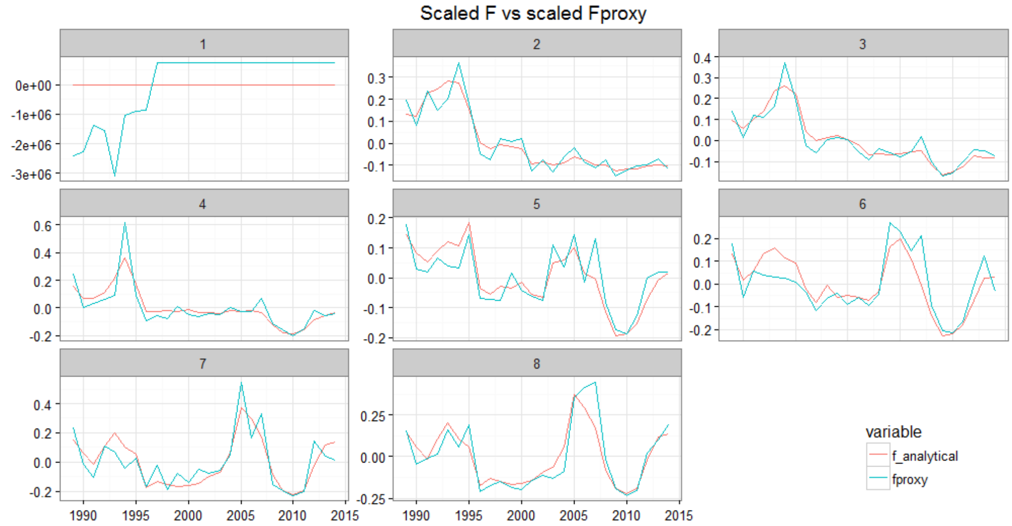


Figure 2.6.2.1. North Sea herring. Comparison of the relative fishing mortality at age, derived from the 2016 SAM assessment, with the relative F-proxy at age, derived by dividing the catch numbers at age by the acoustic index as age (i.e. similar to harvest rate). Both series are scaled to the mean for each age separately.

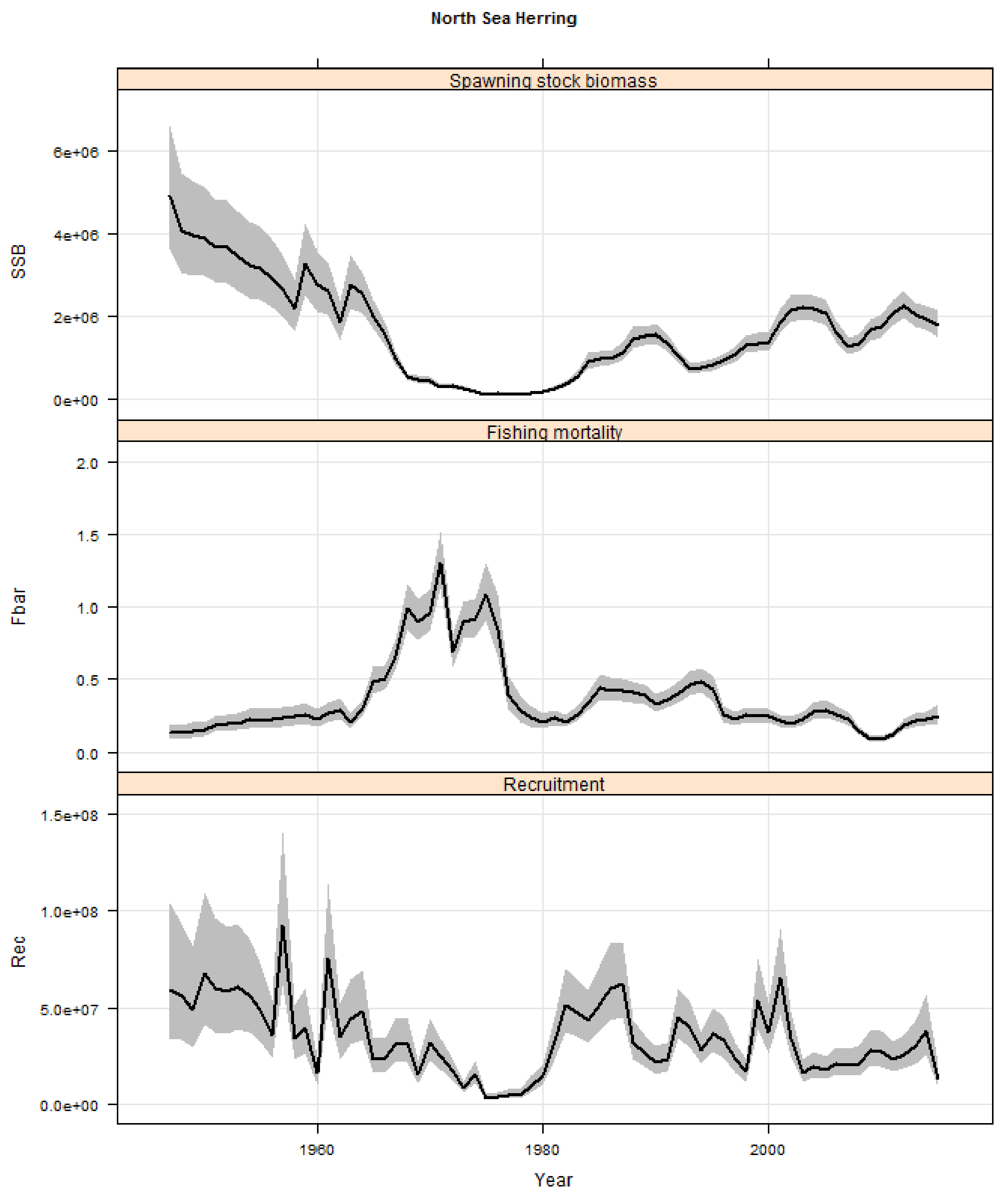


Figure 2.6.3.1 North Sea herring. Stock summary plot of North Sea herring with associated uncertainty for SSB (top panel), F ages 2–6 (middle panel) and recruitment (bottom panel).

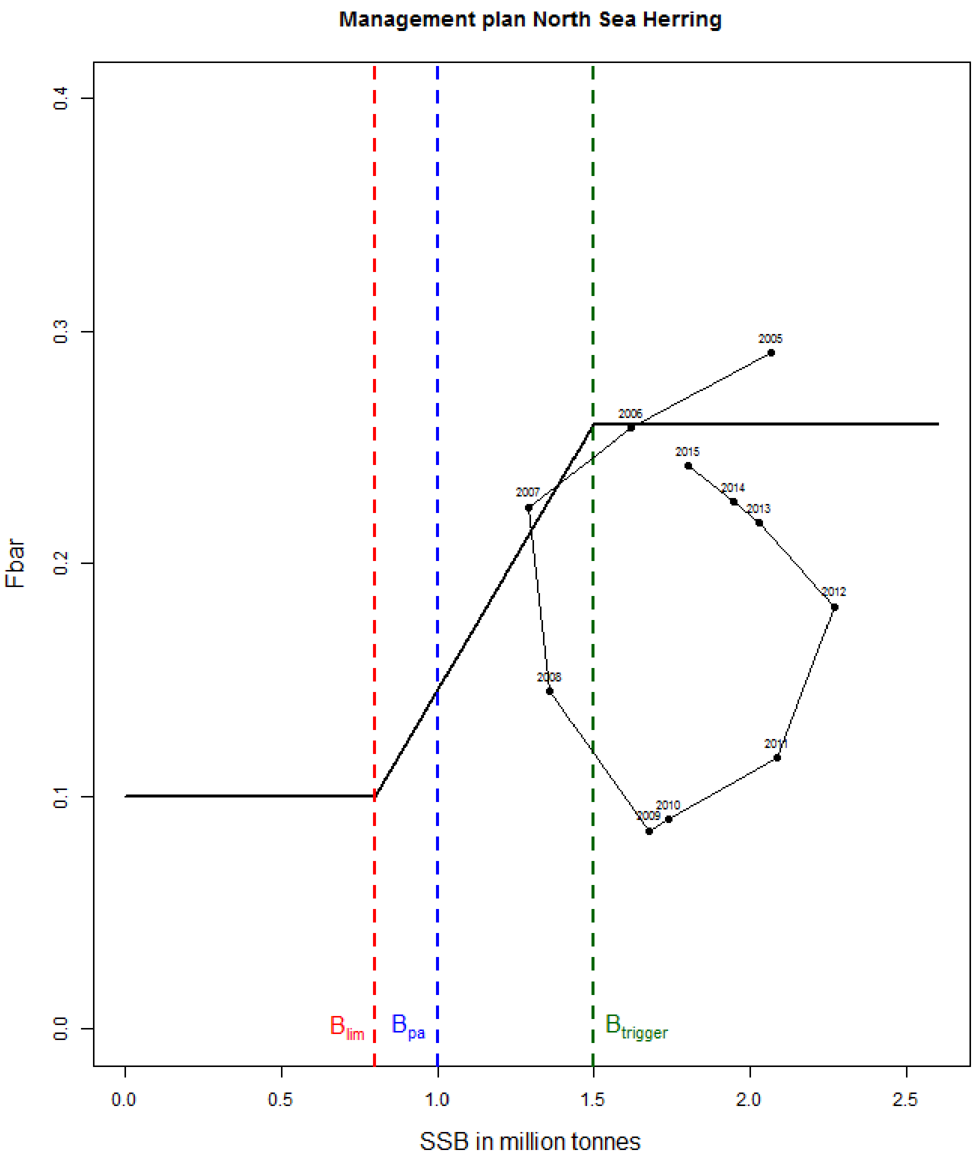


Figure 2.6.3.2. North Sea herring. Agreed management plan for North Sea herring including the most recent 10 years of SSB and F as estimated within the assessment in relation with the management plan.

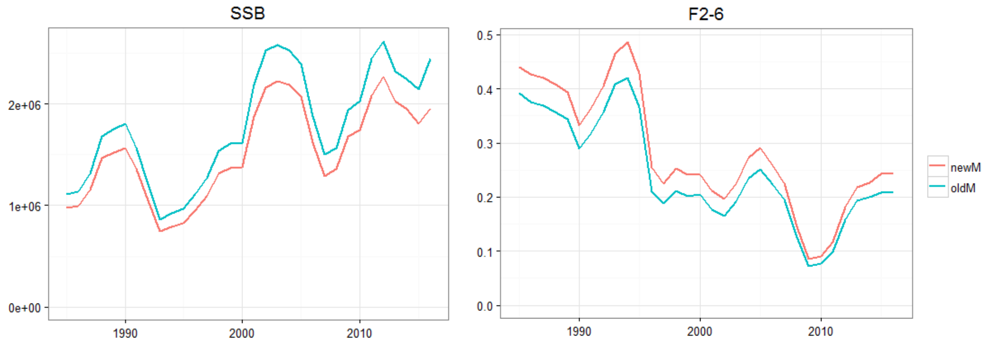


Figure 2.6.3.3. North Sea herring. Comparison of the North Sea SSB and fishing mortality using the new and the new natural mortality time series.

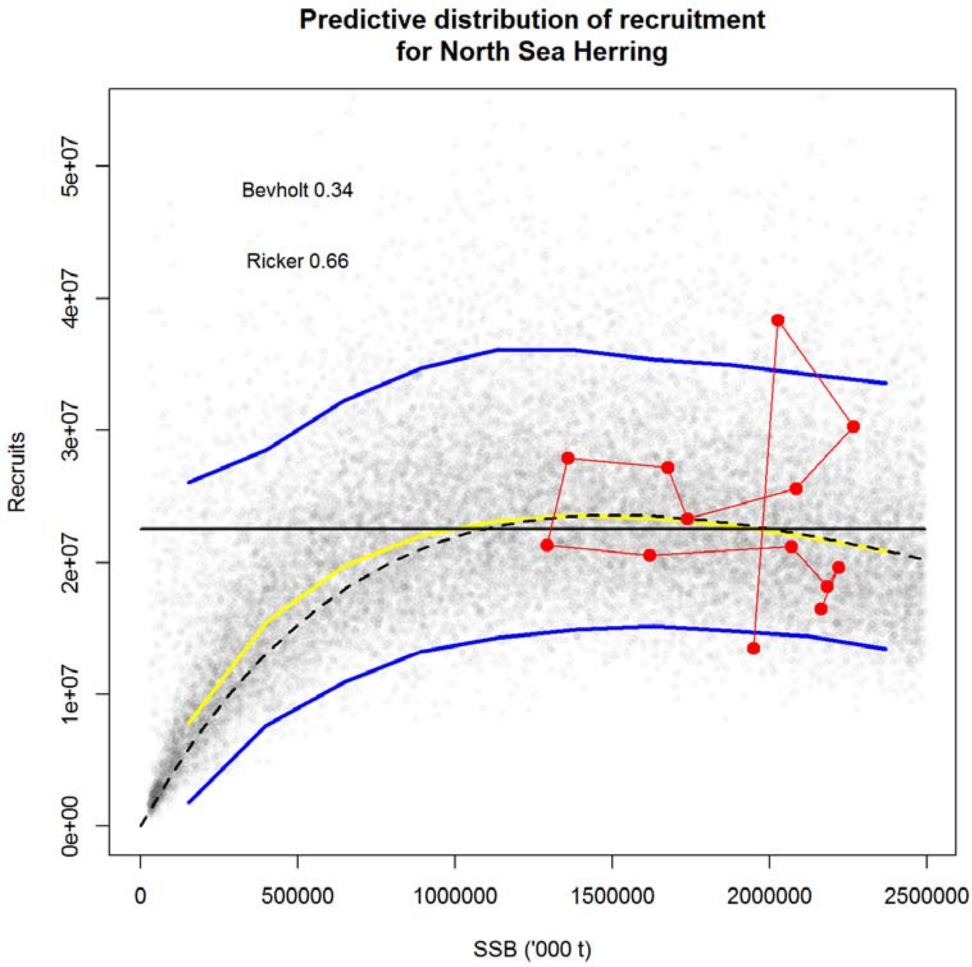


Figure 2.9.1. North Sea herring. Stock recruitment estimation for the period 2002–2015 based on the current assessment.

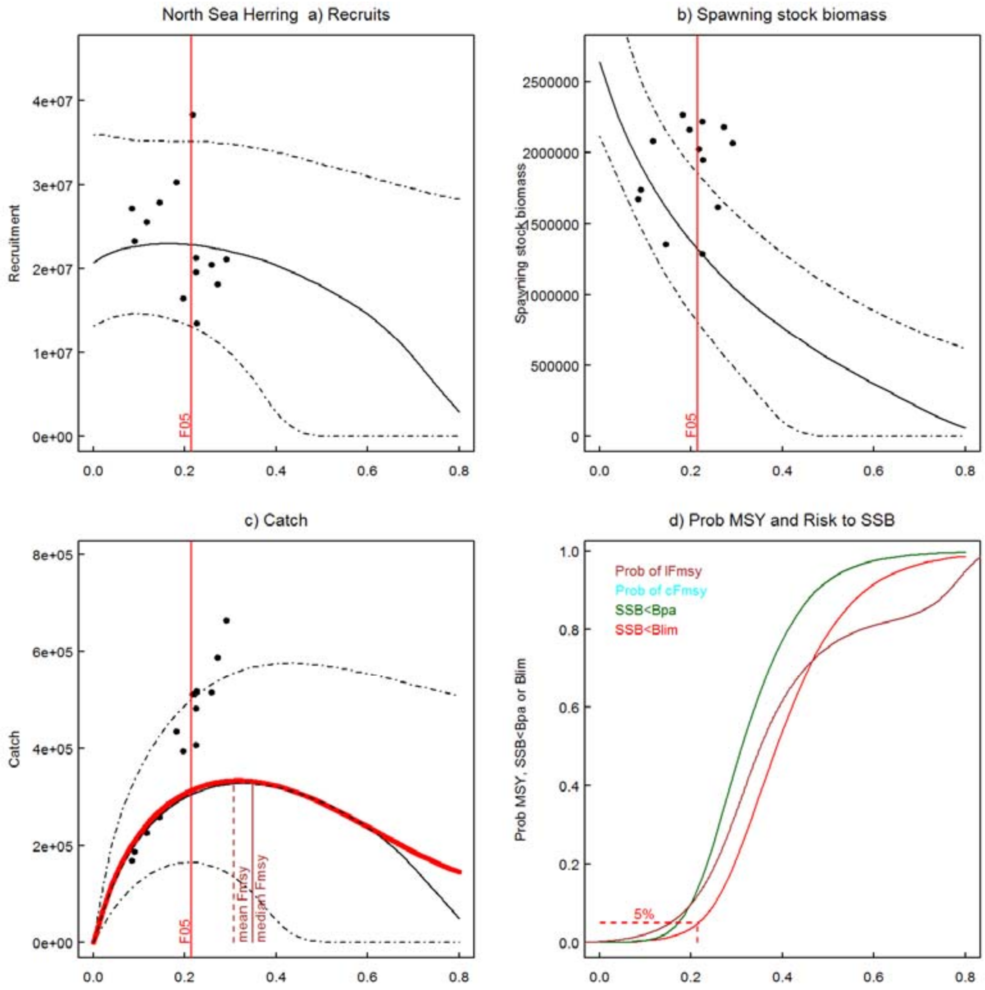


Figure 2.9.2. North Sea herring. Fmsy estimation using Eqsim based on the 2002–2015 stock-recruitment, biological and selectivity period.

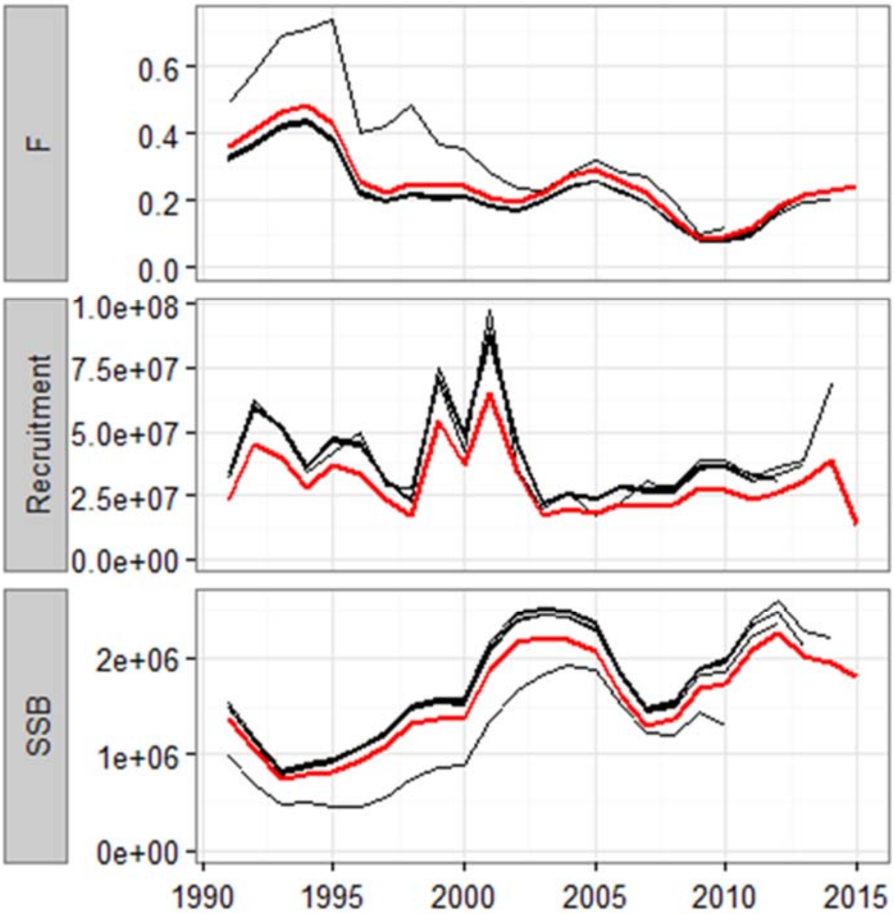


Figure 2.10.1 North Sea Autumn Spawning Herring. Historical retrospective of the estimated fishing mortality, recruitment and spawning stock biomass from assessments 2009–2015.

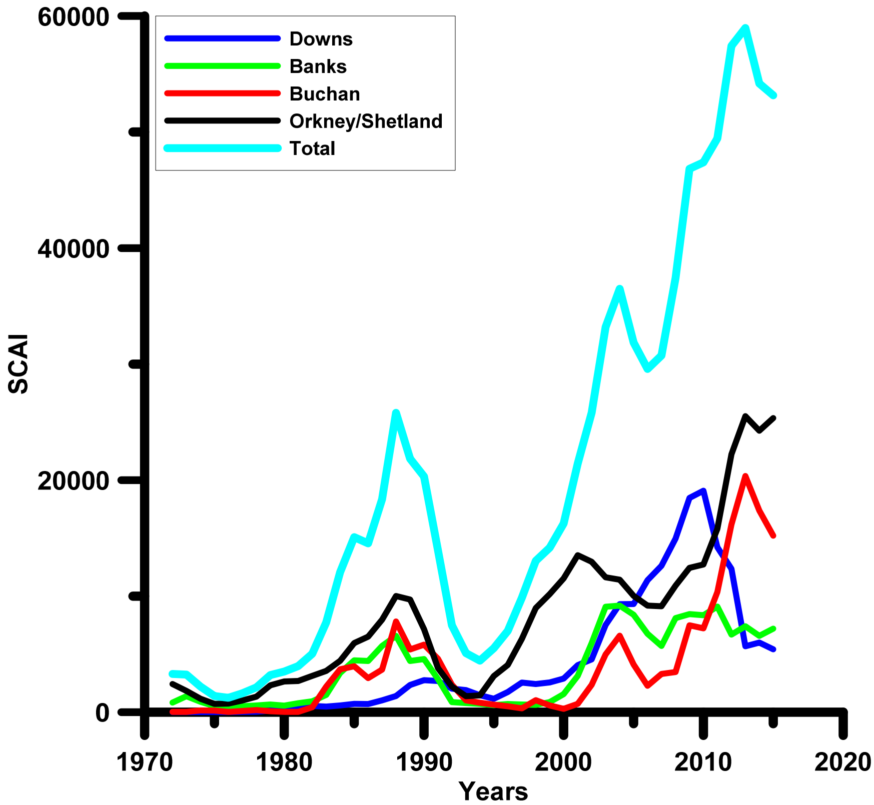


Figure 2.11.1: North Sea herring. SCAI indices for the individual North Sea spawning components.

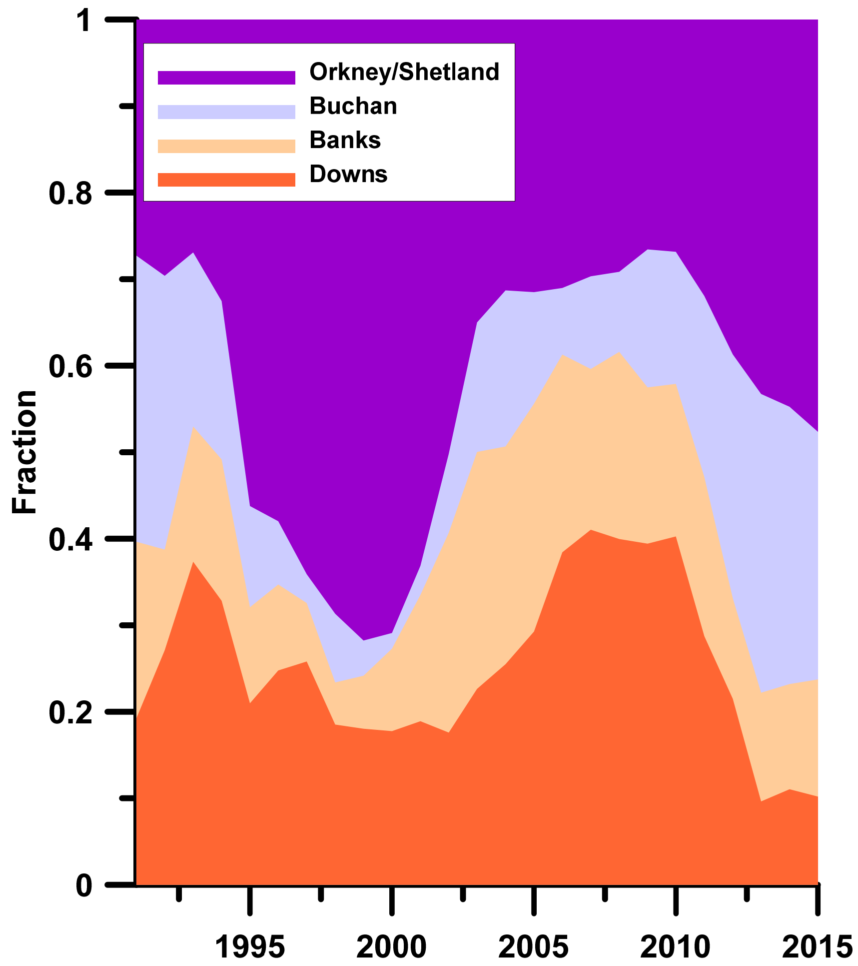


Figure 2.11.2. North Sea herring. Time-series of the contribution of each spawning component to the total stock, as estimated from the SCAI index (Payne, 2010). Areas are arranged from top to bottom according to the north-to-south arrangement of the components.

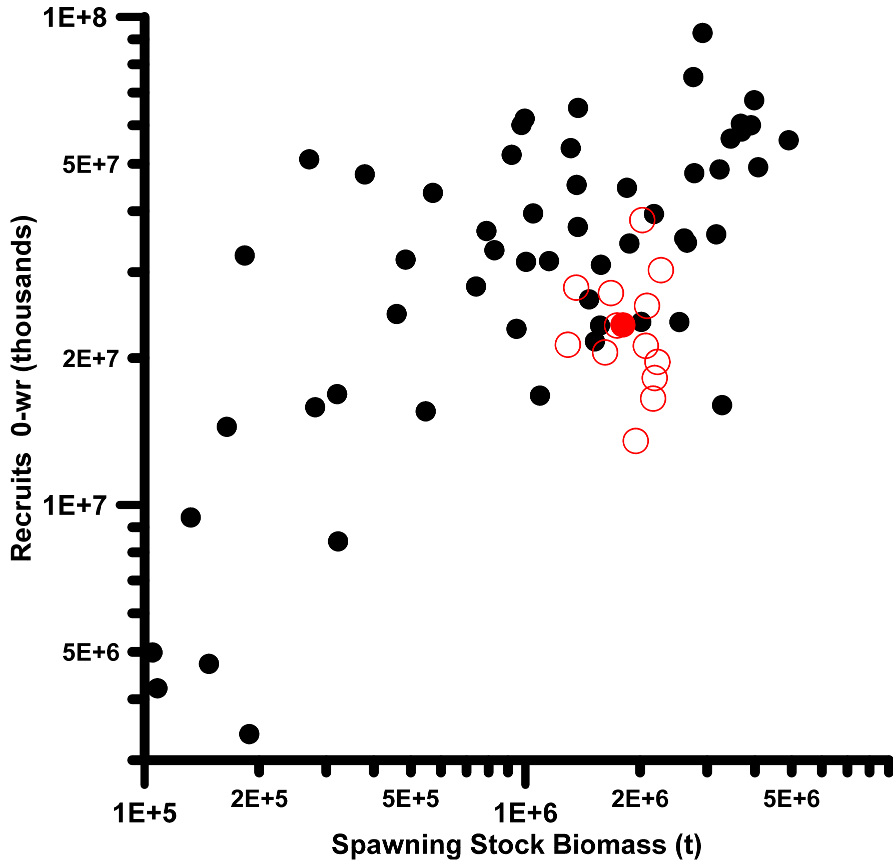


Figure 2.14.1. North Sea Autumn Spawning Herring. Stock recruitment curve, plotting estimated spawning stock biomass against the resulting recruitment. Year classes spawned after 2001 are plotted with open red circles, to highlight the years of recent poor recruitment. The most recent year class is plotted in solid red. Note the logarithmic scaling on both axes.

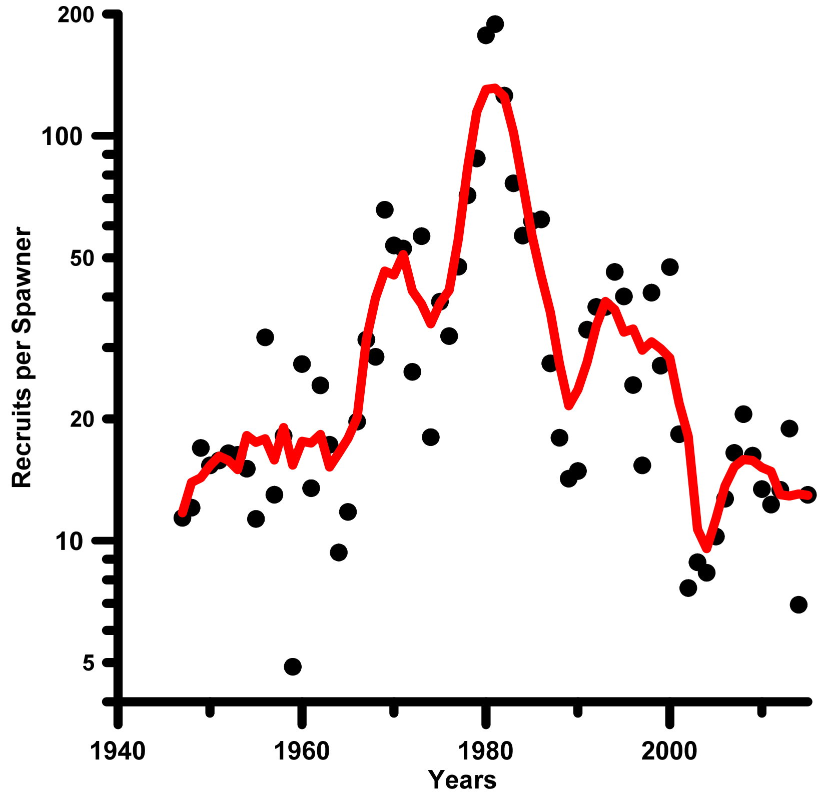


Figure 2.14.2. North Sea Autumn Spawning Herring. Time series of recruits per spawner (RPS). RPS is calculated as the estimated number of recruits from the assessment divided by the estimated number of mature fish at the time of spawning and is plotted against the year in which spawning occurred. Black points: RPS in a given year. Red line: Smoother to aid visual interpretation. Note the logarithmic scale on the vertical axis.

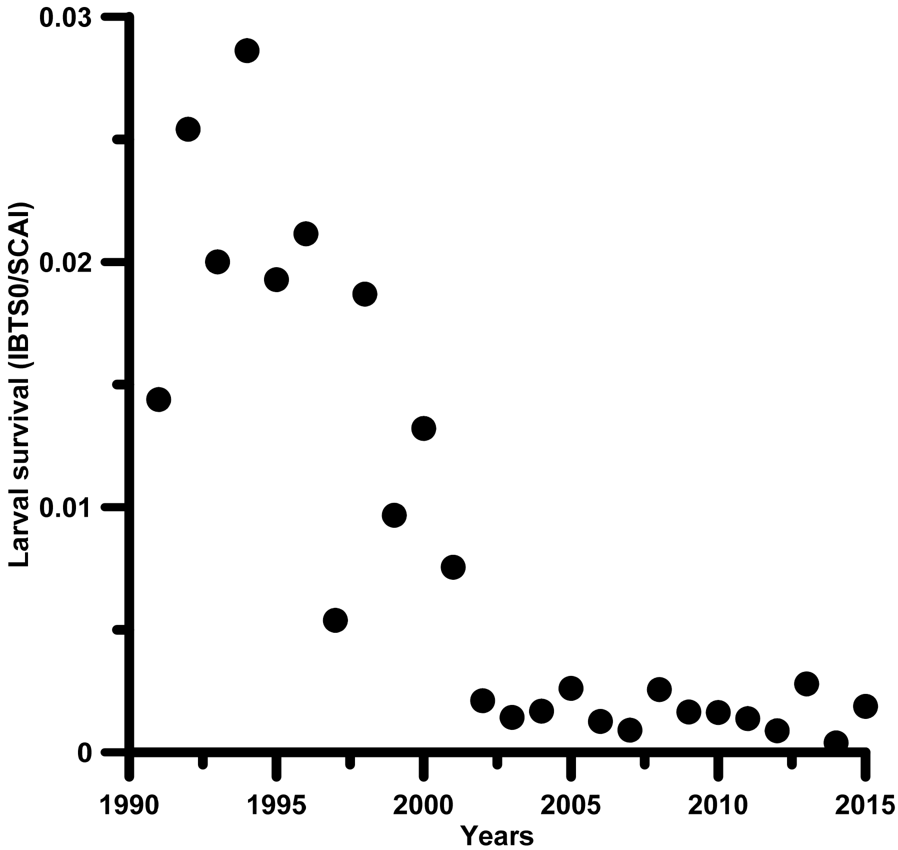


Figure 2.14.3. North Sea Autumn Spawning Herring. Time series of larval survival ratio (Dickey-Collas & Nash 2005; Payne et al. 2009), defined as the ratio of the SCAI index (representing larvae less than 10–11mm) and the IBTS0 index (representing the late larvae, of approximately 20–30 mm). Survival ratio is plotted against the year in which the larvae are spawned.

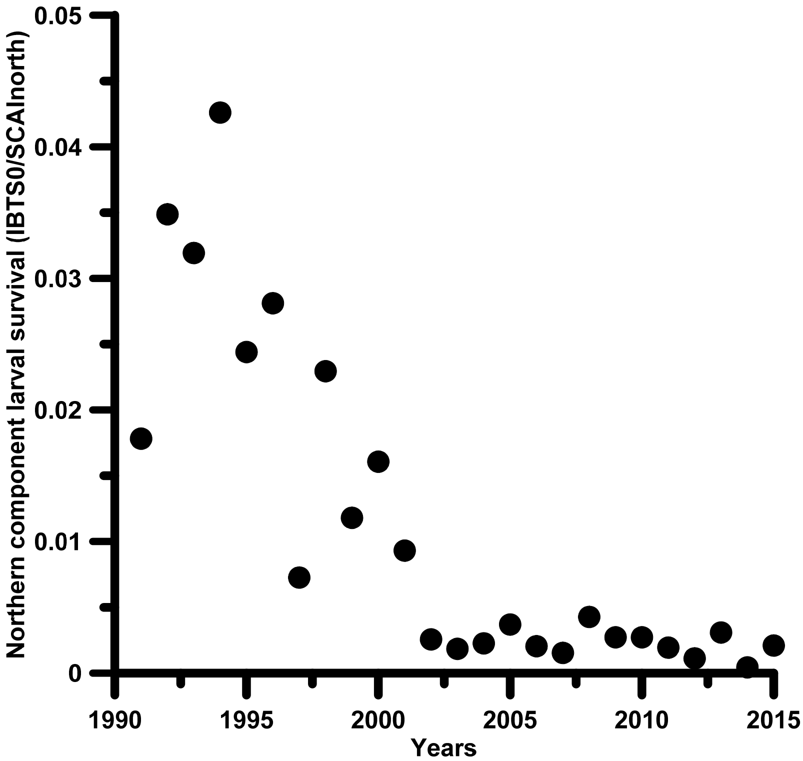


Figure 2.14.4. North Sea Autumn Spawning Herring. Time series of larval survival ratio (Dickey-Collas & Nash 2005; Payne *et al.* 2009) for the northern-most spawning components (Banks, Buchan, Orkney-Shetland), defined as the ratio of the sum of the SCAI indices for these components (representing larvae less than 10–11mm) and the IBTS0 index (representing the late larvae, of approximately 20–30 mm). Survival ratio is plotted against the year in which the larvae are spawned.

3 Herring in Division 3.a and subareas 22–24 [update assessment]

3.1 The Fishery

3.1.1 Advice and management applicable to 2015 and 2016

ICES advised in 2015 on the basis of the MSY approach. This corresponds to landings of no more than 52 547 t in 2016 as estimated by the last year assessment (ICES CM 2015/ACOM:06).

The EU and Norway agreement on a herring TAC for 2015 was 52 547 t in Division 3.a for the human consumption fleet and a by-catch ceiling of 6 659 t to be taken in the small mesh fishery. For 2016, the EU and Norway agreement on herring TACs in Division 3.a was 51 084 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 2015, a TAC of 22 220 t was set on the Western Baltic stock component. The TAC for 2016 was set at 26 274 t.

3.1.2 Landings in 2015

Herring caught in Division 3.a 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 2015 are given in Table 3.1.1 and Figure 3.1.1. In 2015 the total landings in Division 3.a and subdivisions 22–24 have overall increased to 49 979 t. Landings in 2015 decreased of 4% in the Skagerrak and increased of 21% in subdivisions 22–24. As in previous years the 2015 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 2015 in thousands of tonnes by fleet (as defined by HAWG) and quarter.

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 3.a and for the F-fleet in subdivisions 22–24.

	TAC	DK	GER	FI	PL	SWE	EC	NOR
	2015							
Div. 3.a fleet-C	43 604	18 325*	293*			19 169*	37 788	5 816
Div. 3.a fleet-D	6 659	5 692	51			916	6 659	
SD 22–24 fleet-F	22 220	3 115	12 259	2	2 891	3 953	22 220	
% of 3.a fleet-C can be taken in 4 EU waters							-50%	
% of 3.a fleet-C can be taken in 4 Norwigian waters								-50%
	2016							
Div. 3.a fleet-C	51 084	21 178*	339*	600		22 154*	43 671	6 813
Div. 3.a fleet-D	6 659	5 692	51			916	6 659	
SD 22–24 fleet-F	26 274	3 683	14 496	2	3 419	4 674	26 274	26 274
% of 3.a fleet-C can be taken in 4 EU waters							-50%	
% of 3.a fleet-C can be taken in 4 Norwigian waters								-50%

*** calculated assuming same proportions as in 2015**

3.1.3 Regulations and their effects

Before 2009, HAWG has calculated a substantial part of the catch reported as taken in Division 3.a in fleet C actually has been taken in Area 4. 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 3.a does not occur. Thus no catches were moved out of Division 3.a to the North Sea for catches taken in 2015.

Regulations allowing quota transfers from Division 3.a 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 3.a 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 2016 the industry (Pelagic RAC) informed HAWG that about 54% of the catches in the C-fleet will be taken in Division 3.a.

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. The amount of catch taken in the first quarter varies between years in Division 3.a, however, there is no clear trend over the time-series.

3.1.5 Winter rings vs. ages

To avoid confusion and facilitate comparability among herring stocks with different "spawning style" (i.e., NSAS) the age of WBSS, as well as other HAWG herring stocks, is specified in terms of winter rings (wr) throughout the entire assessment and advice. In the case of WBSS perfect correspondence exists between wr and age with no actual risk of confusion, so that a wr 1 is also an age 1 WBSS herring.

3.2 Biological composition of the landings

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 DCMAP, however, as the landings were minor in certain areas and periods, the regulation of 1 sample per 1 000 t landed resulted in few samples being taken (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 3.a 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 3.a in 2015 was estimated to be 15 348 t, which is the second lowest value of the time series (Table 3.2.13).

Total catches of WBSS from the North Sea, Division 3.a, and subdivisions 22–24 respectively, by quarter, were estimated for 2015 (Table 3.2.14). Additionally, the total catches of WBSS in numbers and tonnes, divided between the North Sea and Division 3.a and subdivisions 22–24 respectively for 1993–2015, are presented in Tables 3.2.15 and 3.2.16.

The total catch of NSAS in Division 3.a amounted to 14 692 t in 2015, which is within the lower ranges of values of the time series (Table 3.2.17).

The catches of WBSS from Subarea 4.aE and the catches of NSAS from Division 3.a in 2015 were reallocated to the appropriate stocks as shown in the text table below:

Stock	Catch reallocation	Tonnes
WBSS	4.aE (A-fleet)	2 205
NSAS	3.a (C-fleet)	14 692

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 2015 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 2015 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). 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 (Spring spawners) and NSAS (Autumn spawners) in Division 3.a 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 1671 with 42% of the samples in Division 3.a North (Skagerrak) and 58% in Division 3.a South (Kattegat).

Sampling for split of commercial catches in the transfer area in Division 4.a East in 2015 was based on 3106 Norwegian vertebral count (VC) observations from scientific cruises and commercial catches in the period 2008-2015 The applied method was based on the average VC by age group and quarters 1-3 as described in the stock annex. For 2015 quarter 4 the split was based on 361 Danish samples of otolith microstructure and otolith shape.

There are indications of mixing with Central Baltic herring in catches from SD 24 throughout the year from most of the countries. However, the catches are dominated by the German directed fishery in the spawning areas where mixing is likely to be minimum. Catch data are not corrected for this mixing neither potential catches of Western Baltic Spring Spawning herring from SD 25–26.

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 1 – 19 October 2015 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 (ICES CM 2016/SSGEIOM:05). 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 (wr) classes (0–8+) are included in the assessment.

In the western Baltic, the distribution areas of two stocks, the Western Baltic Spring Spawning herring (WBSSH) and the Central Baltic herring (CBH) overlap. Survey results indicated in the recent years 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 (ICES 2013/ACOM:46). Accordingly, a stock separation function (SF) based on growth parameters in 2005 to 2010 has been developed to quantify the proportion of CBH and WBSSH in the area (Gröhsler *et al.* 2013; Gröhsler *et al*. 2016). The estimates of the growth parameters based on baseline samples of WBSSH and CBH in 2011-2014 and in 2015 support the applicability of SF (Oeberst *et al.*, 2013 – WD for HAWG 2013; Oeberst *et al.*, 2014 – WD for WGIPS 2014; Oeberst *et al.*, 2015 – WD for WGIPS 2015; Oeberst *et al.*, 2016 – WD for WGBIFS 2016). Thus, SF was applied to correct the GERAS index for WBSS from 2005–2015.

The age-length distribution of herring in SD 22 in 2015 for the first time indicated a higher contribution of older fish of CBH origin. Thus, the SF was also applied in SD 22.

The present results in SD 23 further show an unusual, very high contribution of mature herring in 2015 (percentage of maturity stages ≥6 in 2015: 31%; mean 1994–2014: 3%), which cannot be considered of WBSSH origin. Accordingly, the fraction of 'mature' herring has not been taken into account in the final analysis.

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 index in 2015 was estimated to be 2.5×10^9 fish or about 146.1×10^3 tonnes in subdivisions 21–24. Compared to previous results, the present estimates of herring show a significant decrease in biomass. The biomass index in 2015 is now below its long-time average (1993–2014: 195.5 kt).

3.3.2 Herring Summer Acoustic Survey (HERAS) in Division 3.a

The Herring acoustic survey (HERAS) was conducted from 25 to 8 July 2015 and covered the Skagerrak and the Kattegat. The 1999 survey was excluded from the assessment due to different survey area coverage. The 2015 estimate of Western Baltic spring-spawning herring SSB was 207 000 tonnes and 1 447 million herring. This is nearly a doubling of the 2014 estimates of 128 000 tonnes and 791 million fish and brings the stock back in line with abundances observed in the period prior to 2009. (ICES CM 2016/SSGIEOM:05). The stock is dominated by 1 and 2 wr fishes, and their abundance increased by a factor of 4 and 3 respectively when compared to estimate in 2014 and now in a comparable order of magnitude as it has been in the past. The numbers of older herring (3+ wr group) in the stock has continued to be relatively low, although an increase was observed in 2015. When compared to 2014, the mean weight at age has increased considerably for herring aged 0 wr but decreased for all ages above (exception age 3 with similar weight at age between years). The amount of mature fish was twice as high as the numbers measured in 2014 (791 million).The results from the HERAS index are summarised in Table 3.3.2. Ages (wr) 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 2015 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 2015 recruitment index N20 derived from the survey is 2,478 million larvae, which is in the lower range of the time series (Table 3.3.3). However, it is about five times higher than the record low of 2014 (539 million larvae).

3.3.4 IBTS Q1 and Q3

The International Bottom Trawl Surveys (IBTS) in Division 3.a are part of the IBTS surveys in the North Sea. The survey is conducted during January (Q1) and August (Q3) 2014, and covers the Kattegat and Skagerrak. Details of the surveys are provided in the IBTSWG report (ICES CM 2015/SSGEIOM:24). Catch per unit effort (CPUE; n/h) were retrieved from DATRAS database (http://datras.ices.dk). The IBTS Q1 index for 2015 shows a high value for age (wr) 1. The index is low for age (wr) 3 and particularly age (wr) 4 which records the third lowest value of the time series.

The IBTS Q3 age (wr) 1 index shows high values in the last two years and records a even higher value in 2015. Age (wr) 2 and 3 are comparable with the average values during the time series. The age (wr) 4 index in 2015 records the highest value of the last 20 years. However, the IBTS indices show overall highly variable behaviour and low internal consistency. Since the recent benchmark (ICES 2013/ACOM:46), ages (wr) 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/ACOM:46). WKPELA in 2013 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 2015/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 2015 were available from both the GERAS and the N20 larval surveys (see Section 3.3.1 and 3.3.3, respectively). Consistency between the two surveys appears poor also in 2015. The N20-based index shows a minor increase from the last year low record, (Table 3.3.3), while the GERAS-based index for age 0 shows a major decrease after the very high value recorded in 2014.

3.6 Assessment of Western Baltic spring spawners in Division 3.a and subdivisions 22-24

3.6.1 Input data

3.6.1.1 Landings data

Catch in numbers at age from 1991 to 2015 were available for Subdivision 4.a (East), Division 3.a 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 (wr) 0-1 are assumed to be all immature, ages (wr) 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

According to the last benchmark of WBSS (ICES 2013/ACOM:46), the following age (w-rings) classes (in grey) are used from each survey to tune the assessment of this stock:

<table>
<tr><th>Survey</th><th>0</th><th>1</th><th>2</th><th>3</th><th>4</th><th>5</th><th>6</th><th>7</th><th>8+</th></tr>
<tr><td>HERAS</td><td></td><td bgcolor="grey"></td><td bgcolor="grey"></td><td bgcolor="grey"></td><td bgcolor="grey"></td><td bgcolor="grey"></td><td bgcolor="grey"></td><td bgcolor="grey"></td><td bgcolor="grey"></td></tr>
<tr><td>GERAS</td><td bgcolor="grey"></td><td bgcolor="grey"></td><td bgcolor="grey"></td><td bgcolor="grey"></td><td bgcolor="grey"></td><td bgcolor="grey"></td><td bgcolor="grey"></td><td bgcolor="grey"></td><td bgcolor="grey"></td></tr>
<tr><td>N20</td><td bgcolor="grey"></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>IBTS Q1</td><td></td><td bgcolor="grey"></td><td bgcolor="grey"></td><td bgcolor="grey"></td><td bgcolor="grey"></td><td></td><td></td><td></td><td></td></tr>
<tr><td>IBTS Q3</td><td></td><td bgcolor="grey"></td><td bgcolor="grey"></td><td bgcolor="grey"></td><td bgcolor="grey"></td><td></td><td></td><td></td><td></td></tr>
</table>

3.6.2 Assessment method

The assessment of WBSS is based on the state-space assessment model SAM (https://www.stockassessment.org). The assessment is run using FLSAM which implements an R based version of SAM embedded within the FLR library (Kell *et al.* 2007). 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 2015 is 125 744 [102 630, 153 586 (95% CI)] t. The mean fishing mortality (ages 3–6) is estimated as 0.256 [0.196, 0.333 (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 less than 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. SSB is progressively increased afterward. The 2015 estimate records a 5% increase from 2014.

Fishing mortality on this stock was high in the mid-1990s, reaching a maximum of over 0.6 yr^{-1}. In 1999–2009 F_{3-6} stabilised around 0.5. In 2010 and 2011 F_{3-6} decreased significantly to the value of approx. 0.32 yr^{-1}. Estimates of F_{3-6} are at the lowest in 2014 with a value of 0.24. The 0.26 yr^{-1} value estimated in 2015 represents the second lowest estimates (Table 3.6.12, Figure 3.6.4.1).

0.86 in 2015 (it was 0.83 in 2014). The observation variance estimated for each data component is largely in agreement with the last year assessment (ICES 2015/ACOM:06).

Inspection of the residuals for the catch shows a good fitting of the catch-at-age matrix. The catch residuals are very small to the last year assessment and generally free from patterns over both time or ages (Figure 3.6.4.5–13, 3.6.4.41).

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 3.6.4.15–39, 3.6.4.41). In this respect, a generally good fit is found for the age (wr) 3–6 of the HERAS index, age (wr) 4 of the GERAS index, with the exception of a major outlier in 2009, and for the ages (wr) 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 (wr) 1–2 in IBTS Q3. The model shows also poor fitting of the age (wr) 1 HERAS index and the age (wr) 0 GERAS index. Inspection of the residuals shows the occurrence of some year effects (i.e., 2009 in the GERAS and 2013 in HERAS; Figure 3.6.4.41) 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 (wr) 5+. The selection pattern is relatively stable throughout the time period of the assessment, but selectivity of age (wr) 4 has progressively increased in recent years (Figure 3.6.4.4).

The estimated surveys catchability are rather different among the surveys (Figure 3.6.4.40). In the GERAS survey, age (wr) 0 has the highest catchability, which rapidly drops for age (wr) 1 and 2. Then it progressively increases up to age (wr) 5 to level a bit lower in ages (wr) 7–8+. In the HERAS survey, age (wr) 1 has the lowest catchability, while ages (wr) 2–3 have the highest catchability which declines for the oldest age groups. Even more pronounced reduction in catchability is estimated from age (wr) 1 to age (wr) 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.

The estimated correlation parameter in the F random walk of 0.86 is reflected in highly parallel fishing mortality at age estimates (Figure 3.6.4.42).

Retrospective analysis suggests that the assessment method gives a consistent perception of the stock and its dynamics (Figure 3.6.4.43). The changes from year-to-year retrospective analysis are within the uncertainty of the estimated values 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 3.6.4.44).

The stock-recruitment plot for this stock (Figure 3.6.4.45) does not show a 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 progressively increased after the estimated minimum in 2011. Fishing mortality ($F_{3–6}$) was drastically reduced in 2010 (0.35 yr^{-1}) and 2011 (0.29 yr^{-1}), it showed some increase in 2012 and 2013 (0.31 yr^{-1}) and decreased again to minimum levels in the last two years. The estimate of F_{3-6} for 2015 is 0.26 yr^{-1}.

Recruitment has declined consistently from 1999, causing the following continuous reduction of SSB. After a minimum in 2008–2009 recruitment has fluctuated around low values. Under a historical perspective the estimates of SSB are considered still low, but show a positive trend since 2012.

3.8 Comparison with previous years perception of the stock

Overall there is a minor upward revision of SSB and downward revision of F for the 2013 and 2014 estimates, which do not change our perception of the stock dynamics. F has been revised downward of 5.5% for 2013 and 6.5% for 2014. The text table below summarises the differences between the current and the previous year assessments.

Parameter	Assessment in 2015	Assessment in 2016	Diff. 16–15 (+/-) %
SSB (t) 2013	110757	112885	1,9
F(3-6) 2013	0,327	0,309	-5,5
Recr. ('000) 2013	1943498	1928012	-0,8
SSB (t) 2014	118542	119857	1,1
F(3-6) 2014	0,261	0,244	-6,5
Recr. ('000) 2014	2024837	1955194	-3,4

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 2016 assessment, recruitment for the forecasts was calculated on the period 2010–2014). 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 (2013–2015). 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 2016

A catch constraint was assumed for the intermediate year (2016) by the following procedure:

The EU – Norway agreement allows an optional transfer of 50% of the human consumption TAC for herring in Division 3.a into the Area 4 in the North Sea. Based on industry consultations the 2015 advice assumed a 46% transfer of the C-fleet quota from Division 3.a to the North Sea. With an actual transfer of 49%, forecasts are considered relatively precise. Based on information from the Pelagic RAC ICES assumes a 46% TAC transfer in 2016. This assumption influences the perception of the stock development in 2016 and 2017.

Misreporting of catches from the North Sea into Division 3.a is no longer assumed to occur after 2008. Therefore no account was taken in the compilations.

The catch by the F-fleet fishing for human consumption in subdivisions 22–24 in 2015 was close to the TAC and utilisation of 100% is assumed for the intermediate year. The TAC utilisation for the C-fleet in Division 3.a is assumed to be 54% (based on consultation with the industry). The proportion of the TAC taken in the small meshed fishery (D-fleet) has varied between 43% and 94% during the last four years. However with the landings obligation in force from 2015 a 100% TAC utilisation for the intermediate year is assumed for the D-fleet.

The catch of herring in Division 3.a consists of both WBSS and NSAS components. The expected catch of WBSS in Division 3.a was calculated assuming the same WBSS proportions in the catch of each fleet in 2016 as the average of 2013–2015 in Division 3.a (58% and, 28% of WBSS in the C- and the D-fleet, respectively).

For the MSY based advice the fractions of the total catch of WBSS in Division 3.a and subdivisions 22–24 taken by each of the three fleets C, D, and F are assumed to be equal to the predicted utilised TAC in the respective areas times the proportion of WBSS in the catches for the assessment year 2015.

A constant amount of 2205 t of WBSS taken in Division 4.aE by the A-fleet in 2015 is also assumed in 2016.

The mix of the two stocks in the Division 3.a catches is used to derive the out-take of NSAS and total catches in Division 3.a, whereas the Subdivision 22–24 TAC is assumed to be only WBSS herring.

Summary: predicted catches for 2016 of WBSS and NSAS by fleet in 3.a are based on 1) the expected TAC utilisation of 54% by the C-fleet (provided by the industry) a TAC utilisation of 100% in the D-fleet plus a constant catch of WBSS in 4.aE (2015 catch) and 2) the 2013–2015 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 46 362 t WBSS in 2016.

3.9.3 Catch options for 2017

The output of the short-term prediction, based on a catch constraint in the intermediate year 2015 of 41 483 t is given in Table 3.9.2.

The following catch options for 2016 were explored with an invariant selection pattern over all fleets for options 1–4:

1) F_{MSY} = 0.32.
2) Zero catch.

3) F_{MSY} lower bound
4) F_{MSY} upper bound
5) A proportional 15% reduction of F_{MSY} based catches for 2017.
6) As for option 3, but with no change in the TAC.
7) A proportional 15% increase of F_{MSY} based catches for 2017.
8) 0.01 intervals between F_{MSY} lower and upper bounds

For catches following the management rule for the C-fleet in catch options 7-9 the following changes were made to the assumptions:

i) Individual fleet wise selection patterns are applied according to the 2012-2015fishing pattern

ii) The F fleet takes 50% of the catch calculated according to F_{MSY} = 0.32 and thus kept constant.

iii) The D fleet catches are kept constant taking 100% of the by-catch quota.

iv) The WBSS catch in the A fleet corresponds to 0.38% of the catch.

9) Catches according to i)-iv) with 0% transfer of quotas to the North Sea
10) Catches according to i)-iv) with a 50% transfer of quotas to the North Sea

3.9.4 Exploring a range of total WBSS catches for 2017 (advice year)

ICES gives advice according to F_{MSY} = 0.32 for the WBSS stock.

Option	Rationale	Catch (2017)	Basis	F catch (2017)	SSB (2017)*	SSB (2018)*	% SSB change**	% Advice change***
1	FMSY	56802	F = FMSY	0.32	153971	154361	+0.3	+8.1
2	Zero catch	0	F(2015) × 0	0	158875	210237	+32.3	-100.0
3.a	FMSY ranges without Advice Rule^	42375	MSY Flower	0.23	155334	168262	+8.3	-19.4
3.b		70164	MSY Fupper	0.41	152620	141682	-7.2	+33.5
4.a	FMSY ranges with Advice Rule included^	42375	F = MSY Flower(AR) × (SSB2016/ MSY Btrigger)	0.23	155334	168262	+8.3	-19.4
4.b		70164	F = MSY Fupper(AR) × (SSB2016/ MSY Btrigger)	0.41	152620	141682	-7.2	+33.5
5	TAC roll-over − 15%	51254	TAC(2015) × 0.85	0.29	154506	159120	+3.0	-2.5
6	TAC roll-over	59910	TAC(2015) × 1	0.34	153665	151700	-1.3	+14.0
7	TAC roll-over + 15%	68566	TAC(2015) × 1.15	0.40	152786	144310	-5.5	+30.5
8	Other options	44033	MSY Flower differing by 0.01	0.24	155182	166653	+7.4	-16.2
		45678	MSY Flower differing by 0.02	0.25	155030	165061	+6.5	-13.1
		47308	MSY Flower differing by 0.03	0.26	154878	163485	+5.6	-10.0
		48924	MSY Flower differing by 0.04	0.27	154727	161925	+4.7	-6.9
		50527	MSY Flower differing by 0.05	0.28	154575	160381	+3.8	-3.8
		52115	MSY Flower differing by 0.06	0.29	154424	158853	+2.9	-0.8
		53691	MSY Flower differing by 0.07	0.30	154273	157340	+2.0	+2.2
		55253	MSY Flower differing by 0.08	0.31	154122	155843	+1.1	+5.1
		58337	MSY Fupper(AR) differing by 0.08	0.33	153820	152894	-0.6	+11.0
		59860	MSY Fupper(AR) differing by 0.07	0.34	153670	151442	-1.4	+13.9
		61370	MSY Fupper(AR) differing by 0.06	0.35	153519	150005	-2.3	+16.8
		62867	MSY Fupper(AR) differing by 0.05	0.36	153369	148582	-3.1	+19.6
		64351	MSY Fupper(AR) differing by 0.04	0.37	153219	147174	-3.9	+22.5
		65823	MSY Fupper(AR) differing by 0.03	0.38	153069	145780	-4.8	+25.3
		67282	MSY Fupper(AR) differing by 0.02	0.39	152919	144400	-5.6	+28.0
		68729	MSY Fupper(AR) differing by 0.01	0.40	152769	143034	-6.4	+30.8

*** For spring-spawning stocks, the SSB is determined at spawning time and is influenced by fisheries and natural mortality between 1 January and spawning time (April).**

**** SSB (2018) relative to SSB (2017).**

***** Catch 2017 relative to ICES advice 2016 for the western Baltic spring-spawning herring stock.**

^ According to ICES (2015c), F_{MSY} ranges are specified with and without the ICES Advice Rule (AR). For ranges without the AR, F_{lower} and F_{upper} are not modified by SSB in the catch advice year. For the ranges with the AR, SSB_{2016} < MSY $B_{trigger}$; therefore, $F_{lower(AR)}$ and $F_{upper(AR)}$ are reduced by the factor SSB / MSY $B_{trigger}$.

ICES has evaluated the agreed management rule between EU and No and found it precautionary under the assumption of a minimum 10% quota transfer from Division 3.a to the North Sea, see management considerations (ICES 2015c). The TAC for 2016 was set according to the management rule and ICES assumes that TAC settings for 2017 will follow the management rule. Therefore ICES also provides fleet-wise catch options based on the implementation of the LTMP for the North Sea. Catch options 9 and 10 assume 0% and 50% quota transfer from 3.a into 4

The tables below gives the 2017 fleet wise catch options for the Western Baltic spring spawners and North Sea North Sea autumn spawners in Division 3.a, in subdivisions 22–24, and in Subarea 4.aE for the catch options described in section 3.9.3. The options follow the North Sea LTMP, the WBSS catch advice with F_{MSY} = 0.32, and the agreed EU Norway management rule with 0% and 50% TAC transfer flexibility.

Option		Fishing mortality			TACs and catch (t) by fleet									
		NSAS	NSAS	WBSS	Fleet A		Fleet B	Fleet C		Fleet D		Fleet F	Total catch	
		F ages (wr)2-6	F ages (wr)0-1	F ages (wr)3-6										
	Area	All	All	All	4 & 7.d		4 & 7.d	3.a		3.a		22–24	NSAS	WBSS
9	Area TAC (LTMP, F_{MSY})	0.286	0.05	0.339	427964		8020	47586		6659		28401	458926	59704
	Stock	NSAS F ages (wr)2-6	NSAS F ages (wr)0-1	WBSS F ages (wr)3-6	NSAS	WBSS	NSAS	NSAS	WBSS	NSAS	WBSS	WBSS	NSAS	WBSS
9	Predicted catch 0% transfer	0.286	0.05	0.339	426259	1705	8020	19986	27600	4661	1998	28401	458926	59704
10	Predicted catch 50% transfer	0.298	0.05	0.252	450052	1800	8020	9993	13800	4661	1998	28401	472726	45999

The amount of WBSS catch in Division 4a East is highly variable since it is dependent on the geographical distribution of the stock components. As for 2015 a catch of 2 205 t WBSS herring taken in the transfer area in Division 4.a East is assumed for the MSY-based advice. For the fleet-wise catch options based on the 3.a management rule a % split for herring catch in 4a east is applied.

3.10 Reference points

Based on a B_{lim} value of 90 000 t (equal B_{loss}, ICES 2013/ACOM:46), the B_{pa} 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).

The F_{MSY} reference point for WBSS was estimated in 2014 by WKMSYREF 2014 (ICES 2014/ACOM:64) using the function eqSim in the R package 'msy'. The estimated F_{MSY} value of 0.32 yr^{-1} with lower and upper bounds (F_{MSY} lower = 0.23 and F_{MSY} upper=0.41) and FP0.5=0.46 (5% risk to B_{lim}) as proxy for F_{pa} were based on stochastic simulation of recruitment generated on a combination of Beverton & Holt, Ricker and segmented regression (ICES 2014/ACOM:64). F_{lim} was estimated using eqSim with settings F_{phi} and F_{cv} set to 0 and the returned value for F50 was adopted as F_{lim}, as stipulated by the ICES guidelines on estimation of reference points.

For the only purpose of monitoring the development of reference points, the same settings were applied on the present assessment and on 5-years retrospective and value of F_{MSY} estimated (Figure 3.10.1). This year assessment resulted in $F_{MSY} = 0.27$ which appears in line with old estimates prior the 2014 revision.

Further scrutinising of F_{MSY} is needed for WBSS, together with an evaluation for a long term management plan for the stock.

3.11 Quality of the Assessment

The 2015 assessment follows the procedures and settings specified in the Stock Annex. The assessment has proved to provide stable estimates and perception of the stock. This is also confirmed by the low variability in the retrospective perception of the stock which is within the estimated confidence limits. Model residuals were examined for all the components (catch and survey indices) and no major undesirable pattern was observed.

During the 2013 benchmark mixing of WBSS and Central Baltic herring (CBH) in SD24 was investigated. The mixing in catches and its variability in time is unknown, but it is expected to change as a function of variable distributions of the two stocks as well as variability in the spatial and temporal distribution of the fisheries. Indications of mixing between the two stocks exist in 2015 catch data and the working group reiterates the need for future specific investigations on the issue.

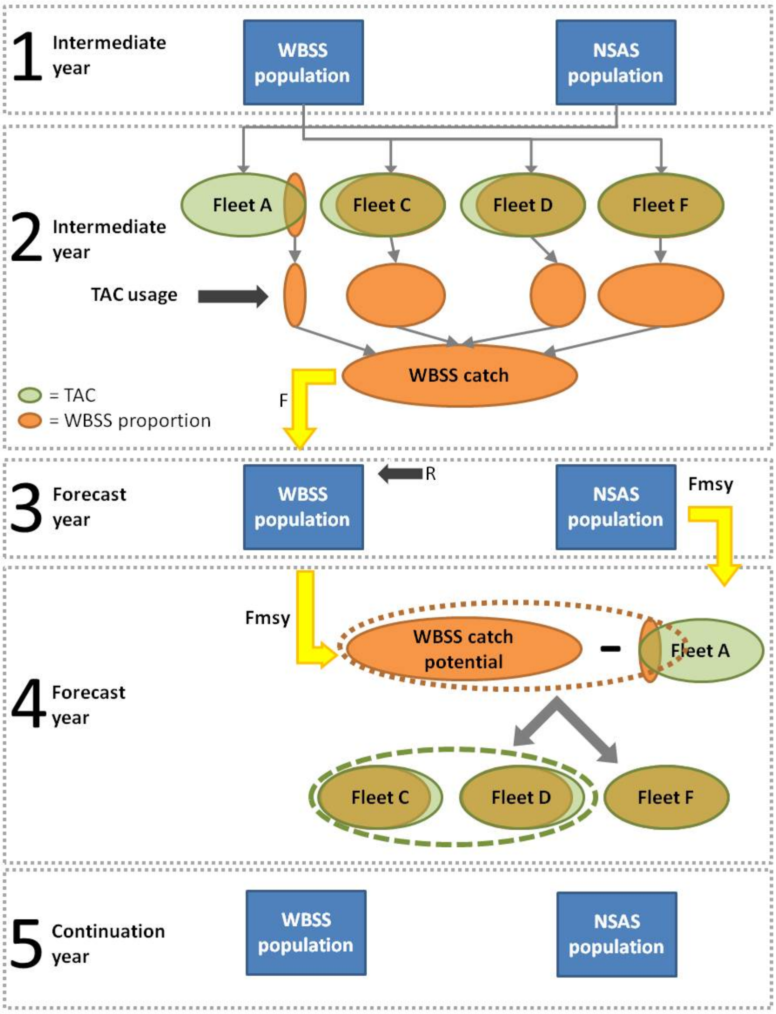
3.12 Management Considerations

Quotas in Division 3.a

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 for human consumption can optionally be transferred from Division 3.a and taken in Area 4 as NSAS in 2016. ICES assumes that a transfer of 46% will be applied in 2016.

ICES catch predictions versus management TAC

ICES gives advice on catch options for the entire distribution of the NSAS and WBSS herring stocks separately whereas herring is managed by areas (see the following text diagram). The procedure of setting TACs in ICES Division 3.a and SD22–24 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 are 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 4a East area where they take it as a mixture of mainly NSAS and partly WBSS) the C and D fleet (within the 3.a 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 that the WBSS stock is 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 constant recruitment. The calculation of the stock size January 1st in the forecast year is needed to project catches in the forecast year.

Box 4: The management rule for the C-fleet TAC uses the potential WBSS catches calculated from the F_{msy} advice plus a fraction of the NSAS LTMP TAC to define the total TAC in ICES Division 3.a as well as SD22–24 (see Application of the management rule below). Dependent on the relative development of the NSAS and WBSS stocks and the quota transfer from the C-fleet to the A-fleet the realised WBSS catches may deviate from the predictions based on F_{msy}.

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.

Application of the management rule for the herring fishery for human consumption in Division 3.a

The agreed management rule was evaluated by ICES and found precautionary under the conditions of a minimum quota transfer of 10% from Division 3.a C fleet to the North Sea (ICES 2015/ACOM:47).

This management rule is the basis for setting the C-fleet TAC in Division 3.a, calculated as the sum of 41% of the WBSS MSY advised catch and 5.7% of the North Sea herring management plan determined TAC for the A-fleet, with a further associated TAC constraint of +/- 15% for the C-fleet.

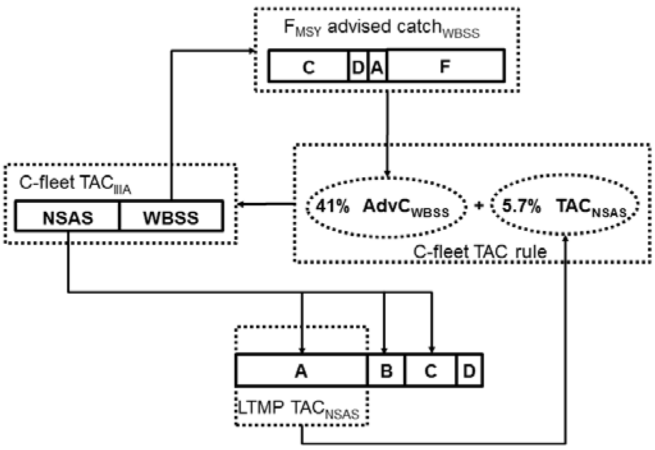
Data used for catch options for 2017 (advice year)

The catches at F_{msy} in 2017 of WBSS were calculated according to the specifications in sec. 3.9.3 option 1. Of this total WBSS ICES MSY advice, 50% was allocated to the F fleet, a constant catch in the D fleet was calculated as the bycatch TAC x $split._D$ = 1 731 t ($split._D$ = 0.28) and a percentage of the A-fleet (0.38%) allocated to catches of WBSS in the A fleet in 4aEast. The catch of WBSS in the C fleet was estimated as the WBSS proportion ($split._C$=0.58) in the C fleet TAC according to the rule:

*TAC Skagerrak and Kattegat = (TAC_NSAS * 5.7%) + (WBSS ICES MSY advice * 41%) with an associated TAC constraint of +/- 15%.*

The TAC calculation is circular and may be described by the following pseudo code and illustrated by the schematic below:

1. Rule starting conditions are calculated as 41% of $WBSS_{MSYadvice}$*(1+NSAS:WBSS) → C-fleet TAC^1
2. C-fleet TAC^i → resulting catches are split according to stock composition: WBSS in C-fleet + NSAS in C-fleet
3. NSAS in C-fleet + NSAS in D-fleet are fixed → catch options for NSAS in B-fleet and A-fleet (given F_{0-1} and F_{2-6} in LTMP)
4. 5.7% of NSAS in A,B,C and D-fleets + 41% of $WBSS_{MSYadvice}$ → C-fleet TAC^{i+1}
5. i=i+1
6. IF C-fleet TAC^{i+1} <> C-fleet TAC^i GOTO 1)



3.13 Ecosystem considerations

Herring in Division 3.a and subdivisions 22–24 is a migratory stock. There are feeding migrations from the Western Baltic into more saline waters of Division 3.a and the eastern parts of Division 4a. 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 3.a 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 2013 and 2014 point estimates of recruitment appear slightly higher than the estimates for the previous 7 years, but the associated confidence intervals still suggests high uncertainty in the interpretation. 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), however at the moment there is no understanding of the mechanisms driving this relationship. At the current stage there are no indications of systematic changes in growth or age at maturity that could be related to environmental variability, as well as there is no clear study that linked WBSS recruitment to the abundance of prey and/or predators. 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 not conclusive (Cardinale *et al.* 2009).

Table 3.1.1 Western Baltic Spring Spawning Herring. Total catch (both WBSS and NSAS) in 1989–2015 (1000 tonnes). (Data provided by Working Group members 2016).

Year	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Skagerrak													
Denmark	47.4	62.3	58.7	64.7	87.8	44.9	43.7	28.7	14.3	10.3	10.1	16.0	16.2
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	9.7	
Sweden	47.9	56.5	54.7	88.0	56.4	66.4	48.5	32.7	32.9	46.9	36.4	45.8	30.8
Total	96.9	124.4	121.5	166.6	168.4	129.0	108.9	70.8	56.0	65.2	53.9	71.5	47.0
Kattegat													
Denmark	57.1	32.2	29.7	33.5	28.7	23.6	16.9	17.2	8.8	23.7	17.9	18.9	18.8
Sweden	37.9	45.2	36.7	26.4	16.7	15.4	30.8	27.0	18.0	29.9	14.6	17.3	16.2
Total	95.0	77.4	66.4	59.9	45.4	39.0	47.7	44.2	26.8	53.6	32.5	36.2	35.0
Subdivisions 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	32.6	28.3
Germany	56.4	45.5	15.8	15.6	11.1	11.4	13.4	7.3	12.8	9.0	9.8	9.3	11.4
Poland	8.5	9.7	5.6	15.5	11.8	6.3	7.3	6.0	6.9	6.5	5.3	6.6	9.3
Sweden	6.3	8.1	19.3	22.3	16.2	7.4	15.8	9.0	14.5	4.3	2.6	4.8	13.9
Total	92.9	76.9	65.9	80.3	77.1	64.6	73.3	56.7	64.7	49.9	50.2	53.3	62.9
Subdivision 23													
Denmark	1.5	1.1	1.7	2.9	3.3	1.5	0.9	0.7	2.2	0.4	0.5	0.9	0.6
Sweden	0.1	0.1	2.3	1.7	0.7	0.3	0.2	0.3	0.1	0.3	0.1	0.1	0.2
Total	1.6	1.2	4.0	4.6	4.0	1.8	1.1	1.0	2.3	0.7	0.6	1.0	0.8
Grand Total	286.4	279.9	257.8	311.4	294.9	234.4	231.0	172.7	149.8	169.4	137.2	162.0	145.7

Year	2002	2003	2004	2005	2006**	2007	2008	2009	2010	2011	2012	2013	2014	2015*
Skagerrak														
Denmark	26.0	15.5	11.8	14.8	5.2	3.6	3.9	12.7	5.3	3.6	3.2	4.9	6.4	4.1
Faroe Islands				0.4			0.0	0.6	0.4					0.5
Germany		0.7	0.5	0.8	0.6	0.5	1.6	0.3	0.1	0.1	0.6	0.2	0.1	0.1
Lithuania									0.4					
Netherlands														0.03
Norway						3.5	4.0	3.3	3.3	0.1	0.4	3.0	2.0	2.5
Sweden	26.4	25.8	21.8	32.5	26.0	19.4	16.5	12.9	17.4	9.5	16.2	16.7	12.6	12.9
Total	52.3	42.0	34.1	48.5	31.8	26.9	26.0	29.7	27.0	13.2	20.5	24.8	21.2	20.1
Kattegat														
Denmark	18.6	16.0	7.6	11.1	8.6	9.2	7.0	4.9	7.6	5.2	6.3	3.9	4.3	4.0
Sweden	7.2	10.2	9.6	10.0	10.8	11.2	5.2	3.6	2.7	1.7	0.8	2.6	3.4	3.8
Germany								0.6	0.0					
Total	25.9	26.2	17.2	21.1	19.4	20.3	12.2	9.1	10.3	6.8	7.1	6.5	7.7	7.7
Subdivisions 22+24														
Denmark	13.1	6.1	7.3	5.3	1.4	2.8	3.1	2.1	0.8	3.1	4.1	5.1	4.3	4.5
Germany	22.4	18.8	18.5	21.0	22.9	24.6	22.8	16.0	12.2	8.2	11.2	14.6	10.2	13.3
Poland		4.4	5.5	6.3	5.5	2.9	5.5	5.2	1.8	1.8	2.4	3.1	2.4	2.6
Sweden	10.7	9.4	9.9	9.2	9.6	7.2	7.0	4.1	2.0	2.2	2.7	2.1	1.1	1.5
Total	46.2	38.7	41.2	41.8	39.4	37.6	38.5	27.4	16.8	15.3	20.4	24.8	18.0	21.9
Subdivision 23														
Denmark	4.6	2.3	0.1	1.8	1.8	2.9	5.3	2.8	0.1***	0.03	0.04	0.04	0.05	0.03
Sweden		0.2	0.3	0.4	0.7		0.3	0.8	0.9	0.5	0.7	0.6	0.3	0.2
Total	4.6	2.6	0.4	2.2	2.5	2.9	5.7	3.6	1.0	0.6	0.7	0.7	0.4	0.2
Grand Total	128.9	109.5	92.8	113.6	93.0	87.7	82.3	69.9	55.2	35.9	48.8	56.7	47.2	50.0

*Preliminary data

**2,000 t of Danish catches are missing (HAWG 2007)

***3,103 t officially reported catches (HAWG 2011)

Table 3.1.2 Western Baltic Spring Spawning Herring. Catch (SOP) in 2003–2015 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
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
2013	1	8.5	0.8	11.7	20.9
	2	1.7	0.6	8.5	10.8
	3	8.4	1.0	1.1	10.4
	4	9.8	0.5	4.3	14.7
	Total	28.4	2.9	25.5	56.7
2014	1	6.2	0.2	10.8	17.3
	2	2.3	0.5	2.3	5.1
	3	10.7	2.4	0.8	14.0
	4	5.7	0.8	4.4	10.9
	Total	24.9	4.0	18.3	47.2
2015	1	9.0	1.9	14.2	25.1
	2	1.0	0.1	2.8	3.9
	3	7.5	1.5	0.9	9.9
	4	4.1	2.8	4.3	11.1
	Total	21.6	6.3	22.1	50.0

Table 3.2.1 Western Baltic Spring Spawning Herring. Catch in numbers (mill.), mean weight (g.) and SOP (t) by age as W-ringers and quarter (both WBSS and NSAS). Division: Skagerrak, Year: 2015, Country: ALL

		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
1	1	3.60	21	11.28	13	14.88	15
	2	54.21	65	10.11	56	64.32	64
	3	9.57	104	0.23	98	9.80	104
	4	3.20	142			3.20	142
	5	4.35	164	0.13	147	4.49	164
	6	0.76	193			0.76	193
	7	0.23	188			0.23	188
	8+	0.56	208			0.56	208
	Total	76.48		21.76		98.24	
	SOP		6,092		759		6,851
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
2	1	0.49	21	4.65	13	5.15	14
	2	7.44	65	4.65	17	12.10	47
	3	1.31	104			1.31	104
	4	0.44	142			0.44	142
	5	0.60	164			0.60	164
	6	0.10	193			0.10	193
	7	0.03	188			0.03	188
	8+	0.08	208			0.08	208
	Total	10.50		9.31		19.81	
	SOP		836		142		978
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
3	0			2.21	18	2.21	18
	1	10.28	50	39.04	27	49.32	32
	2	15.59	112	0.85	56	16.44	109
	3	9.33	150			9.33	150
	4	6.02	164			6.02	164
	5	5.82	182			5.82	182
	6	2.40	196			2.40	196
	7	1.91	197			1.91	197
	8+	1.09	215			1.09	215
	Total	52.45		42.11		94.55	
	SOP		6,787		1,130		7,917
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
4	0	0.73	18	21.98	16	22.71	16
	1	42.36	44	39.89	27	82.24	36
	2	6.71	96	0.57	33	7.28	91
	3	0.76	104			0.76	104
	4	0.77	165			0.77	165
	5	0.73	192			0.73	192
	6	0.17	197			0.17	197
	7						
	8+	0.15	222			0.15	222
	Total	52.37		62.44		114.81	
	SOP		2,926		1,434		4,361
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
Total	0	0.73	18	24.19	16	24.92	16
	1	56.73	43	94.86	24	151.59	31
	2	83.96	76	16.19	44	100.15	71
	3	20.98	124	0.23	98	21.21	124
	4	10.43	156			10.43	156
	5	11.50	175	0.13	147	11.63	175
	6	3.43	195			3.43	195
	7	2.16	196			2.16	196
	8+	1.88	213			1.88	213
	Total	191.80		135.61		327.41	
	SOP		16,641		3,466		20,107

Table 3.2.2 Western Baltic Spring Spawning Herring. Catch in numbers (mill.), mean weight (g.) and SOP (t) by age as W-ringers and quarter (both WBSS and NSAS). Division: Kattegat, Year: 2015, Country: ALL

		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
1	1	1.17	16	16.64	13	17.81	13
	2	31.86	61	14.91	56	46.77	59
	3	4.08	95	0.34	98	4.42	96
	4	1.36	119			1.36	119
	5	1.76	162	0.20	147	1.96	161
	6	0.31	158			0.31	158
	7	0.20	184			0.20	184
	8+	0.11	160			0.11	160
	Total	40.85		32.09		72.94	
	SOP		2,895		1,120		4,015
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
2	1	1.57	19	0.25	13	1.83	18
	2	1.88	49	0.25	17	2.13	45
	3	0.10	72			0.10	72
	4	0.07	80			0.07	80
	5						
	6	0.03	155			0.03	155
	7						
	8+						
	Total	3.65		0.51		4.15	
	SOP		138		8		145
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
3	0	0.13	14	1.74	14	1.87	14
	1	0.60	39	12.22	26	12.82	26
	2	3.26	77	0.12	26	3.38	75
	3	0.47	105	0.04	78	0.51	103
	4	1.24	159			1.24	159
	5	1.11	163			1.11	163
	6	0.20	169			0.20	169
	7	0.05	168			0.05	168
	8+	0.06	180			0.06	180
	Total	7.11		14.12		21.24	
	SOP		758		343		1,101
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
4	0	1.25	14	5.97	15	7.23	15
	1	7.98	39	35.29	34	43.26	35
	2	4.33	92	0.65	45	4.98	85
	3	0.84	124			0.84	124
	4	0.73	122	0.12	284	0.85	145
	5	0.91	188			0.91	188
	6	0.15	166			0.15	166
	7	0.03	212			0.03	212
	8+	0.03	239			0.03	239
	Total	16.25		42.03		58.28	
	SOP		1,127		1,339		2,466
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
Total	0	1.38	14	7.71	14	9.09	14
	1	11.33	34	64.40	27	75.72	28
	2	41.32	65	15.94	55	57.26	62
	3	5.48	100	0.38	96	5.87	100
	4	3.40	133	0.12	284	3.52	138
	5	3.78	169	0.20	147	3.97	168
	6	0.69	163			0.69	163
	7	0.27	184			0.27	184
	8+	0.20	177			0.20	177
	Total	67.86		88.75		156.61	
	SOP		4,917		2,810		7,728

Table 3.2.3 Western Baltic Spring Spawning Herring. Catch in numbers (mill.), mean weight (g.) and SOP (t) by age as W-ringers and quarter (WBSS). Subdivisions: 22–24, Year: 2015, 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	35.98	15	0.00	23	6.46	16	42.44	15
	2	11.13	32	0.00	45	32.82	44	43.95	41
	3	0.73	53	0.00	69	16.96	79	17.69	78
	4	0.15	76	0.00	84	30.27	113	30.42	112
	5	0.33	105	0.00	102	20.74	156	21.07	155
	6	0.09	159	0.00	115	11.52	180	11.62	179
	7	0.12	117	0.00	88	4.14	167	4.26	165
	8+	0.06	195	0.00	84	4.82	190	4.88	190
	Total	48.59		0.01		127.73		176.32	
	SOP		1,016		1		13,193		14,209
		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	0.37	14	0.01	11	0.53	15	0.90	15
	2	0.12	38	0.14	25	8.73	33	8.99	33
	3	0.04	75	0.08	40	7.61	59	7.74	59
	4	0.07	106	0.03	57	7.95	89	8.05	89
	5	0.05	158	0.03	62	5.12	113	5.20	113
	6	0.04	178	0.004	115	1.59	161	1.64	162
	7	0.03	186	0.008	82	1.27	141	1.31	142
	8+	0.04	192	0.010	59	1.75	137	1.79	138
	Total	0.75		0.31		34.55		35.61	
	SOP		48		12		2,702		2,762
		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	10.22	7	2.28	7	0.00	14	12.50	7
	1	0.54	23	0.18	30	0.61	27	1.33	26
	2	0.02	76	0.44	78	2.06	65	2.53	68
	3	0.013	84	0.23	86	2.06	68	2.31	70
	4	0.007	99	0.09	100	2.22	64	2.32	66
	5	0.003	139	0.03	131	0.78	71	0.81	74
	6	0.002	152	0.01	98	0.62	63	0.64	64
	7	0.001	156	0.01	116	1.51	58	1.53	58
	8+	0.001	148	0.01	59	1.81	58	1.82	58
	Total	10.81		3.28		11.69		25.78	
	SOP		90		92		721		902
		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	13.66	7	0.41	7	0.10	14	14.17	7
	1	0.73	23	0.11	40	0.73	42	1.57	33
	2	0.50	84	0.69	78	16.12	81	17.32	81
	3	0.30	107	0.36	86	10.11	99	10.77	98
	4	0.25	130	0.15	100	7.26	121	7.65	121
	5	0.11	159	0.05	131	2.60	147	2.76	147
	6	0.05	178	0.02	98	0.90	150	0.97	150
	7	0.04	167	0.02	116	0.72	113	0.77	115
	8+	0.04	196	0.01	59	0.58	132	0.63	134
	Total	15.68		1.81		39.12		56.60	
	SOP		260		117		3,893		4,270
		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	23.88	7	2.69	7	0.10	14	26.67	7
	1	37.62	15	0.29	33	8.34	19	46.24	16
	2	11.77	35	1.28	72	59.73	53	72.78	50
	3	1.08	69	0.67	80	36.75	80	38.51	79
	4	0.48	109	0.28	95	47.68	108	48.44	108
	5	0.49	123	0.11	114	29.25	145	29.85	145
	6	0.19	168	0.03	100	14.64	171	14.86	171
	7	0.18	137	0.03	108	7.64	136	7.86	136
	8+	0.13	194	0.03	59	8.96	149	9.12	149
	Total	75.83		5.41		213.08		294.32	
	SOP		1,413		222		20,508		22,144

Table 3.2.4 Western Baltic Spring Spawning Herring. Samples of commercial catch by quarter and area for 2015 available to the Working Group.

	Country	Quarter	Landings ('000 tons)	Numbers of samples	Numbers of fish meas.	Numbers of fish aged
Skagerrak	**Denmark**	**1**	0.76		No data available	
		2	0.15		No data available	
		3	1.80	15	370	186
		4	1.43	4	151	112
	Total		4.14	19	521	298
	Germany	**1**	-		-	
		2	-		-	
		3	-		-	
		4	0.13		No data available	
	Total		0.13			
	Norway	**1**	0.72		No data available	
		2	0.63		No data available	
		3	0.51		No data available	
		4	0.62		No data available	
	Total		2.48	0	0	0
	Faroe Islands	**1**	0.48		No data available	
		2	-		-	
		3	-		-	
		4	-		-	
	Total		0.48	0	0	0
	Netherlands	**1**	-		-	
		2	-		-	
		3	0.03		No data available	
		4	-		-	
	Total		0.03	0	0	0
	Sweden	**1**	4.90	19	666	666
		2	0.20		No data available	
		3	5.58	29	930	930
		4	2.18	8	670	670
	Total		12.86	56	2,266	2,266
Kattegat	**Denmark**	**1**	1.35	9	3,132	109
		2	0.01	2	42	34
		3	1.01	23	582	357
		4	1.61	6	599	239
	Total		3.98	40	4,355	739
	Sweden	**1**	2.67	9	799	799
		2	0.14	1	150	150
		3	0.09		No data available	
		4	0.86	8	735	735
	Total		3.75	18	1,684	949

Table 3.2.4 (cont') Western Baltic Spring Spawning Herring. Samples of commercial catch by quarter and area for 2015 available to the Working Group.

	Country	Quarter	Landings ('000 tons)	Numbers of samples	Numbers of fish meas.	Numbers of fish aged
Subdivision 22	**Denmark**	**1**	0.73	6	228	136
		2	0.01	No data available		
		3	0.08	No data available		
		4	0.11	2	20	20
	Total		0.93	8	248	156
	Sweden	**1**	-	-		
		2	-	-		
		3	0.00	No data available		
		4	-	-		
	Total		0.00	0	0	0
	Germany	**1**	0.29	3	971	263
		2	0.04	No data available		
		3	0.00	No data available		
		4	0.15	1	590	94
	Total		0.48	4	1,561	357
Subdivision 23	**Denmark**	**1**	-	-		
		2	0.01	No data available		
		3	0.02	No data available		
		4	0.00	No data available		
	Total		0.03	0	0	0
	Sweden	**1**	0.00	No data available		
		2	0.00	No data available		
		3	0.07	No data available		
		4	0.11	No data available		
	Total		0.19	0	0	0
Subdivision 24	**Denmark**	**1**	1.97	3	472	159
		2	0.34	5	62	62
		3	0.12	No data available		
		4	1.13	No data available		
	Total		3.55	8	534	221
	Germany	**1**	9.39	18	6,714	1,466
		2	1.49	7	3,260	615
		3	0.00	No data available		
		4	1.93	3	1,793	374
	Total		12.81	28	11,767	2,455
	Poland	**1**	0.82	7	1,644	449
		2	0.85	9	1,923	589
		3	0.60	2	542	126
		4	0.37	2	306	97
	Total		2.65	20	4,415	1261
	Sweden	**1**	1.01	8	919	919
		2	0.02	No data available		
		3	0.00	No data available		
		4	0.47	4	662	662
	Total		1.49	12	1,581	1,581
Total	**Skagerrak**	**1-4**	**20.1**	**75**	**2,787**	**2,564**
	Kattegat	**1-4**	**7.7**	**58**	**6,039**	**1,688**
	Subdivision 22	**1-4**	**1.4**	**12**	**1,809**	**513**
	Subdivision 23	**1-4**	**0.2**	**0**	**0**	**0**
	Subdivision 24	**1-4**	**20.5**	**68**	**18,297**	**5,518**
	Total	**1-4**	**50.0**	**213**	**28,932**	**10,283**

Table 3.2.5 Western Baltic Spring Spawning Herring. Samples of catch by quarter and area used to estimate catch in numbers and mean weight at age as W-ringers for 2015.

	Country	Quarter	Fleet	Sampling
Skagerrak	**Denmark**	**1**	**C**	No landings
		2	**C**	Swedish sampling in Q1
		3	**C**	Danish sampling in Q3
		4	**C**	No landings
	Germany	**1**	**C**	No landings
		2	**C**	No landings
		3	**C**	No landings
		4	**C**	Swedish sampling in Q4
	Sweden	**1**	**C**	Swedish sampling in Q1
		2	**C**	Swedish sampling in Q1
		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
	Netherlands	**1**	**C**	No landings
		2	**C**	No landings
		3	**C**	Danish sampling in Q3
		4	**C**	No landings
	Faroe Islands	**1**	**C**	Swedish sampling Q1
		2	**C**	No landings
		3	**C**	No landings
		4	**C**	No landings
	Norway	**1**	**C**	Swedish sampling in Q1
		2	**C**	Swedish sampling in Q1
		3	**C**	Danish sampling in Q3
		4	**C**	Swedish sampling in Q4
Kattegat	**Denmark**	**1**	**C**	Swedish sampling in Q1
		2	**C**	Swedish sampling in Q2
		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 Q4
		4	**C**	Swedish sampling in Q4
	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 Q1
		3	**F**	Danish sampling in Q4
		4	**F**	Danish sampling in Q4
	Sweden	**1**	**F**	No landings
		2	**F**	No landings
		3	**F**	Swedish sampling Q4 Fleet F SD 24
		4	**F**	No landings
	Germany	**1**	**F**	German sampling as in WD1 Gröhsler
		2	**F**	German sampling as in WD1 Gröhsler
		3	**F**	German sampling as in WD1 Gröhsler
		4	**F**	German sampling as in WD1 Gröhsler

Fleet C = Human consumption, Fleet D = Industrial catch, Fleet F = All catch from subdivisions 22–24.

Table 3.2.5 (cont') Western Baltic Spring Spawning Herring. Samples of catch by quarter and area used to estimate catch in numbers and mean weight at age as W-ringers for 2015.

	Country	Quarter	Fleet	Sampling
Subdivision 23	**Denmark**	1	F	No landings
		2	F	Danish sampling SD 24 Q2
		3	F	Danish sampling SD 24 Q4
		4	F	Danish sampling SD 24 Q4
	Sweden	1	F	Swedish sampling SD 24 Q1
		2	F	Swedish sampling SD 24 Q1
		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 Q2
		3	F	German sampling of trawlfishery SD 24 Q3
		4	F	German sampling of trawlfishery SD 24 Q4
	Germany	1	F	German sampling as in WD1 Gröhsler
		2	F	German sampling as in WD1 Gröhsler
		3	F	German sampling as in WD1 Gröhsler
		4	F	German sampling as in WD1 Gröhsler
	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 Q1
		3	F	Swedish sampling in Q4
		4	F	Swedish sampling in Q4

Fleet C = Human consumption, Fleet D = Industrial catch, Fleet F = All catch from subdivisions 22–24.

Table 3.2.6 Western Baltic Spring Spawning Herring. Proportion of North Sea autumn spawners (NSAS) and Western Baltic spring spawners (WBSS) given in % in Skagerrak and Kattegat by age as W-ringers and quarter. Year: 2015

		Skagerrak			Kattegat		
Quarter	W-rings	NSAS	WBSS	n	NSAS	WBSS	n
1	1	94.29%	5.71%	35	98.30%	1.70%	54
	2	75.51%	24.49%	49	70.51%	29.49%	61
	3	16.67%	83.33%	48	10.85%	89.15%	50
	4	0.00%	100.00%	20	11.76%	88.24%	17
	5	0.00%	100.00%	23	9.09%	90.91%	22
	6	0.00%	100.00%	4	2.27%	97.73%	5
	7	0.00%	100.00%	0	2.27%	97.73%	2
	8	0.00%	100.00%	2	2.27%	97.73%	2
		Skagerrak			Kattegat		
Quarter	W-rings	NSAS	WBSS	n	NSAS	WBSS	n
2	1	26.76%	73.24%	0	26.76%	73.24%	51
	2	14.00%	86.00%	0	14.00%	86.00%	50
	3	0.00%	100.00%	0	0.00%	100.00%	4
	4	0.00%	100.00%	0	0.00%	100.00%	3
	5	0.00%	100.00%	0	0.00%	100.00%	0
	6	0.00%	100.00%	0	0.00%	100.00%	1
	7	0.00%	100.00%	0	0.00%	100.00%	0
	8	0.00%	100.00%	0	0.00%	100.00%	0
		Skagerrak			Kattegat		
Quarter	W-rings	NSAS	WBSS	n	NSAS	WBSS	n
3	0	100.00%	0.00%	1	90.48%	9.52%	21
	1	85.00%	15.00%	138	66.97%	33.03%	109
	2	72.02%	27.98%	74	18.37%	81.63%	49
	3	47.91%	52.09%	64	33.33%	66.67%	9
	4	9.61%	90.39%	25	29.17%	70.83%	24
	5	73.32%	26.68%	22	40.00%	60.00%	20
	6	46.04%	53.96%	8	0.00%	100.00%	4
	7	62.95%	37.05%	12	0.00%	100.00%	1
	8	31.67%	68.33%	5	0.00%	100.00%	1
		Skagerrak			Kattegat		
Quarter	W-rings	NSAS	WBSS	n	NSAS	WBSS	n
4	0	86.27%	13.73%	16	99.81%	0.19%	64
	1	75.99%	24.01%	74	53.56%	46.44%	169
	2	14.50%	85.50%	49	10.14%	89.86%	70
	3	20.00%	80.00%	10	6.25%	93.75%	48
	4	20.00%	80.00%	10	0.00%	100.00%	19
	5	0.00%	100.00%	10	0.00%	100.00%	31
	6	0.00%	100.00%	2	0.00%	100.00%	5
	7	0.00%	100.00%	0	0.00%	100.00%	0
	8	0.00%	100.00%	1	0.00%	100.00%	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(Ka) Q1
2	3-8+	mean(Ka)	*n=8	3-8+	mean(Ka) Q2
3				6-8+	mean(Ka) Q3
4	5-8+	mean(Sk) Q4		5-8+	mean(Ka) Q4

Table 3.2.7 Western Baltic Spring Spawning Herring. Catch in numbers (mill.), mean weight (g.) and SOP (t) by age as W-ringers, quarter and fleet. North Sea Autumn spawners Division: Kattegat. Year: 2015. Country: All

		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
1	1	1.15	16	16.35	13	17.51	13
	2	22.46	61	10.52	56	32.98	59
	3	0.44	95	0.04	98	0.48	96
	4	0.16	119			0.16	119
	5	0.16	162	0.02	147	0.18	161
	6	0.01	158			0.01	158
	7	0.00	184			0.00	184
	8+	0.00	160			0.00	160
	Total	24.39		26.92		51.32	
	SOP		1,474		812		2,285
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
2	1	0.42	19	0.07	13	0.49	18
	2	0.26	49	0.04	17	0.30	45
	3						
	4						
	5						
	6						
	7						
	8+						
	Total	0.68		0.10		0.79	
	SOP		21		2		22
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
3	0	0.12	14	1.57	14	1.69	14
	1	0.40	39	8.18	26	8.59	26
	2	0.60	77	0.02	26	0.62	75
	3	0.16	105	0.01	78	0.17	103
	4	0.36	159			0.36	159
	5	0.45	163			0.45	163
	6						
	7						
	8+						
	Total	2.08		9.79		11.87	
	SOP		210		233		443
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
4	0	1.25	14	5.96	15	7.22	15
	1	4.27	39	18.90	34	23.17	35
	2	0.44	92	0.07	45	0.50	85
	3	0.05	124			0.05	124
	4						
	5						
	6						
	7						
	8+						
	Total	6.02		24.93		30.94	
	SOP		231		727		958
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
Total	0	1.37	14	7.53	14	8.90	14
	1	6.25	33	43.51	24	49.75	25
	2	23.77	62	10.64	56	34.40	60
	3	0.65	100	0.05	93	0.70	99
	4	0.52	147			0.52	147
	5	0.61	163	0.02	147	0.62	163
	6	0.01	158			0.01	158
	7	0.00	184			0.00	184
	8+	0.00	160			0.00	160
	Total	33.17		61.75		94.92	
	SOP		1,936		1,773		3,709

Table 3.2.8 Western Baltic Spring Spawning Herring. Catch in numbers (mill.), mean weight (g.) and SOP (t) by age as W-ringers, quarter and fleet. North Sea Autumn spawners. Division: Skagerrak. Year: 2015. Country: All

		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
1	1	3.39	21	10.64	13	14.03	15
	2	40.94	65	7.64	56	48.57	64
	3	1.60	104	0.04	98	1.63	104
	4						
	5						
	6						
	7						
	8+						
	Total	45.92		18.31		64.23	
	SOP		2,915		573		3,487
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
2	1	0.13	21	1.25	13	1.38	14
	2	1.04	65	0.65	17	1.69	47
	3						
	4						
	5						
	6						
	7						
	8+						
	Total	1.17		1.90		3.07	
	SOP		71		28		99
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
3	0			2.21	18	2.21	18
	1	8.74	50	33.19	27	41.93	32
	2	11.23	112	0.62	56	11.84	109
	3	4.47	150			4.47	150
	4	0.58	164			0.58	164
	5	4.27	182			4.27	182
	6	1.10	196			1.10	196
	7	1.20	197			1.20	197
	8+	0.35	215			0.35	215
	Total	31.94		36.01		67.95	
	SOP		3,764		960		4,724
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
4	0	0.63	18	18.96	16	19.59	16
	1	32.19	44	30.31	27	62.50	36
	2	0.97	96	0.08	33	1.06	91
	3	0.15	104			0.15	104
	4	0.15	165			0.15	165
	5						
	6						
	7						
	8+						
	Total	34.10		49.36		83.45	
	SOP		1,559		1,115		2,673
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
Total	0	0.63	18	21.17	16	21.80	16
	1	44.45	43	75.38	25	119.83	31
	2	54.18	76	8.99	53	63.16	72
	3	6.22	137	0.04	98	6.26	137
	4	0.73	164			0.73	164
	5	4.27	182			4.27	182
	6	1.10	196			1.10	196
	7	1.20	197			1.20	197
	8+	0.35	215			0.35	215
	Total	113.13		105.57		218.71	
	SOP		8,308		2,675		10,983

Table 3.2.9 Western Baltic Spring Spawning Herring. Catch in numbers (mill.), mean weight (g.) and SOP (t) by age as W-ringers, quarter and fleet. Baltic Spring spawners. Division: Kattegat.Year: 2015. Country: All

		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
1	1	0.02	16	0.28	13	0.30	13
	2	9.40	61	4.40	56	13.79	59
	3	3.63	95	0.30	98	3.94	96
	4	1.20	119			1.20	119
	5	1.60	162	0.18	147	1.78	161
	6	0.30	158			0.30	158
	7	0.20	184			0.20	184
	8+	0.11	160			0.11	160
	Total	16.46		5.17		21.62	
	SOP		1,422		308		1,730
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
2	1	1.15	19	0.19	13	1.34	18
	2	1.62	49	0.22	17	1.83	45
	3	0.10	72			0.10	72
	4	0.07	80			0.07	80
	5						
	6	0.03	155			0.03	155
	7						
	8+						
	Total	2.96		0.40		3.37	
	SOP		117		6		123
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
3	0	0.01	14	0.17	14	0.18	14
	1	0.20	39	4.04	26	4.23	26
	2	2.66	77	0.10	26	2.76	75
	3	0.31	105	0.03	78	0.34	103
	4	0.88	159			0.88	159
	5	0.67	163			0.67	163
	6	0.20	169			0.20	169
	7	0.05	168			0.05	168
	8+	0.06	180			0.06	180
	Total	5.03		4.33		9.36	
	SOP		547		110		658
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
4	0	0.00	14	0.01	15	0.01	15
	1	3.71	39	16.39	34	20.09	35
	2	3.89	92	0.58	45	4.47	85
	3	0.79	124			0.79	124
	4	0.73	122	0.12	284	0.85	145
	5	0.91	188			0.91	188
	6	0.15	166			0.15	166
	7	0.03	212			0.03	212
	8+	0.03	239			0.03	239
	Total	10.23		17.10		27.33	
	SOP		896		613		1,508
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
Total	0	0.01	14	0.18	14	0.19	14
	1	5.08	34	20.89	32	25.97	32
	2	17.56	69	5.30	53	22.86	65
	3	4.83	100	0.33	96	5.16	100
	4	2.88	131	0.12	284	3.00	137
	5	3.17	170	0.18	147	3.35	168
	6	0.69	163			0.69	163
	7	0.27	184			0.27	184
	8+	0.20	177			0.20	177
	Total	34.69		27.00		61.69	
	SOP		2,982		1,038		4,019

Table 3.2.10 Western Baltic Spring Spawning Herring. Catch in numbers (mill.), mean weight (g.) and SOP (t) by age as W-ringers, quarter and fleet. Baltic Spring spawners. Division: Skagerrak. Year: 2015. Country: All

		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
1	1	0.21	21	0.64	13	0.85	15
	2	13.28	65	2.48	56	15.75	64
	3	7.97	104	0.19	98	8.17	104
	4	3.20	142			3.20	142
	5	4.35	164	0.13	147	4.49	164
	6	0.76	193			0.76	193
	7	0.23	188			0.23	188
	8+	0.56	208			0.56	208
	Total	30.55		3.45		34.00	
	SOP		3,177		187		3,364
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
2	1	0.36	21	3.41	13	3.77	14
	2	6.40	65	4.00	17	10.40	47
	3	1.31	104			1.31	104
	4	0.44	142			0.44	142
	5	0.60	164			0.60	164
	6	0.10	193			0.10	193
	7	0.03	188			0.03	188
	8+	0.08	208			0.08	208
	Total	9.33		7.41		16.74	
	SOP		765		114		879
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
3	0						
	1	1.54	50	5.86	27	7.40	32
	2	4.36	112	0.24	56	4.60	109
	3	4.86	150			4.86	150
	4	5.44	164			5.44	164
	5	1.55	182			1.55	182
	6	1.29	196			1.29	196
	7	0.71	197			0.71	197
	8+	0.75	215			0.75	215
	Total	20.51		6.10		26.61	
	SOP		3,024		170		3,193
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
4	0	0.10	18	3.02	16	3.12	16
	1	10.17	44	9.58	27	19.75	36
	2	5.74	96	0.49	33	6.23	91
	3	0.61	104			0.61	104
	4	0.61	165			0.61	165
	5	0.73	192			0.73	192
	6	0.17	197			0.17	197
	7						
	8+	0.15	222			0.15	222
	Total	18.28		13.08		31.36	
	SOP		1,368		320		1,688
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
Total	0	0.10	18	3.02	16	3.12	16
	1	12.28	44	19.49	24	31.76	32
	2	29.78	78	7.21	33	36.99	69
	3	14.76	119	0.19	98	14.95	119
	4	9.70	156			9.70	156
	5	7.23	171	0.13	147	7.36	171
	6	2.33	195			2.33	195
	7	0.96	195			0.96	195
	8+	1.53	213			1.53	213
	Total	78.67		30.04		108.70	
	SOP		8,334		790		9,124

Table 3.2.11 Western Baltic Spring Spawning Herring. Catch in numbers (mill.), mean weight (g.) and SOP (t) by age as W-ringers, quarter and fleet. North Sea Autumn spawners. Division: 3.a. Year: 2015. Country: All

		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
1	1	4.54	20	26.99	13	31.53	14
	2	63.40	64	18.15	56	81.55	62
	3	2.04	102	0.08	98	2.11	102
	4	0.16	119			0.16	119
	5	0.16	162	0.02	147	0.18	161
	6	0.01	158			0.01	158
	7	0.005	184			0.00	184
	8+	0.003	160			0.00	160
	Total	70.32		45.24		115.55	
	SOP		4,388		1,384		5,773
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
2	1	0.55	19	1.31	13	1.87	15
	2	1.31	62	0.69	17	1.99	47
	3					0.00	0
	4					0.00	0
	5					0.00	0
	6					0.00	0
	7					0.00	0
	8+					0.00	0
	Total	1.86		2.00		3.86	
	SOP		92		29		121
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
3	0	0.12	14	3.78	17	3.90	17
	1	9.14	50	41.37	26	50.51	31
	2	11.83	110	0.64	54	12.46	107
	3	4.63	148	0.01	78	4.64	148
	4	0.94	162			0.94	162
	5	4.72	181			4.72	181
	6	1.10	196			1.10	196
	7	1.20	197			1.20	197
	8+	0.35	215			0.35	215
	Total	34.02		45.80		79.82	
	SOP		3,974		1,193		5,167
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
4	0	1.88	16	24.93	16	26.81	16
	1	36.46	43	49.21	29	85.67	35
	2	1.41	94	0.15	38	1.56	89
	3	0.21	109			0.21	109
	4	0.15	165			0.15	165
	5					0.00	0
	6					0.00	0
	7					0.00	0
	8+					0.00	0
	Total	40.11		74.28		114.40	
	SOP		1,790		1,841		3,631
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
Total	0	2.00	15	28.71	16	30.71	16
	1	50.70	42	118.88	24	169.58	30
	2	77.94	71	19.63	55	97.57	68
	3	6.87	133	0.09	95	6.96	133
	4	1.25	157			1.25	157
	5	4.87	180	0.02	147	4.89	180
	6	1.11	196			1.11	196
	7	1.20	197			1.20	197
	8+	0.35	215			0.35	215
	Total	146.31		167.32		313.63	
	SOP		10,244		4,448		14,692

Table 3.2.12 Western Baltic Spring Spawning Herring. Catch in numbers (mill.), mean weight (g.) and SOP (t) by age as W-ringers, quarter and fleet. Baltic Spring spawners. Division: 3.a. Year: 2015. Country: All

		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
1	1	0.23	21	0.93	13	1.15	14
	2	22.67	63	6.87	56	29.55	62
	3	11.61	101	0.50	98	12.11	101
	4	4.40	135			4.40	135
	5	5.95	164	0.31	147	6.26	163
	6	1.07	183			1.07	183
	7	0.42	186			0.42	186
	8+	0.67	200			0.67	200
	Total	47.01		8.61		55.63	
	SOP		4,598		495		5,094
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
2	1	1.52	19	3.59	13	5.11	15
	2	8.02	62	4.22	17	12.24	47
	3	1.41	102			1.41	102
	4	0.51	133			0.51	133
	5	0.60	164			0.60	164
	6	0.13	186			0.13	186
	7	0.03	188			0.03	188
	8+	0.08	208			0.08	208
	Total	12.29		7.81		20.10	
	SOP		882		120		1,002
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
3	0	0.01	14	0.17	14	0.18	14
	1	1.74	49	9.89	26	11.63	30
	2	7.02	99	0.34	47	7.36	96
	3	5.17	147	0.03	78	5.20	147
	4	6.32	164			6.32	164
	5	2.22	177			2.22	177
	6	1.50	192			1.50	192
	7	0.75	195			0.75	195
	8+	0.81	213			0.81	213
	Total	25.54		10.43		35.97	
	SOP		3,571		280		3,851
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
4	0	0.10	18	3.03	16	3.13	16
	1	13.88	43	25.96	31	39.84	35
	2	9.63	94	1.07	39	10.70	89
	3	1.40	116	0.00	0	1.40	116
	4	1.34	142	0.12	284	1.47	153
	5	1.63	190			1.63	190
	6	0.32	182			0.32	182
	7	0.03	212			0.03	212
	8+	0.18	225			0.18	225
	Total	28.51		30.19		58.69	
	SOP		2,263		933		3,196
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
Total	0	0.11	18	3.19	16	3.31	16
	1	17.36	41	40.38	28	57.73	32
	2	47.34	75	12.51	42	59.84	68
	3	19.59	114	0.53	97	20.12	114
	4	12.58	150	0.12	284	12.70	151
	5	10.40	171	0.31	147	10.71	170
	6	3.02	188			3.02	188
	7	1.23	192			1.23	192
	8+	1.73	209			1.73	209
	Total	113.35		57.04		170.39	
	SOP		11,315		1,828		13,143

Table 3.2.13 Western Baltic Spring Spawning Herring. Total catch in numbers (mill) and mean weight (g), SOP (tonnes) of *Western Baltic Spring spawners* in Division 3.a and the North Sea in the years 1993–2015.

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
2013	Numbers		12.0	51.7	71.4	11.3	4.4	1.4	0.5	1.0	153.62
	Mean W.		59.5	94.2	131.8	162.6	195.0	207.8	247.9	238.1	119.29
	SOP		716	4,872	9,409	1,830	848	290	118	242	18,325
2014	Numbers	25.3	31.5	22.4	24.2	44.6	7.6	4.6	2.3	2.9	165.42
	Mean W.	9.3	52.2	98.5	137.4	178.2	199.2	211.7	225.1	227.0	114.98
	SOP	236	1,647	2,203	3,332	7,942	1,513	964	524	659	19,020
2015	Numbers	3.3	57.8	59.9	21.0	14.1	14.6	4.9	2.7	3.9	182.10
	Mean W.	16.0	31.8	67.9	115.2	152.4	172.8	193.4	198.7	212.9	84.28
	SOP	53	1,838	4,067	2,418	2,150	2,521	939	532	830	15,348

Data for 1995 to 2001 was revised in 2003.

c values have been corrected in 2007.

Table 3.2.14 Western Baltic Spring Spawning Herring. Catch in numbers (mill.), mean weight (g.) and SOP (t) by age as W-ringers, quarter and fleet. Western Baltic Spring spawners (values from the North Sea, see Table 2.2.1–2.2.5) Division: 4 + 3.a + 22–24. Year: 2015. Country: All

		Division IV		Division IIIa		Subdivision 22-24		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
	1	0.0004	107.00	1.15	14.43	42.44	15.00	43.59	14.99
	2			29.55	61.86	43.95	40.82	73.50	49.28
	3	0.496	126.80	12.11	101.24	17.69	77.91	30.29	88.04
	4	0.849	143.70	4.40	135.31	30.42	112.48	35.67	116.04
1	5	0.931	158.50	6.26	162.94	21.07	155.01	28.26	156.88
	6	0.700	177.60	1.07	183.04	11.62	179.38	13.38	179.58
	7	0.447	193.50	0.42	186.12	4.26	165.22	5.13	169.41
	8+	1.291	206.00	0.67	199.97	4.88	189.70	6.84	193.78
	Total	4.714		55.63		176.32		236.66	
	SOP		809		5,094		14,209		20,112
		Division IV		Division IIIa		Subdivision 22-24		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
	1	0.018	116.00	5.11	15.01	0.90	14.59	6.03	15.24
	2			12.24	46.58	8.99	32.94	21.22	40.80
	3			1.41	101.95	7.74	58.73	9.15	65.39
	4			0.51	132.93	8.05	88.72	8.57	91.36
2	5	2.047	181.70	0.60	164.40	5.20	112.84	7.85	134.74
	6			0.13	185.59	1.64	161.55	1.77	163.32
	7	0.530	202.00	0.03	188.00	1.31	141.60	1.87	159.53
	8+			0.08	208.00	1.79	137.97	1.87	140.83
	Total	2.595		20.10		35.61		58.31	
	SOP		481		1,002		2,762		4,245
		Division IV		Division IIIa		Subdivision 22-24		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
	0			0.18	14.13	12.50	7.11	12.68	7.21
	1	0.002	103.70	11.63	29.61	1.33	25.91	12.97	29.24
	2	0.10	136.70	7.36	96.31	2.53	67.66	9.98	89.45
	3	0.37	166.10	5.20	146.59	2.31	69.74	7.88	125.00
	4	0.52	192.20	6.32	163.51	2.32	65.58	9.16	140.36
3	5	0.89	202.20	2.22	176.68	0.81	73.82	3.93	161.17
	6	0.84	225.40	1.50	192.45	0.64	64.15	2.97	174.29
	7	0.47	216.20	0.75	195.50	1.53	58.30	2.75	122.80
	8+	0.38	238.53	0.81	212.84	1.82	57.85	3.01	122.34
	Total	3.57		35.97		25.78		65.32	
	SOP		737		3,851		902		5,490
		Division IV		Division IIIa		Subdivision 22-24		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
	0			3.13	16.10	14.17	7.15	17.30	8.77
	1			39.84	35.10	1.57	33.31	41.41	35.03
	2			10.70	88.52	17.32	81.42	28.01	84.13
	3			1.40	115.59	10.77	98.38	12.17	100.36
	4	0.037	177.00	1.47	153.32	7.65	120.71	9.15	126.16
4	5			1.63	189.62	2.76	146.85	4.40	162.73
	6	0.298	198.00	0.32	182.00	0.97	150.47	1.59	165.72
	7			0.03	212.00	0.77	115.24	0.79	118.30
	8+	0.497	224.99	0.18	224.65	0.63	133.61	1.30	180.99
	Total	0.832		58.69		56.60		116.13	
	SOP		177		3,196		4,270		7,644
		Division IV		Division IIIa		Subdivision 22-24		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
	0			3.31	16.00	26.67	7.13	29.979	8.11
	1	0.02	114.69	57.73	31.80	46.24	15.93	103.995	24.76
	2	0.10	136.70	59.84	67.74	72.78	50.44	132.720	58.30
	3	0.87	143.62	20.12	114.01	38.51	79.29	59.489	91.97
	4	1.40	162.45	12.70	151.33	48.44	107.58	62.543	117.70
Total	5	3.87	180.86	10.71	169.94	29.85	144.69	44.432	153.93
	6	1.84	202.75	3.02	187.71	14.86	170.59	19.713	176.21
	7	1.45	203.97	1.23	192.42	7.86	135.65	10.535	151.66
	8+	2.17	216.09	1.73	208.89	9.12	149.36	13.018	168.38
	Total	11.71		170.39		294.32		476.423	
	SOP		2,205		13,143		22,144		37,491

Table 3.2.15 Western Baltic Spring Spawning Herring. Total catch in numbers (mill) of *Western Baltic Spring Spawners* in Division 3.a + North Sea + subdivisions 22–24 in the years 1993–2015.

	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
2013	Div. IV+Div. IIIa		12.0	51.7	71.4	11.3	4.4	1.4	0.5	1.0	153.6
	Subdiv. 22-24	1.0	60.6	37.1	43.3	55.9	28.7	25.3	11.5	11.0	274.5
2014	Div. IV+Div. IIIa	25.3	31.5	22.4	24.2	44.6	7.6	4.6	2.3	2.9	165.4
	Subdiv. 22-24	5.8	35.3	37.7	42.1	37.5	19.0	11.2	6.5	6.2	201.4
2015	Div. IV+Div. IIIa	3.3	57.8	59.9	21.0	14.1	14.6	4.9	2.7	3.9	182.1
	Subdiv. 22-24	26.7	46.2	72.8	38.5	48.4	29.8	14.9	7.9	9.1	294.3

Data for 1995–2001 for the North Sea and Division 3.a was revised in 2003.

C values have been corrected in 2007.

Table 3.2.16 Western Baltic Spring Spawning Herring. Mean weight (g) and SOP (t) of *Western Baltic Spring Spawners* in Division 3.a + North Sea + subdivisions 22–24 in the years 1993–2015.

	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
2013	**Div. IV+Div. IIIa**		59.5	94.2	131.8	162.6	195.0	207.8	247.9	238.1	18,325
	Subdiv. 22-24	13.7	17.8	54.1	86.8	129.4	136.9	145.3	159.1	179.8	25,504
2014	**Div. IV+Div. IIIa**	9.3	52.2	98.5	137.4	178.2	199.2	211.7	225.1	227.0	19,020
	Subdiv. 22-24	16.5	30.0	59.0	82.3	122.1	158.4	156.0	163.0	175.5	18,338
2015	**Div. IV+Div. IIIa**	16.0	31.8	67.9	115.2	152.4	172.8	193.4	198.7	212.9	15,348
	Subdiv. 22-24	7.1	15.9	50.4	79.3	107.6	144.7	170.6	135.6	149.4	22,144

Data for 1995–2001 for the North Sea and Division 3.a was revised in 2003.

C values have been corrected in 2007.

Table 3.2.17 Western Baltic Spring Spawning Herring. Transfers of *North Sea autumn spawners* from Division 3.a to the North Sea. Numbers (millions) and mean weight (g), SOP (tonnes) in 1993–2015.

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	367.1
	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
2013	Number	0.90	86.19	85.82	2.39	0.36	0.28				175.9
	Mean W.	33.66	75.39	74.64	133.88	160.14	200.37				
	SOP	30	6,498	6,405	320	57	56				13,367
2014	Number	284.74	61.13	80.21	5.90	0.54	0.50	0.17	0.03	0.06	433.3
	Mean W.	8.98	56.96	73.62	108.56	162.38	190.94	209.02	221.12	227.82	
	SOP	2,557	3,482	5,905	641	88	95	36	6	13	12,823
2015	Number	30.71	169.58	97.57	6.96	1.25	4.89	1.11	1.20	0.35	313.6
	Mean W.	15.79	29.72	68.01	132.87	157.09	179.85	195.87	197.22	214.93	
	SOP	485	5,040	6,636	925	197	880	218	238	75	14,692

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 Spring Spawning Herring. German acoustic survey (GERAS) on the Spring Spawning Herring in subdivisions 21 (Southern Kattegat, 41G0-42G2) –24 in autumn 1993–2015 (September/October).

Year	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Numbers in millions									*	**			***	***	***	***	***	***	***	***	***	***	****
W-rings																							
0	893.140	5,474.540	5,107.780	1,833.130	2,859.220	2,490.090	5,993.820	1,008.910	2,477.972	4,102.595	3,776.780	2,554.680	3,055.595	4,159.311	2,588.922	2,150.306	2,821.022	4,561.405	2,929.434	4,103.180	8,996.225	5,492.210	891.710
1	491.880	415.730	1,675.340	1,439.460	1,955.400	801.350	1,338.710	1,429.880	1,125.716	837.557	1,238.480	968.860	750.199	940.892	558.851	392.737	270.959	534.633	1,206.762	755.034	893.837	771.550	440.807
2	436.550	883.810	328.610	590.010	738.180	678.530	287.240	453.980	1,226.932	421.396	222.530	592.360	590.756	226.959	260.402	165.347	95.866	305.540	360.354	294.242	456.204	242.650	510.016
3	529.670	559.720	357.960	434.090	394.530	394.070	232.510	328.960	844.088	575.358	217.270	346.230	295.659	279.618	117.412	166.301	43.553	214.539	210.455	193.974	307.567	279.650	221.403
4	403.400	443.730	353.850	295.170	162.430	236.830	155.950	201.590	366.841	341.120	260.350	163.150	142.778	212.201	76.782	102.018	17.761	107.364	115.984	124.548	262.908	332.660	129.822
5	125.140	189.420	253.510	305.550	118.910	100.190	51.940	78.930	131.430	63.678	96.960	143.320	78.541	139.813	43.919	82.174	9.016	85.635	57.840	70.135	87.114	317.240	95.606
6	55.290	60.400	126.760	119.260	99.290	50.980	8.130	38.610	85.690	24.520	38.040	79.030	79.018	97.261	12.144	29.727	3.227	47.140	50.844	45.017	32.684	211.600	86.176
7	28.030	23.510	46.430	46.980	33.280	23.640	1.470	5.920	19.471	9.690	8.580	22.600	25.564	66.937	9.262	11.443	1.947	25.021	29.234	22.520	22.565	85.630	47.109
8+	12.940	2.330	27.240	18.910	47.850	9.330	2.100	4.190	9.683	13.380	9.890	11.770	15.013	27.789	8.839	9.262	1.704	15.309	14.774	21.404	11.300	56.590	37.897
Total	2,976.040	8,053.190	8,277.480	5,082.560	6,409.090	4,785.010	8,071.870	3,550.970	6,287.823	6,389.293	5,868.880	4,882.000	5,033.123	6,150.781	3,676.532	3,109.314	3,265.055	5,896.586	4,975.682	5,630.054	11,070.405	7,789.780	2,460.544
3+ group	1,154.470	1,279.110	1,165.750	1,219.960	856.290	815.040	452.100	658.200	1,457.203	1,027.746	631.090	766.100	636.573	823.619	268.357	400.924	77.208	495.007	479.131	477.597	724.139	1,283.370	618.012
Biomass ('000 tonnnes)																							
W-rings																							
0	12.765	66.889	58.540	16.564	28.497	23.760	71.814	13.784	31.163	38.209	33.928	23.074	32.794	42.958	25.202	23.699	29.449	36.791	35.064	46.955	85.185	61.917	8.191
1	19.520	14.466	58.620	46.643	76.396	39.899	51.117	57.530	48.177	34.165	44.791	35.885	29.790	38.230	22.782	17.602	10.473	21.336	46.384	29.825	38.404	30.470	16.826
2	21.696	40.972	20.939	29.127	43.461	50.085	22.016	28.431	75.879	29.957	16.089	34.542	46.478	18.013	20.202	10.446	7.069	24.593	29.560	20.380	30.587	21.494	38.590
3	33.838	40.749	30.091	31.035	35.942	35.280	27.484	27.740	77.137	56.769	22.008	27.726	31.876	31.946	11.366	15.297	4.433	23.540	24.382	22.068	27.349	32.448	22.848
4	25.674	43.038	40.104	21.174	22.291	28.049	16.664	24.065	37.936	40.360	34.167	18.364	20.414	31.253	9.679	11.077	1.961	15.193	16.361	18.653	27.350	58.819	15.199
5	12.695	24.198	27.268	37.141	16.743	11.430	6.768	9.259	18.458	9.029	14.561	17.348	12.772	24.876	6.724	11.584	1.385	15.433	9.867	11.450	10.934	63.755	14.585
6	7.058	12.313	14.915	16.056	13.998	6.157	0.867	5.620	13.267	3.497	5.715	12.225	13.820	17.959	2.001	4.823	0.616	9.018	8.391	7.985	4.849	45.705	14.309
7	2.269	5.294	9.269	6.101	5.333	3.716	0.350	1.210	3.866	1.075	1.343	3.413	5.111	13.431	1.703	1.756	0.384	4.728	5.295	4.448	3.751	18.709	8.436
8+	1.781	0.627	6.570	2.930	10.636	2.170	0.458	0.757	2.101	1.908	1.615	1.991	3.447	6.344	1.798	1.303	0.284	3.013	3.015	3.876	1.821	13.498	7.110
Total	137.296	248.545	266.316	206.771	253.297	200.547	197.537	168.395	307.984	214.967	174.218	174.568	196.503	225.010	101.456	97.588	56.055	153.646	178.320	165.640	230.231	346.813	146.093
3+ group	83.315	126.218	128.217	114.438	104.943	86.802	52.590	68.651	152.765	112.637	79.410	81.067	87.441	125.809	33.270	45.840	9.064	70.926	67.312	68.480	76.055	232.933	82.487
Mean weight (g)																							
W-rings																							
0	14.3	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	9.5	11.3	9.2
1	39.7	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	43.0	39.5	38.2
2	49.7	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	77.6	63.2	73.7	80.5	82.0	69.3	67.0	88.6	75.7
3	63.9	72.8	84.1	71.5	91.1	89.5	118.2	84.3	91.4	98.7	101.3	80.1	107.8	114.2	96.8	92.0	101.8	109.7	115.9	113.8	88.9	116.0	103.2
4	63.6	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	126.1	108.6	110.4	141.5	141.1	149.8	104.0	176.8	117.1
5	101.4	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	125.5	201.0	152.6
6	127.7	203.9	117.7	134.6	141.0	120.8	106.6	145.5	154.8	142.6	150.2	154.7	174.9	184.6	164.8	162.2	190.9	191.3	165.0	177.4	148.4	216.0	166.0
7	81.0	225.2	199.6	129.9	160.2	157.2	237.9	204.5	198.6	110.9	156.6	151.0	199.9	200.6	183.8	153.5	197.4	189.0	181.1	197.5	166.2	218.5	179.1
8+	137.7	269.1	241.2	154.9	222.3	232.6	217.9	180.7	217.0	142.6	163.3	169.2	229.6	228.3	203.4	140.7	166.9	196.8	204.1	181.1	161.1	238.5	187.6
Total	46.1	30.9	32.2	40.7	39.5	41.9	24.5	47.4	49.0	33.6	29.7	35.8	39.0	36.6	27.6	31.4	17.2	26.1	35.8	29.4	20.8	44.5	59.4

small revision in 2015 (1999) — small revision in 2015 (2006–2009)

* 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. 2013)**

****** excl. Central Baltic Herring in SD 22, SD 24 (SD 23) based on SF (Gröhsler et al. 2013) & excl. mature herring in SD 23 (stages>=6)**

Table 3.3.2 Western Baltic Spring Spawning Herring. Acoustic surveys (HERAS) on the Western Baltic Spring Spawning Herring in the North Sea/Division 3.a in 1991–2015 (July).

Year	1991	* 1992	* 1993	* 1994	* 1995	* 1996	1997	1998	** 1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Numbers in millions																									
W-rings																									
0		3,853	372	964														112				1		314	2
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	49	513	1,949
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	627	415	1,244
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	525	176	446
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	53	248	224
5	350	556	434	239	255	119	67	111	28	186	96	88	103	184	103	180	154	274	82	65	70	76	30	28	171
6	88	197	154	186	174	37	69	51	3	56	38	40	25	72	84	27	34	176	86	24	53	33	12	37	82
7	72	122	63	62	39	20	80	31	2	7	23	18	12	22	37	10	26	45	39	28	22	14	8	26	89
8+	10	20	13	34	21	13	77	53	1	10	12	17	5	18	21	0.1	14	44	65	34	46	60	15	42	115
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**	**1,319**	**1,799**	**4,322**
3+ 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**	**643**	**557**	**1,127**
Biomass ('000 tonnnes)																									
W-rings																									
0		34.3	1	8.7																		0.0		1.0	0.03
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	3.0	26.0	61.5
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	51.0	48.0	106.2
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	59.0	21.0	54.7
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	7.0	43.0	33.8
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	4.0	6.0	30.3
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	2.0	8.0	16.7
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	1.0	6.0	17.7
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	3.0	11.0	25.2
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	130.0	169.0	346.0
3+ 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	76.0	95.0	178.3
Mean weight (g)																									
W-rings																									
0		8.9	4.0	9.0														6.3				3.0		4.3	14.2
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	58.1	51.6	31.5
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	80.8	114.9	85.4
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	111.7	122.4	122.7
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	128.5	175.0	150.9
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	138.3	210.6	177.1
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	157.2	220.2	202.3
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	155.5	213.3	198.9
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	198.5	244.1	218.9
Total	115.6	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	97.9	94.6	80.1

* 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 Spring Spawning 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
2013	3,021
2014	539
2015	2,478

*** small revision during HAWG 2010**

Table 3.6.1 Western Baltic Spring Spawning Herring. Catch in number (CANUM, thousands).

year

Wr	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

year

Wr	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

year

Wr	2009	2010	2011	2012	2013	2014	2015
0	20734	12394	11813	2000	1029	31157	29979
1	181083	75083	98516	76854	72606	66799	103995
2	243007	136419	46282	130803	88827	60110	132720
3	101330	82970	38787	64468	114676	66362	59489
4	69937	46833	49324	47322	67175	82074	62543
5	48091	29979	27630	35444	33067	26620	44432
6	39750	18589	22632	18169	26718	15751	19713
7	20907	10996	12236	11238	11974	8869	10535
8	12529	11262	9335	17001	12005	9088	13018

Table 3.6.2 Western Baltic Spring Spawning Herring. Weight at age as W-ringers in the catch (WECA, kg).

year

Wr	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

year

Wr	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

year

Wr	2009	2010	2011	2012	2013	2014	2015
0	0.01260	0.00928	0.01033	0.01141	0.01368	0.01065	0.00811
1	0.04789	0.04619	0.03199	0.02822	0.02467	0.04051	0.02476
2	0.07105	0.07688	0.07699	0.07024	0.07742	0.07370	0.05830
3	0.10319	0.10873	0.10092	0.10790	0.11481	0.10243	0.09197
4	0.13903	0.13535	0.12051	0.12513	0.13497	0.15254	0.11769
5	0.15341	0.16464	0.14385	0.15666	0.14451	0.17006	0.15392
6	0.17088	0.18078	0.15263	0.17606	0.14852	0.17210	0.17620
7	0.19236	0.19751	0.16584	0.18626	0.16263	0.17931	0.15166
8	0.21459	0.20551	0.17326	0.20851	0.18474	0.19196	0.16838

Table 3.6.3 Western Baltic Spring Spawning Herring. Weight at age as W-ringers in the stock (WEST, kg).

Wr	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

Wr	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

Wr	2009	2010	2011	2012	2013	2014	2015
0	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010
1	0.02300	0.01404	0.00900	0.01200	0.01400	0.01600	0.01500
2	0.05200	0.06265	0.05800	0.05000	0.05600	0.05200	0.04900
3	0.09000	0.09735	0.09500	0.09200	0.09500	0.08100	0.08800
4	0.13000	0.12833	0.12600	0.11400	0.12900	0.13000	0.11600
5	0.15600	0.16176	0.15600	0.15800	0.14300	0.16500	0.15700
6	0.17400	0.18131	0.17300	0.17800	0.16100	0.17400	0.18000
7	0.18500	0.20229	0.18500	0.19100	0.17900	0.19000	0.16900
8	0.19900	0.20447	0.19200	0.20100	0.19900	0.20500	0.19400

Table 3.6.4 Western Baltic Spring Spawning Herring. Natural mortality (NATMOR).

Wr	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

Wr	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
0	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
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
4	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
6	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
8	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2

Table 3.6.5 Western Baltic Spring Spawning Herring. Proportion mature (MATPROP).

Wr \ 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

Wr \ year	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
0	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
2	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
4	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
6	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
8	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Table 3.6.6 Western Baltic Spring Spawning Herring. Fraction of harvest before spawning (FPROP).

Wr \ 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

Wr \ year	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
0	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
2	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
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
7	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

Table 3.6.7 Western Baltic Spring Spawning Herring. Fraction of natural mortality before spawning (MPROP).

year

Wr	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

year

Wr	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
0	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
2	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
4	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
6	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
8	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25

Table 3.6.8 Western Baltic Spring Spawning Herring. Survey indices/ HERAS (number).

year

Wr	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

year

Wr	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

year

Wr	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

year

Wr	2009	2010	2011	2012	2013	2014	2015
1	565000000	999000000	2980000000	1018000000	49000000	513000000	1949000000
2	398000000	511000000	473000000	1081000000	627000000	415000000	1244000000
3	205000000	254000000	259000000	236000000	525000000	176000000	446000000
4	161000000	115000000	163000000	87000000	53000000	248000000	224000000
5	82000000	65000000	70000000	76000000	30000000	28000000	171000000
6	86000000	24000000	53000000	33000000	12000000	37000000	82000000
7	39000000	28000000	22000000	14000000	8000000	26000000	89000000
8	65000000	34000000	46000000	60000000	15000000	42000000	115000000

Table 3.6.8 (cont') Western Baltic Spring Spawning Herring. Survey indices/GERAS (number in thousands)

Wr \ year	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

Wr \ year	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

Wr \ year	2009	2010	2011	2012	2013	2014	2015
0	2821022	4561405	2929434	4103180	8996225	5492210	891710
1	270959	534633	1206762	755034	893837	771550	440807
2	95866	305540	360354	294242	456204	242650	510016
3	43553	214539	210455	193974	307567	279650	221403
4	17761	107364	115984	124548	262908	332660	129822
5	9016	85635	57840	70135	87114	317240	95606
6	3227	47140	50844	45017	32684	211600	86176
7	1947	25021	29234	22520	22565	85630	47109
8	1704	15309	14774	21404	11300	56590	37897

Survey indices/N20 (number in millions)

Wr \ year	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

Wr \ year	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
0	5640	3887	3774	1829	1622	6464	7037	4444	1140	3021	539	2478

Survey indices/IBTS Q1 (number per hour)

Wr \ year	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

Wr \ year	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

Wr \ year	2011	2012	2013	2014	2015
1	165.62	84.87	33.89	130.98	353.01
2	167.28	318.00	31.71	30.05	41.66
3	55.92	18.96	23.89	8.02	4.62
4	14.29	3.56	3.32	7.11	1.07

Table 3.6.8 (cont') Western Baltic Spring Spawning Herring. Survey indices/IBTS Q3 (number per hour).

```
   year
 Wr   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
   year
 Wr   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
   year
 Wr   2011   2012   2013   2014   2015
  1 224.61  59.27 139.43 133.44 225.16
  2  15.49  38.08 114.24  19.36  30.07
  3   4.92   4.37  13.44  14.33   8.11
  4   3.05   0.81   2.83   2.73   5.11
```

Table 3.6.9 Western Baltic Spring Spawning Herring. STOCK OBJECT CONFIGURATION

```
      min       max plusgroup   minyear   maxyear   minfbar   maxfbar
        0         8         8      1991      2015         3         6
```

Table 3.6.10 Western Baltic Spring Spawning Herring. FLSAM CONFIGURATION SETTINGS.

```
An object of class "FLSAM.control"
Slot "name":[1] "WBSSher"
Slot "desc": character(0)
Slot "range":
      min       max plusgroup   minyear   maxyear   minfbar   maxfbar
        0         8         8      1991      2015         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":         wr
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":
         wr
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":
         wr
```

Table 3.6.10 (cont') Western Baltic Spring Spawning Herring. FLSAM CONFIGURATION SETTINGS.

```
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":
         wr
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":
         wr
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
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 Western Baltic Spring Spawning Herring. FLR, R SOFTWARE VERSIONS.

```
Packwr: FLSAM
Type: Packwr
Title: FLSAM, an implementation of the State-space Assessment Model
for
        FLR
Version: 1.0
Date: 2014-03-19
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
Packwrd: 2014-08-25 06:24:08 UTC; imosqueira
Built: R 3.1.1; ; 2014-11-13 07:49:12 UTC; unix
-- File: /usr/local/lib/R/site-library/FLSAM/Meta/packwr.rds s
```

Table 3.6.12 WESTERN BALTICv SPRING SPAWNING HERRING. STOCK SUMMARY

	Year	Recruitment	TSB	SSB	F3-6	Landings
[1,]	1991	3957013	539320.5	302818.25	0.3980115	191573
[2,]	1992	3707988	462659.8	310401.21	0.5238037	194411
[3,]	1993	3594804	392506.4	278014.88	0.5748519	185010
[4,]	1994	4256680	329572.6	225284.37	0.6060975	172438
[5,]	1995	4110273	283381.5	193810.85	0.5733186	150831
[6,]	1996	4024857	250569.2	135144.02	0.6413730	121266
[7,]	1997	3843908	244086.5	147571.63	0.5860672	115588
[8,]	1998	4032915	231217.6	115664.29	0.5819374	107032
[9,]	1999	4077522	226883.9	114033.29	0.4946163	97240
[10,]	2000	3433189	219841.0	122005.83	0.5863403	109914
[11,]	2001	3355126	238559.1	130394.10	0.5651491	105803
[12,]	2002	2984671	271214.7	163199.91	0.5291174	106191
[13,]	2003	2922646	206725.6	131511.38	0.4694967	78309
[14,]	2004	2508010	214502.3	139415.57	0.4613973	76815
[15,]	2005	2167316	216742.0	134309.41	0.5096107	88406
[16,]	2006	1905014	239087.6	156510.86	0.5311573	90549
[17,]	2007	1751530	183739.2	123048.87	0.4912135	68997
[18,]	2008	1679489	166244.4	106004.35	0.5249495	68484
[19,]	2009	1676133	154206.5	95946.98	0.5122982	67262
[20,]	2010	1867292	144150.2	93634.88	0.3503543	42214
[21,]	2011	1786913	136298.5	92202.59	0.2940629	27771
[22,]	2012	1749779	150802.8	96078.08	0.3113324	38648
[23,]	2013	1928012	170529.4	112855.01	0.3087239	43827
[24,]	2014	1955194	175559.7	119857.40	0.2437954	37358
[25,]	2015	1843175	188996.4	125704.65	0.2557125	37491

Table 3.6.13 Western Baltic Spring Spawning Herring. ESTIMATED FISHING MORTALITY.

```
An object of class "FLQuant"
, , unit = unique, season = all, area = unique
```

year

Wr	1991	1992	1993	1994	1995	1996	1997
0	0.0327386	0.0590188	0.0732850	0.0822822	0.0791034	0.1004897	0.0824305
1	0.2200061	0.2733780	0.2993625	0.3178741	0.3255628	0.3580080	0.3280137
2	0.2976312	0.3741232	0.4020254	0.4246118	0.4189222	0.4554543	0.4187924
3	0.3408544	0.4272611	0.4648688	0.4864116	0.4782651	0.5294535	0.4853282
4	0.3801041	0.4783656	0.5213780	0.5527055	0.5391023	0.5997574	0.5453595
5	0.4355438	0.5947941	0.6565805	0.6926365	0.6379534	0.7181405	0.6567906
6	0.4355438	0.5947941	0.6565805	0.6926365	0.6379534	0.7181405	0.6567906
7	0.4355438	0.5947941	0.6565805	0.6926365	0.6379534	0.7181405	0.6567906
8	0.4355438	0.5947941	0.6565805	0.6926365	0.6379534	0.7181405	0.6567906

year

Wr	1998	1999	2000	2001	2002	2003	2004
0	0.0817410	0.0549682	0.0761995	0.0643705	0.0491244	0.0315116	0.0275542
1	0.3271947	0.2773985	0.3144281	0.2890083	0.2546666	0.2047634	0.1952060
2	0.4237973	0.3676955	0.4226166	0.3975478	0.3635640	0.3112994	0.2992129
3	0.4835454	0.4189725	0.4800620	0.4541989	0.4202355	0.3644376	0.3542686
4	0.5449670	0.4657809	0.5412468	0.5216179	0.4875561	0.4301893	0.4232679
5	0.6496185	0.5468559	0.6620263	0.6423898	0.6043390	0.5416799	0.5340264
6	0.6496185	0.5468559	0.6620263	0.6423898	0.6043390	0.5416799	0.5340264
7	0.6496185	0.5468559	0.6620263	0.6423898	0.6043390	0.5416799	0.5340264
8	0.6496185	0.5468559	0.6620263	0.6423898	0.6043390	0.5416799	0.5340264

year

Wr	2005	2006	2007	2008	2009	2010	2011
0	0.0301853	0.0280659	0.0217118	0.0237921	0.0220487	0.0085965	0.0052701
1	0.2027260	0.1957142	0.1773553	0.1818997	0.1737044	0.1153828	0.0925783
2	0.3231948	0.3298887	0.3098088	0.3311115	0.3278825	0.2225285	0.1763473
3	0.3838935	0.3946958	0.3712795	0.3936315	0.3830959	0.2613748	0.2123117
4	0.4646876	0.4805039	0.4527433	0.4872685	0.4830573	0.3395616	0.2866481
5	0.5949309	0.6247148	0.5704156	0.6094490	0.5915199	0.4002404	0.3386460
6	0.5949309	0.6247148	0.5704156	0.6094490	0.5915199	0.4002404	0.3386460
7	0.5949309	0.6247148	0.5704156	0.6094490	0.5915199	0.4002404	0.3386460
8	0.5949309	0.6247148	0.5704156	0.6094490	0.5915199	0.4002404	0.3386460

year

Wr	2012	2013	2014	2015
0	0.0057959	0.0057942	0.0037019	0.0044068
1	0.0946566	0.0928844	0.0751251	0.0802427
2	0.1828114	0.1801077	0.1465190	0.1564686
3	0.2229963	0.2221950	0.1803962	0.1901770
4	0.3070330	0.3117044	0.2557385	0.2702791
5	0.3576502	0.3504981	0.2695234	0.2811969
6	0.3576502	0.3504981	0.2695234	0.2811969
7	0.3576502	0.3504981	0.2695234	0.2811969
8	0.3576502	0.3504981	0.2695234	0.2811969

Table 3.6.14 Western Baltic Spring Spawning Herring. ESTIMATED POPULATION ABUNDANCE.

An object of class "FLQuant"
, , unit = unique, season = all, area = unique

year

Wr	1991	1992	1993	1994	1995	1996	1997	1998	1999
0	3957013	3707988	3594804	4256680	4110273	4024857	3843908	4032915	4077522
1	4073446	3026750	2628700	2065742	3495545	2735979	2905163	2480573	2905163
2	2145751	1949337	1642943	1188259	984609	1485111	1110144	1305374	1047587
3	1941555	1285939	1088161	1038201	650177	517622	792541	601992	675359
4	930986	1101298	698018	583617	569207	313953	238948	389648	305285
5	568070	507372	535523	358613	261712	260928	127644	112196	172474
6	169566	308353	229808	227294	151146	118895	94561	55492	46723
7	51072	99111	133786	95703	85221	65973	46537	35846	23365
8	16287	40905	58571	72548	59456	58865	50212	35066	23553

year

Wr	2000	2001	2002	2003	2004	2005	2006	2007	2008
0	3433189	3355126	2984671	2922646	2508010	2167316	1905014	1751530	1679489
1	3242970	2310559	2518062	1854267	2395254	1774448	1501537	1285939	1240469
2	1388869	1545719	1019681	1119060	959339	1266794	824061	763753	591845
3	576655	783871	937526	561856	661325	618468	771429	466961	436263
4	364762	286072	455887	508897	317426	375871	369535	410446	253723
5	169906	177017	144929	247212	275130	175255	201793	192144	213844
6	85734	76803	83366	70052	125995	143918	90310	82207	101519
7	23957	37347	32696	39301	35490	63450	66370	43739	38677
8	22026	17740	22427	23837	29673	30792	39144	42277	39815

year

Wr	2009	2010	2011	2012	2013	2014	2015
0	1676133	1867292	1786913	1749779	1928012	1955194	1843175
1	1206218	1048635	1492555	1245441	1148538	1449893	1503040
2	642422	575503	514011	855122	663312	574928	870654
3	328733	375120	325136	348363	586542	440207	400713
4	226613	186839	232118	199386	228205	369535	297450
5	125618	115960	108880	136489	120090	133119	219038
6	91766	62944	70333	65644	78905	72911	86769
7	46258	39696	39616	40015	39144	45071	47240
8	33024	36352	40660	50564	47763	48291	59338

units: NA

Table 3.6.15 Western Baltic Spring Spawning Herring. SURVIVORS AFTER TERMINAL YEAR

[1] NA NA NA NA NA NA NA NA NA

Table 3.6.16 Western Baltic Spring Spawning Herring. FITTED SELECTION PATTERN.

Wr	1991	1992	1993	1994	1995	1996	1997
0	0.08225545	0.1126734	0.1274849	0.1357574	0.1379745	0.1566790	0.1406502
1	0.55276317	0.5219092	0.5207646	0.5244603	0.5678567	0.5581900	0.5596861
2	0.74779557	0.7142432	0.6993547	0.7005668	0.7306971	0.7101238	0.7145808
3	0.85639322	0.8156893	0.8086758	0.8025303	0.8342049	0.8255001	0.8281100
4	0.95500793	0.9132535	0.9069779	0.9119085	0.9403189	0.9351149	0.9305409
5	1.09429942	1.1355286	1.1421732	1.1427806	1.1127381	1.1196925	1.1206745
6	1.09429942	1.1355286	1.1421732	1.1427806	1.1127381	1.1196925	1.1206745
7	1.09429942	1.1355286	1.1421732	1.1427806	1.1127381	1.1196925	1.1206745
8	1.09429942	1.1355286	1.1421732	1.1427806	1.1127381	1.1196925	1.1206745

Wr	1998	1999	2000	2001	2002	2003	2004
0	0.1404635	0.1111331	0.1299578	0.1139000	0.0928421	0.0671178	0.05971905
1	0.5622506	0.5608359	0.5362552	0.5113841	0.4813046	0.4361339	0.42307566
2	0.7282524	0.7433956	0.7207700	0.7034389	0.6871140	0.6630493	0.64849289
3	0.8309235	0.8470657	0.8187429	0.8036798	0.7942198	0.7762304	0.76781670
4	0.9364702	0.9417015	0.9230932	0.9229739	0.9214516	0.9162776	0.91736097
5	1.1163031	1.1056164	1.1290820	1.1366731	1.1421643	1.1537460	1.15741116
6	1.1163031	1.1056164	1.1290820	1.1366731	1.1421643	1.1537460	1.15741116
7	1.1163031	1.1056164	1.1290820	1.1366731	1.1421643	1.1537460	1.15741116
8	1.1163031	1.1056164	1.1290820	1.1366731	1.1421643	1.1537460	1.15741116

Wr	2005	2006	2007	2008	2009	2010	2011
0	0.05923209	0.05283914	0.0442003	0.04532272	0.04303887	0.0245366	0.01792178
1	0.39780558	0.36846742	0.3610555	0.34650889	0.33906900	0.3293318	0.31482495
2	0.63419939	0.62107528	0.6307008	0.63074930	0.64002269	0.6351529	0.59969235
3	0.75330741	0.74308638	0.7558415	0.74984647	0.74779855	0.7460299	0.72199396
4	0.91184808	0.90463568	0.9216833	0.92821972	0.94292206	0.9691949	0.97478484
5	1.16742225	1.17613897	1.1612376	1.16096690	1.15463970	1.1423876	1.15161060
6	1.16742225	1.17613897	1.1612376	1.16096690	1.15463970	1.1423876	1.15161060
7	1.16742225	1.17613897	1.1612376	1.16096690	1.15463970	1.1423876	1.15161060
8	1.16742225	1.17613897	1.1612376	1.16096690	1.15463970	1.1423876	1.15161060

Wr	2012	2013	2014	2015
0	0.01861652	0.01876819	0.01518459	0.01723353
1	0.30403699	0.30086547	0.30814836	0.31380029
2	0.58719054	0.58339427	0.60099185	0.61189259
3	0.71626440	0.71972071	0.73994907	0.74371415
4	0.98619034	1.00965426	1.04898821	1.05696488
5	1.14877263	1.13531251	1.10553136	1.09966048
6	1.14877263	1.13531251	1.10553136	1.09966048
7	1.14877263	1.13531251	1.10553136	1.09966048
8	1.14877263	1.13531251	1.10553136	1.09966048

Table 3.6.17 Western Baltic Spring Spawning Herring. PREDICTED CATCH IN NUMBERS.

Wr	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
0	110271	183873	219916	291064	270709	333167	263313	274114	188773	218120	181063
1	639090	576252	541988	448382	774676	657500	648229	552164	560116	697739	461667
2	502977	554765	496431	375382	307460	496183	346660	411638	293843	436830	462592
3	511038	407950	369498	365236	225709	194639	278285	210934	210955	200827	261215
4	268633	382468	259212	226749	216967	129677	91867	149777	103798	139372	106266
5	183121	208147	236239	164259	113040	122651	56297	49119	66450	75403	76872
6	54650	126488	101377	104183	65271	55871	41706	24294	17998	38025	33350
7	16460	40688	58995	43853	36824	30999	20524	15685	9006	10626	16210
8	5250	16786	25820	33243	25683	27662	22146	15354	9075	9776	7702

Wr	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
0	123797	78378	58924	55687	45565	32513	34125	31584	13811	8117	8737
1	450089	272447	336886	258513	211695	165694	163505	152405	90355	104287	88894
2	283424	272665	226025	318730	210997	185313	152025	163571	104454	75531	129845
3	293461	156436	179926	179890	229441	132032	129521	95416	78566	56585	63316
4	160733	162348	99997	127542	128849	136448	89384	79285	49011	52686	48021
5	60180	94552	104089	71955	85837	76405	89366	51318	34881	28518	37410
6	34620	26790	47648	59042	38426	32683	42417	37489	18938	18416	18002
7	13573	15032	13426	26035	28243	17396	16160	18895	11949	10377	10969
8	9314	9115	11224	12637	16657	16816	16636	13500	10940	10646	13864

Wr	2013	2014	2015
0	9620	6242	7002
1	80443	82801	91537
2	99360	71189	114611
3	106319	66079	63127
4	55687	75879	64126
5	32354	28621	48889
6	21258	15686	19377
7	10556	9691	10545
8	12876	10388	13250

Table 3.6.18 Western Baltic Spring Spawning Herring. SURVEY STANDARDIZED RESIDUALS/HERAS.

Wr	1991	1992	1993	1994	1995	1996	1997	1998	2000
1	NA	-0.7238	-1.1887	-2.7373	0.3714	0.1280	-1.1132	-0.9830	0.1988
2	-0.4190	0.0342	0.8525	-1.8838	1.0978	-0.6839	-0.8103	0.4079	0.5037
3	-0.0289	0.7666	0.4565	-0.0411	1.0635	-1.2598	0.1534	0.9706	0.4711
4	0.2521	1.2597	0.2654	0.3074	2.2021	-0.9303	-0.1247	-0.0440	0.5952
5	-0.2121	1.1401	0.6126	0.2672	0.9585	-0.4614	-0.2557	1.0029	1.2179
6	-0.3316	0.2842	0.4558	0.9003	1.5165	-1.0019	0.6274	1.0790	0.3981
7	0.8648	0.8285	-0.0837	0.2540	-0.1240	-0.4817	1.1982	0.5137	-0.5668
8	0.0420	-0.0849	-0.8279	-0.0664	-0.3801	-0.7953	1.0850	1.0656	-0.1575

Wr	2001	2002	2003	2004	2005	2006	2007	2008	2009
1	-1.3727	0.7645	0.5817	0.3829	0.8188	0.7673	1.2007	1.4468	0.1537
2	-1.6033	0.6608	-0.1722	-0.2270	-0.0442	1.5934	2.5629	1.0407	-0.9770
3	-0.9723	0.8781	-0.6915	0.1885	-0.5382	1.7274	1.4096	1.3699	-0.9063
4	-0.6759	0.8118	-0.4462	0.3840	-0.7453	1.0872	0.8800	1.0766	-0.1568
5	-0.2009	-0.0416	-0.8543	0.0720	-0.1175	0.7698	0.4835	1.4702	0.0995
6	-0.1901	-0.3031	-0.9322	-0.0121	0.0940	-1.1991	-0.6164	2.2995	1.0468
7	0.1732	0.0276	-0.5838	0.0897	0.0952	-1.2825	0.0934	0.7822	0.4528
8	0.2575	0.3606	-0.8790	0.0911	0.2633	-5.2671	-0.4857	0.7312	1.2912

Wr	2010	2011	2012	2013	2014	2015
1	0.5297	0.9349	0.4367	-1.2129	-0.0374	0.6895
2	-0.4633	-0.4513	0.1117	-0.3999	-0.9086	0.2963
3	-0.8946	-0.6305	-0.9400	-0.3846	-2.0503	0.0108
4	-0.6234	-0.4268	-1.3534	-2.6097	-0.5552	-0.3067
5	-0.4445	-0.2486	-0.5115	-2.1240	-2.5696	0.0688
6	-0.9924	0.2933	-0.4936	-2.8936	-0.5846	0.6737
7	0.1572	-0.1178	-0.5627	-1.0998	-0.1220	1.0561
8	0.4367	0.5870	0.6458	-0.6743	0.2839	1.0838

Table 3.6.19 Western Baltic Spring Spawning Herring. SURVEY STANDARDIZED RESIDUALS/GERAS.

Wr	1994	1995	1996	1997	1998	1999	2000	2002	2003
0	0.1048	0.0263	-2.0512	-1.0486	-1.4428	0.3393	-3.0167	0.1884	0.0294
1	-1.5016	0.3394	0.5907	1.0583	-0.4892	0.1757	0.1440	-0.5493	0.8351
2	1.4639	-0.2326	0.1954	1.2190	0.7082	-0.7331	-0.2704	0.1233	-1.5052
3	0.4713	0.5019	1.4732	0.3018	0.8741	-0.5878	0.5792	0.6331	-0.4346
4	0.7559	0.4162	1.1564	0.5677	0.3873	0.0086	0.2314	0.6474	-0.0346
5	0.1903	1.0915	1.4974	1.0532	0.9755	-0.8972	-0.0554	-0.2183	-0.4804
6	-0.5988	0.6738	0.9530	0.9495	0.7886	-1.2194	-0.0193	-0.5630	0.0850
7	-0.2829	0.5829	0.9650	0.9137	0.8139	-1.9843	-0.3038	-0.1479	-0.5574
8	-2.6232	0.3838	0.0493	1.2439	-0.2310	-1.5829	-0.6055	0.6564	0.1815

Wr	2004	2005	2006	2007	2008	2009	2010	2011	2012
0	-0.4788	0.2112	1.1286	0.2955	-0.0034	0.5700	1.3317	0.4854	1.2410
1	-0.2375	-0.1332	0.6853	-0.1171	-0.7757	-1.5130	0.1151	1.0475	0.4441
2	0.8608	0.3104	-0.7878	-0.3715	-0.7557	-2.0817	0.4139	0.9218	-0.5663
3	0.1854	0.0439	-0.5198	-1.3298	-0.4162	-2.6604	0.2151	0.3934	0.0957
4	-0.0367	-0.4673	0.2138	-1.6177	-0.3473	-2.9722	0.0355	-0.2571	0.1268
5	-0.0356	-0.1991	0.5378	-1.3082	-0.4268	-3.1367	0.3528	-0.2551	-0.2831
6	0.2442	0.1470	0.9488	-1.3856	-0.5632	-3.0173	0.3248	0.2271	0.1836
7	0.6671	0.1968	1.2790	-0.5660	-0.1455	-2.4044	0.5318	0.6562	0.3627
8	0.1227	0.4159	0.8752	-0.5807	-0.4221	-2.1710	0.0682	-0.1582	0.0348

Wr	2013	2014	2015
0	2.6914	1.6182	-2.0865
1	0.9691	0.1382	-1.1100
2	0.8881	-0.1977	0.5093
3	-0.0333	0.2999	0.0222
4	1.1134	0.6472	-0.4942
5	0.2605	2.0622	-0.6429
6	-0.4020	1.7622	0.5391
7	0.3831	1.6814	0.9501
8	-0.6410	1.1251	0.4372

Table 3.6.20 Western Baltic Spring Spawning Herring. SURVEY STANDARDIZED RESIDUALS/N20.

Wr	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
0	-2.1982	-0.8255	0.745	0.213	1.4766	-0.3132	1.1783	1.397	-0.7737	-0.1586

Wr	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
0	1.0486	0.16	0.3803	0.0975	0.2212	-0.5877	-0.6847	1.0559	1.0198	0.4952	-1.189

Wr	2013	2014	2015
0	-0.0849	-2.2716	-0.2783

Table 3.6.21 Western Baltic Spring Spawning Herring. SURVEY STANDARDIZED RESIDUALS/IBTS Q1.

Wr	1991	1992	1993	1994	1995	1996	1997	1998	1999
1	-2.4169	-1.2031	0.9669	-0.3279	-1.0607	-0.0847	1.1746	-1.2604	-0.8145
2	0.5759	-1.6438	-0.1885	-0.2233	-1.4373	0.7548	-0.9461	0.7758	-0.6962
3	0.9904	-1.1428	-0.9952	0.5512	-0.7154	1.5652	1.1286	1.0993	0.0283
4	1.1348	-0.3880	-1.1469	-0.2583	0.2689	1.7016	0.2106	1.6941	0.5319

Wr	2000	2001	2002	2003	2004	2005	2006	2007	2008
1	0.3373	-0.3997	1.2808	0.5653	-0.9433	-0.2107	0.4715	0.6059	-0.3934
2	-0.7445	0.4279	-0.9675	1.1131	-0.2749	0.9314	-0.7450	0.3690	-0.6925
3	-1.1978	-0.2036	0.3990	-0.7997	-0.6085	-0.1719	-0.1192	-0.1998	-0.9561
4	-0.9894	-1.6410	-0.1445	-1.3125	-1.0469	-0.4452	-0.4186	-0.7152	-1.4049

Wr	2009	2010	2011	2012	2013	2014	2015
1	2.6205	-0.2361	0.5750	0.0162	-0.9427	0.3375	1.4328
2	0.5807	0.1640	1.8603	2.0144	-0.3380	-0.2407	-0.3407
3	-1.5716	0.0908	2.3119	0.9951	0.6620	-0.2666	-0.7898
4	-0.1638	0.5673	2.3414	0.9254	0.6912	1.0042	-0.9163

Table 3.6.22 Western Baltic Spring Spawning Herring: SURVEY STANDARDIZED RESIDUALS/IBTS Q3.

Wr	1991	1992	1993	1994	1995	1996	1997	1998	1999
1	-1.0201	-0.0905	0.8354	-0.2507	-0.0616	0.3374	-1.1381	-0.4363	-0.4157
2	-0.5513	-0.1975	-0.0718	0.0642	0.1085	0.3425	0.0200	-0.2044	-0.3986
3	-0.6589	-0.0732	-2.5629	0.5327	0.9033	-0.8493	0.4591	-1.2724	-1.9824
4	-0.4604	0.6481	-0.8760	0.5983	2.1289	-0.3629	0.2864	0.3502	-1.4674

Wr	2000	2001	2002	2003	2004	2005	2006	2007	2008
1	-4.4981	-0.7738	0.9951	0.2268	0.8223	0.0001	0.5362	0.4401	-0.0080
2	-3.8686	-0.1029	0.0899	0.3207	0.5848	0.3160	0.2715	0.0785	-0.2329
3	NA	-0.6840	0.0553	0.5936	0.6888	0.4602	0.6658	-0.6624	-0.4590
4	NA	-0.4282	-0.7907	-0.3050	-0.2255	-0.4620	-1.1551	0.3621	-1.0148

Wr	2009	2010	2011	2012	2013	2014	2015
1	1.0261	0.0039	0.9279	0.2382	0.7996	0.6269	0.9205
2	0.9684	0.0478	0.2089	0.4457	1.2558	0.2643	0.2831
3	1.9997	0.4589	0.0268	-0.3115	0.8179	1.4277	0.5466
4	1.5850	1.2576	0.6677	-1.5126	0.5885	-0.4490	1.1526

Table 3.6.23 Western Baltic Spring Spawning Herring. FIT PARAMETERS.

	name	value	std.dev
1	logFpar	-0.612180	0.376030
2	logFpar	0.410090	0.123990
3	logFpar	0.345130	0.109850
4	logFpar	0.163810	0.109660
5	logFpar	0.018848	0.110350
6	logFpar	-0.092912	0.114210
7	logFpar	-0.132990	0.157870
8	logFpar	0.507820	0.116930
9	logFpar	-0.236000	0.114490
10	logFpar	-0.491520	0.113390
11	logFpar	-0.292080	0.112960
12	logFpar	-0.144130	0.143500
13	logFpar	-0.042721	0.144490
14	logFpar	-0.091024	0.198230
15	logFpar	-0.443930	0.149950
16	logFpar	-6.268600	0.170040
17	logFpar	-9.534100	0.179170
18	logFpar	-9.605800	0.178390
19	logFpar	-10.633000	0.178120
20	logFpar	-11.677000	0.177970
21	logFpar	-9.978800	0.336370
22	logFpar	-10.523000	0.336040
23	logFpar	-10.855000	0.116080
24	logFpar	-11.291000	0.115920
25	logSdLogFsta	-0.869940	0.306040
26	logSdLogFsta	-1.787000	0.191210
27	logSdLogN	-2.042300	0.174380
28	logSdLogObs	0.081694	0.167170
29	logSdLogObs	-1.423300	0.112050
30	logSdLogObs	-1.737100	0.174040
31	logSdLogObs	0.582310	0.148440
32	logSdLogObs	-0.559210	0.150480
33	logSdLogObs	-0.693770	0.081833
34	logSdLogObs	0.010287	0.104110
35	logSdLogObs	-0.745260	0.083765
36	logSdLogObs	-0.471290	0.114570
37	logSdLogObs	-0.139990	0.092801
38	logSdLogObs	-0.229280	0.147970
39	logSdLogObs	-0.136670	0.072767
40	logSdLogObs	0.511270	0.100790
41	logSdLogObs	-0.630150	0.108440
42	rho	0.855760	0.104460

Table 3.9.1 Western Baltic Spring Spawning Herring. Input table for short term predictions.

2016

wr	N	M	Mat	PF	PM	Sel	SWt	CWt
0	1855751	0.3	0.00	0.25	0.1	0.017	0.000	0.011
1	1368729	0.5	0.00	0.25	0.1	0.307	0.015	0.030
2	841345	0.2	0.20	0.25	0.1	0.598	0.052	0.070
3	609584	0.2	0.75	0.25	0.1	0.733	0.088	0.103
4	271257	0.2	0.90	0.25	0.1	1.036	0.125	0.135
5	185855	0.2	1.00	0.25	0.1	1.115	0.155	0.156
6	135375	0.2	1.00	0.25	0.1	1.115	0.172	0.166
7	53627	0.2	1.00	0.25	0.1	1.115	0.179	0.165
8	65870	0.2	1.00	0.25	0.1	1.115	0.199	0.182

2017

wr	N	M	Mat	PF	PM	Sel	SWt	CWt
0	1855751	0.3	0.00	0.25	0.1	0.017	0.000	0.011
1		0.5	0.00	0.25	0.1	0.307	0.015	0.030
2		0.2	0.20	0.25	0.1	0.598	0.052	0.070
3		0.2	0.75	0.25	0.1	0.733	0.088	0.103
4		0.2	0.90	0.25	0.1	1.036	0.125	0.135
5		0.2	1.00	0.25	0.1	1.115	0.155	0.156
6		0.2	1.00	0.25	0.1	1.115	0.172	0.166
7		0.2	1.00	0.25	0.1	1.115	0.179	0.165
8		0.2	1.00	0.25	0.1	1.115	0.199	0.182

2018

wr	N	M	Mat	PF	PM	Sel	SWt	CWt
0	1855751	0.3	0.00	0.25	0.1	0.017	0.000	0.011
1		0.5	0.00	0.25	0.1	0.307	0.015	0.030
2		0.2	0.20	0.25	0.1	0.598	0.052	0.070
3		0.2	0.75	0.25	0.1	0.733	0.088	0.103
4		0.2	0.90	0.25	0.1	1.036	0.125	0.135
5		0.2	1.00	0.25	0.1	1.115	0.155	0.156
6		0.2	1.00	0.25	0.1	1.115	0.172	0.166
7		0.2	1.00	0.25	0.1	1.115	0.179	0.165
8		0.2	1.00	0.25	0.1	1.115	0.199	0.182

Input units are thousands and kg

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)

$N_{2016/2017/2018}$ wr 0:	Geometric Mean of wr 0 (Table 3.6.14) for the years 2010-2014
Natural Mortality (M):	Average for 2013-2015
Weight in the Catch/Stock (CWt/SWt):	Average for 2013-2015
Expoitation pattern (Sel):	Average for 2013-2015

Table 3.9.2 Western Baltic Spring Spawning 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: 01/04/2016
Fbar age (wr) range: 3-6

2016 Biomass	SSB	FMult	FBar	Catch	GM Recr. 2010-2014 (x100
209,752	143,004	1.0096	0.272	46,362	1,855,751

	2017 Biomass	SSB	FMult	FBar	Catch	2018 Biomass	SSB
	224,695	158,875	0.0000	0.000	0	280,447	210,237
		158,456	0.1000	0.027	5,412	274,288	204,788
		158,038	0.2000	0.054	10,699	268,290	199,490
		157,621	0.3000	0.081	15,863	262,447	194,337
		157,206	0.4000	0.108	20,907	256,756	189,326
		156,791	0.5000	0.135	25,835	251,213	184,453
		156,378	0.6000	0.162	30,650	245,813	179,713
		155,966	0.7000	0.189	35,354	240,552	175,103
		155,555	0.8000	0.216	39,950	235,427	170,620
		155,145	0.9000	0.242	44,441	230,433	166,259
		154,736	1.0000	0.269	48,829	225,567	162,017
		154,328	1.1000	0.296	53,118	220,826	157,890
		153,921	1.2000	0.323	57,309	216,206	153,876
		153,516	1.3000	0.350	61,405	211,703	149,971
		153,111	1.4000	0.377	65,408	207,315	146,172
		152,708	1.5000	0.404	69,321	203,038	142,476
		152,306	1.6000	0.431	73,146	198,869	138,880
		151,904	1.7000	0.458	76,885	194,806	135,381
		151,504	1.8000	0.485	80,541	190,844	131,977
		151,105	1.9000	0.512	84,114	186,983	128,664
		150,707	2.0000	0.539	87,608	183,218	125,441
F_{MSY}-framework		155,334	0.8540	0.230	42,375	232,728	168,262
		155,182	0.8910	0.240	44,033	230,885	166,653
		155,030	0.9280	0.250	45,678	229,060	165,061
		154,878	0.9650	0.260	47,308	227,252	163,485
		154,727	1.0020	0.270	48,924	225,462	161,925
		154,575	1.0390	0.280	50,527	223,689	160,381
		154,424	1.0760	0.290	52,115	221,933	158,853
		154,273	1.1140	0.300	53,691	220,193	157,340
		154,122	1.1510	0.310	55,253	218,470	155,843
$F_{3-6}=F_{MSY}$		**153,971**	**1.1880**	**0.320**	**56,802**	**216,764**	**154,361**
		153,820	1.2250	0.330	58,337	215,074	152,894
		153,670	1.2620	0.340	59,860	213,400	151,442
		153,519	1.2990	0.350	61,370	211,742	150,005
		153,369	1.3360	0.360	62,867	210,099	148,582
		153,219	1.3730	0.370	64,351	208,472	147,174
		153,069	1.4100	0.380	65,823	206,861	145,780
		152,919	1.4480	0.390	67,282	205,265	144,400
		152,769	1.4850	0.400	68,729	203,684	143,034
		152,620	1.5220	0.410	70,164	202,118	141,682
TAC as in 2015 -15 %		154,506	1.0580	0.285	51,254	222,196	159,120
TAC as in 2015		153,665	1.2620	0.340	59,910	213,721	151,700
TAC as in 2015 +15 %		152,786	1.4810	0.399	68,566	205,254	144,310

output in tonnes

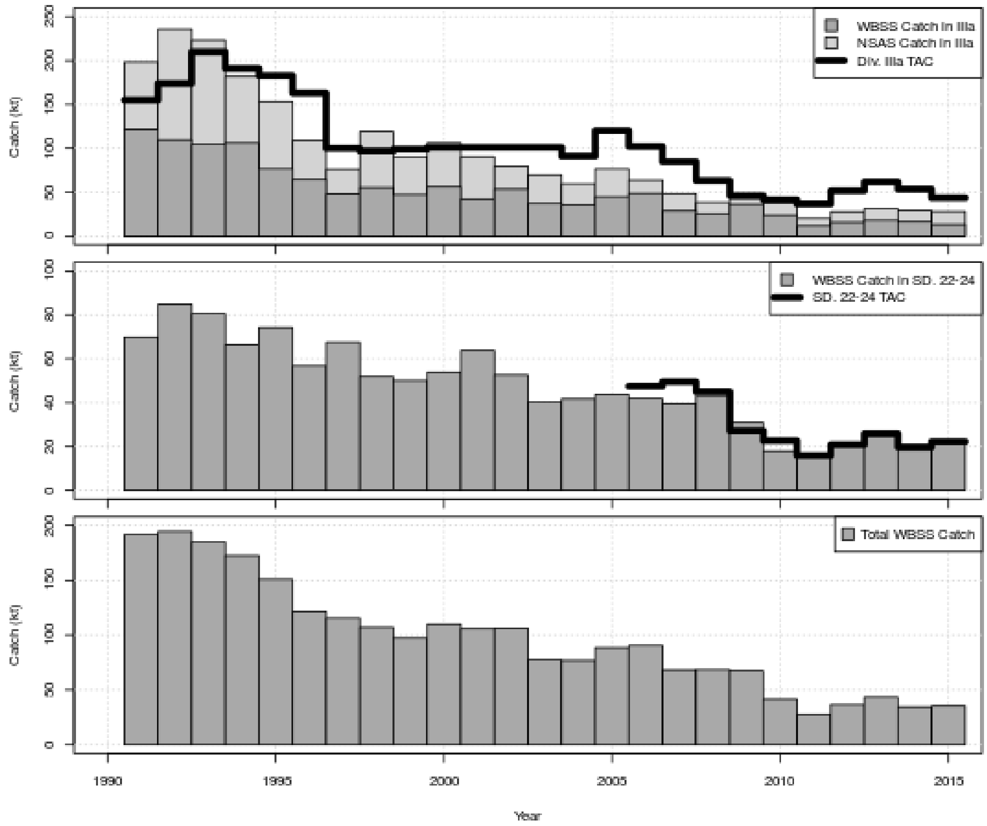


Figure 3.1.1 Western Baltic Spring Spawning Herring. CATCH and TACs (1000 t) by area.
***Top panel:* Total catch of Western Baltic Spring Spawning (WBSS) and North Sea Autumn Spawning (NSAS) herring in Division 3.a and the total TAC for both stocks.**
***Middle panel:* Total catch and TACs of WBSS herring in subdivisions 22–24.**
***Bottom panel:* Total catch of WBSS herring in Division 4.a, Division 3.a and subdivisions 22–24.**

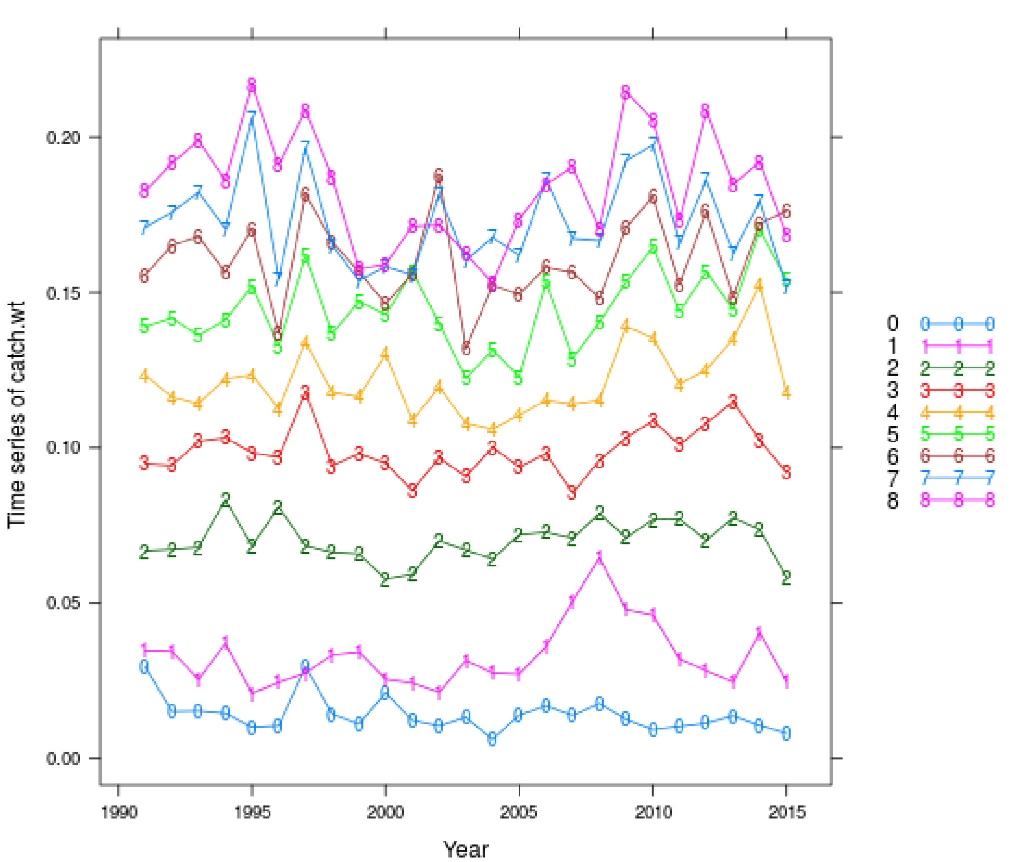


Figure 3.6.1.1 Western Baltic Spring Spawning Herring. Weight at age as W-ringers (kg) in the catch (WECA).

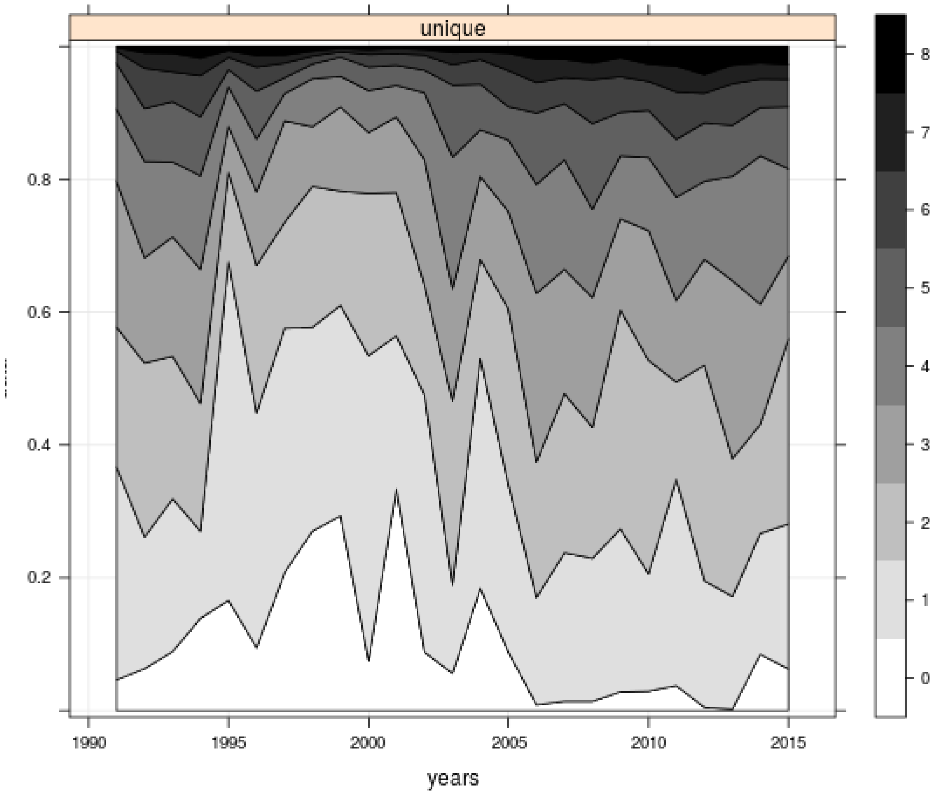


Figure 3.6.1.2 Western Baltic Spring Spawning Herring. Proportion (by numbers) of a given age as W-ringers in the catch.

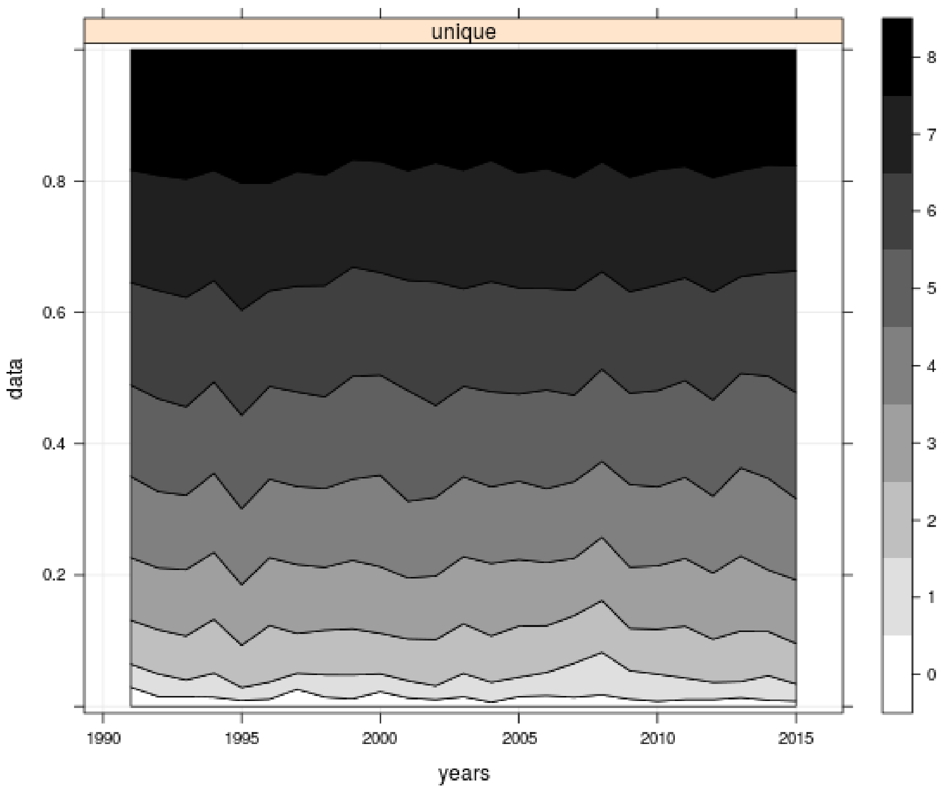


Figure 3.6.1.3 WESTERN BALTIC SPRING SPAWNING HERRING. Proportion (by weight) of a given age as W-ringers in the catch.

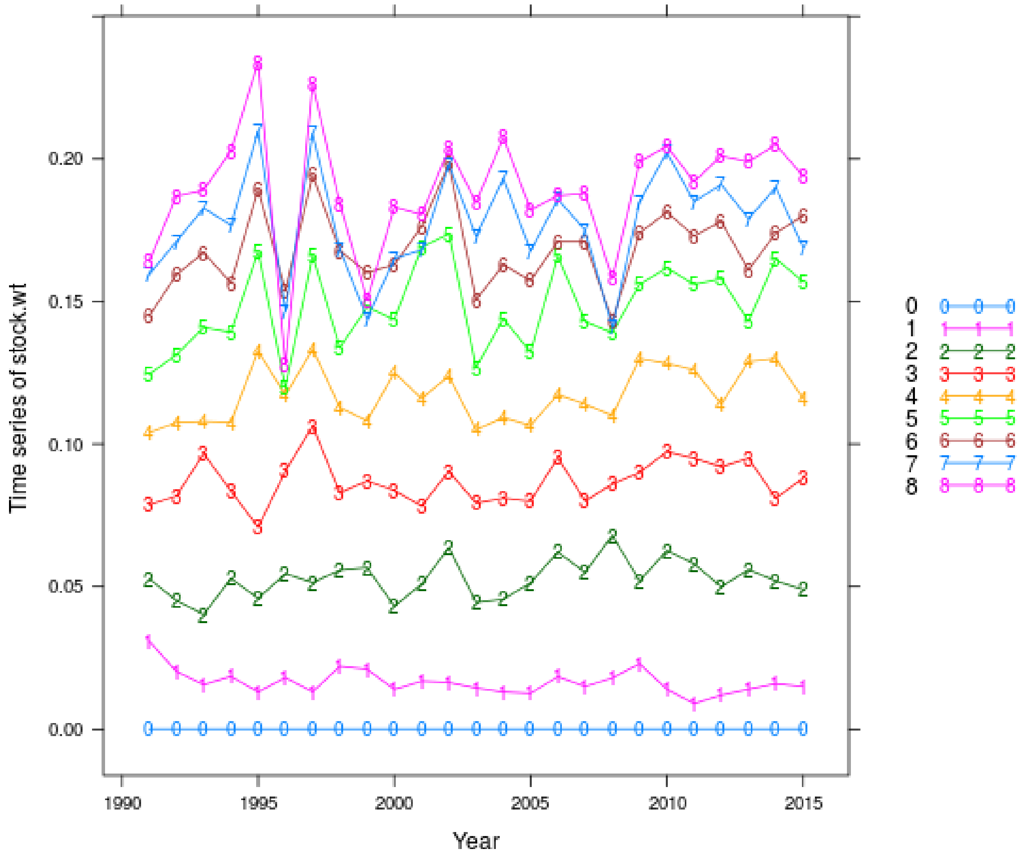


Figure 3.6.1.4 Western Baltic Spring Spawning Herring. Weight at age as W-ringers (kg) in the stock (WEST).

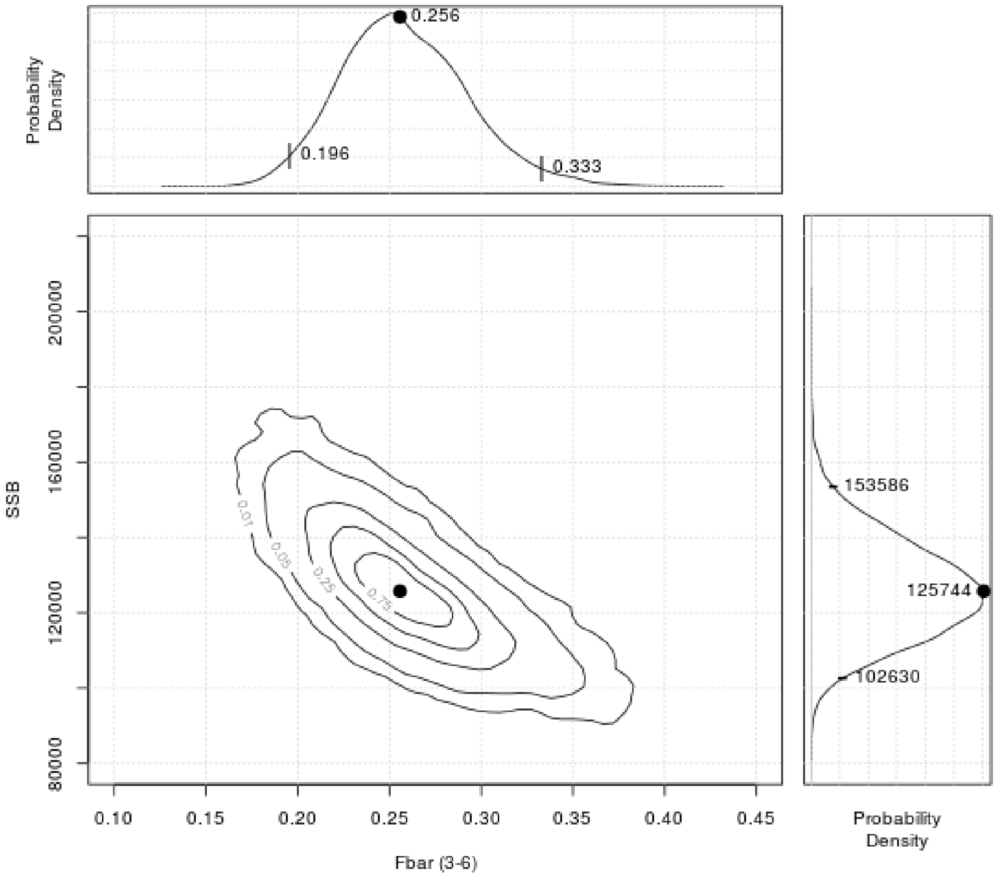


Figure 3.6.4.1 Western Baltic Spring Spawning Herring. "OTOLITH" PLOT. The main figure depicts the uncertainty in the estimated spawning stock biomass and average fishing mortality, and their correlation. Contour lines give the 1%, 5%, 25%, 50% and 75% confidence intervals for the two estimated parameters 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 (t) 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.

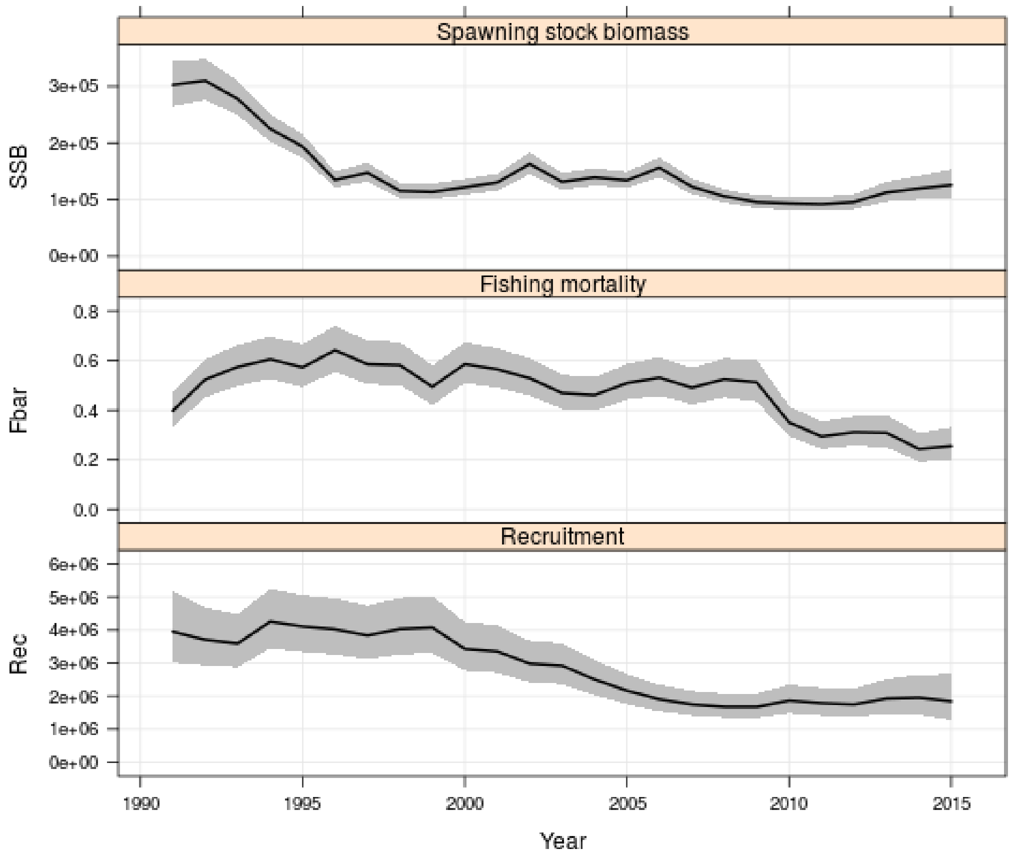


Figure 3.6.4.2 Western Baltic Spring Spawning Herring. Stock summary plot. Top panel: Spawning stock biomass. Second panel: Recruitment (at age as 0-wr) as a function of time. Bottom panel: Mean annual fishing mortality on 3–6 ringers as a function of time.

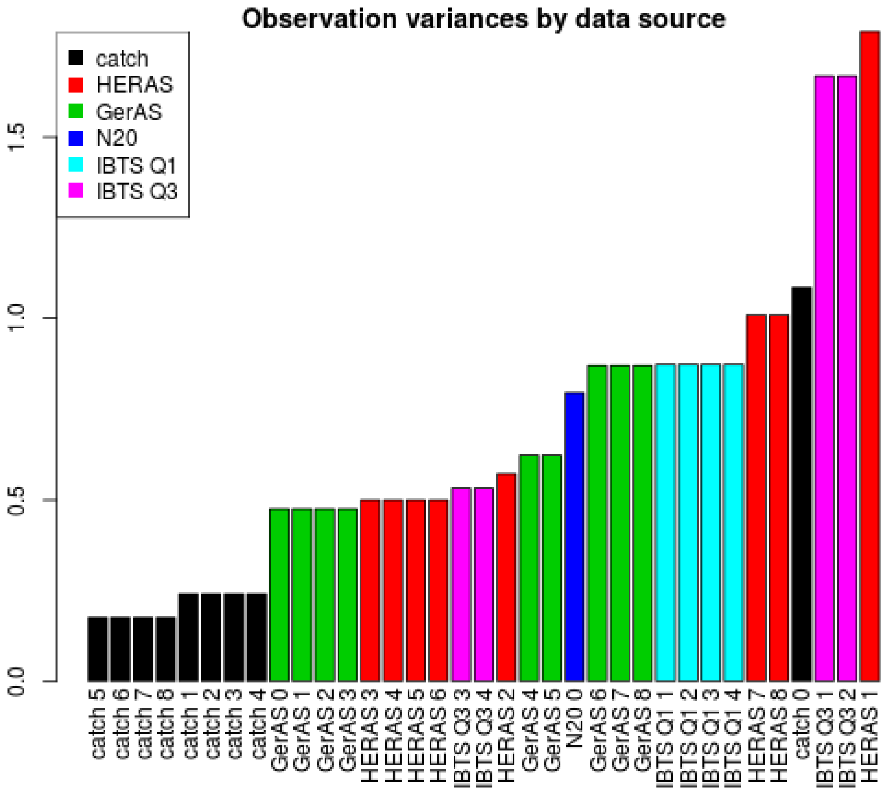


Figure 3.6.4.3 Western Baltic Spring Spawning Herring. Estimated observation variance for the WBSS assessment.

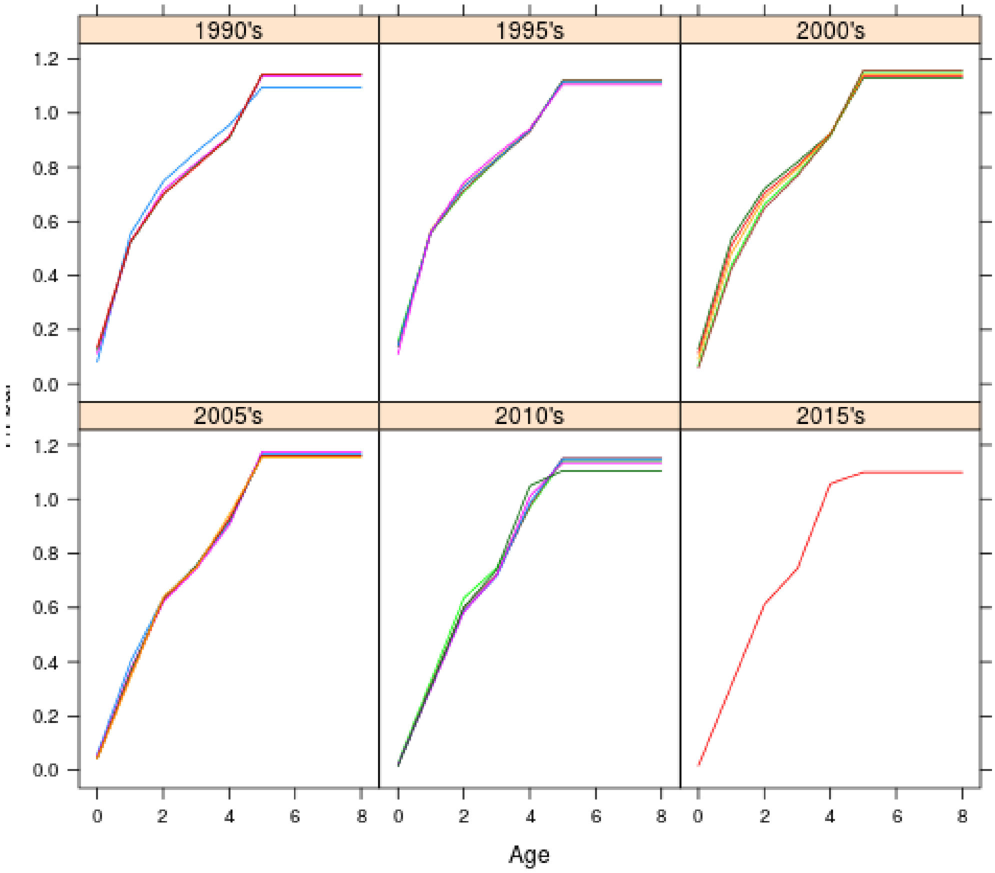


Figure 3.6.4.4 WESTERN BALTIC SPRING SPAWNING HERRING. Estimated selection pattern at age as W-ringers of the fisheries for the whole time period of the assessment.

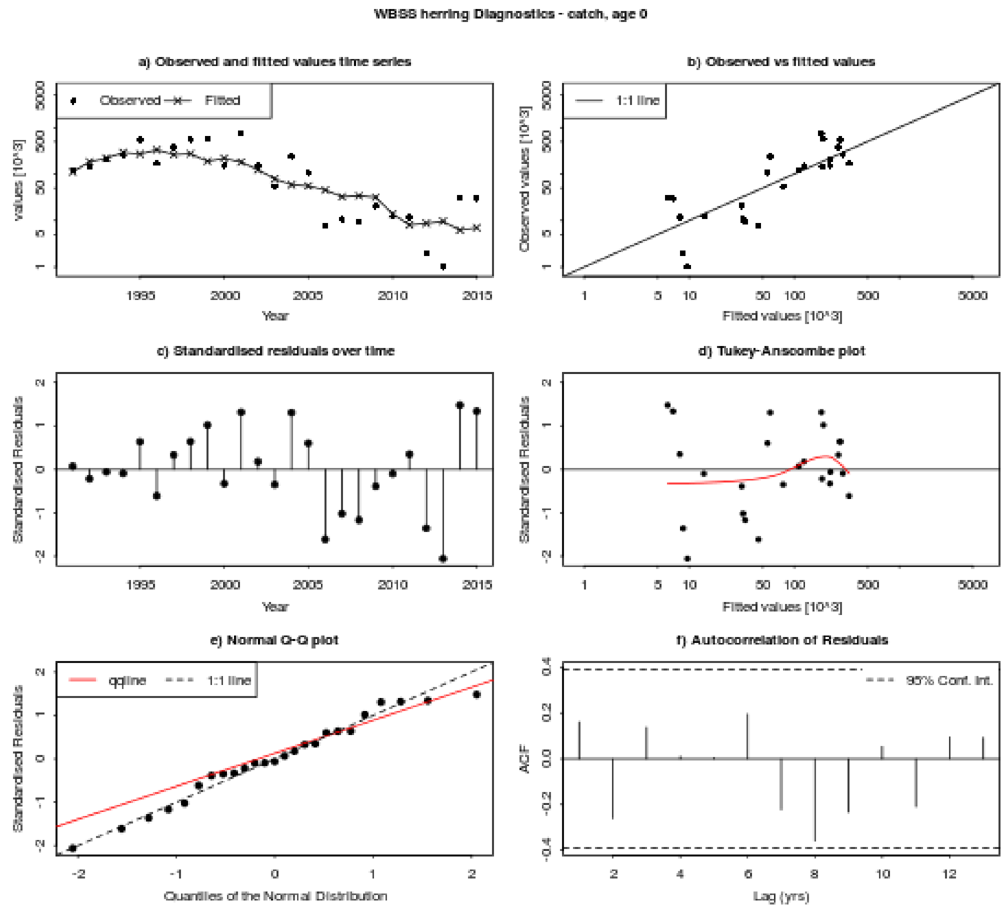


Figure 3.6.4.5 Western Baltic Spring Spawning Herring. Diagnostics of the commercial landings fit at 0 wr from the assessment. a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus model estimates of stock numbers at age as W-ringers. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log residuals 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 as W-ringers. e) Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for prediction (dotted line). f) Temporal autocorrelation of residuals.

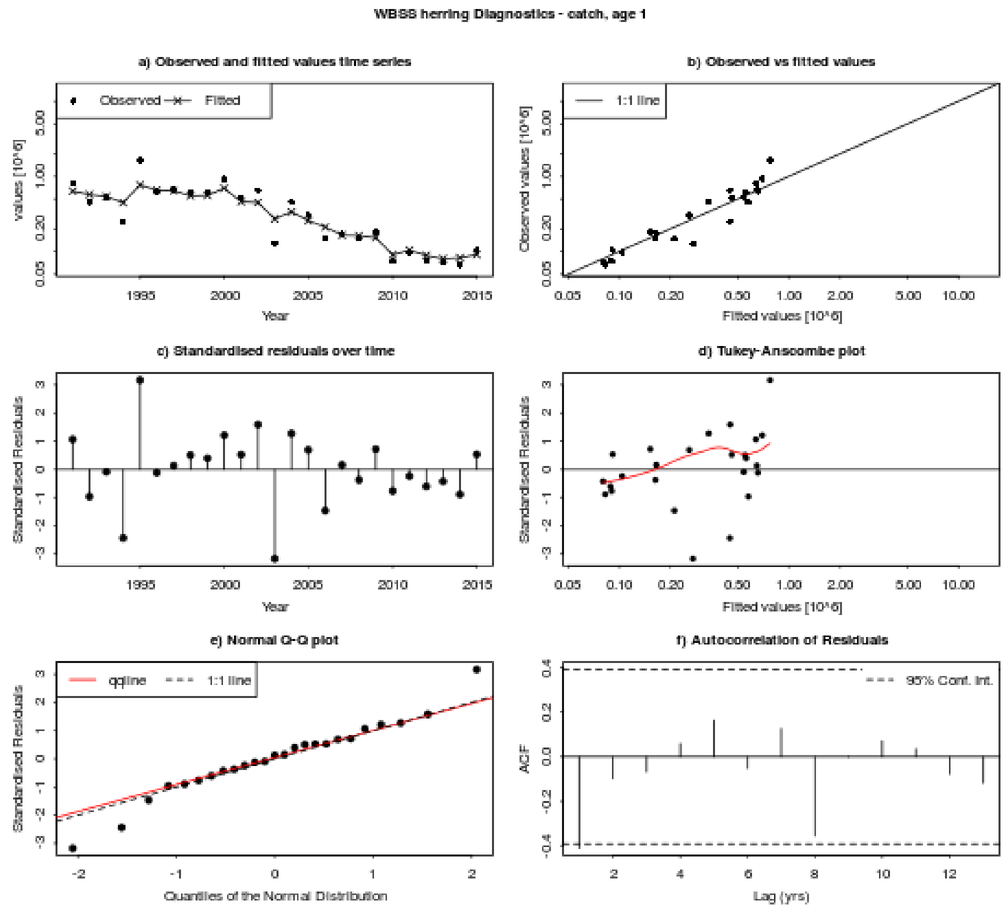


Figure 3.6.4.6 Western Baltic Spring Spawning Herring. Diagnostics of the commercial landings fit at 1 wr from the assessment. a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus model estimates of stock numbers at age as W-ringers. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log residuals 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 as W-ringers. e) Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for prediction (dotted line). f) Temporal autocorrelation of residuals.

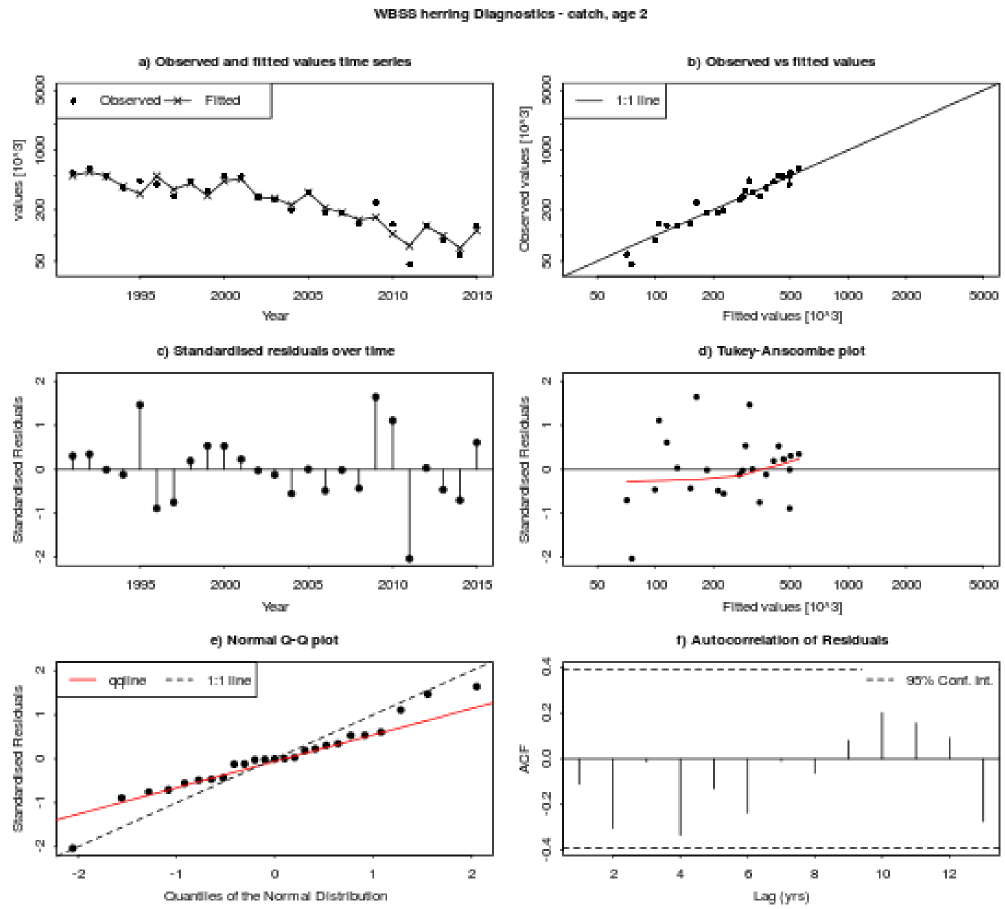


Figure 3.6.4.7 Western Baltic Spring Spawning Herring. Diagnostics of the commercial landings fit at 2 wr from the assessment. a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus model estimates of stock numbers at age as W-ringers. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log residuals 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 as W-ringers. e) Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for prediction (dotted line). f) Temporal autocorrelation of residuals.

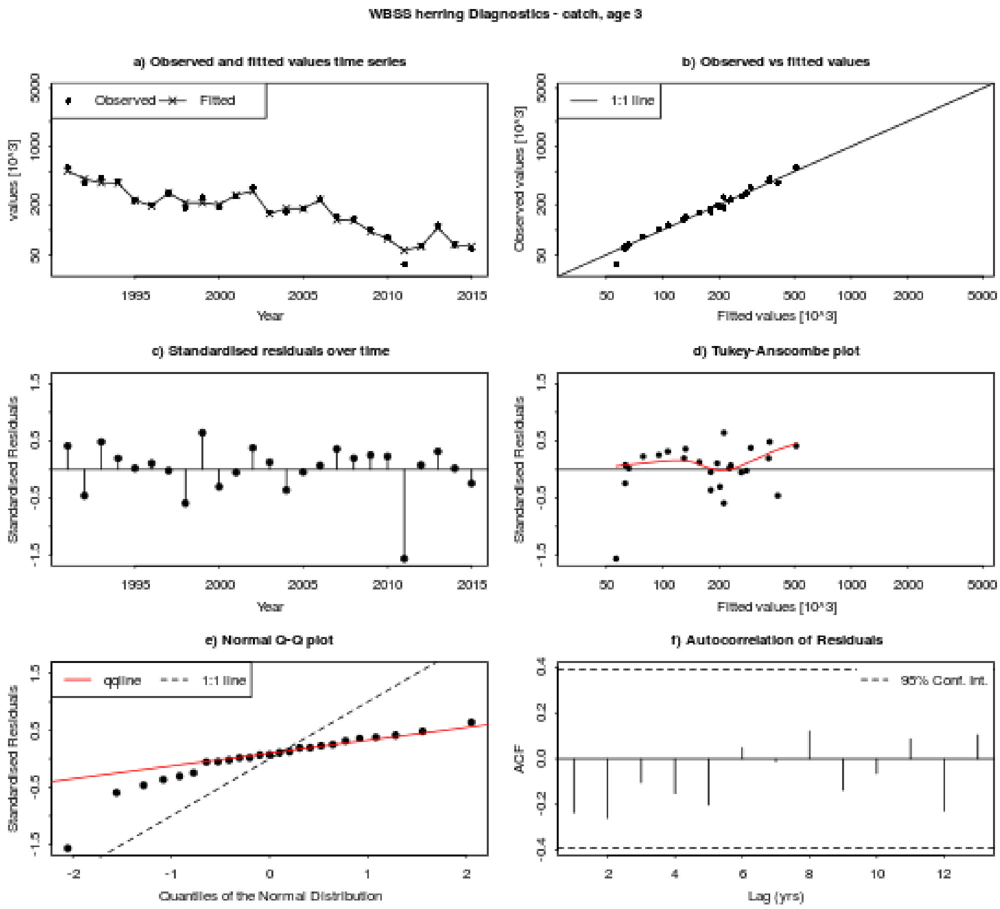


Figure 3.6.4.8 Western Baltic Spring Spawning Herring. Diagnostics of the commercial landings fit at 3 wr from the assessment. a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus model estimates of stock numbers at age as W-ringers. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log residuals 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 as W-ringers. e) Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line). f) Temporal autocorrelation of residuals.

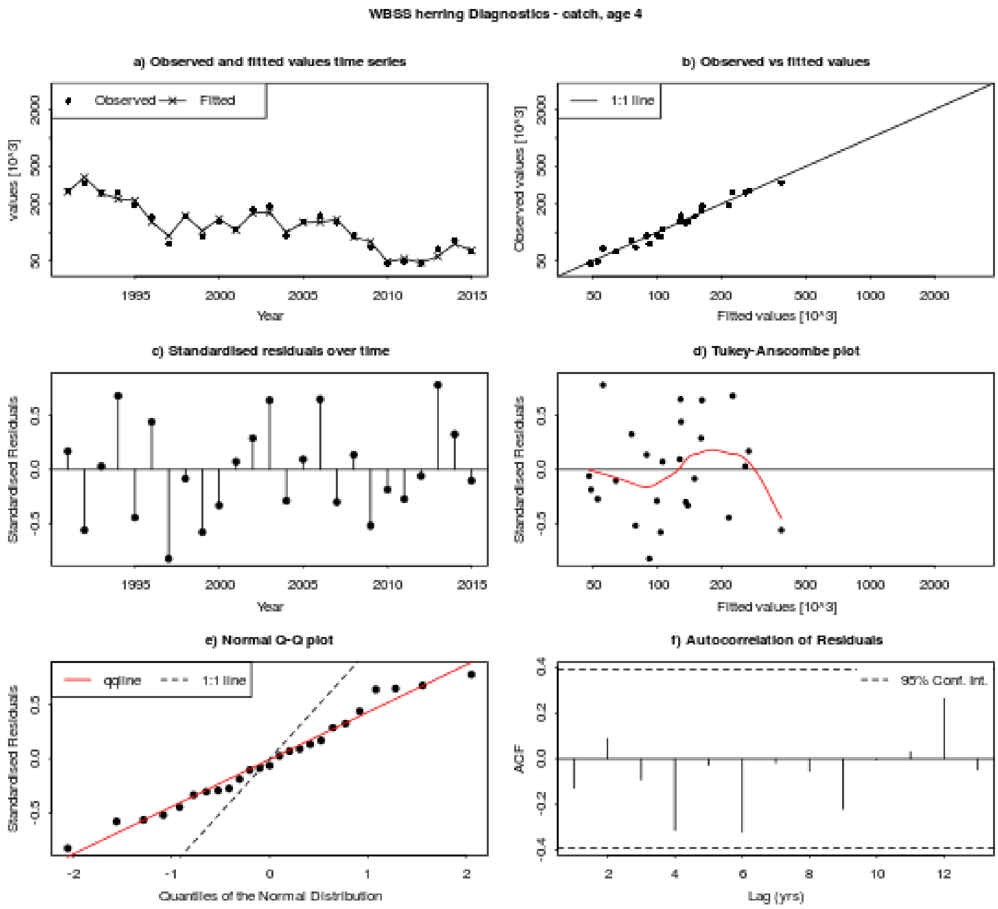


Figure 3.6.4.9 Western Baltic Spring Spawning Herring. Diagnostics of the commercial landings fit at 4 wr from the assessment. a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus model estimates of stock numbers at age as W-ringers. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log residuals 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 as W-ringers. e) Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for prediction (dotted line). f) Temporal autocorrelation of residuals.

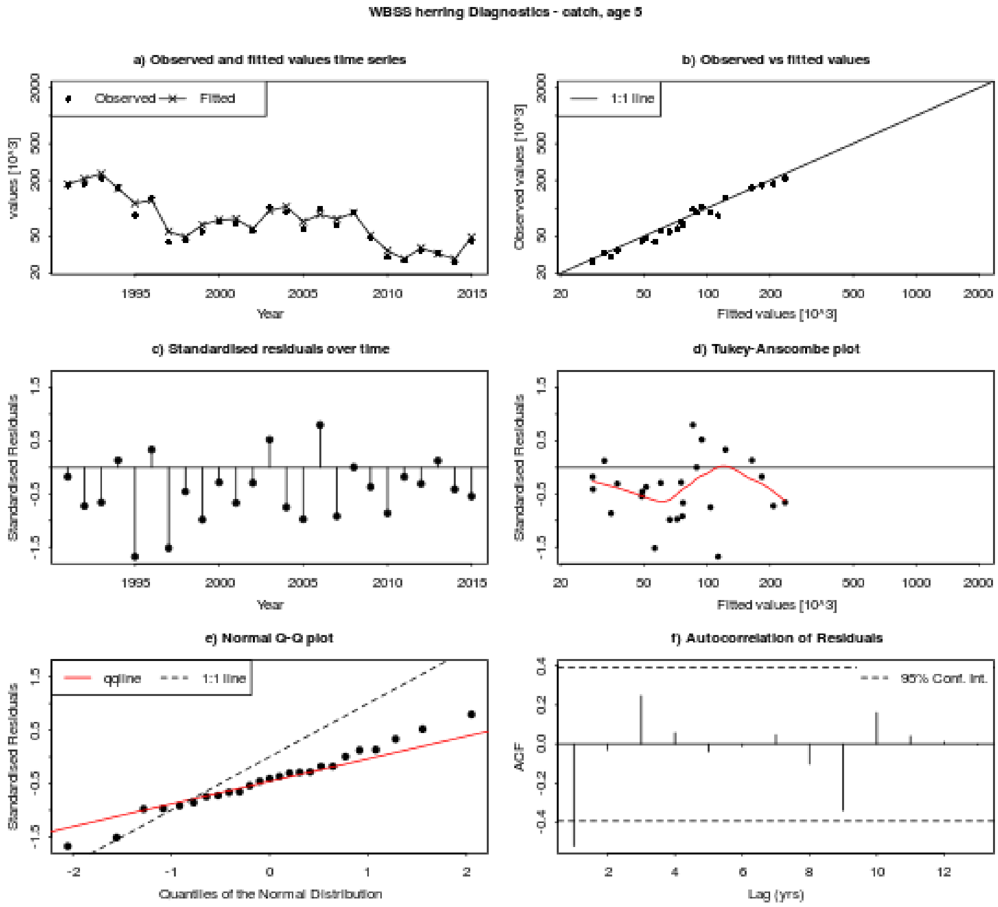


Figure 3.6.4.10 Western Baltic Spring Spawning Herring. Diagnostics of the commercial landings fit at 5 wr from the assessment. a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus model estimates of stock numbers at age as W-ringers. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log residuals 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 as W-ringers. e) Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for prediction (dotted line). f) Temporal autocorrelation of residuals.

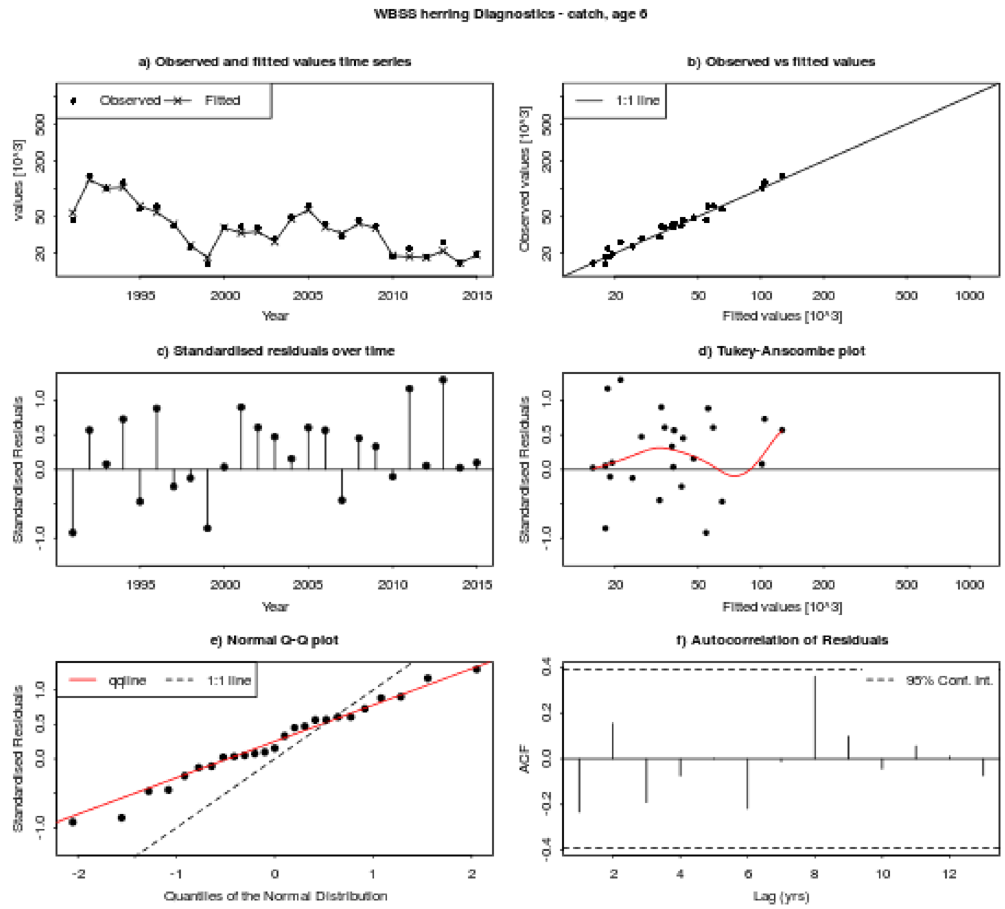


Figure 3.6.4.11 Western Baltic Spring Spawning Herring. Diagnostics of the commercial landings fit at 6 wr from the assessment. a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus model estimates of stock numbers at age as W-ringers. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log residuals 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 as W-ringers. e) Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for prediction (dotted line). f) Temporal autocorrelation of residuals.

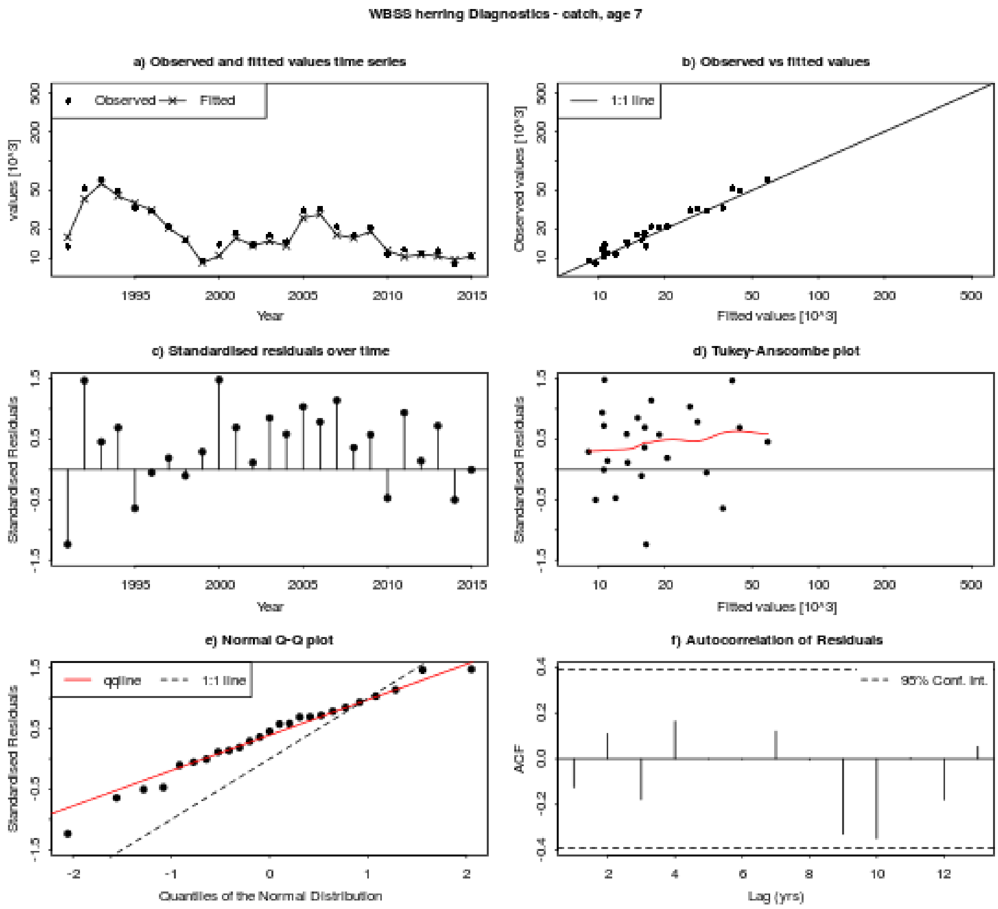


Figure 3.6.4.12 Western Baltic Spring Spawning Herring. Diagnostics of the commercial landings fit at 7 wr from the assessment. a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus model estimates of stock numbers at age as W-ringers. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log residuals 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 as W-ringers. e) Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for prediction (dotted line). f) Temporal autocorrelation of residuals.

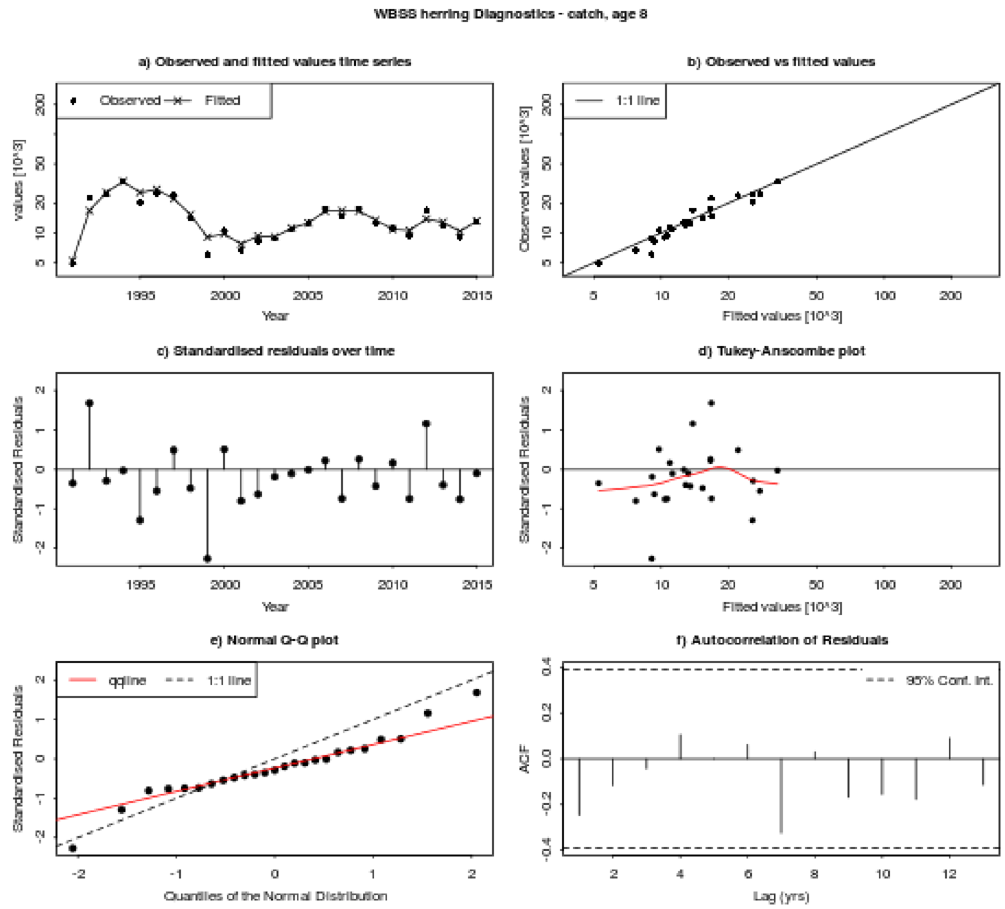


Figure 3.6.4.13 Western Baltic Spring Spawning Herring. Diagnostics of the commercial landings fit at 8 wr from the assessment. a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus model estimates of stock numbers at age as W-ringers. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log residuals 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 as W-ringers. e) Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for prediction (dotted line). f) Temporal autocorrelation of residuals.

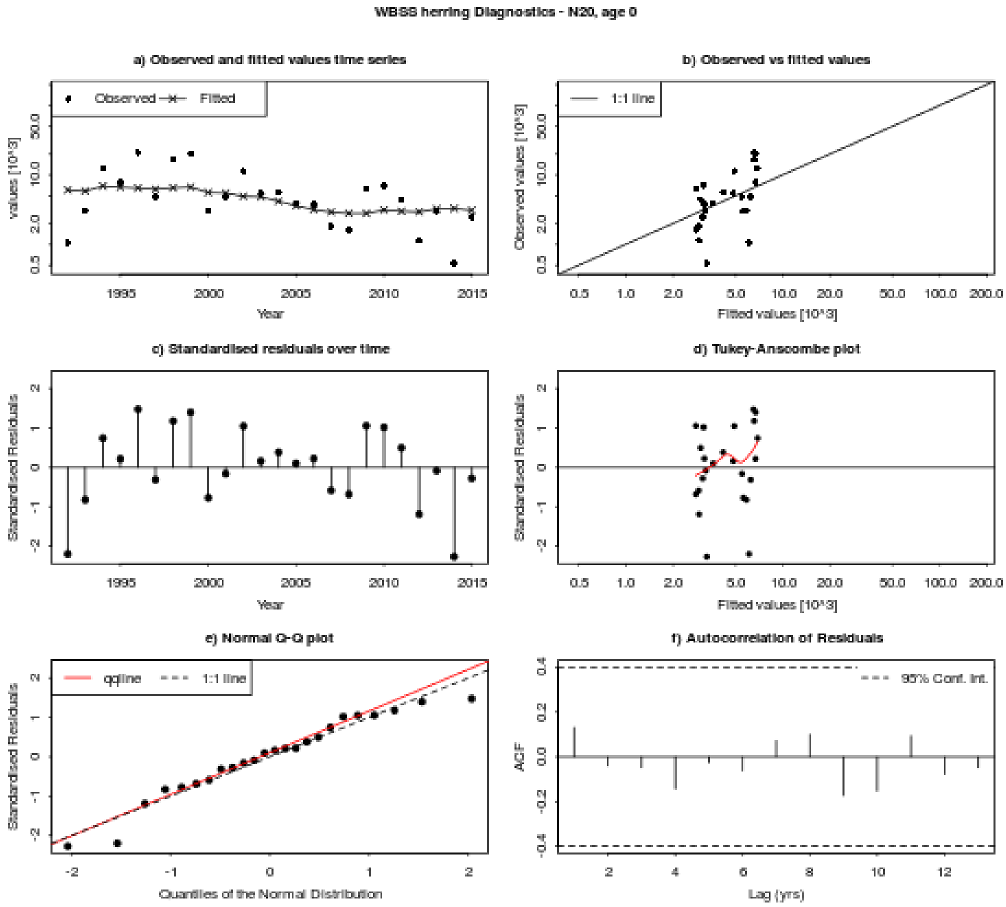


Figure 3.6.4.14 Western Baltic Spring Spawning Herring. Diagnostics of the N20 larval index. a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus model estimates of stock numbers at age as W-ringers. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log residuals 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 as W-ringers. e) Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line). f) Temporal autocorrelation of residuals.

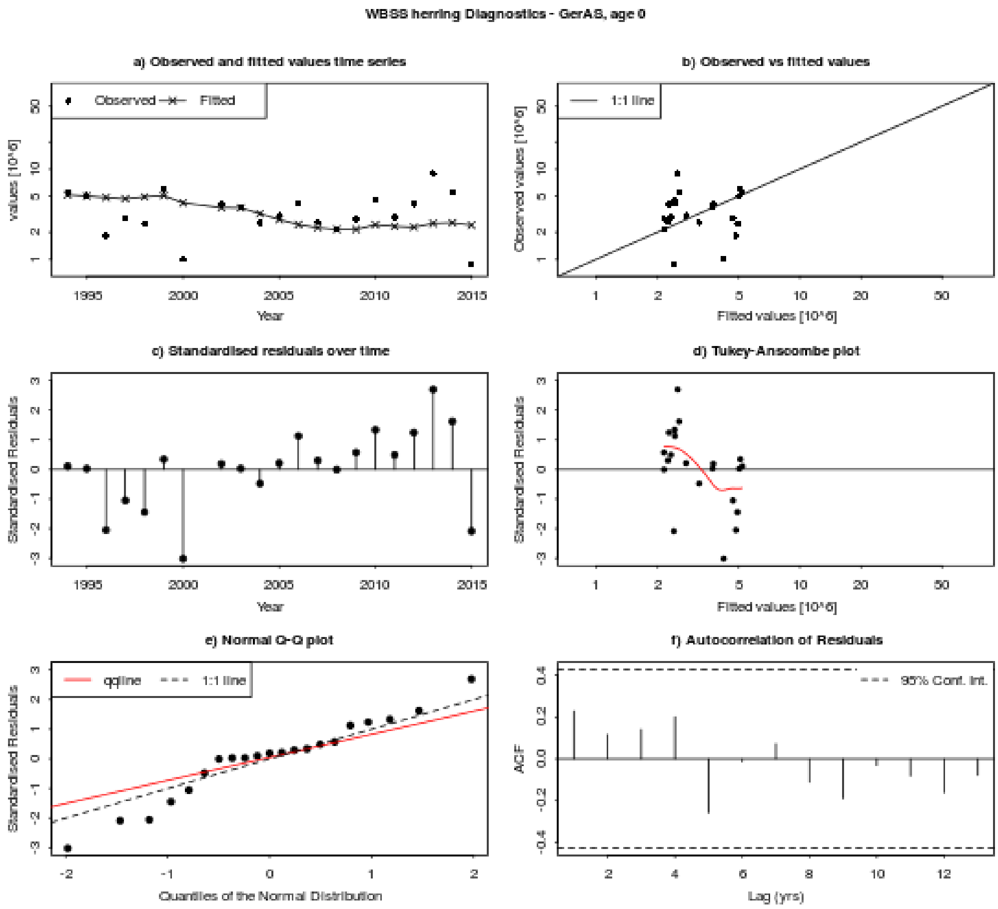


Figure 3.6.4.15 Western Baltic Spring Spawning Herring. Diagnostics of the German acoustic survey in Subdivision 21–24 (GERAS) fit at 0 wr from the assessment. a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus model estimates of stock numbers at age as W-ringers. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log residuals 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 as W-ringers. e) Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line). f) Temporal autocorrelation of residuals.

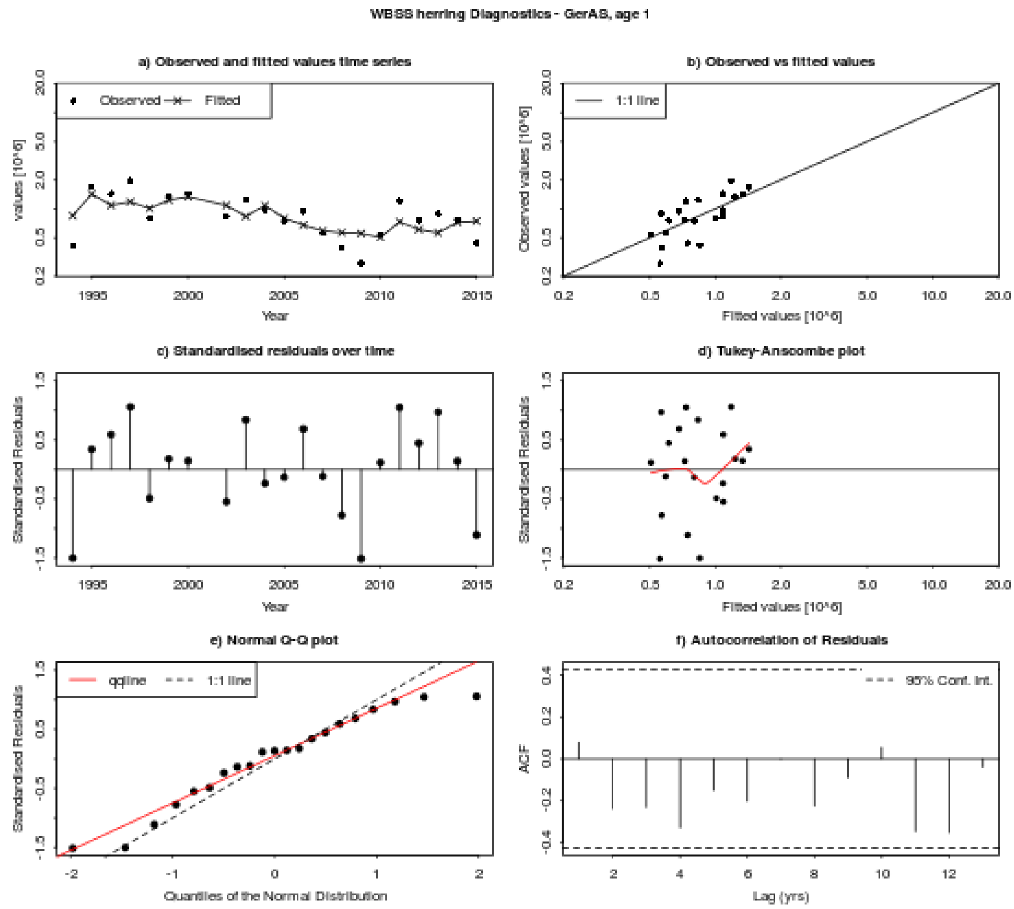


Figure 3.6.4.16 Western Baltic Spring Spawning Herring. Diagnostics of the German acoustic survey in Subdivision 21–24 (GERAS) fit at 1 wr from the assessment. a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus model estimates of stock numbers at age as W-ringers. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log residuals 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 as W-ringers. e) Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line). f) Temporal autocorrelation of residuals.

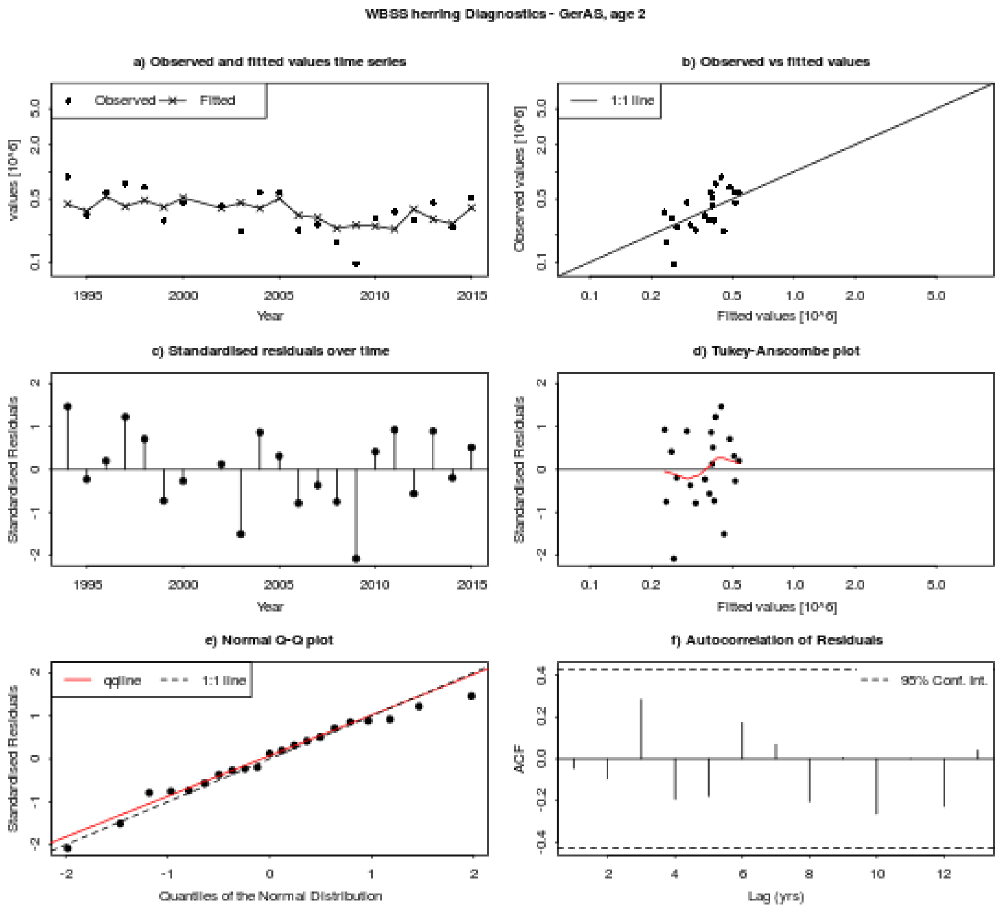


Figure 3.6.4.17 Western Baltic Spring Spawning Herring. Diagnostics of the German acoustic survey in Subdivision 21–24 (GERAS) fit at 2 wr from the assessment. a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus model estimates of stock numbers at age as W-ringers. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log residuals 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 as W-ringers. e) Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line). f) Temporal autocorrelation of residuals.

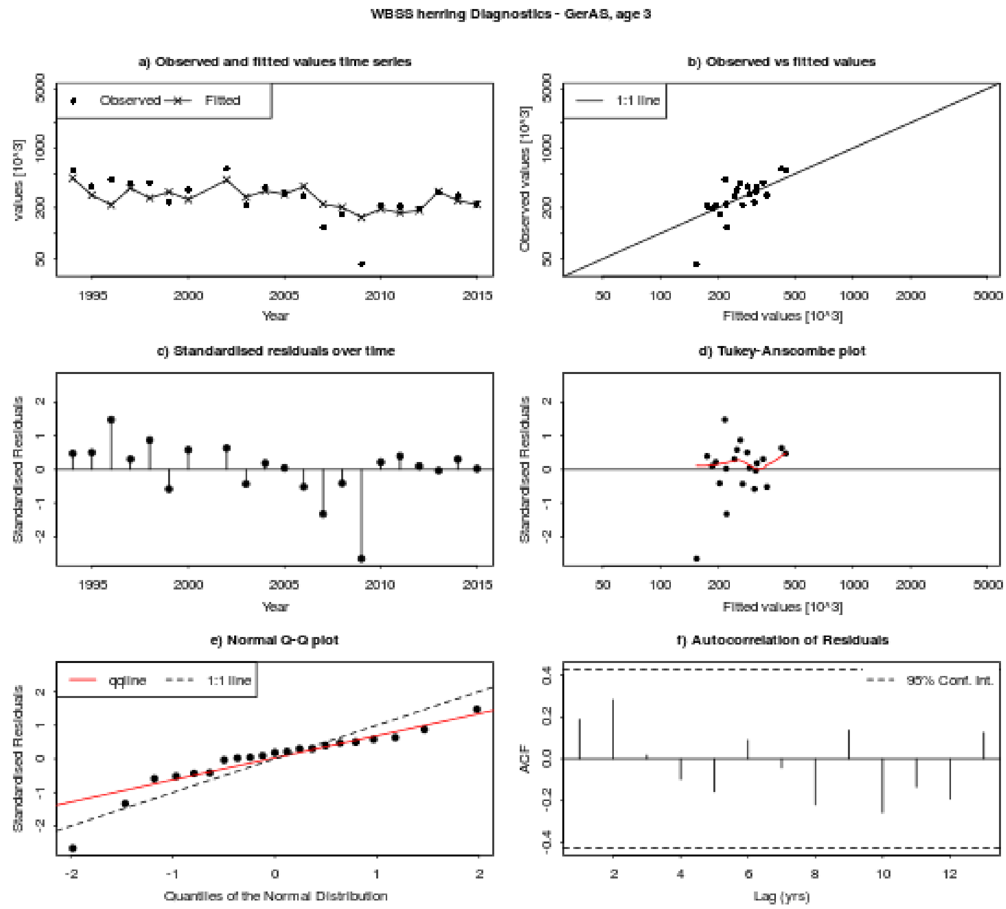


Figure 3.6.4.18 Western Baltic Spring Spawning Herring. Diagnostics of the German acoustic survey in Subdivision 21–24 (GERAS) fit at 3 wr from the assessment. a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus model estimates of stock numbers at age as W-ringers. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log residuals 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 as W-ringers. e) Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line). f) Temporal autocorrelation of residuals.

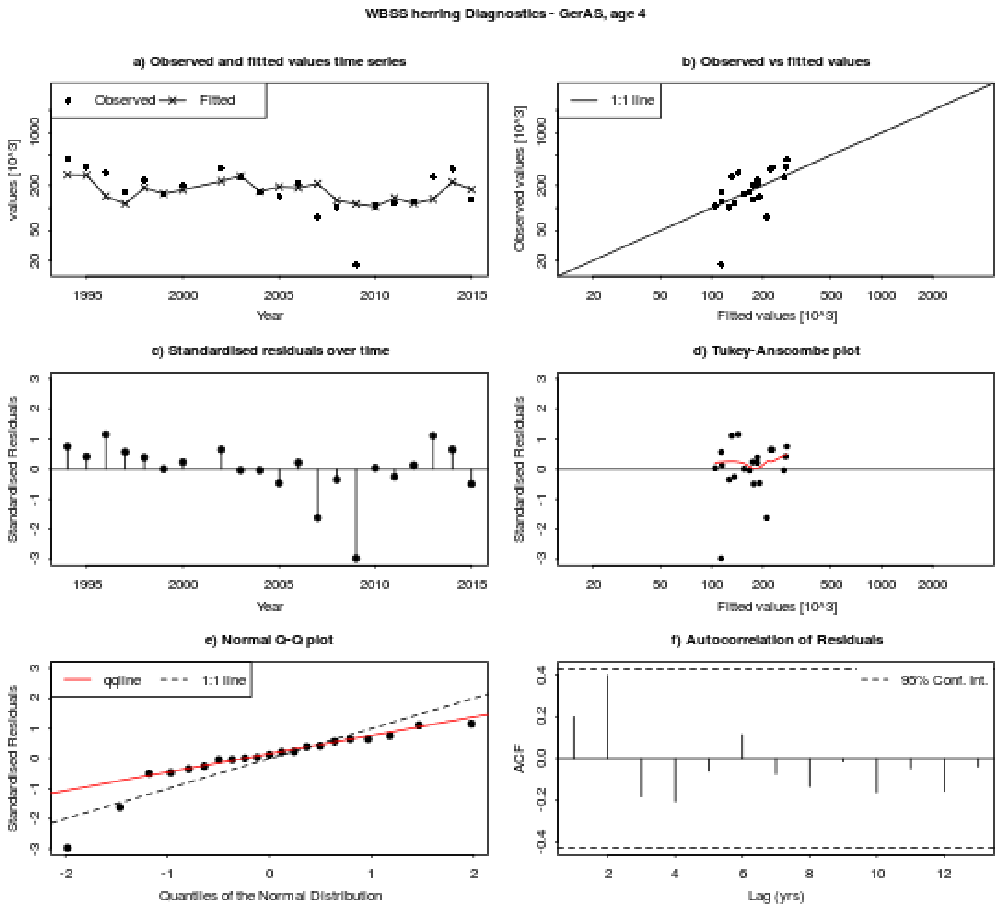


Figure 3.6.4.19 Western Baltic Spring Spawning Herring. Diagnostics of the German acoustic survey in Subdivision 21–24 (GERAS) fit at 4 wr from the assessment. a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus model estimates of stock numbers at age as W-ringers. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log residuals 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 as W-ringers. e) Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line). f) Temporal autocorrelation of residuals.

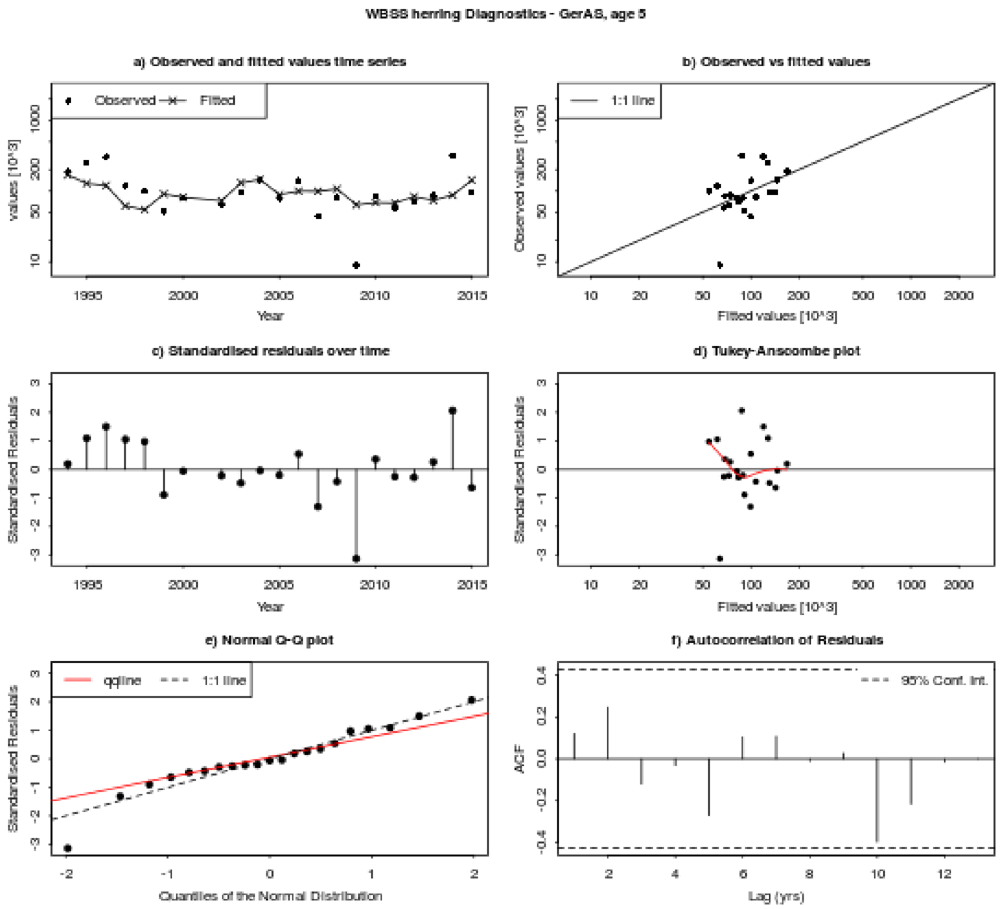


Figure 3.6.4.20 Western Baltic Spring Spawning Herring. Diagnostics of the German acoustic survey in Subdivision 21–24 (GERAS) fit at 5 wr from the assessment. a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus model estimates of stock numbers at age as W-ringers. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log residuals 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 as W-ringers. e) Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line). f) Temporal autocorrelation of residuals.

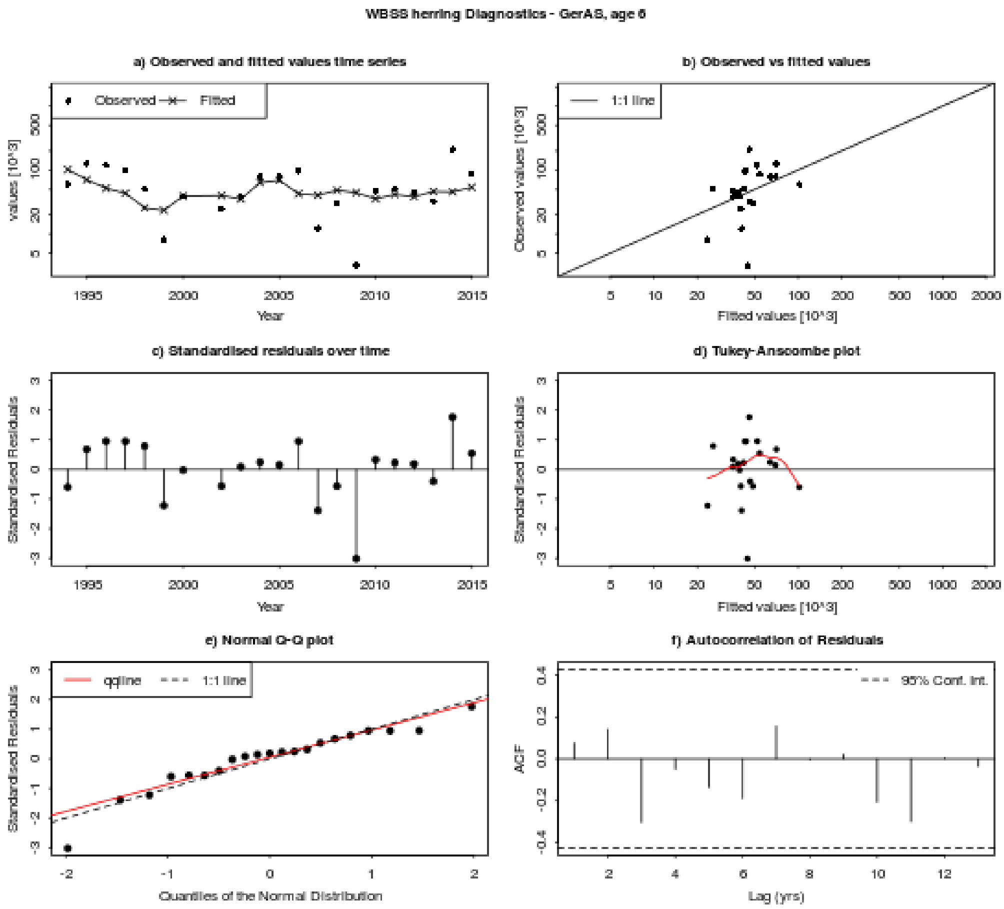


Figure 3.6.4.21 Western Baltic Spring Spawning Herring. Diagnostics of the German acoustic survey in Subdivision 21–24 (GERAS) fit at 6 wr from the assessment. a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus model estimates of stock numbers at age as W-ringers. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log residuals 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 as W-ringers. e) Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line). f) Temporal autocorrelation of residuals.

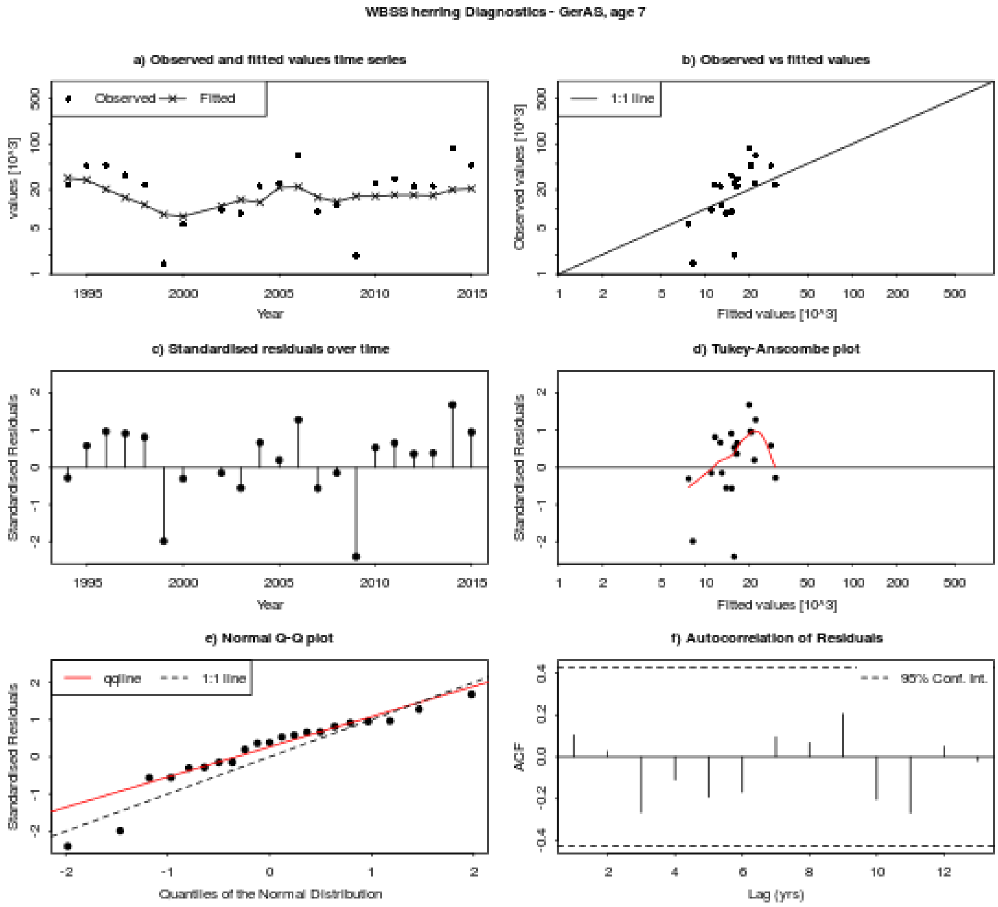


Figure 3.6.4.22 Western Baltic Spring Spawning Herring. Diagnostics of the German acoustic survey in Subdivision 21–24 (GERAS) fit at 7 wr from the assessment. a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus model estimates of stock numbers at age as W-ringers. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log residuals 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 as W-ringers. e) Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line). f) Temporal autocorrelation of residuals.

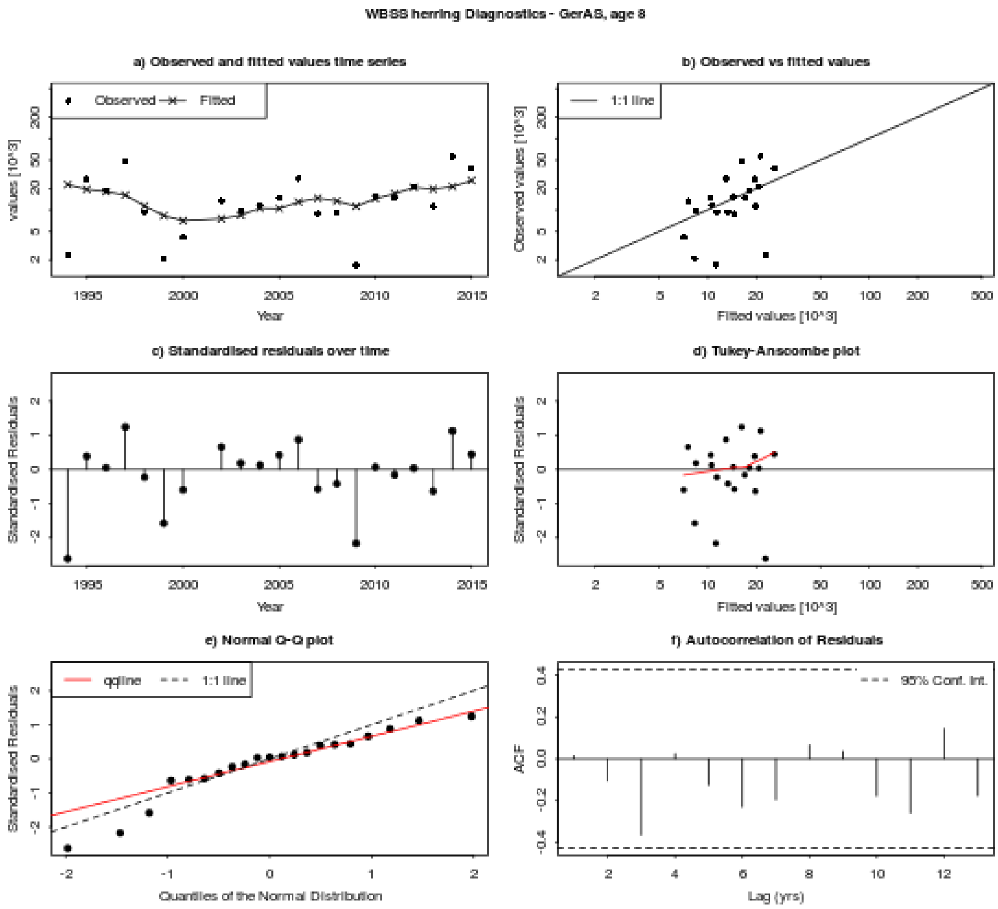


Figure 3.6.4.23 Western Baltic Spring Spawning Herring. Diagnostics of the German acoustic survey in Subdivision 21–24 (GERAS) fit at 8 wr from the assessment. a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus model estimates of stock numbers at age as W-ringers. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log residuals 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 as W-ringers. e) Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line). f) Temporal autocorrelation of residuals.

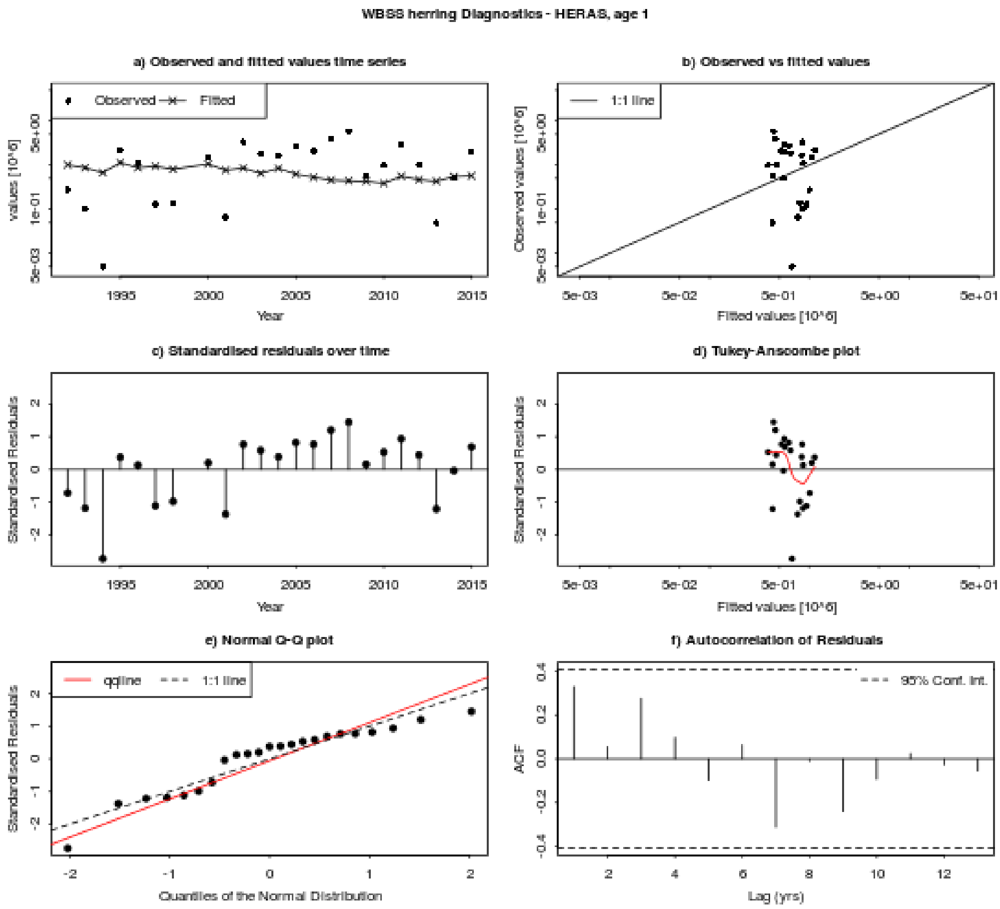


Figure 3.6.4.24 Western Baltic Spring Spawning Herring. Diagnostics of the Herring acoustic survey in the North Sea and division 3.a (HERAS) fit at 1 wr from the assessment. a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus model estimates of stock numbers at age as W-ringers. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log residuals 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 as W-ringers. e) Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line). f) Temporal autocorrelation of residuals.

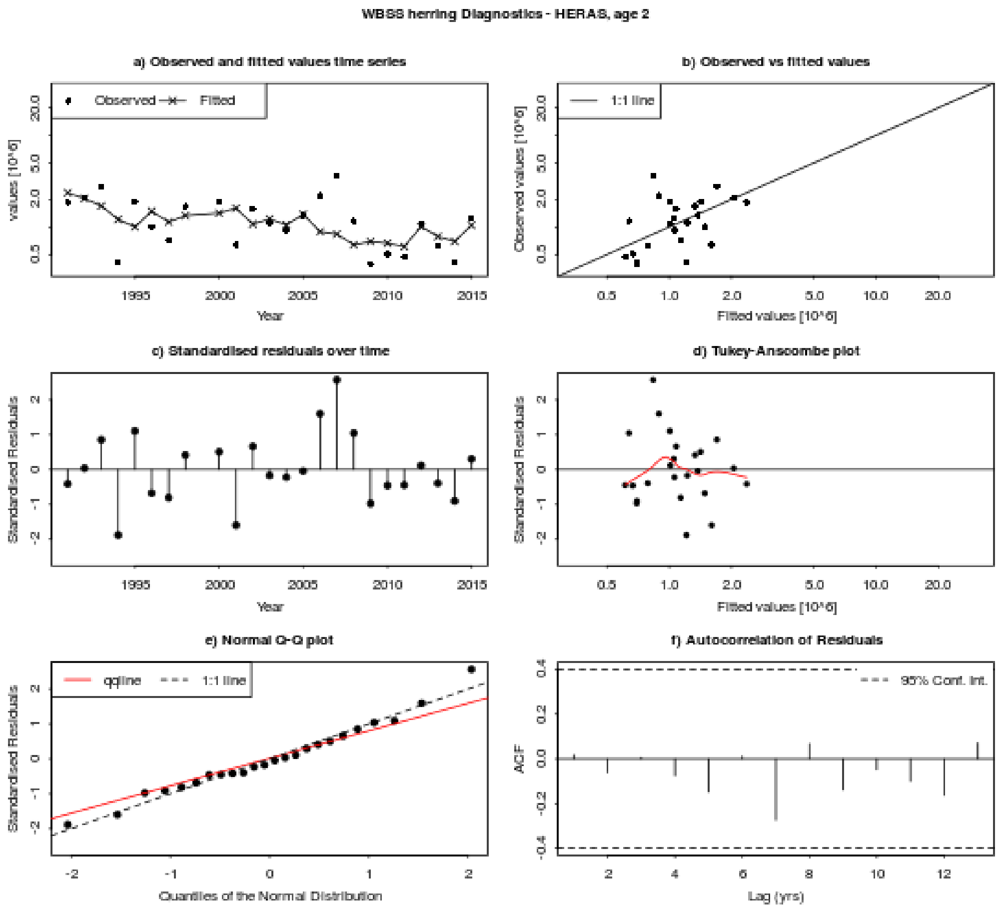


Figure 3.6.4.25 Western Baltic Spring Spawning Herring. Diagnostics of the Herring acoustic survey in the North Sea and division 3.a (HERAS) fit at 2 wr from the assessment. a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus model estimates of stock numbers at age as W-ringers. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log residuals 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 as W-ringers. e) Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line). f) Temporal autocorrelation of residuals.

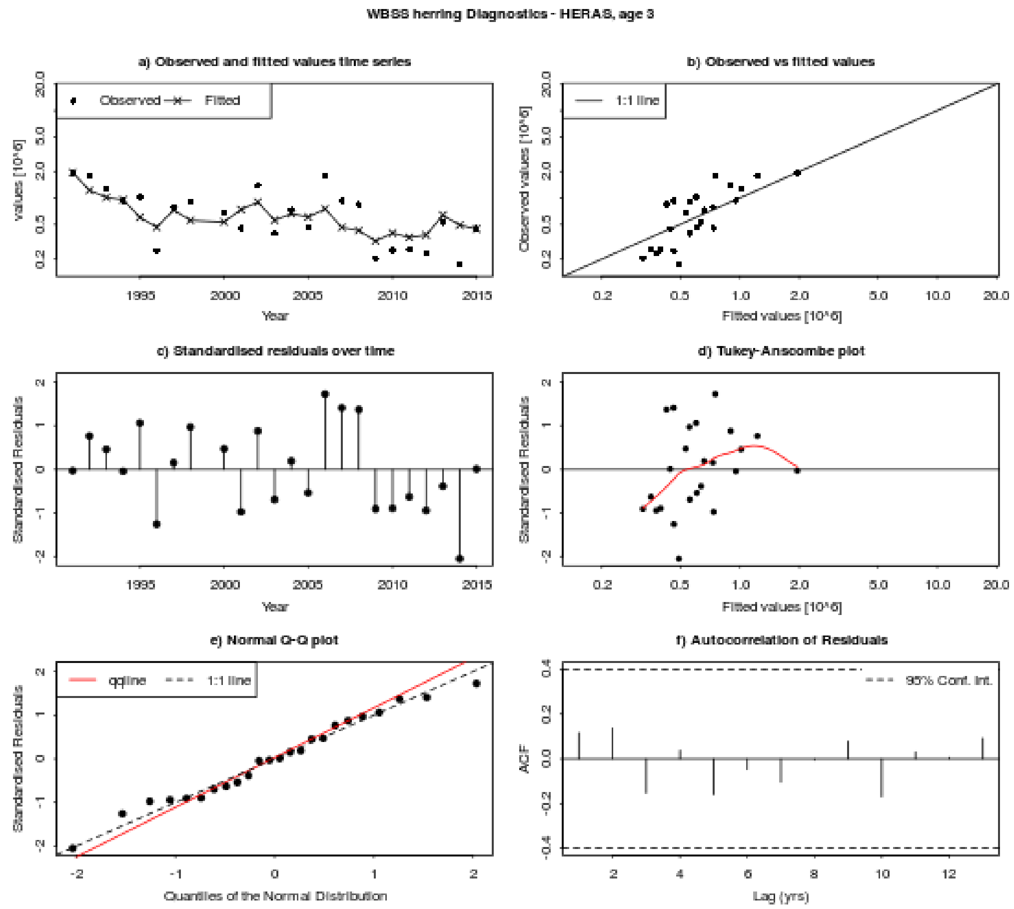


Figure 3.6.4.26 Western Baltic Spring Spawning Herring. Diagnostics of the Herring acoustic survey in the North Sea and division 3.a (HERAS) fit at 3 wr from the assessment. a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus model estimates of stock numbers at age as W-ringers. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log residuals 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 as W-ringers. e) Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line). f) Temporal autocorrelation of residuals.

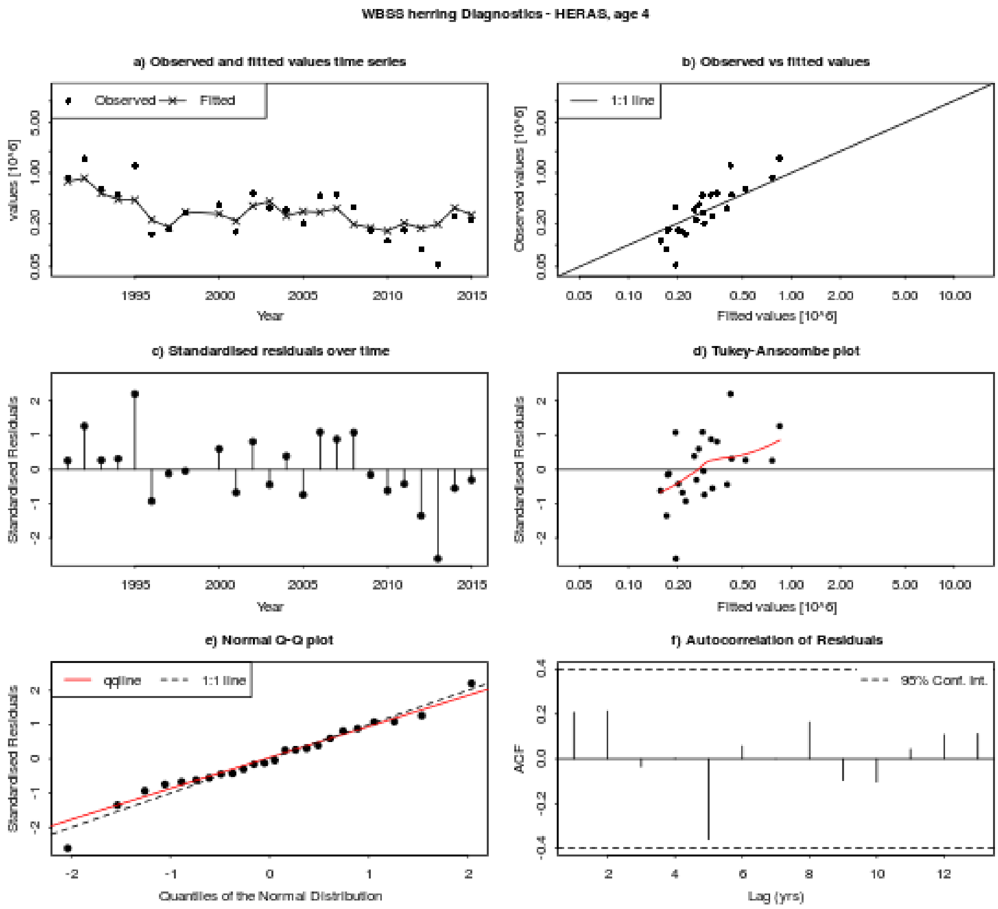


Figure 3.6.4.27 Western Baltic Spring Spawning Herring. Diagnostics of the Herring acoustic survey in the North Sea and division 3.a (HERAS) fit at 4 wr from the assessment. a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus model estimates of stock numbers at age as W-ringers. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log residuals 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 as W-ringers. e) Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line). f) Temporal autocorrelation of residuals.

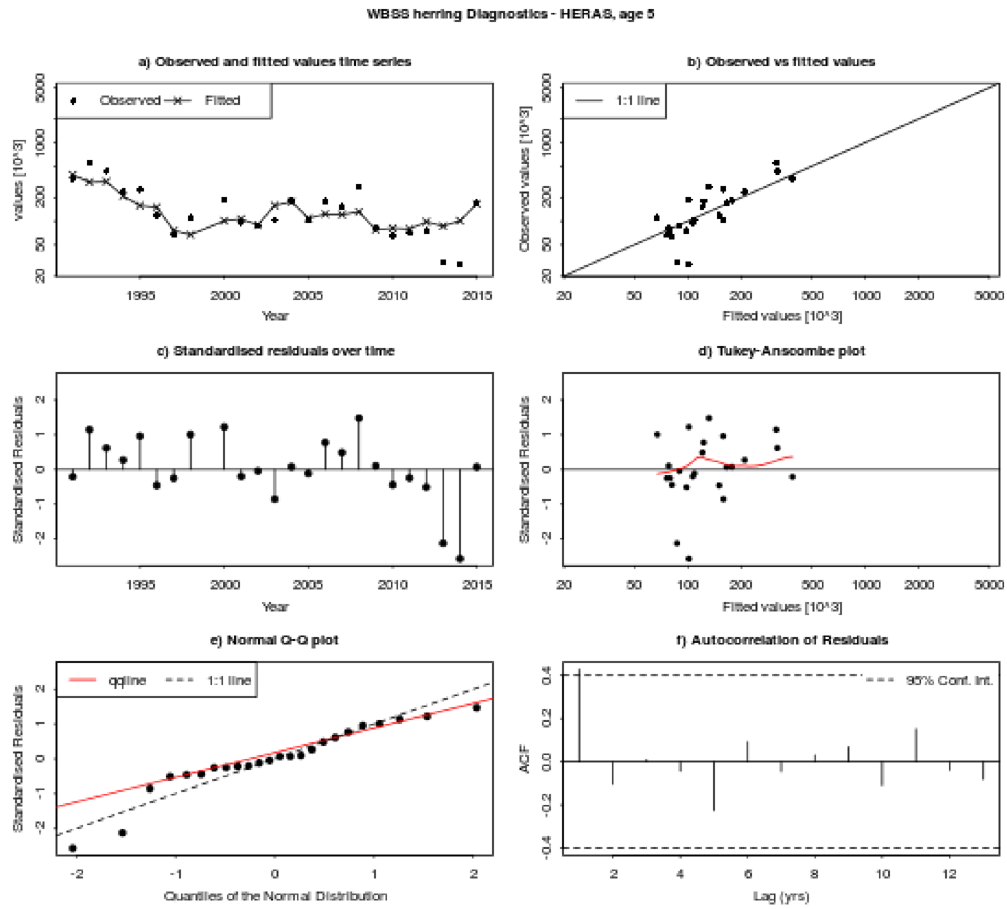


Figure 3.6.4.28 Western Baltic Spring Spawning Herring. Diagnostics of the Herring acoustic survey in the North Sea and division 3.a (HERAS) fit at 5 wr from the assessment. a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus model estimates of stock numbers at age as W-ringers. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log residuals 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 as W-ringers. e) Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line) f) Temporal autocorrelation of residuals.

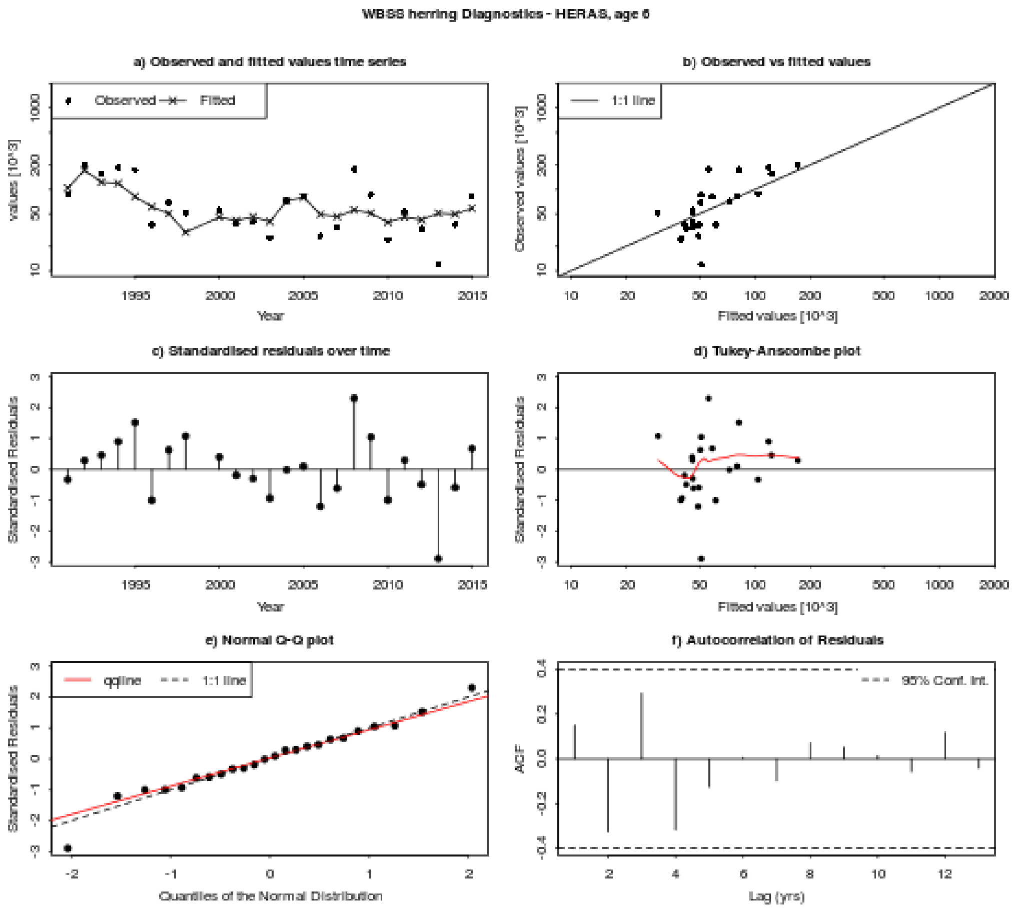


Figure 3.6.4.29 Western Baltic Spring Spawning Herring. Diagnostics of the Herring acoustic survey in the North Sea and division 3.a (HERAS) fit at 6 wr from the assessment. a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus model estimates of stock numbers at age as W-ringers. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log residuals 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 as W-ringers. e) Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line). f) Temporal autocorrelation of residuals.

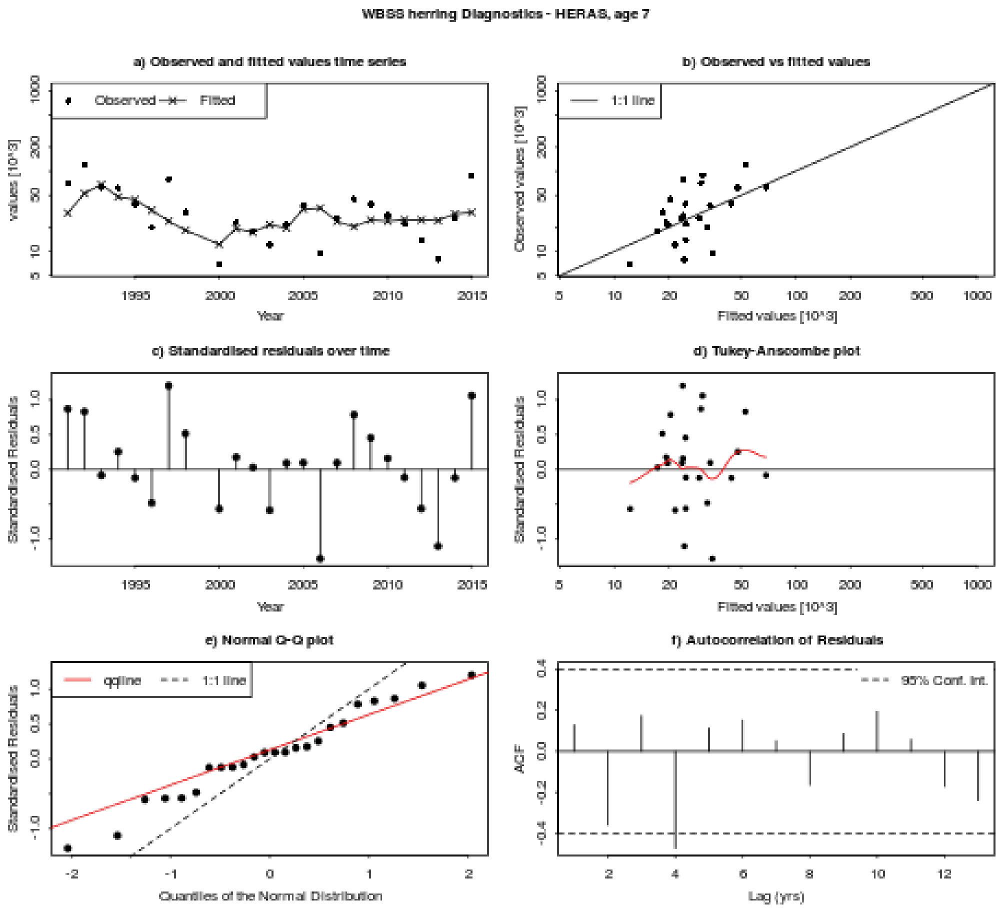


Figure 3.6.4.30 Western Baltic Spring Spawning Herring. Diagnostics of the Herring acoustic survey in the North Sea and division 3.a (HERAS) fit at 7 wr from the assessment. a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus model estimates of stock numbers at age as W-ringers. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log residuals 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 as W-ringers. e) Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line). f) Temporal autocorrelation of residuals.

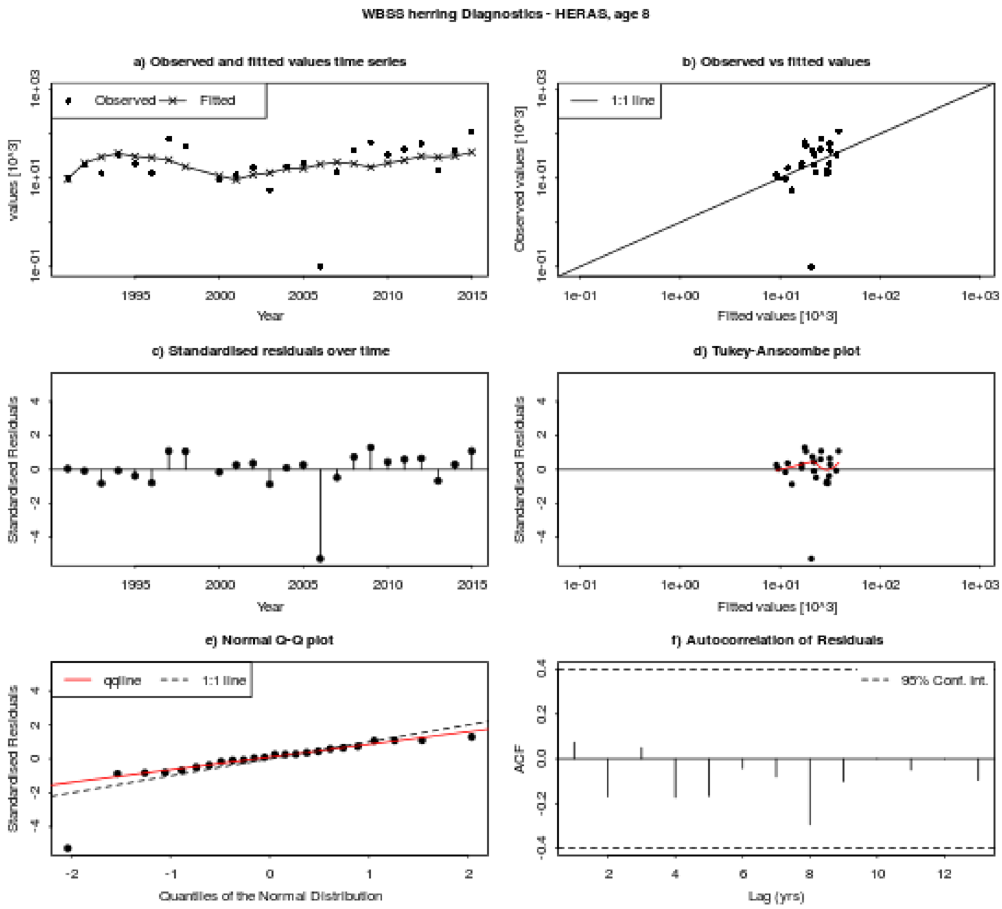


Figure 3.6.4.31 Western Baltic Spring Spawning Herring. Diagnostics of the Herring acoustic survey in the North Sea and division 3.a (HERAS) fit at 8 wr from the assessment. a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus model estimates of stock numbers at age as W-ringers. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log residuals 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 as W-ringers. e) Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line). f) Temporal autocorrelation of residuals.

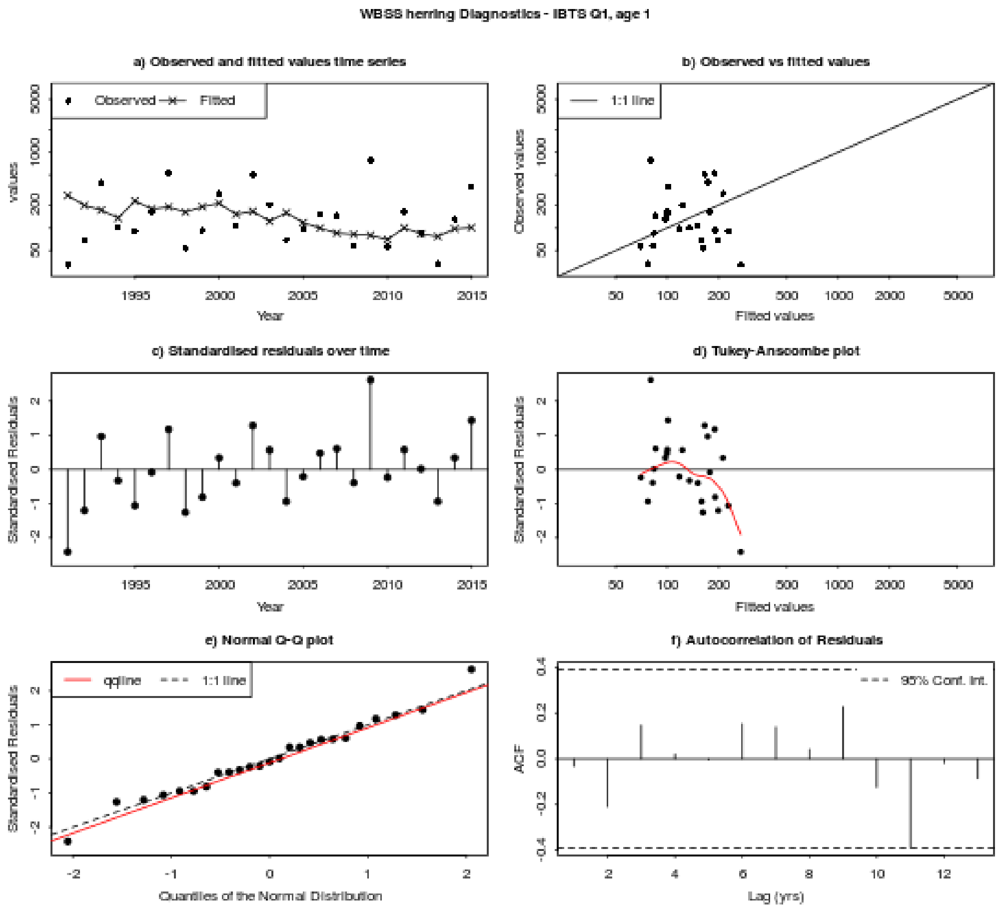


Figure 3.6.4.32 Western Baltic Spring Spawning Herring. Diagnostics of the International Bottom Trawl Survey in Division 3.a in quarter 1 (IBTS Q1) fit at 1 wr from the assessment. a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus model estimates of stock numbers at age as W-ringers. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log residuals 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 as W-ringers. e) Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line). f) Temporal autocorrelation of residuals.

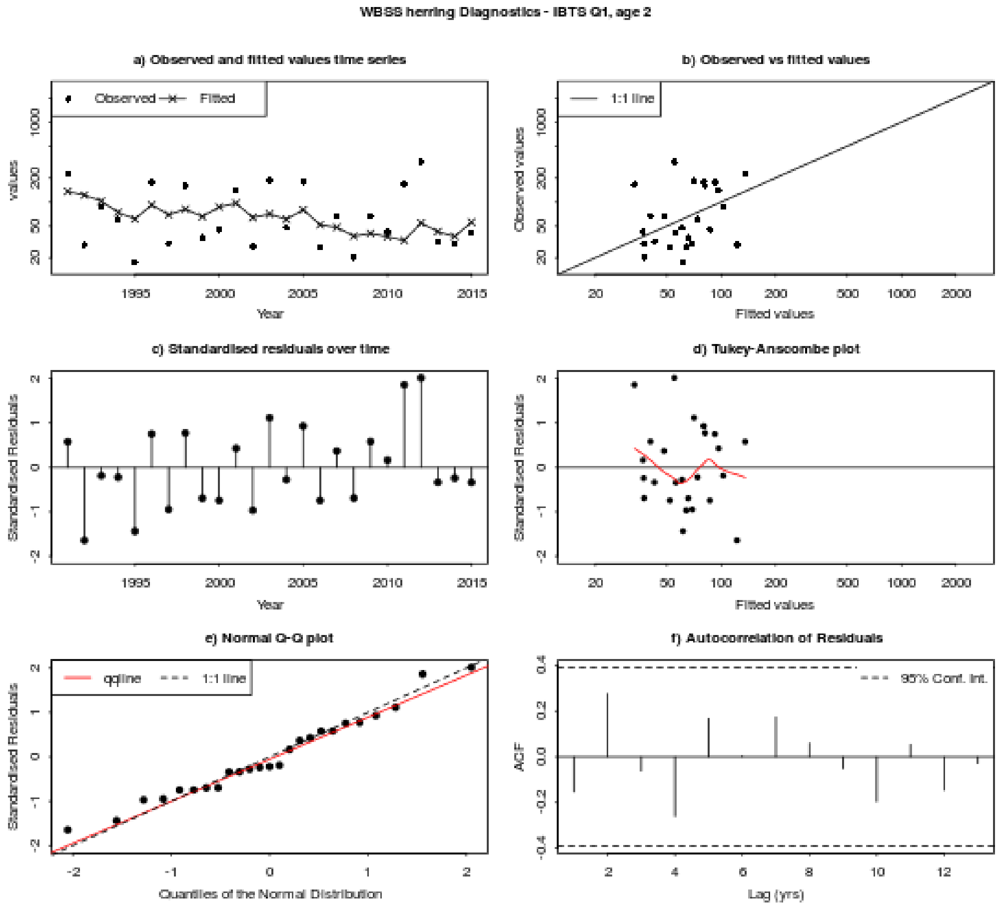


Figure 3.6.4.33 Western Baltic Spring Spawning Herring. Diagnostics of the International Bottom Trawl Survey in Division 3.a in quarter 1 (IBTS Q1) fit at 2 wr from the assessment. a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus model estimates of stock numbers at age as W-ringers. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log residuals 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 as W-ringers. e) Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line). f) Temporal autocorrelation of residuals.

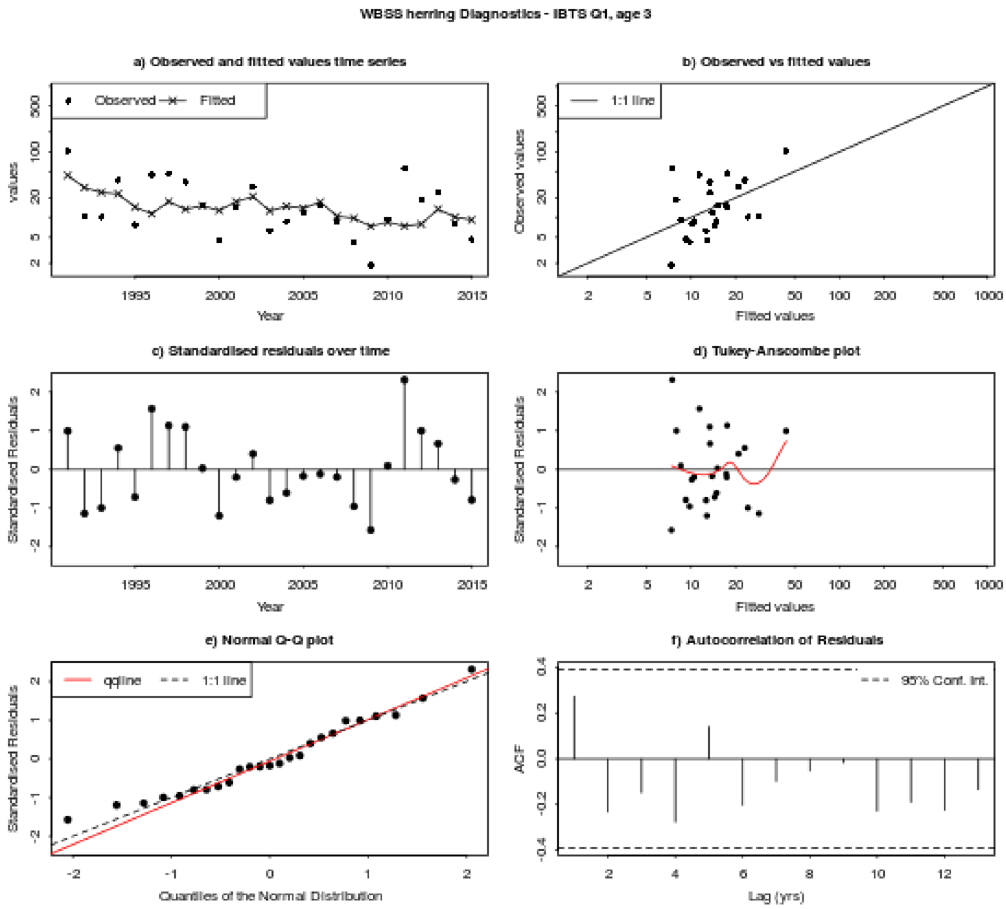


Figure 3.6.4.34 Western Baltic Spring Spawning Herring. Diagnostics of the International Bottom Trawl Survey in Division 3.a in quarter 1 (IBTS Q1) fit at 3 wr from the assessment. a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus model estimates of stock numbers at age as W-ringers. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log residuals 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 as W-ringers. e) Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line). f) Temporal autocorrelation of residuals.

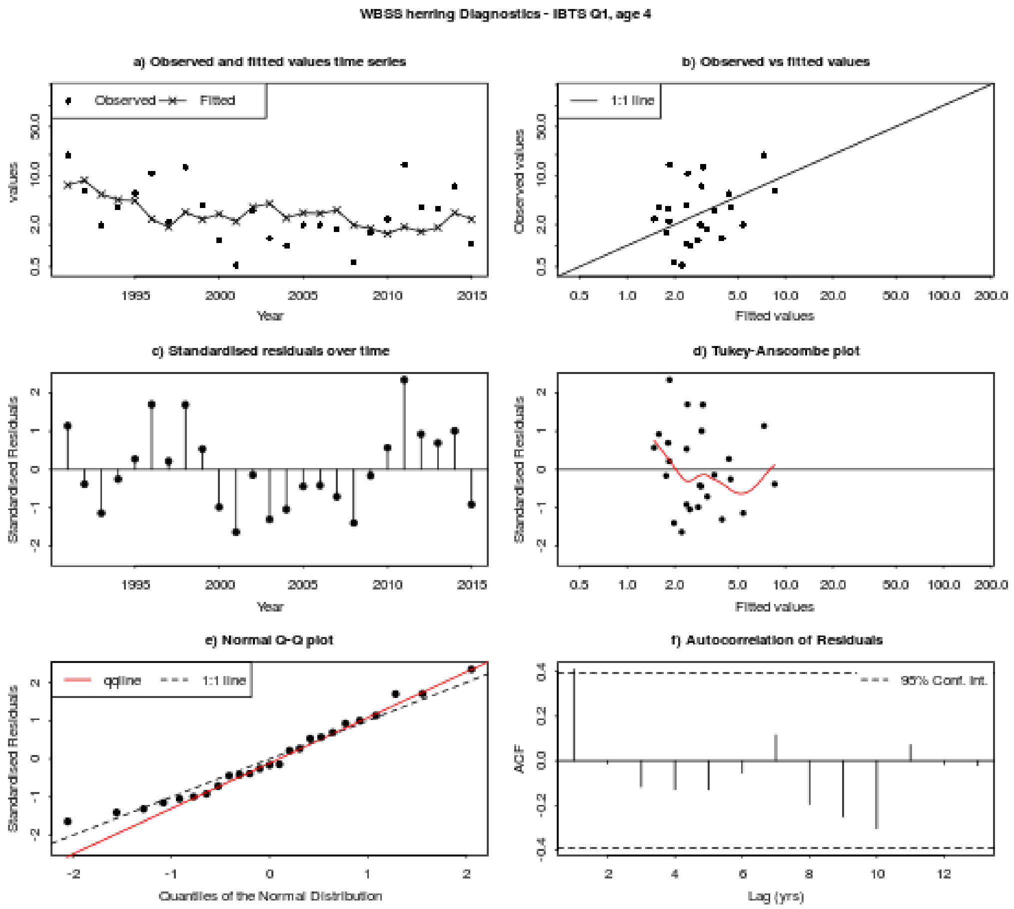


Figure 3.6.4.35 Western Baltic Spring Spawning Herring. Diagnostics of the International Bottom Trawl Survey in Division 3.a in quarter 1 (IBTS Q1) fit at 4 wr from the assessment. a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus model estimates of stock numbers at age as W-ringers. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log residuals 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 as W-ringers. e) Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line). f) Temporal autocorrelation of residuals.

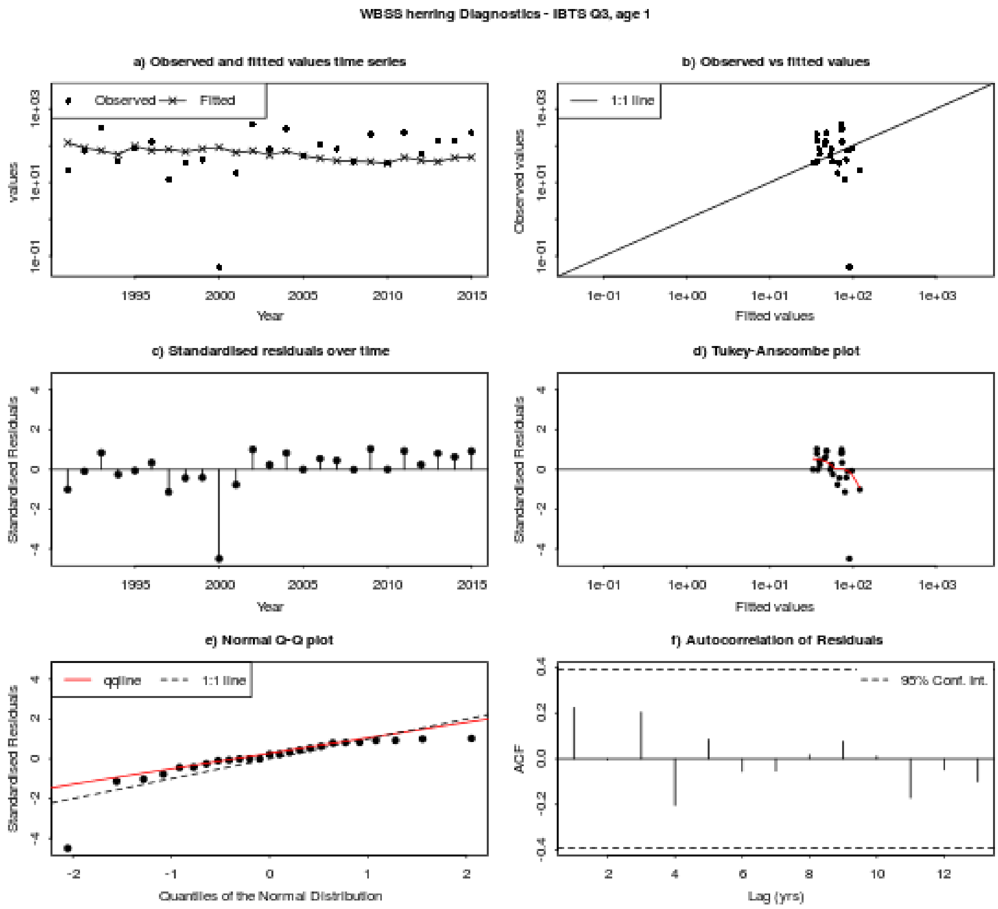


Figure 3.6.4.36 Western Baltic Spring Spawning Herring. Diagnostics of the International Bottom Trawl Survey in Division 3.a in quarter 3 (IBTS Q3) fit at 1 wr from the assessment. a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus model estimates of stock numbers at age as W-ringers. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log residuals 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 as W-ringers. e) Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line). f) Temporal autocorrelation of residuals.

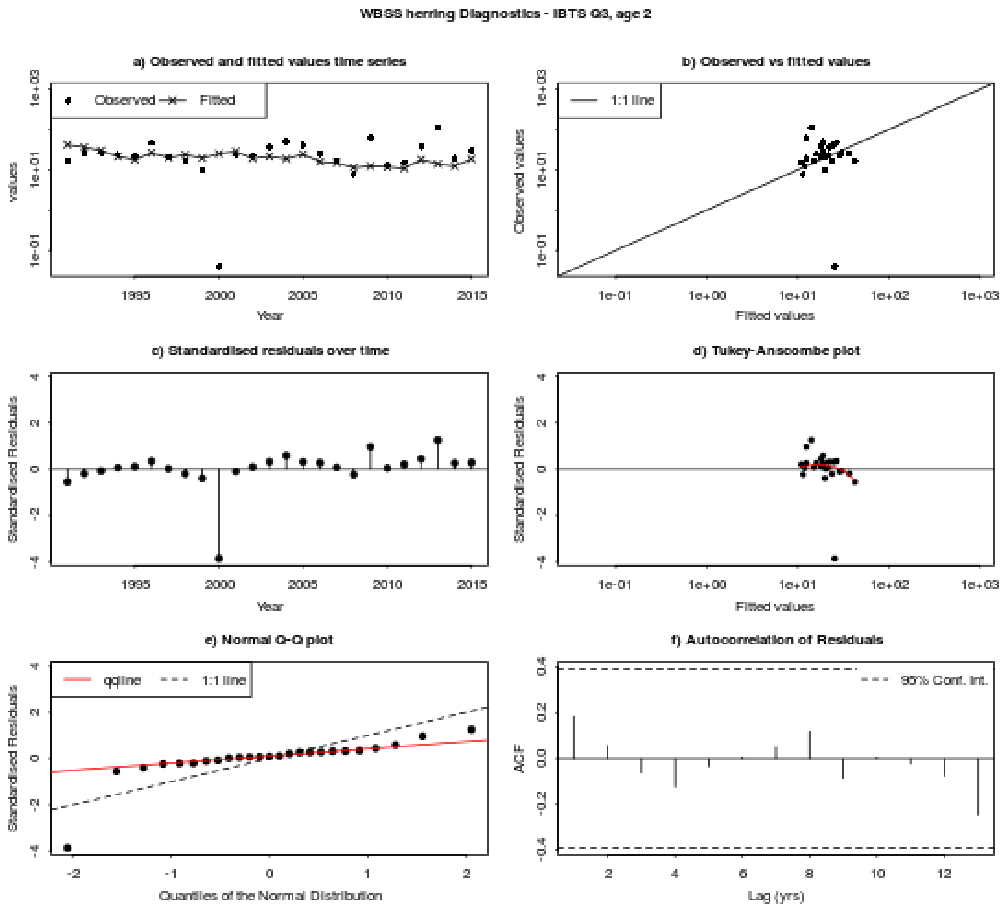


Figure 3.6.4.37 Western Baltic Spring Spawning Herring. Diagnostics of the International Bottom Trawl Survey in Division 3.a in quarter 3 (IBTS Q3) fit at 2 wr from the assessment. a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus model estimates of stock numbers at age as W-ringers. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log residuals 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 as W-ringers. e) Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line). f) Temporal autocorrelation of residuals.

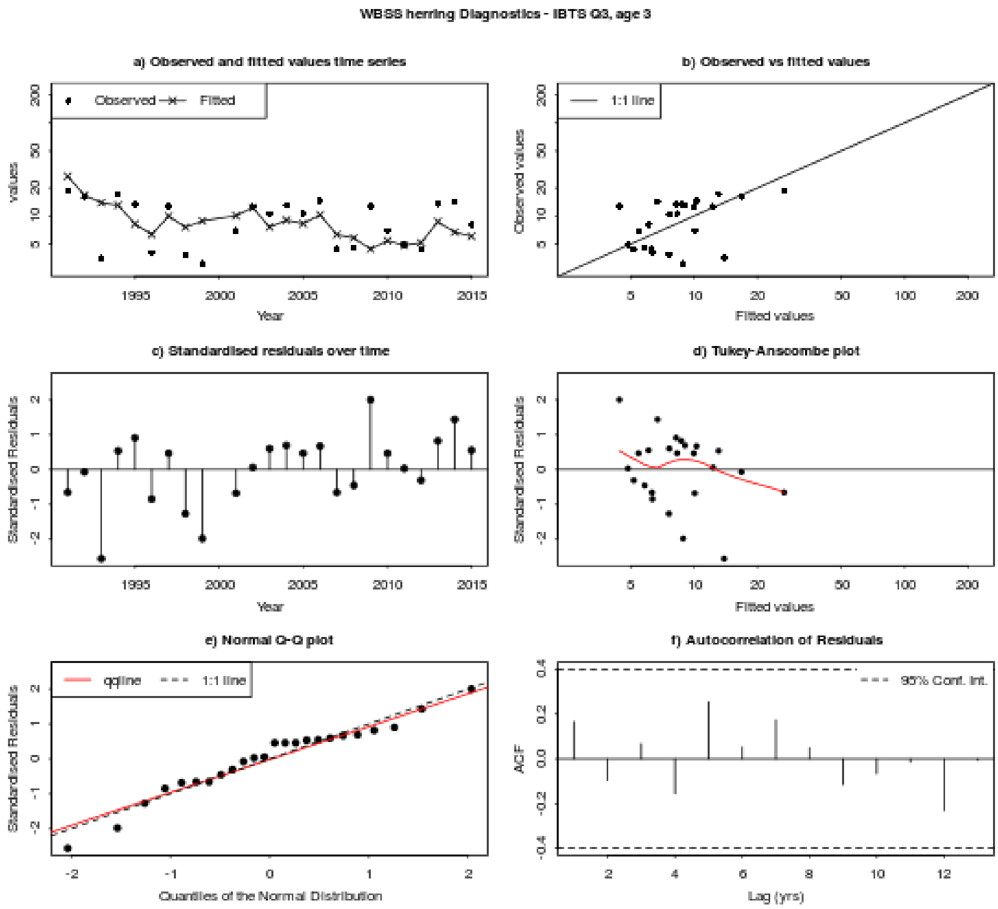


Figure 3.6.4.38 Western Baltic Spring Spawning Herring. Diagnostics of the International Bottom Trawl Survey in Division 3.a in quarter 3 (IBTS Q3) fit at 3 wr from the assessment. a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus model estimates of stock numbers at age as W-ringers. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log residuals 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 as W-ringers. e) Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line). f) Temporal autocorrelation of residuals.

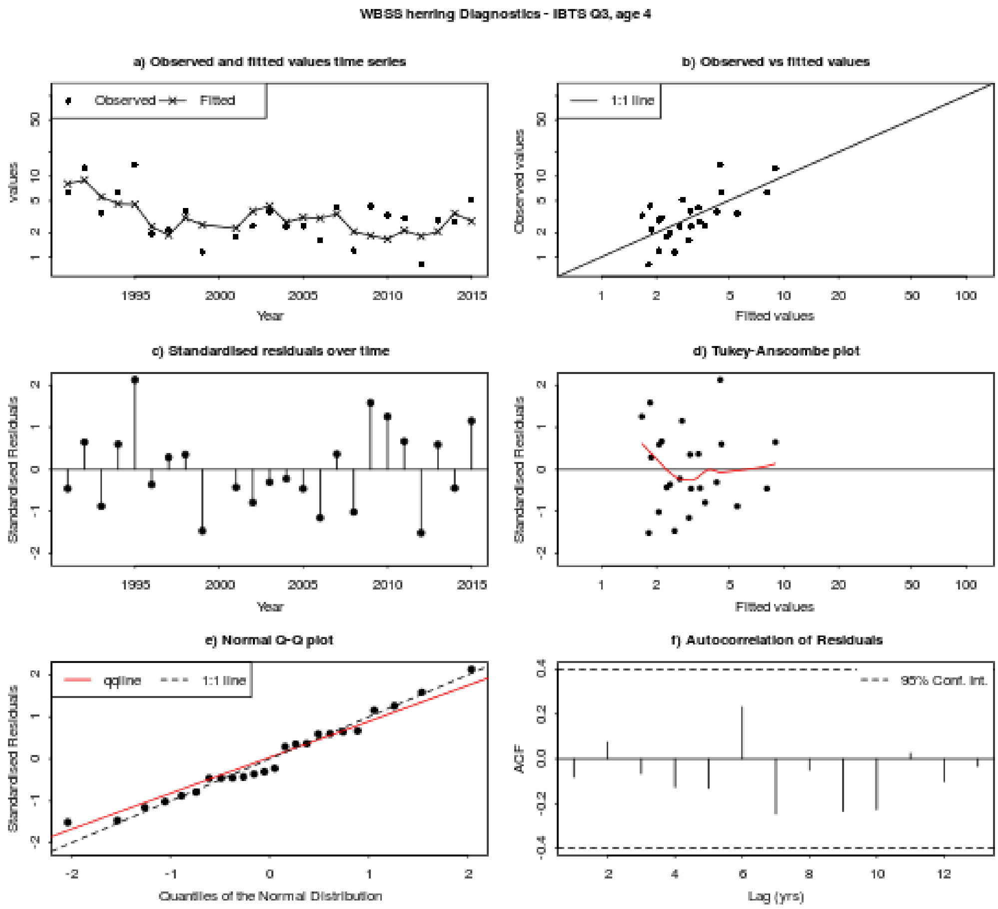


Figure 3.6.4.39 Western Baltic Spring Spawning Herring. Diagnostics of the International Bottom Trawl Survey in Division 3.a in quarter 3 (IBTS Q3) fit at 4 wr from the assessment. a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus model estimates of stock numbers at age as W-ringers. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log residuals 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 as W-ringers. e) Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line). f) Temporal autocorrelation of residuals.

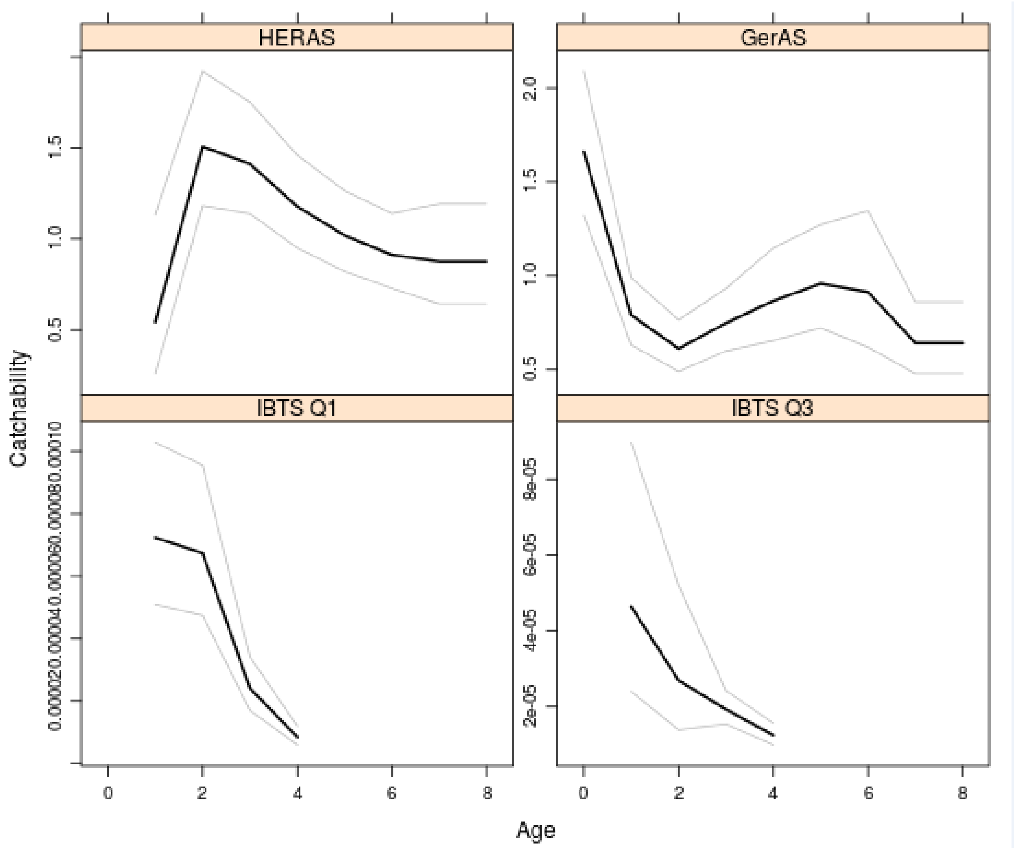


Figure 3.6.4.40 Western Baltic Spring Spawning Herring. Estimated survey catchabilities with 95% CI.

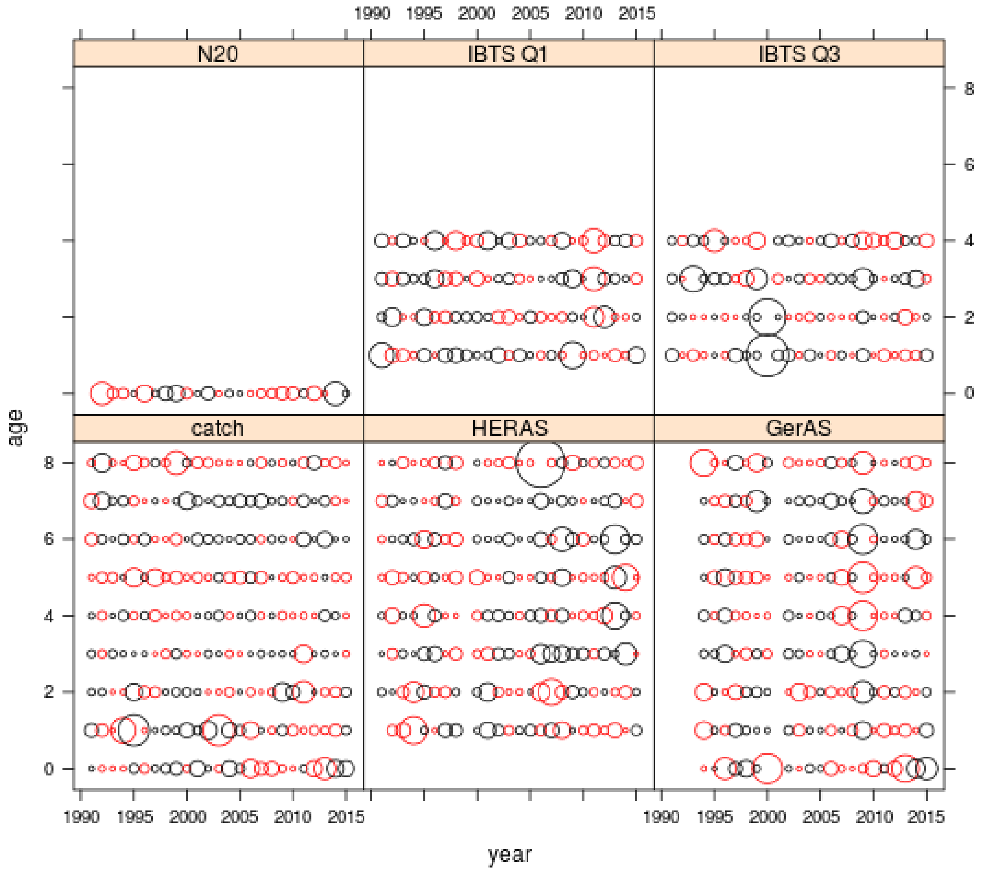


Figure 3.6.4.41 Western Baltic Spring Spawning Herring. BUBBLE PLOT showing the weighted residuals for each piece of fitted information. Individual values are weighted following the procedures employed internally with SAM in calculating the objective function. The bubble scale is consistent between all panels (age as W-ringers).

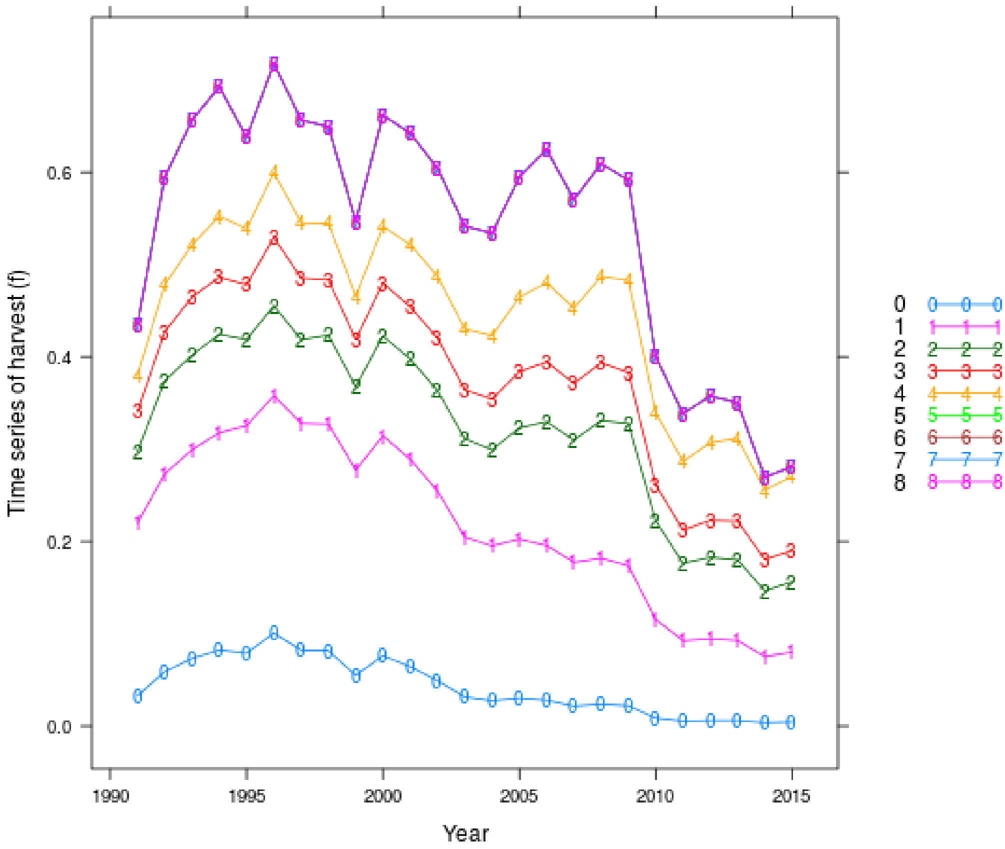


Figure 3.6.4.42 Western Baltic Spring Spawning Herring. Time-series of fishing mortality-at-age as estimated by the assessment model.

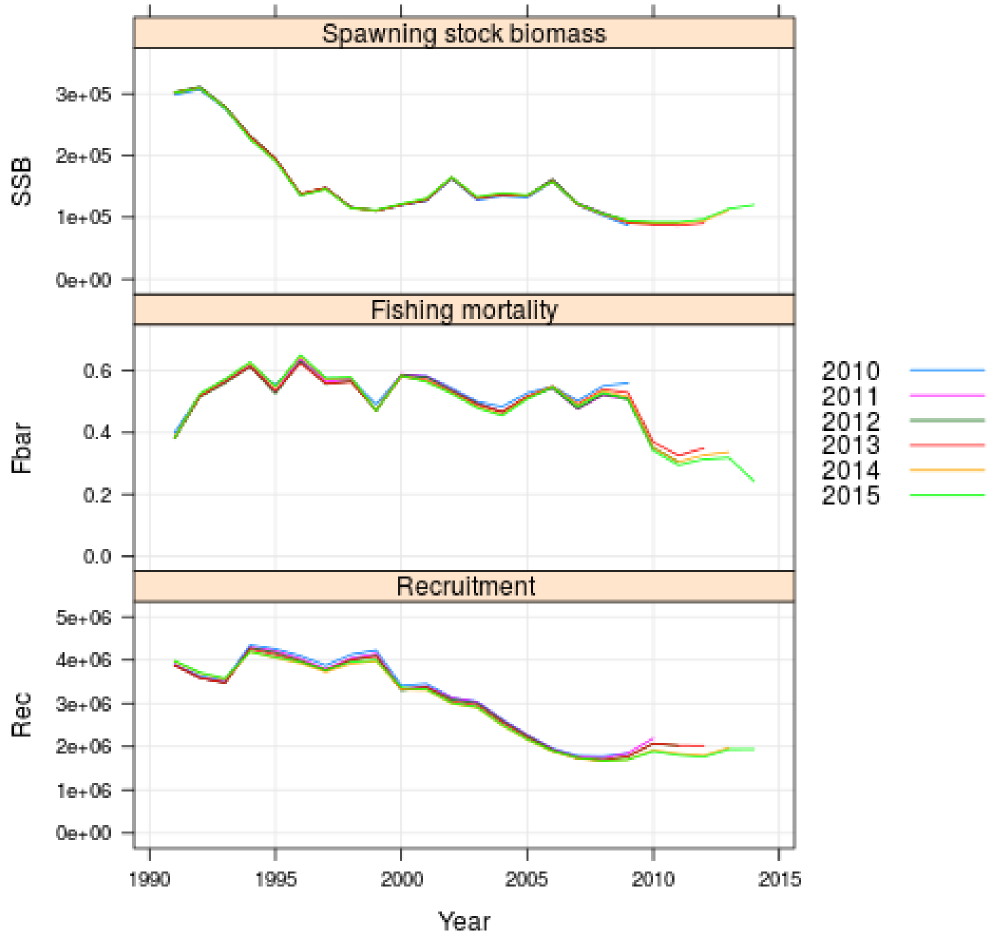


Figure 3.6.4.43 Western Baltic Spring Spawning Herring. Analytical retrospective pattern over 5 years, in the assessment for spawning stock biomass, recruitment (0 wr) and mean fishing mortality in the ages 3–6 ringer.

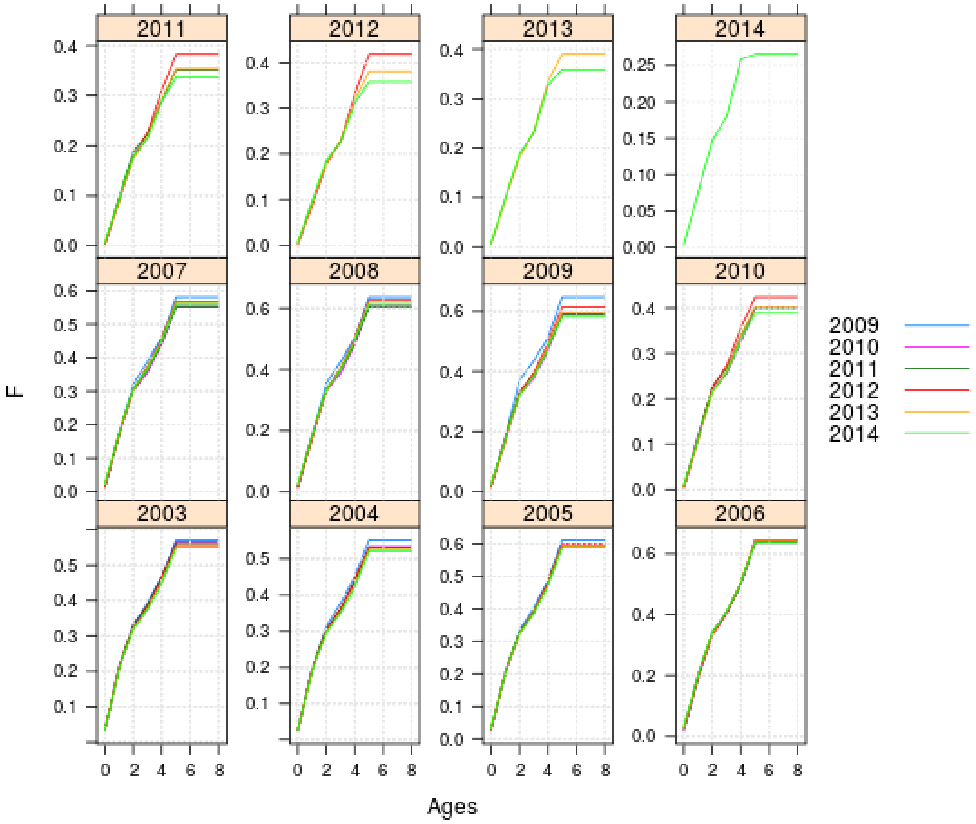


Figure 3.6.4.44 Western Baltic Spring Spawning Herring. Retrospective selectivity pattern at age as W-ringers.

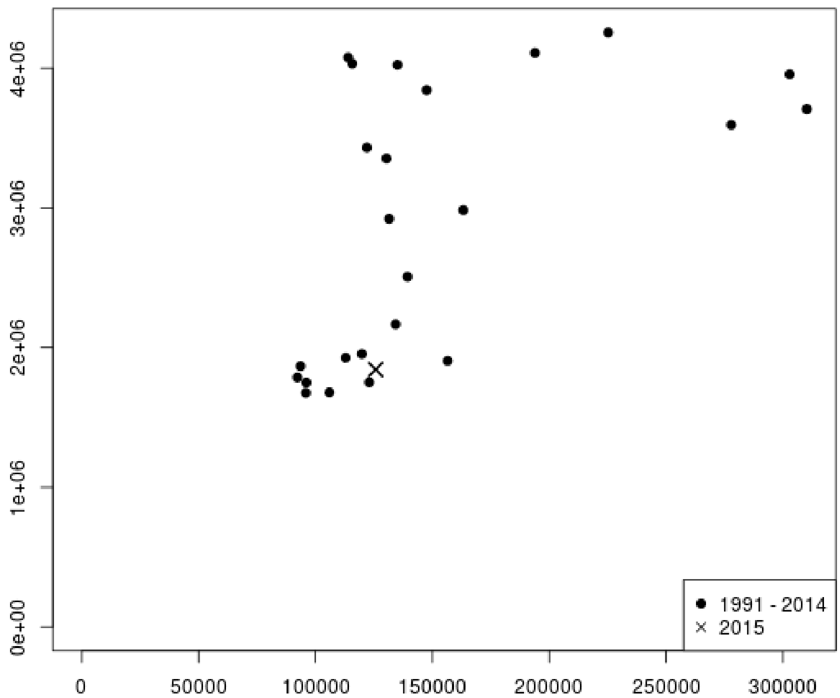


Figure 3.6.4.45 Western Baltic Spring Spawning Herring. Recruitment at age 0-wr (in thousands) is plotted against spawning stock biomass (tonnes) as estimated by the assessment.

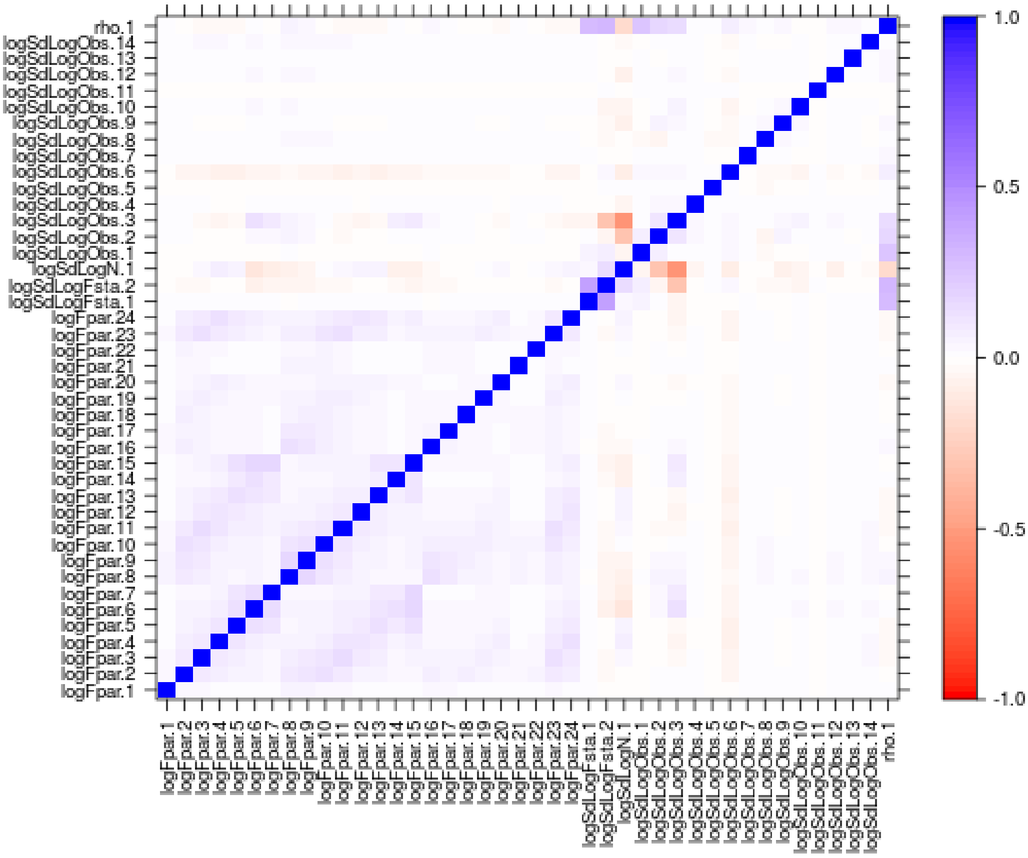


Figure 3.6.4.46 Western Baltic Spring Spawning Herring. Plot of all the estimated parameters cross-correlation.

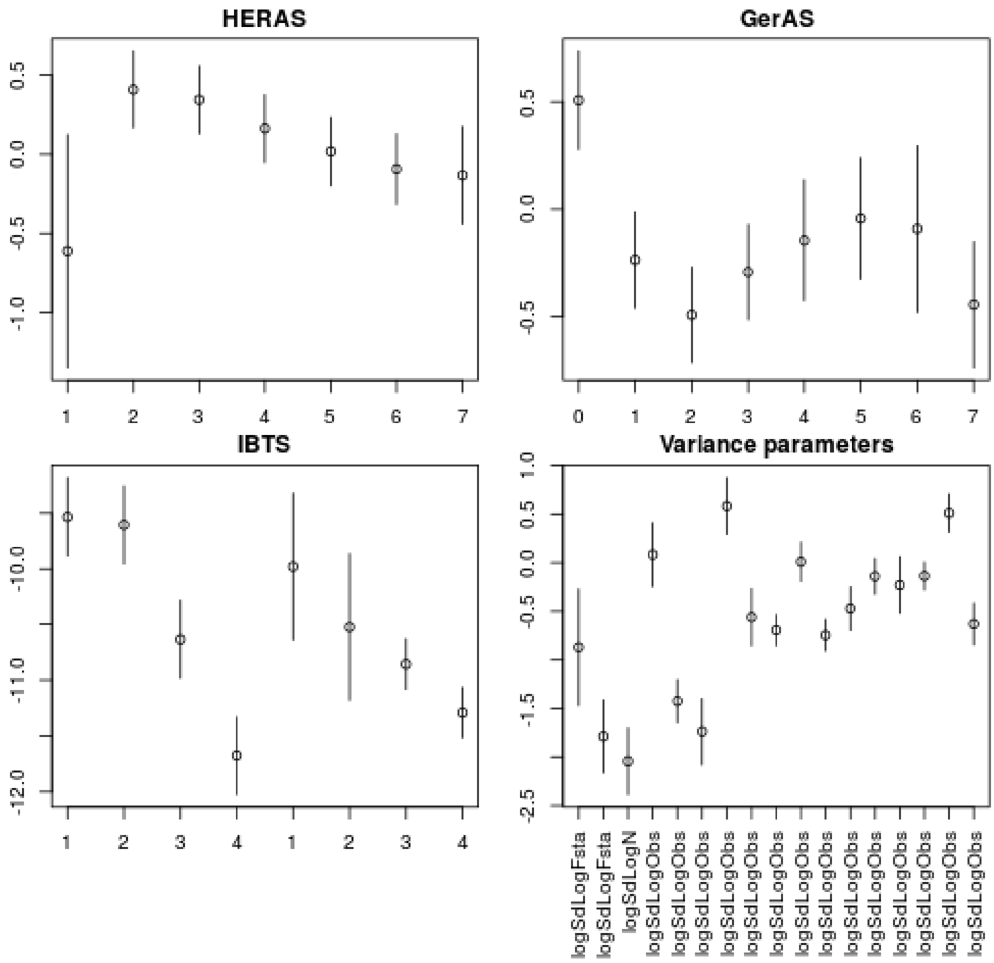


Figure 3.6.4.47 Western Baltic Spring Spawning Herring. Plot of the model estimates (in log scale) with associated 95% CI.

4 Herring in the Celtic Sea (Division 7.a South of 52° 30' N and 7.g, 7.h and 7.j,)

The assessment year for this stock runs from 1 April – 31 March. Unless otherwise stated, year and year class are referred to by the first year in the season i.e. 2015 refers to the 2015/2016 season.

The WG notes that the use of "age", "winter rings", "rings" and "ringers" still causes confusion outside the group (and sometimes even among WG members). The WG tries to avoid this by consequently using "rings", "ringers", "winter ringers" or "wr" instead of "age" throughout the report. However, if the word "age" is used it is qualified in brackets with one of the ring designations. It should be observed that, for autumn and winter spawning stocks such as this one, there is a difference of one year between "age" and "rings". Further elaboration on the rationale behind this, specific to each stock, can be found in the individual Stock Annexes. It is the responsibility of any user of age based data for any of these herring stocks to consult the relevant annex and if in doubt consult a relevant member of the Working Group.

4.1 The Fishery

4.1.1 Advice and management applicable to 2015–2016

The TAC is set by calendar year and in 2015 was initially set at 15 652 t but was revised in September 2015 to 19 189 t and for 2016 is 15 442 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 again in 2015 (ICES, HAWG, 2015) 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.

4.1.2 The fishery in 2015/2016

The Irish fishery took place in the third and fourth quarter of 2015 and in the first quarter of 2016. In the third quarter, fishing took place in 7.g only, and in the fourth quarter it occurred in 7.j, 7.g, 7.k and 7.aS. The third quarter fishery landed a total of 2155 from 21 September. The fourth quarter fishery took place mainly in 7.g (12 624 t), with smaller catches further east in 7.aS (858 t) and in 7.j (161 t). The Irish fishery was opened in the first quarter of 2016 in response to a request to the Irish management advisory committee, with landings of 522 t.

The Netherlands reported catches of 1300 t and Germany almost 500 t. As usual, the German catches were from Division 7.h. This is part of the management area, but it is unclear if it is part of the stock area.

The distribution of the total landings is presented in Figure 4.1.2.1.

In 2015 the Irish quota available was enhanced by the availability of carryover from previous years. In total, 4723 t was carried over from 2013. In 2013 and 2014 Russian markets were not open to Irish herring, due to a trade embargo. Therefore, the EU authorities allowed carryover of more than the usual 10% of the catches in 2015/2016.

The estimated national catches from 1988–2015 for the combined areas by year and by season (1 April–31 March) are given in Table 4.1.3.1 and Table 4.1.3.2 respectively. The catch taken during the 2015/2016 season decreased slightly to about 18 000 t (Figure 4.1.3.1).

The catch data include discards until 1997, and again from 2012. Discards were raised to the total international catch using a weighted average of 1.041% derived from Pinfield and Berrow (2015).

4.1.3 Regulations and their effects

Under the rebuilding plan, the closure of Subdivision 7.aS from the 2007-present, 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 7.aS to vessels under 50 feet, but the total quota allocation increased from 8% to 11%. Therefore from 2012 there was a slight increase in landings from this area.

There is evidence that closure of Subdivision 7.aS, under the rebuilding plan, has helped to reduce fishing mortality substantially (HAWG 2011). The exact mechanisms for this are unclear. 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 Subdivision 7.aS will be closed with only a small scale sentinel fishery permitted.

In 2015, an in year revision was made of the TAC. The local management advisory committee sought a revision, through the Pelagic Advisory Council, and the European Commission made a special request to ICES for additional catch options. The reason for the request was the realisation that the initial TAC in 2015 would have been higher using the 2015 benchmark procedures.

4.1.4 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 (7.aS and 7.g) during the winter period. The refrigerated seawater (RSW) tank vessels target the stock inshore in winter and offshore during the summer feeding phase (7.g). These boats were excluded from 7.aS 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 7.aS has been increased to 11%, but vessels of over 50 feet length are still excluded. 7.aS 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 from 2010–2012 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 mitigate slippage.

In recent years, the main Irish fishery has been on the Smalls ground, just south of the 7.a closed box.

Since 2007 the 7.aS area is closed to vessels of over 50 feet. In recent seasons these boats target herring just south of this box in quarter 3 and 4. Before that there was no history of fishing herring in this area. It is not clear if herring always occurred here, and are only being fished now, or whether they existed there unbeknownst to the fishery. The answer to this has implications for the design of the acoustic survey (Section 4.3.1).

4.1.5 Discarding

It is thought that discarding has declined since 2012 due to the flexibility incorporated into the weekly quota system. Estimates of discarding from observed trips for the purposes of marine mammal by-catch studies, reported 1% discarding in 2012, 0.8% in 2013 (McKeogh and Berrow, 2013), 3.4% in 2014 (McKeogh and Berrow, 2014) and 1.4% in 2015 in the main fishery and 1.5% in the 7.aS small boat fishery (Pinfield and Berrow, 2015, Working Document 4).

As in 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 provided a sensitivity analysis of the assessment to maximum possible discarding. The risk of discarding (slippage induced by restrictive vessel quotas) is now reduced, due to a new flexibility mechanism being introduced in quota allocation, since 2012. It now seems that discard rate is negligible.

In 2015, this stock is now covered by the landings obligation.

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 2015. In 2015, the most abundant age classes were 4 ringers (2010 year class 24%), 5 ringers (2009 year class 21%) 3 ringers (2011 year class) and 6 ringers (2008 year class) were 18% and 15% respectively.

The yearly mean standardised catch numbers-at-age is shown in Figure 4.2.1.1 shows the 2010 year class as the strongest cohort in 2015. The strong 2005 cohort, the second strong year class to recover the stock, is now in the plus group.

The overall proportions-at-age in all sampled metiers (division*quarter) are presented in Figure 4.2.1.3. The fisheries age profiles generally show good agreement, with the exception of the Q3 7.g fishery. However that metier agreed with the survey profile, with 2- and 3-ringer being more abundant than generally. The number of 1-ringers is very low, though this is not indicative of any trend in recruitment. Table 4.2.1.2 and Figure 4.2.1.4 show the length frequency data by area and quarter. Length frequencies were very similar in all areas.

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 2014/2015 only preliminary data were available at the time of the Working Group. Best estimates of small boat catches were used for the 7.aS 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 2002–2015 and is presented in Table 4.3.1.1.

The acoustic survey of the 2015/2016 season was carried out between 2–22 October 2015, on the *Celtic Explorer* (O'Donnell, *et al.* in ICES 2016/SGGEST:01). Survey effort (2,336 nmi of transects for acoustic integration) and geographical coverage (6,580 nmi^2) remained the same as recent years for all core areas (Figure 4.3.1.1a).

In 2014\2015 the very low biomass estimate from the CSHAS was omitted from the assessment at the recommendation of WGIPS due to the offshore distribution of the migrating herring and the possibility that some of the stock still lay outside the boundary of the survey (WGIPS 2015 and HAWG 2015). During the 2015\2016 survey the distribution of herring was again completely offshore and no schools were observed in the inshore spawning areas (Figure 4.3.1.1b). Despite taking precautions to avoid a repeat of the 2014\2015 situation the 2015\2016 survey has to be omitted from the assessment for the similar reasons (ICES WGIPS 2016). The precautions and measures taken to reliably quantify the stock biomass in recent years are detailed in a working document to the current report (O'Donnell 2016, Working Document 5). In brief, time gained by removing redundant transects was used to adaptively survey two offshore areas of dense herring schools (Figure 4.3.1.1b). These adaptive 'mini-surveys' increased the estimated total biomass from almost zero to 24 710 t. However, because the 2015 estimate of abundance was determined exclusively from adaptive mini-surveys, it is not considered as comparable to the current time series or representative of the larger stock. Furthermore, as in 2014\2015, it is not possible to say if the stock was contained within the survey area and may therefore not be a representative measure of abundance. Although the distribution of the stock observed during the survey was substantiated by the co-occurring fishery that was centred offshore. For these reasons the 2015\2016 acoustic survey results were not included in the assessment. Containment within the larger survey bounds is an ongoing issue and is exacerbated in warmer years by the later arrival of herring to inshore spawning areas. Survey timing will be considered in future years as a means to ensure containment within the survey area.

For the sake of completeness the best available survey results using the adaptive survey design are presented here but they were not used in the assessment:

Herring TSB (total stock biomass) and abundance (TSN) estimates were 24 710 t and 184 million individuals (CV 18.4%) respectively. No immature fish were encountered during the adaptive surveys. A total of 27 trawl hauls were carried out during the survey (Figure 4.3.1.1a), with 3 hauls containing > 50% herring by weight of catch. A total of 149 herring were aged from survey samples in addition to 1250 length measurements and 300 length-weights recorded. Herring age samples ranged from 2–8 winter-rings. Three and four winter-ring herring dominated the 2015 estimate (26% and 22% of TSN respectively). This is consistent with the 2014 survey estimate where two and three winter-ring fish dominated. No immature fish were observed from catches within the adaptive strata.

4.4 Mean weights-at-age and maturity-at-age and Natural Mortality

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. After a slight increase around 2008 they have declined again from 2013 and 2015. Mean weights in the stock at spawning time were calculated from biological samples from the fourth quarter (Figure 4.4.1.2). The overall trends in stock weights are as in the catch weights.

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). However, the 2014 benchmark (ICES 2014/ACOM: in prep.) concluded that there was insufficient information to change the maturity ogive.

Following the final procedure of ICES HAWG 2015, the natural mortality values used in the final assessment incorporated the SMS run as obtained in 2011.

The time-invariant natural mortalities and maturities at age are presented in the text table below.

	1	2	3	4	5	6	7	8	9+
Maturity	0.5	1	1	1	1	1	1	1	1
Natural mortality	0.767	0.385	0.356	0.339	0.319	0.314	0.307	0.307	0.307

4.5 Recruitment

At present there are no independent recruitment estimates for this stock. However the acoustic survey age range has now been extended to include 1 ringers (Section 4.6). This offers an independent estimate of recruits, and suggests a large increase in recruitment in recent years.

4.6 Assessment

This stock was benchmarked in 2015 by WKWEST (ICES, 2015).

4.6.1 Stock Assessment

This update assessment was carried out using ASAP. The assessment was tuned using the Celtic Sea herring acoustic survey (CSHAS) ages 2–9 winter ring, but excluding surveys 2014 and 2015. HAWG supported the decision to remove the problematic 2014 survey due to the lack of stock containment and the low precision associated with the biomass estimate and the 2015 survey due to the offshore distribution of the migrating herring and the possibility that some of the stock still lay outside the boundary of the survey. The settings are as per the 2015 benchmark and are presented in (Table 4.6.2.3). The input data are presented in tables 4.6.2.1 and 4.6.2.2. The stock summary is presented in Table 4.6.2.4.

Figure 4.6.2.1 shows the catch proportions-at-age residuals. The residuals are large for the young ages, which is to be expected because these are estimated with low precision. Larger residuals can be seen for the older ages in the earlier part of the time series. Overall there are no clear patterns in the residuals. Figure 4.6.2.2 shows the observed and predicted catches. In general, the model followed the observed catches quite closely. Figure 4.6.2.3 shows the residuals of the index proportions-at-age. These survey residuals show a band of negative residuals at older ages in the past 3 tuning years.

The selection pattern for the final assessment run is shown in Figure 4.6.2.4. In this run, selection is fixed at 1 for 3-wr which is the age that Celtic Sea herring are considered to be fully selected. Selection at all other ages is estimated by the model. This gives a dome shaped selection pattern which is considered appropriate for this fishery. The model predicts a drop in selection at age 9-wr. This may be the case given the lower abundance of 9-wr in the catch data.

The analytical retrospective from ASAP is shown in Figure 4.6.2.5. There is little analytical retrospective with rho (Mohn 1999) calculated as 0.03 for 7 year peels. Figure 4.6.2.8 shows uncertainties over time in the assessment estimates.

State of the stock

The stock summary plots from the final update ASAP assessment is presented in Figure 4.6.2.6. with the stock summary in Table 4.6.2.4 The stock is estimated to be declining from a high level. SSB in 2015 is estimated as 101 000 t in 2015, having rebuilt from 36 000 t in 2004. Mean F (2–5 ring) in 2015 is estimated as being 0.19, having increased from 0.06 in 2009. Overall there has been a substantial decrease in F from 0.43 in 2004. Recruitment was good for several years with strong cohorts in 2003, 2005, 2007, 2009, 2010 and 2012 having entered the stock.

4.7 Short term projections

4.7.1 Deterministic Short Term Projections

An updated procedure for STF was performed, using the procedure agreed at the 2014 benchmark (ICES 2014/ACOM 43). The 2016 short term forecast follows the benchmark procedures. However it is based on an assessment that departs from these procedures by omitting the 2014 and 2015 survey data.

Recruitment (final year, interim year and advice year) in the short term forecast is to be set to the same value based on the segmented stock recruit relationship, based on the SSB in Y-2 (the final year – 2 years).

Interim year catch was taken to be the full TAC, plus carryover on the national quotas (data provided as an output from the FIIDES database. Non-Irish intermediate year catches were further adjusted for recent quota uptake. No quarter 1 fishery is assumed to take place in 2017. Discards, based on the 2015 estimate of 1.4% for all metiers except the 7.a small boat fishery where 1.5% was assumed) were included. Thus, the interim catch was taken as 18 590 t.

A deterministic short term forecast was performed using MFDP (Smith, 2000) and in FLR. The input data are presented in Table 4.7.1.1.

The results of the short term projection are presented in Table 4.7.1.2. Fishing according to the long term management plan, implies catches of 14 467 t in 2017. All scenarios show SSB will be above B_{pa} in 2017/2018.

4.7.2 Multi-annual short term forecasts

In order to test the utility of multi-year advice, 2-year forecasts were performed retrospectively in 2016. Further details of these calculations, for this stock, are to be found in Section 1.

4.7.3 Yield Per Recruit

No yield per recruit analyses were conducted in 2015.

4.8 Long term simulations

No long term simulations were performed in 2016.

4.9 Precautionary and yield based reference points

Reference points in use were proposed by HAWG 2015. The approach to precautionary and yield based reference points that was taken by ICES WKWEST (2015) was analogous to that followed by WKPELA, in 2014 and HAWG 2014. Examination of the stock recruit relationship from the final ASAP run showed wide range of recruitments, from very low to very high at low stock size, and a rather clear plateau, excepting four abnormally high values. This follows the recommendations of ICES RG/ADGCSHER (2012) and ICES SGBRP (2003), and is using the same basis to the procedure used for western Baltic spring spawning herring reference point proposals of 2013. Based on these considerations, B_{lim} is proposed as 33 000 t (B_{loss}). B_{pa} is based on B_{lim} raised by assessment uncertainty (σ) in estimation of terminal SSB, capped σ = 0.3 (ICES SGPA 1997). This results in a proposed B_{pa} of 54 000 t. This value is also a candidate for ICES MSY $B_{trigger}$.

For F_{msy} the same procedure was used as in ICES HAWG (2010 and 2013) using HCS 10–3 (Skagen, 2010; 2013). This approach performs stochastic simulations from a segmented regression stock recruitment relationship (Figure 4.9.1) where the plateau level of recruitment was 541 287 individuals and the breakpoint was estimated by applying the method of Julios. Then the changepoint was fixed at as 33 219 t, which is B_{lim}. This follows the procedures of ICES ADGCELTIC (2012). No errors or biases were incorporated into these simulations, following the procedure of HAWG 2013. Results showed that the highest F consistent with low (< 5%) risk of SSB < breakpoint in <u>any</u> year (ICES Risk 2) is F = 0.26.

In 2016, the working group was tasked to propose F_{pa} reference points for all stocks. Precautionary F reference points were never previously defined for this stock, although a proposal for F ~ 0.4 was made by ICES HAWG 1998. The approach taken was to follow the procedures used by ICES WKWEST in 2015. The *EqSim* application was used to fit a segmented regression with a breakpoint specified at B_{lim} based on the full stock and recruit dataset and to estimate F_{lim}, the fishing mortality (F) that in equilibrium will maintain the stock above B_{lim} with a 50% probability. For this purpose, *EqSim* was run with a $B_{trigger}$ parameter set to zero and no assessment/advice error (F_{cv}, F_{phi} = 0) error, in line with ACOM Leadership guidelines (2016). A candidate value for F_{lim} of 0.61 was then used as a basis for calculating F_{pa} taking account of assessment uncertainty in the final year (σ, capped at 0.3) (ACOM Leadership, 2016; ICES SGPA 1997). This results in a proposed F_{pa} of F = 0.37. The *EqSim* output is shown in Figure 4.9.1.

4.10 Quality of the Assessment

Figure 4.6.2.8 shows uncertainties over time in the assessment estimates. The uncertainties are higher in 2016, relative to 2015. This probably reflects the lack of tuning for the past 2 years.

The 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.

2015 Assessment				2016 assessment				% change in the estimates	
Year	SSB	Catch	F 2–5	Year	SSB	Catch	F 2–5	SSB	F 2–5
2013	141 113	21 820	0.18	2013	156 272	16 247	0.12	-11%	34%
2014	132 941	16 247	0.14	2014	133 362	19 574	0.16	0%	-11%
2015*	126 991	21 932	0.19	2015	101 382	18 355	0.19	20%	0%

***from intermediate year in STF.**

Investigations will continue to evaluate if a multi-annual forecast is appropriate for this stock. Such an approach could make advice more robust to noise, especially year effects in the survey, or retrospective revisions. In 2016, a process of conducting exploratory 2- and 3-year forecasts was begun, with their performance being examined in future years, comparing with the traditional (1-year) forecast.

Further work to investigate the suitability of 2- and 3-year forecasts as a basis of management advice, could include retrospective analyses of *ex-post* and *ex-ante* 2- and 3-year forecasts for past years. This would also provide estimates of precision and accuracy, to be used in MSE work to evaluate the utility of medium term forecasts in an MSE context.

4.11 Management Considerations

Fishing mortality on this stock was high for many years. 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 0.19, less than F_{MSY}. SSB is well above B_{pa} (54 000 t).

The long term management plan, proposed by the Pelagic RAC, has been endorsed by ICES and implemented for setting the TAC by the Council of the European Union. It is also on the list of management plans that the EU askes ICES to provide advice upon. 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, 2014, 2015 and 2016. The plan was reviewed in 2015 by HAWG 2015 and judged to be precautionary.

The stock should continue to be managed according to the long term management plan. Evaluations conducted in 2015 by HAWG show that the long term plan is still precautionary and can be a basis for management of the stock. However the plan is sensitive to potential retrospective downward revisions of SSB, such as took place in between 2013 and 2014.

The closure of the Subdivision 7.aS as a measure to protect first time spawners has been in place since 2007/2008, with limited fishing allowed. 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.

It is thought that discarding has declined since 2012 due to the flexibility incorporated into the weekly quota system. Estimates of discarding from observed trips for the purposes of marine mammal by-catch studies, see Section 4.1.5 for more details.

4.12 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, blue sharks, tunas, and whitefish are caught from time to time, and the latter species was confirmed as by-catch in recent work (McKeogh and Berrow, 2014; 2015).

4.13 Changes in the environment

Weights in the catch and in the stock at spawning time have shown considerable fluctuations over time (figures 4.4.4.1 and 4.4.1.2) but with a decline to lowest observations in the series at the end. The declines in mean weights are a cause for concern, because of their impact on yield and yield per recruit. Harma (unpublished) and Lyashevska *et al*. (in prep) found that global environmental factors, reflecting recent temperature increases (AMO and ice extent) were linked to changes in the size characteristics during the 1970s-1980s. Outside of this time period, size-at-age patterns were correlated with more local factors (SST, salinity, trophic and fishery-related indicators). Generally, length at age was mostly correlated with global temperature-related indices (AMO and Ice), whilst weight was linked more to local temperature variables (SST). There was no evidence of density-dependent growth in the Celtic Sea herring population, which is in accordance with previous studies (Molloy 1984, Brunel and Dickey-Collas 2010, Lynch 2011). Rather, stock size exhibited a positive relationship with long-term size-at-age of Celtic Sea herring (Harma, unpublished).

In the Celtic Sea, a change towards spawning taking place later in the season has been documented by Harma *et al.* (2013). The causes of this are likely to be environmental, though to date they have not been elucidated (Harma *et al.* 2013). It should be noted that declines in mean weights, examined by Harma *et al.* (2013) are not explained by the relative contribution of heavier-at-age autumn spawners. Rather, both autumn and winter spawners experienced declines in mean weights in recent years.

A shift towards later spawning has also been reported by local fishermen in this area. WKWEST received a submission from the Celtic Sea Herring Management Advisory Committee of substantial spawning aggregations in Division 7.j in January 2015. This area was considered mainly as an autumn spawning area (O'Sullivan *et al.* 2012).

Analyses of productivity changes over time in European herring stocks was examined by ICES HAWG (2006). It was found that this stock was the only one not to experience a change in productivity or so-called regime shift. This is also seen in the Surplus Production per unit stock biomass using information from the 2013 assessment. Evidence from the new ASAP assessment, in terms of recruits per spawner, does not alter this perception (ICES WKWEST 2015).

Table 4.1.3.1. Herring in the Celtic Sea. Landings by quota year (t), 1988–2015. (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	-	-	16800	-	-	-	2400	19200
1989	+	-	16000	1900	-	1300	3500	22700
1990	+	-	15800	1000	200	700	2500	20200
1991	+	100	19400	1600	-	600	1900	23600
1992	500	-	18000	100	+	2300	2100	23000
1993	-	-	19000	1300	+	-1100	1900	21100
1994	+	200	17400	1300	+	-1500	1700	19100
1995	200	200	18000	100	+	-200	700	19000
1996	1000	0	18600	1000	-	-1800	3000	21800
1997	1300	0	18000	1400	-	-2600	700	18800
1998	+	-	19300	1200	-	-200	-	20300
1999		200	17900	1300	+	-1300	-	18100
2000	573	228	18038	44	1	-617	-	18267
2001	1359	219	17729	-	-	-1578	-	17729
2002	734	-	10550	257	-	-991	-	10550
2003	800	-	10875	692	14	-1506	-	10875
2004	801	41	11024	-	-	-801	-	11065
2005	821	150	8452	799	-	-1770	-	8452
2006	-	-	8530	518	5	-523	-	8530
2007	581	248	8268	463	63	-1355	-	8268
2008	503	191	6853	291	-	-985	-	6853
2009	364	135	5760	-	-	-499	-	5760
2010	636	278	8406	325	-	-1239	na	8406
2011	241	-	11503	7	-	-248	na	11503
2012	3	230	16132	3135	-	2104	161*	21765
2013	-	450	14785	832	-	-	118	16185
2014	244	578	17287	821	-		644	19574
2015	-	477	15798	1304	+	-	247	17825

*** Added in 2014 after report of 1% discarding.**

Table 4.1.3.2. Herring in the Celtic Sea. Landings (t) by assessment year (1 April–31 March) 1988/1989–2014/2015. (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
1988/1989	-	-	17 000	-	-	-	3 400	20 400
1989/1990	+	-	15 000	1 900	-	2 600	3 600	23 100
1990/1991	+	-	15 000	1 000	200	700	1 700	18 600
1991/1992	500	100	21 400	1 600	-	-100	2 100	25 600
1992/1993	-	-	18 000	1 300	-	-100	2 000	21 200
1993/1994	-	-	16 600	1 300	+	-1 100	1 800	18 600
1994/1995	+	200	17 400	1 300	+	-1 500	1 900	19 300
1995/1996	200	200	20 000	100	+	-200	3 000	23 300
1996/1997	1 000	-	17 900	1 000	-	-1 800	750	18 800
1997/1998	1 300	-	19 900	1 400	-	-2100	-	20 500
1998/1999	+	-	17 700	1 200	-	-700	-	18 200
1999/2000		200	18 300	1300	+	-1300	-	18 500
2000/2001	573	228	16 962	44	1	-617	-	17 191
2001/2002	-	-	15 236	-	-	-	-	15 236
2002/2003	734	-	7 465	257	-	-991	-	7 465
2003/2004	800	-	11 536	610	14	-1 424	-	11 536
2004/2005	801	41	12 702	-	-	-801	-	12 743
2005/2006	821	150	9 494	799	-	-1770	-	9 494
2006/2007	-	-	6 944	518	5	-523	-	6 944
2007/2008	379	248	7 636	327	-	-954	-	7 636
2008/2009	503	191	5 872	150	-	-844	-	5 872
2009/2010	364	135	5 745	-	-	-499	-	5 745
2010/2011	636	278	8 370	325	-	-1239	na	8 370
2011/2012	241	-	11 470	7	-	-248	na	11 470
2012/2013	3	230	16132	3135	-	2104	161*	21765
2013/2014	-	450	14 785	832	-	-	118	16 185
2014/2015	244	578	17287	821	-	-	644	19 574
2015/2016	-	477	16320	1304	+	-	254	18355

*** Added in 2014 after report of 1% discarding**

Table 4.2.1.1. Herring in the Celtic Sea. Comparison of age distributions (percentages) in the catches of Celtic Sea and 7.j herring from 1970–2013/2014. Age is in winter rings.

Year	1	2	3	4	5	6	7	8	9
1970	1%	24%	33%	17%	12%	5%	4%	1%	2%
1971	8%	15%	24%	27%	12%	7%	3%	3%	1%
1972	4%	67%	9%	8%	7%	2%	1%	1%	0%
1973	16%	26%	38%	5%	7%	4%	2%	2%	1%
1974	5%	43%	17%	22%	4%	4%	3%	1%	1%
1975	18%	22%	25%	11%	13%	5%	2%	2%	2%
1976	26%	22%	14%	14%	6%	9%	4%	2%	3%
1977	20%	31%	22%	13%	4%	5%	3%	1%	1%
1978	7%	35%	31%	14%	4%	4%	1%	2%	1%
1979	21%	26%	23%	16%	5%	2%	2%	1%	1%
1980	11%	47%	18%	10%	4%	3%	2%	2%	1%
1981	40%	22%	22%	6%	5%	4%	1%	0%	1%
1982	20%	55%	11%	6%	2%	2%	2%	0%	1%
1983	9%	68%	18%	2%	1%	0%	0%	1%	0%
1984	11%	53%	24%	9%	1%	1%	0%	0%	0%
1985	14%	44%	28%	12%	2%	0%	0%	0%	0%
1986	3%	39%	29%	22%	6%	1%	0%	0%	0%
1987	4%	42%	27%	15%	9%	2%	1%	0%	0%
1988	2%	61%	23%	7%	4%	2%	1%	0%	0%
1989	5%	27%	44%	13%	5%	2%	2%	0%	0%
1990	2%	35%	21%	30%	7%	3%	1%	1%	0%
1991	1%	40%	24%	11%	18%	3%	2%	1%	0%
1992	8%	19%	25%	20%	7%	13%	2%	5%	0%
1993	1%	72%	7%	8%	3%	2%	5%	1%	0%
1994	10%	29%	50%	3%	2%	4%	1%	1%	0%
1995	6%	49%	14%	23%	2%	2%	2%	1%	1%
1996	3%	46%	29%	6%	12%	2%	1%	1%	1%
1997	3%	26%	37%	22%	6%	4%	1%	1%	0%
1998	5%	34%	22%	23%	11%	3%	2%	0%	0%
1999	11%	27%	28%	11%	12%	7%	1%	2%	0%
2000	7%	58%	14%	9%	4%	5%	2%	0%	0%
2001	12%	49%	28%	5%	3%	1%	1%	0%	0%
2002	6%	46%	32%	9%	2%	2%	1%	0%	0%
2003	3%	41%	27%	16%	6%	4%	3%	0%	1%
2004	5%	10%	50%	24%	9%	2%	1%	0%	0%
2005	12%	38%	30%	10%	4%	3%	2%	1%	1%
2006	3%	58%	19%	4%	11%	4%	1%	0%	0%
2007	12%	17%	56%	9%	2%	3%	1%	0%	0%
2008	3%	31%	20%	38%	6%	1%	1%	0%	0%
2009	24%	11%	30%	12%	20%	2%	1%	1%	0%
2010	4%	33%	13%	25%	8%	16%	1%	0%	1%
2011	7%	19%	38%	8%	15%	6%	6%	1%	0%
2012	6%	34%	24%	20%	3%	6%	3%	2%	0%
2013	5%	24%	33%	18%	13%	3%	4%	1%	0%
2014	11%	16%	25%	22%	15%	7%	2%	2%	1%
2015	0%	9%	18%	24%	21%	15%	7%	3%	2%

Table 4.2.1.2. Herring in the Celtic Sea. Length frequency distributions of the Irish catches (raised numbers in '000s) in the 2015/2016 season.

Length (cm)	Quarter 3 2015	Quarter 4 2015	Quarter 1 2016	All year
19.5			29	29
20		62	29	91
20.5		78	19	97
21	40	218	10	268
21.5	160	203	10	372
22	319	797	58	1174
22.5	758	1233	136	2128
23	838	2108	175	3122
23.5	918	3232	175	4326
24	758	5653	214	6626
24.5	1437	8871	272	10580
25	1517	12257	486	14260
25.5	2595	15567	914	19076
26	2874	19377	700	22952
26.5	1597	12833	671	15101
27	1118	9228	360	10705
27.5	758	4418	185	5361
28	160	1374	107	1640
28.5	40	421	49	510
29	40	62	0	102
29.5	80	31	0	111
30		62	0	62
30.5		0	0	0
31		0	10	10
31.5		0		0
32		0		0
32.5		31		31
TOTAL	16008	98118	4610	118735

Table 4.2.2.1 Herring in the Celtic Sea. Sampling intensity of commercial catches (2015/2016). Only Ireland provides samples of this stock.

Division	Year	Quarter	Landings (t)	No. Samples	No. Measured	No. aged	Aged/1000 t
7.a	2015	4	858	4	418	200	233
7.a	2016	1	522	5	474	250	479
7.g	2015	3	2155	2	401	446	207
7.g	2015	4	12624	15	2933	755	60
7.j	2015	4	161	0	0	0	0
			16319	26	4226	1651	101

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). 2–9 ring abundances are used in tuning. 2014 and 2015 (shaded) were not recommended for tuning by ICES WGIPS.

	2002	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
0	0	24	-	2	-	1	99	239	5	0	31	4	0	0
1	42	13	-	65	21	106	64	381	346	342	270	698	41	0
2	185	62	-	137	211	70	295	112	549	479	856	291	117	40
3	151	60	-	28	48	220	111	210	156	299	615	197	112	48
4	30	17	-	54	14	31	162	57	193	47	330	43	69	41
5	7	5	-	22	11	9	27	125	65	71	49	38	20	38
6	7	1	-	5	1	13	6	12	91	24	121	10	24	7
7	3	0	-	1	-	4	5	4	7	33	25	5	7	6
8	0	0	-	0	-	1		6	3	4	23	0	17	5
9	0	0	-	0	-	0		1		2	3	1	1	0
Nos.	423	183	-	312	305	454	769	1,147	1,414	1,300	2,322	1,286	408	184
SSB	41	20	-	33	36	46	90	91	122	122	246	71	48	25
CV	49	34	-	48	35	25	20	24	20	28	25	28	59	18.4
Design*	AR	AR		R	R	R	R	R	R	AR	AR	AR	AR	AR

*** AR Adaptive random; R random**

Table 4.6.2.1 Herring in the Celtic Sea: Selected inputs to the ASAP model. Age is in winter rings.

Natural Mortality

1	2	3	4	5	6	7	8	9
0.767	0.385	0.356	0.339	0.319	0.314	0.307	0.307	0.307
0.767	0.385	0.356	0.339	0.319	0.314	0.307	0.307	0.307
0.767	0.385	0.356	0.339	0.319	0.314	0.307	0.307	0.307
0.767	0.385	0.356	0.339	0.319	0.314	0.307	0.307	0.307
0.767	0.385	0.356	0.339	0.319	0.314	0.307	0.307	0.307
0.767	0.385	0.356	0.339	0.319	0.314	0.307	0.307	0.307
0.767	0.385	0.356	0.339	0.319	0.314	0.307	0.307	0.307
0.767	0.385	0.356	0.339	0.319	0.314	0.307	0.307	0.307
0.767	0.385	0.356	0.339	0.319	0.314	0.307	0.307	0.307
0.767	0.385	0.356	0.339	0.319	0.314	0.307	0.307	0.307
0.767	0.385	0.356	0.339	0.319	0.314	0.307	0.307	0.307
0.767	0.385	0.356	0.339	0.319	0.314	0.307	0.307	0.307
0.767	0.385	0.356	0.339	0.319	0.314	0.307	0.307	0.307
0.767	0.385	0.356	0.339	0.319	0.314	0.307	0.307	0.307
0.767	0.385	0.356	0.339	0.319	0.314	0.307	0.307	0.307
0.767	0.385	0.356	0.339	0.319	0.314	0.307	0.307	0.307
0.767	0.385	0.356	0.339	0.319	0.314	0.307	0.307	0.307
0.767	0.385	0.356	0.339	0.319	0.314	0.307	0.307	0.307
0.767	0.385	0.356	0.339	0.319	0.314	0.307	0.307	0.307
0.767	0.385	0.356	0.339	0.319	0.314	0.307	0.307	0.307
0.767	0.385	0.356	0.339	0.319	0.314	0.307	0.307	0.307
0.767	0.385	0.356	0.339	0.319	0.314	0.307	0.307	0.307
0.767	0.385	0.356	0.339	0.319	0.314	0.307	0.307	0.307
0.767	0.385	0.356	0.339	0.319	0.314	0.307	0.307	0.307
0.767	0.385	0.356	0.339	0.319	0.314	0.307	0.307	0.307
0.767	0.385	0.356	0.339	0.319	0.314	0.307	0.307	0.307
0.767	0.385	0.356	0.339	0.319	0.314	0.307	0.307	0.307
0.767	0.385	0.356	0.339	0.319	0.314	0.307	0.307	0.307
0.767	0.385	0.356	0.339	0.319	0.314	0.307	0.307	0.307
0.767	0.385	0.356	0.339	0.319	0.314	0.307	0.307	0.307
0.767	0.385	0.356	0.339	0.319	0.314	0.307	0.307	0.307
0.767	0.385	0.356	0.339	0.319	0.314	0.307	0.307	0.307
0.767	0.385	0.356	0.339	0.319	0.314	0.307	0.307	0.307
0.767	0.385	0.356	0.339	0.319	0.314	0.307	0.307	0.307
0.767	0.385	0.356	0.339	0.319	0.314	0.307	0.307	0.307
0.767	0.385	0.356	0.339	0.319	0.314	0.307	0.307	0.307
0.767	0.385	0.356	0.339	0.319	0.314	0.307	0.307	0.307
0.767	0.385	0.356	0.339	0.319	0.314	0.307	0.307	0.307
0.767	0.385	0.356	0.339	0.319	0.314	0.307	0.307	0.307
0.767	0.385	0.356	0.339	0.319	0.314	0.307	0.307	0.307
0.767	0.385	0.356	0.339	0.319	0.314	0.307	0.307	0.307
0.767	0.385	0.356	0.339	0.319	0.314	0.307	0.307	0.307
0.767	0.385	0.356	0.339	0.319	0.314	0.307	0.307	0.307
0.767	0.385	0.356	0.339	0.319	0.314	0.307	0.307	0.307

Natural Mortality

1	2	3	4	5	6	7	8	9
0.767	0.385	0.356	0.339	0.319	0.314	0.307	0.307	0.307
0.767	0.385	0.356	0.339	0.319	0.314	0.307	0.307	0.307
0.767	0.385	0.356	0.339	0.319	0.314	0.307	0.307	0.307
0.767	0.385	0.356	0.339	0.319	0.314	0.307	0.307	0.307
0.767	0.385	0.356	0.339	0.319	0.314	0.307	0.307	0.307
0.767	0.385	0.356	0.339	0.319	0.314	0.307	0.307	0.307
0.767	0.385	0.356	0.339	0.319	0.314	0.307	0.307	0.307
0.767	0.385	0.356	0.339	0.319	0.314	0.307	0.307	0.307
0.767	0.385	0.356	0.339	0.319	0.314	0.307	0.307	0.307
0.767	0.385	0.356	0.339	0.319	0.314	0.307	0.307	0.307
0.767	0.385	0.356	0.339	0.319	0.314	0.307	0.307	0.307
0.767	0.385	0.356	0.339	0.319	0.314	0.307	0.307	0.307
0.767	0.385	0.356	0.339	0.319	0.314	0.307	0.307	0.307
0.767	0.385	0.356	0.339	0.319	0.314	0.307	0.307	0.307

Maturity

1	2	3	4	5	6	7	8	9
0.5	1	1	1	1	1	1	1	1
0.5	1	1	1	1	1	1	1	1
0.5	1	1	1	1	1	1	1	1
0.5	1	1	1	1	1	1	1	1
0.5	1	1	1	1	1	1	1	1
0.5	1	1	1	1	1	1	1	1
0.5	1	1	1	1	1	1	1	1
0.5	1	1	1	1	1	1	1	1
0.5	1	1	1	1	1	1	1	1
0.5	1	1	1	1	1	1	1	1
0.5	1	1	1	1	1	1	1	1
0.5	1	1	1	1	1	1	1	1
0.5	1	1	1	1	1	1	1	1
0.5	1	1	1	1	1	1	1	1
0.5	1	1	1	1	1	1	1	1
0.5	1	1	1	1	1	1	1	1
0.5	1	1	1	1	1	1	1	1
0.5	1	1	1	1	1	1	1	1
0.5	1	1	1	1	1	1	1	1
0.5	1	1	1	1	1	1	1	1
0.5	1	1	1	1	1	1	1	1
0.5	1	1	1	1	1	1	1	1
0.5	1	1	1	1	1	1	1	1
0.5	1	1	1	1	1	1	1	1
0.5	1	1	1	1	1	1	1	1
0.5	1	1	1	1	1	1	1	1
0.5	1	1	1	1	1	1	1	1

Maturity

1	2	3	4	5	6	7	8	9
0.5	1	1	1	1	1	1	1	1
0.5	1	1	1	1	1	1	1	1
0.5	1	1	1	1	1	1	1	1
0.5	1	1	1	1	1	1	1	1
0.5	1	1	1	1	1	1	1	1
0.5	1	1	1	1	1	1	1	1
0.5	1	1	1	1	1	1	1	1
0.5	1	1	1	1	1	1	1	1
0.5	1	1	1	1	1	1	1	1
0.5	1	1	1	1	1	1	1	1
0.5	1	1	1	1	1	1	1	1
0.5	1	1	1	1	1	1	1	1
0.5	1	1	1	1	1	1	1	1
0.5	1	1	1	1	1	1	1	1
0.5	1	1	1	1	1	1	1	1
0.5	1	1	1	1	1	1	1	1
0.5	1	1	1	1	1	1	1	1
0.5	1	1	1	1	1	1	1	1
0.5	1	1	1	1	1	1	1	1
0.5	1	1	1	1	1	1	1	1
0.5	1	1	1	1	1	1	1	1
0.5	1	1	1	1	1	1	1	1
0.5	1	1	1	1	1	1	1	1
0.5	1	1	1	1	1	1	1	1
0.5	1	1	1	1	1	1	1	1
0.5	1	1	1	1	1	1	1	1
0.5	1	1	1	1	1	1	1	1
0.5	1	1	1	1	1	1	1	1
0.5	1	1	1	1	1	1	1	1
0.5	1	1	1	1	1	1	1	1
0.5	1	1	1	1	1	1	1	1

Weight Matrix - 1

1	2	3	4	5	6	7	8	9
0.096	0.115	0.162	0.185	0.205	0.217	0.227	0.232	0.23
0.087	0.119	0.166	0.185	0.2	0.21	0.217	0.23	0.231
0.093	0.122	0.156	0.191	0.205	0.207	0.22	0.225	0.239
0.098	0.127	0.156	0.185	0.207	0.212	0.22	0.235	0.235
0.109	0.146	0.17	0.187	0.21	0.227	0.232	0.237	0.24
0.103	0.139	0.194	0.205	0.217	0.23	0.237	0.245	0.251
0.105	0.139	0.182	0.215	0.225	0.23	0.237	0.245	0.253
0.103	0.143	0.18	0.212	0.232	0.243	0.243	0.256	0.26
0.122	0.154	0.191	0.212	0.237	0.248	0.24	0.253	0.257

Weight	Matrix	-	1					
1	2	3	4	5	6	7	8	9
0.119	0.158	0.185	0.217	0.243	0.251	0.256	0.259	0.264
0.119	0.166	0.196	0.215	0.235	0.248	0.256	0.262	0.266
0.122	0.164	0.2	0.217	0.237	0.245	0.264	0.264	0.262
0.128	0.162	0.2	0.225	0.24	0.253	0.264	0.276	0.272
0.117	0.166	0.2	0.225	0.245	0.253	0.262	0.267	0.283
0.132	0.17	0.194	0.22	0.245	0.259	0.264	0.27	0.285
0.125	0.174	0.205	0.215	0.245	0.262	0.262	0.285	0.285
0.141	0.18	0.21	0.225	0.237	0.259	0.262	0.288	0.27
0.137	0.187	0.215	0.24	0.251	0.26	0.27	0.279	0.284
0.137	0.174	0.205	0.235	0.259	0.27	0.279	0.288	0.293
0.134	0.185	0.212	0.222	0.243	0.267	0.259	0.292	0.298
0.127	0.189	0.217	0.24	0.279	0.276	0.291	0.297	0.302
0.127	0.174	0.212	0.23	0.253	0.273	0.291	0.279	0.284
0.117	0.174	0.207	0.237	0.259	0.276	0.27	0.27	0.275
0.115	0.172	0.21	0.245	0.267	0.276	0.297	0.309	0.315
0.115	0.154	0.194	0.237	0.262	0.273	0.279	0.288	0.293
0.109	0.148	0.198	0.22	0.276	0.282	0.276	0.319	0.325
0.093	0.142	0.185	0.213	0.213	0.245	0.246	0.263	0.262
0.104	0.14	0.17	0.201	0.234	0.248	0.256	0.26	0.263
0.112	0.155	0.172	0.187	0.215	0.248	0.276	0.284	0.332
0.096	0.138	0.186	0.192	0.204	0.231	0.255	0.267	0.284
0.097	0.132	0.168	0.203	0.209	0.215	0.237	0.257	0.283
0.106	0.129	0.151	0.169	0.194	0.199	0.21	0.221	0.24
0.099	0.137	0.153	0.167	0.188	0.208	0.209	0.229	0.251
0.092	0.128	0.168	0.182	0.19	0.206	0.229	0.236	0.251
0.096	0.123	0.15	0.177	0.191	0.194	0.212	0.228	0.248
0.092	0.129	0.155	0.18	0.201	0.204	0.21	0.225	0.24
0.097	0.135	0.168	0.179	0.19	0.21	0.218	0.217	0.227
0.088	0.126	0.151	0.178	0.188	0.198	0.207	0.227	0.227
0.088	0.118	0.147	0.159	0.185	0.196	0.207	0.219	0.231
0.093	0.124	0.141	0.157	0.172	0.192	0.206	0.216	0.22
0.099	0.121	0.153	0.163	0.173	0.185	0.199	0.204	0.225
0.09	0.12	0.149	0.167	0.18	0.183	0.202	0.209	0.208
0.092	0.111	0.148	0.168	0.185	0.187	0.197	0.21	0.224
0.082	0.107	0.139	0.162	0.177	0.19	0.185	0.204	0.229
0.096	0.115	0.139	0.156	0.185	0.196	0.203	0.211	0.226
0.089	0.102	0.128	0.146	0.165	0.184	0.195	0.202	0.214
0.08	0.13	0.134	0.151	0.159	0.174	0.203	0.215	0.225
0.077	0.102	0.142	0.147	0.158	0.168	0.181	0.208	0.252
0.093	0.105	0.127	0.151	0.155	0.165	0.174	0.186	0.198
0.074	0.106	0.123	0.141	0.166	0.162	0.17	0.171	0.229
0.091	0.12	0.144	0.156	0.172	0.191	0.194	0.199	0.224
0.078	0.122	0.146	0.16	0.169	0.185	0.187	0.197	0.211
0.076	0.111	0.131	0.145	0.158	0.159	0.163	0.178	0.19
0.07	0.104	0.127	0.141	0.154	0.161	0.167	0.18	0.179

Weight Matrix - 1

1	2	3	4	5	6	7	8	9
0.072	0.094	0.124	0.138	0.152	0.157	0.164	0.164	0.171
0.062	0.101	0.122	0.142	0.153	0.164	0.17	0.166	0.18
0.067	0.1	0.127	0.14	0.153	0.161	0.163	0.179	0.176
0.071	0.102	0.122	0.137	0.143	0.151	0.158	0.167	0.182

Weight Matrix - 2

1	2	3	4	5	6	7	8	9
0.096	0.115	0.162	0.185	0.205	0.217	0.227	0.232	0.23
0.087	0.119	0.166	0.185	0.2	0.21	0.217	0.23	0.231
0.093	0.122	0.156	0.191	0.205	0.207	0.22	0.225	0.239
0.098	0.127	0.156	0.185	0.207	0.212	0.22	0.235	0.235
0.109	0.146	0.17	0.187	0.21	0.227	0.232	0.237	0.24
0.103	0.139	0.194	0.205	0.217	0.23	0.237	0.245	0.251
0.105	0.139	0.182	0.215	0.225	0.23	0.237	0.245	0.253
0.103	0.143	0.18	0.212	0.232	0.243	0.243	0.256	0.26
0.122	0.154	0.191	0.212	0.237	0.248	0.24	0.253	0.257
0.119	0.158	0.185	0.217	0.243	0.251	0.256	0.259	0.264
0.119	0.166	0.196	0.215	0.235	0.248	0.256	0.262	0.266
0.122	0.164	0.2	0.217	0.237	0.245	0.264	0.264	0.262
0.128	0.162	0.2	0.225	0.24	0.253	0.264	0.276	0.272
0.117	0.166	0.2	0.225	0.245	0.253	0.262	0.267	0.283
0.132	0.17	0.194	0.22	0.245	0.259	0.264	0.27	0.285
0.125	0.174	0.205	0.215	0.245	0.262	0.262	0.285	0.285
0.141	0.18	0.21	0.225	0.237	0.259	0.262	0.288	0.27
0.137	0.187	0.215	0.24	0.251	0.26	0.27	0.279	0.284
0.137	0.174	0.205	0.235	0.259	0.27	0.279	0.288	0.293
0.134	0.185	0.212	0.222	0.243	0.267	0.259	0.292	0.298
0.127	0.189	0.217	0.24	0.279	0.276	0.291	0.297	0.302
0.127	0.174	0.212	0.23	0.253	0.273	0.291	0.279	0.284
0.117	0.174	0.207	0.237	0.259	0.276	0.27	0.27	0.275
0.115	0.172	0.21	0.245	0.267	0.276	0.297	0.309	0.315
0.115	0.154	0.194	0.237	0.262	0.273	0.279	0.288	0.293
0.109	0.148	0.198	0.22	0.276	0.282	0.276	0.319	0.325
0.093	0.142	0.185	0.213	0.213	0.245	0.246	0.263	0.262
0.104	0.14	0.17	0.201	0.234	0.248	0.256	0.26	0.263
0.112	0.155	0.172	0.187	0.215	0.248	0.276	0.284	0.332
0.096	0.138	0.186	0.192	0.204	0.231	0.255	0.267	0.284
0.097	0.132	0.168	0.203	0.209	0.215	0.237	0.257	0.283
0.106	0.129	0.151	0.169	0.194	0.199	0.21	0.221	0.24
0.099	0.137	0.153	0.167	0.188	0.208	0.209	0.229	0.251
0.092	0.128	0.168	0.182	0.19	0.206	0.229	0.236	0.251
0.096	0.123	0.15	0.177	0.191	0.194	0.212	0.228	0.248
0.092	0.129	0.155	0.18	0.201	0.204	0.21	0.225	0.24

Weight	Matrix	-	2					
1	2	3	4	5	6	7	8	9
0.097	0.135	0.168	0.179	0.19	0.21	0.218	0.217	0.227
0.088	0.126	0.151	0.178	0.188	0.198	0.207	0.227	0.227
0.088	0.118	0.147	0.159	0.185	0.196	0.207	0.219	0.231
0.093	0.124	0.141	0.157	0.172	0.192	0.206	0.216	0.22
0.099	0.121	0.153	0.163	0.173	0.185	0.199	0.204	0.225
0.09	0.12	0.149	0.167	0.18	0.183	0.202	0.209	0.208
0.092	0.111	0.148	0.168	0.185	0.187	0.197	0.21	0.224
0.082	0.107	0.139	0.162	0.177	0.19	0.185	0.204	0.229
0.096	0.115	0.139	0.156	0.184	0.196	0.203	0.211	0.223
0.078	0.1	0.13	0.141	0.156	0.158	0.168	0.2	0.213
0.077	0.127	0.133	0.151	0.156	0.168	0.216	0.228	0.257
0.074	0.103	0.145	0.143	0.155	0.161	0.175	0.221	0.233
0.085	0.104	0.123	0.153	0.15	0.157	0.164	0.177	0.188
0.068	0.101	0.122	0.138	0.156	0.159	0.163	0.167	0.251
0.083	0.117	0.14	0.156	0.17	0.18	0.177	0.189	0.232
0.076	0.117	0.142	0.158	0.168	0.176	0.17	0.186	0.226
0.076	0.106	0.127	0.139	0.152	0.157	0.164	0.188	0.18
0.067	0.108	0.127	0.138	0.148	0.16	0.17	0.194	0.197
0.061	0.094	0.125	0.138	0.149	0.159	0.161	0.165	0.167
0.06	0.101	0.126	0.144	0.153	0.159	0.168	0.17	0.186
0.065	0.1	0.128	0.142	0.153	0.158	0.163	0.177	0.169
0.065	0.098	0.119	0.133	0.14	0.146	0.153	0.16	0.162

Selectivity	Block	#1	Data
0.3	1	0	1
0.5	1	0	1
1	-1	0	1
1	1	0	1
1	1	0	1
1	1	0	1
1	1	0	1
1	1	0	1
1	1	0	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

Fleet-1 Catch Data

1	2	3	4	5	6	7	8	9	
1642	3742	33094	25746	12551	23949	16093	9384	5584	22978
1203	25717	2274	19262	11015	5830	17821	3745	7352	15086
2840	72246	24658	3779	13698	4431	6096	4379	4151	18283
2129	16058	32044	5631	2034	5067	2825	1524	4947	15372
772	18567	19909	48061	8075	3584	8593	3805	5322	21552
297	51935	13033	4179	20694	2686	1392	2488	2787	17349
7529	15058	17250	6658	1719	8716	1304	577	2193	10599
57	70248	9365	15757	3399	4539	12127	1377	7493	19126
7093	19559	59893	9924	13211	5602	3586	8746	3842	27030
7599	39991	20062	49113	9218	9444	3939	6510	6757	27658
12197	54790	39604	11544	22599	4929	4170	1310	4936	30236
9472	93279	55039	33145	12217	17837	4762	2174	3469	44389
1319	37260	50087	26481	18763	7853	6351	2175	3367	31727
12658	23313	37563	41904	18759	10443	4276	4942	2239	31396
8422	137690	17855	15842	14531	4645	3012	2374	1020	38203
23547	38133	55805	7012	9651	5323	3352	2332	1209	26936
5507	42808	17184	22530	4225	3737	2978	903	827	19940
12768	15429	17783	7333	9006	3520	1644	1136	1194	15588
13317	11113	7286	7011	2872	4785	1980	1243	1769	9771
8159	12516	8610	5280	1585	1898	1043	383	470	7833
2800	13385	11948	5583	1580	1476	540	858	482	7559
11335	13913	12399	8636	2889	1316	1283	551	635	10321
7162	30093	11726	6585	2812	2204	1184	1262	565	13130
39361	21285	21861	5505	4438	3436	795	313	866	17103
15339	42725	8728	4817	1497	1891	1670	335	596	13000
13540	102871	26993	3225	1862	327	372	932	308	24981
19517	92892	41121	16043	2450	1085	376	231	180	26779
17916	57054	36258	16032	2306	228	85	173	132	20426
4159	56747	42881	32930	8790	1127	98	29	12	25024
5976	67000	43075	23014	14323	2716	1175	296	464	26200
2307	82027	30962	9398	5963	3047	869	297	86	20447
8260	42413	68399	19601	8205	3837	2589	767	682	23254
2702	41756	24634	35258	8116	3808	1671	695	462	18404
1912	63854	38342	16916	28405	4869	2588	954	593	25562
10410	26752	35019	27591	10139	18061	3021	6285	689	21127
1608	94061	9372	10221	4491	2790	5932	855	508	18618
12130	35768	61737	3289	3025	4773	1713	1705	474	19300
9450	79159	22591	36541	3686	3420	2651	1859	842	23305
3476	61923	38244	7943	16114	2077	1586	1507	1025	18816
3849	37440	53040	31442	8318	6142	1148	827	603	20496
5818	41510	27102	28274	13178	3746	2675	597	387	18041
14274	34072	36086	14642	15515	8877	1865	2012	551	18485
9953	77378	18952	12060	5230	6227	2320	662	578	17191
15724	62153	35816	5953	4249	1774	1145	466	386	15269
3495	26472	18532	5309	1416	1269	437	154	201	7465

Fleet-1	Catch	Data							
1	2	3	4	5	6	7	8	9	
2711	37006	24444	14763	5719	3363	2335	388	542	11536
4276	9470	46243	21863	8638	1412	473	191	75	12743
15419	30710	5766	18666	7349	1923	435	77	60	9494
1460	33894	10914	2469	6261	2331	561	57	48	6944
8043	11028	36223	5509	1365	2040	410	56	4	7636
1288	12468	8144	15565	2328	518	321	58	11	5872
10171	4465	12859	4887	8458	971	279	247	80	5745
2468	20929	8183	15917	4846	10080	919	273	321	8370
6384	17151	33453	7301	13087	5347	5165	1089	141	11470
11712	62528	44819	37500	6303	11811	5549	3540	347	21820
6191	30471	42133	22649	16687	3305	5463	1778	535	16247
16664	24120	39102	33320	22450	11165	3047	2774	1022	19574
286	12247	23835	32140	27382	19861	9820	4207	3279	18355

Index-1	Selectivity	Data	
0	-4	0	0
0.5	4	0	1
0.5	4	0	1
0.5	4	0	1
1	-1	0	1
1	-1	0	1
1	-1	0	1
1	-1	0	1
1	-1	0	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

Table 4.6.2.2. Herring in the Celtic Sea. Survey data input to ASAP. Age is in winter rings.

Year	Abundance	CV	1	2	3	4	5	6	7	8	9	Sample size
2002	381900	0.49	-1	185200	150600	29700	6600	7100	2700	0	0	20
2003	88000	0.34	-1	3000	60400	17200	5400	1400	300	300	0	20
2004	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	0
2005	246700	0.47	-1	137100	28200	54200	21600	4900	700	0	0	45
2006	284999	0.35	-1	211000	48000	14000	11000	1000	-1	0	0	34
2007	347140	0.25	-1	69800	220000	30600	8970	13100	3650	1020	0	37
2008	606000	0.2	-1	295000	111000	162000	27000	6000	5000	0	0	32
2009	526600	0.24	-1	112040	209850	57490	124630	11710	3650	6350	880	30
2010	1063870	0.2	-1	548940	155860	193030	65240	91040	6650	3110	0	21
2011	959000	0.28	-1	479000	299000	47000	71000	24000	33000	4000	2000	22
2012	2021260	0.25	-1	856000	615000	330000	48500	121000	24800	22700	3260	20
2013	587000	0.28	-1	291400	197400	43700	37900	9800	4700	0	2100	21
2014	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
2015	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1

Table 4.6.2.3. Herring in the Celtic Sea. ASAP final Run settings.

Discards Included	**No**
Use likelihood constant	No
Mean F (Fbar) age (wr)range	2-5
Number of selectivity blocks	1
Fleet selectivity	By Age: 1-9-wr: 0.3,0.5,1,1,1,1,1,1,1 Fixed at age 3-wr
Index units	2 (numbers)
Index month	October (10)
Index selectivity linked to fleet	-1 (not linked)
Index Years	2002-2013 (no survey in 2004. 2014.2015 survey not included)
Index age (wr)range	1-9
Index Selectivity	0.5,0.5,0.5,0.5,1,1,1,1,1 Fixed from ages 5-9-wr
Index CV	Calculated annually
Sample size	No of samples collected per survey
Phase for F-Mult in 1st year	1
Phase for F-Mult deviations	2
Phase for recruitment deviations	3
Phase for N in 1st Year	1
Phase for catchability in 1st Year	1
Phase for catchability deviations	-5
Phase for Stock recruit relationship	1
Phase for steepness -	-5 (Do not fit stock-recruitment curve)
Recruitment CV by year	1
Lambdas by index	1
Lambda for total catch in weight by fleet	1
Catch total CV	0.2 for all years
Catch effective sample size	No of samples from Irish sampling programme
Lambda for F-Mult in 1st year	0 (freely estimated)
CV for F mult in the first year	0.5
Lambda for F-Mult deviations	0 (freely estimated)
CV for f mult deviations by fleet	0.5
Lambda for N in 1st year deviations	0 (freely estimated)
CV for N in the 1st year deviations	1
Lambda for recruitment deviations	1
Lambda for catchability in 1st year index	0
CV for catchability in 1st year by index	1
Lambda for catchability deviations	0
CV for catchability deviations	1
Lambda for deviation from initial steepness	0
CV for deviation from initial steepness	1
Lambda for deviation from unexplained stock size	0
CV for deviation from unexplained stock size	1

Table 4.6.2.4 Herring in the Celtic Sea. Update assessment stock summary table. Recruitment is at 1-winter rings.

Year	Catch (t)	SSB (t)	TSB (t)	F (2-5 wr)	Recruiitment (10^3)
1958	22978	161321	228605	0.153	423324
1959	15086	164667	284643	0.127	1565270
1960	18283	163603	226085	0.136	364697
1961	15372	140800	199141	0.125	392024
1962	21552	141655	235268	0.200	837547
1963	17349	133436	193962	0.158	405668
1964	10599	156257	277926	0.098	1379970
1965	19126	163268	232319	0.141	421470
1966	27030	160551	260966	0.201	741379
1967	27658	155737	256899	0.227	775032
1968	30236	160114	272948	0.244	907348
1969	44389	140420	228612	0.367	469420
1970	31727	105983	165250	0.332	254953
1971	31396	96964	192240	0.456	824165
1972	38203	84869	148080	0.568	282498
1973	26936	63621	117364	0.523	327070
1974	19940	49396	85691	0.500	163084
1975	15588	39142	73476	0.521	204147
1976	9771	36450	68261	0.391	227419
1977	7833	37231	64365	0.292	186588
1978	7559	36167	59261	0.268	148132
1979	10321	36198	71167	0.425	282208
1980	13130	33225	60491	0.548	168544
1981	17103	36513	87009	0.849	465723
1982	13000	57322	126387	0.468	724061
1983	24981	75989	158610	0.572	783387
1984	26779	78359	147983	0.486	664825
1985	20426	84294	152961	0.327	640118
1986	25024	92031	169316	0.377	650690
1987	26200	104063	209465	0.403	1193310
1988	20447	107515	168980	0.239	475132
1989	23254	94444	162942	0.292	574803
1990	18404	88070	145920	0.254	503581
1991	25562	69943	110633	0.391	208741
1992	21127	69723	151426	0.502	958670
1993	18618	72377	118135	0.337	360045
1994	19300	79191	150367	0.330	766900
1995	23305	80664	148493	0.399	719177
1996	18816	71252	115333	0.317	352675
1997	20496	58737	103629	0.421	371770
1998	18041	46804	81957	0.463	248567
1999	18485	40524	85930	0.658	478120
2000	17191	40231	85003	0.678	468872
2001	15269	40036	81851	0.577	497692
2002	7465	49749	90272	0.223	457861
2003	11536	38746	60516	0.342	146665
2004	12743	36467	68443	0.414	383169
2005	9494	56092	123713	0.314	1169010
2006	6944	72288	111612	0.127	408108
2007	7636	79355	136145	0.118	917257
2008	5872	99065	141411	0.067	395932
2009	5745	121558	214077	0.061	1465500
2010	8370	142470	227834	0.074	1169110
2011	11470	164809	264938	0.088	1541530
2012	21820	163226	248099	0.157	1104530
2013	16247	156272	217345	0.118	588701
2014	19574	133362	190983	0.156	539982
2015	18355	101382	145146	0.189	366128

Table 4.7.1.1. Herring in the Celtic Sea. Input data for short term forecast.

2016								
Age	**N**	**M**	**Mat**	**PF**	**PM**	**SWt**	**Sel**	**CWt**
1	537900	0.767	0.5	0.551	0.5	0.063333	0.010333	0.066667
2	167835.3	0.385	1	0.551	0.5	0.099667	0.118	0.101
3	146070	0.356	1	0.551	0.5	0.124333	0.166333	0.123667
4	93595.46	0.339	1	0.551	0.5	0.139667	0.166333	0.139667
5	108563.8	0.319	1	0.551	0.5	0.148667	0.166333	0.149667
6	94544.94	0.314	1	0.551	0.5	0.154333	0.166333	0.158667
7	46642.96	0.307	1	0.551	0.5	0.161333	0.166333	0.163667
8	39566.7	0.307	1	0.551	0.5	0.169	0.166333	0.170667
9	35977.95	0.307	1	0.551	0.5	0.172333	0.069333	0.179333

2017								
Age	**N**	**M**	**Mat**	**PF**	**PM**	**SWt**	**Sel**	**CWt**
1	537900	0.767	0.5	0.551	0.5	0.063333	0.010333	0.066667
2	-	0.385	1	0.551	0.5	0.099667	0.118	0.101
3	-	0.356	1	0.551	0.5	0.124333	0.166333	0.123667
4	-	0.339	1	0.551	0.5	0.139667	0.166333	0.139667
5	-	0.319	1	0.551	0.5	0.148667	0.166333	0.149667
6	-	0.314	1	0.551	0.5	0.154333	0.166333	0.158667
7	-	0.307	1	0.551	0.5	0.161333	0.166333	0.163667
8	-	0.307	1	0.551	0.5	0.169	0.166333	0.170667
9	-	0.307	1	0.551	0.5	0.172333	0.069333	0.179333

2018								
Age	**N**	**M**	**Mat**	**PF**	**PM**	**SWt**	**Sel**	**CWt**
1	537900	0.767	0.5	0.551	0.5	0.063333	0.010333	0.066667
2	-	0.385	1	0.551	0.5	0.099667	0.118	0.101
3	-	0.356	1	0.551	0.5	0.124333	0.166333	0.123667
4	-	0.339	1	0.551	0.5	0.139667	0.166333	0.139667
5	-	0.319	1	0.551	0.5	0.148667	0.166333	0.149667
6	-	0.314	1	0.551	0.5	0.154333	0.166333	0.158667
7	-	0.307	1	0.551	0.5	0.161333	0.166333	0.163667

Table 4.7.1.2. Herring in the Celtic Sea. Results of short term deterministic forecast.

Rationale	F_{bar} (2016)	Catch (2016)	SSB (2016)	F_{bar} (2017)	Catch (2017)	SSB (2017)	SSB (2018)
Catch (2017) = Zero	0.24	18590	84923	0.00	0	83468	89094
Catch (2017) = 2016 TAC -15%	0.24	18590	84923	0.21	13126	76176	73809
Catch (2017) = 2016 TAC +15%	0.24	18590	84923	0.29	17758	73463	70539
Catch (2017) = 2016 TAC +30%	0.24	18590	84923	0.33	20075	72076	68910
Catch (2017) = 2016 TAC -30%	0.24	18590	84923	0.17	10809	77503	75449
F_{bar} (2017) = F_{msy}	0.24	18590	84923	0.26	16145	74417	71676
Catch (2017) = 2016 TAC	0.24	18590	84923	0.25	15442	74829	72172
F_{bar} (2017) = F_{mgt}	0.24	18590	84923	0.23	14467	75399	72861
F_{bar} (2017) = 0.18	0.24	18590	84923	0.18	11569	77070	74911

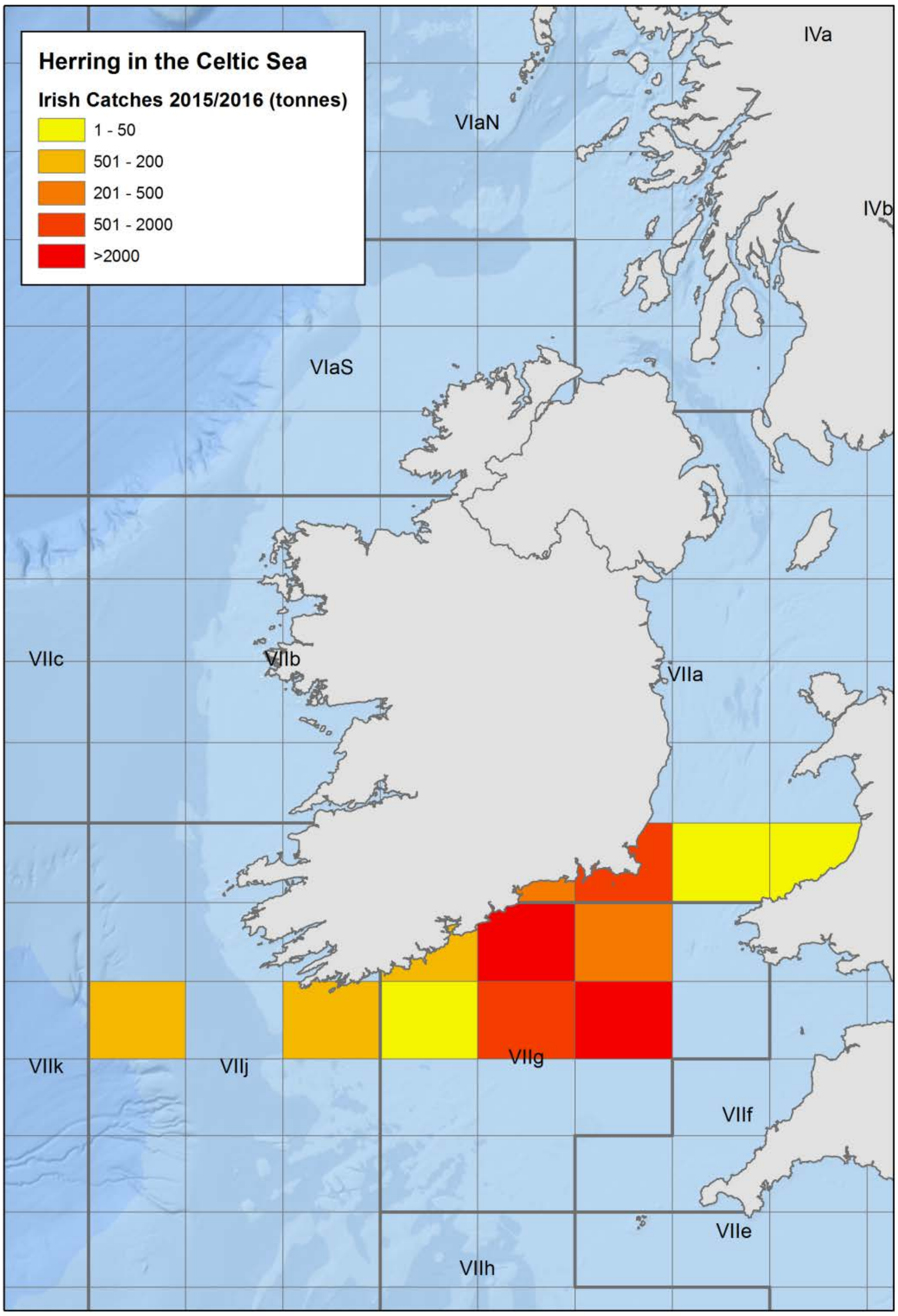


Figure 4.1.2.1. Herring in the Celtic Sea. Irish official herring catches by statistical rectangle in 2015/2016.

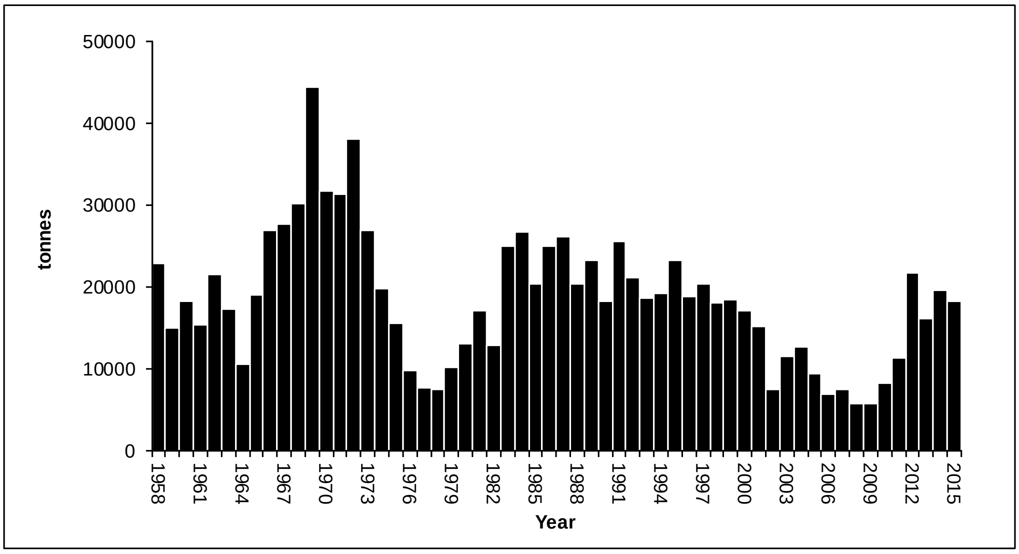


Figure 4.1.3.1. Herring in the Celtic Sea. Working Group estimates of herring catches per season.

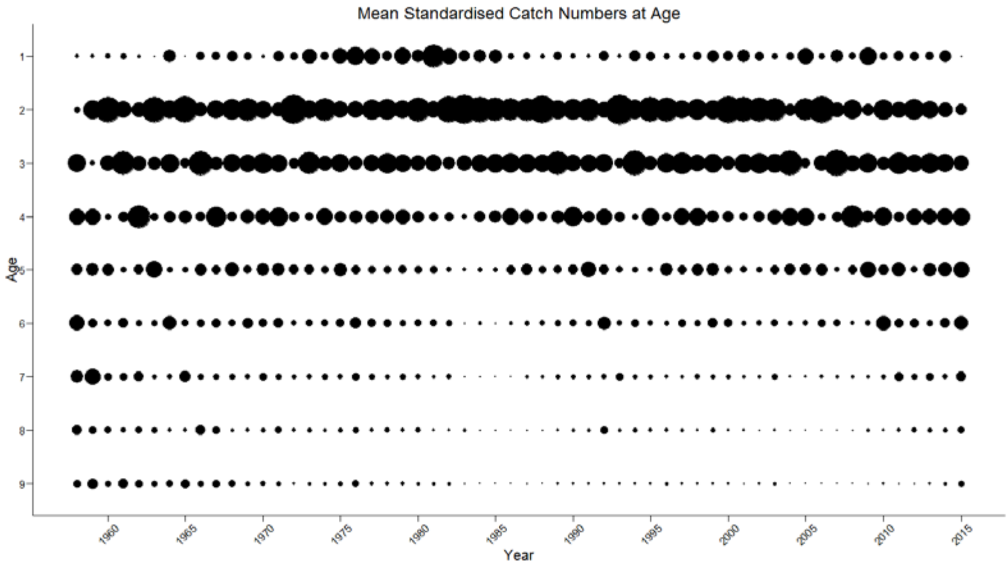


Figure 4.2.1.1. Herring in the Celtic Sea. Catch numbers-at-age standardised by yearly mean. 9-ringer is the plus group. Age in winter rings.

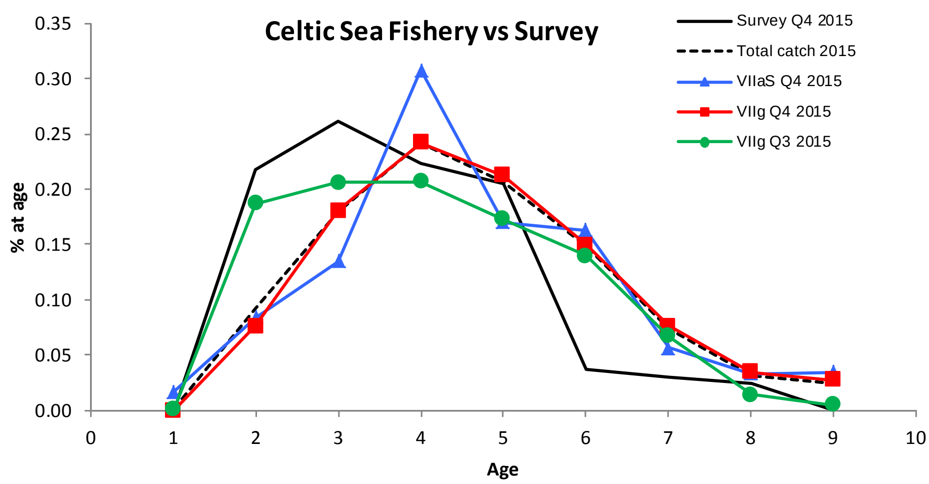


Figure 4.2.1.3. Herring in the Celtic Sea. Percentage age composition in the survey and the commercial fishery 2014/2015. Age in winter rings.

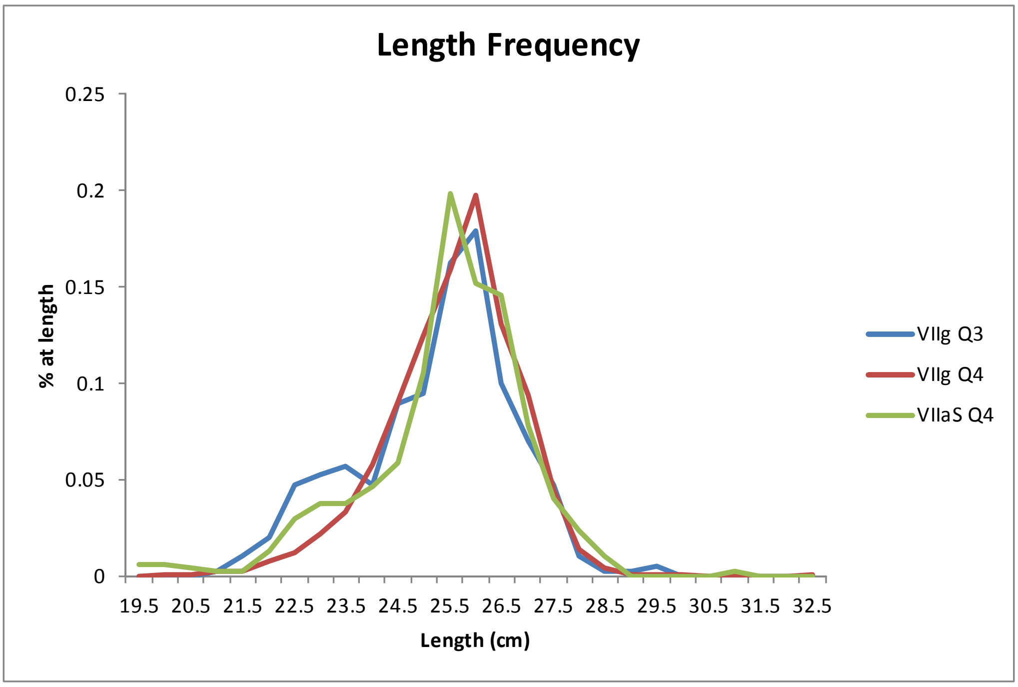


Figure 4.2.1.4. Herring in the Celtic Sea. Length-frequency data from sampling in 2015/2016.

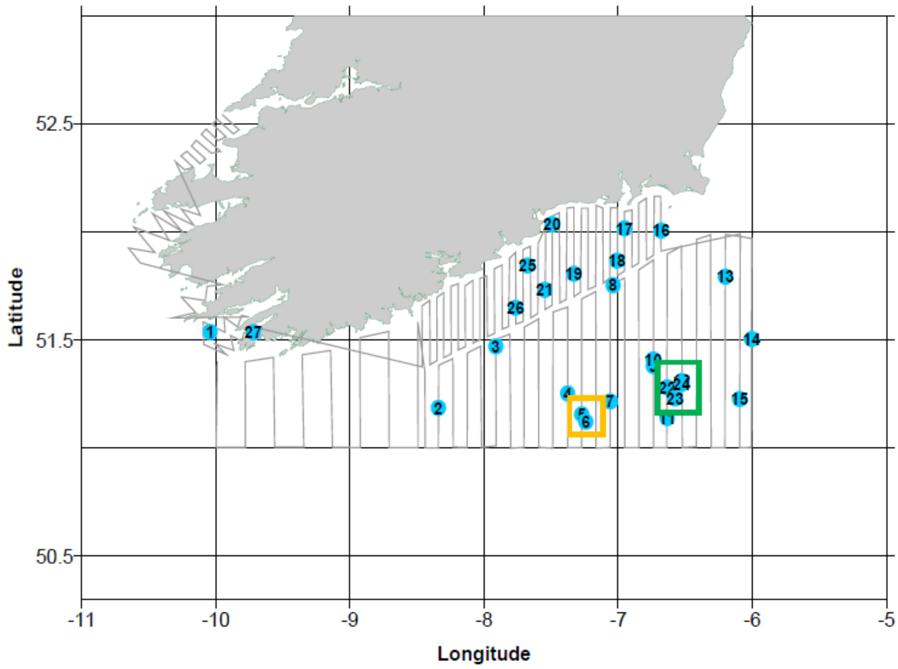


Figure 4.3.1.1a. Herring in the Celtic Sea. Acoustic survey track, haul positions, and adaptive survey strata highlighted in green and gold. Detailed are the Trench (orange) and Smalls (green) adaptive survey areas.

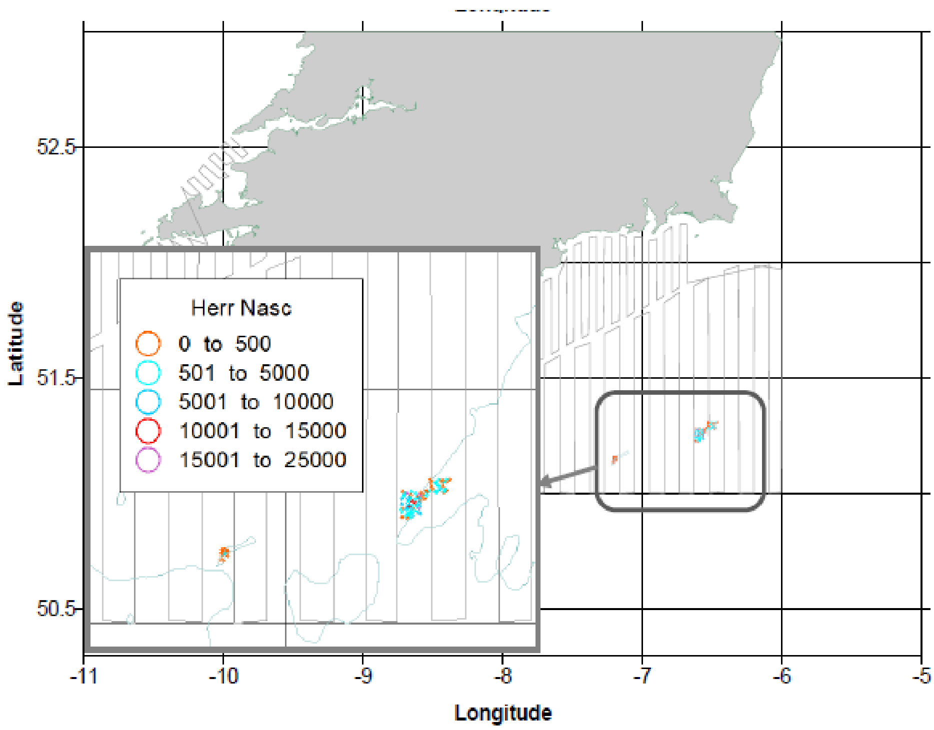


Figure 4.3.1.1b. Herring in the Celtic Sea. Weighted herring NASC (Nautical area scattering coefficient) plot of the distribution of "definitely" and "probably" categories (red circles), "mixed herring" (blue) and "possibly herring" (teal), for adaptive strata. Note the presence of herring echotraces in relation to core survey transects (vertical grey lines).

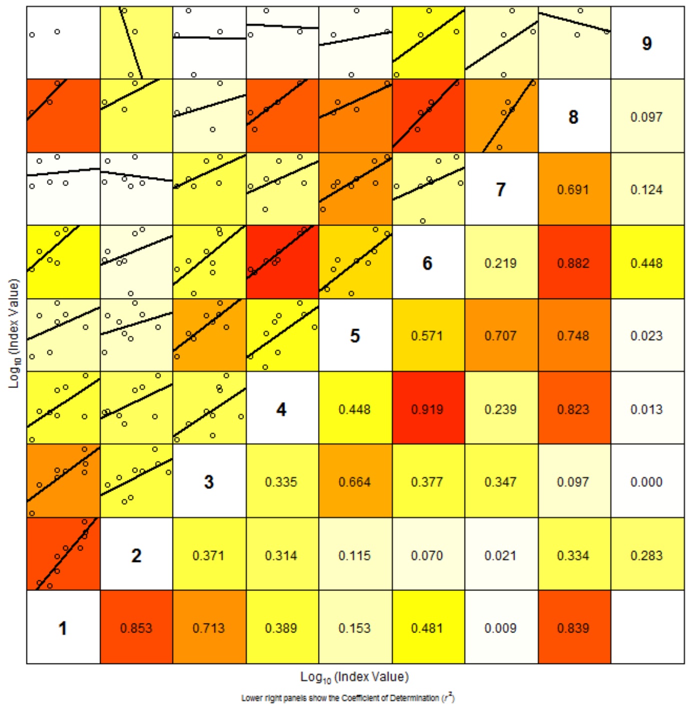


Figure 4.3.1.2. Herring in the Celtic Sea. Internal consistency between ages in the Celtic Sea Herring Acoustic survey time series, including the years not used in tuning. Age in winter rings.

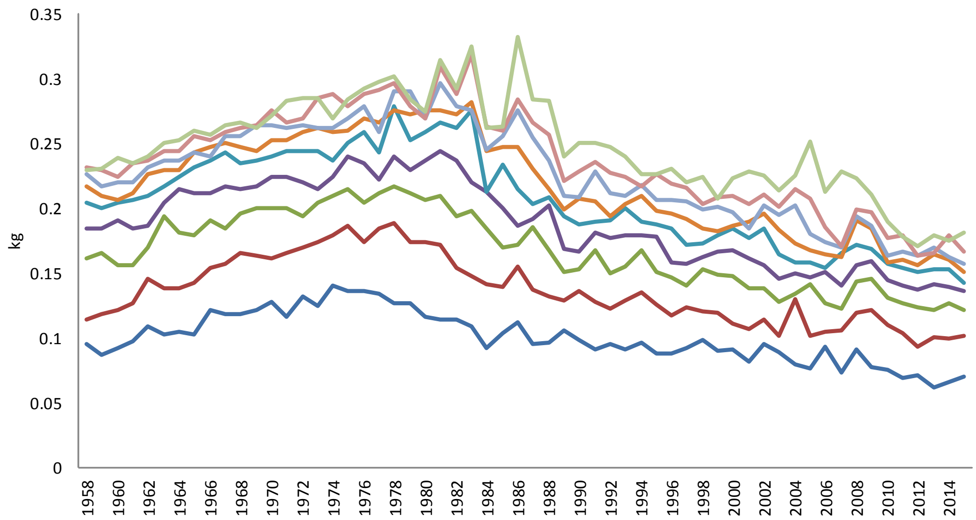


Figure 4.4.1.1. Herring in the Celtic Sea. Trends over time in mean weight-at-age in the catch from 1958–2014 for 1–9+.

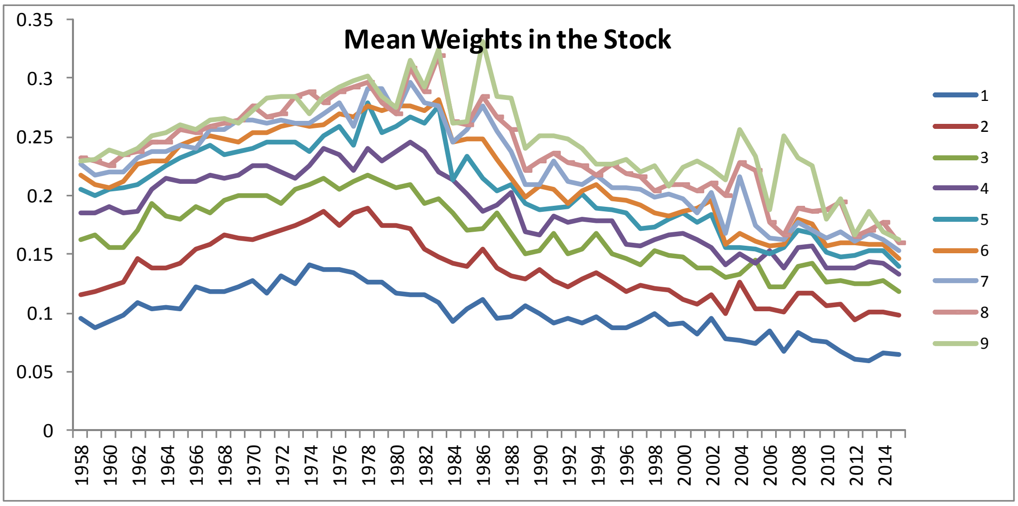


Figure 4.4.1.2. Herring in the Celtic Sea. Trends over time in mean weight-at-age in the stock at spawning time from 1958–2014 for 1–9+. Age in winter rings.

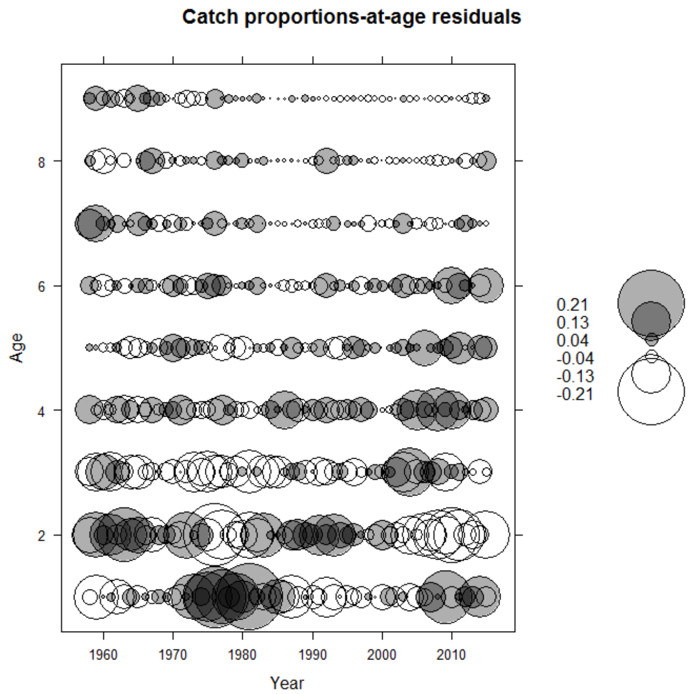


Figure 4.6.2.1. Herring in the Celtic Sea. Catch proportion at age residuals. Age in winter rings.

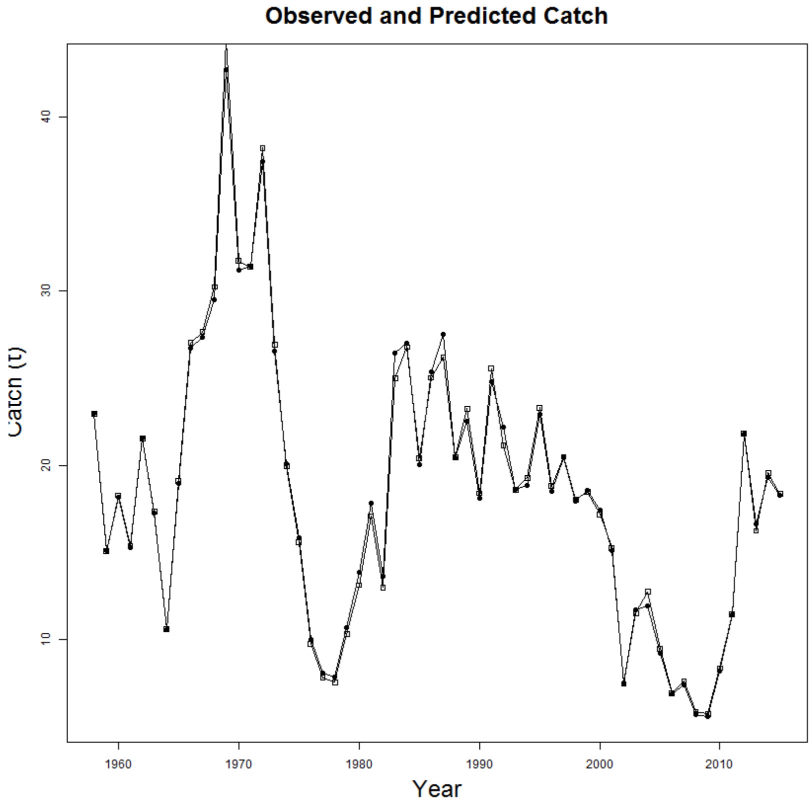


Figure 4.6.2.2. Herring in the Celtic Sea. Observed catch and predicted catch for the final ASAP assessment.

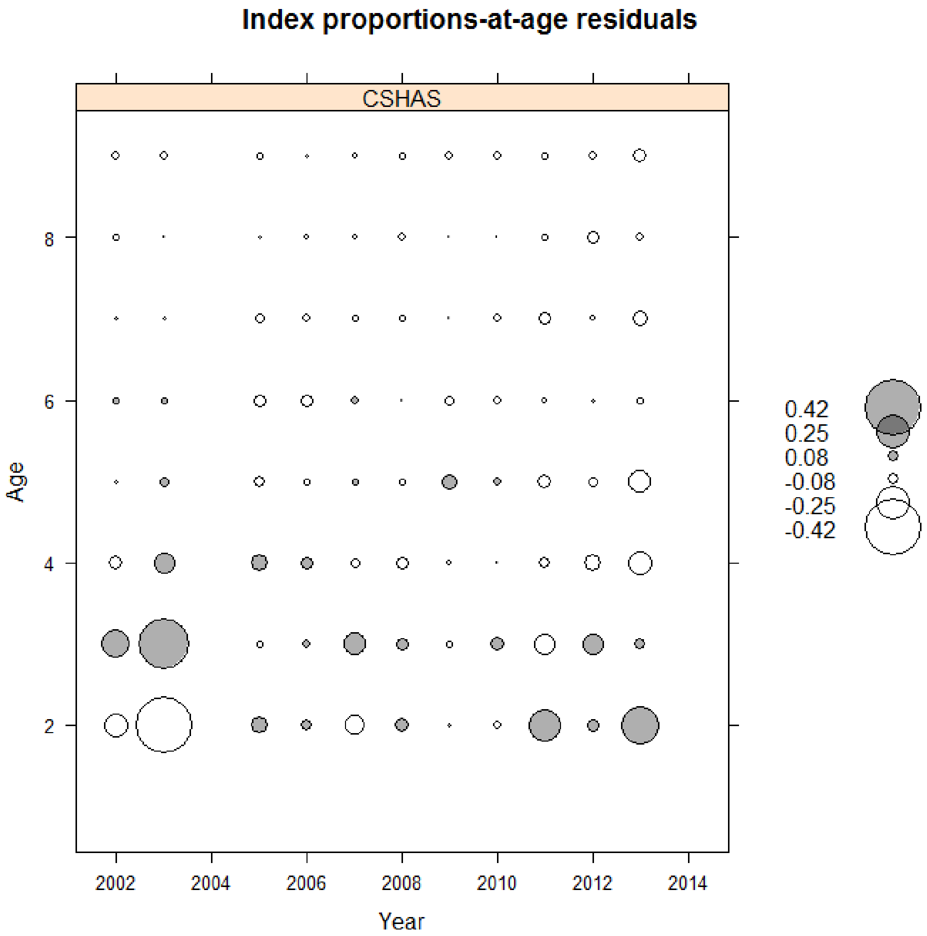


Figure 4.6.2.3. Herring in the Celtic Sea. Index proportions-at-age residuals (observed–predicted). Age in winter rings.

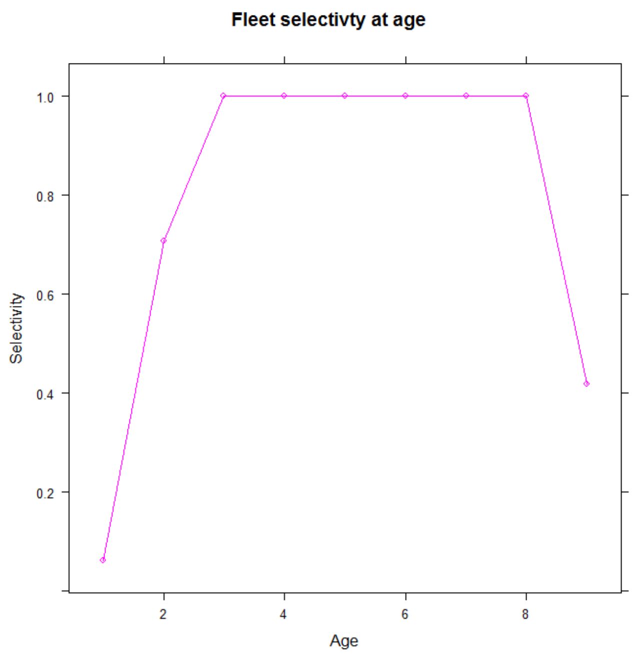


Figure 4.6.2.4. Herring in the Celtic Sea. Selectivity pattern from the final assessment run. Age in winter rings.

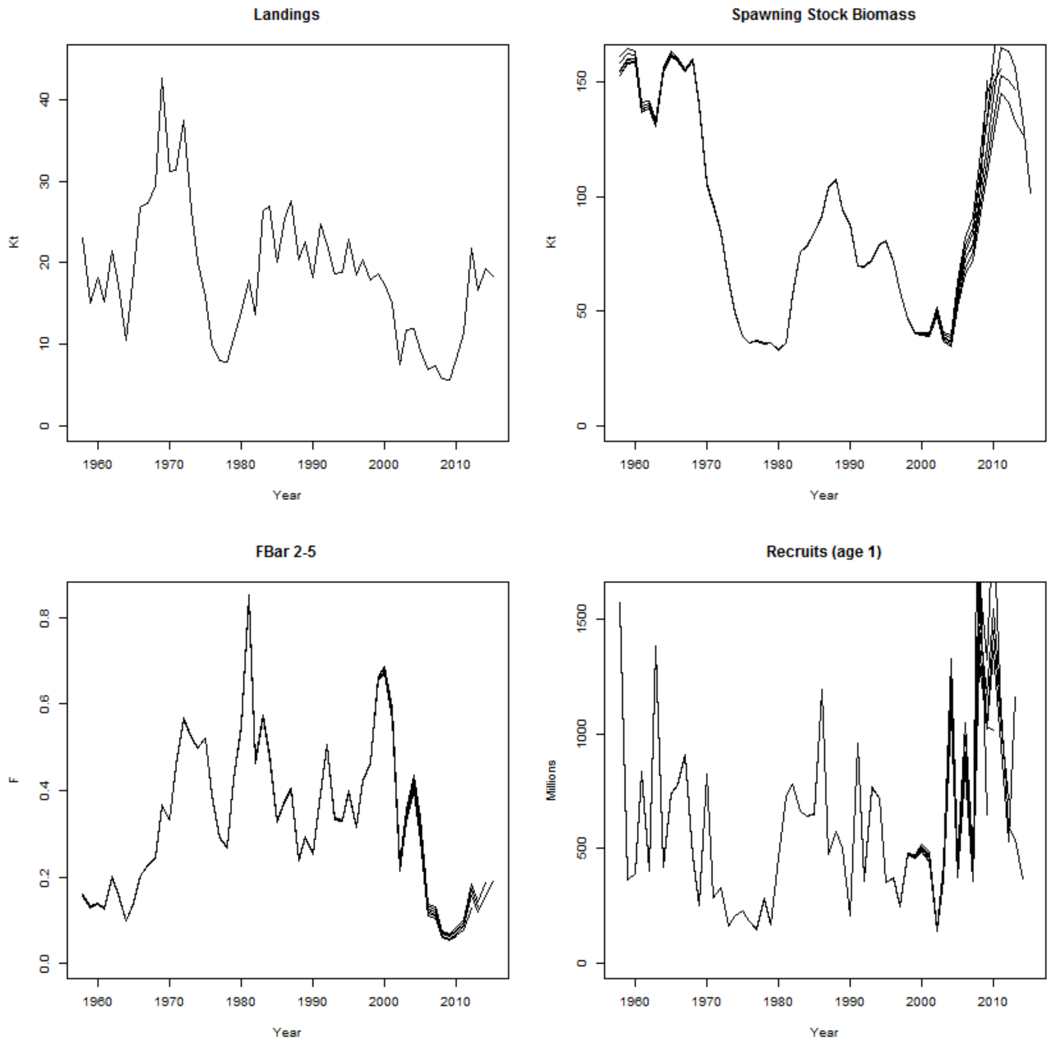


Figure 4.6.2.5. Herring in the Celtic Sea. Retrospective plots for SSB (top right), Mean F (bottom left), Recruitment (bottom right) and the catch data time series (top left). Age in winter rings.

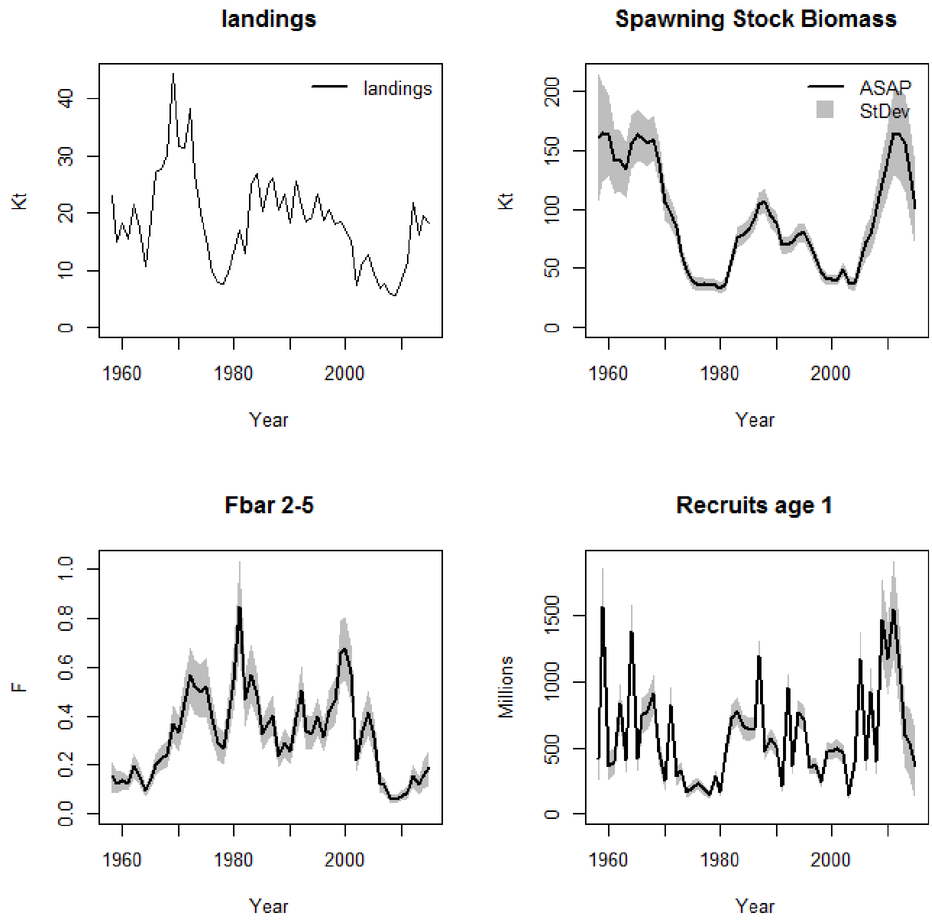


Figure 4.6.2.6. Herring in the Celtic Sea. Stock Summary from the final assessment run showing SSB (top right), Mean F (bottom left), Recruitment (bottom right) and the catch data time series (top left). Age in winter rings.

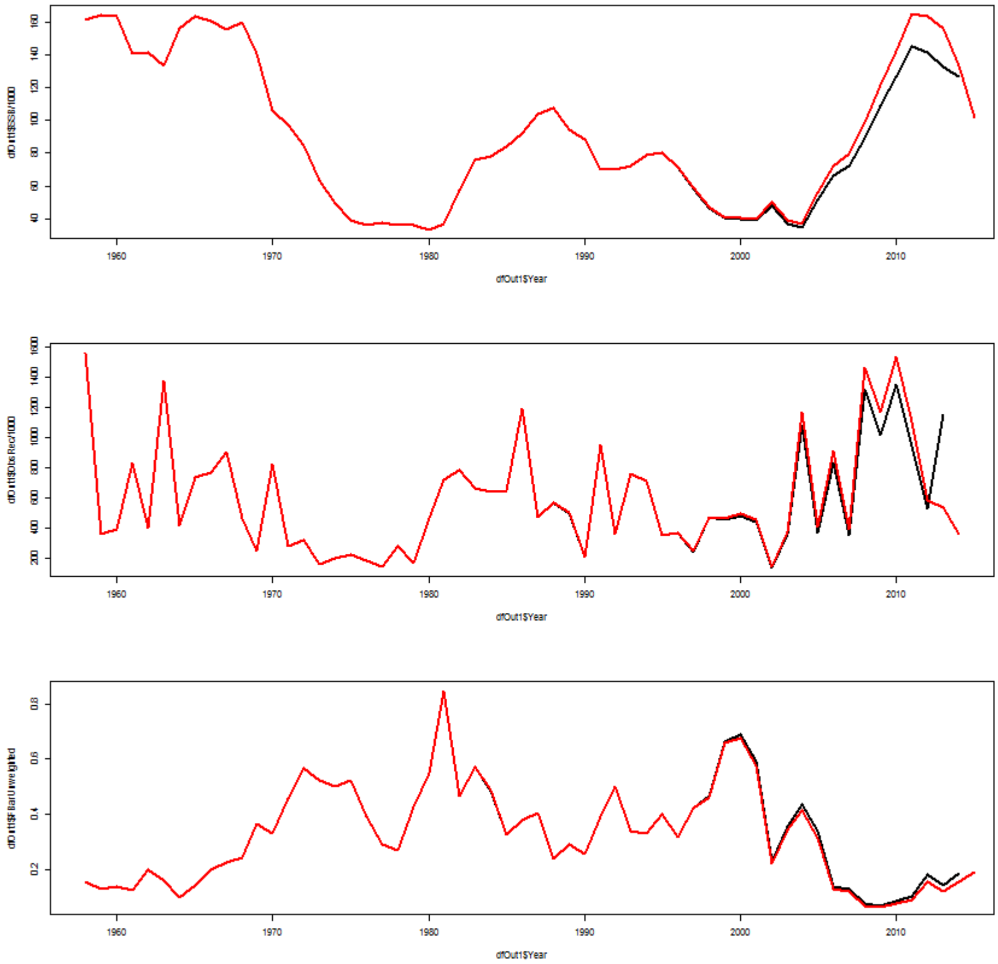


Figure 4.6.2.7. Herring in the Celtic Sea. Comparison of the final assessment runs at HAWG 2015 and 2016.

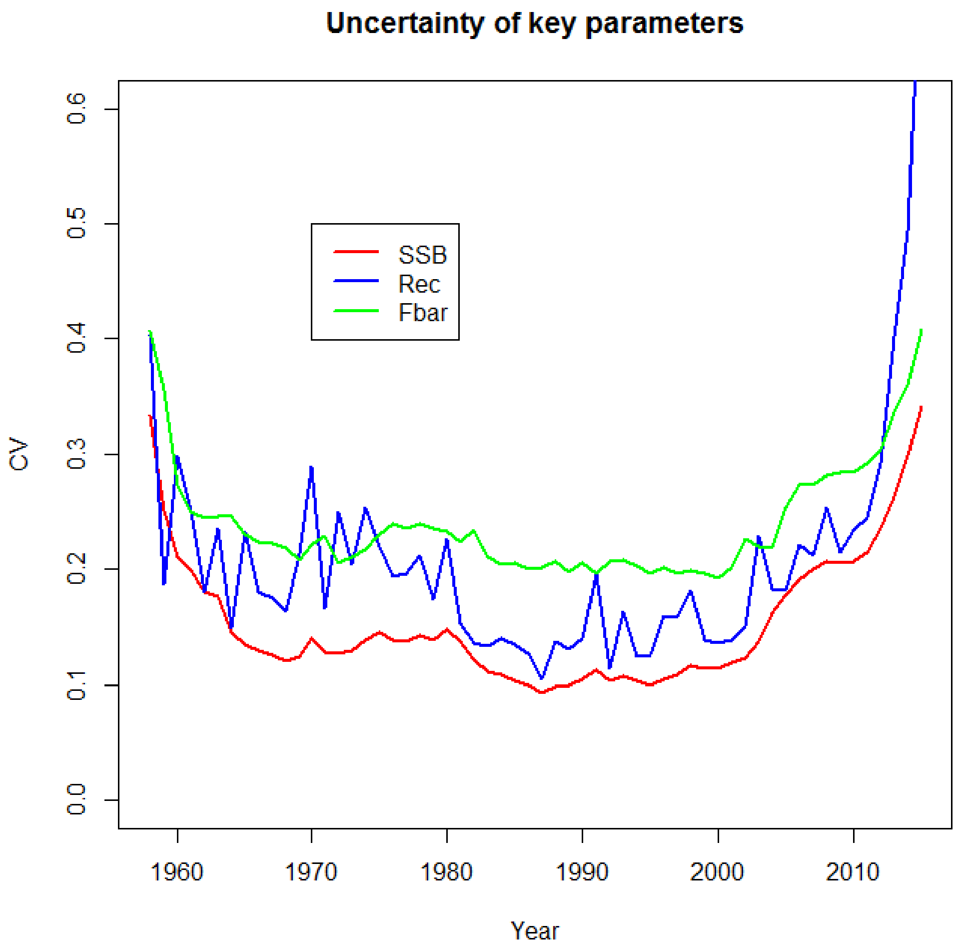


Figure 4.6.2.8. Herring in the Celtic Sea. Uncertainties in assessment over time.

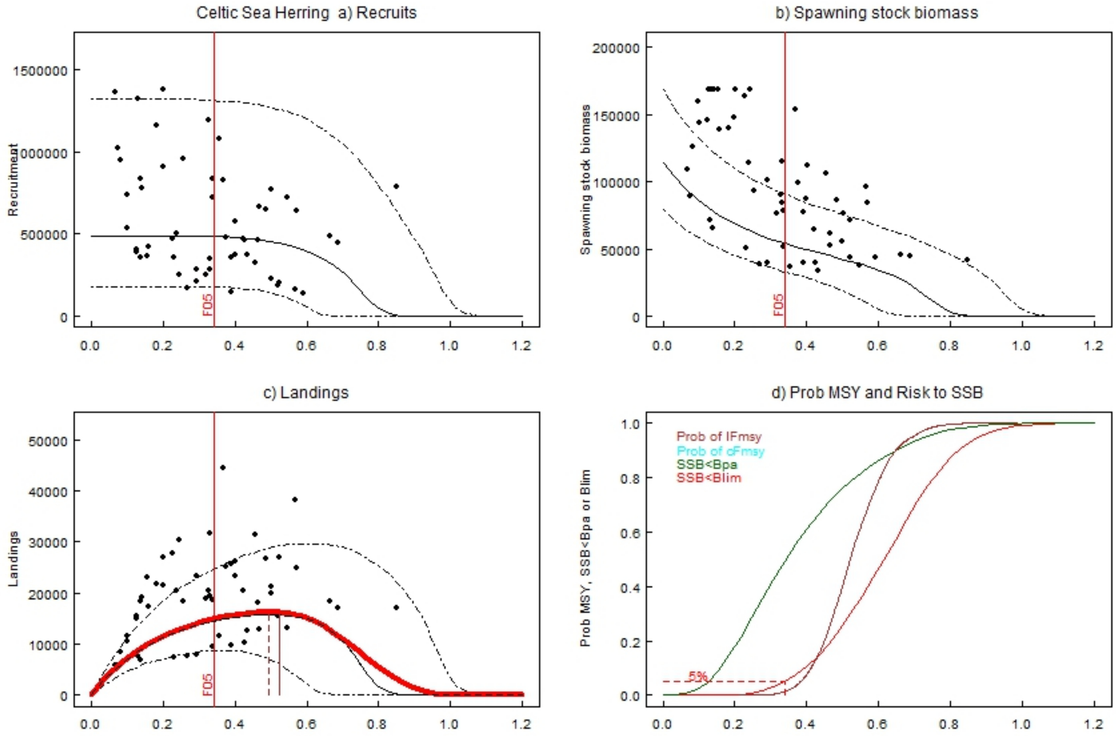


Figure 4.9.1. EqSim output for Herring in the Celtic Sea. Stock recruitment relationship change-point fixed at B_{lim} (33 000 t); $B_{trigger}$ = 0, F_{cv} = 0, F_{phi} = 0.

5 Herring in Division 6.a (Combined) and 7.b and 7.c

This is the second time, since 1982, that the working group presents a joint assessment of herring in Division 6.aN and 6.aS/7.b and 7.c. This follows from the benchmark workshop, ICES WKWEST (2015). This benchmark was unable to differentiate the two stocks and though HAWG still considers them to be discrete, they will be assessed together as a meta-population until the combined survey indices can be successfully split.

The WG noted that the use of "age", "winter rings", "rings" and "ringers" still causes confusion outside the group (and sometimes even among WG members). The WG tries to avoid this by consequently using "rings", "ringers", "winter ringers" or "wr" instead of "age" throughout this section. However, if the word "age" is used it is qualified in brackets with one of the ring designations. It should be observed that, for autumn and winter spawning stocks, there is a difference of one year between "age" and "rings", which is not the case for the spring spawners. Further elaboration on the rationale behind this, specific to the 6.a, 7.b and 7.c autumn, winter and spring spawners, can be found in the Stock Annex. It is the responsibility of any user of age based data for any of these herring stocks to consult the stock annex and if in doubt consult a relevant member of the Working Group.

5.1 The Fishery

5.1.1 Advice applicable to 2014 and 2015

ICES gave separate advice for the constituent stocks up to 2015 and advice for the combined stocks for 2016

For 6.aN, ICES advised that the stock had been fluctuating at a low level over recent years 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 2014 was 22 690t, which was in accordance with the agreed plan (see Section H.1 in the Stock Annex).

For 6.aS/7.b and 7.c ICES advised that the stock was at a low level and that the TAC should be set at 0 t. The TAC followed this advice for 2015.

After an extensive benchmarking process in early 2015 (WKWEST 2015), the stocks were assessed together in 2015. The management plans in place for either stock were no longer applicable for the combined stocks. Considering the low SSB and low recruitment in recent years estimated for the combined stocks, ICES advised that it was not possible to identify any non-zero catch that would be compatible with the MSY and precautionary approach. As there was no catch option for 2016 that was consistent with the combined stocks recovering to above B_{lim} it was advised that the TAC be set at 0 t.

5.1.2 Changes in the fishery

There have been no significant changes in the fishing technology of the fleets in this area in recent years. In 6.aN, the fishery has become restricted to the northern part of the area since 2006. Prior to 2006 there was a much more even distribution of effort, both temporally and spatially. In 6.aS, only two main areas have been fished in the recent past. There has been little effort in 7.b in recent years.

In 6.aN there are 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. In 6.aS a wide size range of pair and single trawlers predominated, with artisanal fisheries using drift and ring nets in coastal waters.

5.1.3 Regulations and their affects

The 4° meridian divides 6.aN from the North Sea stock. It is not clear if this boundary is appropriate, as it bisects some of the spawning grounds. Area misreporting is known to occur across it. The boundary between 6.aN and 6.aS (56th parallel) is not appropriate as a boundary, because it traverses the spawning and feeding grounds of 6.aS herring. Trans-boundary catches occur along this line.

5.1.4 Catches in 2015

The Working Group's best estimate of removals from the stock are shown in Table 6.1.2 for the 6.aS and 7.b and 7.c constituent stock and in Table 6.2.2 for the 6.aN constituent stock.

5.2 Biological Composition of the Catch

Catch and sample data for the 6.aS, 7.b and 7.c and 6.aN constituent stocks were combined to construct the input data for the Herring in Division 6.a (Combined) and 7.b and 7.c assessment. Catch number- and weight-at-age information is given in the stock assessment stock report section 5.6 (cf tables 5.6.1 and 5.6.2 respectively).

5.3 Fishery Independent Information

5.3.1 Acoustic surveys

An acoustic survey has been carried out in Division 6.aN in June-July since 1991 by Marine Scotland Science. It originally covered an area bounded by the 200m depth contour and 4°W in the north and west and extended south to 56°N; it had provided an age-disaggregated index of abundance as the sole tuning index for the analytical assessment of 6.aN herring since 2002 (Table 5.3.1.1; WGIPS ICES 2015b). In 2008, it was decided that these surveys should be expanded into a larger coordinated summer survey on recommendation from WESTHER, HAWG and SGHERWAY (Hatfield *et al.* 2007, HAWG ICES 2007; HAWG ICES 2010a). The Scottish 6.aN survey was augmented with the participation of the Irish Marine Institute and the area was expanded to cover all of ICES divisions 6.a and 7.b. The Malin Shelf Herring Acoustic Survey (MSHAS), as it is now known, has covered this increased geographical area in the period 2008 to 2014 as well as maintaining coverage of the original survey area in 6.aN.

The MSHAS survey is carried out annually in June/July. The survey covers the continental shelf west of Scotland and Ireland from 53.5°N up to a northern limit of 62°N (See Stock Annex). The survey area is bound to the west by the 200 m depth contour on the shelf edge and to the east by the 30 m depth contour on the Irish and Scottish coasts and the 4°W line. A stratified, systematic, parallel transect design with random starting points is used. Survey stratification is based on ICES statistical rectangles. Each ICES rectangle is covered with a minimum of one transect and with higher intensity where historically a high abundance or variability of abundance has been detected. Transect spacing of 7.5 and 15 nautical miles are used and transect mostly run perpendicular to the coast. The Irish and Scottish data are combined to provide estimates for the combined Malin Shelf herring stock (6.aN-S and 7.b and 7.c; WGIPS, ICES 2015a).

The stock is highly contagious in its spatial distribution, which explains some of the high variability in the time series. The survey covers the area at the time of year when aggregations of herring from both the 6.aN and 6.aS, 7.b and 7.c stocks are offshore feeding (i.e not at spawning time). These distributions of offshore herring aggregations are considered to be more available to the survey compared to surveying spawning aggregations, which aggregate close to the seabed and are generally found inshore of the areas able to be surveyed by the large vessels carrying out the summer acoustic surveys.

The 2015 estimate from the Malin Shelf herring acoustic survey (covering divisions 6.aN-S and 7.b and 7.c) was 429 868 tonnes SSB comprising 2181 million herring (Table 5.3.1.2). This is a substantial increase on 2014 and the 4th highest SSB estimates in the eight year time series (Table 5.3.1.3). The estimate is dominated by 4 to 6 winter ring fish. This includes the 2008 and 2009 year classes that have been prominent a number of years. The overall maturity ratio was very high at 0.92, mainly due to the absence of 1 winter ring fishing this year's estimate. The survey is carried out with large research and chartered commercial vessels, which can lead to some limitations. Coastal areas are often too shallow to allow full survey operations (especially trawling) and might produce estimates of high uncertainty due to physical restrictions in sampling of acoustic data. Juvenile herring are typically found further inshore than older herring which is the main target of the survey (WGIPS, ICES 2016). The survey therefore does not fully account for very young herring (particularly on the west coast of Scotland with its highly complex coastline and multitude of sea lochs).

The proportion of total herring biomass observed within 7.b and 7.c during the 2015 survey was 4.5%, the lowest observed in the time series (WGIPS, ICES 2016). In 2015 the patterns in year class proportions in the catch and the survey were fairly consistent (Figure 5.3.1.1). The catch and survey both showed high proportions of 4, 5 and 6 ring fish; however the large proportion of 1 ring fish seen in the survey in 2014 was not seen in 2015.

The Malin Shelf survey time series shows reasonable internal consistency (Figure 5.3.1.2) for the older ages (6- to 9 rings), but less so for ages 1- to 5 rings. This is comparable to the West of Scotland acoustic time series (Figure 5.3.1.3).

5.3.2 Scottish Bottom trawl surveys

Marine Scotland Science carries out two annual bottom trawl surveys in western waters covering the herring stocks in ICES Division 6.a. The Scottish West Coast Ground fish survey in quarter 1 has been carried out in a consistent manner since 1987 and in quarter 4 since 1996.

The target species of the surveys include cod, haddock, whiting and mackerel (Q4) in addition to herring. Both surveys uses a standard 36/47 GOV research trawl fitted with heavy ground gear 'C' and a 20 mm internal liner. Standard haul duration was initially 60 min, but in 1998 this was changed to 30 min. The surveys are carried out in accordance with the IBTS survey manual (IBTS, ICES 2010b).

Until 2010 the survey design used was a typical "fixed station" ICES statistical rectangle based sampling strategy with minimum one trawl per rectangle and two in rectangles with very variable depth to cover deep and shallow part. From 2011 onwards both the Q1 and Q4 Scottish West Coast Ground Fish Surveys changed to a random stratified survey design with station positions being randomly distributed within a series of 'a priori' sampling strata.

The index at year and age (in rings) for herring in 6.a are calculated based on all hauls carried out within ICES Division 6.a. A detailed description of the index calculations can be found in the Stock Annex (a list of links to the Stock annexes can be found in Annex 4). At the latest benchmark for this stock (WKWEST, ICES 2015b) it was decided only to use the index up to 2010 when the survey design was changed, until a further investigation has been carried out into the potential effects the changes might have had on the index for herring. There was no survey in Q4 in 2010 due to vessel break down and in Q4 2013 only 50% of the survey was completed with all hauls in the northern part of 6.a. These two years are therefore excluded from the Q4 index calculations.

The internal consistencies in the trawl surveys indicate some ability to follow cohorts particularly in the Q1 (figures 5.3.2.1 and 5.3.2.2).

The abundance of 2 winter ring fish were at higher levels earlier in the time-series particularly in quarter 1, but since 2003 older fish have been numerically more abundant in the index in both quarters (figures 5.3.2.3 and Figure 5.3.2.4). In the period after 2010 it appears that older fish are decreasing in abundance again, this trend is at the moment not carried into the assessment.

5.4 Mean Weights-At-Age, Maturity-At-Age and natural mortality

5.4.1 Mean weight-at-age

Weights-at-age in the stock are obtained from the acoustic surveys and are given in tables 5.3.1.2 (for the current year) and 5.6.3 (for the time series); weights-at-age in the catches are given in Table 5.6.2 and are used in the assessment. The weights-at-age in the catch in 2015 are similar to 2014. There are no apparent long term trends in these weights. The weights-at-age in the stock are also similar (Table 5.6.3).

5.4.2 Maturity ogive

The maturity ogive is obtained from the acoustic survey (Table 5.3.1.2, Figure 5.4.2.1). The Malin Shelf Acoustic Survey (MSHAS) provides estimated values for the period 2008 to 2015 (cf. Table 5.6.5). For earlier years, the maturity ogive is as per the 6.aN stock, and is taken from the geographic split 6.aN old acoustic tuning series (MSHAS_N; HAWG, ICES 2014).

5.4.3 Natural mortality

The natural mortality used in previous assessments of several herring stocks to the West of Scotland, including 6.aN, were based on the results of a multi-species VPA for North Sea herring calculated by the ICES multispecies working group in 1987 (ICES 1987). From 2012 onwards the assessment of North Sea herring has used variable estimates of M-at-age derived from a new multispecies stock assessment model, the SMS model, used in WGSAM (Lewy and Vinther 2004, ICES 2011).

The most recent benchmark of herring in Division 6.a and 7.b and 7.c (WKWEST 2015) agreed to use the natural mortalities for North Sea herring from the current North Sea multi-species model, as it is deemed the best available proxy for natural mortality of herring in 6.a and 7.b and 7.c. The input data to the assessment of herring in Division 6.a and 7.b and 7.c are averaged annual *M* values from the 2011 SMS keyrun (period 1974–2010) for each age (Table 5.6.4). This approach is similar to the pre-benchmarked assessment in that it is time invariant and age variant. This time series reflects the most recent period of stability in terms of M from the North Sea SMS as it excludes the gadoid outburst of the 1960 which is of little relevance to present day conditions.

Detailed explanation regarding the natural mortality estimates can be found in the Stock Annex.

5.5 Recruitment

There are no specific recruitment indices for this stock. Although both the catch and the surveys 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 6.a (combined) and 7.b and 7.c herring

This is the second assessment carried out on the combined 6.a and 7.b and 7.c herring stock after the 2015 benchmark (ICES, WKWEST 2015). The assessment presented here follows the same procedure as the final assessment carried out at the extension to the WKWEST workshop during May 2015. There are no new data sources to consider since the benchmark extension concluded.

The data for this combined assessment were pooled from the separate data for 6.aN and 6.aS/7.b and 7.c. The text table below sets out the basis of the input data.

TYPE	DESCRIPTION
Catch in tonnes (caton)	Addition of 6.aN and 6.aS/7.b and 7.c data
Catch in numbers (canum)	As above
Mean catch weights (weca)	Sum products of canum and weca per stock, divided by combined canum
Mean stock weights (west)	As per 6.aN stock for all years (from 6.aN component of Malin Shelf Acoustic Survey
Natural mortality (natmor)	ICES WKWEST 2015 extension (average 1974–2010 NS-SMS 2011 key run)
Maturity (matprop)	As per 6.aN, 1957-2007; from Malin Shelf Acoustic Survey 2008–2015
Proportions of F and M before spawning (fprop and mprop)	As per 6.aN and 6.aS/7.b and 7.c
Surveys (fleet)	See section 5.3

Input data sources and the assessment method used to assess the 6.a and 7.b and 7.c herring are thoroughly described in the report from WKWEST 2015 (ICES, WKWEST 2015) and in the Stock Annex. The tool for the assessment of herring in 6.a and 7.b and 7.c is FLSAM, an implementation of the State-space assessment model (www.stock-assessment.org), embedded inside the FLR library (Kell *et al.* 2007).

Two acoustic indices and two bottom trawl indices are available for the assessment of herring in 6.a and 7.b and 7.c. The surveys and the years for which they are included in the assessment are given in the text table below.

Type	Name	Year range	Age range (wr)
Tuning fleet	SWC-IBTS Q1	1987–2010	2-9+
Tuning fleet	SWC-IBTS-Q4	1996–2009	2-9+
Tuning fleet	Malin Shelf acoustic	2008–2015	1-9+
Tuning fleet	West of Scotland acoustic	1991–2007	1-9+

The proportion mature of ages 2- and 3-wr in 2015 were higher than in 2014 but still not as high as earlier in the time series (see Figure 5.4.2.1). This affects SSB.

The 2008 year class is still relatively strong and is apparent in both the catch and survey data in 2015. However the 2015 survey detects the 2010 cohort to be stronger and the largest component of the stock in the survey data.

The two trawl surveys and the West of Scotland acoustic surveys were not updated and the dynamics in those have not changed since the benchmark (WKWEST, ICES 2015). Both of the trawl surveys have obvious year effects (1998 and 2004 in IBTS-Q1 and 2000–2002 in IBTS-Q4), and are generally noisy with low internal consistencies (Figures 5.3.2.1 and 5.3.2.2).

The West of Scotland acoustic survey has a marked year effect in 2005. The Malin Shelf herring acoustic survey is the only extant survey series in the assessment. A group of negative residuals at older ages are still present in the final years in the assessment and appear to be increasing (Figure 5.6.1). Although both catch and survey information in the latest year indicate a decrease in these older ages the model is unable to fit to this decreasing observed abundance.

The survey catchability at age for both acoustic surveys is presented in Figure 5.6.7. The trend in both surveys is the same with constant catchability estimated from age 3–9 winter rings. The catchability estimates are within a reasonable level.

Figure 5.6.10 shows the fishery selectivity by period with a clear shift evident in the mid-1990s. Selection changes to a progressively more dome shape in the late 2000s, representing a change in exploitation away from older fish and indicates full recruitment to the fishery at age 3 wr.

The SAM model fits the catch relatively well and residuals are generally random and small for ages 2–8, but with a group relatively large negative residuals since 1999 in the age 9+ wr (figures 5.6.15 to 5.6.23). There does not appear to be any clear age or year effects present (Figure 5.6.5). One ringers are often poorly estimated in the catch, but have been poorly represented in recent years especially.

The estimated observation variance parameter for each data set fitted by the model are presented in Figure 5.6.8. The model is influenced largely by information from the catch and the two acoustic surveys. These are perceived by the SAM model as being more precise than the IBTS surveys. The youngest age in both catch and all surveys have a higher variance compared to older ages and contribute less to the model fit.

The uncertainty associated with the parameters estimated is low for most data sources where only the CV of the Malin Shelf acoustic survey (MS HERAS) at age 1 is very high (Figure 5.6.9). However, the CVs do not indicate a lack of convergence of the assessment model.

Figure 5.6.12 shows the trajectories for SSB, recruitment and mean F over the complete time series from 1957–2015. SSB peaked in the early 1970s and has been declining steadily since 2004. The estimate for SSB in the terminal year is around 250 196 t, which is at B_{lim}. Recruitment also peaked in the early period of the time series with no strong year classes evident in recent years. Since 2010 recruitment have dropped to even lower levels. Fishing mortality was at its highest in the early 1970s. In the early 2000s F began declining and has stabilised around 0.1.

The 2016 assessment resulted in a slight upwards revision of the SSB and recruitment timeseries since 2006 compared to the 2015 assessment (Figure 5.6.57). The overall trend of a steady decline from 2004 was maintained but at a marginally slower rate.

The analytical retrospective for this stock (Figure 5.6.14) shows some deviation in SSB and recruitment between years with no clear retrospective pattern emerging. The estimates of F are more consistent between years.

Figure 5.6.13 shows the model uncertainty plot, representing the parametric uncertainty of the fit of the assessment model in terminal F and SSB.

5.6.1 Exploratory Assessment for 6.a (combined) and 7.b and 7.c herring

No exploratory assessments were performed in 2016.

5.6.2 Final Assessment for 6.a and 7.b and 7.c herring

In accordance with the settings described in the Stock Annex, the final assessment of 6.a and 7.b and 7.c herring was carried out by fitting a state space model (SAM, in the FLR environment). The input data and model settings are shown in tables 5.6.1–5.6.10, the SAM output is presented in tables 5.6.13–5.6.28, the stock summary in Table 5.6.12 and Figure 5.6.12 and model fit and parameter estimates in Table 5.6.27. The spawning stock at spawning time in 2015 is estimated at approximately 250 Kt [125–500Kt (95% CI)]. Recruitment is estimated to be the lowest in the series, and has declined to very low levels since 2010. Mean $F_{3\text{–}6}$ in 2015 is estimated at approximately 0.071 [0.036–0.141 yr-1 (95% CI)].

5.6.3 State of the combined stocks

The assessment is rather uncertain, with wide confidence intervals. Fishing mortality is low, however there is no information on the F on each of the constituent stocks. F on the smaller stock may be higher than indicated in the overall F.

SSB has decreased steadily in recent years. It increased somewhat in 2012 before declining again. SSB in 2015 is estimated to be at B_{lim}.

Recruitment has been low in recent years; the most recent cohort that appeared stronger was in 2008. Since 2012 recruitment has been very low, and the lowest in the series. Recent catches was among the lowest in the series.

5.7 Short Term Projections

5.7.1 Short-term projections

Short-term forecasts are conducted using the standard projection routines developed under FLR package Flash (version 2.0.0).

Input data are stock numbers on 1 January in 2016 from the 2016 SAM assessment (Section 5.6.1, Table 5.7.1.1). Recruitment in 2016–2018 was estimated as the geometric mean of recruitment over the period 2012–2015. This period was considered to best reflect the recent recruitment regime. 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., 2013–2015).

The results of the short-term projection using the F constraint are given in Table 5.7.1.2. The catch option consistent with the ICES generic MSY harvest control rule is F = 0.082 (F_{msy} * SSB2016 / MSY $B_{trigger}$). This corresponds to a catch option in 2017 of 17 072 t. However, this option is not precautionary as SSB would remain below B_{lim} under such a scenario (SSB 2017 = 192 703 t). Consequently the precautionary approach takes precedence. Given that no catch option can restore the SSB to B_{pa} by 2018, the precautionary catch option is for a catch of 0 t in 2017.

In its autumn 2015 plenary report, STECF noted that from a stock assessment perspective, it would be beneficial to allow small catches to maintain an uninterrupted time series of fishery-dependent catch data from the stocks in both management areas (6.aN and 6.aS/7.b and 7.c). However, it is important that such fisheries do not endanger the recovery of the stocks, and that data from such fisheries contribute to the scientific work needed to continue working towards assessing both stocks separately in the future. Therefore, a Special Request Advice was conducted at HAWG 2016 to consider the details of sampling to be conducted in 2016. A catch constraint of 4840 t in 2016 was used for the basis for the intermediate year in the projection, resulting in an F of 0.02. This corresponds to the estimated minimum effort required to obtain sufficient samples to 1): continue the time series of catch at age data from the fishery, and 2): continue the on-going work in herring genetics and morphology required to split the individual stock components (6.aN and 6.aS/7.b and 7.c) in this area in the future. The estimated minimum number of samples to be taken in 2016 is associated with an F that is lower than any previously observed value. The objective in 2016 is to obtain samples from specific spawning areas and areas where the fishery has been concentrated in recent years. This effort is required to sample with appropriate precision to continue the time-series of catch at age data. Details of agreed sampling areas and precision required to continue the scientific work within the combined assessment area are outlined in the HAWG Special Request Advice (ICES, 2016 - http://www.ices.dk/sites/pub/Publication%20Reports/Advice/2016/Special_Requests/EU_her-6a7bc_monitoring_fishery.pdf).

5.7.2 Yield Per Recruit

No yield per recruit analysis was conducted at HAWG 2016.

5.8 Precautionary and Yield Based Reference Points

B_{lim} is set at 250 000 t. This is based on the median change point in a segmented regression of the entire time series of stock and recruitment (WKWEST, ICES 2015). B_{pa} is set at 410 000 t based on B_{lim} raised by $\exp^{1.645*\sigma)}$, where σ denotes the uncertainty in estimation of terminal SSB from the benchmarked assessment.

F_{msy} was estimated from stochastic simulations using Beverton and Holt, Ricker and segmented regression stock recruitment models, with a median estimate of F = 0.16 (ICES WKWEST, 2015). MSY $B_{trigger}$ was set as equal to B_{pa}. Using a $B_{trigger}$ of 410 000 t, F_{pa} was estimated at 0.18 from stochastic simulations using a Ricker stock–recruitment relationship. The Input data was from the 2015 assessment, with a 2 year time lag because the fish are autumn/winter spawners. The stock recruitment relationship was modelled for the time series 1957–2012. F_{cv} was set to 0.30 and F_{phi} to 0.30. The biological years used were 2004–2014 (the last 10 years).

5.9 Quality of the Assessment

This assessment combines two separate stocks, as estimation of independent stock sizes was not possible. These stocks are 6.aN herring and 6.aS/7.b and 7.c herring. The assessment has quite wide confidence intervals on estimation of SSB and F. However, it is considered the best assessment that can be accomplished for the combined stocks at present (WKWEST; ICES 2015). Individual assessments of the constituent stocks are not possible, because the input data cannot be segregated by stock. The combined assessment does not give any information on the individual stocks. However it does demonstrate that the combined stocks metapopulation is at a low and decreasing level and that it is predicted to decline further.

There is no information in the assessment on the state of either constituent stock. The fishing mortality information from this assessment is not informative of the mortality being experienced by either stock. The overall F may mask important differences in F between the stocks. The smaller stock may be experiencing a much higher F than the overall F estimates imply. For this reason, the low overall estimate of current F should be treated with caution. The combined SSB estimates are thought to be a reasonable indicator of the combined stocks' size. However it remains unclear what the relative strength of each stock is. Recruitment is estimated to be the lowest in the series. This reflects very low numbers of 1-ring fish in the catches. In the past two years, no 1-ringers have been observed in the 6.aN fishery, and very few in the 6.aS/7.b and 7.c fishery.

The trawl survey data included only up to 2010, because the survey design changed after that. Trawl survey since 2010 shows a decline in stock abundance, and this is an additional indicator that the combined stocks' abundance is in decline.

The precision of the assessment estimated through parametric bootstrap is shown in Figure 5.6.13.

5.10 Management Considerations

There is anecdotal evidence that the stocks are not the same size and managers are advised to ensure that any exploitation pattern imposed in this area ensures that the smaller, more vulnerable, stock is not over-exploited. There is a clear need to determine the relative stock sizes and to ensure that the smaller / weaker stock is adequately assessed and protected from over exploitation.

The working group suggests that it returns to assessing each discrete, constituent stock in this area separately when methods allow to do so. Until that is possible, a joint assessment is necessary.

5.11 Ecosystem Considerations

Through complex interactions, herring has a major impact on most other fish stocks as predator and is itself a prey for fish, seabirds and marine mammals (ICES WGSAM 2012). Recent work, using length-based ecosystem modelling, suggests a link between herring biomass and North Sea cod (Speirs *et al.*, 2010). 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. There is no similar model for west of Scotland herring, therefore it is difficult to predict the impact of increasing or reducing the herring biomass on the 6.a ecosystem functioning as a whole. However, as herring constitute a large part of the overall biomass of plankton feeding and forage fish in the west of Scotland and Ireland ecosystem, impacts from changes in productivity from environmental drivers are likely to be widely felt.

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

Herring constitute some of the highest biomass of forage fish to the west of Scotland and Ireland and are thus are an integral part of the ecosystem. Herring link zooplankton production with higher trophic levels (fish, sea mammals and birds) but also can act as predators on other fish species by their predation on fish eggs. Grainger (1978, 1980) found significant negative correlations between sea surface temperature 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. The influence of the environment on herring productivity means that the biomass will always fluctuate (Dickey-Collas *et al.* 2010). Temperature trends are similar for the sea area to the west of Scotland and the North Sea. The broad trend in oceanic temperatures over the period 1900–2006 is for warming. Oceanic temperatures around the Scottish coast for the period (1970–2006) have increased by ~ 0.5°C (Baxter *et al.* 2008). Salinity and surface temperature of coastal waters around the Scottish coast also shows a slight increasing trend over the same time period.

The environmental conditions in the North Sea and west of Scotland are similarly impacted by climate change, with trends in oceanic temperature, sea surface temperature and salinity all increasing over recent decades around the coast of Scotland. Climate models predict a future increase in air and water temperature and a change in wind, cloud cover and precipitation in Europe (Drinkwater, 2010).

Table 5.3.1.1. Herring in Divisions 6.a (combined) and 7.b and 7.c. Abundance from Scottish acoustic surveys conducted in 6.aN before Malin Shelf series began in 2008.

Year\Age(Rings)	1	2	3	4	5	6	7	8	9
1991	338	294	328	368	488	176	99	90	58
1992	74	503	211	258	415	240	106	57	63
1993	2	579	690	689	565	900	296	158	161
1994	494	542	608	286	307	268	407	174	132
1995	441	1103	473	450	153	187	169	237	202
1996	41	576	803	329	95	61	77	78	115
1997	792	642	286	167	66	50	16	29	24
1998	1222	795	667	471	179	79	28	14	37
1999	534	322	1388	432	308	139	87	28	35
2000	448	316	337	900	393	248	200	95	65
2001	313	1062	218	173	438	133	103	52	35
2002	425	436	1437	200	162	424	152	68	60
2003	439	1039	933	1472	181	129	347	114	75
2004	564	275	760	442	577	56	62	82	76
2005	50	243	230	423	245	153	13	39	27
2006	112	835	388	285	582	415	227	22	59
2007	0	126	294	203	145	347	243	164	32

Table 5.3.1.2. Herring in Divisions 6.a (combined) and 7.b and 7.c. Total numbers (millions) and biomass (thousands of tonnes) of Malin Shelf herring (6.aN-S, 7.b and 7.c) June-July 2015. Mean weights, mean lengths and fraction mature by age ring.

Age (ring)	Numbers	Biomass	Maturity	Weight (g)	Length (cm)
0					
1	0	0			
2	212	30	0.48	140	25.0
3	397	70	0.85	177	26.9
4	747	144	0.99	193	27.7
5	423	86	0.98	202	28.3
6	476	100	1.00	210	28.8
7	90	19	0.97	216	29.3
8	24	5	1	214	29.1
9+	2	0	1	220	30.0
Immature	190	25		130.9	24.6
Mature	2181	430		197.1	28.0
Total	2372	455	0.92	191.8	27.7

Table 5.3.1.3. Herring in Divisions 6.a (combined) and 7.b and 7.c. Numbers at age (millions) and SSB (thousands of tonnes) of Malin Shelf survey (6.aN-S, 7.b and 7.c) time series. Age (rings) from acoustic surveys 2008 to 2015.

Year/Age	1	2	3	4	5	6	7	8	9+	SSB
2008	50	267	996	720	363	331	744	386	274	841
2009	773	265	274	444	380	225	193	500	456	593
2010	133	375	374	242	173	146	102	100	297	366
2011	63	257	900	485	213	228	205	113	264	494
2012	796	548	832	517	249	115	111	57	105	427
2013	0	209	434	672	195	71	61	29	37	282
2014	1012	278	242	502	534	148	33	19	13	285
2015	0	212	397	747	423	476	90	24	2	430

Table 5.6.1 Herring in 6.a (combined) and 7.b and 7.c. Catch in number.

Units : thousands

year

age	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967
1	6496	15695	54063	3940	14473	55278	11890	26609	299701	211675	207947
2	80817	33616	74615	115501	50809	99167	82849	87652	23351	517616	28648
3	66094	152801	38547	65703	72914	27189	57688	74309	72085	45317	273723
4	26882	43895	124307	25388	38321	76706	13310	29583	67768	70793	49755
5	38989	28108	27898	50558	24455	49002	42796	8857	24525	38471	48320
6	21547	32025	18942	12196	14296	22707	28698	27075	7001	22691	36143
7	9643	19986	18833	11096	5791	27787	10171	21347	28806	12656	15226
8	1658	10795	8158	6770	5370	7614	14585	10109	21475	20790	10397
9	4817	8887	9364	4856	2887	8435	7885	17655	23515	33175	33967

year

age	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978
1	220870	39160	238361	208594	535964	57593	312390	180239	85666	39321	32695
2	105348	107189	134128	341260	650282	276017	154350	243395	348615	92251	86604
3	26031	84565	279726	419854	195671	855656	192141	114183	139060	109230	47666
4	243304	27604	125140	313064	60396	148347	563757	92893	62046	39293	54000
5	19679	264558	31636	110783	77859	70503	100323	211920	50512	22292	17564
6	28436	25795	182580	29495	35773	67025	58565	41304	91289	22135	9189
7	17699	45908	24591	194977	14585	27433	45530	18206	16126	26526	6370
8	7275	27932	28740	19104	102945	8475	32742	22499	7510	4118	9916
9	14389	29258	25993	34159	20936	83203	51591	45727	27717	5636	4868

year

age	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
1	6166	5548	38360	14052	83440	5001	50400	34686	31612	1708	8457
2	50213	40337	100226	268146	121498	270259	83988	182073	110114	148511	43682
3	19238	65041	147394	89183	142277	78488	215754	113890	125676	88035	188343
4	19988	25191	92801	121764	54578	52855	29970	185243	73529	69429	45072
5	9362	22139	34285	76732	74317	22138	26452	33480	149341	43142	39590
6	8430	7757	25369	31701	45638	24202	14269	25988	23655	74247	22597
7	5447	6954	15044	15605	21404	15274	16092	8274	19946	10198	39929
8	4424	4345	4044	17063	11766	6435	10910	6849	9590	4704	5835
9	4090	5334	6546	6902	12735	5979	4357	4098	16170	4324	6541

year

age	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
1	15172	27071	7845	17910	13437	550	6728	8651	16529	10027	8612
2	65844	57450	39988	115850	92710	116647	62278	112139	146944	86506	57525
3	60279	53039	67454	41376	71418	65812	100206	60912	115183	155239	60750
4	226257	40632	50572	52945	22884	39889	40347	70399	70231	59979	82126
5	50882	137961	34382	36648	29205	24509	17350	37701	53037	23456	28850
6	33469	31454	107176	28348	21745	20286	17815	23477	23510	13416	11737
7	26192	22446	14886	86451	19112	14554	12858	18682	13923	5131	5362
8	29640	18203	12520	12382	43887	16556	20921	8631	6259	2343	2526
9	6652	12116	11797	9753	20299	24002	37580	14147	6269	2038	2178

year

age	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
1	2463	5050	1787	1401	392	730	207	483	2126	11345	1788	6122
2	105035	71122	66151	22358	37756	28727	58903	20163	24083	33847	54795	27797
3	37149	131724	75580	56475	54133	45886	61713	32700	22553	36458	25098	63034
4	27103	27896	77956	49142	47489	44226	29954	33911	28683	16499	19448	13746
5	43625	29737	16895	57400	21012	63024	28003	14330	20906	22196	10576	9873
6	19498	38231	9521	9076	15235	36862	36040	11678	10928	13102	8851	6865
7	8555	11787	15343	9647	2363	23391	23342	17570	9555	6885	6035	4415
8	5769	3153	10111	9999	2053	3874	13816	8887	12647	6050	3591	1233
9	1537	2067	1711	4589	1674	5458	4374	9236	9461	13388	7321	4035

year

age	2013	2014	2015
1	61	34	258
2	16799	9171	12697
3	22714	23970	14536
4	65355	27799	18270
5	13347	54375	21086
6	8885	9537	22306
7	5524	3989	6493
8	4707	3291	1942
9	5234	3715	1251

Table 5.6.2 Herring in 6.a (combined) and 7.b and 7.c. 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	0.080	0.086	0.085	0.079	0.080	0.079	0.079	0.079	0.079	0.079
2	0.108	0.109	0.107	0.112	0.111	0.107	0.108	0.108	0.109	0.105	0.105	0.106
3	0.139	0.134	0.134	0.138	0.142	0.140	0.137	0.136	0.136	0.139	0.137	0.135
4	0.161	0.167	0.161	0.168	0.169	0.165	0.170	0.169	0.164	0.163	0.166	0.165
5	0.176	0.176	0.171	0.168	0.172	0.171	0.171	0.187	0.170	0.215	0.172	0.173
6	0.178	0.185	0.176	0.176	0.185	0.180	0.182	0.185	0.188	0.178	0.179	0.176
7	0.188	0.195	0.187	0.189	0.189	0.191	0.201	0.198	0.194	0.209	0.192	0.184
8	0.199	0.193	0.190	0.192	0.195	0.199	0.192	0.202	0.191	0.191	0.208	0.188
9	0.194	0.209	0.191	0.192	0.198	0.199	0.220	0.207	0.197	0.195	0.198	0.195

age \ year	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
1	0.080	0.079	0.079	0.079	0.092	0.090	0.091	0.094	0.092	0.096	0.109	0.100
2	0.108	0.111	0.104	0.105	0.122	0.123	0.122	0.122	0.125	0.125	0.129	0.129
3	0.136	0.133	0.131	0.134	0.158	0.159	0.160	0.160	0.159	0.162	0.165	0.165
4	0.164	0.161	0.159	0.161	0.177	0.176	0.180	0.182	0.182	0.179	0.191	0.191
5	0.174	0.170	0.168	0.170	0.188	0.190	0.189	0.198	0.199	0.200	0.209	0.209
6	0.181	0.181	0.177	0.185	0.209	0.208	0.210	0.209	0.213	0.215	0.222	0.222
7	0.184	0.186	0.191	0.195	0.222	0.221	0.222	0.222	0.221	0.227	0.231	0.231
8	0.187	0.186	0.189	0.208	0.227	0.228	0.229	0.230	0.228	0.229	0.237	0.237
9	0.192	0.189	0.189	0.197	0.234	0.234	0.236	0.234	0.237	0.236	0.241	0.241

age \ year	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
1	0.091	0.082	0.080	0.095	0.071	0.113	0.078	0.080	0.081	0.080	0.084	0.092
2	0.123	0.139	0.136	0.140	0.106	0.144	0.127	0.109	0.140	0.132	0.128	0.128
3	0.160	0.173	0.172	0.177	0.142	0.171	0.162	0.144	0.143	0.165	0.152	0.160
4	0.180	0.202	0.199	0.207	0.171	0.195	0.187	0.163	0.175	0.167	0.189	0.175
5	0.195	0.226	0.222	0.229	0.188	0.214	0.191	0.183	0.181	0.193	0.179	0.204
6	0.214	0.245	0.241	0.245	0.203	0.228	0.209	0.180	0.193	0.203	0.204	0.186
7	0.221	0.260	0.258	0.259	0.212	0.240	0.218	0.201	0.201	0.207	0.211	0.207
8	0.233	0.275	0.271	0.272	0.224	0.217	0.229	0.201	0.196	0.229	0.227	0.215
9	0.238	0.273	0.277	0.263	0.231	0.274	0.233	0.216	0.224	0.242	0.245	0.236

age \ year	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
1	0.089	0.081	0.093	0.084	0.092	0.096	0.083	0.092	0.084	0.099	0.101	0.085
2	0.130	0.141	0.141	0.134	0.135	0.137	0.138	0.132	0.136	0.137	0.139	0.145
3	0.155	0.166	0.170	0.174	0.168	0.149	0.153	0.157	0.149	0.156	0.156	0.160
4	0.176	0.180	0.183	0.188	0.192	0.177	0.168	0.179	0.173	0.161	0.168	0.184
5	0.190	0.191	0.186	0.212	0.214	0.194	0.189	0.192	0.188	0.166	0.184	0.211
6	0.207	0.192	0.201	0.212	0.221	0.209	0.203	0.208	0.192	0.183	0.198	0.205
7	0.202	0.220	0.202	0.235	0.218	0.218	0.216	0.230	0.208	0.190	0.198	0.202
8	0.242	0.212	0.216	0.239	0.235	0.217	0.220	0.260	0.224	0.231	0.188	0.192
9	0.246	0.243	0.241	0.282	0.256	0.207	0.224	0.217	0.252	0.263	0.282	0.302

age \ year	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
1	0.107	0.103	0.116	0.111	0.109	0.084	0.064	0.087	0.083	0.105	0.078
2	0.134	0.142	0.157	0.157	0.159	0.145	0.146	0.141	0.140	0.145	0.138
3	0.156	0.146	0.157	0.172	0.191	0.177	0.171	0.187	0.168	0.169	0.178
4	0.172	0.169	0.174	0.176	0.219	0.203	0.197	0.204	0.192	0.191	0.198
5	0.192	0.194	0.195	0.188	0.218	0.223	0.221	0.216	0.199	0.215	0.209
6	0.212	0.213	0.216	0.216	0.231	0.225	0.223	0.227	0.209	0.227	0.229
7	0.215	0.240	0.215	0.244	0.249	0.230	0.233	0.239	0.228	0.241	0.238
8	0.248	0.253	0.261	0.277	0.252	0.238	0.239	0.278	0.234	0.251	0.245
9	0.256	0.273	0.301	0.286	0.273	0.255	0.252	0.247	0.247	0.278	0.269

Table 5.6.3. Herring in 6.a (combined) and 7.b and 7.c. Weights at age in the stock.

Units : kg

year

age	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

year

age	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	0.292	0.292

year

age	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

year

age	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

year

age	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
1	0.0751	0.075	0.0750	0.055	0.059	0.068	0.057	0.066	0.064	0.064	0.064
2	0.1296	0.135	0.1675	0.172	0.151	0.162	0.132	0.150	0.155	0.108	0.155
3	0.1538	0.166	0.1830	0.191	0.206	0.194	0.160	0.183	0.165	0.158	0.183
4	0.1665	0.185	0.1914	0.208	0.223	0.227	0.208	0.189	0.202	0.180	0.195
5	0.1802	0.192	0.1951	0.214	0.233	0.239	0.236	0.206	0.210	0.206	0.204
6	0.1911	0.204	0.1951	0.214	0.231	0.248	0.245	0.217	0.236	0.214	0.211
7	0.2125	0.211	0.2021	0.221	0.232	0.258	0.238	0.214	0.243	0.231	0.217
8	0.2030	0.224	0.2034	0.224	0.232	0.226	0.222	0.218	0.245	0.244	0.215
9	0.2284	0.231	0.2138	0.238	0.238	0.212	0.253	0.215	0.254	0.264	0.220

Table 5.6.4. Herring in 6.a (combined) and 7.b and 7.c. Natural mortality.

Units : NA

year

age	1957	1958	……			2013	2014	2015
1	0.767005	0.767005	0.767005	0.767005	0.767005	0.767005	0.767005	0.767005
2	0.384728	0.384728	0.384728	0.384728	0.384728	0.384728	0.384728	0.384728
3	0.355633	0.355633	0.355633	0.355633	0.355633	0.355633	0.355633	0.355633
4	0.338791	0.338791	0.338791	0.338791	0.338791	0.338791	0.338791	0.338791
5	0.319385	0.319385	0.319385	0.319385	0.319385	0.319385	0.319385	0.319385
6	0.313574	0.313574	0.313574	0.313574	0.313574	0.313574	0.313574	0.313574
7	0.306805	0.306805	0.306805	0.306805	0.306805	0.306805	0.306805	0.306805
8	0.306805	0.306805	0.306805	0.306805	0.306805	0.306805	0.306805	0.306805
9	0.306805	0.306805	0.306805	0.306805	0.306805	0.306805	0.306805	0.306805

Table 5.6.5. Herring in 6.a (combined) and 7.b and 7.c. 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	2013	2014	2015
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	0.000	0.00
2	0.92	0.76	0.83	0.84	0.81	1.00	0.91	0.67	0.88	0.50	0.62	0.35	0.178	0.48
3	1.00	1.00	0.97	1.00	0.97	1.00	0.99	0.99	0.99	0.93	0.99	0.72	0.730	0.85
4	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.98	0.990	0.99
5	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.98	1.000	0.98
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	1.000	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	1.000	0.97
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	1.000	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	1.000	1.00

Table 5.6.6. Herring in 6.a (combined) and 7.b and 7.c. Fraction of harvest before spawning.

Units : NA

year															
age	1957	1958	1959	1960	……							2013	2014	2015
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. Herring in 6.a (combined) and 7.b and 7.c. Fraction of natural mortality before spawning.

Units : NA

year															
age	1957	1958	1959	1960	……						2012	2013	2014	2015
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 5.6.8. Herring in 6.a (combined) and 7.b and 7.c. Survey indices.

MS HERAS - Configuration

Malin Shelf assessment . Imported from VPA file.

min	max	plusgroup	minyear	maxyear	startf	endf
1.00	9.00	9.00	2008.00	2015.00	0.52	0.57

Index type : number

MS HERAS - Index Values

Units : NA

age \ year	2008	2009	2010	2011	2012	2013	2014	2015
1	50389	772520	132551	62834	796012	-1	1012160	-1
2	267367	265151	375531	257258	549590	209403	277504	212467
3	997573	273910	373804	899637	832257	435049	242596	396545
4	719782	443603	242388	484732	517544	671542	502471	747121
5	363484	380436	173333	212913	249024	194706	534430	423139
6	331462	225046	145891	227515	114507	70507	148258	476249
7	743706	192866	101960	205093	111385	61392	32565	90102
8	386202	500074	100421	113298	56526	28597	18677	23931
9	273892	456113	297021	263837	104571	37398	13002	2086

WoS HERAS - Configuration

Malin Shelf assessment . Imported from VPA file.

min	max	plusgroup	minyear	maxyear	startf	endf
1.00	9.00	9.00	1991.00	2007.00	0.52	0.57

Index type : number

WoS HERAS - Index Values

Units : NA

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
1	313100	424700	438800	564000	50200	112300	-1
2	1062000	436000	1039400	274500	243400	835200	126000
3	217700	1436900	932500	760200	230300	387900	294400
4	172800	199800	1471800	442300	423100	284500	202500
5	437500	161700	181300	577200	245100	582200	145300
6	132600	424300	129200	55700	152800	414700	346900
7	102800	152300	346700	61800	12600	227000	242900
8	52400	67500	114300	82200	39000	21700	163500
9	34700	59500	75200	76300	26800	59300	32100

IBTS_Q1 - Configuration

Malin Shelf assessment . Imported from VPA file.

min	max	plusgroup	minyear	maxyear	startf	endf
2.00	9.00	9.00	1987.00	2010.00	0.00	0.25

Index type : number

Table 5.6.8 (cont'd). Herring in 6.a (combined) and 7.b and 7.c. Survey indices.

IBTS_Q1 - Index Values

Units : NA

age \ year	1987	1988	1989	1990	1991	1992	1993	1994	1995
2	46.731	3438.321	25.140	58.847	631.824	53.058	122.721	116.670	965.178
3	336.260	430.836	1075.835	83.597	885.241	132.183	294.270	377.264	169.909
4	209.288	134.714	145.932	344.779	567.790	122.177	128.267	104.271	117.504
5	215.407	82.220	87.593	97.848	998.826	152.380	169.440	65.612	38.275
6	43.763	47.236	66.886	66.287	294.298	135.749	192.090	68.307	55.458
7	9.183	13.417	17.304	65.323	187.461	46.193	146.600	49.543	38.004
8	10.353	2.682	6.474	10.261	105.718	32.468	49.505	12.015	43.710
9	6.284	1.586	1.824	3.787	22.696	21.117	17.329	2.941	15.584

age \ year	1996	1997	1998	1999	2000	2001	2002	2003	2004
2	383.453	417.688	11.914	189.848	765.224	49.296	1758.926	245.946	730.099
3	248.635	382.687	113.931	307.107	104.293	123.270	368.190	158.991	624.188
4	43.605	134.279	41.107	135.236	106.222	94.196	104.680	198.292	398.109
5	46.867	50.933	22.230	63.084	56.808	189.256	62.439	59.814	470.369
6	27.309	50.221	6.916	30.863	35.995	93.351	130.905	50.395	149.337
7	16.139	21.929	7.377	23.276	32.187	69.284	73.802	71.241	127.694
8	27.261	37.923	5.146	12.944	9.561	30.127	51.218	29.538	100.189
9	54.021	45.719	14.489	20.234	17.026	25.699	57.611	34.697	85.306

age \ year	2005	2006	2007	2008	2009	2010
2	185.102	378.437	31.209	66.197	55.510	22.061
3	138.260	198.644	135.312	72.550	344.224	165.554
4	273.585	76.948	106.356	82.434	338.236	115.321
5	297.606	235.485	86.229	54.089	219.906	88.455
6	269.862	243.195	186.224	47.992	122.567	67.458
7	67.092	183.140	138.694	75.033	123.955	96.971
8	67.482	35.001	76.793	100.226	328.967	81.877
9	59.980	89.679	54.908	46.867	338.018	254.166

IBTS_Q4 - Configuration

Malin Shelf assessment . Imported from VPA file.

min	max	plusgroup	minyear	maxyear	startf	endf
2.00	9.00	9.00	1996.00	2009.00	0.75	1.00

Index type : number

IBTS_Q4 - Index Values

Units : NA

age \ year	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
2	65.191	23.234	23.441	13.030	14.581	183.761	7.749	329.065	53.062	13.928
3	90.015	36.181	29.796	22.109	9.441	57.258	10.613	66.029	118.066	12.961
4	18.107	27.526	27.177	18.793	14.501	36.430	1.290	65.713	96.276	24.377
5	15.804	18.355	28.670	13.005	7.548	62.726	2.155	8.094	106.528	26.049
6	5.792	11.855	13.800	16.471	7.410	36.270	3.151	11.257	14.917	16.079
7	4.813	3.001	3.173	6.424	4.527	22.954	2.089	11.194	19.443	1.609
8	9.257	7.461	1.384	1.738	2.358	12.784	1.584	5.998	13.908	3.818
9	13.181	10.209	6.996	4.634	2.087	4.980	0.848	6.118	7.874	4.864

age \ year	2006	2007	2008	2009
2	39.061	45.410	9.684	76.799
3	22.908	41.669	36.972	34.133
4	22.019	25.189	23.107	36.367
5	38.832	43.059	17.782	26.475
6	41.902	42.058	18.095	9.901
7	26.687	39.495	33.708	14.979
8	5.658	10.882	18.720	22.104
9	10.420	3.489	15.816	27.149

Table 5.6.9 Herring in 6.a (combined) and 7.b and 7.c. Stock object configuration.

min	max	plusgroup	minyear	maxyear	minfbar	maxfbar
1	9	9	1957	2015	3	6

Table 5.6.10 Herring in 6.a (combined) and 7.b and 7.c. SAM configuration settings.

```
name            :
desc            :
range           :       min       max plusgroup   minyear   maxyear   minfbar
maxfbar
range           :         1         9         9      1957      2015         3
6
fleets          :     catch  MS HERAS WoS HERAS   IBTS_Q1   IBTS_Q4
fleets          :         0         2         2         2         2
plus.group      : TRUE
states          :            age
states          : fleet       1  2  3  4  5  6  7  8  9
states          :   catch     1  2  3  4  5  6  7  8  8
states          :   MS HERAS  NA NA NA NA NA NA NA NA NA
states          :   WoS HERAS NA NA NA NA NA NA NA NA NA
states          :   IBTS_Q1   NA NA NA NA NA NA NA NA NA
states          :   IBTS_Q4   NA NA NA NA NA NA NA NA NA
logN.vars       : 1 2 2 2 2 2 2 2 2
catchabilities  :            age
catchabilities  : fleet       1  2  3  4  5  6  7  8  9
catchabilities  :   catch     NA NA NA NA NA NA NA NA NA
catchabilities  :   MS HERAS   1  2  3  3  3  3  3  3  3
catchabilities  :   WoS HERAS  4  5  6  6  6  6  6  6  6
catchabilities  :   IBTS_Q1   NA  7  7  7  7  7  7  7  7
catchabilities  :   IBTS_Q4   NA  8  8  8  8  8  8  8  8
power.law.exps  :            age
power.law.exps  : fleet       1  2  3  4  5  6  7  8  9
power.law.exps  :   catch     NA NA NA NA NA NA NA NA NA
power.law.exps  :   MS HERAS  NA NA NA NA NA NA NA NA NA
power.law.exps  :   WoS 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  :   IBTS_Q4   NA NA NA NA NA NA NA NA NA
f.vars          :            age
f.vars          : fleet       1  2  3  4  5  6  7  8  9
f.vars          :   catch     1  2  2  2  2  2  2  2  2
f.vars          :   MS HERAS  NA NA NA NA NA NA NA NA NA
f.vars          :   WoS 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          :   IBTS_Q4   NA NA NA NA NA NA NA NA NA
obs.vars        :            age
obs.vars        : fleet       1  2  3  4  5  6  7  8  9
obs.vars        :   catch     1  2  2  2  2  2  2  3  3
obs.vars        :   MS HERAS  4  5  5  5  5  5  5  5  5
obs.vars        :   WoS HERAS 6  7  7  7  7  7  7  7  7
obs.vars        :   IBTS_Q1   NA  8  9  9  9  9  9  9  9
obs.vars        :   IBTS_Q4   NA 10 11 11 11 11 11 11 11
srr             : 0
cor.F           : TRUE
nohess          : FALSE
timeout         : 3600
sam.binary      :
```

Table 5.6.11 Herring in 6.a (combined) and 7.b and 7.c. FLR, R software versions.

FLSAM.version	0.99-99
FLCore.version	2.4
R.version	R version 2.13.2 (2011-09-30)
platform	i386-pc-mingw32
run.date	2016-03-31 23:24:08

Table 5.6.12 Herring in 6.a (combined) and 7.b and 7.c. Stock summary.

Year	Recruitment Age 1	TSB	SSB	Fbar (Ages 3-6)	Landings tonnes	Landings SOP
1957	1218340	712831	355756	0.1392	48508	0.7531
1958	2090680	737484	357182	0.1838	66494	0.7733
1959	3162900	833176	336381	0.1810	70447	0.7446
1960	2160824	861129	392778	0.1346	69160	0.6012
1961	3011654	915293	426770	0.1001	52535	0.6332
1962	3580453	1016626	429338	0.1348	65594	0.7990
1963	3328392	1045494	460469	0.1032	54089	0.7245
1964	2186910	1008526	506865	0.1001	70403	0.6145
1965	7282611	1346474	470711	0.1093	76685	0.8730
1966	2195675	1589611	717121	0.1529	112834	1.0130
1967	3771563	1460077	763753	0.1436	109281	0.8399
1968	4180745	1519664	746387	0.1199	105345	0.8364
1969	3813279	1470334	708567	0.1672	126777	0.7945
1970	5147388	1576945	673336	0.2394	186236	0.7750
1971	8260536	1887946	609869	0.3914	222211	1.0255
1972	4089773	1756792	694537	0.2761	188230	1.0349
1973	2226630	1519664	745641	0.3644	246989	1.0331
1974	2657775	1091431	459549	0.4886	214749	1.1069
1975	2946121	836515	288082	0.4811	152765	0.9806
1976	1861699	682829	244997	0.4743	126409	0.9888
1977	1828488	538746	211928	0.2899	61908	0.9200
1978	2107473	541447	205664	0.1992	41871	0.9961
1979	1899308	537670	216642	0.1109	22668	0.9380
1980	2022814	623435	275130	0.1309	30430	1.0375
1981	2922646	797311	318380	0.2437	76342	0.9699
1982	2294441	810171	320616	0.3259	111569	1.0235
1983	4193306	861991	268069	0.3426	96511	1.0182
1984	2639236	917126	348015	0.2305	83462	0.9756
1985	3399028	994505	421679	0.1951	62485	1.0078
1986	2822123	1057058	472125	0.2233	99549	1.0389
1987	3641841	1041320	427197	0.2501	92960	1.0148
1988	1823011	996496	482627	0.1760	64691	1.0126
1989	1964994	1011556	555154	0.1457	63236	1.0086
1990	2051332	1048635	568638	0.1690	88662	0.9933
1991	1964994	993511	542531	0.1390	66229	1.0315
1992	2796838	893588	470711	0.1301	60841	1.0024
1993	2706048	952647	536059	0.1374	68541	0.9932
1994	3181935	826537	418738	0.1280	58338	0.9999
1995	2024837	733073	334369	0.1368	57367	0.9748
1996	2404855	620326	340783	0.1599	58639	1.0233
1997	3054114	634759	273211	0.2188	62458	1.0033
1998	2774552	717121	346279	0.2295	72248	0.9994
1999	2673770	724328	369165	0.1332	55845	0.9998
2000	4130876	800507	338744	0.1060	43008	0.9990
2001	3265750	861129	477825	0.0972	40007	1.0028
2002	3298571	944112	536059	0.1117	50740	0.9998
2003	2065742	924492	554599	0.0871	44583	1.0021
2004	2224405	797311	486991	0.0799	40186	1.0119
2005	1815733	738222	443299	0.0630	30360	1.0021
2006	1893618	788589	469301	0.0949	46539	0.9990
2007	1372302	765282	498321	0.0996	47407	0.9990
2008	1559694	713544	473544	0.0695	29394	1.0008
2009	2045187	727959	437574	0.0724	28976	1.0312
2010	3054114	753889	401917	0.0837	30118	0.9960
2011	2032953	664639	332701	0.0700	24678	0.9992
2012	1393041	658685	390428	0.0616	25087	1.0017
2013	783088	559613	321901	0.0746	26947	0.9978
2014	812605	455431	270493	0.0762	27123	1.0091
2015	769118	418738	250196	0.0709	19885	0.9982

Table 5.6.13 Herring in 6.a (combined) and 7.b and 7.c. Estimated fishing mortality.

Units : f

age \ year	1957	1958	1959	1960	1961	1962
1	0.01291843	0.02153017	0.0213971	0.01290552	0.007899941	0.01393293
2	0.07119733	0.09555054	0.0971402	0.07525296	0.057717203	0.07791787
3	0.11545205	0.15132885	0.1474450	0.10965678	0.081439082	0.10904442
4	0.12823382	0.17062280	0.1699757	0.12617316	0.094486340	0.12804161
5	0.15349305	0.20284767	0.2006687	0.15049883	0.112253003	0.14883753
6	0.15958158	0.21045151	0.2057281	0.15207218	0.112140806	0.15321701
7	0.19881113	0.26468893	0.2609047	0.19398004	0.143919667	0.19462123
8	0.22011613	0.29437524	0.2903988	0.21629761	0.161944758	0.22170669
9	0.22011613	0.29437524	0.2903988	0.21629761	0.161944758	0.22170669

age \ year	1963	1964	1965	1966	1967	1968
1	0.008896476	0.008742142	0.01046206	0.01918167	0.01662081	0.01156930
2	0.059261229	0.057040143	0.06081614	0.08580311	0.07808167	0.06510851
3	0.084230348	0.081929185	0.08916203	0.12426983	0.11614684	0.09820482
4	0.098657601	0.097149913	0.10833793	0.15260537	0.14420779	0.11963618
5	0.112129593	0.107002830	0.11538280	0.15896043	0.14868876	0.12423256
6	0.117807894	0.114154784	0.12446882	0.17588938	0.16539810	0.13731194
7	0.148673894	0.145715382	0.16063830	0.22463015	0.20771258	0.17134092
8	0.172492762	0.170298926	0.18747683	0.26155780	0.24399684	0.20107044
9	0.172492762	0.170298926	0.18747683	0.26155780	0.24399684	0.20107044

age \ year	1969	1970	1971	1972	1973	1974	1975
1	0.01968890	0.03512297	0.07925379	0.04098292	0.06290057	0.1000485	0.09212582
2	0.08892162	0.12735205	0.21284310	0.15551704	0.20833665	0.2816754	0.28407983
3	0.13869195	0.20494779	0.34269995	0.24077317	0.31311022	0.4103233	0.40028039
4	0.16445801	0.23363388	0.37677767	0.26095691	0.34393589	0.4607406	0.45195620
5	0.17452278	0.24850309	0.40335025	0.28447782	0.37474106	0.5020679	0.49405917
6	0.19101563	0.27065780	0.44277214	0.31816028	0.42575126	0.5813339	0.57790256
7	0.23740209	0.33170807	0.52903007	0.37316298	0.48280617	0.6458875	0.64172848
8	0.27823199	0.38848139	0.62317369	0.44083263	0.57675368	0.7734378	0.77119810
9	0.27823199	0.38848139	0.62317369	0.44083263	0.57675368	0.7734378	0.77119810

age \ year	1976	1977	1978	1979	1980	1981
1	0.0851024	0.03326665	0.01611347	0.005328956	0.006686264	0.01902312
2	0.2843072	0.17306293	0.11903949	0.065056445	0.075110118	0.14022598
3	0.3918367	0.23669095	0.16126602	0.089412034	0.106981431	0.20101012
4	0.4470164	0.27463839	0.19164703	0.106065336	0.124108388	0.22836730
5	0.4851147	0.29638381	0.20372179	0.113824214	0.136013654	0.25294075
6	0.5730399	0.35179734	0.24002793	0.134270347	0.156452943	0.29232181
7	0.6397742	0.39516969	0.27461093	0.156954394	0.186038805	0.34300852
8	0.7674822	0.47008112	0.32742377	0.183966795	0.215434147	0.39486158
9	0.7674822	0.47008112	0.32742377	0.183966795	0.215434147	0.39486158

age \ year	1982	1983	1984	1985	1986	1987
1	0.03021249	0.0315305	0.01485676	0.01070762	0.01307831	0.01546463
2	0.18824707	0.1946407	0.13010675	0.10854396	0.12346470	0.13643595
3	0.26863546	0.2835689	0.19253063	0.16288677	0.18568567	0.20733903
4	0.30261316	0.3138626	0.20902530	0.17511717	0.20070884	0.22575611
5	0.34017333	0.3588323	0.24101406	0.20404800	0.23487543	0.26445081
6	0.39227192	0.4143145	0.27926336	0.23830593	0.27179695	0.30309773
7	0.45747182	0.4850662	0.32667157	0.27778718	0.31505754	0.35590195
8	0.52996199	0.5599264	0.37555137	0.31568828	0.35441030	0.39959250
9	0.52996199	0.5599264	0.37555137	0.31568828	0.35441030	0.39959250

age \ year	1988	1989	1990	1991	1992	1993
1	0.007913382	0.005551428	0.00704174	0.004805953	0.004056235	0.004307059
2	0.095483674	0.079842447	0.09397749	0.078803332	0.075283070	0.082860236
3	0.146738968	0.122542178	0.14270153	0.118374731	0.112725457	0.120548876
4	0.160285288	0.134002074	0.15761499	0.130223900	0.123452353	0.131888290
5	0.185927215	0.154077432	0.17817305	0.145729954	0.134754591	0.142844308
6	0.211252749	0.171976060	0.19748355	0.161588871	0.149329501	0.154478554
7	0.246720293	0.201835958	0.22686503	0.180974345	0.163131281	0.169907688
8	0.274665853	0.224203759	0.25115123	0.197463801	0.175187228	0.176664999
9	0.274665853	0.224203759	0.25115123	0.197463801	0.175187228	0.176664999

Table 5.6.13 (cont'd) Herring in 6.a (combined) and 7.b and 7.c. Estimated fishing mortality.

age	1994	1995	1996	1997	1998	1999
1	0.003568892	0.00372384	0.004692921	0.0077660	0.007988119	0.002862099
2	0.078214518	0.08286852	0.095655699	0.1292509	0.134149558	0.078339761
3	0.113778694	0.12210182	0.143488555	0.1961648	0.210388386	0.126160547
4	0.122652515	0.13235071	0.156499886	0.2163192	0.229856518	0.135051377
5	0.133147199	0.14189045	0.164277206	0.2269558	0.238210629	0.137518063
6	0.142302529	0.15076997	0.175327434	0.2355576	0.239644189	0.134082500
7	0.151313717	0.15628094	0.179837790	0.2411587	0.238830783	0.129070050
8	0.157914742	0.15772536	0.173097545	0.2145956	0.203905220	0.108207998
9	0.157914742	0.15772536	0.173097545	0.2145956	0.203905220	0.108207998

age	2000	2001	2002	2003	2004	2005
1	0.001805351	0.001471755	0.001792758	0.001109107	0.0009165444	0.0005791784
2	0.061871229	0.055821287	0.062480548	0.048117950	0.0435563403	0.0349338153
3	0.101947225	0.093714720	0.107959405	0.084983344	0.0783006010	0.0634311635
4	0.107980999	0.098687203	0.113540009	0.089170947	0.0823727995	0.0655658695
5	0.109909278	0.101733361	0.118422090	0.092541323	0.0842303476	0.0653171920
6	0.104204496	0.094713380	0.106960037	0.081732791	0.0746533410	0.0578616768
7	0.098038012	0.088495816	0.099380437	0.077173434	0.0705664825	0.0545029745
8	0.080854826	0.070580597	0.077196590	0.059249378	0.0536217773	0.0413079625
9	0.080854826	0.070580597	0.077196590	0.059249378	0.0536217773	0.0413079625

age	2006	2007	2008	2009	2010	2011
1	0.00117428	0.001269668	0.0006714977	0.0007309248	0.0009509967	0.0006841728
2	0.05219858	0.056112313	0.0390192564	0.0403606491	0.0463562107	0.0384537138
3	0.09426927	0.098352236	0.0673939519	0.0693353779	0.0793013600	0.0652453826
4	0.09901341	0.103830035	0.0726937404	0.0750050376	0.0856231148	0.0715327423
5	0.09886500	0.104058712	0.0729121491	0.0766427702	0.0893762761	0.0749975374
6	0.08749269	0.092079771	0.0648680547	0.0686798106	0.0803872257	0.0680916968
7	0.08175731	0.085588872	0.0598987286	0.0630391069	0.0735566074	0.0627623442
8	0.06249305	0.065690563	0.0459684494	0.0479978049	0.0559834034	0.0474917152
9	0.06249305	0.065690563	0.0459684494	0.0479978049	0.0559834034	0.0474917152

age	2012	2013	2014	2015
1	0.0005331008	0.0007169532	0.000719323	0.0006320766
2	0.0332367197	0.0390856456	0.039093463	0.0365490531
3	0.0566762515	0.0672592987	0.068817308	0.0644348914
4	0.0626056343	0.0762071491	0.077575781	0.0721866611
5	0.0662645643	0.0810166978	0.083701364	0.0782692871
6	0.0607371343	0.0739327044	0.074548899	0.0688930484
7	0.0558994912	0.0686935480	0.070095267	0.0656905631
8	0.0423409744	0.0528710156	0.054317979	0.0501618751
9	0.0423409744	0.0528710156	0.054317979	0.0501618751

Table 5.6.14 Herring in 6.a (combined) and 7.b and 7.c. Estimated population abundance.

Units : NA

age	1957	1958	1959	1960	1961	1962
1	1218340.20	2090680.15	3162900.36	2160823.59	3011654.04	3580453.41
2	1570649.84	500318.41	1014594.92	1744537.44	895376.88	1452795.22
3	652782.97	1218340.20	351160.97	733072.58	1114593.14	356824.73
4	270492.59	339422.19	809360.74	266732.08	516587.52	741180.90
5	310829.56	179692.08	181316.61	407583.05	235625.75	400712.70
6	162429.61	184609.86	115381.58	99012.36	200787.02	167711.41
7	63959.16	93339.62	93339.62	71111.19	55603.42	166708.16
8	10283.54	41233.24	43303.99	43958.44	42830.25	38870.85
9	34337.73	30121.67	37684.34	35667.67	36717.18	50614.84

age	1963	1964	1965	1966	1967	1968
1	3328392.46	2186909.68	7282610.93	2195674.84	3771562.76	4180744.92
2	1704870.99	1718564.66	646287.67	5615268.71	585956.01	1778000.54
3	805324.03	1103502.75	1019680.60	479740.21	3321742.33	346278.97
4	180412.29	415401.17	700115.08	623435.13	373995.86	2455890.54
5	466960.52	109425.58	260667.26	360771.47	408399.03	217727.60
6	283792.89	301643.16	77342.59	161943.05	249446.56	275405.55
7	94845.07	187587.37	209190.37	66369.97	93995.29	143057.22
8	108988.76	66635.98	128669.19	121661.76	43651.81	53423.18
9	55994.01	116891.33	128669.19	160974.30	162267.26	112532.80

Table 5.6.14 (cont'd) Herring in 6.a (combined) and 7.b and 7.c. Estimated population abundance.

age	1969	1970	1971	1972	1973	1974
1	3813278.97	5147388.21	8260535.72	4089772.90	2226630.47	2657775.36
2	1835816.68	1594387.17	2139323.04	4945556.23	1647879.72	817494.95
3	925417.25	1584849.49	1218340.20	1100197.21	3382075.05	728687.32
4	227066.91	652130.52	1001490.55	405144.88	588304.53	1666106.46
5	1732368.32	159691.64	367691.67	405144.88	252710.54	281813.28
6	160974.30	967044.70	96664.36	162754.79	225032.47	134995.94
7	215345.72	98518.54	577809.78	50161.35	90400.04	111190.47
8	98814.54	114233.51	50868.54	302247.05	24514.01	51585.71
9	108228.50	104924.89	102539.15	64023.15	205048.13	110857.40

age	1975	1976	1977	1978	1979	1980
1	2946121.15	1861698.87	1828488.08	2107472.67	1899307.68	2022813.66
2	1106818.23	1438339.67	717838.58	791749.24	1007517.56	847460.92
3	416232.80	500818.98	627186.99	395141.81	341123.55	741180.90
4	318061.49	203210.97	207108.90	310518.89	246471.09	250696.92
5	636665.70	154507.82	98715.77	114005.28	120933.97	183322.10
6	109097.80	246964.53	76649.63	54720.85	72547.73	73057.35
7	46676.68	40094.72	93807.49	34961.40	38638.33	43477.55
8	45844.02	17188.57	14744.13	43174.27	22404.12	23860.99
9	70052.48	44311.52	20128.66	17111.40	30001.42	30393.98

age	1981	1982	1983	1984	1985	1986
1	2922646.21	2294441.46	4193305.99	2639235.90	3399027.77	2822123.01
2	886467.73	1553467.36	888242.44	2475616.47	1097999.01	1686220.18
3	811792.46	465561.74	712831.25	496331.83	1696367.91	756910.28
4	513497.27	516071.19	239905.41	336044.88	252205.62	1155449.50
5	177016.81	299239.64	270492.59	123377.00	181679.60	174555.85
6	111190.47	110857.40	150391.93	123624.00	73350.16	119014.43
7	57988.50	53690.96	58864.88	66436.37	70969.11	39143.90
8	21093.07	36461.06	26582.28	24489.51	35632.02	35489.78
9	28057.18	22925.38	27805.80	21679.01	20553.78	24686.21

age	1987	1988	1989	1990	1991	1992
1	3641841.43	1823010.84	1964994.49	2051332.21	1964994.49	2796837.86
2	1140525.87	2137184.79	755397.97	909818.13	946948.51	752382.41
3	885581.70	753888.68	1931871.92	545795.70	623435.13	669977.90
4	454066.98	532852.54	461852.11	1631483.04	428480.28	470711.19
5	722158.56	287218.92	329390.75	346972.22	1147389.59	338744.02
6	103053.13	408399.03	184425.34	221903.97	237043.75	780741.98
7	65251.22	53530.13	226386.73	145947.17	152207.50	132455.23
8	23765.73	26608.87	30031.44	122149.38	101214.77	88168.06
9	33556.97	22471.43	26582.28	30976.99	79777.76	92874.09

age	1993	1994	1995	1996	1997	1998	1999
1	2706048.47	3181934.8	2024837.5	2404854.59	3054113.72	2774552.41	2673769.95
2	1470333.79	1294972.5	1646232.7	873269.94	1149686.67	1533402.99	1200201.48
3	469770.71	778403.3	669308.3	900765.29	502323.69	738960.69	1287225.91
4	481181.59	271848.4	379268.6	344207.52	447306.80	371758.60	505852.30
5	334703.38	280688.3	195243.0	168720.71	203210.97	262235.96	225032.47
6	266199.15	205870.0	168889.5	121418.68	117948.10	115497.02	136080.24
7	527550.57	181135.4	131662.9	92595.89	75432.99	64472.88	59694.79
8	96086.11	260928.1	131662.9	95511.31	54666.15	33758.92	32663.06
9	99111.42	112532.8	195633.8	181498.02	103673.31	62068.88	43303.99

age	2000	2001	2002	2003	2004	2005	2006
1	4130875.80	3265749.99	3298571.32	2065741.91	2224405.0	1815733.36	1893618.30
2	1040279.52	2193480.26	1441219.23	1686220.18	810981.1	1075181.45	842391.37
3	646934.29	512471.31	1464464.20	1049684.29	1065548.2	735275.10	609869.33
4	847460.92	364397.29	292728.25	1071960.74	733072.6	834843.87	500318.41
5	325461.68	557936.26	255250.32	204843.18	756153.7	472597.81	713544.44
6	151145.77	239186.77	387704.99	162267.26	130092.4	385385.73	469770.71
7	84204.19	113436.67	153891.02	243774.77	138275.0	60900.70	327420.32
8	40215.19	66903.06	64023.15	119610.99	150693.0	77885.88	50362.39
9	43434.09	44002.42	55215.56	65709.58	107688.7	98420.07	111971.54

Table 5.6.14 (cont'd) Herring in 6.a (combined) and 7.b and 7.c. Estimated population abundance.

age \ year	2007	2008	2009	2010	2011	2012	2013
1	1372301.75	1559693.7	2045187.4	3054113.7	2032953.1	1393041.44	783087.72
2	1008525.58	620325.7	741922.4	865445.8	1644587.3	947895.93	580125.65
3	688313.72	629071.4	410035.9	524919.4	502323.7	1293678.15	513497.27
4	367691.67	510425.5	458630.4	255761.3	329061.5	299838.72	989544.48
5	329720.30	249696.1	333700.8	282660.0	176486.6	193107.05	207316.11
6	499818.34	230268.2	187025.5	193881.0	163243.8	128412.11	127007.32
7	341806.48	375494.8	180954.3	121055.0	111301.7	98715.77	86335.83
8	227976.99	247211.6	301341.7	123624.0	82289.6	55270.80	64601.96
9	91217.31	224134.1	317108.7	335709.0	222348.2	142059.32	97929.20

age \ year	2014	2015
1	812604.66	769118.24
2	341464.84	412916.22
3	419156.65	264078.05
4	423369.25	311763.45
5	705033.08	315842.83
6	153276.69	420416.01
7	69703.09	112420.32
8	48630.20	44667.44
9	67710.73	42744.68

Table 5.6.15 Herring in 6.a (combined) and 7.b and 7.c. Predicted catch numbers at age.

Units : NA

age \ year	1957	1958	1959	1960	1961	1962	1963
1	10933.973	31150.949	46826.286	19358.173	16551.301	34637.771	20604.402
2	89778.428	37979.431	78229.336	105177.008	41772.771	90626.324	81593.102
3	60114.118	144682.939	40668.129	64292.612	73533.767	31126.039	54896.232
4	27711.423	45392.401	107818.011	26913.950	39612.500	75795.939	14420.124
5	38025.034	28407.259	28373.191	48957.115	21483.060	47614.852	42548.505
6	20659.489	30245.419	18519.324	12032.300	18330.470	20525.022	27159.984
7	9980.316	18823.286	18576.080	10855.314	6439.009	25522.099	11321.626
8	1759.526	9118.221	9468.919	7403.588	5535.737	6692.481	14938.096
9	5874.111	6663.232	8237.647	6007.056	4748.386	8717.171	7673.514

age \ year	1964	1965	1966	1967	1968	1969	1970
1	13298.147	52986.900	29190.54	43460.163	33610.708	51979.26	124355.54
2	79213.340	31716.743	384500.36	36614.514	93237.008	129975.34	158942.85
3	73254.869	73350.163	47339.48	307582.924	27342.567	101285.65	248724.22
4	32695.738	61150.909	75146.89	42796.003	235767.163	29357.40	116052.74
5	9533.431	24386.866	45565.22	48469.984	21836.540	238661.14	30275.68
6	28029.141	7792.913	22527.68	32793.972	30430.479	24136.97	198253.14
7	21994.551	26844.064	11568.26	15261.674	19484.216	39410.99	24144.21
8	9027.313	19033.008	24277.37	8191.399	8423.915	20809.19	31987.48
9	15830.441	19037.005	32112.48	30457.879	17736.324	22792.80	29375.02

age \ year	1971	1972	1973	1974	1975	1976	1977
1	441971.20	114955.46	95215.688	177904.11	182134.37	106595.865	41881.522
2	342730.60	594335.94	259004.315	168080.78	229303.10	298045.071	95234.733
3	300438.99	199526.03	771892.060	208855.94	116961.49	138233.560	112049.946
4	269385.85	79522.88	146590.754	528553.87	99389.33	62893.620	42514.480
5	105630.24	86543.29	68302.387	96500.17	215173.51	51472.347	21849.428
6	30028.43	38395.67	67697.193	51865.03	41714.33	93807.492	19699.923
7	207253.92	13584.16	30191.026	46295.50	19345.21	16589.579	26627.505
8	20647.30	93807.49	9386.052	24406.38	21633.10	8085.924	4819.281
9	41589.37	19879.61	78566.447	52412.48	33060.68	20851.059	6578.552

age \ year	1978	1979	1980	1981	1982	1983	1984
1	23550.445	7053.223	9412.746	38503.330	47772.240	91044.165	27211.637
2	74065.121	52807.051	51016.276	96722.371	222526.172	131242.233	251852.783
3	49771.609	24619.645	63487.607	125179.001	93013.507	149342.858	73548.476
4	46184.522	21100.035	24904.406	89536.353	115220.159	55309.502	54095.160
5	18077.439	11173.498	20024.464	34091.385	74540.658	70509.307	22758.637
6	10086.972	7853.543	9115.486	24369.801	31188.353	44249.529	26053.307
7	7277.844	4851.290	6383.042	14628.691	17164.353	19718.844	16079.975
8	10467.495	3255.919	4004.965	5985.409	13088.510	9950.917	6663.632
9	4148.740	4360.186	5101.143	7964.584	8229.413	10408.832	5900.663

Table 5.6.15 (cont'd) Herring in 6.a (combined) and 7.b and 7.c. Predicted catch numbers at age.

age \ year	1985	1986	1987	1988	1989	1990
1	25298.490	25626.955	39077.417	10034.857	7598.225	10055.349
2	94042.304	163145.872	121273.063	162024.040	48262.011	67961.728
3	215539.615	108586.243	140392.872	86950.998	188094.542	61322.371
4	34547.829	179153.812	78346.768	67231.690	49335.540	202683.312
5	28856.773	31479.758	144668.471	41931.810	40432.937	48722.684
6	13430.453	24474.817	23309.120	67097.361	25134.583	34327.429
7	14924.956	9178.876	16976.410	10138.446	35814.209	25647.465
8	8376.119	9205.441	6813.219	5540.555	5223.067	23508.092
9	4829.992	6401.323	9620.101	4682.184	4624.021	5961.814

age \ year	1991	1992	1993	1994	1995	1996	1997
1	6582.435	7904.52	8120.849	7916.623	5254.972	7863.444	16505.187
2	59718.671	45392.40	97304.450	81096.899	108988.756	66297.005	116192.084
3	58770.776	60312.82	45048.727	70671.665	64984.236	101752.635	75720.181
4	44529.181	46541.52	50604.713	26696.827	40026.620	42501.727	74272.794
5	133652.710	36669.48	38265.347	30061.483	22198.944	21966.855	35525.286
6	30479.207	93367.63	32843.200	23536.319	20364.531	16840.467	21378.692
7	21790.732	17238.32	71303.451	21984.216	16463.811	13185.065	14003.184
8	15699.435	12256.23	13461.782	32948.467	16604.848	13126.915	9145.068
9	12367.533	12908.87	13882.717	14213.962	24671.401	24951.769	17334.084

age \ year	1998	1999	2000	2001	2002	2003	2004
1	15414.748	5333.804	5199.616	3354.104	4123.716	1598.179	1423.124
2	160556.310	75237.120	51937.689	99042.071	72627.579	65880.647	28721.464
3	118729.135	128823.689	52933.940	38665.384	126462.361	72157.030	67697.193
4	65192.519	54420.707	73843.259	29129.305	26742.250	77761.366	49286.229
5	47891.820	24832.287	29082.736	46332.549	24482.161	15545.399	52407.238
6	21249.104	14703.488	12876.510	18595.409	33850.194	10958.492	8050.907
7	11872.499	6244.398	6788.532	8289.791	12574.296	15618.010	8129.055
8	5390.266	2893.031	2695.314	3933.481	4103.518	5931.308	6785.614
9	9905.050	3833.985	2910.092	2587.274	3539.002	3259.601	4848.914

age \ year	2005	2006	2007	2008	2009	2010	2011
1	734.0594	1551.519	1215.244	730.844	1043.077	2025.982	971.0908
2	30684.1036	35628.459	45775.304	19729.692	24389.305	32594.538	51585.7113
3	38112.5918	46281.611	54398.943	34585.853	23172.002	33769.051	26750.2741
4	45012.7022	40138.851	30844.076	30427.437	28183.726	17842.526	19299.9928
5	25629.5177	57624.321	27970.342	15054.466	21116.289	20737.107	10938.5661
6	18625.7442	33860.350	37835.383	12437.732	10679.059	12879.858	9238.0860
7	2784.3229	22170.104	24199.809	18821.968	9540.203	7409.587	5838.9134
8	2716.5012	2630.423	12504.077	9574.513	12176.218	5806.423	3291.4715
9	3433.3440	5851.188	5000.684	8678.379	12807.805	15762.358	8893.0024

age \ year	2012	2013	2014	2015
1	518.1164	391.7289	407.7727	339.4376
2	25739.9619	18487.6829	10883.0303	12314.4666
3	60108.1068	28172.4548	23510.4434	13887.8551
4	15457.5062	61703.7509	26876.2963	18461.4490
5	10619.5296	13844.4540	48562.1646	20396.7326
6	6504.3730	7784.1897	9474.8860	24062.2620
7	4626.4726	4942.2699	4072.1647	6166.4587
8	1976.0793	2867.9421	2218.1083	1883.8447
9	5077.3259	4350.5606	3085.8117	1803.2214

Table 5.6.16 Herring in 6.a (combined) and 7.b and 7.c. Catch at age residuals.

Units : NA

year

age	1957	1958	1959	1960	1961	1962	1963
1	-0.471816	-0.6211310	0.1301900	-1.4425100	-0.1215850	0.4235890	-0.4981980
2	-0.593728	-0.6893680	-0.2671110	0.5287340	1.1058300	0.5087100	0.0863621
3	0.535473	0.3082180	-0.3026470	0.1223440	-0.0475579	-0.7636730	0.2803650
4	-0.171609	-0.1897460	0.8038050	-0.3296010	-0.1873470	0.0674414	-0.4524810
5	0.141383	-0.0597908	-0.0954520	0.1815390	0.7318100	0.1622230	0.0327828
6	0.237583	0.3230170	0.1274560	0.0763387	-1.4040300	0.5706100	0.3109520
7	-0.194199	0.3385540	0.0775727	0.1238510	-0.5990880	0.4802430	-0.6053260
8	-0.174278	0.4950310	-0.4369880	-0.2623650	-0.0891253	0.3782950	-0.0701615
9	-0.581822	0.8445150	0.3758130	-0.6238140	-1.4591700	-0.0964894	0.0797256

year

age	1964	1965	1966	1967	1968	1969	1970
1	0.6285180	1.5701300	1.7952300	1.4185400	1.706010	-0.256609	0.589542
2	0.5716500	-1.7295700	1.6790900	-1.3858100	0.689876	-1.088940	-0.958915
3	0.0804586	-0.0981409	-0.2466970	-0.6589260	-0.277547	-1.019040	0.663516
4	-0.5652820	0.5803630	-0.3373630	0.8510570	0.177658	-0.347894	0.425600
5	-0.4156980	0.0321538	-0.9557320	-0.0176350	-0.587617	0.582008	0.248355
6	-0.1958120	-0.6052430	0.0408141	0.5491500	-0.382717	0.375228	-0.465038
7	-0.1687900	0.3981380	0.5075640	-0.0132117	-0.542788	0.861783	0.103427
8	0.3318860	0.3540000	-0.4546680	0.6991960	-0.429993	0.863265	-0.313829
9	0.3199010	0.6194990	0.0954950	0.3197860	-0.613343	0.732302	-0.358593

year

age	1971	1972	1973	1974	1975	1976
1	-0.6803520	1.394980	-0.4555150	0.5101490	-0.00947692	-0.1980830
2	-0.0244948	0.508368	0.3593730	-0.4813390	0.33701800	0.8852620
3	1.8901300	-0.110120	0.5817630	-0.4710910	-0.13562300	0.0339035
4	0.8485380	-1.553980	0.0675300	0.3641960	-0.38196900	-0.0765647
5	0.2689910	-0.597487	0.1788580	0.2197090	-0.08601300	-0.1064540
6	-0.1010840	-0.399737	-0.0564211	0.6863550	-0.05573480	-0.1536650
7	-0.3448190	0.401496	-0.5412100	-0.0944365	-0.34278600	-0.1600730
8	-0.2278050	0.272649	-0.2994200	0.8615790	0.11508700	-0.2166870
9	-0.5770790	0.151843	0.1681650	-0.0462807	0.95100700	0.8347030

year

age	1977	1978	1979	1980	1981	1982	1983
1	-0.0571907	0.297255	-0.121819	-0.4790140	-0.00333435	-1.1088000	-0.0789940
2	-0.1799350	0.883647	-0.284612	-1.3265500	0.20114700	1.0534100	-0.4358640
3	-0.1442330	-0.244321	-1.392980	0.1365980	0.92255600	-0.2373000	-0.2735870
4	-0.4449920	0.883243	-0.305804	0.0644451	0.20248900	0.3118900	-0.0750738
5	0.1132410	-0.162743	-0.999097	0.5670260	0.03173770	0.1636410	0.2968010
6	0.6582770	-0.526629	0.400096	-0.9114800	0.22722400	0.0920413	0.1747860
7	-0.0216110	-0.752557	0.654175	0.4839120	0.15810500	-0.5379760	0.4631460
8	-0.4611640	-0.158725	0.899008	0.2389760	-1.14981000	0.7776380	0.4913390
9	-0.4534890	0.468851	-0.187588	0.1308850	-0.57521400	-0.5158270	0.5914920

year

age	1984	1985	1986	1987	1988	1989
1	-1.5349800	0.62453100	0.274287	-0.192149	-1.6045400	0.09703110
2	0.3984710	-0.63864600	0.620026	-0.545185	-0.4917740	-0.56317300
3	0.3670060	0.00542618	0.269402	-0.625570	0.0700373	0.00737478
4	-0.1311130	-0.80264700	0.188932	-0.358258	0.1817810	-0.51047900
5	-0.1559670	-0.49170000	0.347966	0.179728	0.1606770	-0.11886100
6	-0.4165940	0.34208900	0.338734	0.083188	0.5716220	-0.60096100
7	-0.2904730	0.42524200	-0.586188	0.910505	0.0330536	0.61411700
8	-0.1023690	0.77503800	-0.867109	1.002480	-0.4799910	0.32487800
9	0.0386669	-0.30221600	-1.307910	1.522860	-0.2333790	1.01706000

year

age	1990	1991	1992	1993	1994	1995	1996
1	0.3727360	1.2813400	-0.00685068	0.716692	0.4793940	-2.0451700	-0.141313
2	-0.1785970	-0.2188690	-0.71583600	0.985608	0.7558740	0.3833130	-0.353218
3	-0.0969347	-0.5795200	0.63200800	-0.480191	0.0593275	0.0717067	-0.086322
4	0.6213460	-0.5170620	0.46930900	0.255296	-0.8702760	-0.0193155	-0.294095
5	0.2450630	0.1791360	-0.36403500	-0.243868	-0.1630880	0.5593250	-1.332630
6	-0.1428230	0.1775360	0.77917700	-0.831217	-0.4472650	-0.0218488	0.317767
7	0.1187810	0.1673230	-0.82866400	1.087930	-0.7907960	-0.6964230	-0.141884
8	0.6796910	0.4339020	0.06244700	-0.245176	0.8405430	-0.0086391	1.366810
9	0.3212310	-0.0602629	-0.26413100	-1.035390	1.0449900	-0.0805832	1.200920

Table 5.6.16 (cont'd) Herring in 6.a (combined) and 7.b and 7.c. Catch at age residuals.

age \ year	1997	1998	1999	2000	2001	2002	2003
1	-0.585368	0.0632451	0.571967	0.4572130	-0.279824	0.183611	0.1011950
2	-0.200414	-0.5002980	0.788476	0.5769150	0.331996	-0.118199	0.0231854
3	-1.228990	-0.1713230	1.053720	0.7777410	-0.226191	0.230036	0.2616290
4	-0.302294	0.4202320	0.549473	0.6006630	-0.407450	0.238510	0.0139641
5	0.335672	0.5764240	-0.321931	-0.0455154	-0.339902	1.098260	0.4702320
6	0.528820	0.5710690	-0.517572	-0.5233400	0.267705	0.687605	-0.7942440
7	1.628250	0.8998700	-1.109240	-1.3324100	0.177894	-0.365206	-0.1003570
8	-0.169644	0.4381970	-0.618377	-0.1902600	1.123070	-0.772693	1.5641500
9	-0.595812	-1.3414100	-1.853170	-0.8497600	-1.527160	-1.576950	-1.8900800

age \ year	2004	2005	2006	2007	2008	2009
1	-0.0142011	-0.568445	-0.6831830	-1.60385000	-0.375304	0.64523200
2	-1.4146100	1.171590	-1.2158500	1.42420000	0.122690	-0.07128800
3	-1.0235000	1.981720	-0.0484803	0.71279700	-0.316747	-0.15296300
4	-0.0167798	0.302558	0.5476520	-0.16514900	0.612281	0.09939700
5	0.5138290	-1.121760	0.5056390	0.00650438	-0.278570	-0.05651250
6	0.6769510	-1.134980	0.4797340	-0.27459400	-0.355994	0.13015500
7	0.9669870	-0.926740	0.3025780	-0.20375900	-0.388791	0.00872664
8	1.1368800	-0.821232	1.1352900	0.29257100	-0.218511	0.11125800
9	-0.1615540	-2.106460	-0.2039950	-0.39265800	0.182633	-0.88819000

age \ year	2010	2011	2012	2013	2014	2015
1	1.5610300	0.553137	2.237660	-1.685140	-2.2511600	-0.2485780
2	0.2128980	0.340841	0.434486	-0.541010	-0.9667370	0.1727840
3	0.4326650	-0.359976	0.268339	-1.216650	0.1093310	0.2576330
4	-0.4421500	0.043170	-0.662803	0.324869	0.1908940	-0.0588839
5	0.3840290	-0.190402	-0.411679	-0.206711	0.6383600	0.1877240
6	0.0965679	-0.241747	0.304795	0.747069	0.0368937	-0.4280120
7	-0.4147440	0.186584	-0.264287	0.628511	-0.1165340	0.2914330
8	0.1205190	0.255412	-1.383150	1.452930	1.1569900	0.0891468
9	-0.4787820	-0.570431	-0.673819	0.542139	0.5441700	-1.0722200

Table 5.6.18 Herring in 6.a (combined) and 7.b and 7.c. Predicted index at age IBTS_Q1.

Units : NA

age \ year	1987	1988	1989	1990	1991	1992	1993
2	357.237205	672.787817	238.404783	286.574919	298.78971	237.42695	463.52022
3	275.930770	236.668399	608.155132	171.413711	196.42487	211.27699	147.95675
4	141.488720	167.338716	145.598087	512.581642	135.05337	148.55422	151.63253
5	224.413425	90.153160	103.795228	109.039478	361.77049	106.95092	105.55900
6	31.886094	127.791496	58.036957	69.617084	74.64996	246.41818	83.93645
7	20.070278	16.688669	71.005689	45.616979	47.85043	41.74501	166.16147
8	7.274027	8.266986	9.390326	38.065562	31.76547	27.74623	30.23711
9	10.270647	6.986292	8.313328	9.653688	25.02387	29.22370	31.18259

age \ year	1994	1995	1996	1997	1998	1999	2000
2	408.66674	519.20043	274.77429	360.40918	480.62147	378.49013	329.00403
3	245.35349	210.80215	282.91599	156.71361	230.17272	404.97689	204.26333
4	85.75205	119.53629	108.21175	139.53005	115.78905	159.38458	268.02225
5	88.68138	61.63069	53.07574	63.43210	81.77405	71.02557	103.11347
6	65.03854	53.26024	38.18719	36.81075	36.01516	42.99828	47.96444
7	57.16833	41.52518	29.12742	23.54327	20.13944	18.89637	26.76219
8	82.27934	41.51231	30.05773	17.12707	10.58820	10.36982	12.80941
9	35.49351	61.67755	57.13461	32.46394	19.45667	13.74259	13.83000

age \ year	2001	2002	2003	2004	2005	2006	2007
2	693.97782	455.67963	534.12506	256.85969	341.12876	266.63215	319.10174
3	161.86295	461.76680	332.09464	337.39016	233.28713	192.62205	217.30024
4	115.33143	92.48903	339.63449	232.49297	265.23865	158.40737	116.26825
5	176.96288	80.78409	65.06586	240.32688	150.58535	226.27476	104.53062
6	75.96024	122.95765	51.64637	41.44263	122.98716	149.36456	158.84359
7	36.08546	48.92116	77.65997	44.10310	19.45064	104.22375	108.80529
8	21.33972	20.40072	38.18184	48.16969	24.92696	16.07106	72.75954
9	14.03634	17.59421	20.98337	34.42145	31.50480	35.74892	29.09831

Table 5.6.18 (cont'd) Herring in 6.a (combined) and 7.b and 7.c. Predicted index at age IBTS_Q1.

age \ year	2008	2009	2010
2	196.65482	235.12799	274.16497
3	199.52908	130.03193	166.24789
4	162.10431	145.63886	81.06733
5	79.44937	106.14648	89.77711
6	73.42981	59.62769	61.68372
7	119.86067	57.78678	38.60570
8	79.07209	96.37531	39.50985
9	71.67056	101.37434	107.25616

Table 5.6.19 Herring in 6.a (combined) and 7.b and 7.c. Index at age residuals IBTS_Q1.

Units : NA

age \ year	1987	1988	1989	1990	1991	1992	1993
2	-1.2589500	1.009710	-1.39235000	-0.9798460	0.463520	-0.927493	-0.822556
3	0.2756460	0.835105	0.79517100	-1.0009900	2.098790	-0.653765	0.958481
4	0.5457480	-0.302309	0.00319211	-0.5528020	2.001910	-0.272502	-0.233278
5	-0.0570988	-0.128409	-0.23659500	-0.1509650	1.415710	0.493495	0.659688
6	0.4413690	-1.387380	0.19782800	-0.0683296	1.912280	-0.831141	1.154100
7	-1.0899500	-0.304188	-1.96809000	0.5005350	1.903500	0.141143	-0.174607
8	0.4920380	-1.569250	-0.51841100	-1.8274800	1.676150	0.219073	0.687256
9	-0.6848570	-2.066930	-2.11446000	-1.3044600	-0.136117	-0.452921	-0.818955

age \ year	1994	1995	1996	1997	1998	1999	2000
2	-0.7758920	0.3837680	0.2062800	0.0912899	-2.288510	-0.427060	0.522463
3	0.5997620	-0.3006220	-0.1800500	1.2445600	-0.980315	-0.385630	-0.937061
4	0.2725720	-0.0239007	-1.2670300	-0.0534761	-1.443630	-0.229038	-1.290210
5	-0.4199960	-0.6640570	-0.1734290	-0.3059270	-1.815720	-0.165298	-0.831043
6	0.0683517	0.0563620	-0.4673910	0.4330380	-2.300250	-0.462257	-0.400193
7	-0.1995580	-0.1235180	-0.8230850	-0.0990184	-1.400020	0.290580	0.257300
8	-2.6820100	0.0719080	-0.1361480	1.1081000	-1.005800	0.309103	-0.407731
9	-3.4719200	-1.9176900	-0.0781186	0.4772920	-0.410957	0.539287	0.289810

age \ year	2001	2002	2003	2004	2005	2006	2007
2	-1.6368900	0.8360070	-0.4800080	0.646594	-0.3783990	0.2167470	-1.4389500
3	-0.3796950	-0.3156920	-1.0267900	0.857612	-0.7292510	0.0429079	-0.6603340
4	-0.2821980	0.1725970	-0.7501490	0.749784	0.0431916	-1.0065300	-0.1242160
5	0.0936162	-0.3590790	-0.1173150	0.936094	0.9496480	0.0556199	-0.2683110
6	0.2873800	0.0873125	-0.0341942	1.786980	1.0954600	0.6795430	0.2216830
7	0.9093420	0.5731760	-0.1202580	1.481980	1.7260300	0.7858120	0.3383430
8	0.4807260	1.2832100	-0.3578180	1.020870	1.3883000	1.0850300	0.0752149
9	0.8430980	1.6534900	0.7010800	1.265150	0.8975610	1.2820900	0.8851710

age \ year	2008	2009	2010
2	-0.673929	-0.893506	-1.55972000
3	-1.410300	1.357080	-0.00582773
4	-0.942685	1.174610	0.49130800
5	-0.535977	1.015370	-0.02067660
6	-0.592860	1.004430	0.12474600
7	-0.652960	1.063850	1.28390000
8	0.330477	1.711440	1.01577000
9	-0.592132	1.678770	1.20271000

Table 5.6.20 Herring in 6.a (combined) and 7.b and 7.c. Predicted index at age WoS HERAS

Units : NA

age	1991	1992	1993	1994	1995	1996	1997
1	164950.38	234685.12	227066.91	267185.91	169990.87	201793.46	255889.25
2	390467.49	310736.32	604707.41	534186.34	677388.34	356539.39	461113.73
3	462083.09	498221.48	347771.18	578330.05	495142.06	658552.81	356824.73
4	318379.71	351196.09	357217.46	202804.96	281559.76	252306.53	317235.60
5	854267.79	253723.41	249546.36	210512.43	145757.56	124355.54	144755.30
6	175536.10	582392.56	197955.99	154168.28	125806.46	89277.07	83909.99
7	111915.57	98370.87	390467.49	135388.00	98135.06	68159.10	53690.96
8	73784.21	65055.76	70848.57	194308.04	98046.78	70537.52	39497.79
9	58122.03	68521.31	73064.65	83826.13	145670.14	134081.08	74869.36

age	1998	1999	2000	2001	2002	2003	2004
1	232326.73	224493.04	346972.22	274553.11	277090.65	173615.78	187081.57
2	613662.27	494746.11	433003.03	915751.21	599589.18	707080.64	340680.38
3	520945.13	949603.68	483835.38	384731.13	1091103.36	792303.65	807178.41
4	261790.54	374969.51	637748.96	275515.73	219564.21	814557.26	559220.99
5	185739.42	168299.43	247162.18	425661.62	192952.63	157109.77	582334.32
6	81952.90	102283.13	115531.67	183689.11	295818.09	125580.22	101073.17
7	45972.56	45170.52	64815.50	87745.86	118409.00	189738.10	108055.47
8	24528.72	25006.72	31247.67	52281.61	49841.34	93985.90	118859.81
9	45071.26	33140.12	33738.67	34389.27	42984.72	51652.82	84931.47

age	2005	2006	2007
1	152710.61	159181.45	421005.00
2	454112.39	352356.95	515503.82
3	561630.81	457759.86	277146.08
4	642485.80	378359.47	251173.70
5	367801.99	544923.12	384577.27
6	302065.75	362326.13	264897.97
7	47978.10	254155.10	178617.16
8	61827.28	39505.69	71431.91
9	78143.33	87877.58	164950.38

Table 5.6.21 Herring in 6.a (combined) and 7.b and 7.c. Index at age residuals WoS HERAS

Units : NA

age	1991	1992	1993	1994	1995	1996	1997
1	0.47969100	-0.767945	-3.0502800	0.4105950	0.6369120	-1.060640	0.754708
2	-0.52532800	0.898376	-0.0798982	0.0272797	0.9085670	0.894538	0.615753
3	-0.63874300	-1.599930	1.2745000	0.0923583	-0.0839749	0.368092	-0.410843
4	0.26882400	-0.573613	1.2224400	0.6375530	0.8744040	0.494847	-1.194390
5	-1.04145000	0.915131	1.5209900	0.7010680	0.0902036	-0.494349	-1.459610
6	0.00868095	-1.649860	2.8205500	1.0304200	0.7400410	-0.721387	-0.981892
7	-0.23324400	0.133239	-0.5181160	2.0487000	1.0142500	0.236233	-2.221950
8	0.36642200	-0.255582	1.4918400	-0.2084090	1.6410600	0.191824	-0.575870
9	-0.00260272	-0.143377	1.4762500	0.8437910	0.6059140	-0.288850	-2.084450

age	1998	1999	2000	2001	2002	2003	2004
1	1.1084100	0.578923	0.170041	0.08772680	0.285144	0.6191820	0.7368950
2	0.4811760	-0.797315	-0.585434	0.27594600	-0.593255	0.7173710	-0.4021800
3	0.4595390	0.706778	-0.672933	-1.06034000	0.512664	0.3034080	-0.1116480
4	1.0939200	0.263582	0.640259	-0.86860900	-0.175685	1.1014800	-0.4367160
5	-0.0682713	1.125370	0.865335	0.05109830	-0.329034	0.2666540	-0.0164881
6	-0.0619952	0.567173	1.419320	-0.60692500	0.671552	0.0528933	-1.1094300
7	-0.9199850	1.209680	2.093420	0.29485500	0.468610	1.1224600	-1.0402800
8	-1.0641800	0.183696	2.070430	0.00422904	0.564687	0.3642840	-0.6866280
9	-0.3790730	0.122787	1.221080	0.01680250	0.605367	0.6993610	-0.1995970

age	2005	2006	2007
1	-0.742924	-0.232997	-2.246240
2	-1.161120	1.606920	-1.043120
3	-1.659840	-0.308313	-0.584322
4	-0.777844	-0.530885	-1.019240
5	-0.755694	0.123212	-0.191929
6	-1.268960	0.251468	-0.161369
7	-2.489480	-0.210333	-0.164715
8	-0.857911	-1.115640	-1.489470
9	-1.992500	-0.732451	0.479691

Table 5.6.22 Herring in 6.a (combined) and 7.b and 7.c. Predicted index at age IBTS_Q4.

Units : NA

age	1996	1997	1998	1999	2000	2001	2002
2	47.809291	61.149397	81.246683	66.716347	58.713519	124.410925	81.283253
3	48.539117	25.845590	37.557384	70.389211	36.153725	28.826641	81.362949
4	18.618952	22.954179	18.856355	27.868304	47.824593	20.723328	16.434619
5	9.212396	10.504146	13.427704	12.577758	18.642054	32.190134	14.511914
6	6.602049	6.082951	5.933356	7.667419	8.746818	13.951123	22.376247
7	5.044306	3.893973	3.336792	3.399540	4.927935	6.692450	8.999239
8	5.231772	2.889721	1.800901	1.894985	2.389318	4.011238	3.815761
9	9.944603	5.477397	3.309311	2.511344	2.579697	2.638425	3.290831

age	2003	2004	2005	2006	2007	2008	2009
2	96.307866	46.472930	62.120124	47.929443	57.19291	35.70176	42.64329
3	59.531763	60.784815	42.500677	34.290214	38.56480	36.24314	23.58521
4	61.463899	42.289550	48.858091	28.456312	20.81117	29.70098	26.63803
5	11.917406	44.294034	28.150637	41.248717	18.98122	14.76781	19.67522
6	9.578299	7.726840	23.221069	27.581631	29.23159	13.79147	11.16730
7	14.525707	8.290083	3.700508	19.427508	20.22299	22.71147	10.92365
8	7.238326	9.170392	4.789567	3.039248	13.72680	15.14000	18.42503
9	3.977924	6.553046	6.053399	6.760589	5.48968	13.72296	19.38074

Table 5.6.23 Herring in 6.a (combined) and 7.b and 7.c. Index at age residuals IBTS_Q4.

Units : NA

age	1996	1997	1998	1999	2000	2001	2002
2	0.2650740	-0.827191	-1.0625100	-1.3960500	-1.1906900	0.333411	-2.00909
3	0.8360520	0.455372	-0.3133770	-1.5676700	-1.8176400	0.929008	-2.75728
4	-0.0377467	0.245870	0.4948010	-0.5333700	-1.6154100	0.763673	-3.44484
5	0.7306120	0.755542	1.0268200	0.0452196	-1.2239400	0.903077	-2.58176
6	-0.1772080	0.903268	1.1426300	1.0350700	-0.2245220	1.293380	-2.65364
7	-0.0635469	-0.352618	-0.0681396	0.8615050	-0.1148800	1.668460	-1.97702
8	0.7724690	1.284030	-0.3564430	-0.1170630	-0.0178614	1.569070	-1.19016
9	0.3813950	0.842869	1.0133800	0.8292820	-0.2869100	0.859939	-1.83564

age	2003	2004	2005	2006	2007	2008	2009
2	1.0502900	0.113336	-1.278060	-0.1748950	-0.197201	-1.1152700	0.502891
3	0.1402200	0.898729	-1.607630	-0.5460440	0.104801	0.0269602	0.500396
4	0.0904972	1.113660	-0.941200	-0.3471760	0.258450	-0.3398400	0.421439
5	-0.5237200	1.187960	-0.105030	-0.0817249	1.108840	0.2514270	0.401839
6	0.2186070	0.890471	-0.497551	0.5661000	0.492479	0.3676410	-0.162931
7	-0.3526960	1.153930	-1.127440	0.4297870	0.906102	0.5345340	0.427384
8	-0.2544450	0.563802	-0.306897	0.8412690	-0.314388	0.2873260	0.246442
9	0.5827420	0.248591	-0.296135	0.5856320	-0.613575	0.1921650	0.456274

Table 5.6.24 Herring in 6.a (combined) and 7.b and 7.c. Predicted index at age MS HERAS.

Units : NA

age	2008	2009	2010	2011	2012	2013	2014
1	234544.4	307552.2	459089.3	305865.27	209462.50	241735.64	142272.57
2	258383.4	308754.0	359115.7	685565.96	395932.89	461621.24	376472.39
3	565462.9	368206.8	468785.2	451892.68	1169749.29	892784.05	381971.01
4	461667.4	414364.0	229624.4	297598.34	272556.17	188640.81	640369.09
5	228091.0	304248.5	255966.0	161087.02	177123.06	116343.23	140435.00
6	212033.6	171905.5	176963.7	150001.41	118456.37	79578.56	64247.62
7	347840.7	167476.8	111390.8	102950.13	91628.72	60072.05	45215.72
8	230798.4	281081.5	114840.6	76787.72	51725.18	91126.14	62906.20
9	209211.3	295640.7	311763.4	207461.28	132906.35	122186.03	172215.18

age	2015
1	237589.58
2	282123.44
3	287736.38
4	386118.66
5	103849.71
6	41601.85
7	39819.02
8	234544.36
9	258383.45

Table 5.6.25 Herring in 6.a (combined) and 7.b and 7.c. Index at age residuals MS HERAS.

Units : NA

age \ year	2008	2009	2010	2011	2012	2013	2014
1	-1.0099700	0.604886	-0.8158560	-1.039370	0.8768030	-0.2281710	1.0618700
2	0.0543723	-0.241980	0.0711015	-1.557990	0.5212430	-0.0943116	-0.6985530
3	0.9022990	-0.470313	-0.3599600	1.094450	-0.5411300	-0.4526590	0.4358680
4	0.7059880	0.108423	0.0860450	0.775410	1.0192900	0.0502246	-0.2874190
5	0.7407150	0.355172	-0.6196210	0.443346	0.5415910	-0.7960820	0.0860976
6	0.7101160	0.428125	-0.3069010	0.662197	-0.0538557	-0.4124220	-1.0801100
7	1.2079500	0.224420	-0.1406000	1.095520	0.3103230	-1.1798400	-1.4053700
8	0.8182570	0.915788	-0.2133070	0.618264	0.1410410	-1.4157100	-2.5058800
9	0.4282620	0.689135	-0.0769801	0.382022	-0.3811280	1.3885600	0.3337980

age \ year	2015
1	0.8142430
2	1.5480700
3	0.6130030
4	0.3334480
5	-0.2256980
6	-0.8789260
7	-4.6877300
8	-1.0099700
9	0.0543723

Table 5.6.27 Herring in 6.a (combined) and 7.b and 7.c. Fit parameters.

	name	value	std.dev
1	logFpar	-1.476000	0.691210
2	logFpar	-0.644810	0.363910
3	logFpar	0.123630	0.305760
4	logFpar	-2.057400	0.423960
5	logFpar	-0.633450	0.235310
6	logFpar	-0.041190	0.229630
7	logFpar	-8.003500	0.213340
8	logFpar	-9.391900	0.248940
9	logSdLogFsta	-0.638860	0.180140
10	logSdLogFsta	-1.224400	0.107830
11	logSdLogN	-0.713090	0.202120
12	logSdLogN	-1.403400	0.098735
13	logSdLogObs	0.098563	0.108580
14	logSdLogObs	-1.731300	0.120230
15	logSdLogObs	-1.075900	0.120390
16	logSdLogObs	0.420470	0.296980
17	logSdLogObs	-0.463440	0.118090
18	logSdLogObs	0.403820	0.181280
19	logSdLogObs	-0.621640	0.072894
20	logSdLogObs	0.479720	0.147660
21	logSdLogObs	-0.332180	0.064146
22	logSdLogObs	0.156890	0.197340
23	logSdLogObs	-0.302850	0.076223
24	rho	0.959050	0.019488

Table 5.6.28 Herring in 6.a (combined) and 7.b and 7.c. Negative log-likelihood.

1002.42

Table 5.7.1.1 Herring in 6.a (combined) and 7.b and 7.c. Input data as used in the FLR short term forecast.

2016								
Age	N	M	Mat	PF	PM	SWt	Sel	CWt
1	908682	0.77	0.00	0.67	0.67	0.02	0.00	0.09
2	356954	0.38	0.34	0.67	0.67	0.14	0.04	0.14
3	270959	0.36	0.77	0.67	0.67	0.17	0.07	0.17
4	173499	0.34	0.99	0.67	0.67	0.19	0.08	0.19
5	206699	0.32	0.99	0.67	0.67	0.21	0.08	0.21
6	212212	0.31	1.00	0.67	0.67	0.22	0.07	0.22
7	286797	0.31	0.99	0.67	0.67	0.23	0.07	0.24
8	77459	0.31	1.00	0.67	0.67	0.23	0.05	0.24
9	61170	0.31	1.00	0.67	0.67	0.25	0.05	0.26

2017								
Age	N	M	Mat	PF	PM	SWt	Sel	CWt
1	908682	0.77	0.00	0.67	0.67	0.02	0.00	0.09
2	-	0.38	0.34	0.67	0.67	0.14	0.04	0.14
3	-	0.36	0.77	0.67	0.67	0.17	0.07	0.17
4	-	0.34	0.99	0.67	0.67	0.19	0.08	0.19
5	-	0.32	0.99	0.67	0.67	0.21	0.08	0.21
6	-	0.31	1.00	0.67	0.67	0.22	0.07	0.22
7	-	0.31	0.99	0.67	0.67	0.23	0.07	0.24
8	-	0.31	1.00	0.67	0.67	0.23	0.05	0.24
9	-	0.31	1.00	0.67	0.67	0.25	0.05	0.26

2018								
Age	N	M	Mat	PF	PM	SWt	Sel	CWt
1	908682	0.77	0.00	0.67	0.67	0.02	0.00	0.09
2	-	0.38	0.34	0.67	0.67	0.14	0.04	0.14
3	-	0.36	0.77	0.67	0.67	0.17	0.07	0.17
4	-	0.34	0.99	0.67	0.67	0.19	0.08	0.19
5	-	0.32	0.99	0.67	0.67	0.21	0.08	0.21
6	-	0.31	1.00	0.67	0.67	0.22	0.07	0.22
7	-	0.31	0.99	0.67	0.67	0.23	0.07	0.24
8	-	0.31	1.00	0.67	0.67	0.23	0.05	0.24
9	-	0.31	1.00	0.67	0.67	0.25	0.05	0.26

Table 5.7.1.2 Herring in 6.a (combined) and 7.b and 7.c. Output from FLR short term forecast.

Catch (2017)	Basis	F (2017)	SSB (2017)	% SSB change relative to 2016	% TAC change relative to 2016
0	Zero catch	0	202 073	-7%	-100%
17 072	FMSY × SSB2016 / MSY Btrigger	0.082	192 703	-11%	+253%
4270	F_{2016}	0.020	199 745	-8%	-12%
4840	2016 (special request advice "monitoring AC")	0.022	199 433	-8%	0%
32 290	F_{MSY}	0.16	184 208	-15%	+567%
10 545	F = 0.05	0.05	196 305	-9%	+118%

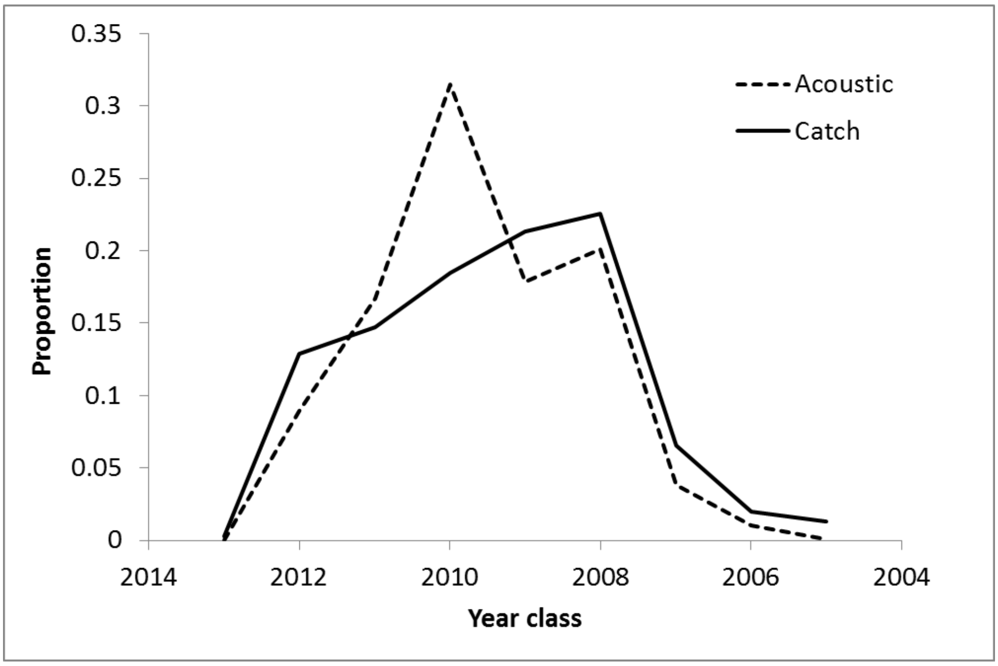


Figure 5.3.1.1. Herring in 6.a (combined) and 7.b and 7.c. Comparison of the proportions-at-age, by year class, in the 2015 acoustic survey (MSHAS) and the 2015 catch.

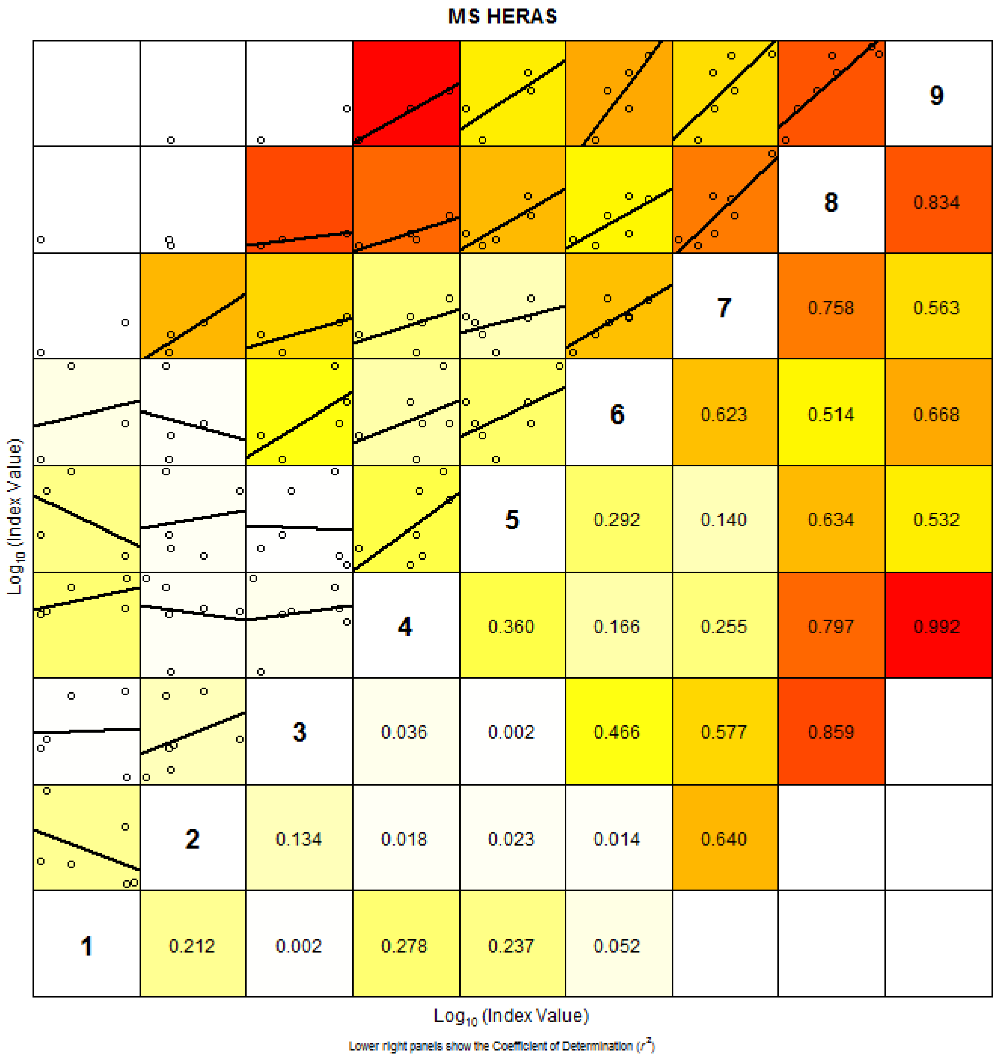


Figure 5.3.1.2. Herring in 6.a (combined) and 7.b and 7.c. Internal consistency between ages (rings) in the Malin Shelf herring acoustic survey time series (2008–2015).

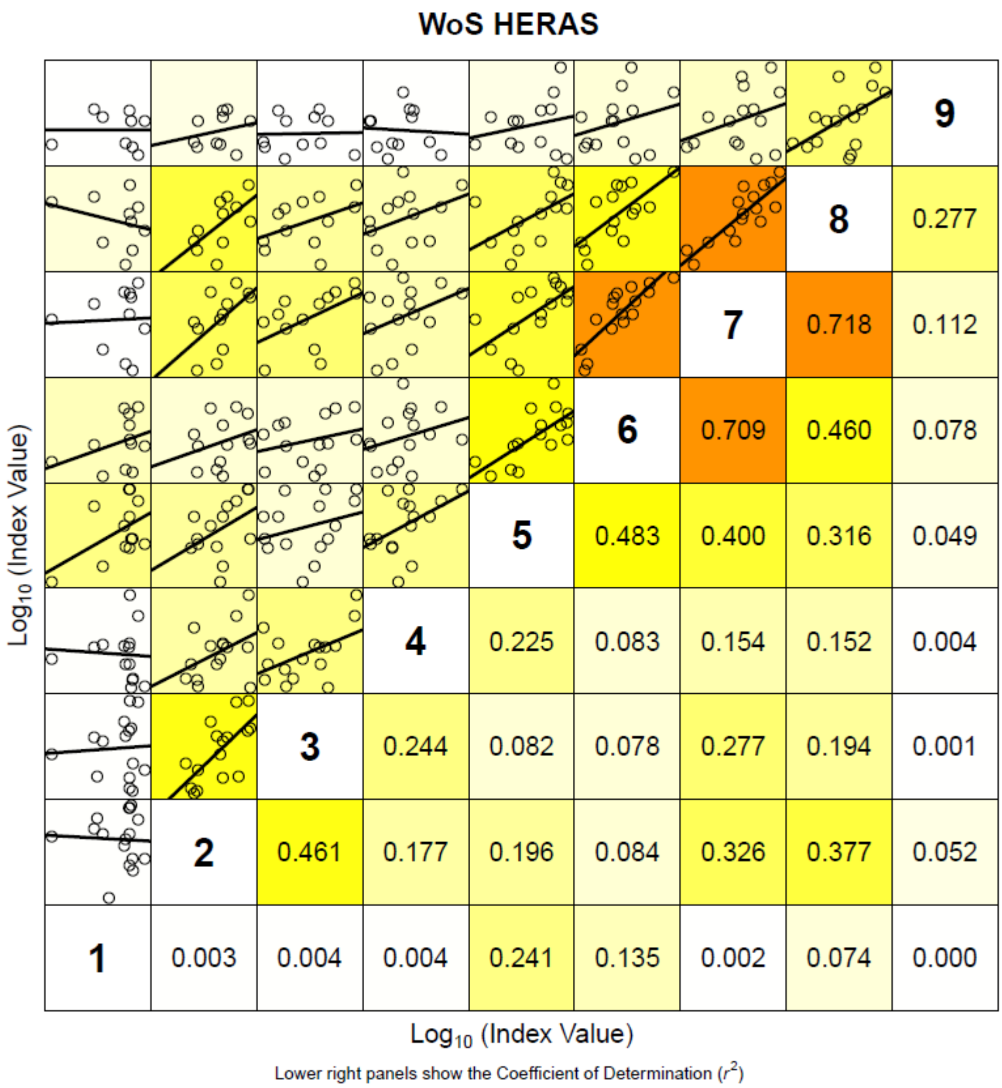


Figure 5.3.1.3. Herring in 6.a (combined) and 7.b and 7.c. Internal consistency between ages (rings) in the West of Scotland acoustic survey time series (MSHAS_N; 1991 to 2007).

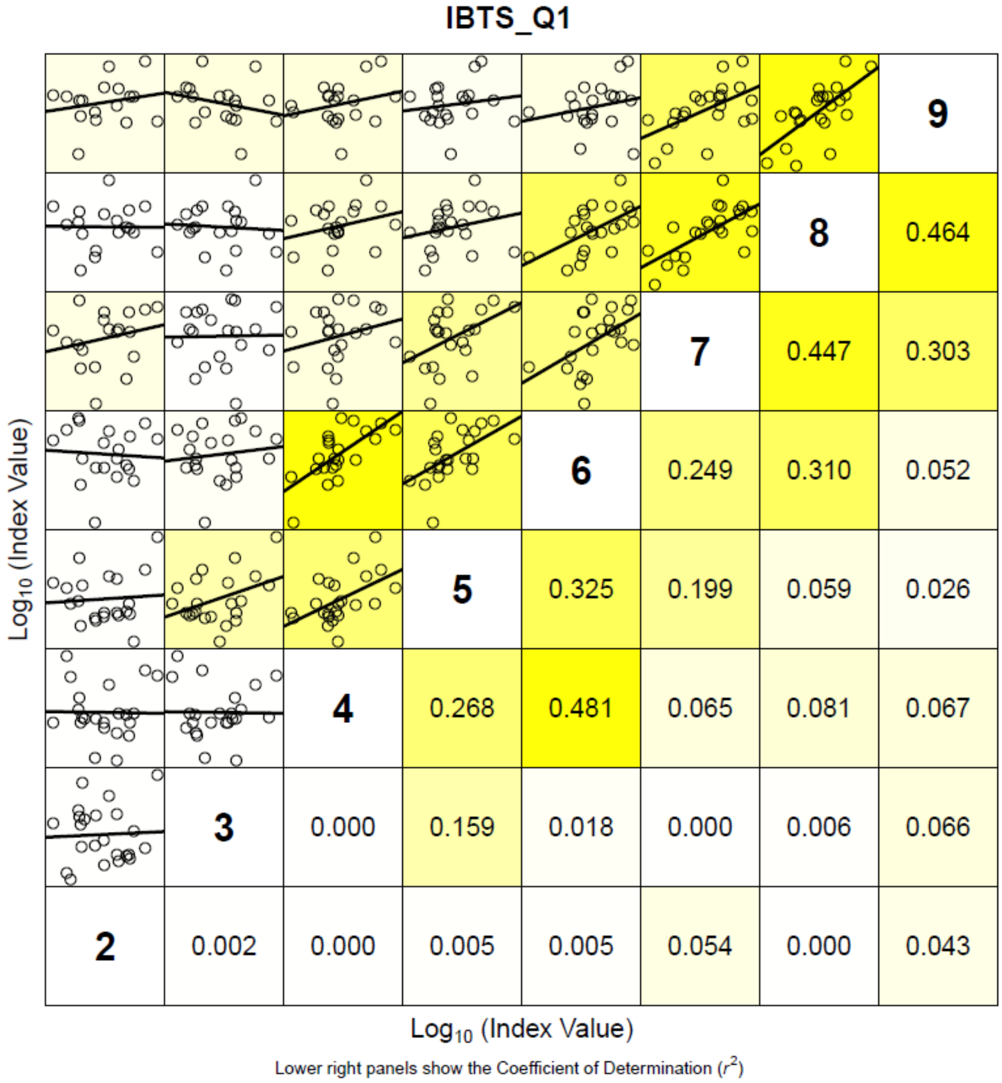


Figure 5.3.2.1. Herring in Division Via (combined) and 7.b and 7.c. Internal consistency plot of the quarter 1 Scottish bottom trawl survey (1987–2010). Above the numbered diagonal the linear regression is shown including the observations (in points) while under the numbered diagonal the r^2 value that is associated with the linear regression is given.

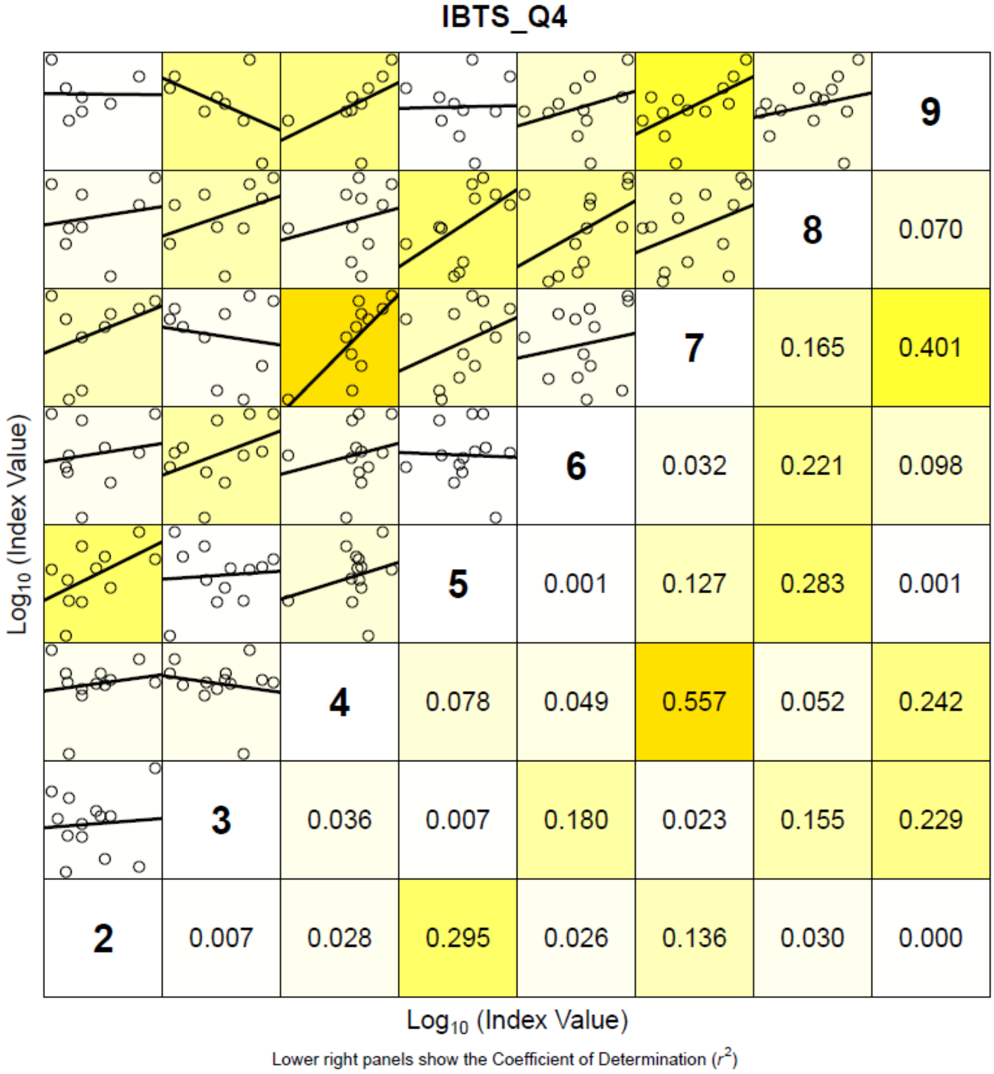


Figure 5.3.2.2. Herring in Division 6.a (combined) and 7.b and 7.c. Internal consistency plot of the quarter 4 Scottish bottom trawl survey in (1996–2009). Above the numbered diagonal the linear regression is shown including the observations (in points) while under the numbered diagonal the r^2 value that is associated with the linear regression is given.

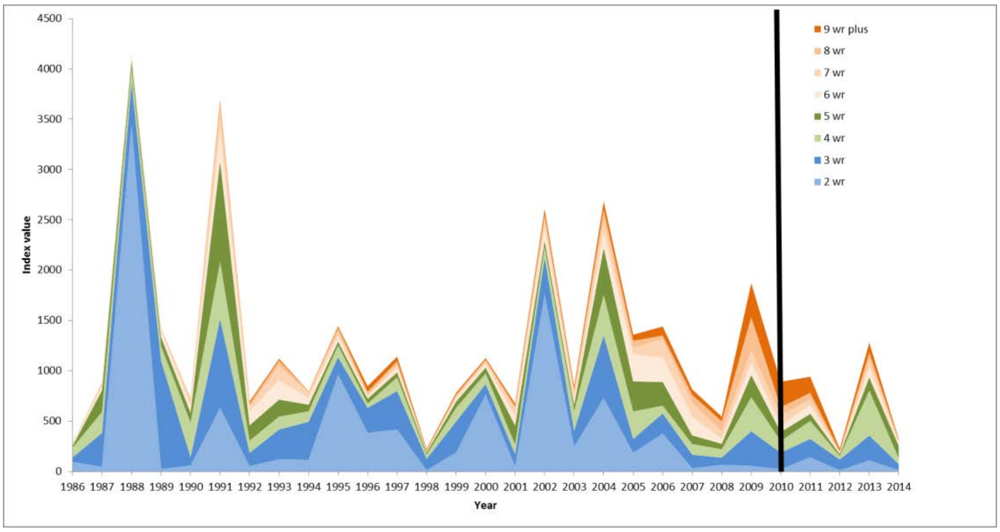


Figure 5.3.2.3. Herring in 6.a (combined) and 7.b and 7.c. Trends in stock composition from abundance at age index from Scottish ground fish survey in Quarter 1. The time series is only used in the assessment up to and including 2010 (black vertical line).

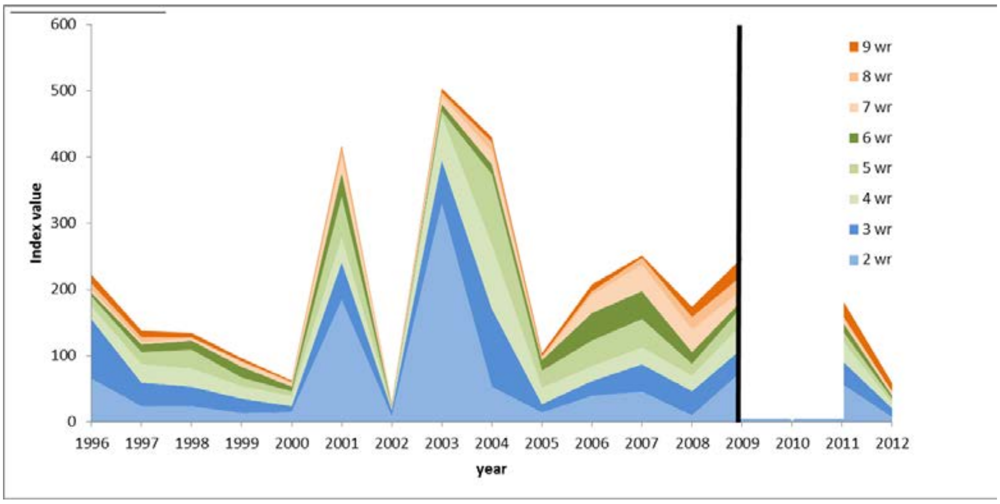


Figure 5.3.2.4. Herring in 6.a (combined) and 7.b and 7.c. Trends in stock composition from abundance at age index from Scottish ground fish survey in Quarter 4. The time series is only used in the assessment up to and including 2009 (black vertical line). There was no survey in 2010 and in 2013 only half of the survey was completed.

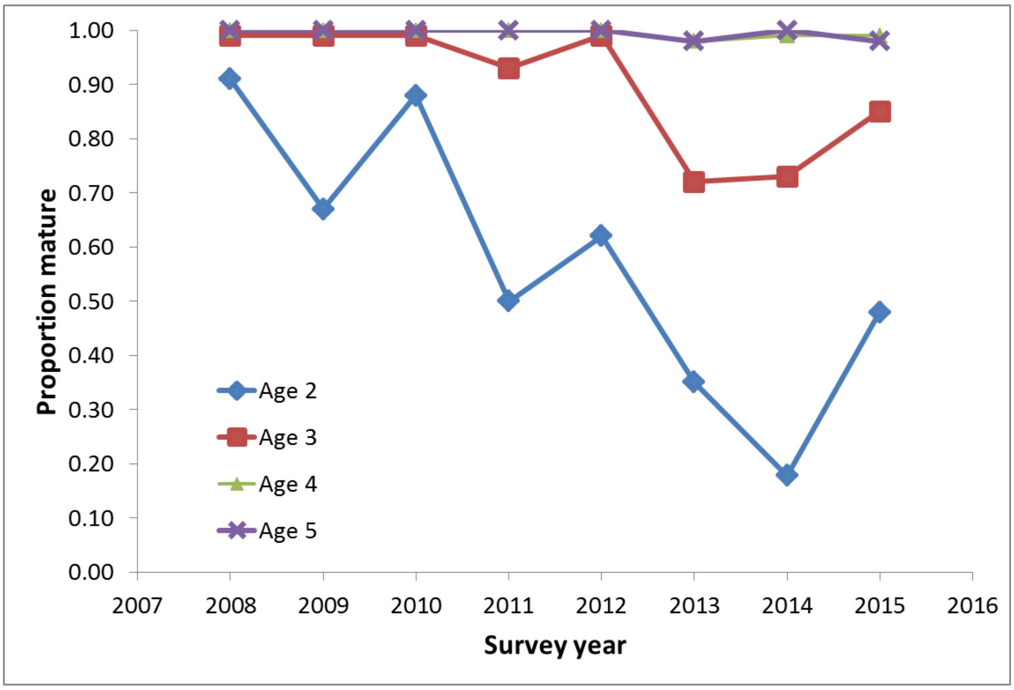


Figure 5.4.2.1. Herring in 6.a (combined) and 7.b and 7.c. Maturity ogive for the years 1993 to 2015.

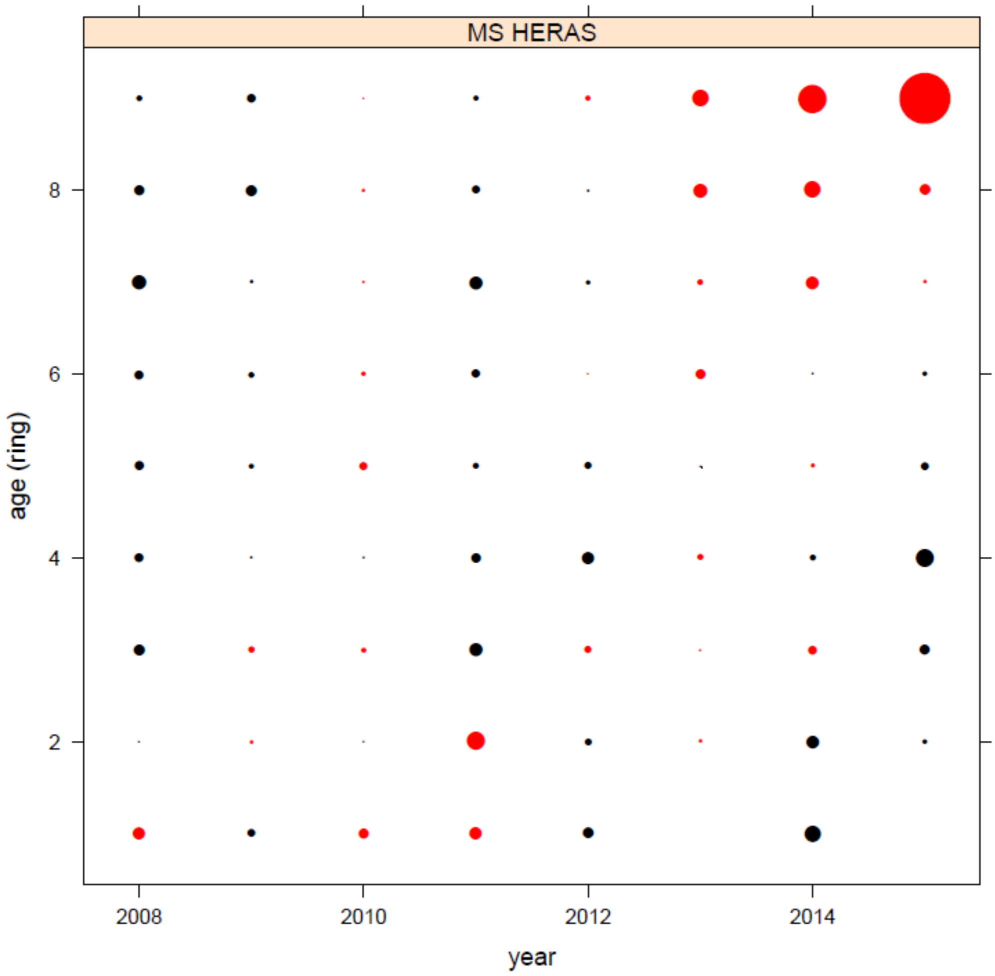


Figure 5.6.1: Herring in 6.a (combined) and 7.b and 7.c. Bubble plot of standardised survey residuals from the Malin Shelf acoustic survey (2008–2015).

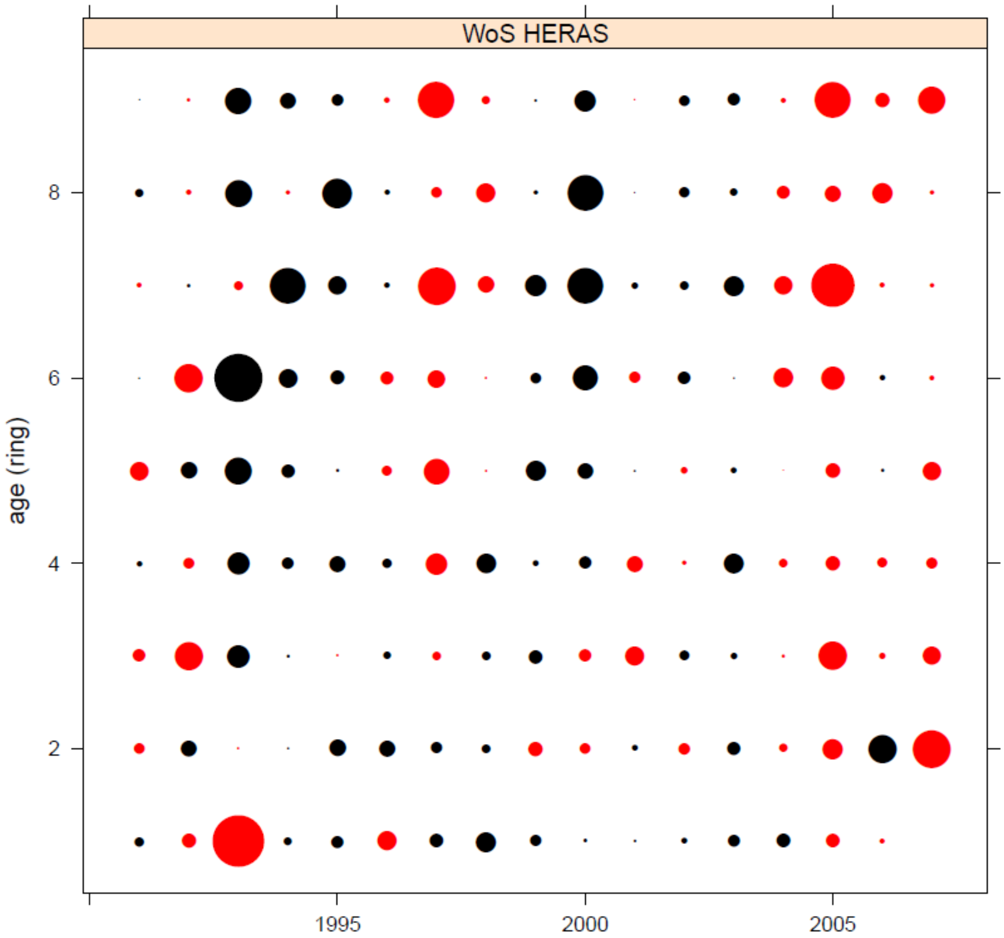


Figure 5.6.2: Herring in 6.a (combined) and 7.b and 7.c. Bubble plot of standardised survey residuals from the West of Scotland geographical area (6.aN) acoustic survey (1991–2007).

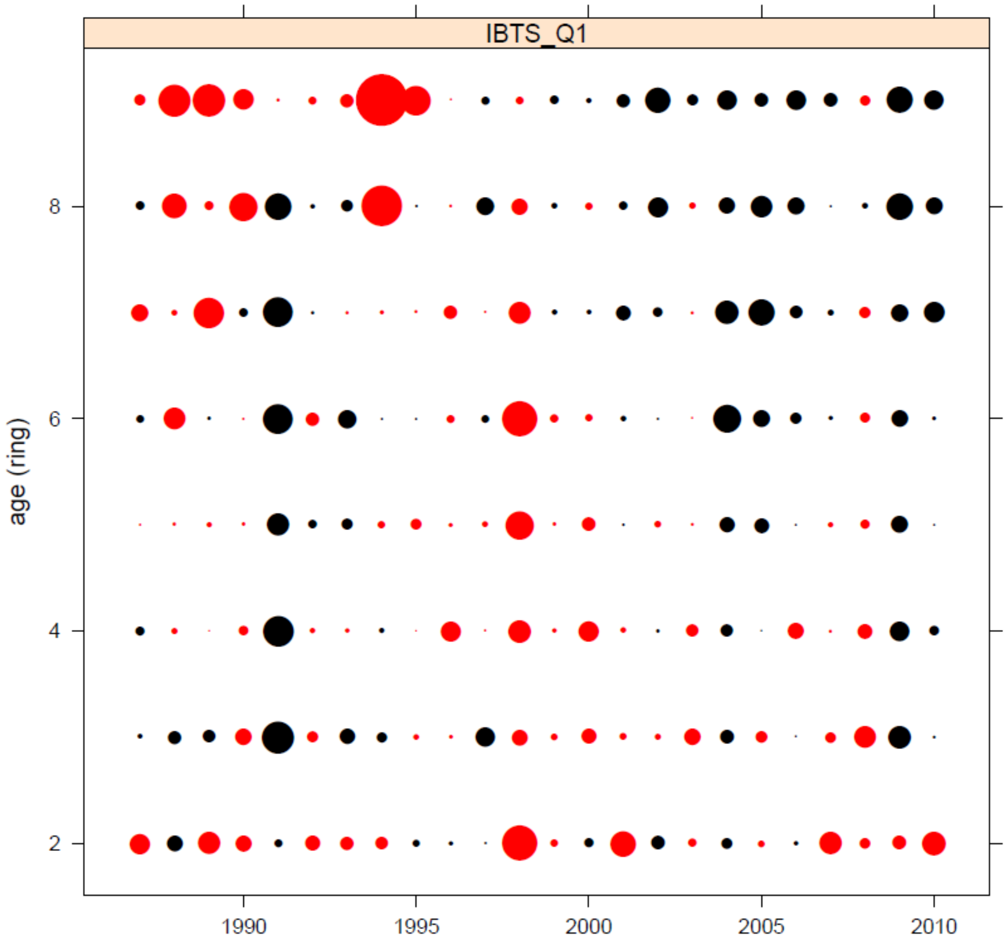


Figure 5.6.3: Herring in 6.a (combined) and 7.b and 7.c. Bubble plot of standardised survey residuals from the Scottish bottom trawl survey in quarter 1 (1987–2010).

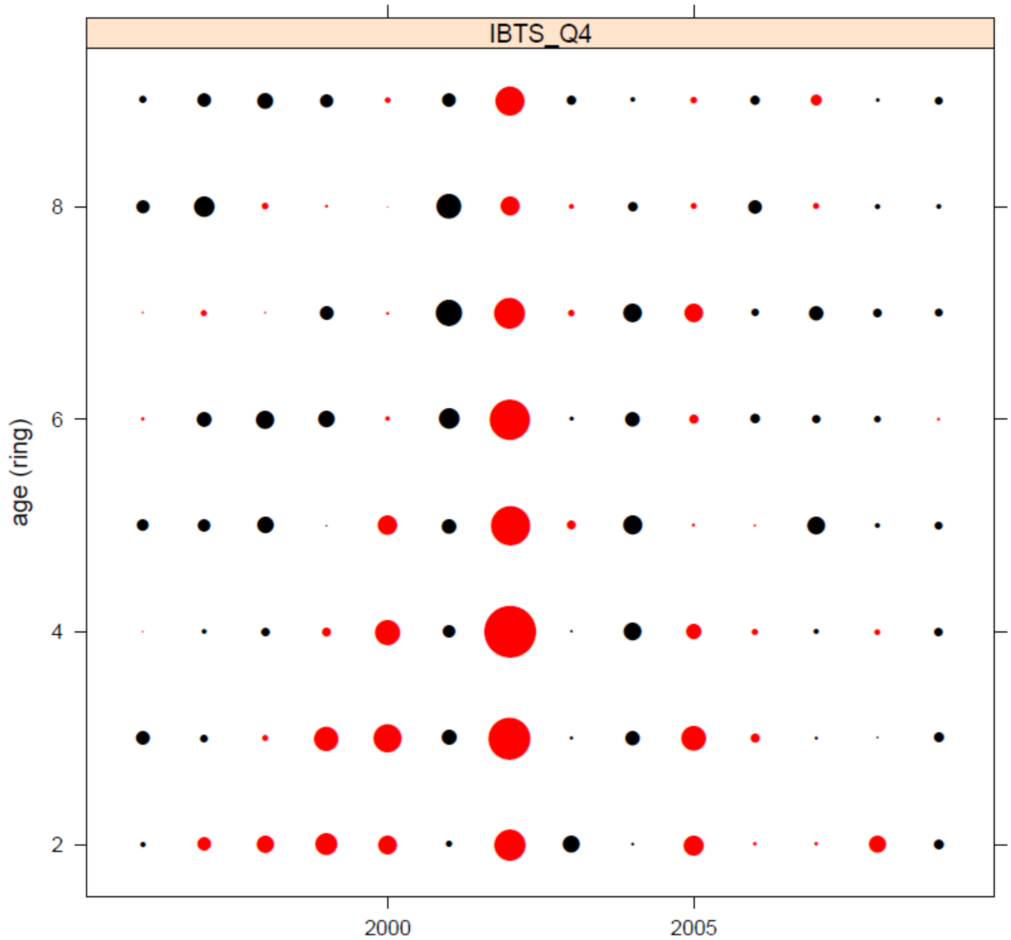


Figure 5.6.4: Herring in 6.a (combined) and 7.b and 7.c. Bubble plot of standardised survey residuals from the Scottish bottom trawl survey in quarter 4 (1996–2009).

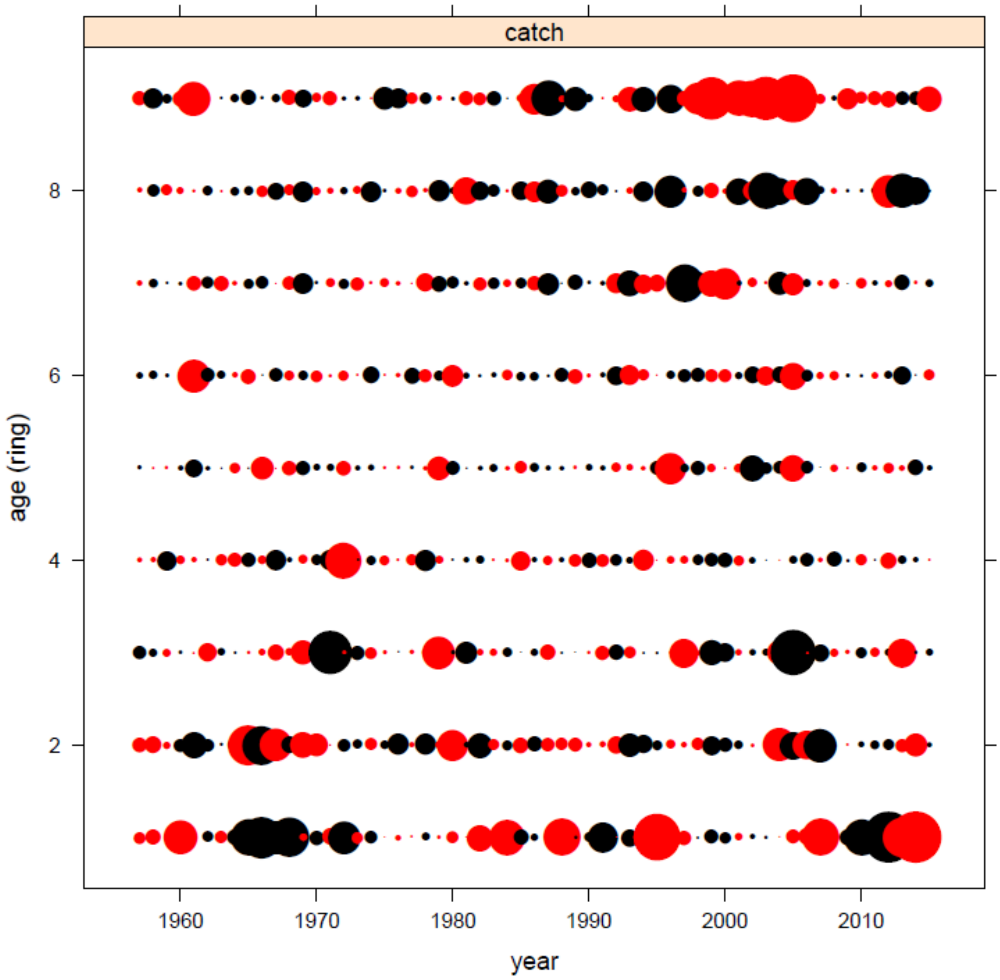


Figure 5.6.5: Herring in 6.a (combined) and 7.b and 7.c. Bubble plot of standardised catch residuals (1957–2015).

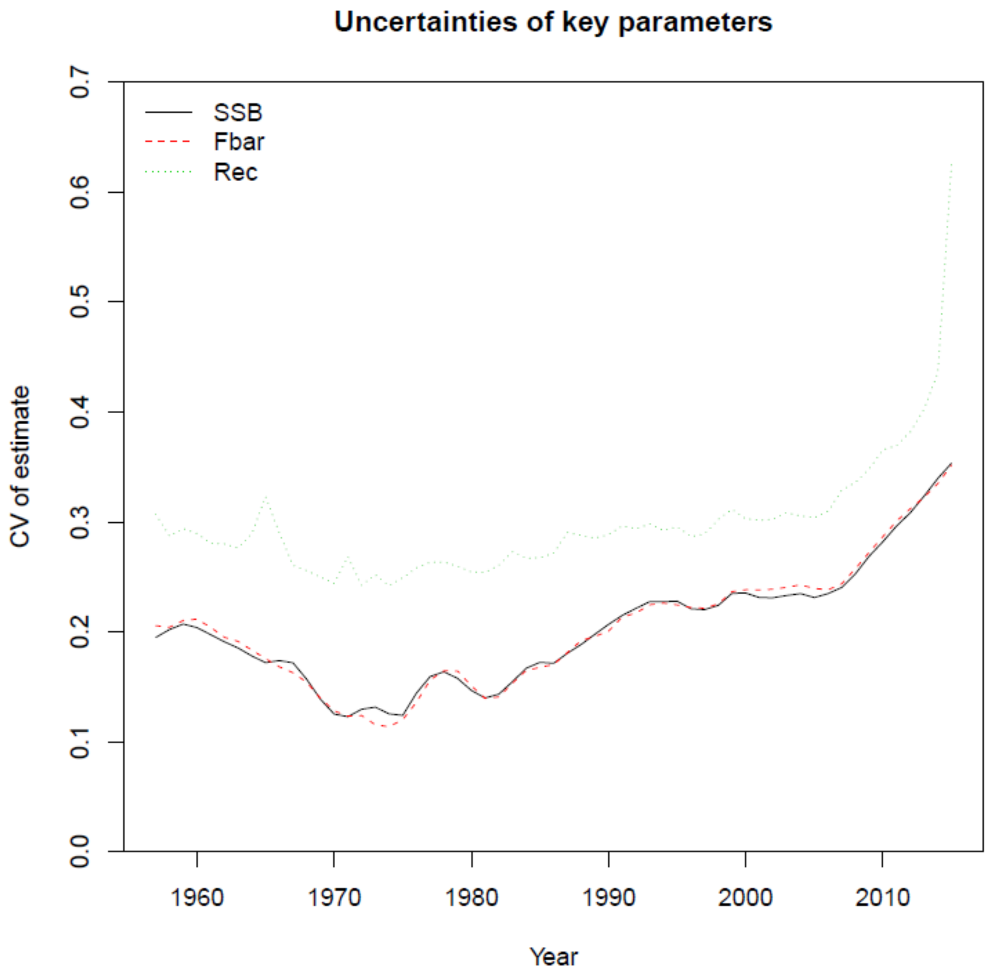


Figure 5.6.6: Herring in 6.a (combined) and 7.b and 7.c. Uncertainty estimates in SSB, F_{bar} and recruitment parameters (1957–2015).

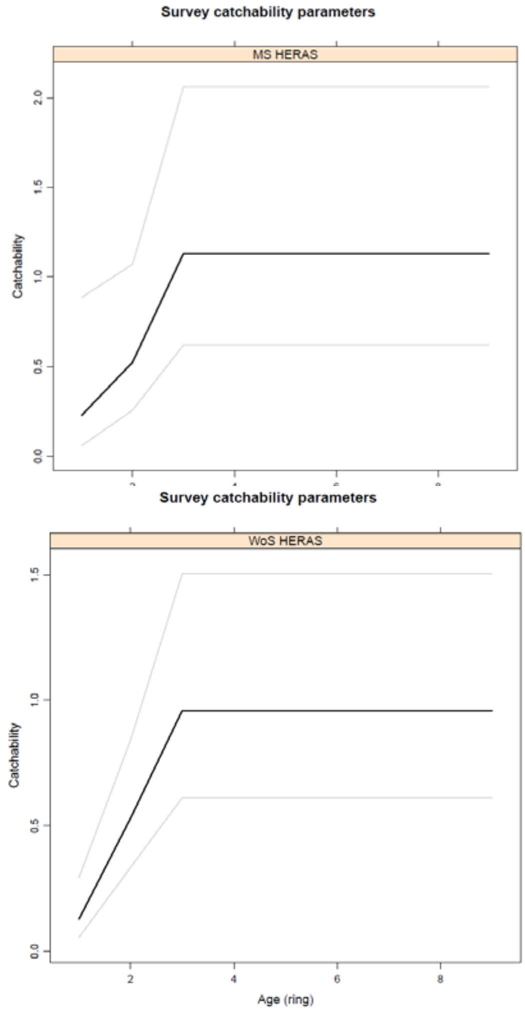


Figure 5.6.7: Herring in 6.a (combined) and 7.b and 7.c. Survey catchability parameters from the Malin Shelf acoustic survey (top) and the West of Scotland geographical area (6.aN) acoustic survey (bottom).

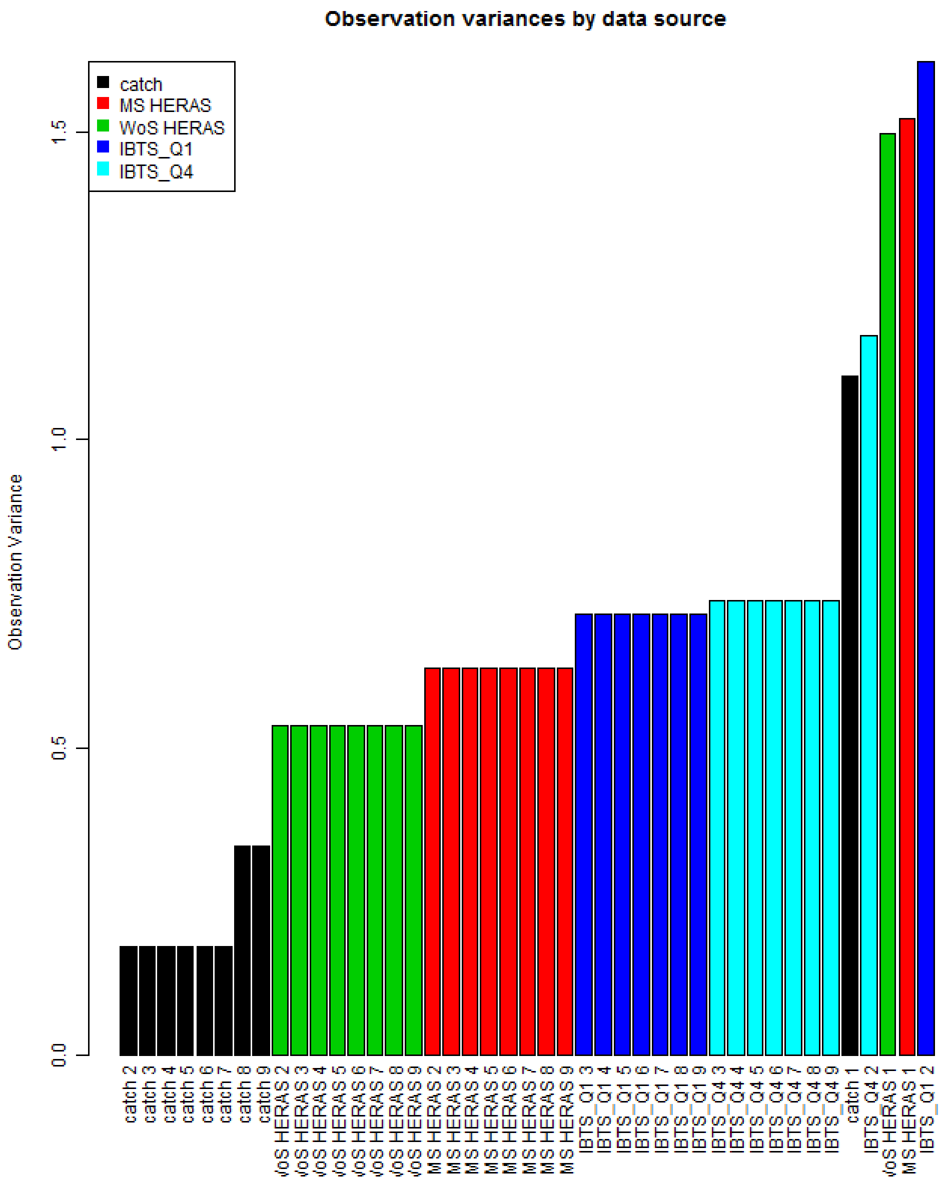


Figure 5.6.8: Herring in 6.a (combined) and 7.b and 7.c. Observation variance by data source - ordered from least (left) to most (right). Colours indicate the different data sources. In cases where parameters are bound, observation variances have equal values.

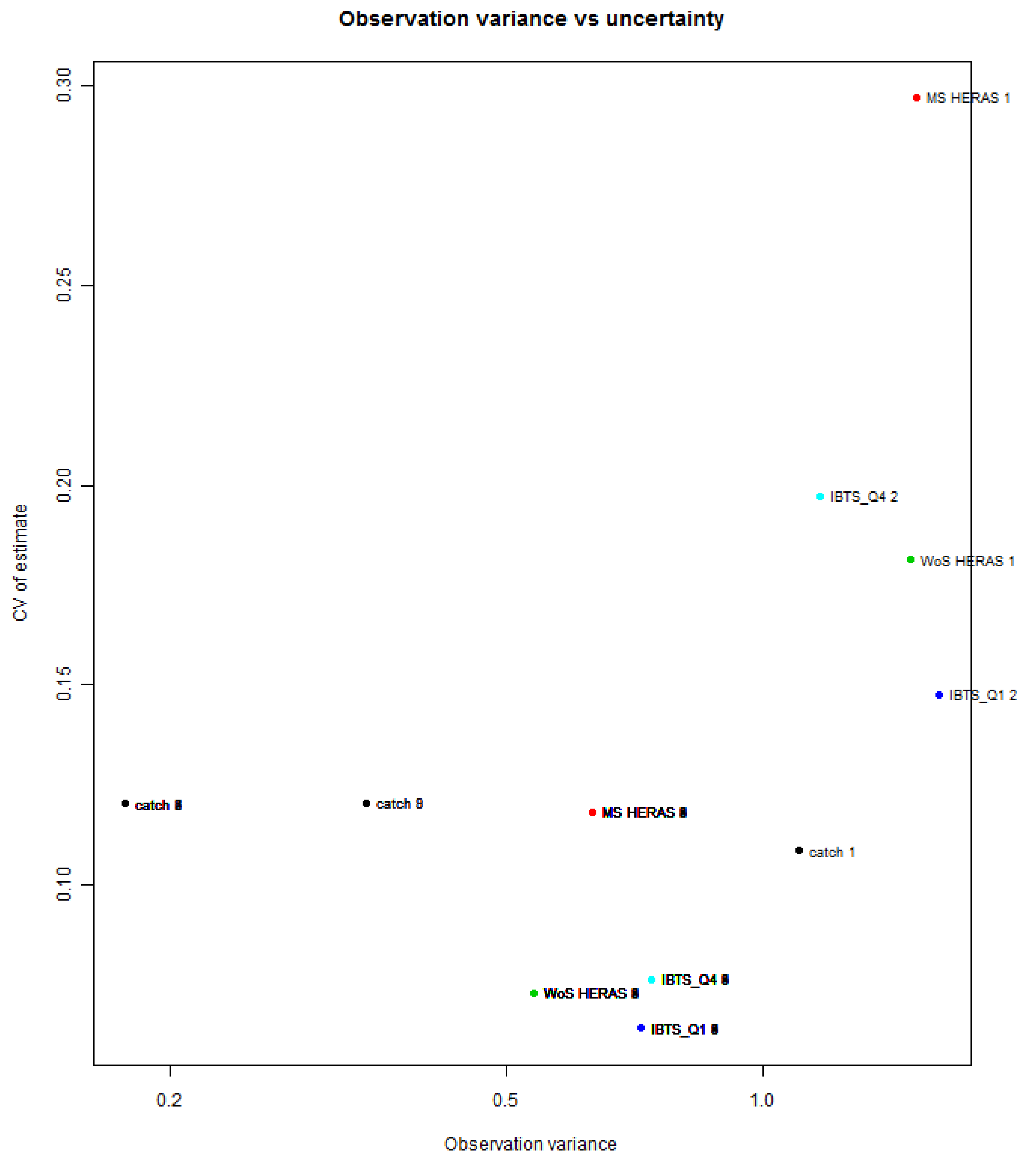


Figure 5.6.9: Herring in 6.a (combined) and 7.b and 7.c. Observation variance by data source as estimated by the assessment model plotted against the CV estimate of the observation variance parameter.

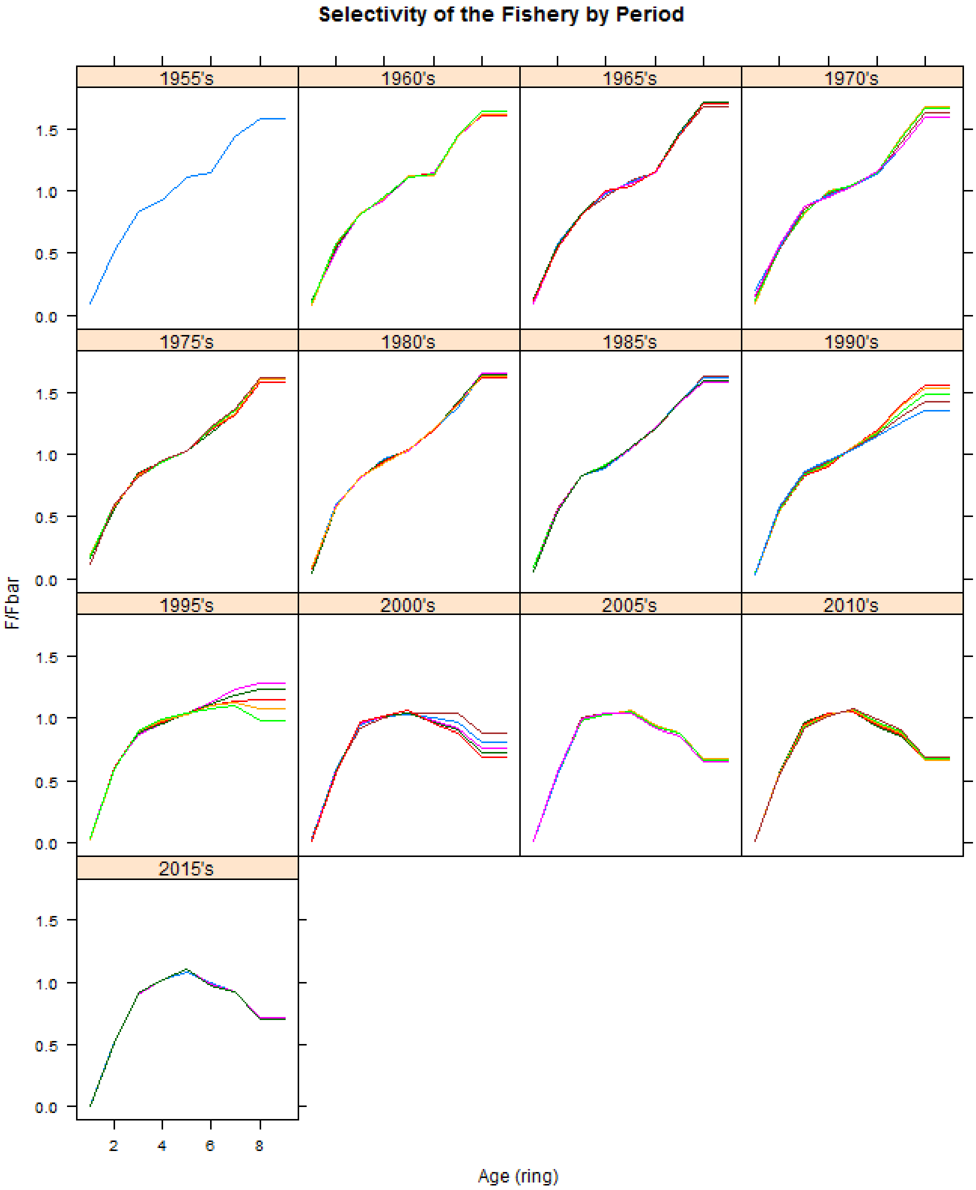


Figure 5.6.10: Herring in 6.a (combined) and 7.b and 7.c. Selectivity of the fishery at age (winter rings) by 5-year period.

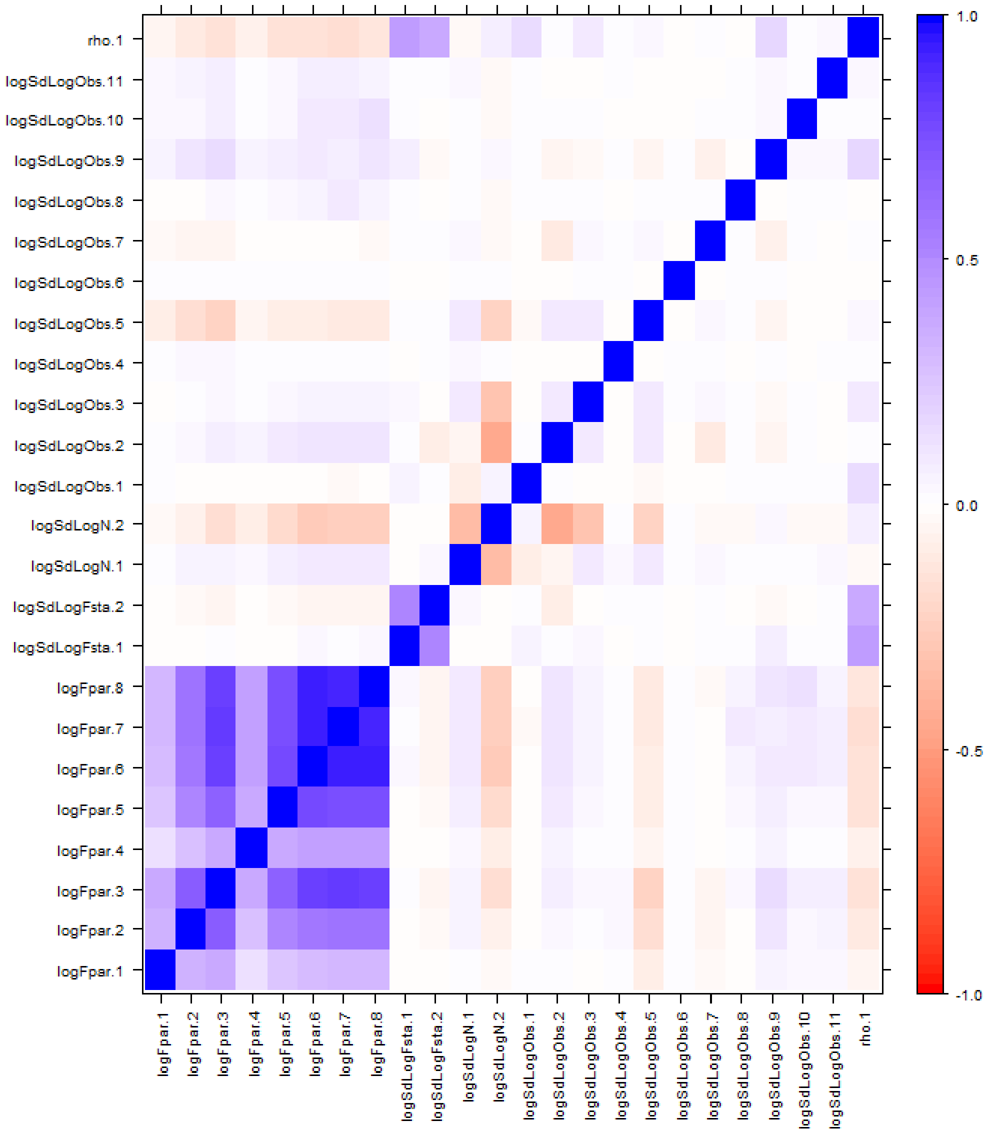


Figure 5.6.11: Herring in 6.a (combined) and 7.b and 7.c. Correlation plot of the parameters estimated in the model. The horizontal and vertical axes show the parameters fitted by the model (labelled with names stored and fitted by FLSAM). The colouring of each pixel indicates the Pearson correlation between the two parameters. The diagonal represents the correlation with the data source itself.

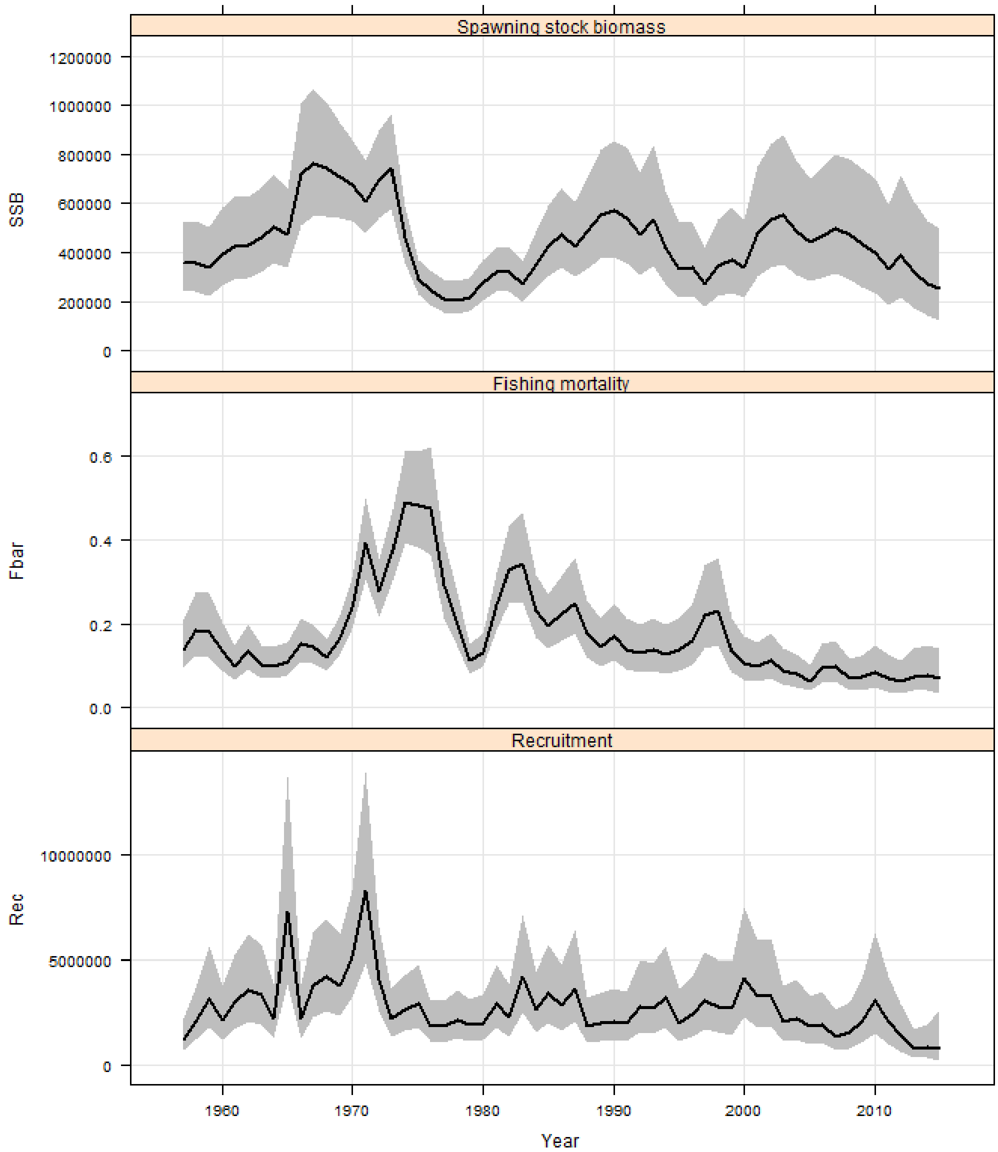


Figure 5.6.12: Herring in 6.a (combined) and 7.b and 7.c. Stock summary plot with associated uncertainty for SSB (top panel), F ages 2–6 (middle panel) and recruitment (bottom panel).

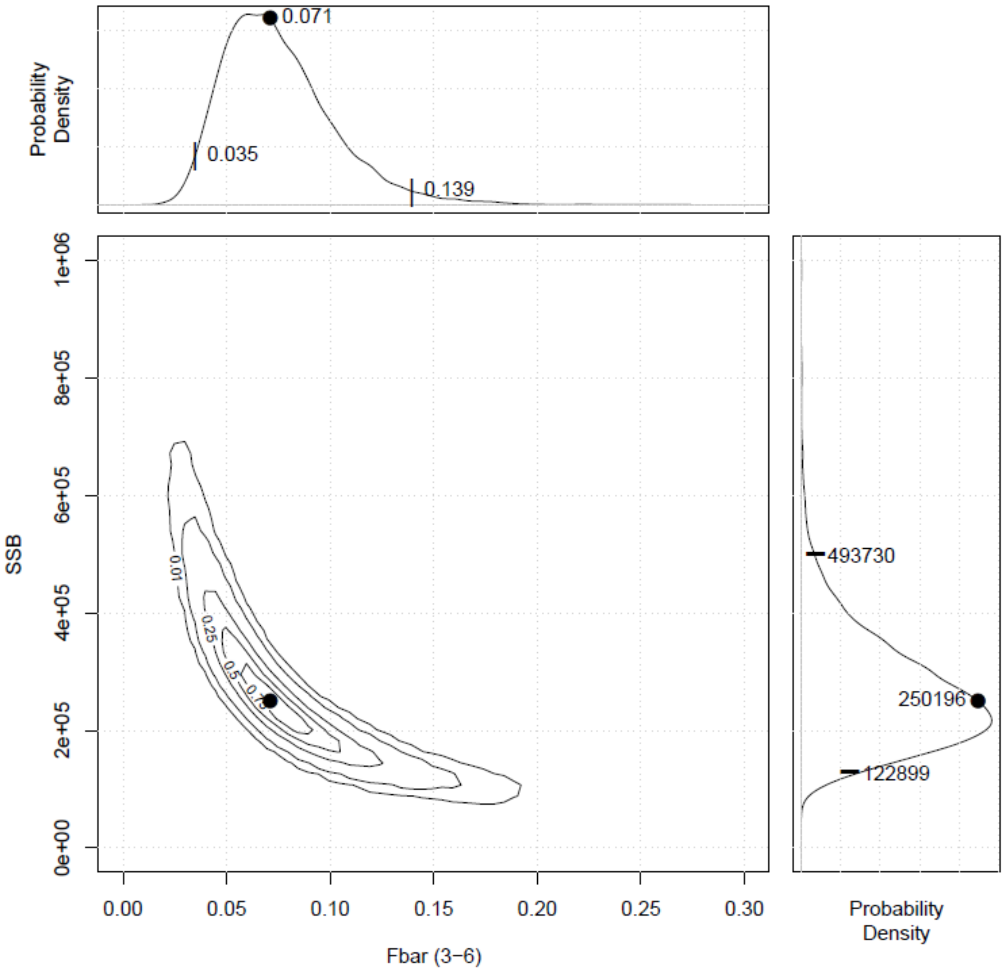


Figure 5.6.13: Herring in 6.a (combined) and 7.b and 7.c. Model uncertainty; distribution and quantiles of estimated SSB and F3–6 in the terminal year of the assessment. Estimates of precision are based on a parametric bootstrap from the model estimated variance/covariance estimates.

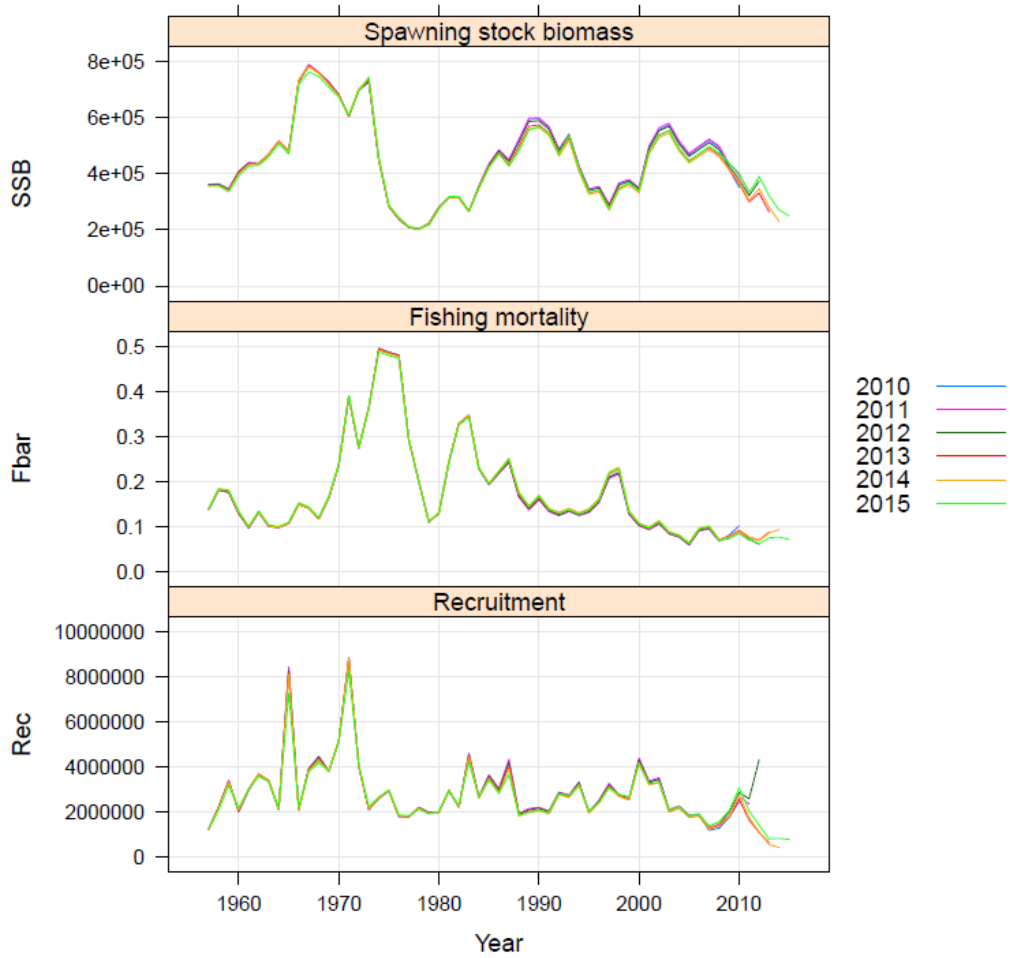


Figure 5.6.14: Herring in 6.a (combined) and 7.b and 7.c. Analytical retrospective of the estimated spawning stock biomass (top panel), fishing mortality (middle panel) and recruitment (bottom panel) as estimated over the years 2010–2015.

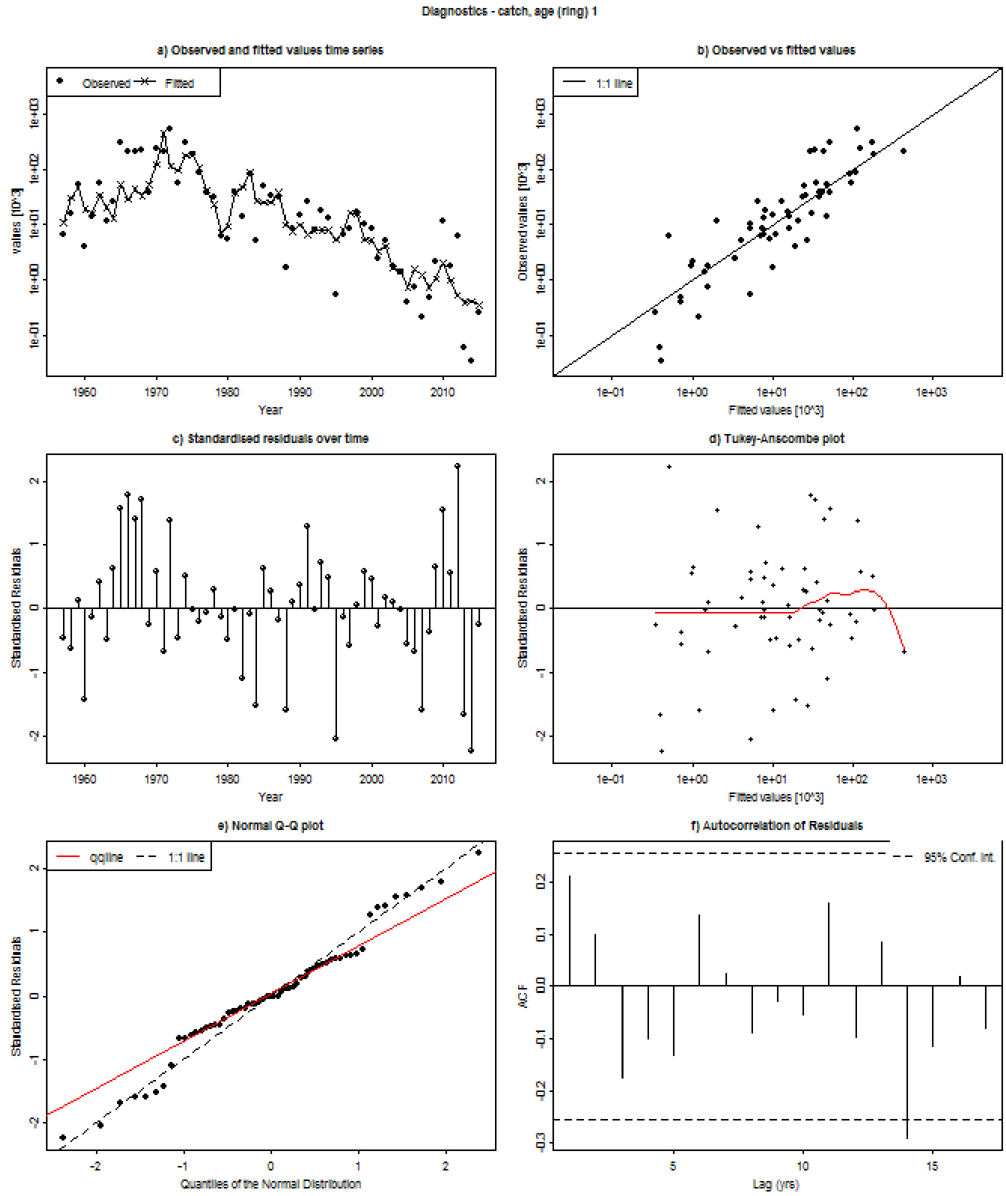


Figure 5.6.15: Herring in 6.a (combined) and 7.b and 7.c. Diagnostics of the assessment model fit to the catch at 1-winter ring time series. Top left: Estimates of numbers at 1-winter ring (line) and numbers predicted from catch abundance at 1-winter ring. Top right: scatterplot of catch observations versus assessment model estimates of numbers at 1-winter ring with the best-fit catchability model (linear function). Middle left: Time series of standardized residuals of the catch at 1-winter ring. Middle right: catch observation versus standardized residuals at 1-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

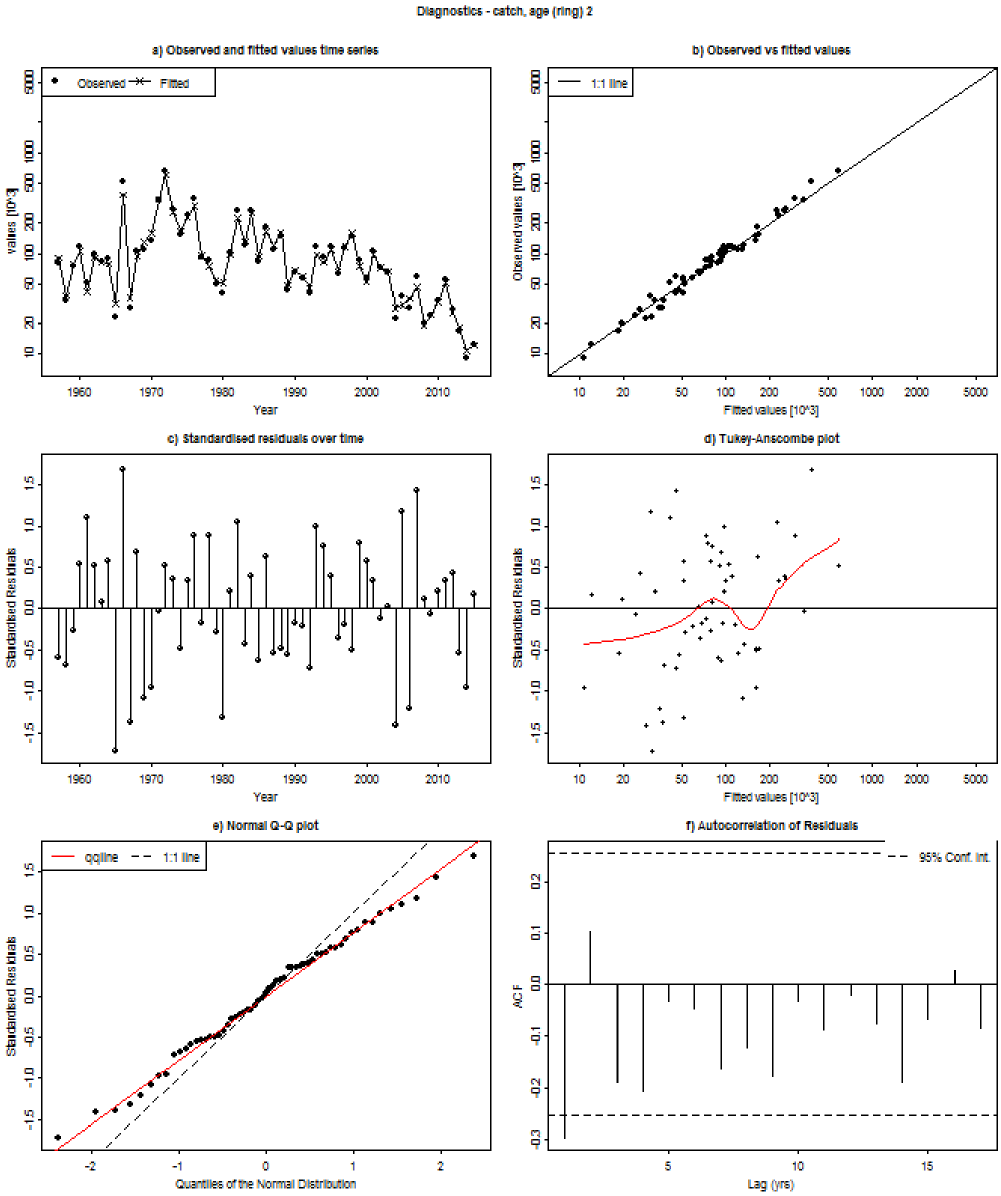


Figure 5.6.16: Herring in 6.a (combined) and 7.b and 7.c. Diagnostics of the assessment model fit to the catch at 2-winter ring time series. Top left: Estimates of numbers at 2-winter ring (line) and numbers predicted from catch abundance at 2-winter ring. Top right: scatterplot of catch observations versus assessment model estimates of numbers at 2-winter ring with the best-fit catchability model (linear function). Middle left: Time series of standardized residuals of the catch at 2-winter ring. Middle right: catch observation versus standardized residuals at 2-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

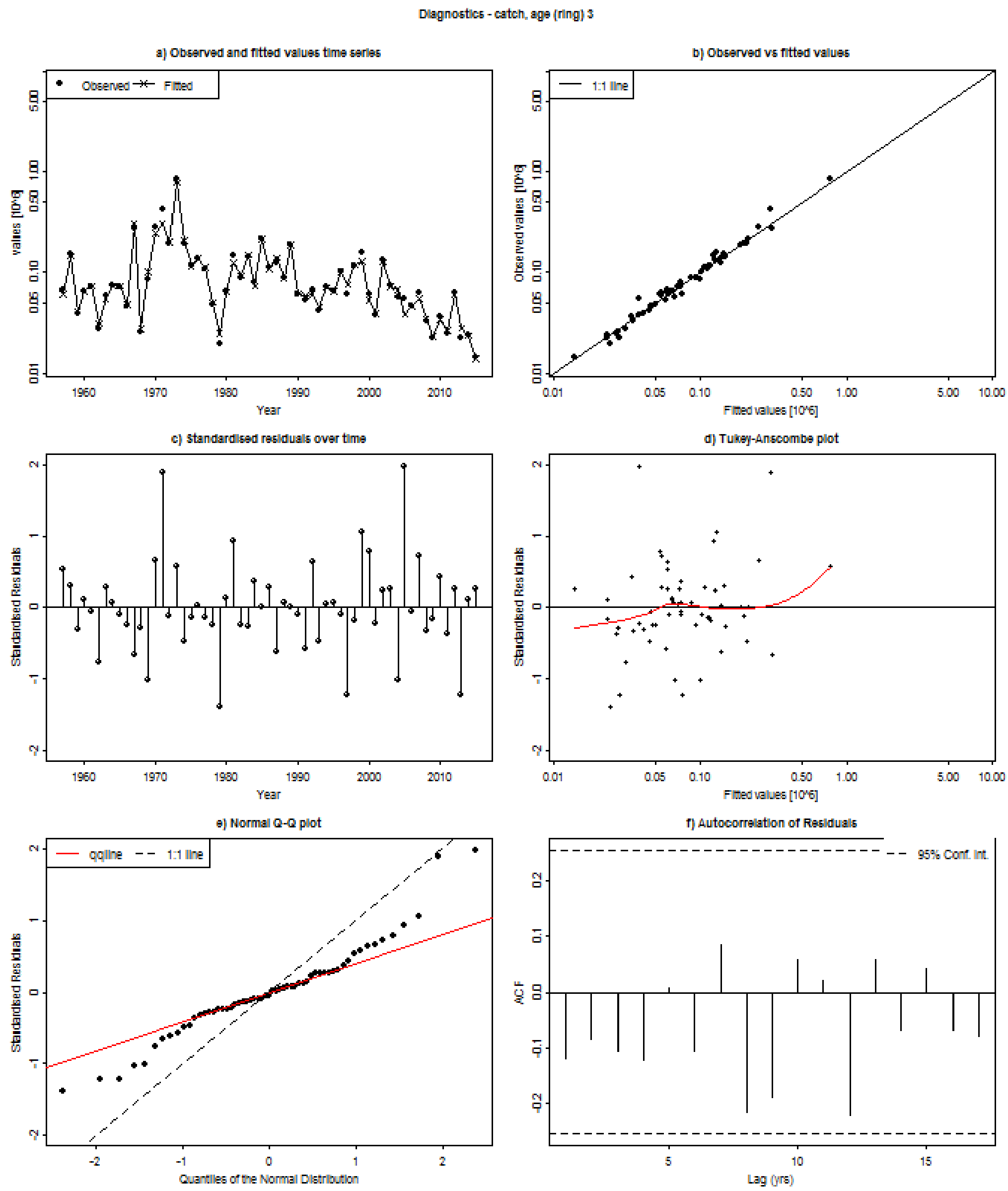


Figure 5.6.17: Herring in 6.a (combined) and 7.b and 7.c. Diagnostics of the assessment model fit to the catch at 3-winter ring time series. Top left: Estimates of numbers at 3-winter ring (line) and numbers predicted from catch abundance at 3-winter ring. Top right: scatterplot of catch observations versus assessment model estimates of numbers at 3-winter ring with the best-fit catchability model (linear function). Middle left: Time series of standardized residuals of the catch at 3-winter ring. Middle right: catch observation versus standardized residuals at 3-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

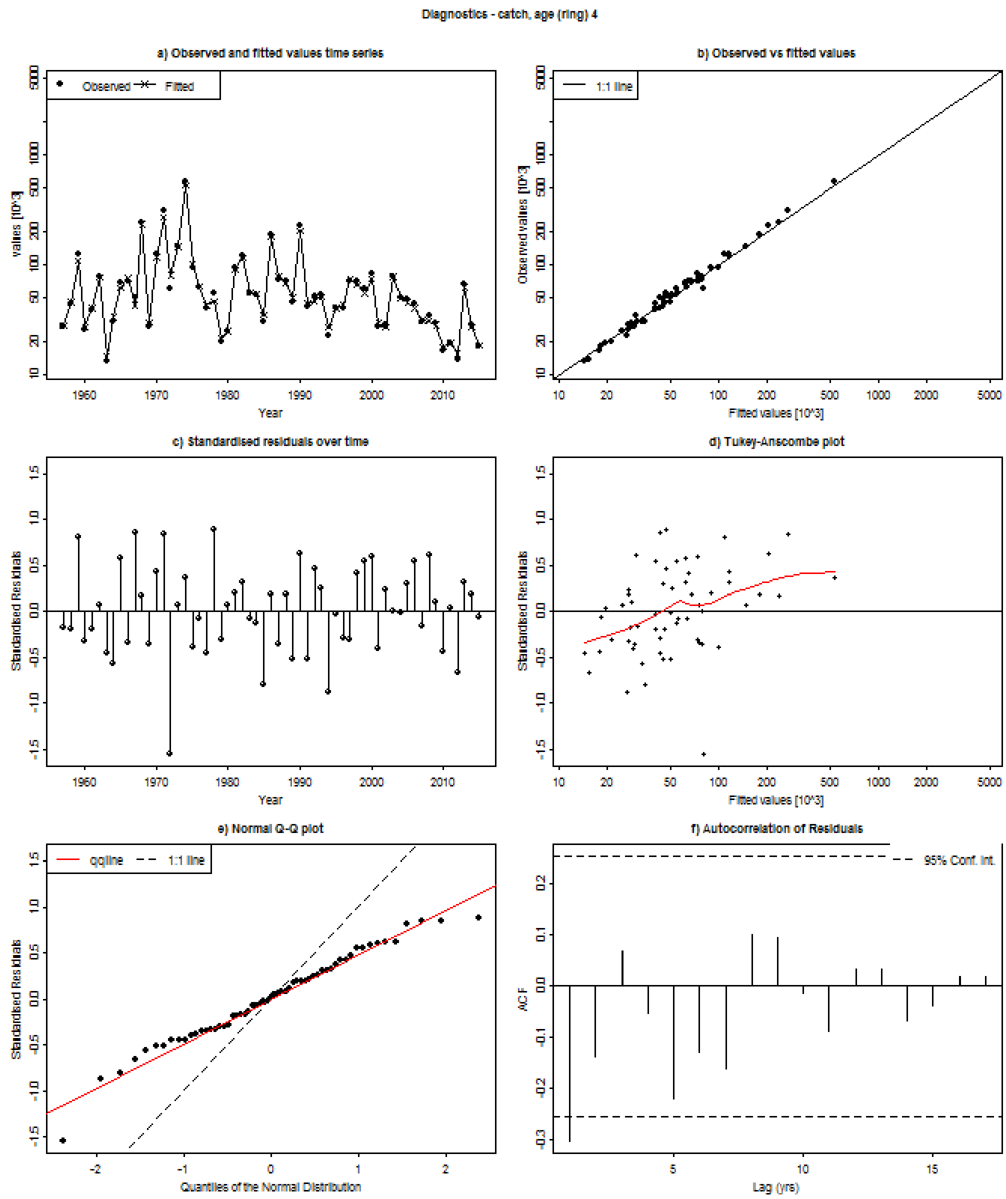


Figure 5.6.18: Herring in 6.a (combined) and 7.b and 7.c. Diagnostics of the assessment model fit to the catch at 4-winter ring time series. Top left: Estimates of numbers at 4-winter ring (line) and numbers predicted from catch abundance at 4-winter ring. Top right: scatterplot of catch observations versus assessment model estimates of numbers at 4-winter ring with the best-fit catchability model (linear function). Middle left: Time series of standardized residuals of the catch at 4-winter ring. Middle right: catch observation versus standardized residuals at 4-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

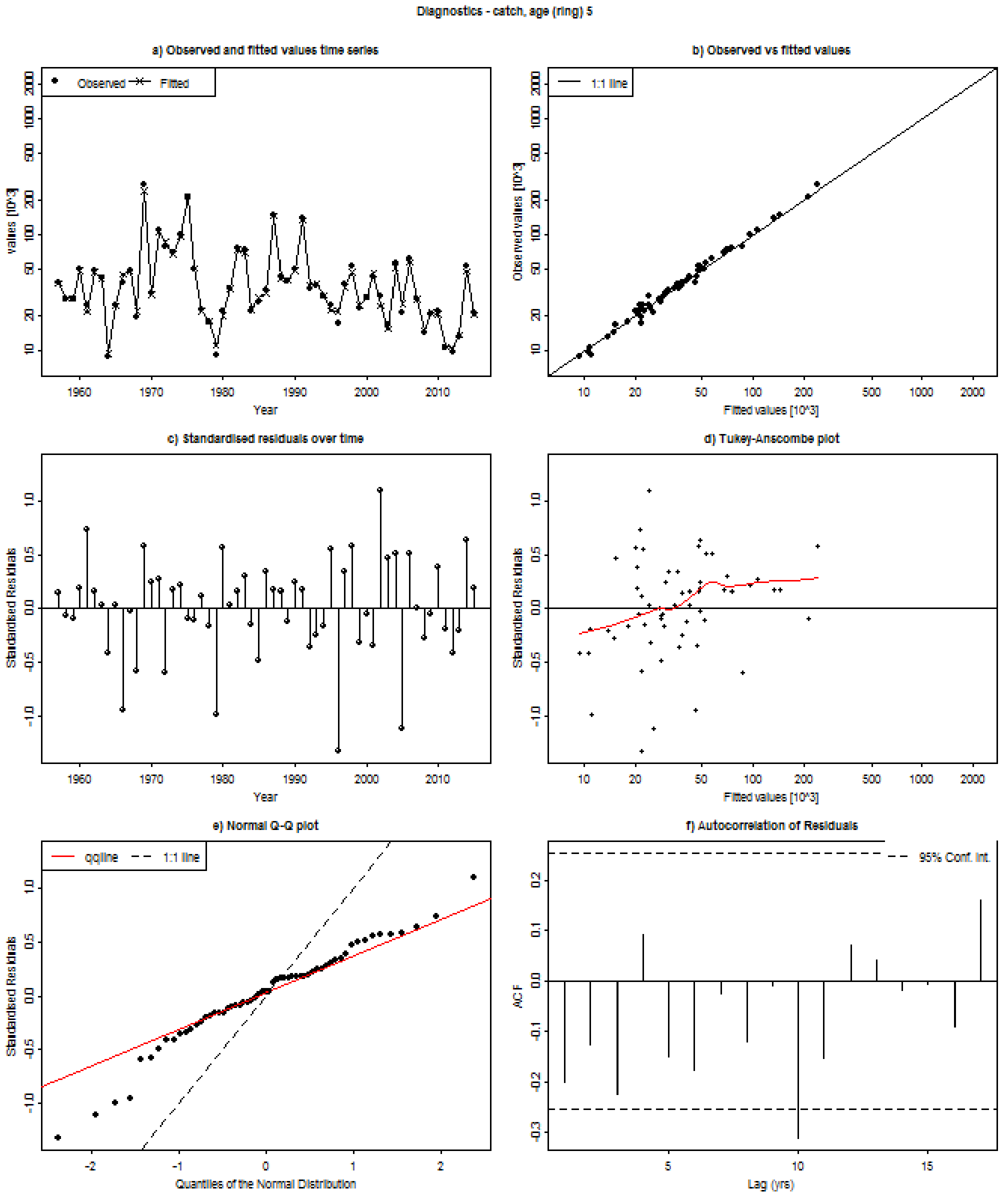


Figure 5.6.19: Herring in 6.a (combined) and 7.b and 7.c. Diagnostics of the assessment model fit to the catch at 5-winter ring time series. Top left: Estimates of numbers at 5-winter ring (line) and numbers predicted from catch abundance at 5-winter ring. Top right: scatterplot of catch observations versus assessment model estimates of numbers at 5-winter ring with the best-fit catchability model (linear function). Middle left: Time series of standardized residuals of the catch at 5-winter ring. Middle right: catch observation versus standardized residuals at 5-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

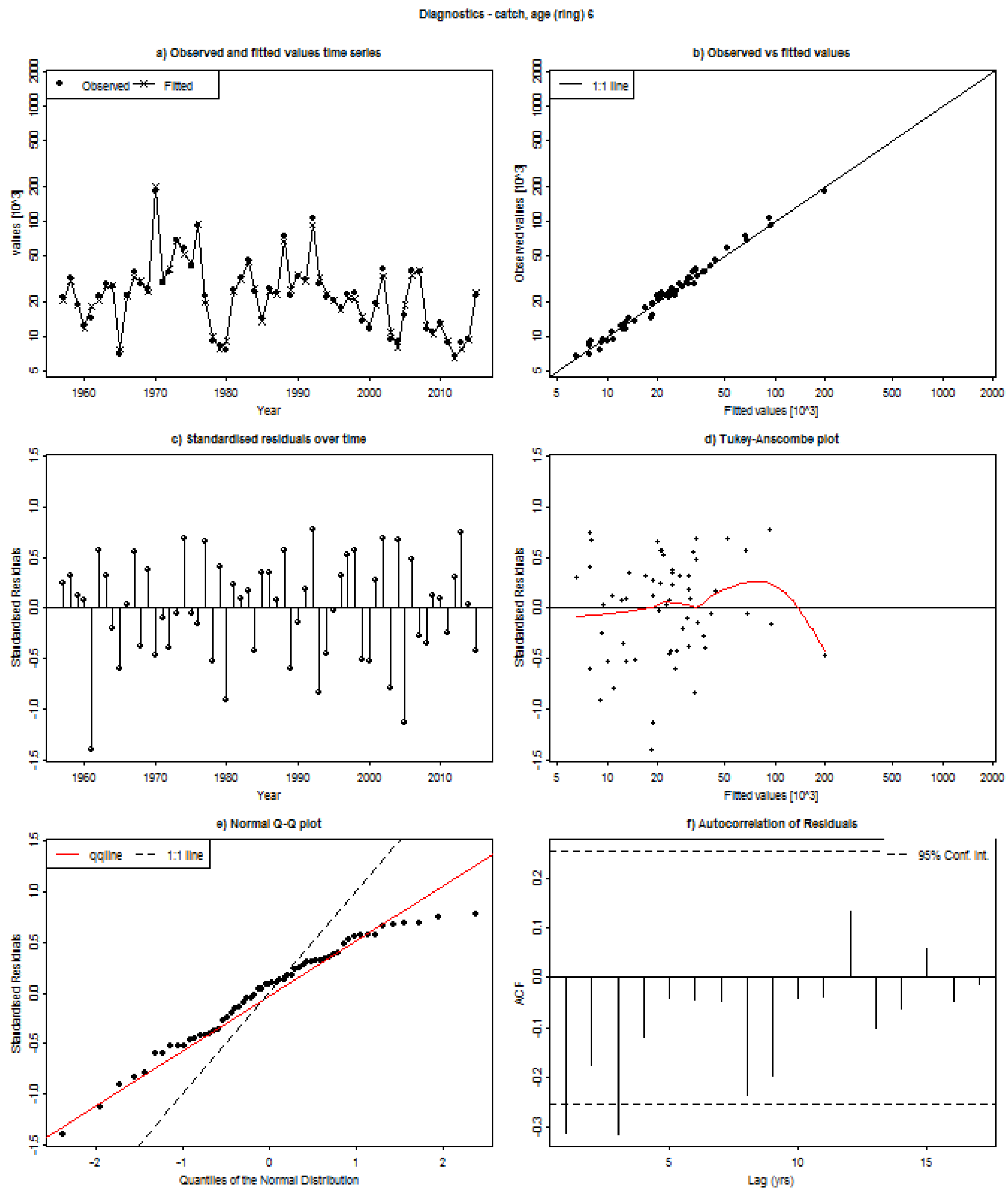


Figure 5.6.20: Herring in 6.a (combined) and 7.b and 7.c. Diagnostics of the assessment model fit to the catch at 6-winter ring time series. Top left: Estimates of numbers at 6-winter ring (line) and numbers predicted from catch abundance at 6-winter ring. Top right: scatterplot of catch observations versus assessment model estimates of numbers at 6-winter ring with the best-fit catchability model (linear function). Middle left: Time series of standardized residuals of the catch at 6-winter ring. Middle right: catch observation versus standardized residuals at 6-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

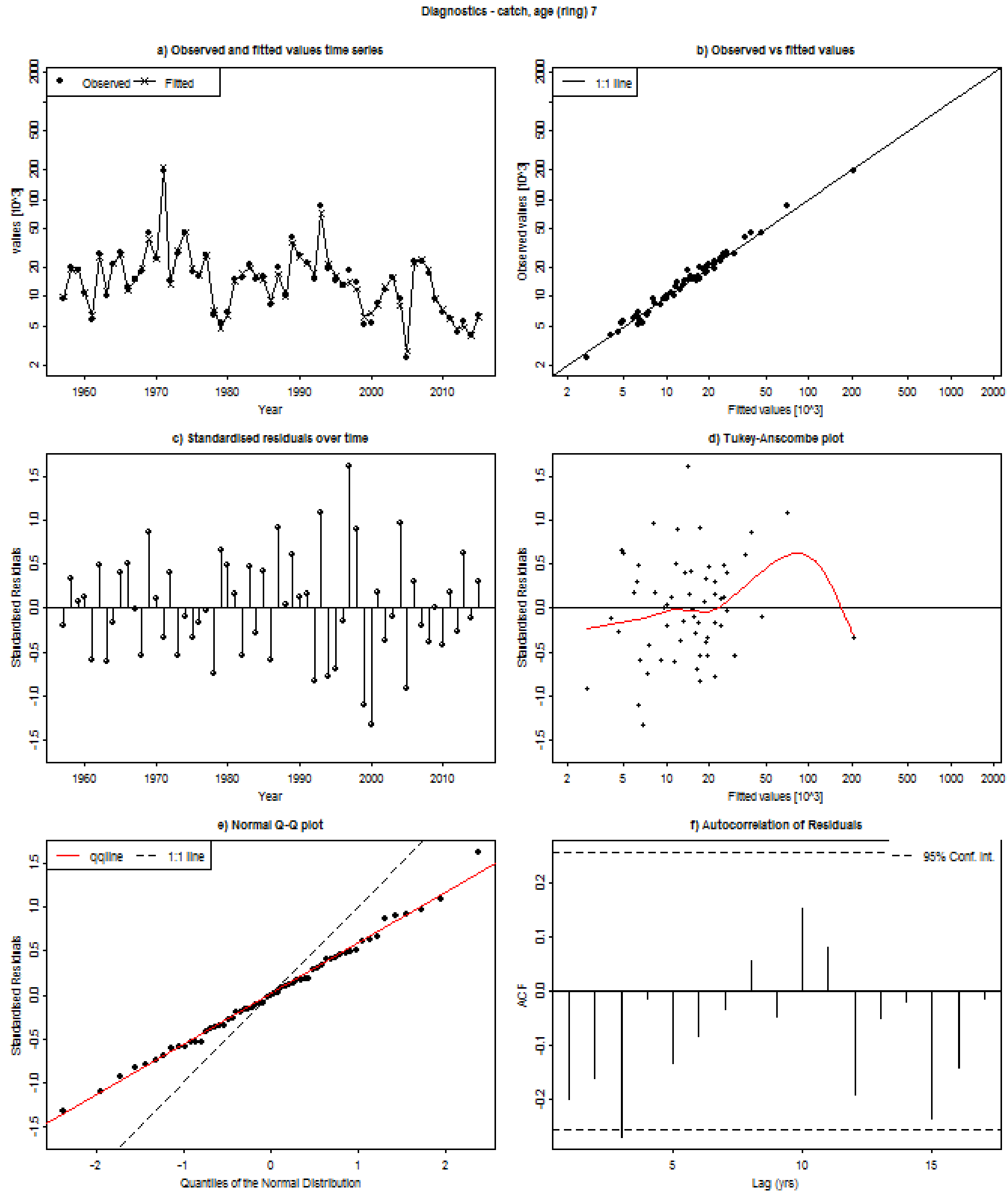


Figure 5.6.21: Herring in 6.a (combined) and 7.b and 7.c. Diagnostics of the assessment model fit to the catch at 7-winter ring time series. Top left: Estimates of numbers at 7-winter ring (line) and numbers predicted from catch abundance at 7-winter ring. Top right: scatterplot of catch observations versus assessment model estimates of numbers at 7-winter ring with the best-fit catchability model (linear function). Middle left: Time series of standardized residuals of the catch at 7-winter ring. Middle right: catch observation versus standardized residuals at 7-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

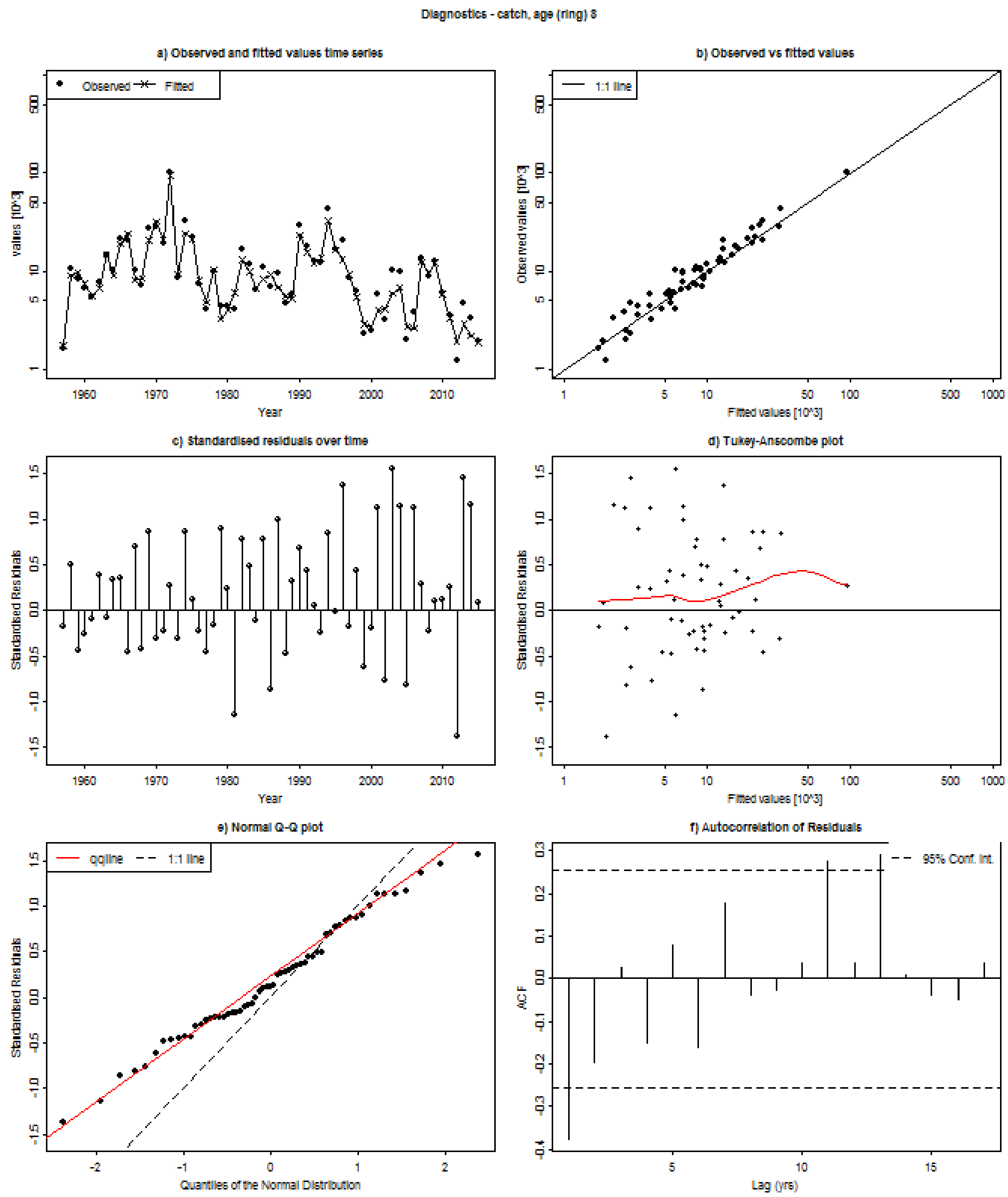


Figure 5.6.22: Herring in 6.a (combined) and 7.b and 7.c. Diagnostics of the assessment model fit to the catch at 8-winter ring time series. Top left: Estimates of numbers at 8-winter ring (line) and numbers predicted from catch abundance at 8-winter ring. Top right: scatterplot of catch observations versus assessment model estimates of numbers at 8-winter ring with the best-fit catchability model (linear function). Middle left: Time series of standardized residuals of the catch at 8-winter ring. Middle right: catch observation versus standardized residuals at 8-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

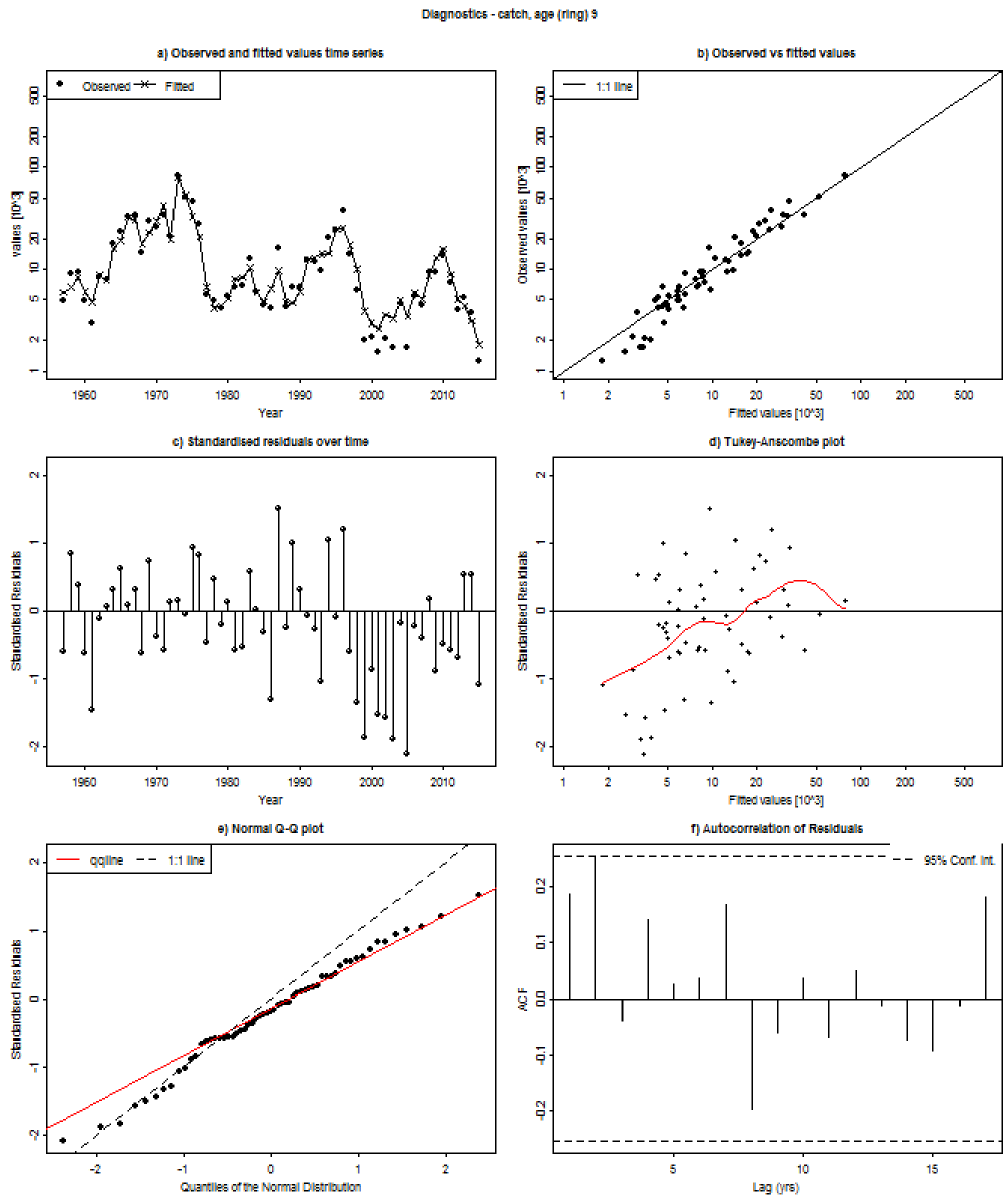


Figure 5.6.23: Herring in 6.a (combined) and 7.b and 7.c. Diagnostics of the assessment model fit to the catch at 9-winter ring time series. Top left: Estimates of numbers at 9-winter ring (line) and numbers predicted from catch abundance at 9-winter ring. Top right: scatterplot of catch observations versus assessment model estimates of numbers at 9-winter ring with the best-fit catchability model (linear function). Middle left: Time series of standardized residuals of the catch at 9-winter ring. Middle right: catch observation versus standardized residuals at 9-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

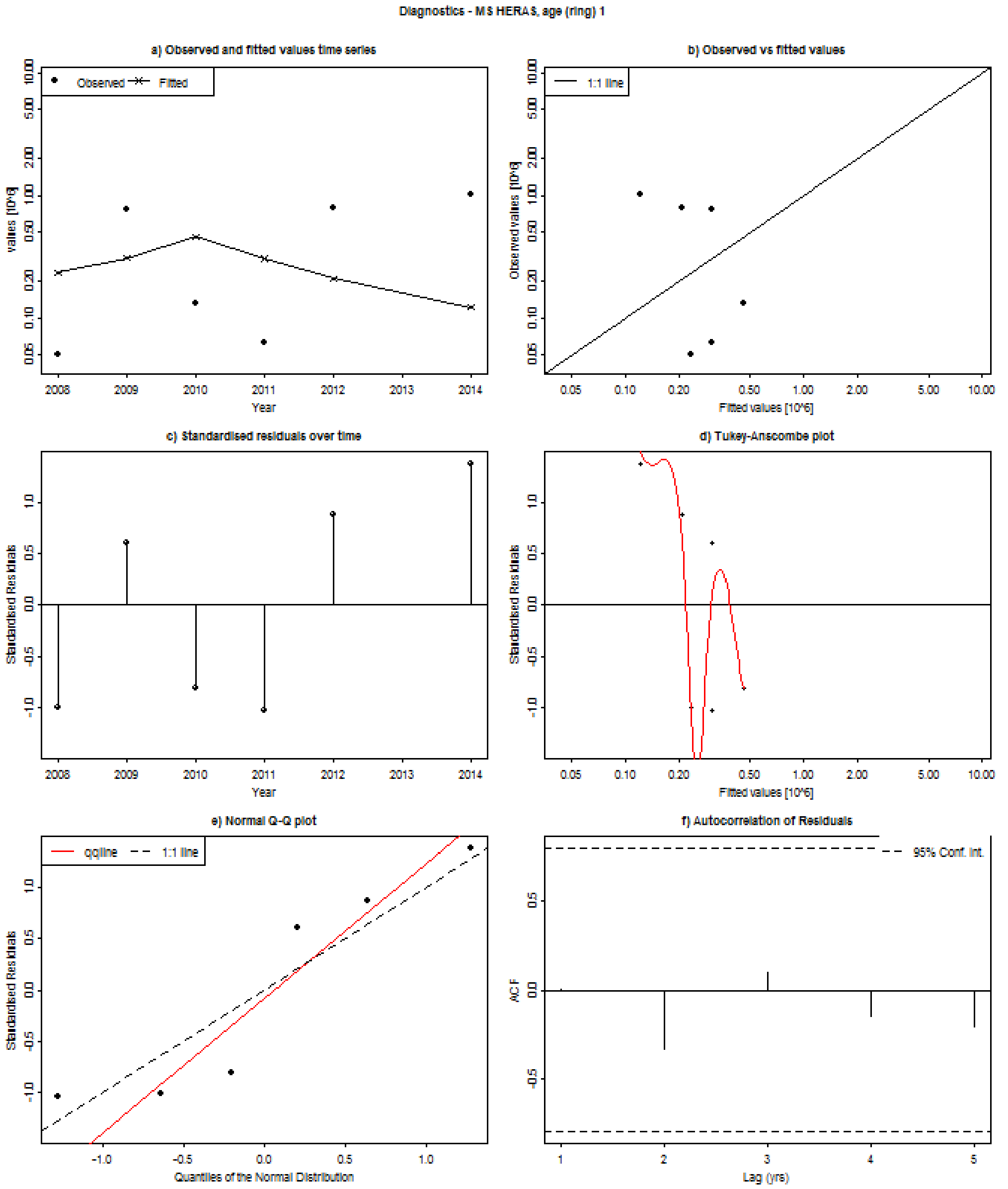


Figure 5.6.24: Herring in 6.a (combined) and 7.b and 7.c. Diagnostics of the assessment model fit to the Malin Shelf acoustic survey index at 1-winter ring time series. Top left: Estimates of numbers at 1-winter ring (line) and numbers predicted from index abundance at 1-winter ring. Top right: scatterplot of index observations versus assessment model estimates of numbers at 1-winter ring with the best-fit catchability model (linear function). Middle left: Time series of standardized residuals of the index at 1-winter ring. Middle right: index observation versus standardized residuals at 1-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

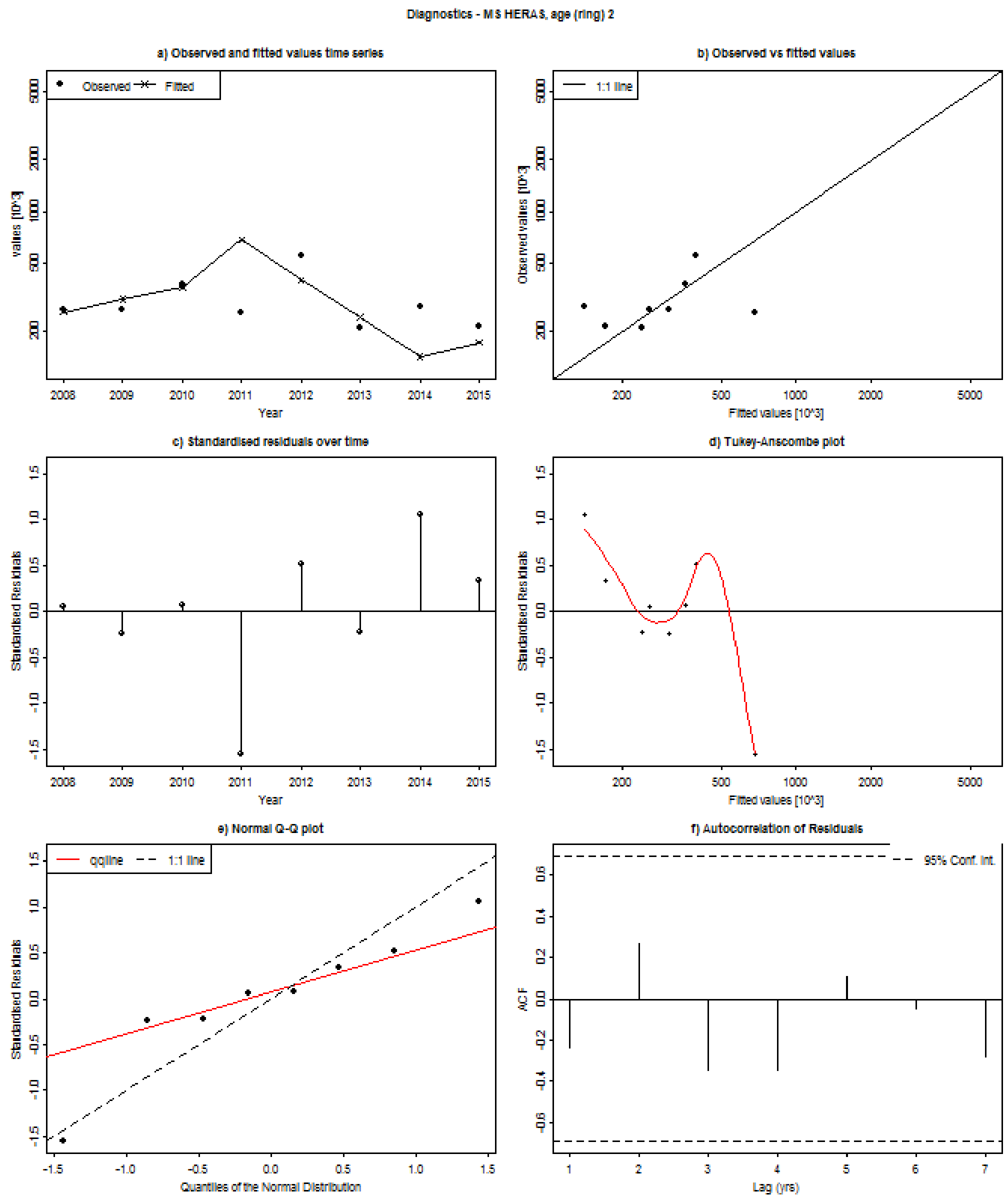


Figure 5.6.25: Herring in 6.a (combined) and 7.b and 7.c. Diagnostics of the assessment model fit to the Malin Shelf acoustic survey index at 2-winter ring time series. Top left: Estimates of numbers at 2-winter ring (line) and numbers predicted from index abundance at 2-winter ring. Top right: scatterplot of index observations versus assessment model estimates of numbers at 2-winter ring with the best-fit catchability model (linear function). Middle left: Time series of standardized residuals of the index at 2-winter ring. Middle right: index observation versus standardized residuals at 2-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

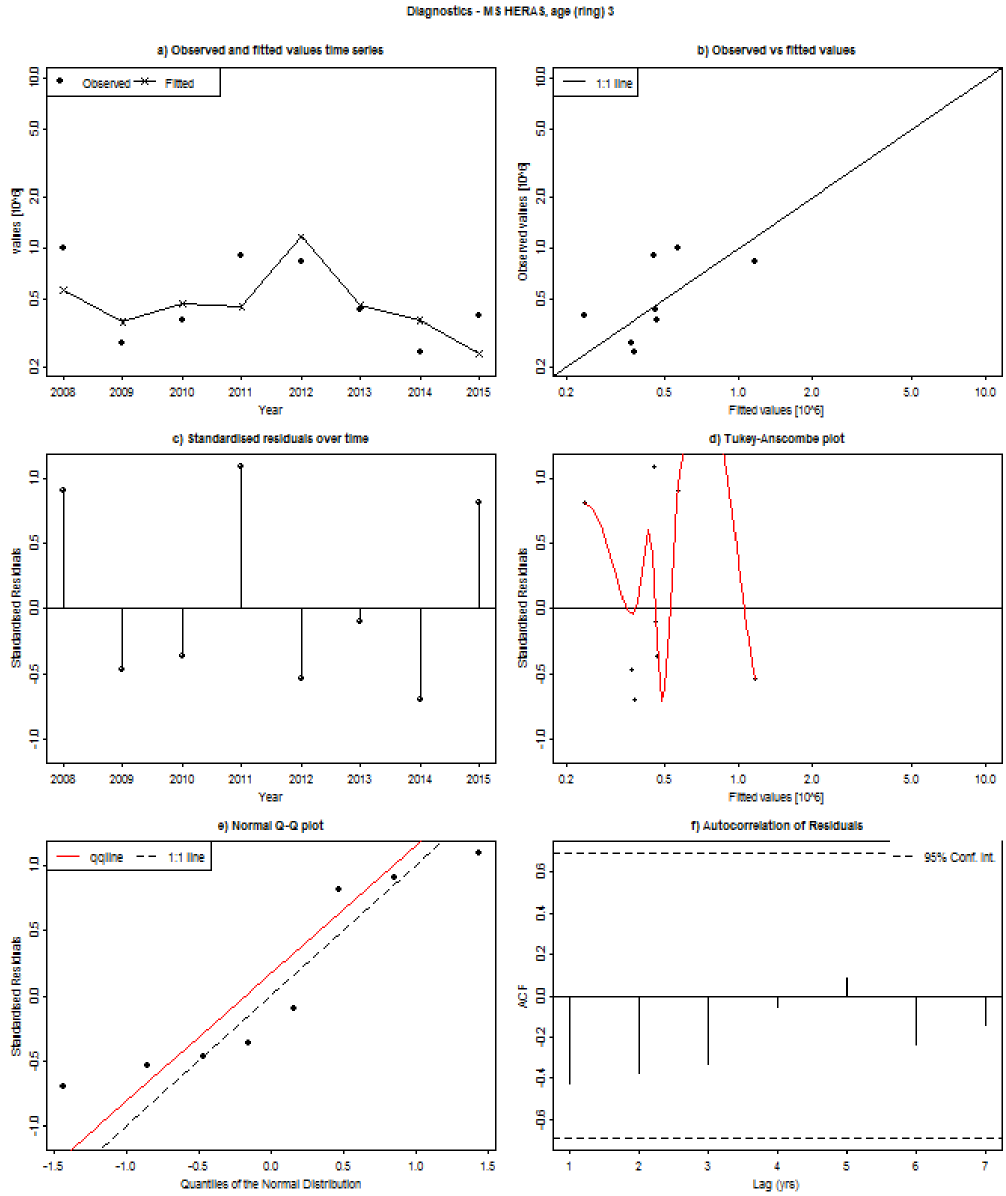


Figure 5.6.26: Herring in 6.a (combined) and 7.b and 7.c. Diagnostics of the assessment model fit to the Malin Shelf acoustic survey index at 3-winter ring time series. Top left: Estimates of numbers at 3-winter ring (line) and numbers predicted from index abundance at 3-winter ring. Top right: scatterplot of index observations versus assessment model estimates of numbers at 3-winter ring with the best-fit catchability model (linear function). Middle left: Time series of standardized residuals of the index at 3-winter ring. Middle right: index observation versus standardized residuals at 3-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

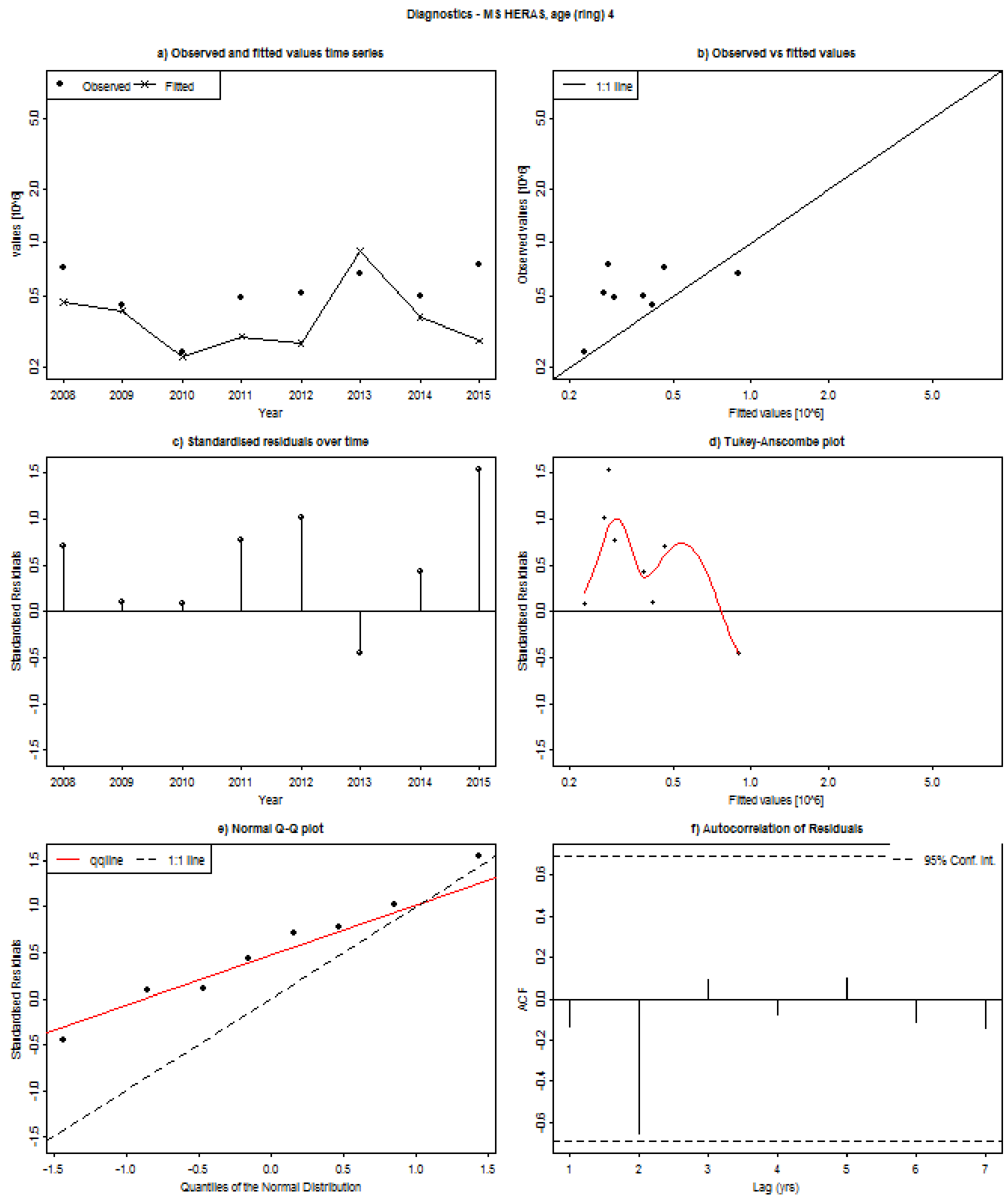


Figure 5.6.27: Herring in 6.a (combined) and 7.b and 7.c. Diagnostics of the assessment model fit to the Malin Shelf acoustic survey index at 4-winter ring time series. Top left: Estimates of numbers at 4-winter ring (line) and numbers predicted from index abundance at 4-winter ring. Top right: scatterplot of index observations versus assessment model estimates of numbers at 4-winter ring with the best-fit catchability model (linear function). Middle left: Time series of standardized residuals of the index at 4-winter ring. Middle right: index observation versus standardized residuals at 4-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

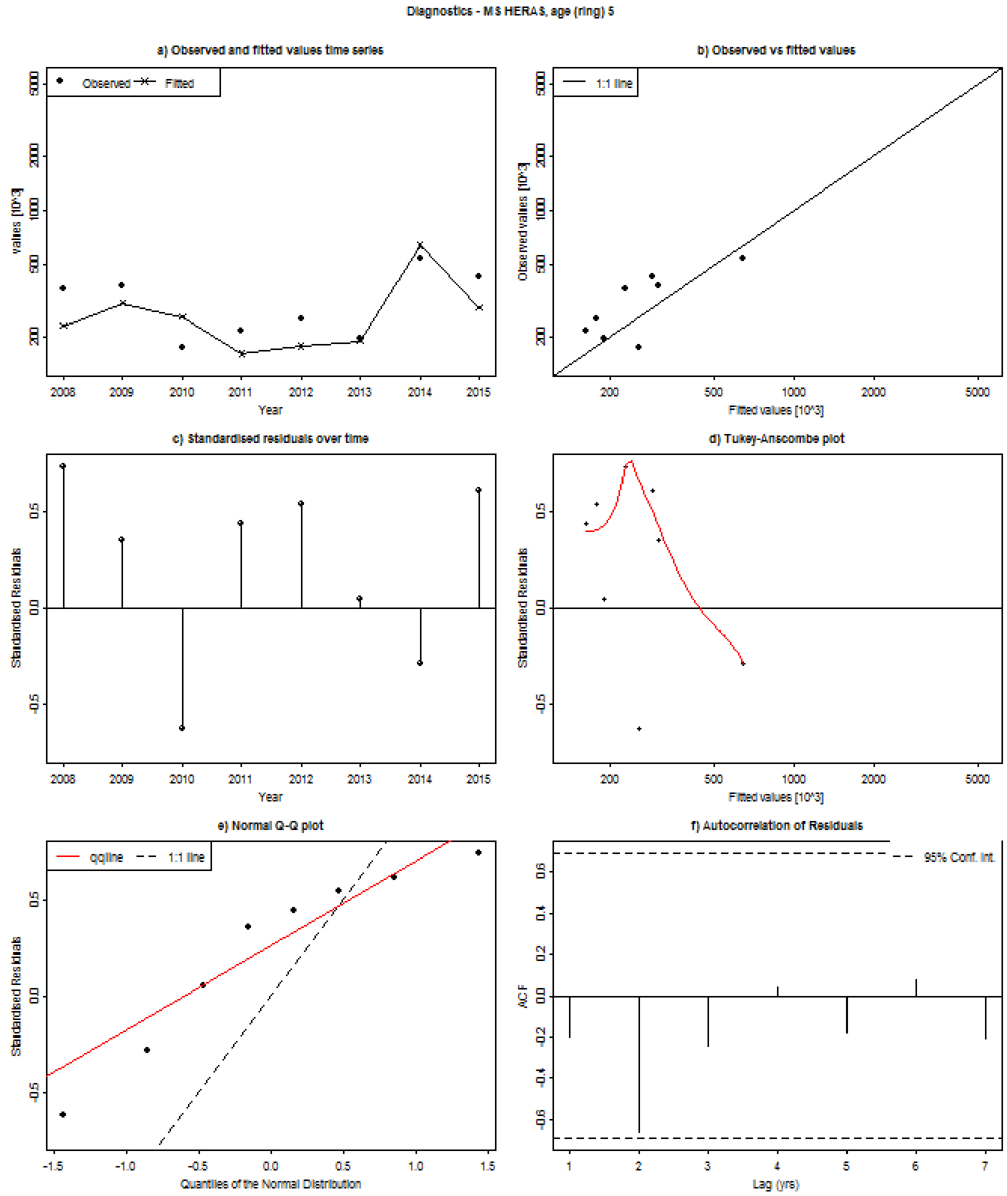


Figure 5.6.28: Herring in 6.a (combined) and 7.b and 7.c. Diagnostics of the assessment model fit to the Malin Shelf acoustic survey index at 5-winter ring time series. Top left: Estimates of numbers at 5-winter ring (line) and numbers predicted from index abundance at 5-winter ring. Top right: scatterplot of index observations versus assessment model estimates of numbers at 5-winter ring with the best-fit catchability model (linear function). Middle left: Time series of standardized residuals of the index at 5-winter ring. Middle right: index observation versus standardized residuals at 5-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

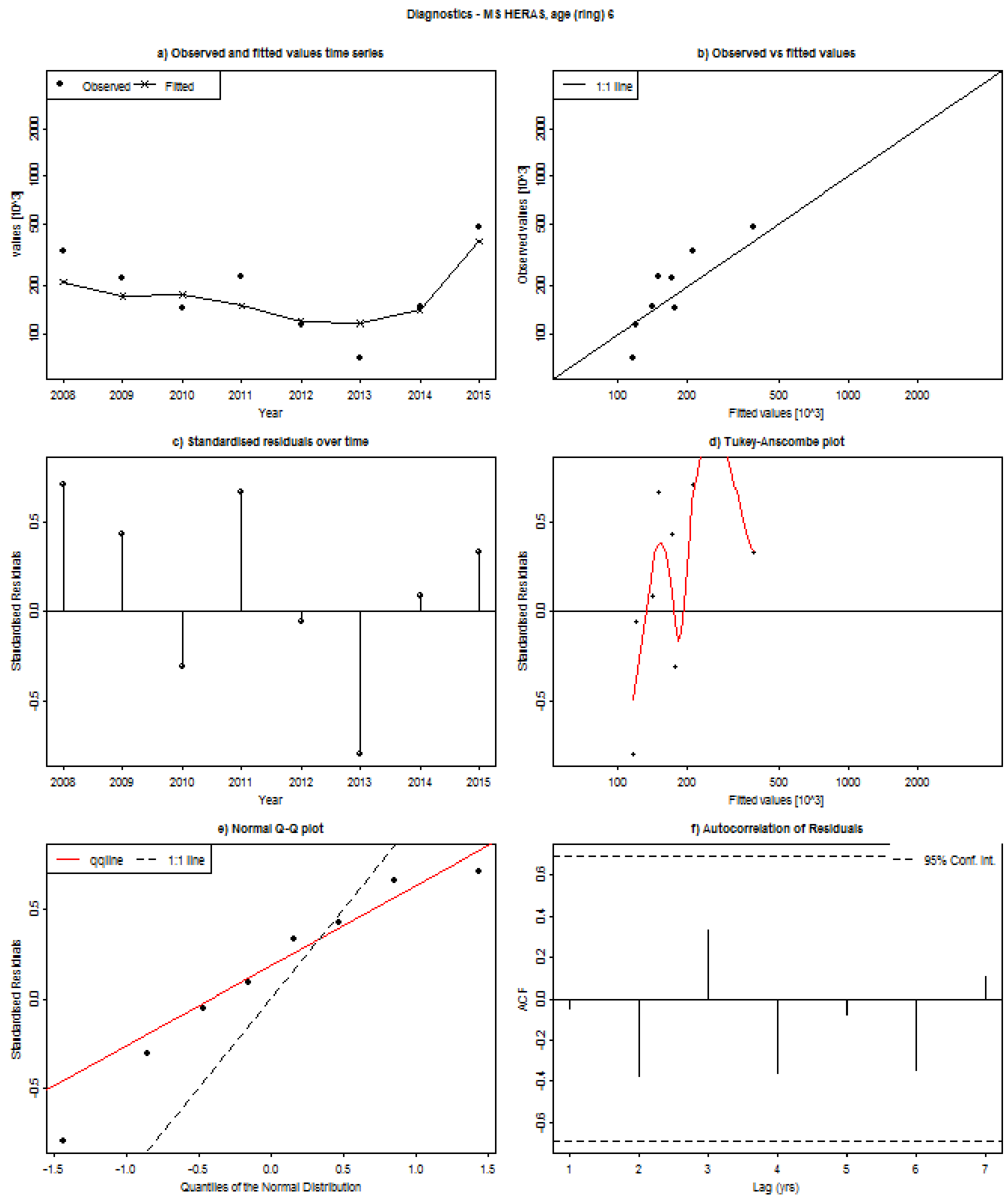


Figure 5.6.29: Herring in 6.a (combined) and 7.b and 7.c. Diagnostics of the assessment model fit to the Malin Shelf acoustic survey index at 6-winter ring time series. Top left: Estimates of numbers at 6-winter ring (line) and numbers predicted from index abundance at 6-winter ring. Top right: scatterplot of index observations versus assessment model estimates of numbers at 6-winter ring with the best-fit catchability model (linear function). Middle left: Time series of standardized residuals of the index at 6-winter ring. Middle right: index observation versus standardized residuals at 6-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

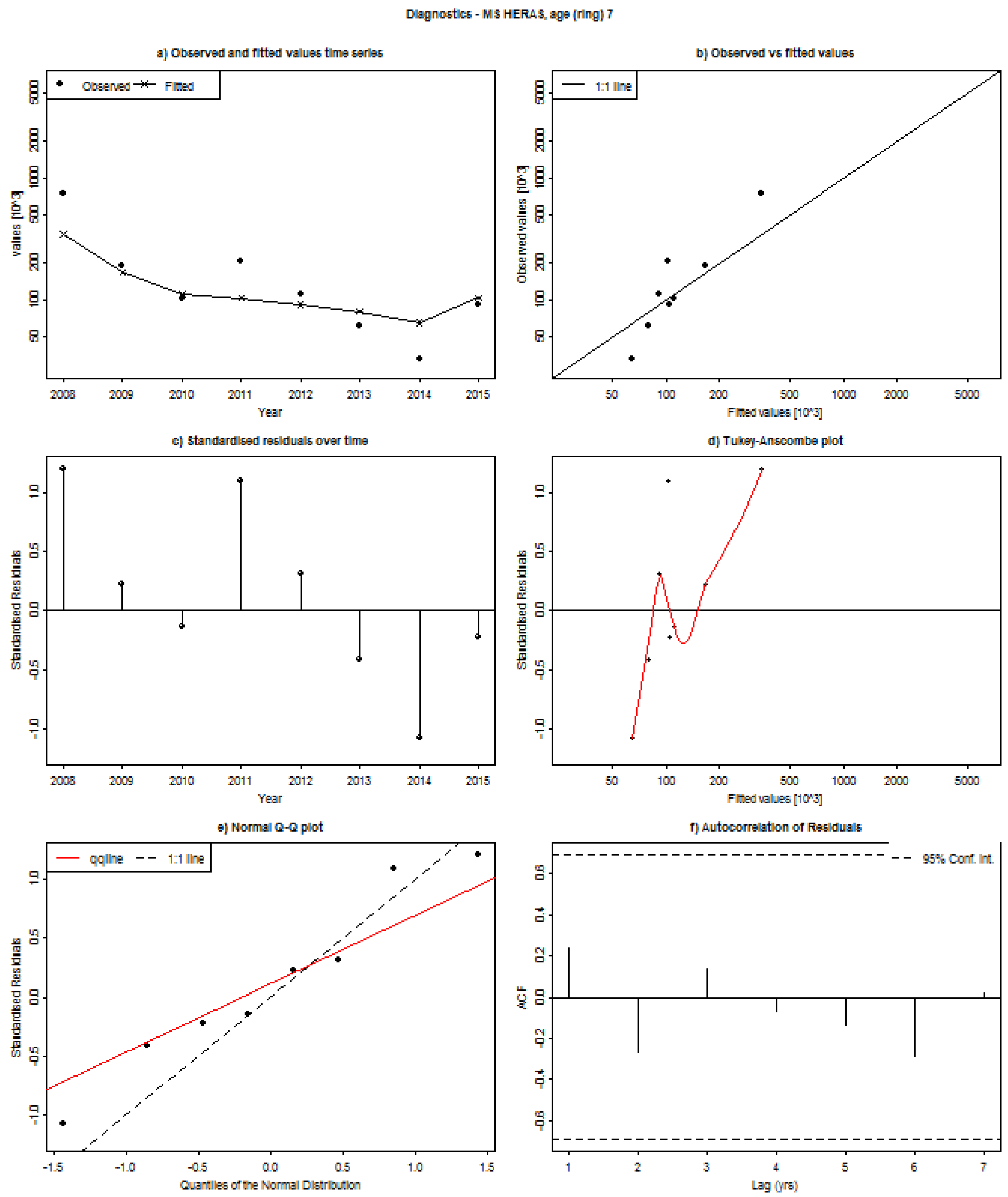


Figure 5.6.30: Herring in 6.a (combined) and 7.b and 7.c. Diagnostics of the assessment model fit to the Malin Shelf acoustic survey index at 7-winter ring time series. Top left: Estimates of numbers at 7-winter ring (line) and numbers predicted from index abundance at 7-winter ring. Top right: scatterplot of index observations versus assessment model estimates of numbers at 7-winter ring with the best-fit catchability model (linear function). Middle left: Time series of standardized residuals of the index at 7-winter ring. Middle right: index observation versus standardized residuals at 7-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

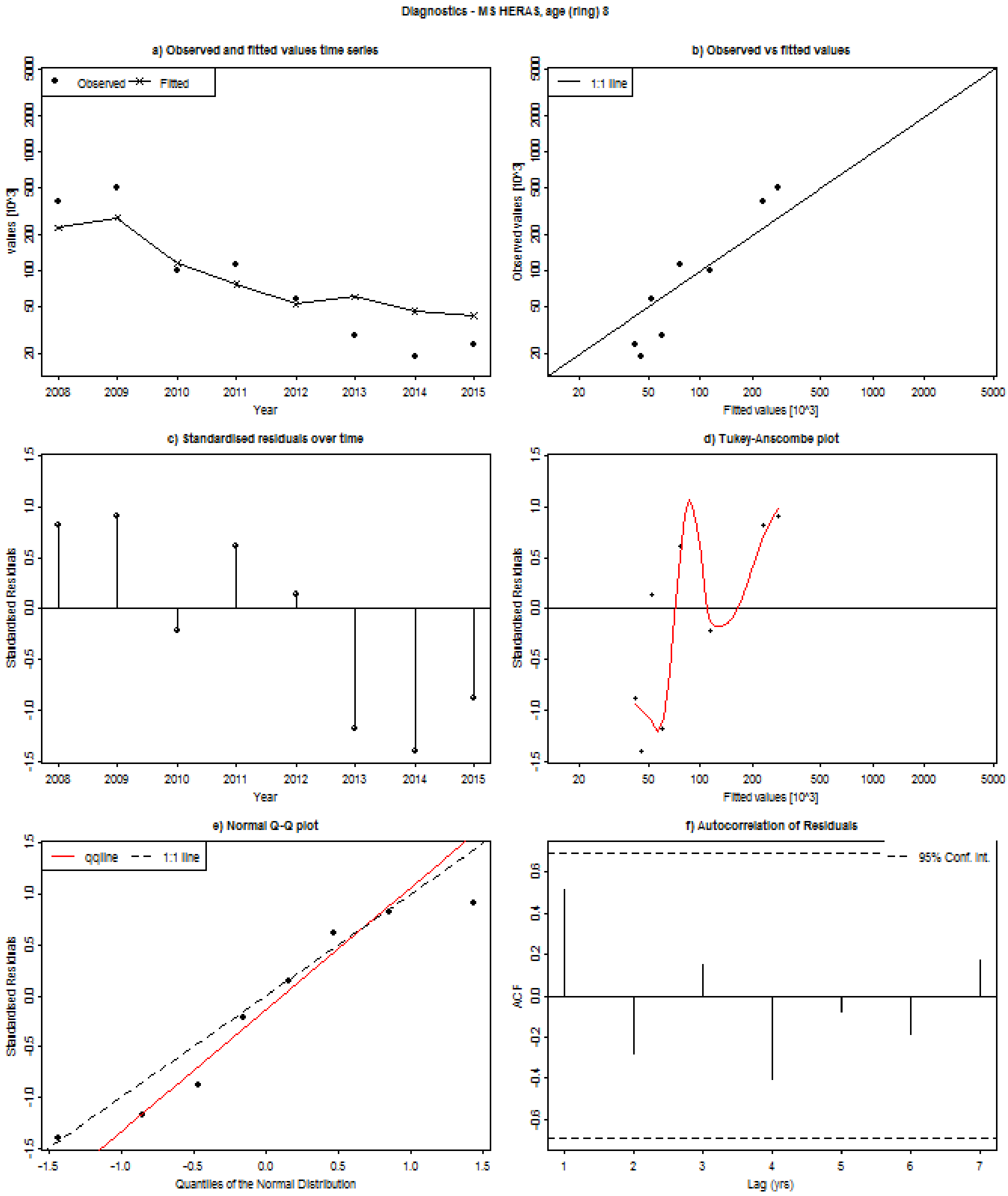


Figure 5.6.31: Herring in 6.a (combined) and 7.b and 7.c. Diagnostics of the assessment model fit to the Malin Shelf acoustic survey index at 8-winter ring time series. Top left: Estimates of numbers at 8-winter ring (line) and numbers predicted from index abundance at 8-winter ring. Top right: scatterplot of index observations versus assessment model estimates of numbers at 8-winter ring with the best-fit catchability model (linear function). Middle left: Time series of standardized residuals of the index at 8-winter ring. Middle right: index observation versus standardized residuals at 8-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

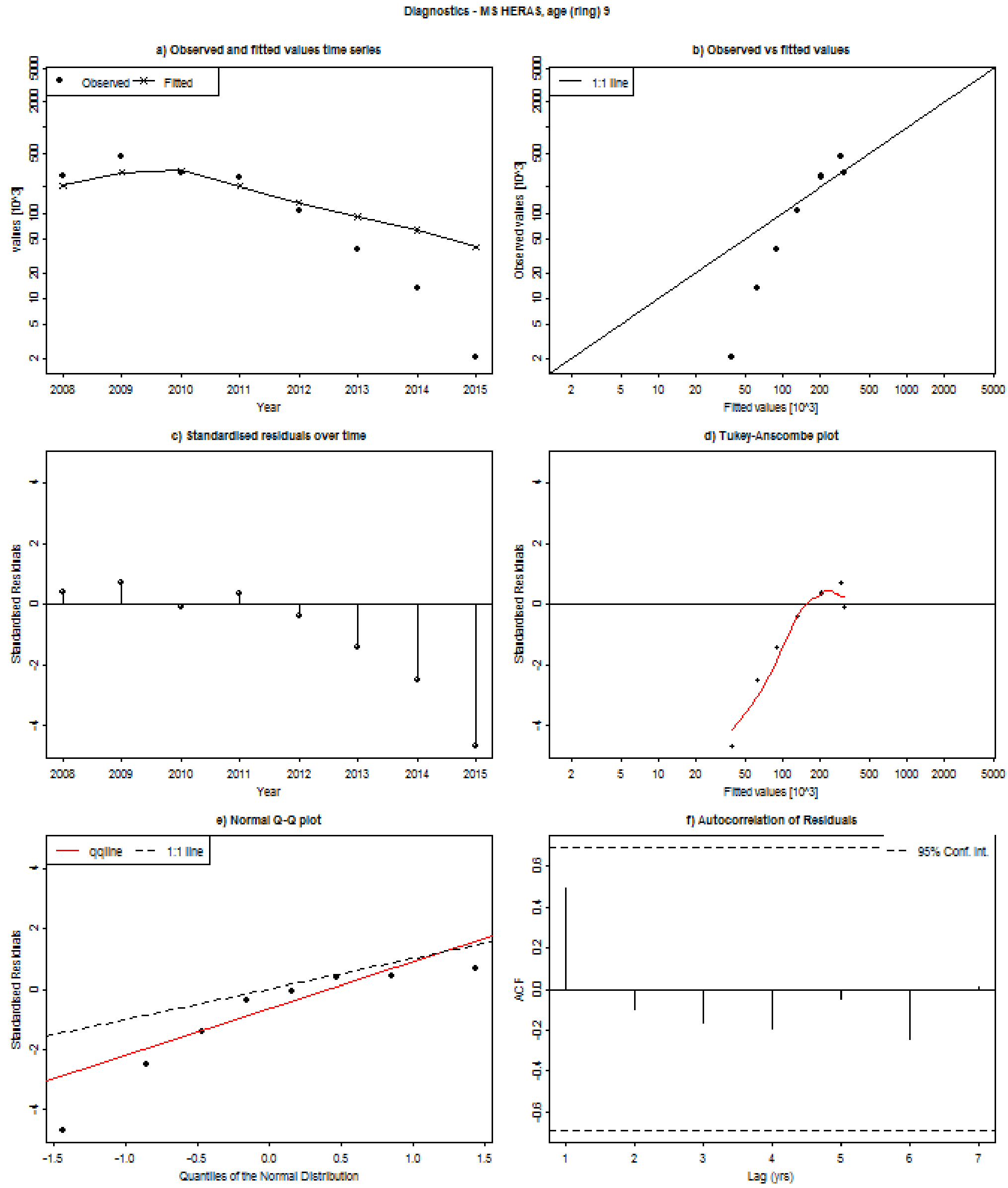


Figure 5.6.32: Herring in 6.a (combined) and 7.b and 7.c. Diagnostics of the assessment model fit to the Malin Shelf acoustic survey index at 9-winter ring time series. Top left: Estimates of numbers at 9-winter ring (line) and numbers predicted from index abundance at 9-winter ring. Top right: scatterplot of index observations versus assessment model estimates of numbers at 9-winter ring with the best-fit catchability model (linear function). Middle left: Time series of standardized residuals of the index at 9-winter ring. Middle right: index observation versus standardized residuals at 9-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

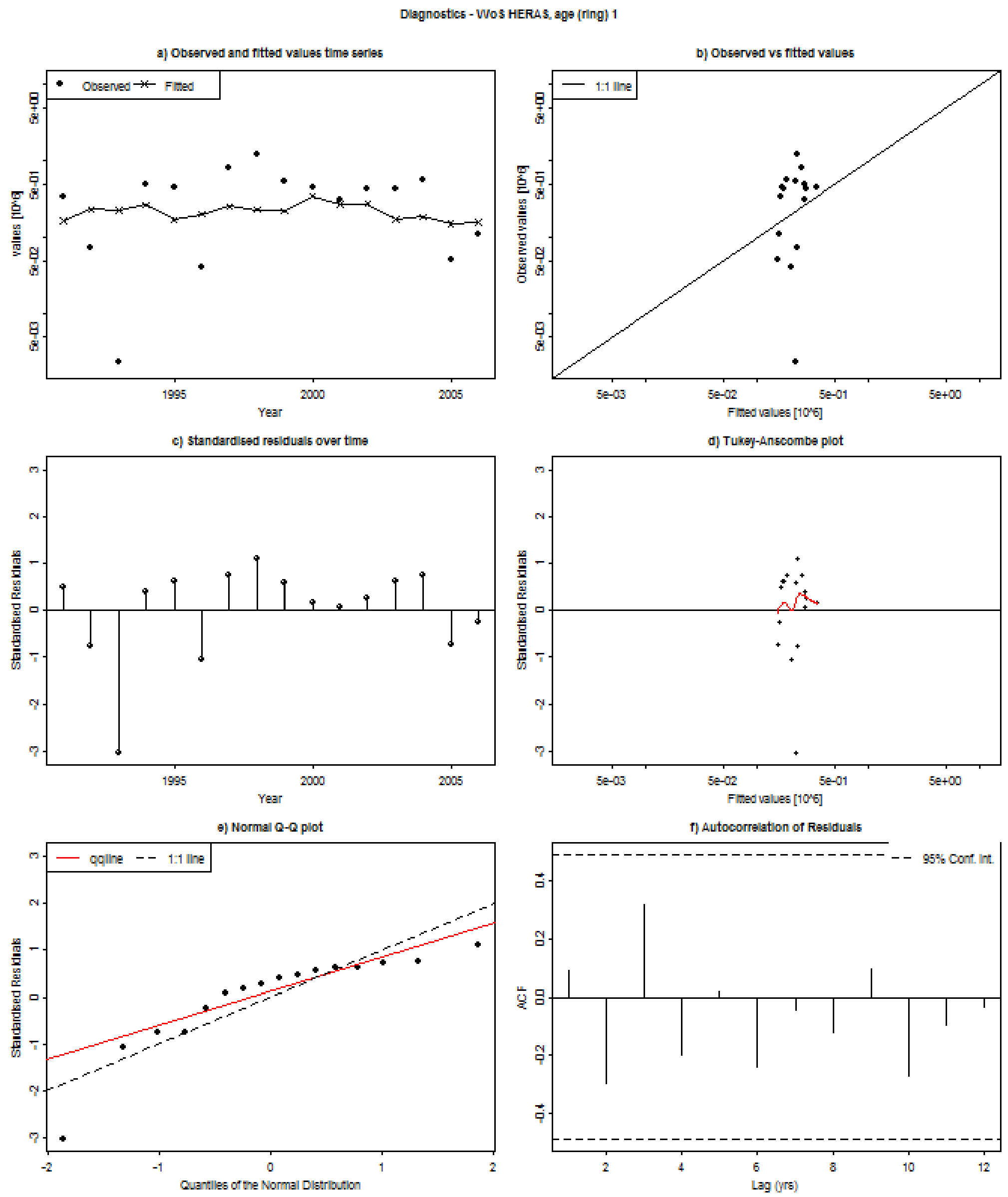


Figure 5.6.33: Herring in 6.a (combined) and 7.b and 7.c. Diagnostics of the assessment model fit to the West of Scotland geographical area (6.aN) acoustic survey index at 1-winter ring time series. Top left: Estimates of numbers at 1-winter ring (line) and numbers predicted from index abundance at 1-winter ring. Top right: scatterplot of index observations versus assessment model estimates of numbers at 1-winter ring with the best-fit catchability model (linear function). Middle left: Time series of standardized residuals of the index at 1-winter ring. Middle right: index observation versus standardized residuals at 1-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

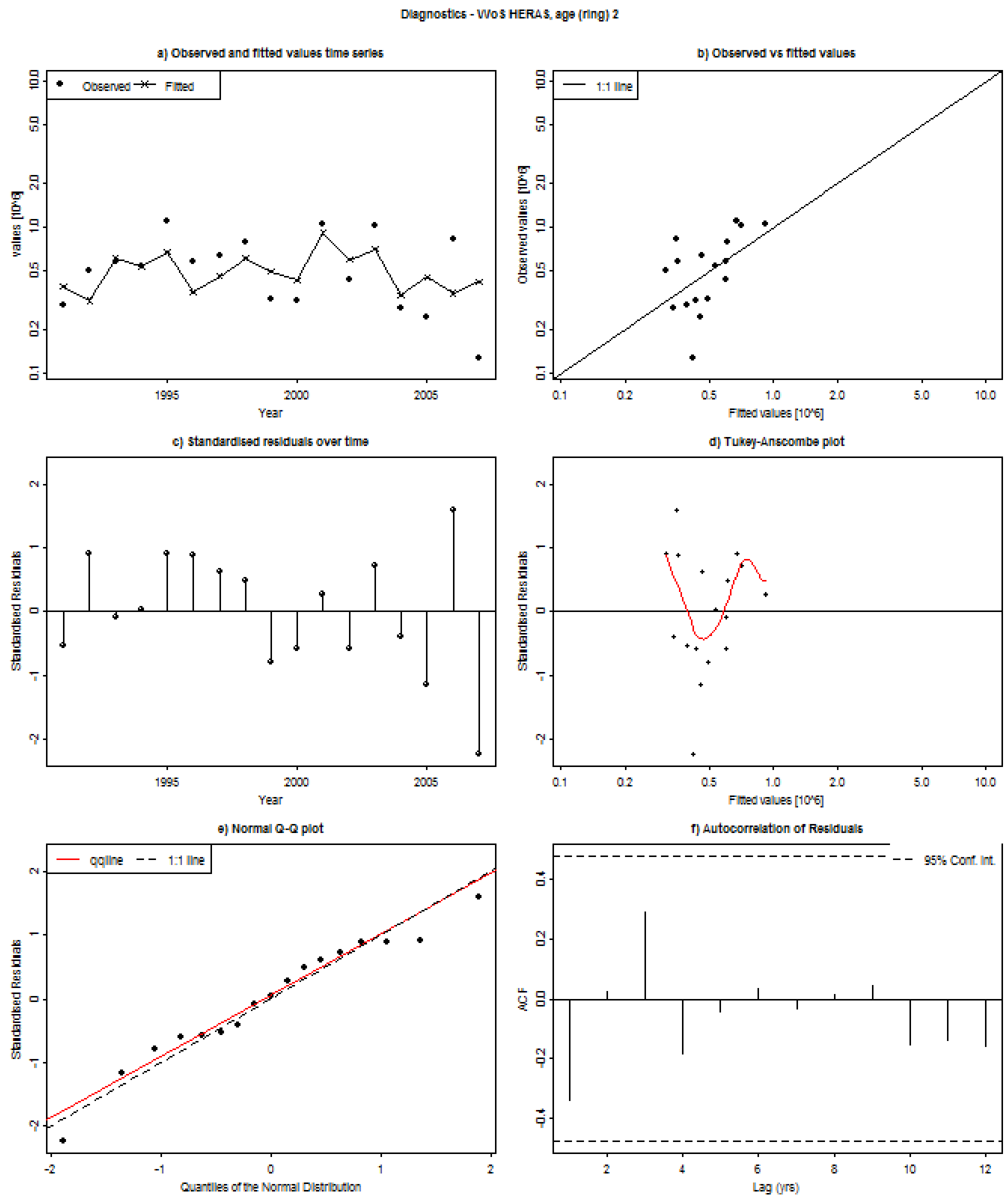


Figure 5.6.34: Herring in 6.a (combined) and 7.b and 7.c. Diagnostics of the assessment model fit to the West of Scotland geographical area (6.aN) acoustic survey index at 2-winter ring time series. Top left: Estimates of numbers at 2-winter ring (line) and numbers predicted from index abundance at 2-winter ring. Top right: scatterplot of index observations versus assessment model estimates of numbers at 2-winter ring with the best-fit catchability model (linear function). Middle left: Time series of standardized residuals of the index at 2-winter ring. Middle right: index observation versus standardized residuals at 2-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

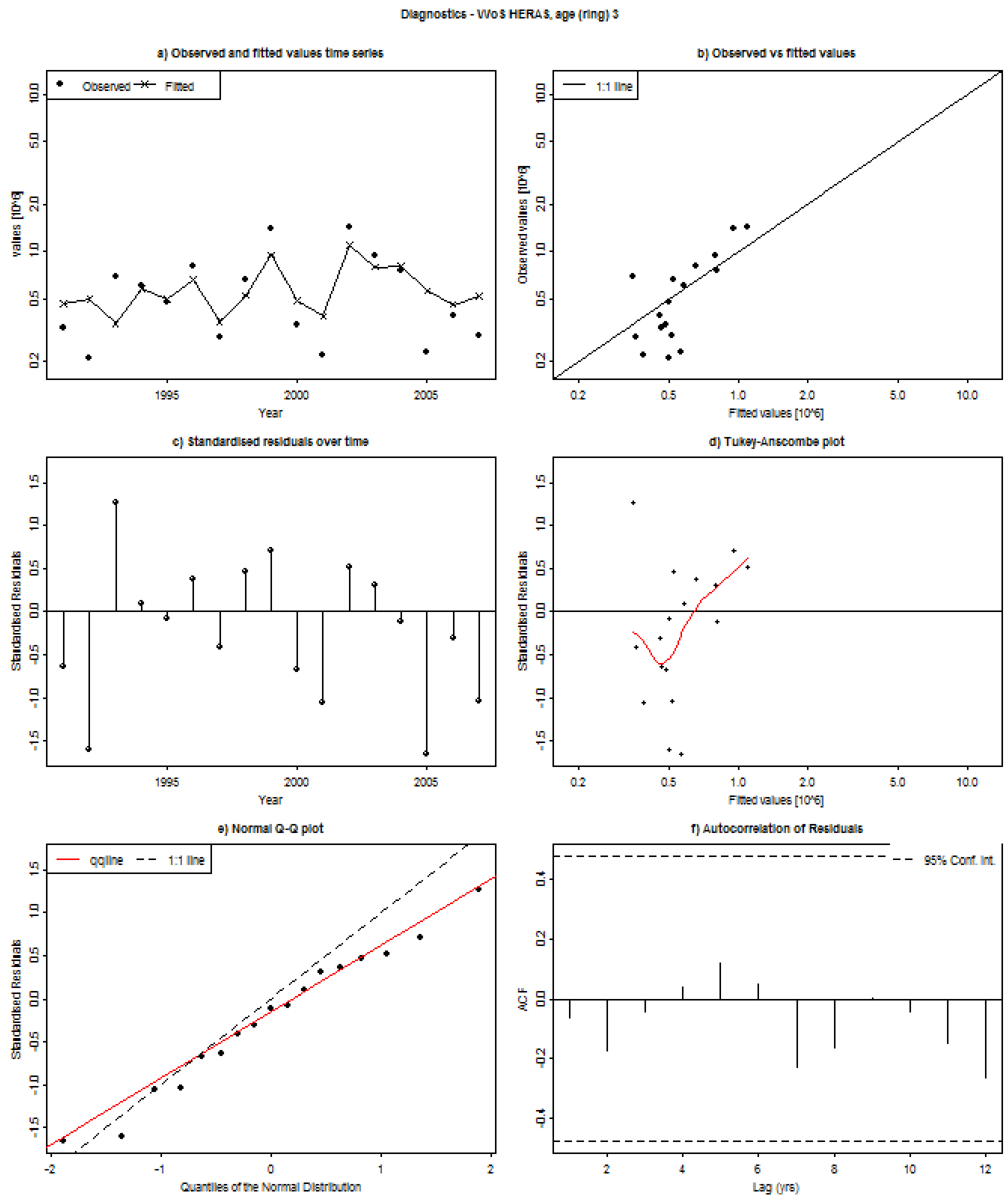


Figure 5.6.35: Herring in 6.a (combined) and 7.b and 7.c. Diagnostics of the assessment model fit to the West of Scotland geographical area (6.aN) acoustic survey index at 3-winter ring time series. Top left: Estimates of numbers at 3-winter ring (line) and numbers predicted from index abundance at 3-winter ring. Top right: scatterplot of index observations versus assessment model estimates of numbers at 3-winter ring with the best-fit catchability model (linear function). Middle left: Time series of standardized residuals of the index at 3-winter ring. Middle right: index observation versus standardized residuals at 3-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

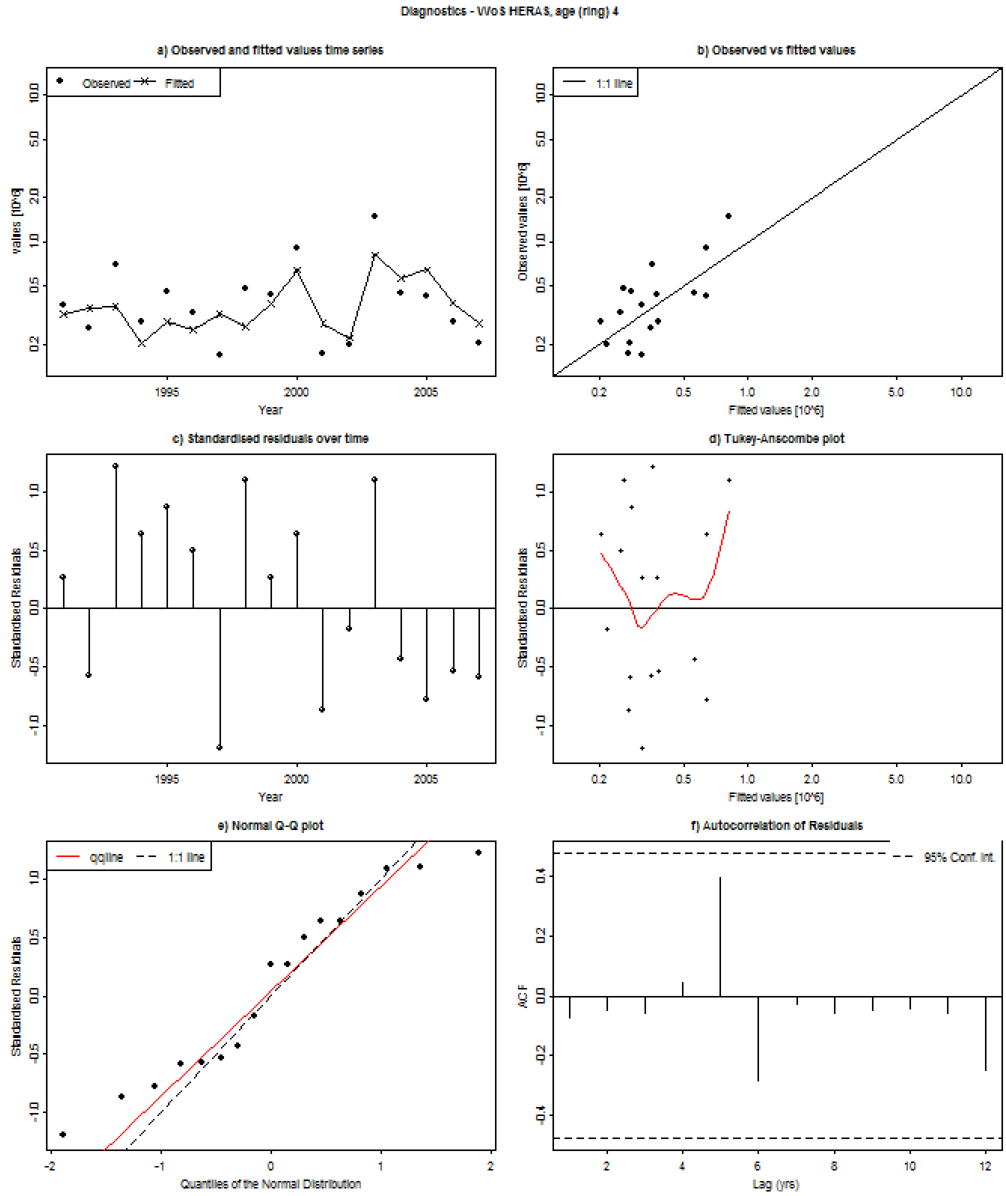


Figure 5.6.36: Herring in 6.a (combined) and 7.b and 7.c. Diagnostics of the assessment model fit to the West of Scotland geographical area (6.aN) acoustic survey index at 4-winter ring time series. Top left: Estimates of numbers at 4-winter ring (line) and numbers predicted from index abundance at 4-winter ring. Top right: scatterplot of index observations versus assessment model estimates of numbers at 4-winter ring with the best-fit catchability model (linear function). Middle left: Time series of standardized residuals of the index at 4-winter ring. Middle right: index observation versus standardized residuals at 4-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

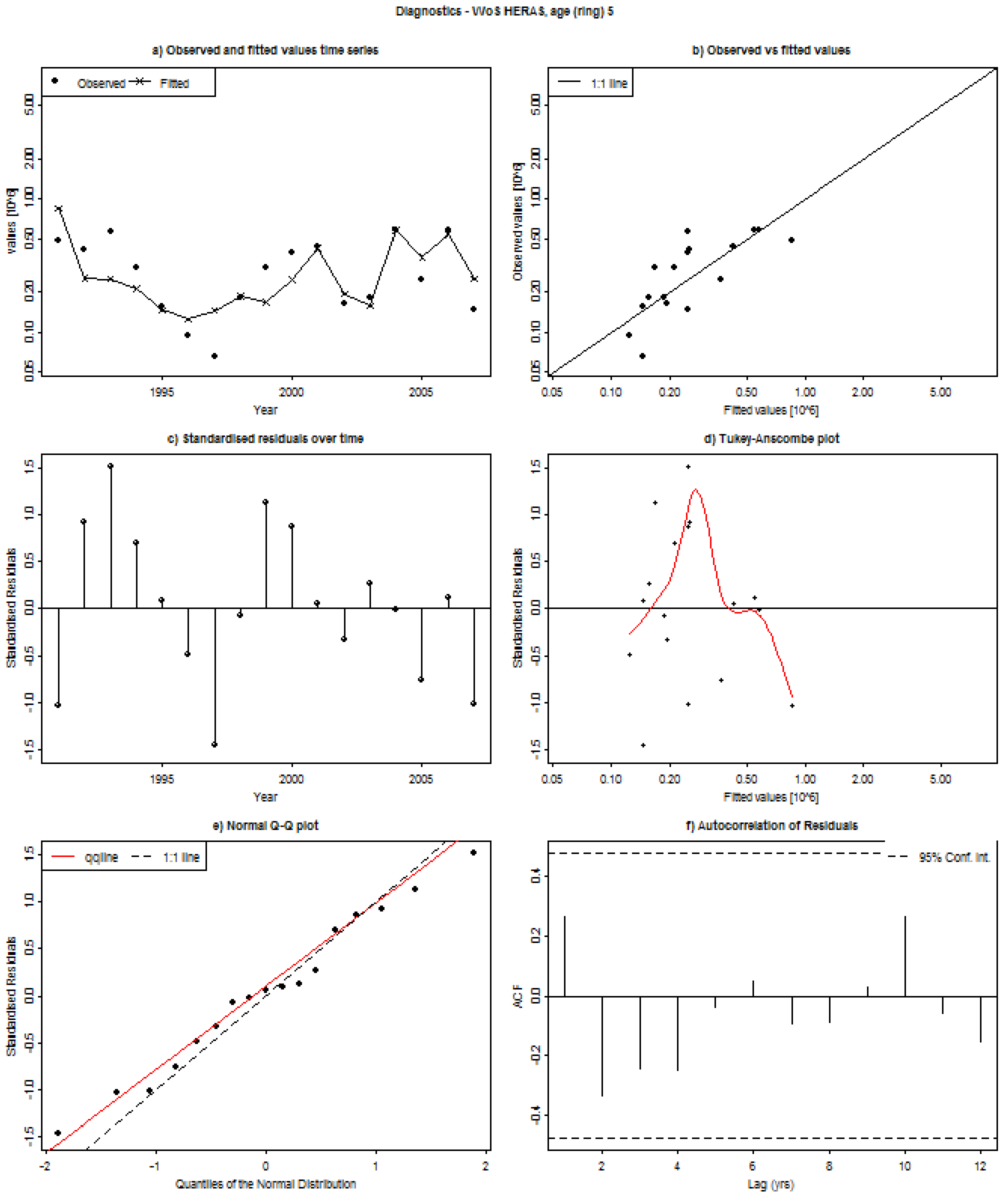


Figure 5.6.37: Herring in 6.a (combined) and 7.b and 7.c. Diagnostics of the assessment model fit to the West of Scotland geographical area (6.aN) acoustic survey index at 5-winter ring time series. Top left: Estimates of numbers at 5-winter ring (line) and numbers predicted from index abundance at 5-winter ring. Top right: scatterplot of index observations versus assessment model estimates of numbers at 5-winter ring with the best-fit catchability model (linear function). Middle left: Time series of standardized residuals of the index at 5-winter ring. Middle right: index observation versus standardized residuals at 5-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

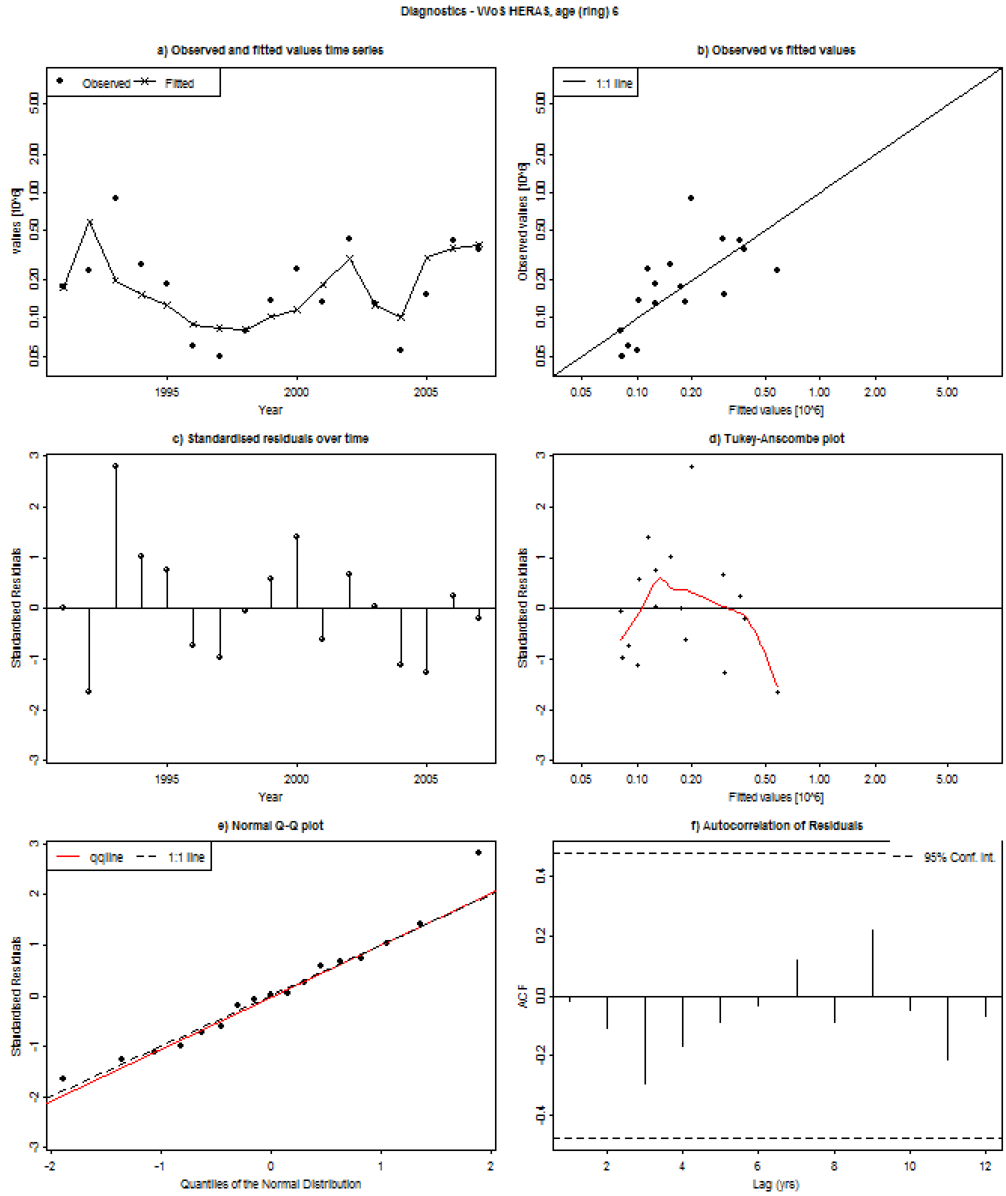


Figure 5.6.38: Herring in 6.a (combined) and 7.b and 7.c. Diagnostics of the assessment model fit to the West of Scotland geographical area (6.aN) acoustic survey index at 6-winter ring time series. Top left: Estimates of numbers at 6-winter ring (line) and numbers predicted from index abundance at 6-winter ring. Top right: scatterplot of index observations versus assessment model estimates of numbers at 6-winter ring with the best-fit catchability model (linear function). Middle left: Time series of standardized residuals of the index at 6-winter ring. Middle right: index observation versus standardized residuals at 6-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

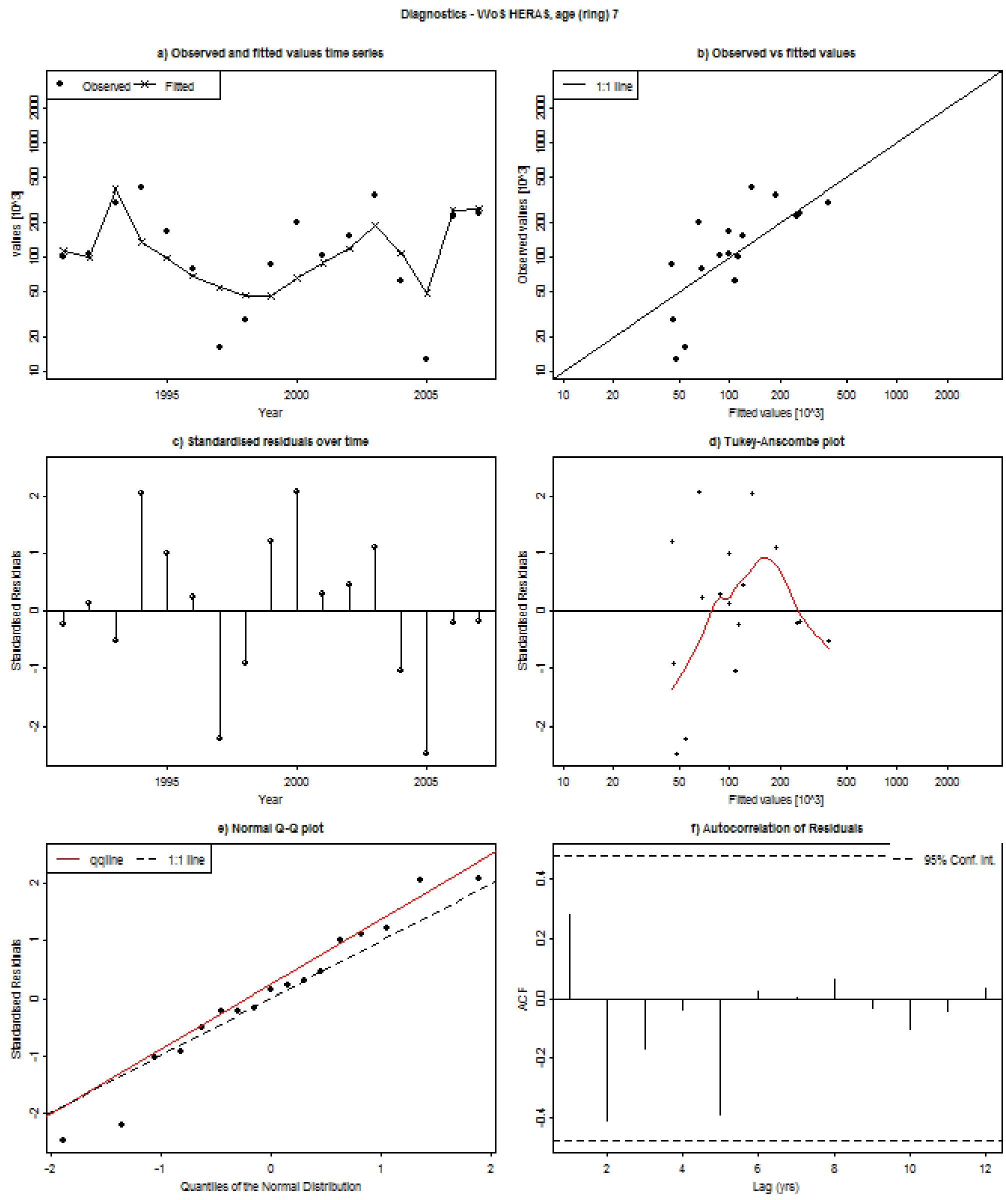


Figure 5.6.39: Herring in 6.a (combined) and 7.b and 7.c. Diagnostics of the assessment model fit to the West of Scotland geographical area (6.aN) acoustic survey index at 7-winter ring time series. Top left: Estimates of numbers at 7-winter ring (line) and numbers predicted from index abundance at 7-winter ring. Top right: scatterplot of index observations versus assessment model estimates of numbers at 7-winter ring with the best-fit catchability model (linear function). Middle left: Time series of standardized residuals of the index at 7-winter ring. Middle right: index observation versus standardized residuals at 7-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

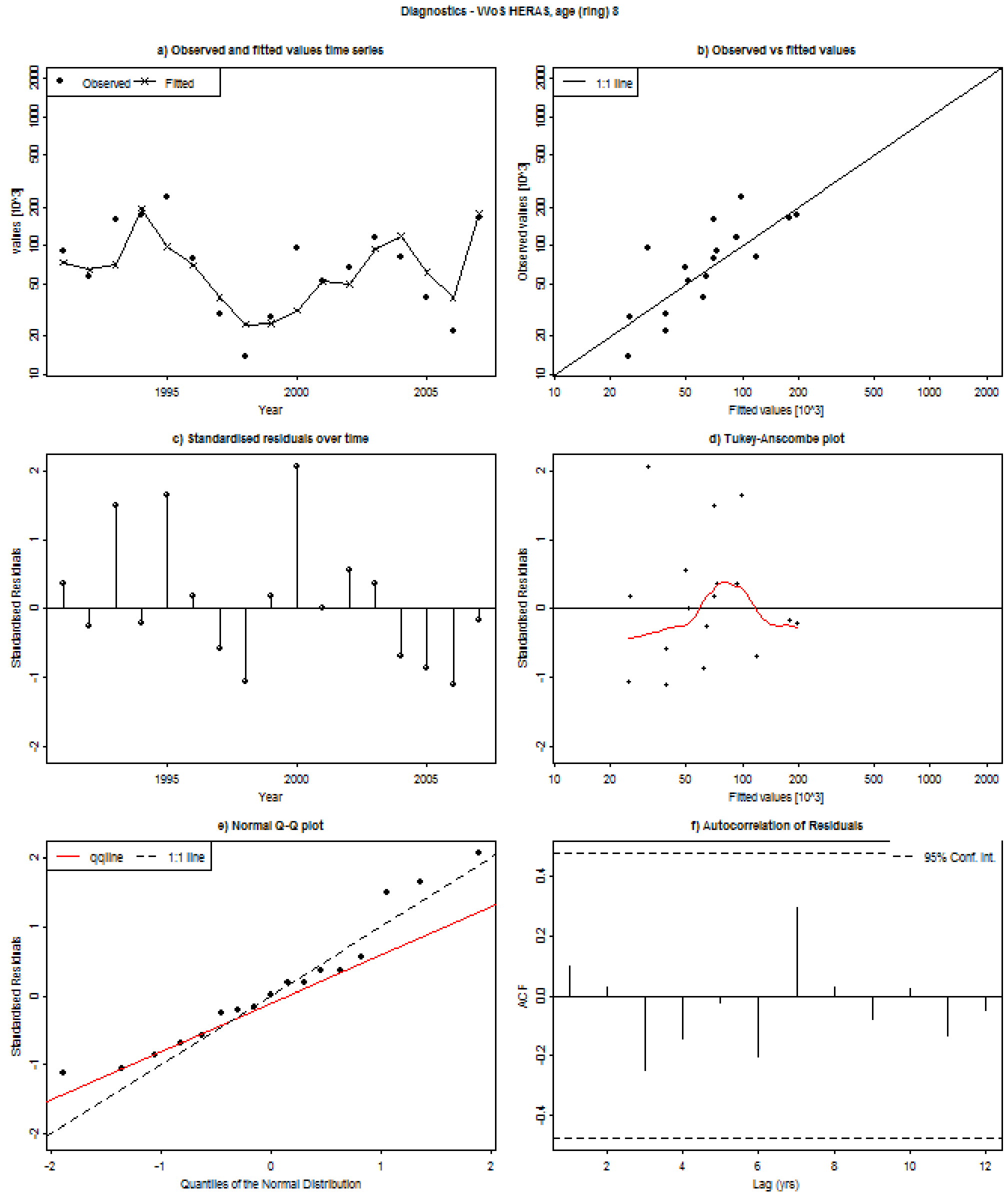


Figure 5.6.40: Herring in 6.a (combined) and 7.b and 7.c. Diagnostics of the assessment model fit to the West of Scotland geographical area (6.aN) acoustic survey index at 8-winter ring time series. Top left: Estimates of numbers at 8-winter ring (line) and numbers predicted from index abundance at 8-winter ring. Top right: scatterplot of index observations versus assessment model estimates of numbers at 8-winter ring with the best-fit catchability model (linear function). Middle left: Time series of standardized residuals of the index at 8-winter ring. Middle right: index observation versus standardized residuals at 8-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

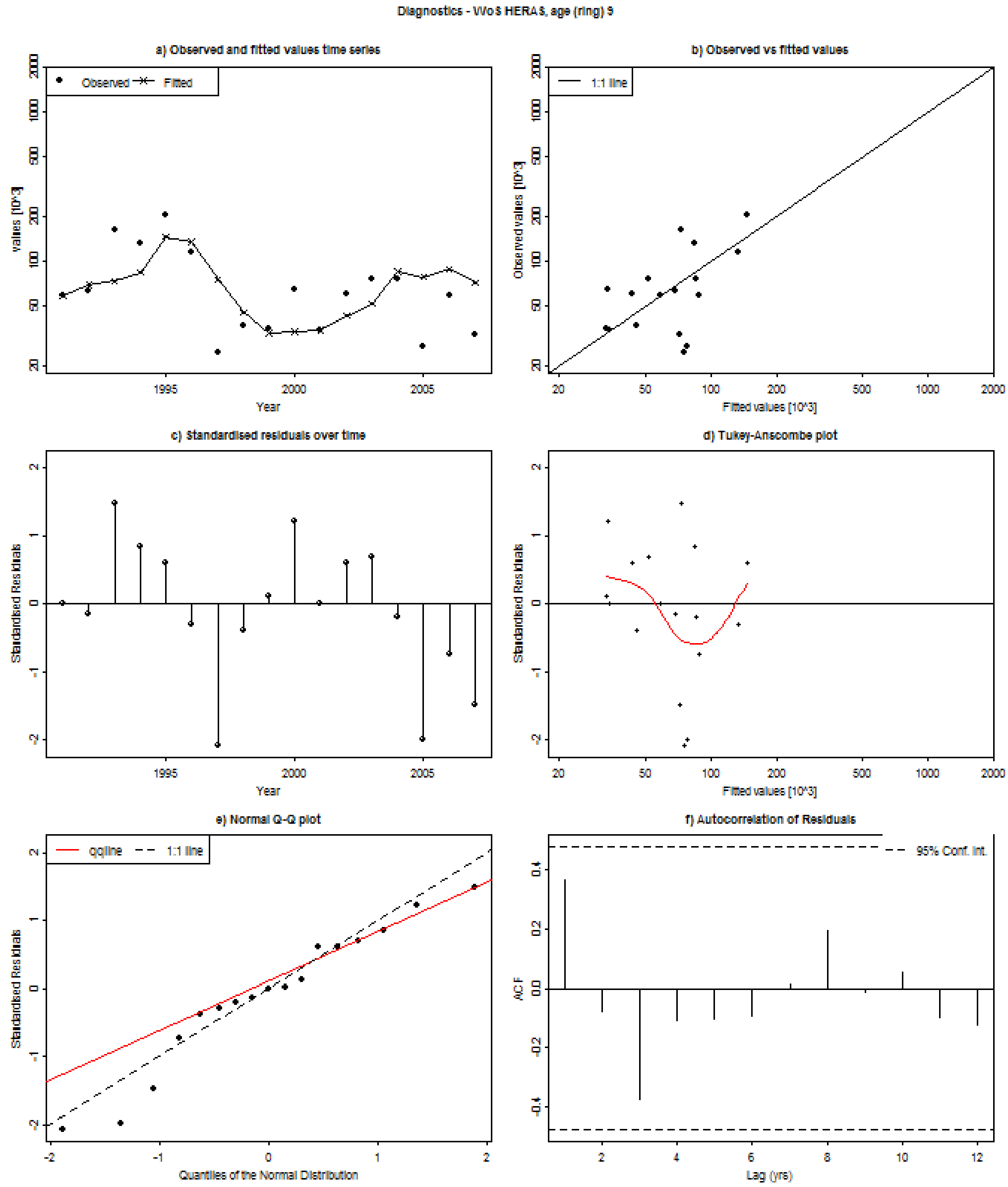


Figure 5.6.41: Herring in 6.a (combined) and 7.b and 7.c. Diagnostics of the assessment model fit to the West of Scotland geographical area (6.aN) acoustic survey index at 9-winter ring time series. Top left: Estimates of numbers at 9-winter ring (line) and numbers predicted from index abundance at 9-winter ring. Top right: scatterplot of index observations versus assessment model estimates of numbers at 9-winter ring with the best-fit catchability model (linear function). Middle left: Time series of standardized residuals of the index at 9-winter ring. Middle right: index observation versus standardized residuals at 9-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

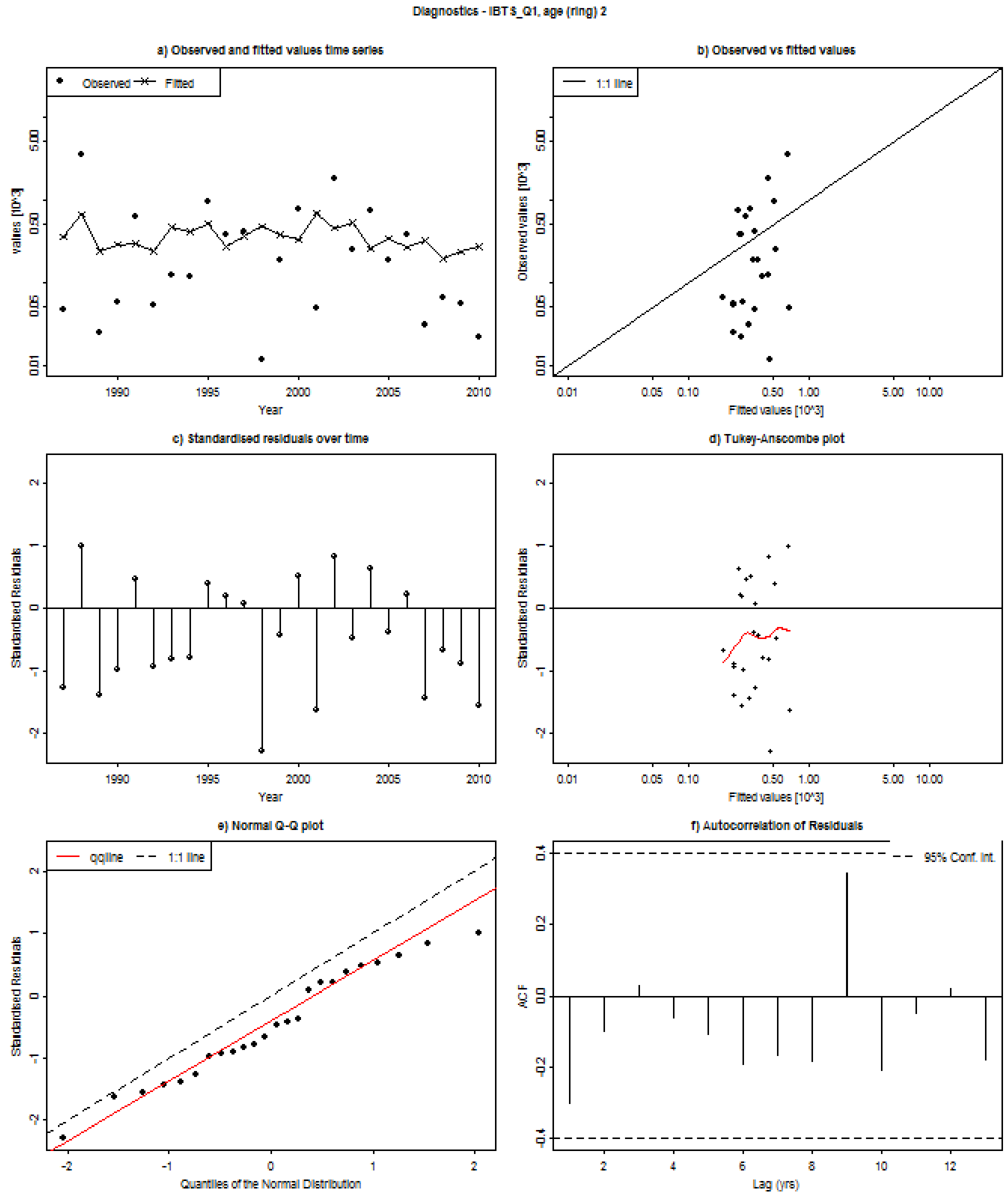


Figure 5.6.42: Herring in 6.a (combined) and 7.b and 7.c. Diagnostics of the assessment model fit to the Scottish bottom trawl survey index in quarter 1 at 2-winter ring time series. Top left: Estimates of numbers at 2-winter ring (line) and numbers predicted from index abundance at 2-winter ring. Top right: scatterplot of index observations versus assessment model estimates of numbers at 2-winter ring with the best-fit catchability model (linear function). Middle left: Time series of standardized residuals of the index at 2-winter ring. Middle right: index observation versus standardized residuals at 2-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

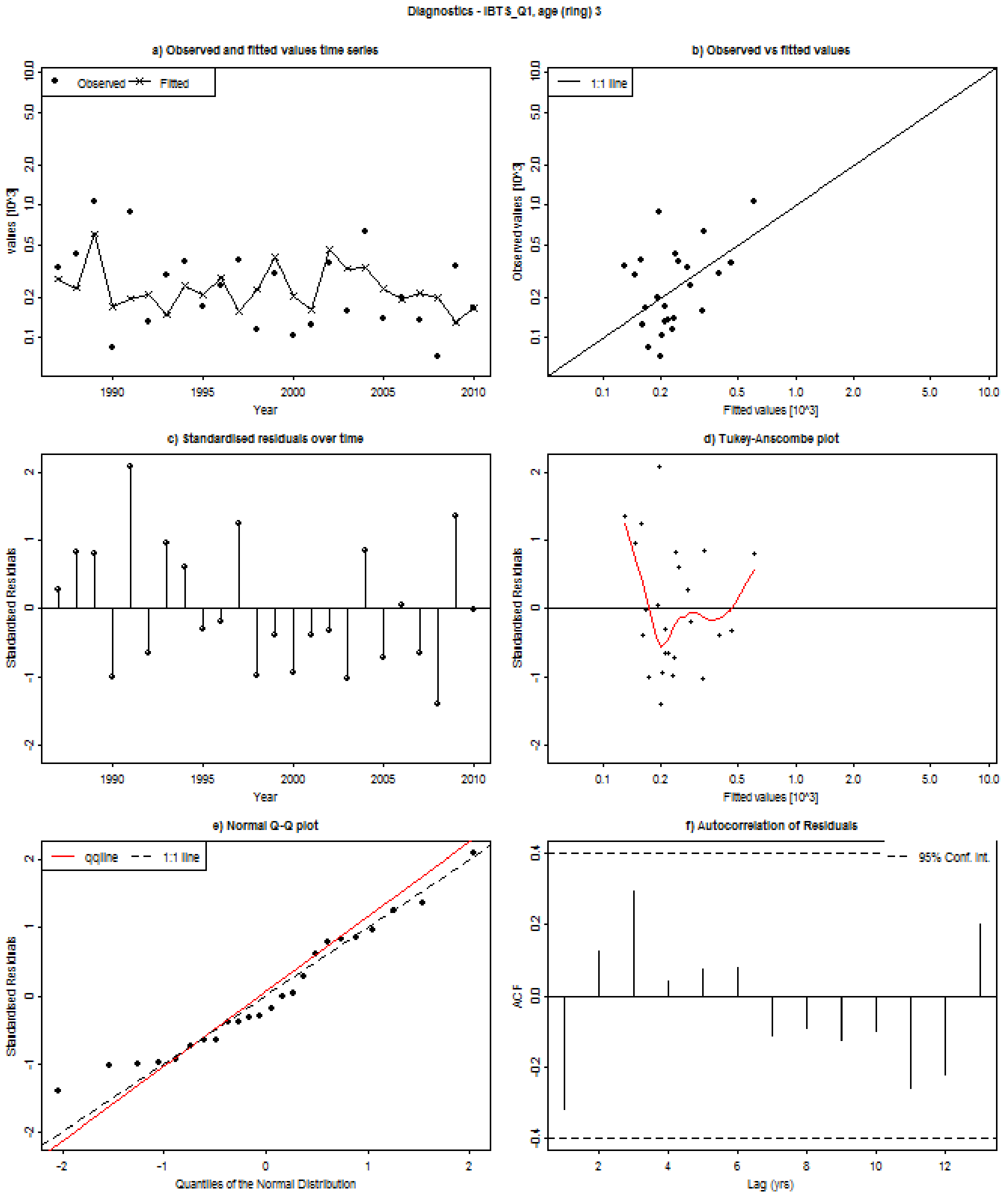


Figure 5.6.43: Herring in 6.a (combined) and 7.b and 7.c. Diagnostics of the assessment model fit to the Scottish bottom trawl survey index in quarter 1 at 3-winter ring time series. Top left: Estimates of numbers at 3-winter ring (line) and numbers predicted from index abundance at 3-winter ring. Top right: scatterplot of index observations versus assessment model estimates of numbers at 3-winter ring with the best-fit catchability model (linear function). Middle left: Time series of standardized residuals of the index at 3-winter ring. Middle right: index observation versus standardized residuals at 3-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

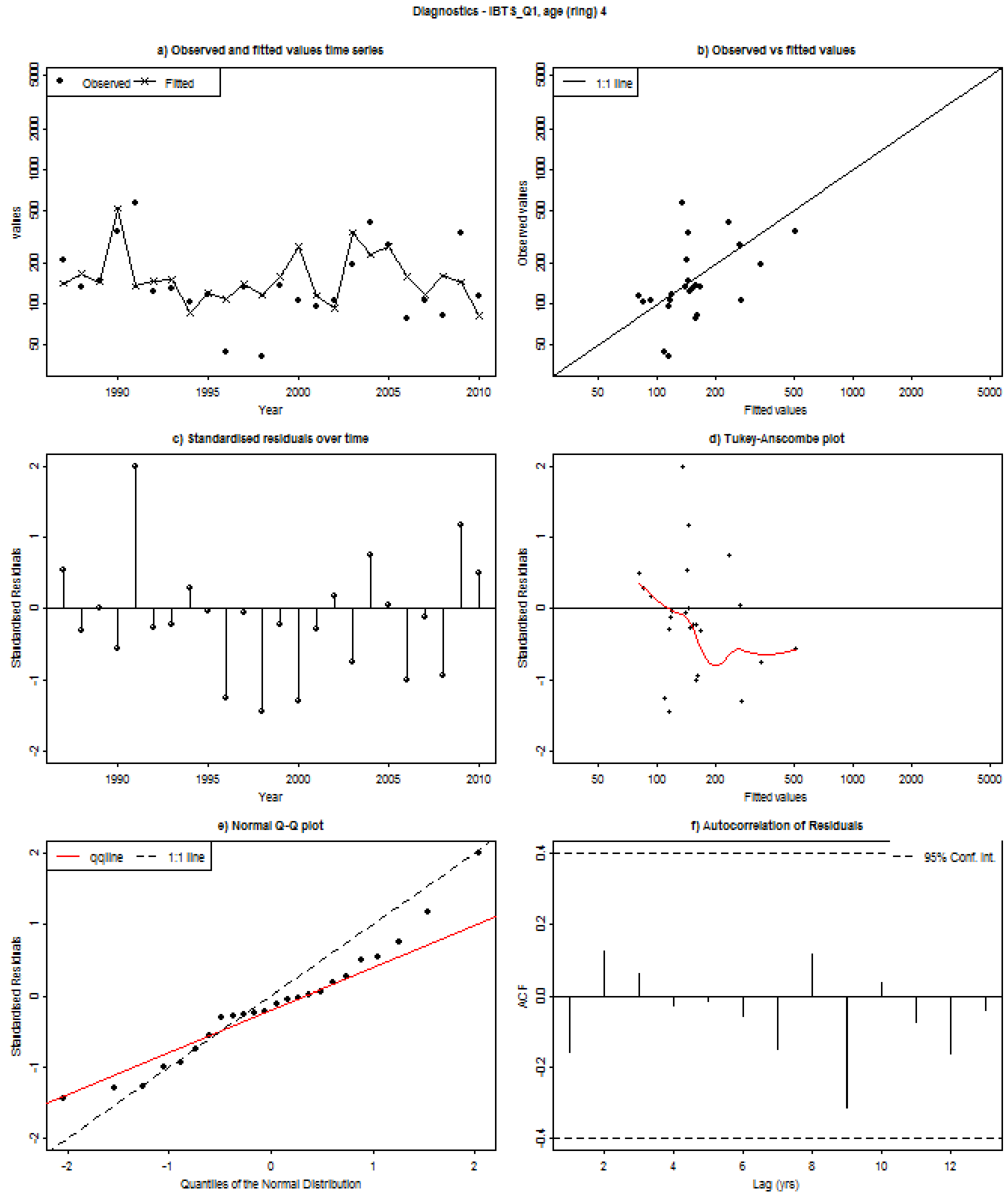


Figure 5.6.44: Herring in 6.a (combined) and 7.b and 7.c. Diagnostics of the assessment model fit to the Scottish bottom trawl survey index in quarter 1 at 4-winter ring time series. Top left: Estimates of numbers at 4-winter ring (line) and numbers predicted from index abundance at 4-winter ring. Top right: scatterplot of index observations versus assessment model estimates of numbers at 4-winter ring with the best-fit catchability model (linear function). Middle left: Time series of standardized residuals of the index at 4-winter ring. Middle right: index observation versus standardized residuals at 4-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

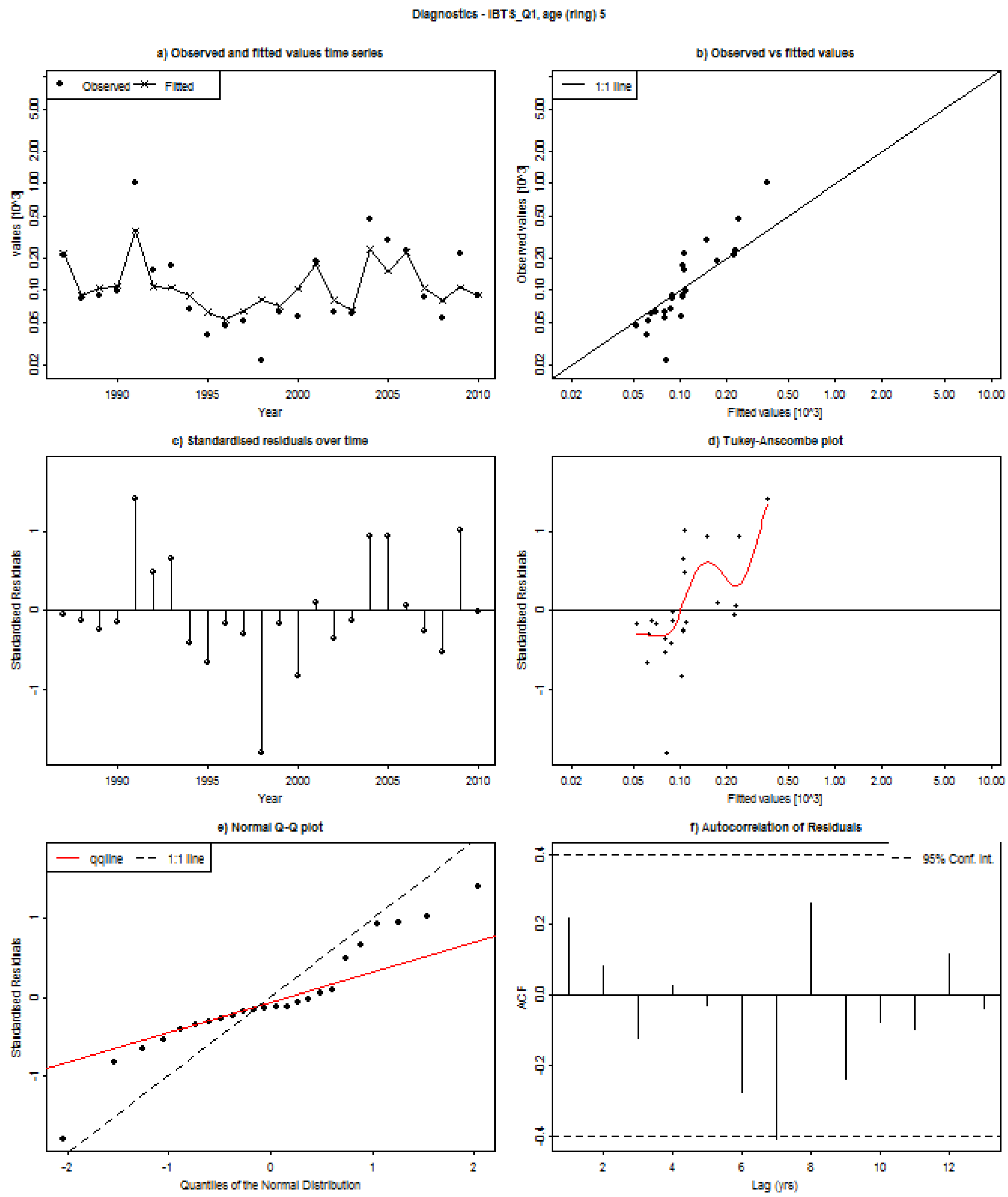


Figure 5.6.45: Herring in 6.a (combined) and 7.b and 7.c. Diagnostics of the assessment model fit to the Scottish bottom trawl survey index in quarter 1 at 5-winter ring time series. Top left: Estimates of numbers at 5-winter ring (line) and numbers predicted from index abundance at 5-winter ring. Top right: scatterplot of index observations versus assessment model estimates of numbers at 5-winter ring with the best-fit catchability model (linear function). Middle left: Time series of standardized residuals of the index at 5-winter ring. Middle right: index observation versus standardized residuals at 5-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

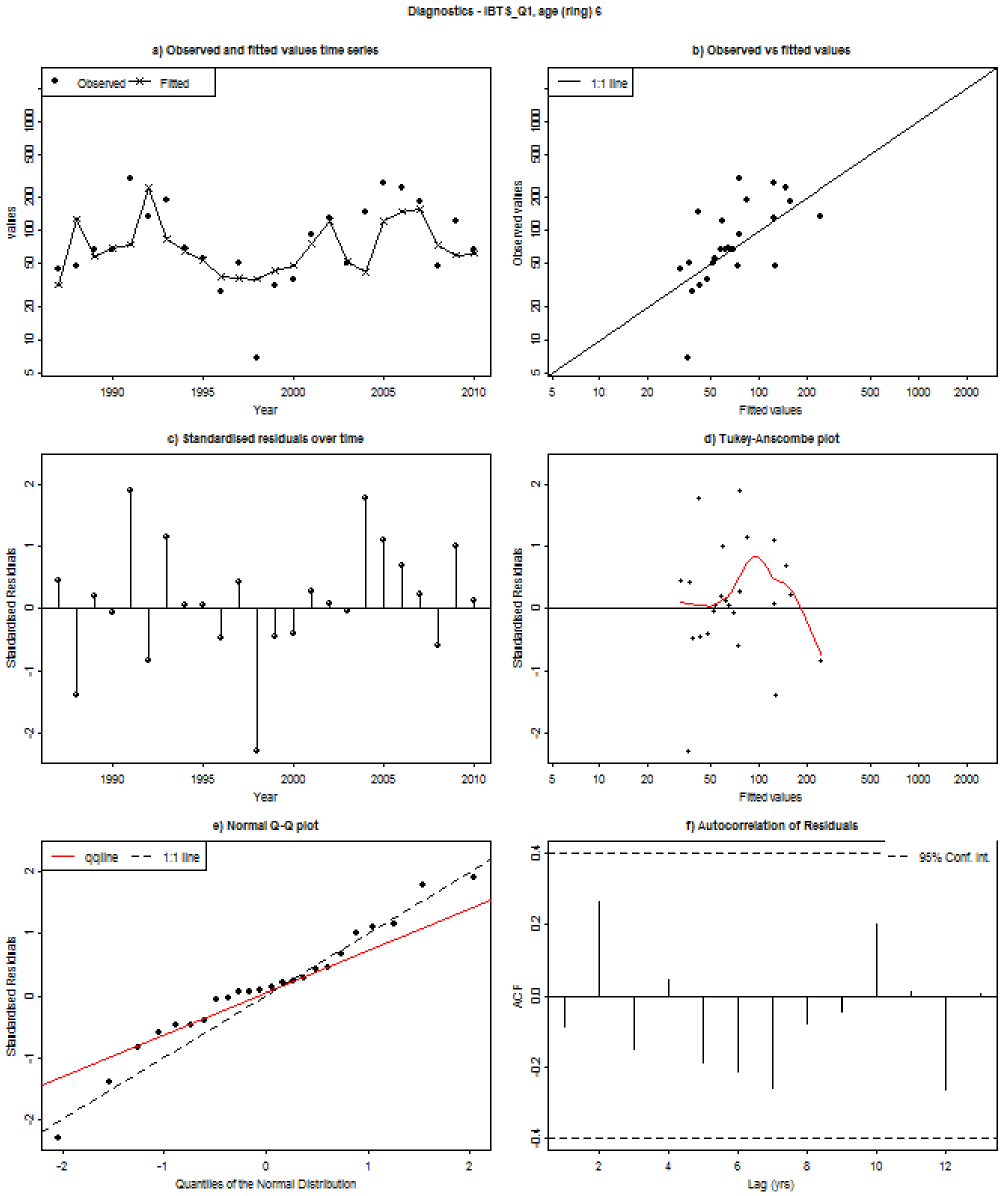


Figure 5.6.46: Herring in 6.a (combined) and 7.b and 7.c. Diagnostics of the assessment model fit to the Scottish bottom trawl survey index in quarter 1 at 6-winter ring time series. Top left: Estimates of numbers at 6-winter ring (line) and numbers predicted from index abundance at 6-winter ring. Top right: scatterplot of index observations versus assessment model estimates of numbers at 6-winter ring with the best-fit catchability model (linear function). Middle left: Time series of standardized residuals of the index at 6-winter ring. Middle right: index observation versus standardized residuals at 6-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

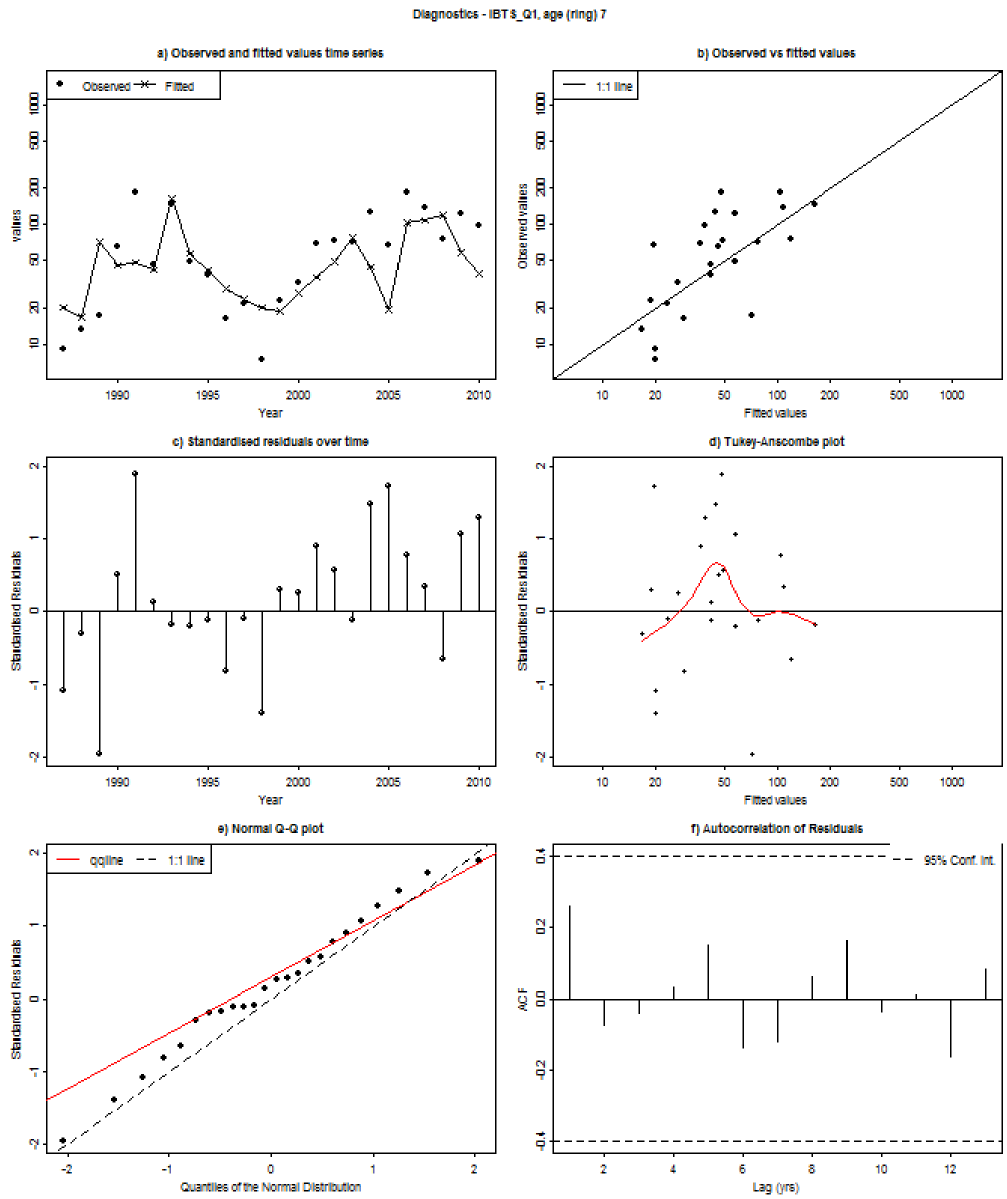


Figure 5.6.47: Herring in 6.a (combined) and 7.b and 7.c. Diagnostics of the assessment model fit to the Scottish bottom trawl survey index in quarter 1 at 7-winter ring time series. Top left: Estimates of numbers at 7-winter ring (line) and numbers predicted from index abundance at 7-winter ring. Top right: scatterplot of index observations versus assessment model estimates of numbers at 7-winter ring with the best-fit catchability model (linear function). Middle left: Time series of standardized residuals of the index at 7-winter ring. Middle right: index observation versus standardized residuals at 7-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

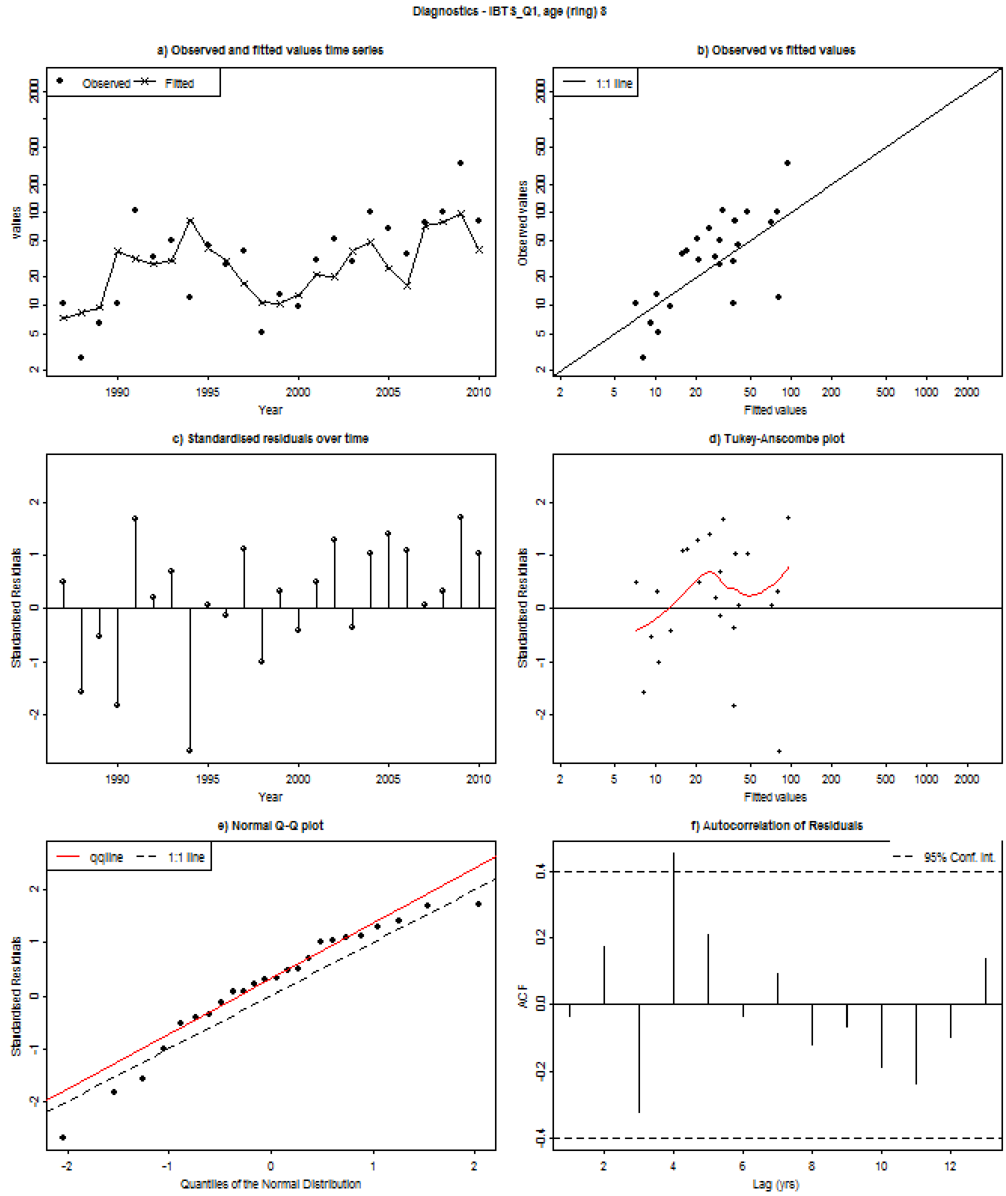


Figure 5.6.48: Herring in 6.a (combined) and 7.b and 7.c. Diagnostics of the assessment model fit to the Scottish bottom trawl survey index in quarter 1 at 8-winter ring time series. Top left: Estimates of numbers at 8-winter ring (line) and numbers predicted from index abundance at 8-winter ring. Top right: scatterplot of index observations versus assessment model estimates of numbers at 8-winter ring with the best-fit catchability model (linear function). Middle left: Time series of standardized residuals of the index at 8-winter ring. Middle right: index observation versus standardized residuals at 8-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

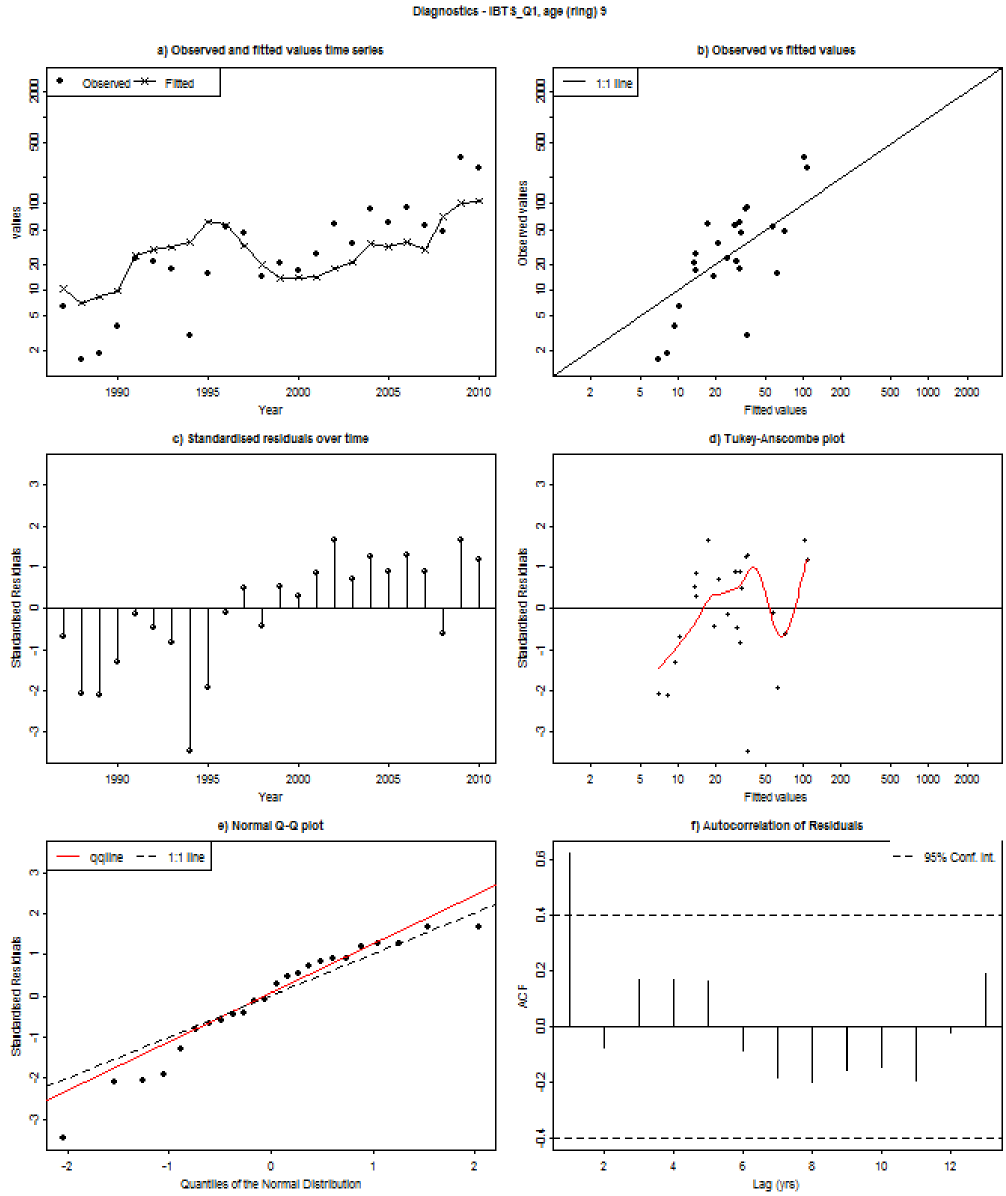


Figure 5.6.49: Herring in 6.a (combined) and 7.b and 7.c. Diagnostics of the assessment model fit to the Scottish bottom trawl survey index in quarter 1 at 9-winter ring time series. Top left: Estimates of numbers at 9-winter ring (line) and numbers predicted from index abundance at 9-winter ring. Top right: scatterplot of index observations versus assessment model estimates of numbers at 9-winter ring with the best-fit catchability model (linear function). Middle left: Time series of standardized residuals of the index at 9-winter ring. Middle right: index observation versus standardized residuals at 9-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

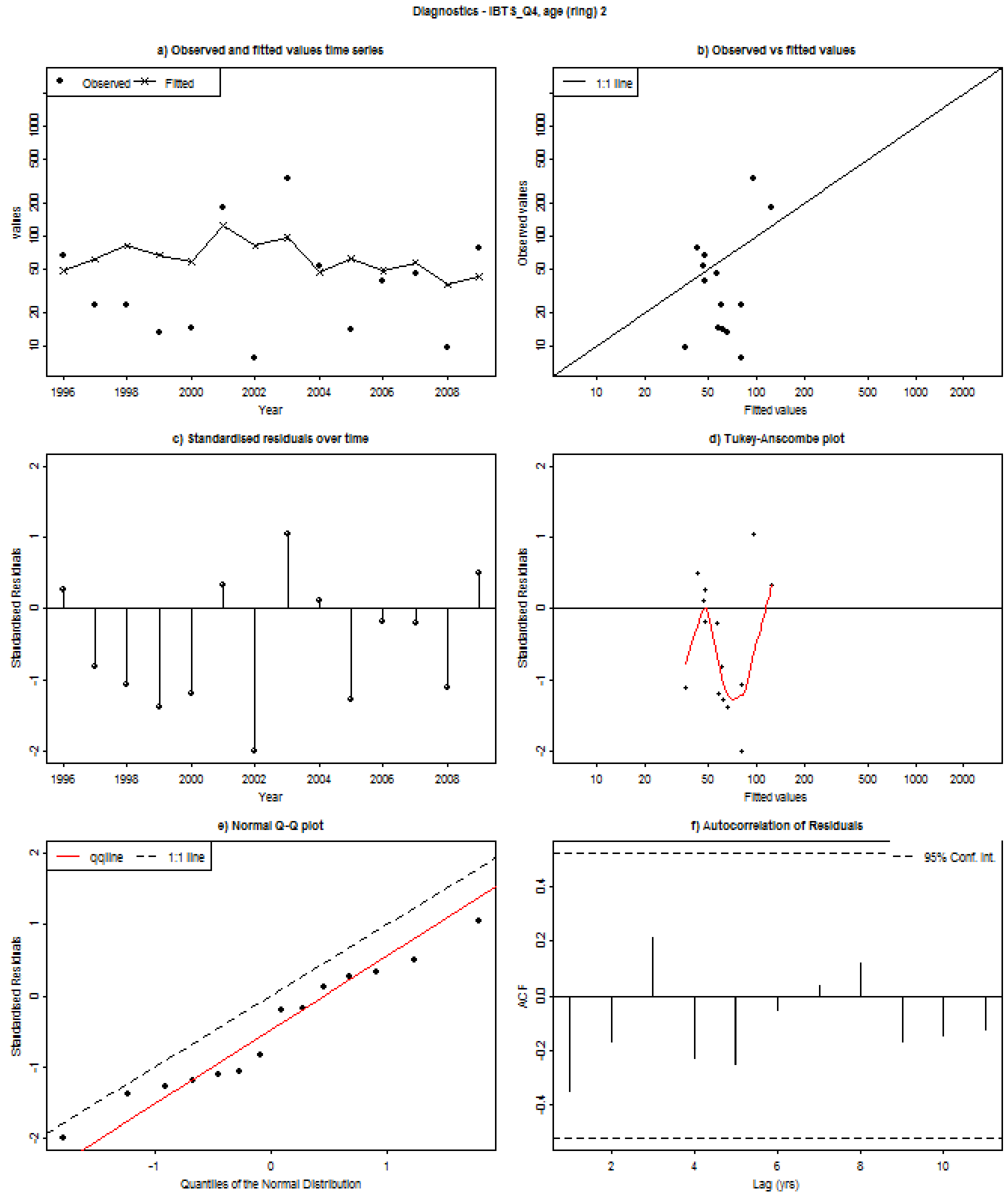


Figure 5.6.50: Herring in 6.a (combined) and 7.b and 7.c. Diagnostics of the assessment model fit to the Scottish bottom trawl survey index in quarter 4 at 2-winter ring time series. Top left: Estimates of numbers at 2-winter ring (line) and numbers predicted from index abundance at 2-winter ring. Top right: scatterplot of index observations versus assessment model estimates of numbers at 2-winter ring with the best-fit catchability model (linear function). Middle left: Time series of standardized residuals of the index at 2-winter ring. Middle right: index observation versus standardized residuals at 2-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

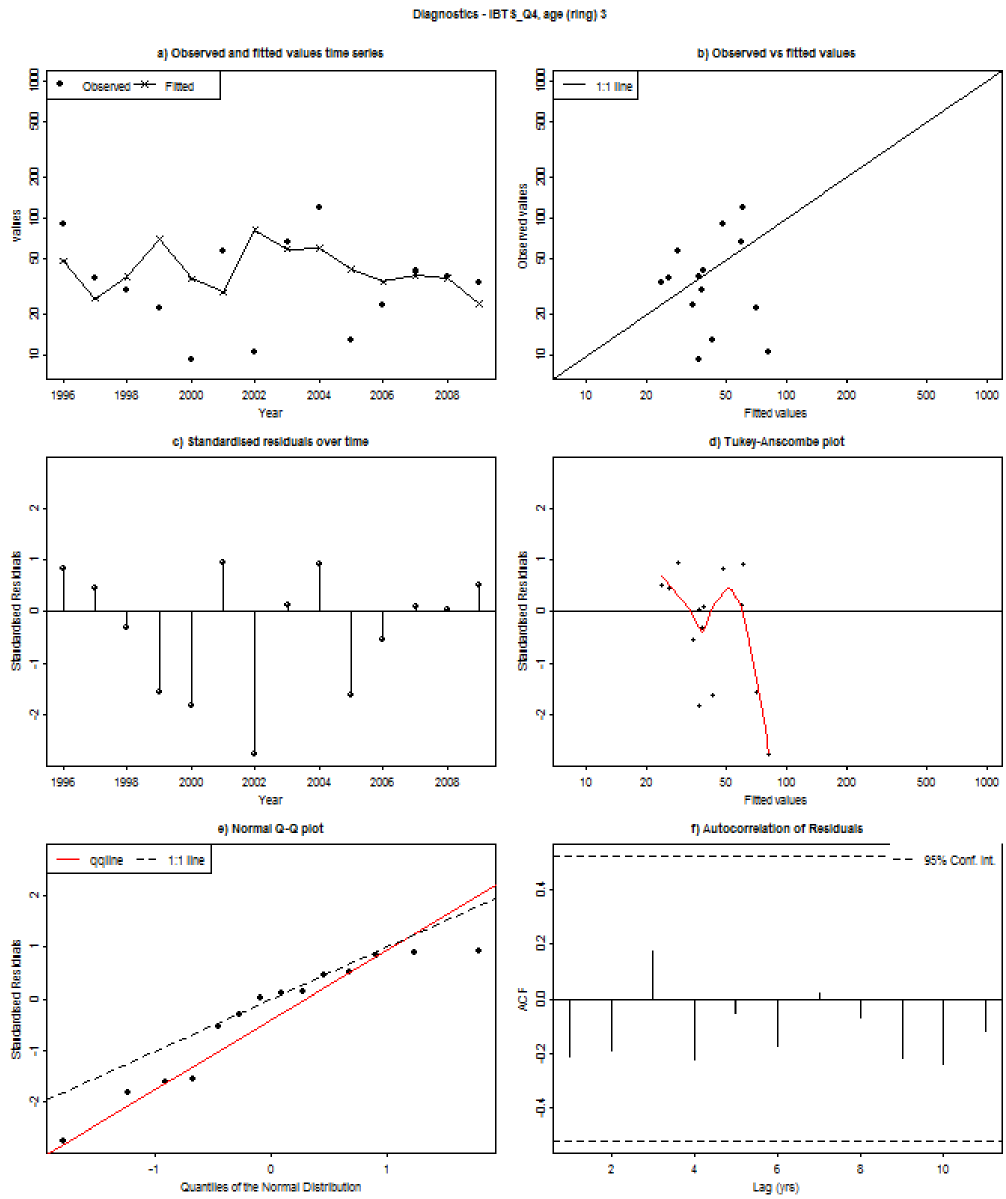


Figure 5.6.51: Herring in 6.a (combined) and 7.b and 7.c. Diagnostics of the assessment model fit to the Scottish bottom trawl survey index in quarter 4 at 3-winter ring time series. Top left: Estimates of numbers at 3-winter ring (line) and numbers predicted from index abundance at 3-winter ring. Top right: scatterplot of index observations versus assessment model estimates of numbers at 3-winter ring with the best-fit catchability model (linear function). Middle left: Time series of standardized residuals of the index at 3-winter ring. Middle right: index observation versus standardized residuals at 3-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

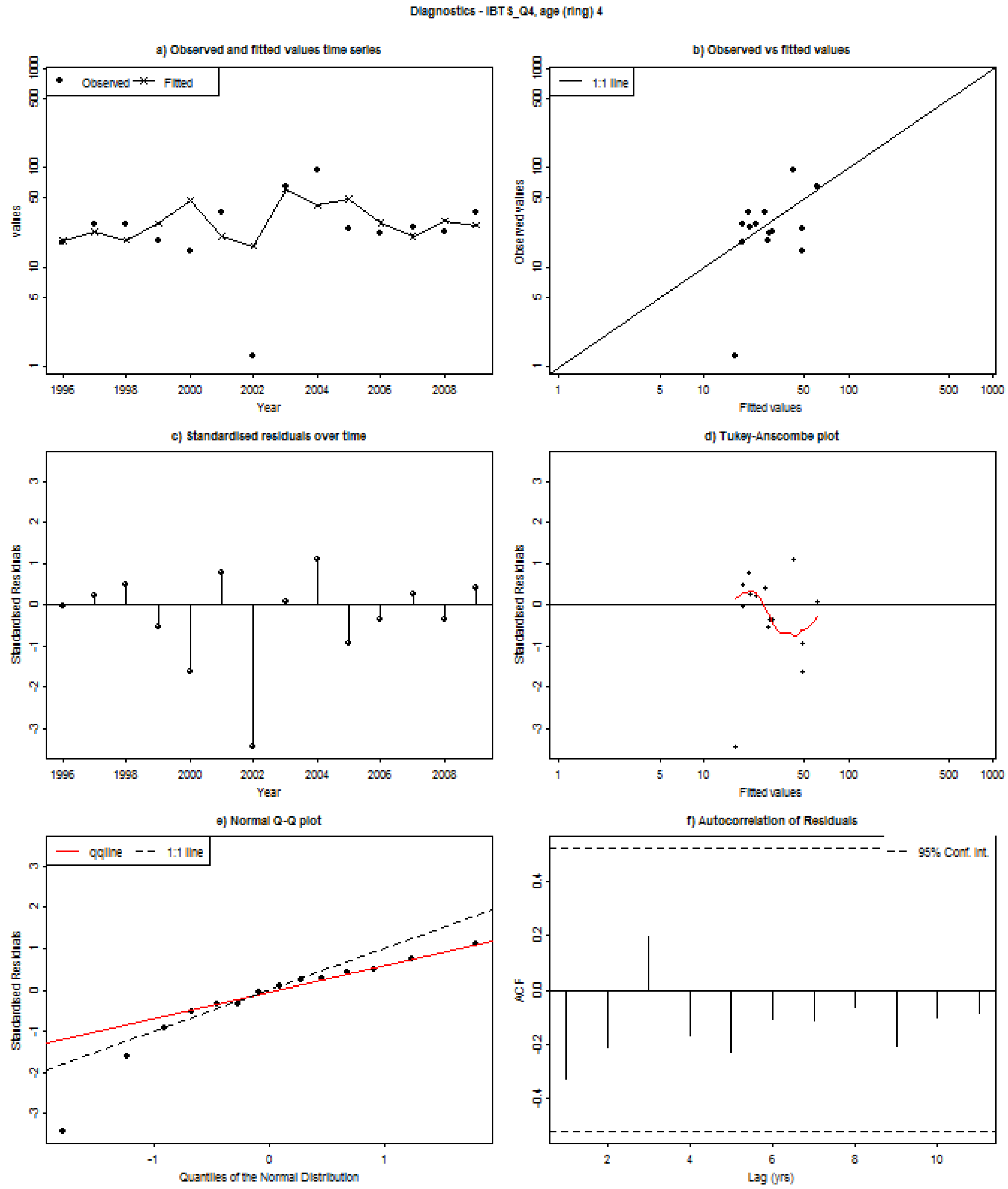


Figure 5.6.52: Herring in 6.a (combined) and 7.b and 7.c. Diagnostics of the assessment model fit to the Scottish bottom trawl survey index in quarter 4 at 4-winter ring time series. Top left: Estimates of numbers at 4-winter ring (line) and numbers predicted from index abundance at 4-winter ring. Top right: scatterplot of index observations versus assessment model estimates of numbers at 4-winter ring with the best-fit catchability model (linear function). Middle left: Time series of standardized residuals of the index at 4-winter ring. Middle right: index observation versus standardized residuals at 4-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

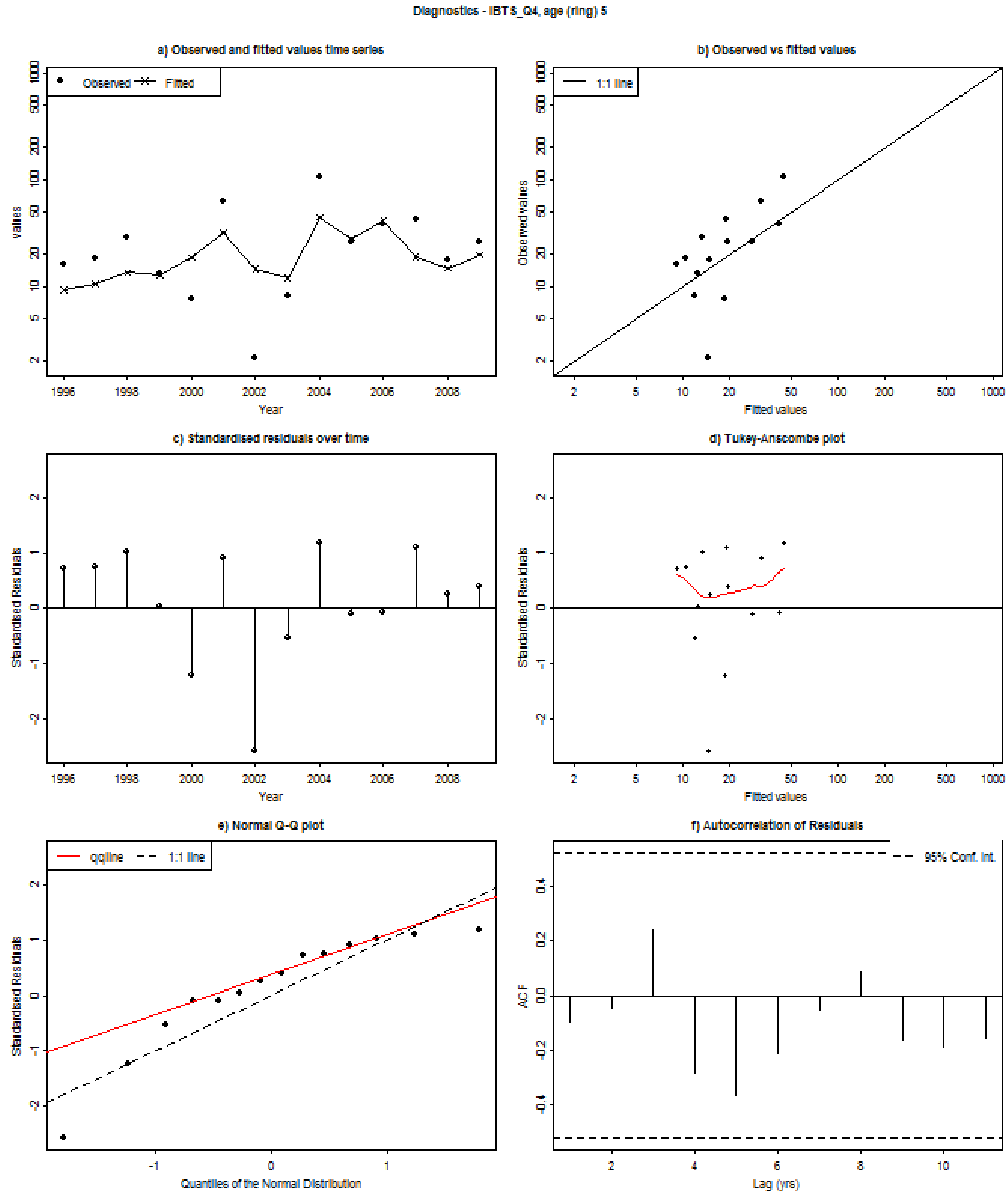


Figure 5.6.53: Herring in 6.a (combined) and 7.b and 7.c. Diagnostics of the assessment model fit to the Scottish bottom trawl survey index in quarter 4 at 5-winter ring time series. Top left: Estimates of numbers at 5-winter ring (line) and numbers predicted from index abundance at 5-winter ring. Top right: scatterplot of index observations versus assessment model estimates of numbers at 5-winter ring with the best-fit catchability model (linear function). Middle left: Time series of standardized residuals of the index at 5-winter ring. Middle right: index observation versus standardized residuals at 5-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

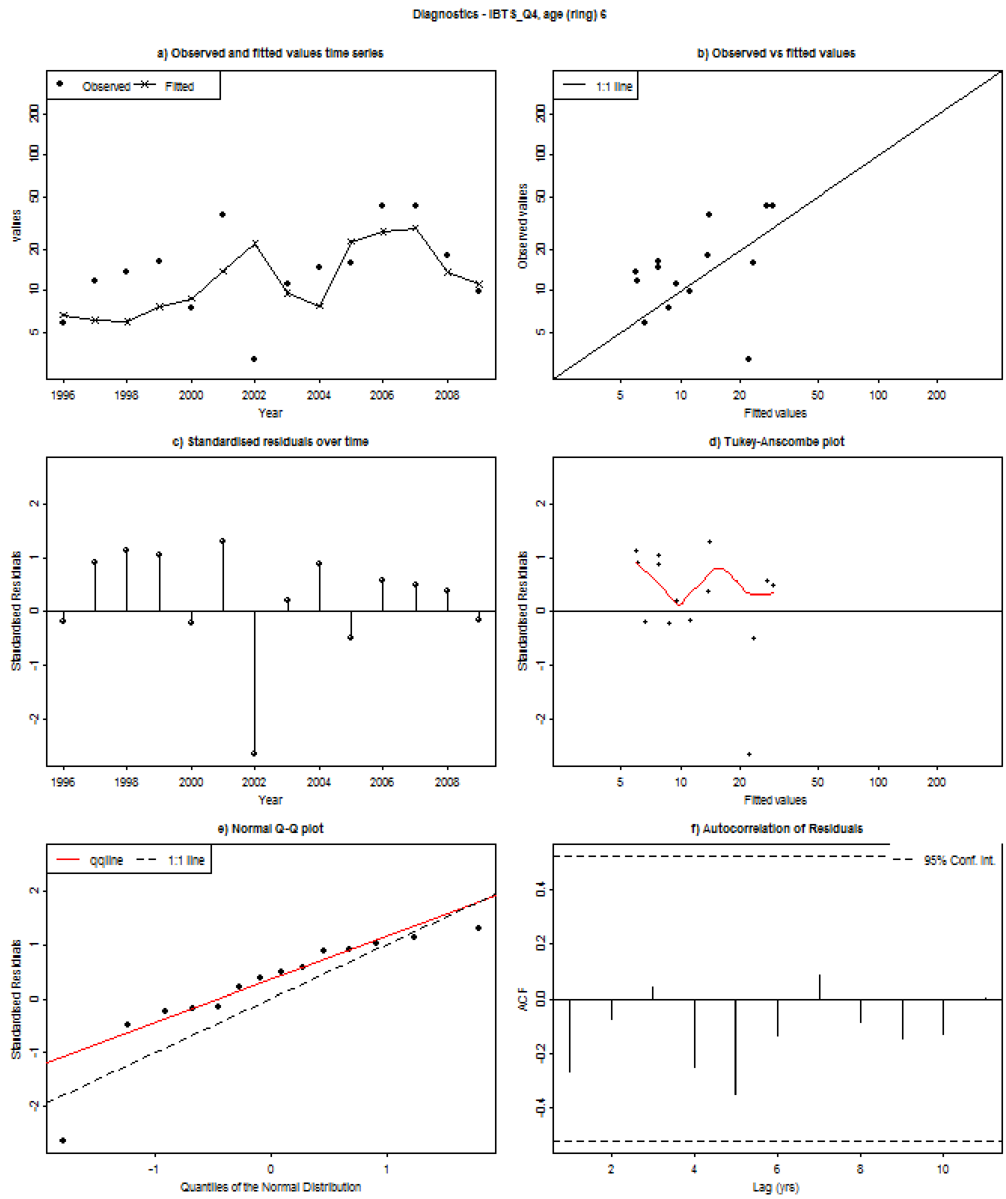


Figure 5.6.54: Herring in 6.a (combined) and 7.b and 7.c. Diagnostics of the assessment model fit to the Scottish bottom trawl survey index in quarter 4 at 6-winter ring time series. Top left: Estimates of numbers at 6-winter ring (line) and numbers predicted from index abundance at 6-winter ring. Top right: scatterplot of index observations versus assessment model estimates of numbers at 6-winter ring with the best-fit catchability model (linear function). Middle left: Time series of standardized residuals of the index at 6-winter ring. Middle right: index observation versus standardized residuals at 6-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

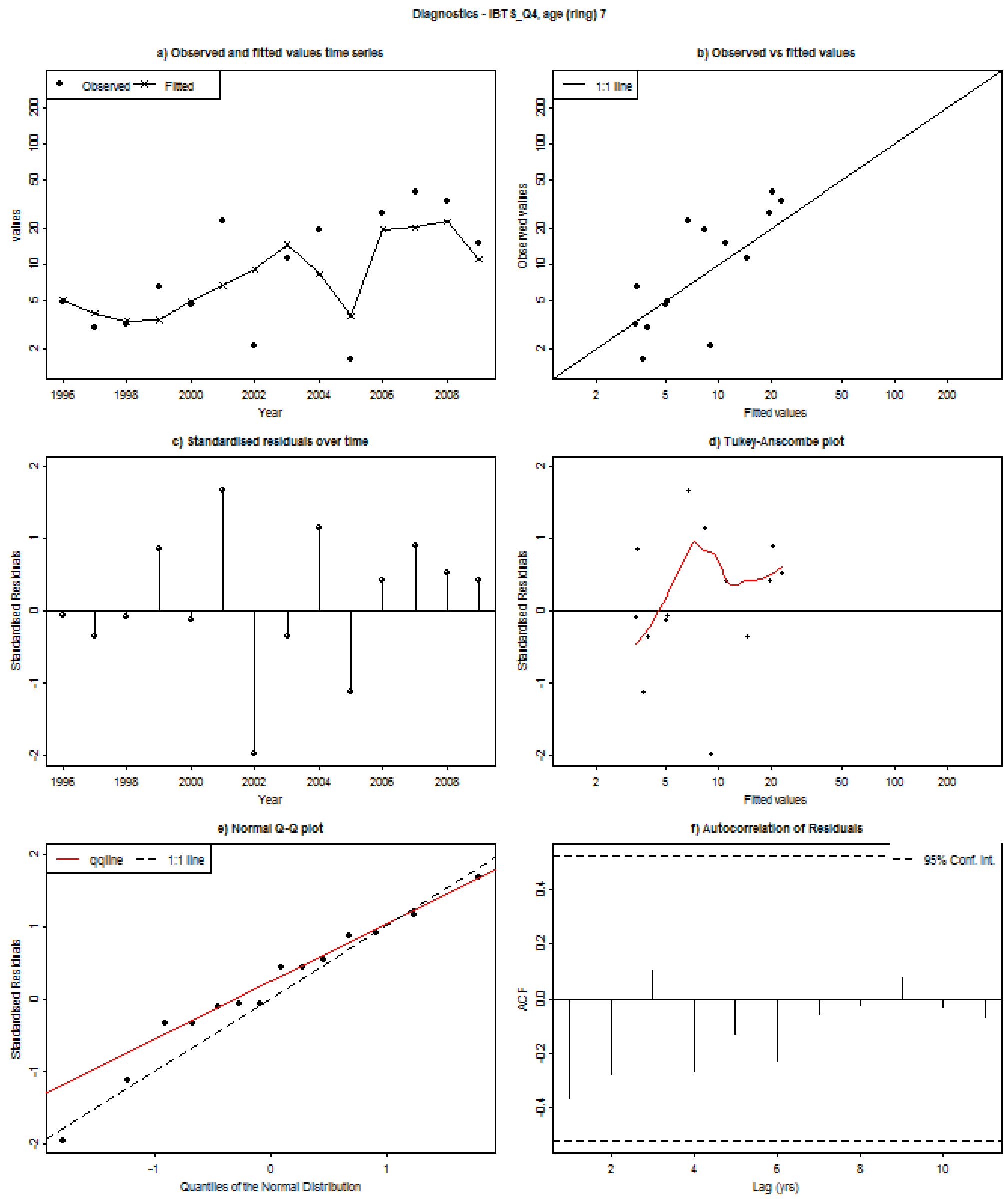


Figure 5.6.55: Herring in 6.a (combined) and 7.b and 7.c. Diagnostics of the assessment model fit to the Scottish bottom trawl survey index in quarter 4 at 7-winter ring time series. Top left: Estimates of numbers at 7-winter ring (line) and numbers predicted from index abundance at 7-winter ring. Top right: scatterplot of index observations versus assessment model estimates of numbers at 7-winter ring with the best-fit catchability model (linear function). Middle left: Time series of standardized residuals of the index at 7-winter ring. Middle right: index observation versus standardized residuals at 7-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

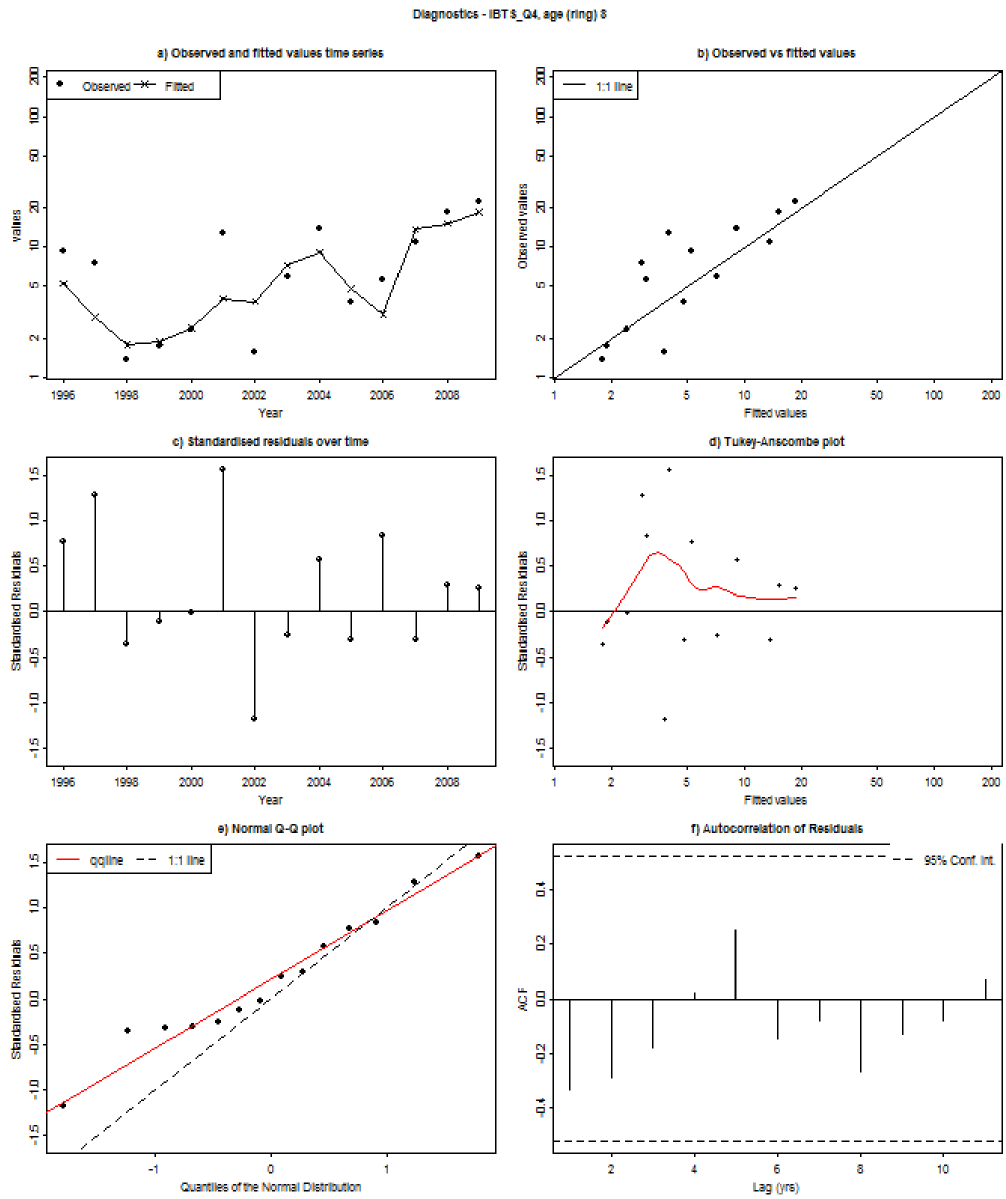


Figure 5.6.56: Herring in 6.a (combined) and 7.b and 7.c. Diagnostics of the assessment model fit to the Scottish bottom trawl survey index in quarter 4 at 8-winter ring time series. Top left: Estimates of numbers at 8-winter ring (line) and numbers predicted from index abundance at 8-winter ring. Top right: scatterplot of index observations versus assessment model estimates of numbers at 8-winter ring with the best-fit catchability model (linear function). Middle left: Time series of standardized residuals of the index at 8-winter ring. Middle right: index observation versus standardized residuals at 8-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

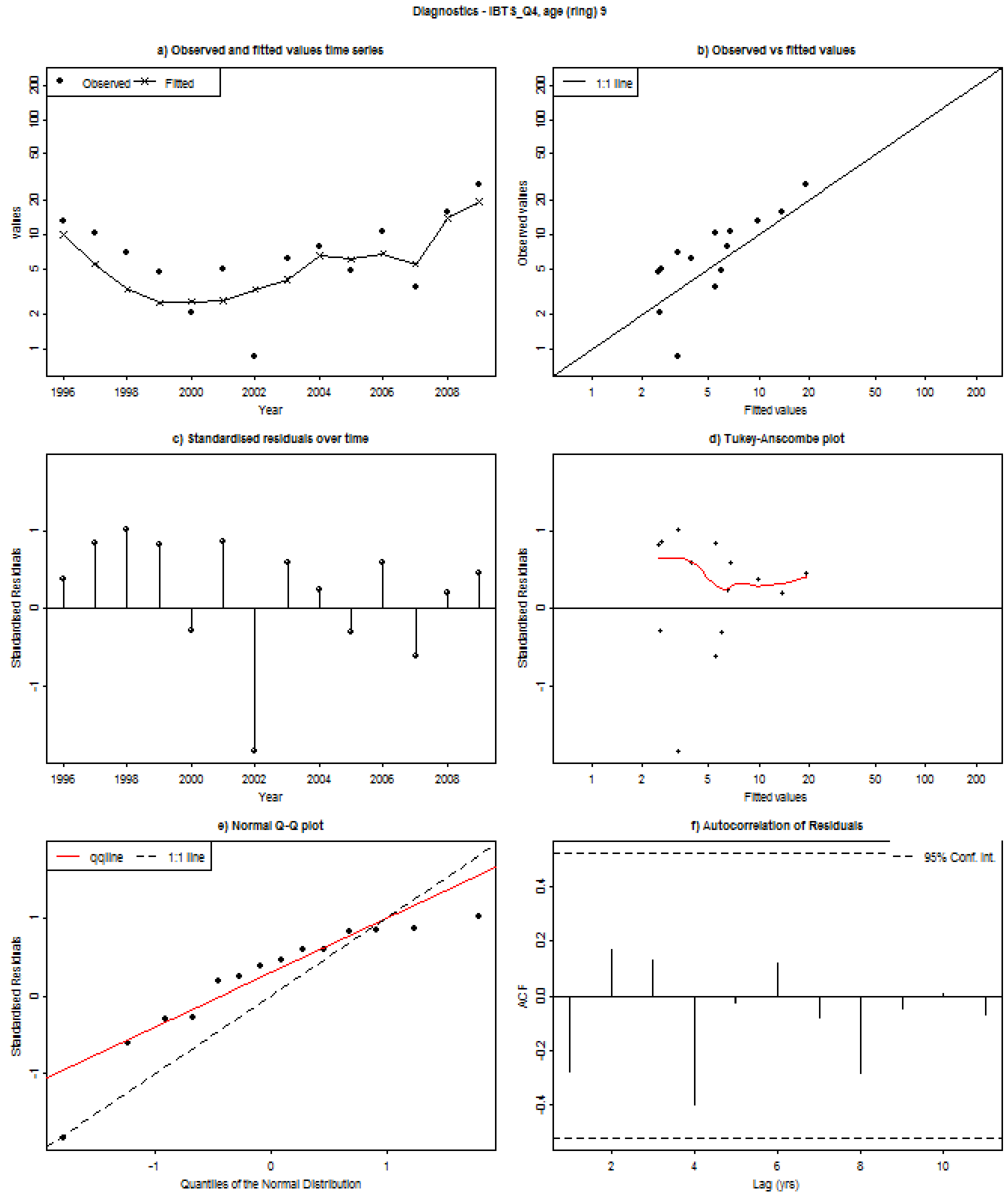


Figure 5.6.57: Herring in 6.a (combined) and 7.b and 7.c. Diagnostics of the assessment model fit to the Scottish bottom trawl survey index in quarter 4 at 9-winter ring time series. Top left: Estimates of numbers at 9-winter ring (line) and numbers predicted from index abundance at 9-winter ring. Top right: scatterplot of index observations versus assessment model estimates of numbers at 9-winter ring with the best-fit catchability model (linear function). Middle left: Time series of standardized residuals of the index at 9-winter ring. Middle right: index observation versus standardized residuals at 9-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

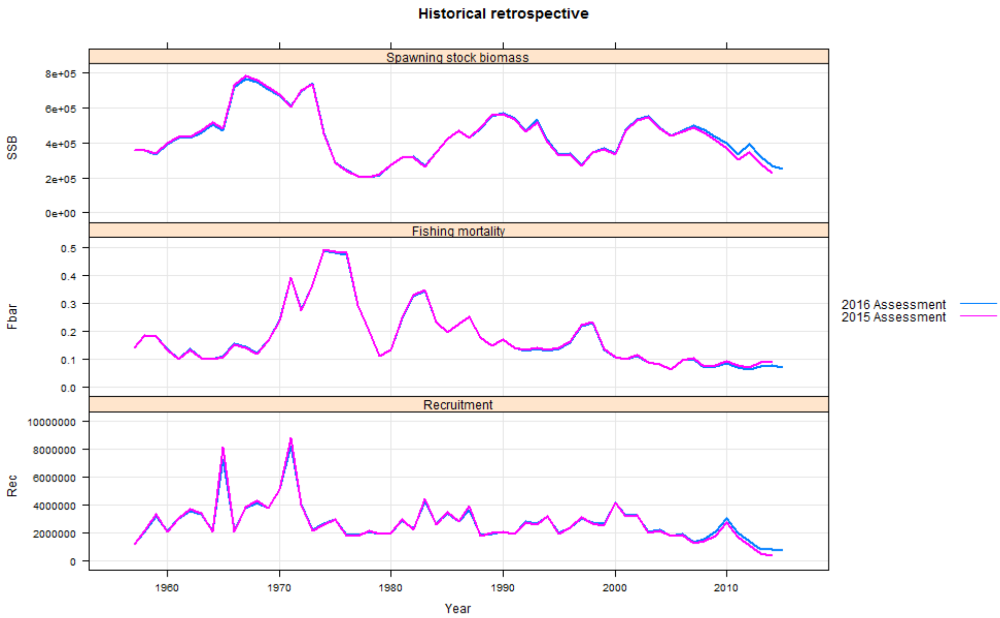


Figure 5.6.57: Herring in 6.a (combined) and 7.b and 7.c. Perception of stock estimates in 2015 and 2016 assessment.

6 Herring in divisions 6.a (South), 7.b–c, and 6.a (North)

6.1 Herring in divisions 6.a (South) and 7.b–c

Since 2015, this stock has been combined with herring in 6.aN (Section 6.2) for assessment and advisory purposes. This management unit existed since 1982 when it was separated from 6.aN. Until that time, 7.b–c was a separate management unit. The stock comprises autumn, winter, and spring spawning components.

The WG noted that the use of "age", "winter rings", "rings" and "ringers" still causes confusion outside the group (and sometimes even among WG members). The WG tries to avoid this by consequently using "rings", "ringers", "winter ringers" or "wr" instead of "age" throughout this section. However, if the word "age" is used it is qualified in brackets with one of the ring designations. It should be observed that, for autumn and winter spawning stocks, there is a difference of one year between "age" and "rings", which is not the case for the spring spawners. Further elaboration on the rationale behind this, specific to Area 6.aS, 7.b–c autumn, winter and spring spawners, can be found in the Stock Annex. It is the responsibility of any user of age based data for any of these herring stocks to consult the stock annex and if in doubt consult a relevant member of the Working Group.

6.1.1 The Fishery

6.1.1.1 Advice and management applicable to 2015–2016

The TAC for this area in 2015 was 0 t, based on the proposed rebuilding plan. In 2016 the TAC is set at 0 t, based on MSY considerations for the combined stocks.

Rebuilding plan

A rebuilding plan was developed by the Federation of Irish Fishermen's Organisations and the Pelagic RAC in 2013 (Table 6.1.1), based on comments received from STECF (2012). The new plan contains a harvest control rule. F is reduced towards zero as SSB decreases below B_{pa}. STECF evaluated the plan judging it to be precautionary and capable of rebuilding the stock, if trans-boundary catches in 6.aN, can be managed. The plan cannot be implemented at present because no separate advice is available for the stock.

6.1.1.2 Catches in 2015

The Working Group estimates of landings from 1990–2015 are given in Table 6.1.2. The total working group catch recorded for 2015 was 1000 t compared with 5000 t in 2014, 4000 t in 2013 and 6500 t in 2012. These data are shown in Figure 6.1.1. Estimated catch declined from 19 000 t in 2006.

It is thought that the Dutch freezer trawler fleet take some catches of this stock, though data are lacking. In 2015 the majority (70%) of WG catches were reported from the fourth quarter. Subdivision 6.aS accounted for the vast majority of catch, with only 70 t reported from 7.b.

6.1.1.3 Regulations and their effects

No new information.

6.1.1.4 Changes in fishing technology and fishing pattern

No new information.

6.1.2 Biological composition of the catch

6.1.2.1 Catch in numbers-at-age

In 2011, the time series was extended 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 6.1.3 with percentages since 1992 shown in Table 6.1.4. In 2015 the fishery was dominated by 4-ringers (2010 cohort), accounting for 34% of the catch, followed by 5-ringer (2009 cohort) at 23% and 2-ringer (2012) at 25% (Table 6.1.4).

6.1.2.2 Quality of the catch and biological data

The numbers of samples and the associated biological data are shown in Table 6.1.7. Overall, 400 fish were aged per 1000 t landed in 2015. The catch at age matrix does not track cohorts well, and there is weak agreement in age profiles between years. This is despite sampling levels being an order of magnitude higher than for other stocks.

Mixing of autumn, winter and spring spawners takes place in this area which may lead to ageing difficulties regarding counting of winter rings.

6.1.3 Fishery Independent Information

6.1.3.1 Acoustic Surveys

The Irish Marine Institute conducted acoustic surveys in 6.aS and 7.b–c on the west and north-west coasts of Ireland between 1994 and 2007 at various times of the year. An acoustic survey has been carried out in Division 6.aN in June–July since 1991 by Marine Scotland Science. It originally covered an area bounded by the 200 m depth contour and 4°W in the north and west and extended south to 56°N, it had provided an age-disaggregated index of abundance as the sole tuning index for the analytical assessment of 6.aN herring since 2002 (ICES, 2015b). In 2008, it was decided that these surveys should be expanded into a larger coordinated summer survey on recommendation from WESTHER, HAWG and SGHERWAY (Hatfield *et al.* 2007; ICES, 2007; ICES, 2010a). The Scottish 6.aN survey was augmented with the participation of the Irish Marine Institute and the area was expanded to cover all of ICES divisions 6.a and 7.b. The Malin Shelf Herring Acoustic Survey (MSHAS), as it is now known, has covered this increased geographical area in the period 2008 to 2014 as well as maintaining coverage of the original survey area in 6.aN.

6.1.4 Mean weights-at-age and maturity-at-age

6.1.4.1 Mean Weights-at-Age

The mean weights-at-age (kg) in the catches in 2015 are presented in Figure 6.1.5. In 2015 there was a continued decrease in mean weights since the mid-2000s. Over the longer time series there is little trend over time in weights at age (rings).

The mean weights in the stock at spawning time have been calculated from samples taken during the main spawning period that extends from October to February (Figure 6.1.6). Trends over the recent and longer time series are similar to those in the catches.

6.1.4.2 Maturity Ogive

One ringers are considered to be immature. All older ages are assumed to be 100% mature.

6.1.5 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 2012 (2010 cohort), have been consistently low in recent years. Since the mid-1990s recruitment has been low, based on exploratory assessments. However there is evidence from surveys that the 2007, 2008 and 2010 year classes were stronger than those in the previous 10 years.

6.1.6 Stock Assessment of 6.a (South) and 7.b–c

The ICES WKWEST 2015 benchmark workshop (ICES, 2015) for the herring stocks in 6.aN, 6.aS and 7.b–c concluded that the assessment would be a combined stock assessment. Details of the 2016 assessment for 6.a (combined) and 7.b–c are outlined in Section 5.6. No separate assessment is presented in 2016.

6.1.6.1 State of the stock

Not analytically determined.

6.1.7 Short term projections

Not undertaken.

6.1.8 Medium term simulations

Not undertaken.

6.1.9 Long term simulations

Not undertaken.

6.1.10 Precautionary and yield based reference points

Not determined.

6.1.11 Quality of the assessment

Not ascertained.

6.1.12 Management considerations

Fishing mortality should be zero, or as close to zero as possible for this stock.

The overall metapopulation (the two stocks in 6.a, 7.b–c) is not in a healthy state and may be at or below any potential B_{lim} value However the working group does not advocate a change to the current management procedures (separate TACs).

6.1.13 Environment

6.1.13.1 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. These data are combined with periods of good recruitment. It can be seen that strong historic herring recruitments/fisheries (Clarke *et al.*, WD 02 to HAWG 2012) correspond with cooler temperatures.

6.1.13.2 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/.

Colder temperatures implied by such a negative phase may be associated with improved recruitment in this stock.

Table 6.1.2. Herring in divisions 6.a(S) and 7.b–c. Estimated Herring catches in tonnes, 1989–2015. These data do not in all cases correspond to the official statistics and cannot be used for management purposes.

Country	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
France	+	-	-	-	-	-	-	-	-	-
Germany, Fed.Rep.	-	-	250	-	-	11	-	-	-	-
Ireland	25000	22500	26000	27600	24400	25450	23800	24400	25200	16325
Netherlands	2533	600	900	2500	2500	1207	1800	3400	2500	1868
UK (N.Ireland)	80	-	-	-	-	-	-	-	-	-
UK (England + Wales)	-	-	-	-	50	24	-	-	-	-
UK Scotland	-	+	-	200	-	-	-	-	-	-
Total landings	27613	23100	27150	30300	26950	26692	25600	27800	27700	18193
Unallocated/ area misreported	13826	11200	4600	6250	6250	1100	6900	-700	11200	7916
Discards	2530	3400	100	250	700	-	-	50		-
WG catch	43969	37700	31850	36800	33900	27792	32500	27150	38900	26109

Country	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
France	-	-	515	-	-	-	-	-	-	-
Germany, Fed.Rep.	-	-	-	-	-	-	-	-	-	-
Ireland	10164	11278	13072	12921	10950	13351	14840	12662	10237	8533
Netherlands	1234	2088	366	-	64	-	353	13	-	-
UK (N.Ireland)	-	-	-	-	-	-	-	-	-	-
UK (England + Wales)	-	-	-	-	-	-	-	-	-	-
UK Scotland	-	-	-	-	-	-	6	-	-	-
Total landings	11398	13366	13953	12921	11014	13351	15199	12675	10237	8533
Unallocated/ area misreported	8448	1390	3873	3581	2813	2880	4000	5116	3103	1935
Discards	-	-	-	-	-	-	-	-	-	-
WG catch	19846	14756	17826	16502	13827	16231	19199	17791	13340	10468

Country	2010	2011	2012	2013	2014	2015
France	-	-	-	-	-	-
Germany, Fed.Rep.	-	-	-	-	-	-
Ireland	7513	4247	3791	1460	2933	73
Netherlands	-	-	-	40	-	+
UK (N.Ireland)	-	-	-	-	-	-
UK (England + Wales)	-	-	-	-	-	-
UK Scotland	-	-	-	-	-	5
Total landings	7513	4247	3791	1500	2933	78
Unallocated/ area misreported	2728	2672	2780	2468	2163	1000
Discards	-	-	-	-	-	-
WG catch	10241	6919	6571	3968	5096	1078

Table 6.1.3. Herring in divisions 6.a(S) and 7.b–c. Catch in numbers-at-age (winter rings) from 1957–2015.

	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

	1	2	3	4	5	6	7	8	9
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
2013	61	3118	4532	12238	1665	1792	425	382	202
2014	34	465	8825	6735	12146	2406	1045	437	204
2015	27	1842	598	2553	1699	685	96	9	0

Table 6.1.4. Herring in divisions 6.a(S) and 7.b–c. Percentage age composition (winter rings).

Year	1	2	3	4	5	6	7	8	9+
1992	1%	8%	22%	14%	6%	37%	4%	4%	3%
1993	0%	10%	11%	21%	12%	7%	33%	4%	3%
1994	6%	28%	15%	8%	11%	7%	4%	16%	5%
1995	0%	23%	23%	12%	13%	11%	4%	6%	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%	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%
2013	0%	13%	19%	50%	7%	7%	2%	2%	1%
2014	0%	1%	27%	21%	38%	7%	3%	1%	1%
2015	0%	25%	8%	34%	23%	9%	1%	0%	0%

Table 6.1.5. Herring in divisions 6.a(S) and 7.b–c. Mean weights at age in the catches 1970–2015.

	1	2	3	4	5	6	7	8	9+
1970	0.110	0.129	0.165	0.191	0.209	0.222	0.231	0.237	0.241
1971	0.110	0.129	0.165	0.191	0.209	0.222	0.231	0.237	0.241
1972	0.110	0.129	0.165	0.191	0.209	0.222	0.231	0.237	0.241
1973	0.110	0.129	0.165	0.191	0.209	0.222	0.231	0.237	0.241
1974	0.110	0.129	0.165	0.191	0.209	0.222	0.231	0.237	0.241
1975	0.110	0.129	0.165	0.191	0.209	0.222	0.231	0.237	0.241
1976	0.110	0.129	0.165	0.191	0.209	0.222	0.231	0.237	0.241
1977	0.110	0.129	0.165	0.191	0.209	0.222	0.231	0.237	0.241
1978	0.110	0.129	0.165	0.191	0.209	0.222	0.231	0.237	0.241
1979	0.110	0.129	0.165	0.191	0.209	0.222	0.231	0.237	0.241
1980	0.110	0.129	0.165	0.191	0.209	0.222	0.231	0.237	0.241
1981	0.110	0.129	0.165	0.191	0.209	0.222	0.231	0.237	0.241
1982	0.110	0.129	0.165	0.191	0.209	0.222	0.231	0.237	0.241
1983	0.090	0.129	0.165	0.191	0.209	0.222	0.231	0.237	0.241
1984	0.106	0.141	0.181	0.210	0.226	0.237	0.243	0.247	0.248
1985	0.077	0.122	0.161	0.184	0.196	0.206	0.212	0.225	0.230
1986	0.095	0.138	0.164	0.194	0.212	0.225	0.239	0.208	0.288
1987	0.085	0.102	0.150	0.169	0.177	0.193	0.205	0.215	0.220
1988		0.098	0.133	0.153	0.166	0.171	0.183	0.191	0.201
1989	0.080	0.130	0.141	0.164	0.174	0.183	0.192	0.193	0.203
1990	0.094	0.138	0.148	0.160	0.176	0.189	0.194	0.208	0.216
1991	0.089	0.134	0.145	0.157	0.167	0.185	0.199	0.207	0.230
1992	0.095	0.141	0.147	0.157	0.165	0.171	0.180	0.194	0.219
1993	0.112	0.138	0.153	0.170	0.181	0.184	0.196	0.229	0.236
1994	0.081	0.141	0.164	0.177	0.189	0.187	0.191	0.204	0.220
1995	0.080	0.140	0.161	0.173	0.182	0.198	0.194	0.206	0.217
1996	0.085	0.135	0.172	0.182	0.199	0.209	0.220	0.233	0.237
1997	0.093	0.135	0.155	0.181	0.201	0.217	0.217	0.231	0.239
1998	0.095	0.136	0.145	0.173	0.191	0.196	0.202	0.222	0.217
1999	0.106	0.144	0.145	0.163	0.186	0.195	0.200	0.216	0.222
2000	0.102	0.129	0.154	0.172	0.180	0.184	0.204	0.203	0.204
2001	0.086	0.122	0.139	0.167	0.183	0.188	0.222	0.222	0.213
2002	0.097	0.127	0.140	0.155	0.175	0.196	0.204	0.218	0.226
2003	0.102	0.134	0.150	0.167	0.183	0.196	0.216	0.210	0.228
2004	0.085	0.140	0.150	0.167	0.182	0.193	0.222	0.221	0.285
2005	0.105	0.135	0.150	0.162	0.174	0.188	0.200	0.237	0.296
2006	0.106	0.137	0.141	0.158	0.169	0.178	0.199	0.221	0.243
2007	0.118	0.144	0.145	0.168	0.179	0.189	0.197	0.233	0.237
2008	0.1108	0.1478	0.1503	0.1663	0.1745	0.1845	0.1938	0.1990	0.2407
2009	0.077	0.146	0.171	0.194	0.200	0.207	0.211	0.218	0.275
2010	0.104	0.131	0.168	0.189	0.201	0.212	0.218	0.226	0.229
2011	0.094	0.122	0.141	0.174	0.193	0.202	0.217	0.218	0.246
2012	0.09	0.134	0.179	0.196	0.214	0.237	0.228	0.243	0.236
2013	0.083	0.121	0.141	0.170	0.181	0.196	0.202	0.226	0.226
2014	0.105	0.139	0.136	0.155	0.168	0.175	0.184	0.183	0.187
2015	0.090	0.113	0.145	0.152	0.161	0.168	0.176	0.185	0.188

Table 6.1.6. Herring in divisions 6.a(S) and 7.b–c. Mean weights at age in the stock at spawning time 1970–2015.

	1	2	3	4	5	6	7	8	9+
1970	0.120	0.169	0.210	0.236	0.260	0.273	0.283	0.290	0.296
1971	0.120	0.169	0.210	0.236	0.260	0.273	0.283	0.290	0.296
1972	0.120	0.169	0.210	0.236	0.260	0.273	0.283	0.290	0.296
1973	0.120	0.169	0.210	0.236	0.260	0.273	0.283	0.290	0.296
1974	0.120	0.169	0.210	0.236	0.260	0.273	0.283	0.290	0.296
1975	0.120	0.169	0.210	0.236	0.260	0.273	0.283	0.290	0.296
1976	0.120	0.169	0.210	0.236	0.260	0.273	0.283	0.290	0.296
1977	0.120	0.169	0.210	0.236	0.260	0.273	0.283	0.290	0.296
1978	0.120	0.169	0.210	0.236	0.260	0.273	0.283	0.290	0.296
1979	0.120	0.169	0.210	0.236	0.260	0.273	0.283	0.290	0.296
1980	0.120	0.169	0.210	0.236	0.260	0.273	0.283	0.290	0.296
1981	0.120	0.169	0.210	0.236	0.260	0.273	0.283	0.290	0.296
1982	0.120	0.169	0.210	0.236	0.260	0.273	0.283	0.290	0.296
1983	0.120	0.169	0.210	0.236	0.260	0.273	0.283	0.290	0.296
1984	0.120	0.169	0.210	0.236	0.260	0.273	0.283	0.290	0.296
1985	0.100	0.150	0.196	0.227	0.238	0.251	0.252	0.269	0.284
1986	0.098	0.169	0.209	0.238	0.256	0.276	0.280	0.287	0.312
1987	0.097	0.164	0.206	0.233	0.252	0.271	0.280	0.296	0.317
1988	0.097	0.164	0.206	0.233	0.252	0.271	0.280	0.296	0.317
1989	0.138	0.157	0.168	0.182	0.200	0.217	0.227	0.238	0.245
1990	0.113	0.152	0.170	0.180	0.200	0.217	0.225	0.233	0.255
1991	0.102	0.149	0.174	0.190	0.195	0.206	0.226	0.236	0.248
1992	0.102	0.144	0.167	0.182	0.194	0.197	0.214	0.218	0.242
1993	0.118	0.166	0.196	0.205	0.214	0.220	0.223	0.242	0.258
1994	0.098	0.156	0.192	0.209	0.216	0.223	0.226	0.230	0.247
1995	0.090	0.144	0.181	0.203	0.217	0.226	0.227	0.239	0.246
1996	0.086	0.137	0.186	0.206	0.219	0.234	0.233	0.249	0.253
1997	0.094	0.135	0.169	0.194	0.210	0.224	0.231	0.230	0.239
1998	0.095	0.136	0.145	0.173	0.191	0.196	0.202	0.222	0.217
1999	0.104	0.145	0.154	0.174	0.200	0.222	0.230	0.240	0.246
2000	0.100	0.134	0.157	0.177	0.197	0.207	0.217	0.230	0.245
2001	0.091	0.125	0.150	0.172	0.191	0.200	0.203	0.203	0.216
2002	0.092	0.127	0.146	0.170	0.190	0.201	0.210	0.227	0.229
2003	0.094	0.131	0.155	0.175	0.192	0.203	0.232	0.222	0.243
2004	0.081	0.133	0.151	0.175	0.194	0.207	0.238	0.233	0.276
2005	0.095	0.127	0.15	0.172	0.185	0.196	0.223	0.234	0.274
2006	0.092	0.130	0.133	0.162	0.177	0.186	0.209	0.238	0.247
2007	0.114	0.133	0.133	0.171	0.186	0.196	0.208	0.228	0.229
2008	0.098	0.136	0.140	0.174	0.185	0.196	0.192	0.205	0.234
2009	0.072	0.141	0.162	0.197	0.215	0.223	0.225	0.221	0.286
2010	0.092	0.128	0.157	0.189	0.208	0.227	0.234	0.239	0.247
2011	0.082	0.118	0.136	0.177	0.199	0.207	0.225	0.239	0.240
2012	0.084	0.135	0.182	0.203	0.214	0.226	0.225	0.21	0.226
2013	0.074	0.114	0.140	0.170	0.188	0.198	0.204	0.223	0.222
2014	0.093	0.128	0.135	0.154	0.169	0.170	0.188	0.169	0.206
2015	0.077	0.112	0.146	0.155	0.165	0.173	0.179	0.183	0.217

Table 6.1.7. Herring in divisions 6.a(S) and 7.b–c. Sampling intensity of catches in 2015.

Year	Quarter	Landings (t)	No. Samples	No. aged	No. Measured	Aged/1000 t
2015	1	329	0	0	0	0
2015	4	744	7	438	1764	589
Total		1073	7	438	1764	408

Table 6.1.8. Herring in divisions 6.a(S) and 7.b–c. Details of previous Irish acoustic surveys conducted in 6.aS before Malin Shelf series began in 2008.

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	23,762	22,788
2000	Autumn	21,000	20,500
2001	Autumn	11,100	9,800
2002	Winter	8,900	7,200
2003	Winter	10,300	9,500
2004	Winter	41,700	41,399
2005	Winter	71,253	66,138
2006	Winter	27,770	27,200
2007	Winter	14,222	13,974

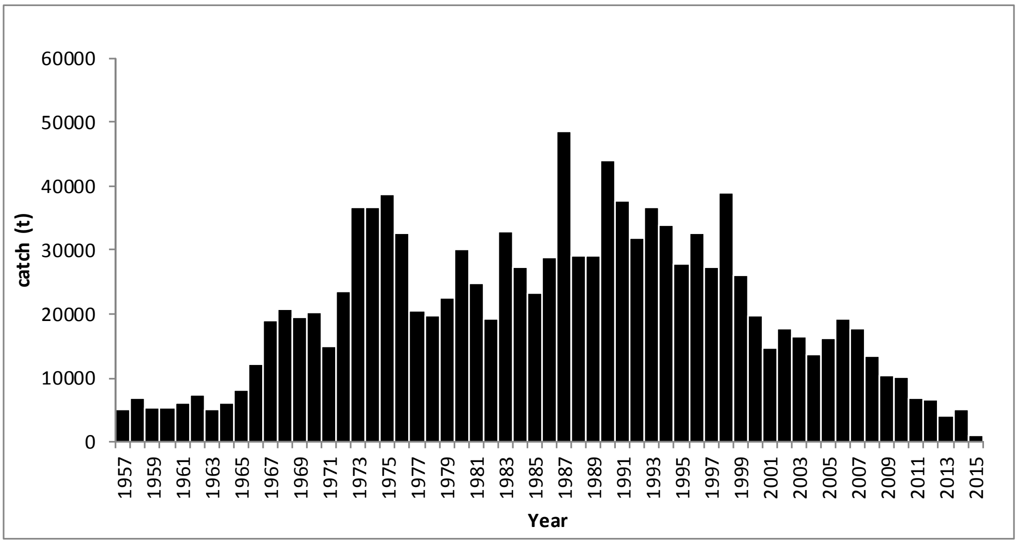


Figure 6.1.1. Herring in divisions 6.a(S) and 7.b–c. Working group estimate of catches from 1957–2015.

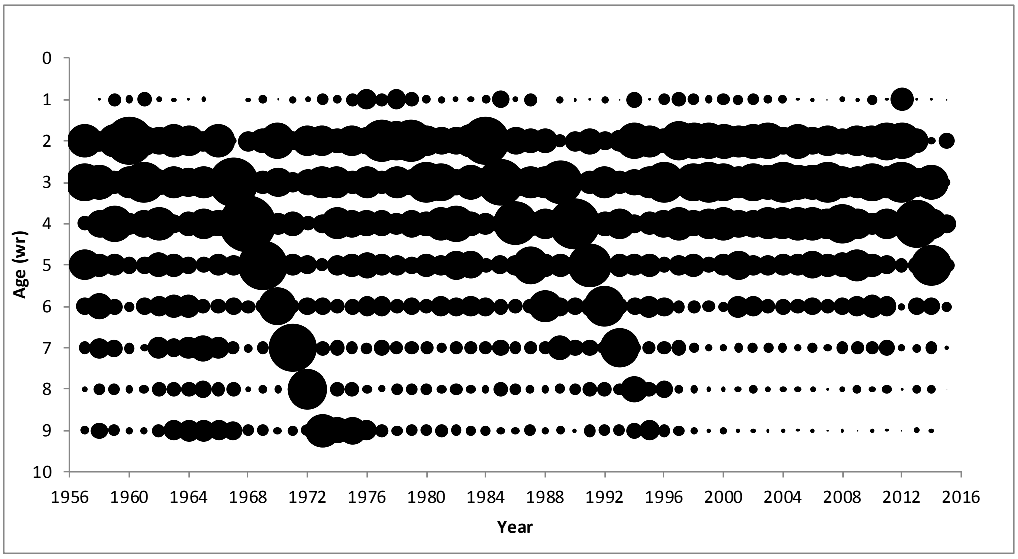


Figure 6.1.2. Herring in divisions 6.a(S) and 7.b–c. Mean standardised catch numbers at age standardised by year for the fishery.

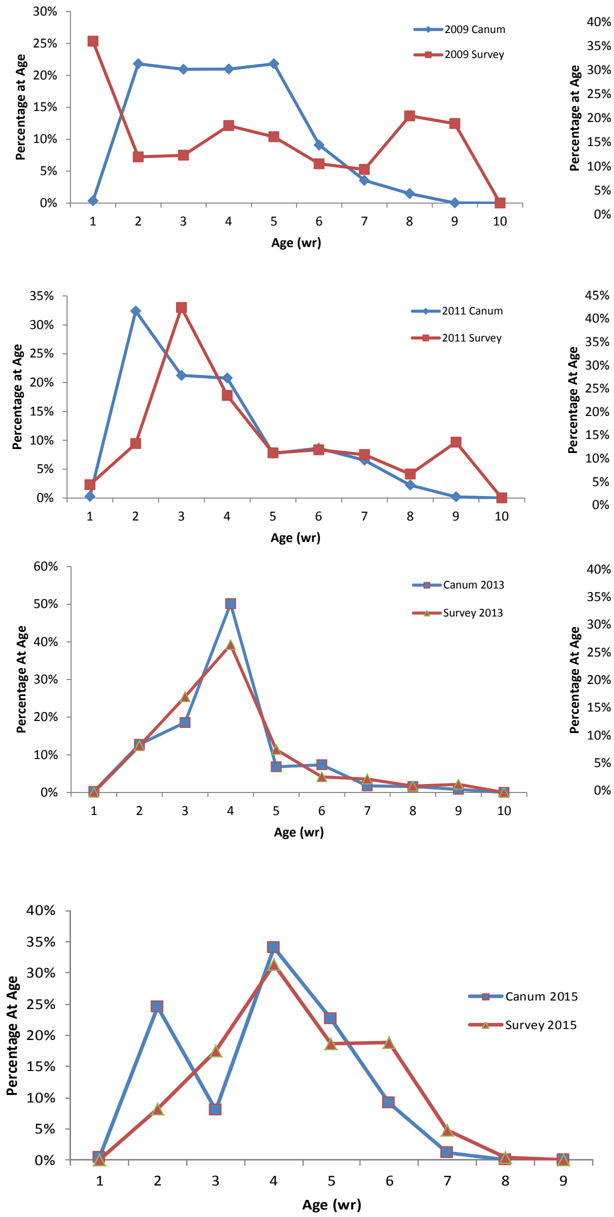


Figure 6.1.4. Herring in divisions 6.a(S) and 7.b–c. Percentages at age in the catch and survey data, MSHAS 2008–2014.

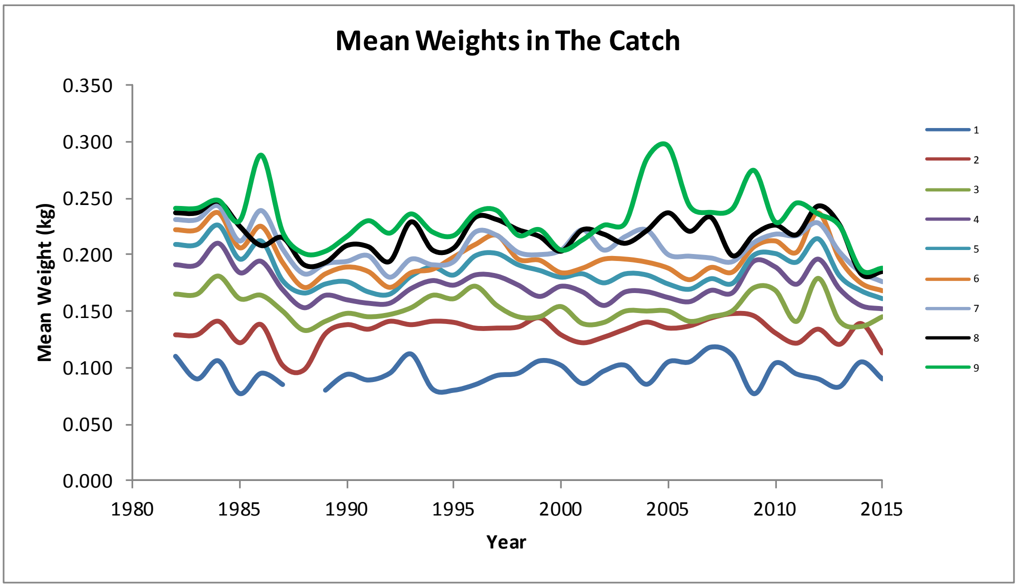


Figure 6.1.5. Herring in divisions 6.a(S) and 7.b–c. Mean Weights in the Catch (kg) by age in winter rings. For years before 1981 fixed at 1981 used.

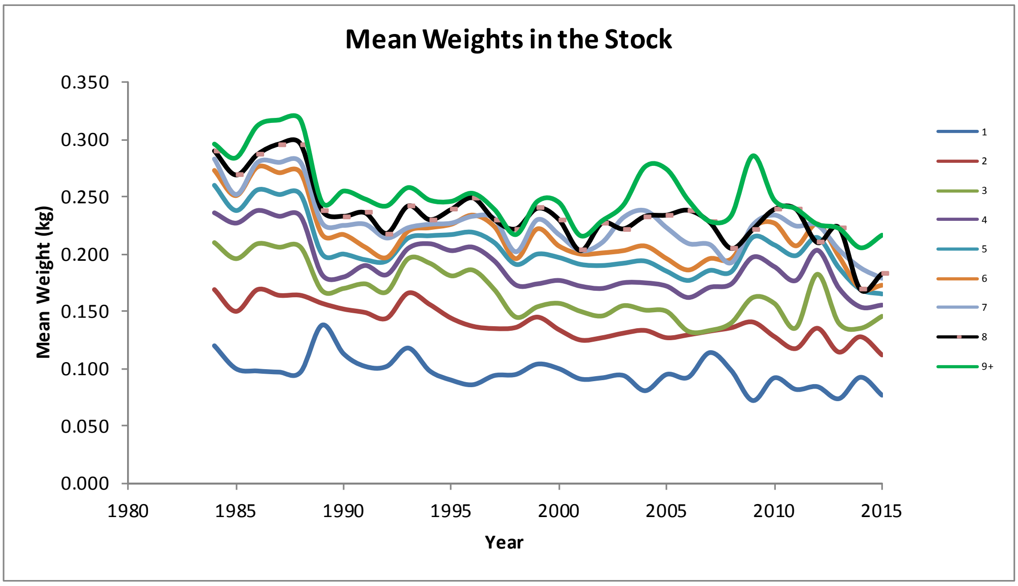


Figure 6.1.6. Herring in divisions 6.a(S) and 7.b–c. Mean weights in the stock (kg) by age in winter rings. For years before 1981 fixed at 1981 used.

6.2 Herring in Division 6.a (North)

The location of the area occupied by the stock is shown in Figure 6.2.1. The stock is considered as and autumn spawner only, despite spring spawning components occurring in the area.

The WG noted that the use of "age", "winter rings", "rings" and "ringers" still causes confusion outside the group (and sometimes even among WG members). The WG tries to avoid this by consequently using "rings", "ringers", "winter ringers" or "wr" instead of "age" throughout this section. However, if the word "age" is used it is qualified in brackets with one of the ring designations. It should be observed that, for autumn and winter spawning stocks, there is a difference of one year between "age" and "rings", which is not the case for the spring spawners. Further elaboration on the rationale behind this, specific to Division 6.aN autumn spawners, can be found in the Stock Annex. It is the responsibility of any user of age based data for any of these herring stocks to consult the stock annex and if in doubt consult a relevant member of the Working Group.

6.2.1 The Fishery

6.2.1.1 Advice applicable to 2014 and 2015

6.2.1.2 Changes in the 6.a (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 2015, 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 6.a (N) (Figure 6.2.2). Recently (since 2006) the majority of the fishery has been prosecuted in quarter 3 (see ICES WKWEST 2015). This pattern has continued in 2015, with 95% of catches taken in quarter 3. Since 2006, the quarter 3 fishery has concentrated in the northern and eastern part of the area. This trend has continued in 2015, with around 86% of the quarter 3 catches taken north of the Hebrides and to the north of Scotland (Figure 6.2.2). Prior to 2006 there was a 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.

6.2.1.3 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 2015 there was evidence of misreporting of catch from 4.a (North Sea) into 6.a (North).

There are no new changes to the regulations relevant to the fishery in 6.a (North).

6.2.1.4 Catches in 2015 and allocation of catches to area for 6.a (North)

For 2015 the preliminary report of official catches corresponding to the 6.a (N) herring stock unit total 21 307 t, compared with the TAC of 22 690 t. The Working Group's estimates of reallocated catches are 2506 t. There were no discards in 2015. Various observer programs suggest that discarding is not a problem (see, for example, Van Helmond and Van Overzee, WD to HAWG 2014 (WD_ HAWG14_02)).

The Working Group's best estimate of removals from the stock in 2014 is 18 801 t (Table 6.2.2).

6.2.2 Biological Composition of the Catch

Catch and sample data, by country and by period (quarter), are detailed in Table 6.2.3. The number of samples used to allocate an age-distribution for the 6.a (N) catches increased to 32 in 2015, from 16 in 2014. Samples were obtained from the Scottish (8), English (11), German (9) and Irish (4) fleets. 52.5% of the catch was taken by the Scottish and Northern Irish RSW fleet; 39% was taken by the international freezer trawler fleet; the remaining 8.5% was caught by the Irish fleet. 28 of the 32 samples obtained came from quarter 3; with 4 from quarter 4. The available samples were used to allocate a mean age (winter rings) distribution (using the sample number weighting) to unsampled catches, in the same or adjacent quarters. Quarter 3 samples were used for unsampled quarter 1, quarter 2 and quarter 3 catches; quarter 4 samples were used for quarter 4 unsampled catches. 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) and InterCatch as a comparison.

The 2008 year class (6-rings in 2015) dominated the catch (24% of the catch) (Figure 6.2.4). The 2009 year class (5-ringers in 2015) contributed 21% of the catch. The 2010 year class (4-ringers in 2015) comprised an additional 17% of the catch. 1-ring herring in the catch are observed intermittently and are rarely representative of year class strength.

6.2.3 Fishery Independent Information

6.2.3.1 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 2015 survey values are shown in Table 6.2.4.

The 2015 acoustic survey in 6.aN was carried out on the Celtic Explorer. Further details are available in the Report of the Working Group for International Pelagic Surveys (ICES WGIPS 2016).

Table 6.2.1 The 2015 acoustic survey in 6.aN

Vessel	Period	Area	Rectangles
Celtic Explorer (IRL)	24 June–14 July	53°30′–58°30′N ,12°–4°W	41E0–E3, 42E0–E3, 43E0–E3, 44E0–E3, 45E0–E4, 46E2–E5, 47E3–E6, 48E4–E5, 49E5

The spawning stock biomass estimate for the acoustic survey in the area historically used for the 6.a (North) spawning stock biomass (Table 6.2.5) has increased by approximately 42% from 2014 (from 272 000 tonnes to 387 000 tonnes).

The proportions of year class in the catch and the survey are shown in Figure 6.2.4. The 2010 year class were most prominent in the survey, and the 2008 year class had highest proportions in the catch. 1-ringers were absent from the survey and were a very small proportion of the catch.

6.2.4 Mean Weights-At-Age and Maturity-At-Age

6.2.4.1 Mean weight-at-age

Weights-at-age in the stock are obtained from the acoustic surveys and are given in Table 6.2.4 (for the current year). The weights-at-age in the catch in 2015 (Table 6.2.7) have decreased relative to 2014 for all ages (rings) apart from 4-ringers (there were no 0-ringers in 2014). The weights-at-age in the stock in 2015 have increased in 0 to 4-ringers and decreased in 5 to 9-ringers (Table 6.2.8).

6.2.4.2 Maturity ogive

The 2014 maturity ogive is obtained from the acoustic survey (Table 6.2.4). The survey provides estimated values for the period 1992 to 2015 (Table 6.2.9). In 2015, 58% of the 2-ring fish were mature, compared to 18% in 2014 and 52% in 2013. It is not unusual for 2-ringer maturity to be variable for this stock, however the trend is towards lower maturity at age in recent years is reversed in 2015. In 2015, 92% of the 3-ring fish; 99% of the 4-ring fish and 98% of the 5-ring fish were mature. This is the third time that 4-ring, the second time 5-ring fish, and first time that 7-ring fish have not been 100% mature.

6.2.5 Recruitment

There are no specific recruitment indices for this stock. Although both catch and acoustic survey can 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 survey.

6.2.6 Assessment of 6.a (North) Herring

6.2.6.1 Stock Assessment

The ICES WKWEST 2015 benchmark workshop (ICES, 2015/ACOM:34) for the herring stocks in 6.aN, 6.aS and 7.b–c concluded that a combined stock assessment would be undertaken in 2015. Data for this stock was examined in detail by the benchmark group WKWEST (ICES, 2015/ACOM:34). Details of the 2016 assessment for 6.a (combined) and 7.b–c are outlined in Section 5.6.

6.2.6.2 State of the stock

Not determined.

6.2.7 Short Term Projections

6.2.7.1 Deterministic short term projections

Not undertaken.

6.2.7.2 Yield per recruit

Not undertaken.

6.2.8 Precautionary and Yield Based Reference Points

Not determined.

6.2.9 Quality of the Assessment

Not relevant.

6.2.10 Management Considerations

The stock was perceived to have fluctuated at a low level. Recruitment has been low since 1998. The 2008 year class appears to be the strongest since 2000 from the catch data (Figure 6.2.4). The 2010 year class was strong in the 2015 HERAS.

There has been considerable uncertainty in the amount of landings from this stock in the past. Area misreporting is less of a problem, but almost all countries still take catches of herring in other areas and report it into 6.a (N). Increased observer coverage and use of VMS and electronic log books is helping to reduce these problems.

The stock identity of herring west of the British Isles was reviewed by the EU-funded project WESTHER. This identified Division 6.a (N) as an area where catches comprise a mixture of fish from divisions 6.a (N), 6.a (S), and 7.a (N). Concerning the management plan for Division 6.a (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 6.a (N), this should be considered in the management of the Division 6.a (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.

6.2.11 Ecosystem Considerations

Observers monitor some of the fleets. Herring fisheries tend to be clean with little by-catch 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. The Scottish discard observer program is no longer active.

Herring are an important prey species in the ecosystem and also one of the dominant planktivorous fish in 6.aN. Mackerel and horse mackerel are considerable predators of 0-ring herring in the North Sea; it is possible that predation on the 6.aN herring stock is even greater for 0-ring fish as the stock is also in the North Sea for a significant period (Marine Scotland Science 2014). Stocks are currently high and increasing for mackerel and although decreasing for horse mackerel, are still at relatively high levels compared to herring. Cod has declined in biomass in the North Sea and 6.a overall, while saithe increased considerably over the years 1990 to 2005. Saithe SSB trends have been decreasing since 2005, but are also likely to be an important predator of herring to the west of Scotland due to its distribution and abundance compared to other gadoids (Marine Scotland Science 2014). Whiting is an important predator of 1-ring herring, but has less of an impact for older herring in the North Sea multi-species model (ICES, 2011). However, whiting SSB is relatively low and decreasing in recent years to the west of Scotland. Herring mortality for ages 2 and older increased over the period 1991–2007 but seems to have decreased in more recent years (ICES 2011). This trend appears to be in broad agreement with the development of the saithe stock, the most prolific predator of 2+ ring herring.

The grey seal population estimates to the west of Scotland appear to have increased from the 1980s to a present estimation of about 35 000 in the area including the Inner and Outer Hebrides (Thomas, 2014). Grey seals around the Orkney Islands have increased dramatically in recent years to around 47 000 individuals from around 20 000 in the 1980s. The total estimated abundance of grey seals in the West of Scotland in 2013 including Orkney is approximately 82 000 individuals. Grey seals from Orkney and North Sea will also impact on herring from both the North Sea and to the west of Scotland. Numbers of grey seals are higher to the west of Scotland than the North Sea (approximately 25 000 individuals currently); therefore their contribution to M is likely to be higher to the west of Scotland than in the North Sea. Grey seals are also known to travel much further offshore than harbour seals.

Harbour seal populations appear to be relatively stable at ~14 500 individuals to the west of Scotland (SW Scotland, W Scotland and Outer Hebrides). Harbour seals are likely to consume a greater proportion of herring in their diet than grey seals; however, numbers are smaller than grey seals to the west of Scotland (Hammond, pers. comm.).

There has been no rigorous quantification of predation levels in this area so a time and age variable estimate of predation (natural mortality) is not possible but obviously it has varied over time.

6.2.12 Changes in the Environment

Temperatures in this area have been increasing over the last number of decades (Baxter *et al.*, 2008). 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).

Table 6.2.2. Herring in 6.a (North). Catch in tonnes by country, 1991–2015. These figures do not in all cases correspond to the official statistics and cannot be used for management purposes.

Country	1991	1992	1993	1994	1995	1996	1997	1998	1999
Faroes	482			274					
France	1168	119	818	5087	3672	2297	3093	1903	463
Germany	6450	5640	4693	7938	3733	7836	8873	8253	6752
Ireland	8000	7985	8236	6093	3548	9721	1875	11199	7915
Netherlands	7979	8000	6132	8183	7808	9396	9873	8483	7244
Norway	3318	2389	7447	30676	4840	6223	4962	5317	2695
UK	32628	32730	32602	-4287	42661	46639	44273	42302	36446
Unallocated	-10597	-5485	-3753	700	-4541	-17753	-8015	-11748	-8155
Discards*	1180	200					62	90	
Total	50608	51578	56175	54664	61271	64359	64995	65799	61514
Area-Misreported	-22079	-22593	-24397	-30234	-32146	-38254	-29766	-32446	-23623
WG Estimate	28529	28985	31778	24430	29575	26105	35233	33353	29736
Source (WG)	1993	1994	1995	1996	1997	1997	1998	1999	2000

Country	2000	2001	2002	2003	2004	2005	2006	2007	2008
Faroes			800	400	228	1810	570	484	927
France	870	760	1340	1370	625	613	701	703	564
Germany	4615	3944	3810	2935	1046	2691	3152	1749	2526
Ireland	4841	4311	4239	3581	1894	2880	4352	5129	3103
Netherlands	4647	4534	4612	3609	8232	5132	7008	8052	4133
Norway									
UK	22816	21862	20604	16947	17706	17494	18284	17618	13963
Unallocated		277$	6244$	2820$	3490$				
Discards*					123	772	163		
Total	37789	35688$	41649$	31662$	33344$	31392	34230	33735	25216
Area-Misreported	-14627$	-10437$	-8735	-3581	-6885$	-17263	-6884	-4119	-9162
WG Estimate	23162$	25251$	32914	28081$	26459$	14129	27346	29616	16054
Source (WG)	2001	2002	2003	2004	2005	2006	2007	2008	2009

Country	2009	2010	2011	2012	2013	2014	2015
Faroes	1544	70				360	
France	1049	511	504	244	586	589	
Germany	27	3583	3518	1829	4025	3354	3292
Ireland	1935	2728	3956	3451	3124	2632	1799
Lithuania						770	
Norway							0.98
Netherlands	5675	3600	1684	3523	1775	1641	956
UK	11076	12018	11696	12249	15906	16769	15260
Unallocated							
Discards*		95			30		
Total	21306	22510	21358	21296	25446	26115	21307
Area-Misreported	-2798	-2728	-3599	-2780	-2468	-4088	-2506
WG Estimate	18508	19877	17759	18516	22978	22027	18801
Source (WG)	2010	2011	2012	2013	2014	2015	2016

*** Unraised discards**

$ Revised at WKWEST 2015

Table 6.2.3. Herring in 6.a (North). Catch and sampling effort by nations participating in the fishery in 2015.

AREA : VIa(N)

Country	Sampled Catch	Official Catch	No. of samples	No. measured	No. aged	SOP %
Germany	3213.00	3291.99	9	3374	166	99.53
Ireland	1305.60	1798.82	4	965	304	100.00
Netherlands	0.00	955.79	0	0	0	0.00
Norway	0.00	0.98	0	0	0	0.00
UK(England_Wales)	4055.24	4055.24	11	3975	275	99.99
UK(Northern Ireland)	0.00	805.83	0	0	0	0.00
UK(Scotland)	8839.00	10398.70	8	1129	330	99.78
Total VIa(N)	17412.84	21307.36	32	9443	1075	99.80

Sum of Offical Catches : 21307.36
Unallocated Catch : -2506.22
Working Group Catch : 18801.14

PERIOD : 1

Country	Sampled Catch	Official Catch	No. of samples	No. measured	No. aged	SOP %
Ireland	0.00	493.22	0	0	0	0.00
Netherlands	0.00	0.19	0	0	0	0.00
Norway	0.00	0.98	0	0	0	0.00
UK(Scotland)	0.00	4.60	0	0	0	0.00
Period Total	0.00	498.99	0	0	0	0.00

Sum of Offical Catches : 498.99
Unallocated Catch : -319.22
Working Group Catch : 179.77

PERIOD : 2

Country	Sampled Catch	Official Catch	No. of samples	No. measured	No. aged	SOP %
Germany	0.00	79.21	0	0	0	0.00
Period Total	0.00	79.21	0	0	0	0.00

Sum of Offical Catches : 79.21
Unallocated Catch : 0.00
Working Group Catch : 79.21

Table 6.2.3 (con't). Herring in 6.a (North). Catch and sampling effort by nations participating in the fishery in 2015.

PERIOD : 3

Country	Sampled Catch	Official Catch	No. of samples	No. measured	No. aged	SOP %
Germany	3213.00	3212.79	9	3374	166	99.53
Netherlands	0.00	925.96	0	0	0	0.00
UK(England_Wales)	4055.24	4055.24	11	3975	275	99.99
UK(Northern Ireland)	0.00	805.83	0	0	0	0.00
UK(Scotland)	8839.00	10355.00	8	1129	330	99.78
Period Total	16107.24	19354.82	28	8478	771	99.78

Sum of Offical Catches : 19354.82
Unallocated Catch : -1516.00
Working Group Catch : 17838.82

PERIOD : 4

Country	Sampled Catch	Official Catch	No. of samples	No. measured	No. aged	SOP %
Ireland	1305.60	1305.60	4	965	304	100.00
Netherlands	0.00	29.65	0	0	0	0.00
UK(Scotland)	0.00	39.10	0	0	0	0.00
Period Total	1305.60	1374.35	4	965	304	100.00

Sum of Offical Catches : 1374.35
Unallocated Catch : -671.00
Working Group Catch : 703.35

Table 6.2.4. Total numbers (millions) and biomass (thousands of tonnes) of autumn spawning West of Scotland herring in the area surveyed in the acoustic surveys July 2015, with mean weights, mean lengths and fraction mature by age ring.

Age (ring)	Numbers	Biomass	Maturity	Weight (g)	Length (cm)
0	0	0			
1	0	0			
2	121.64	18.83	0.58	154.8	25.8
3	324.96	59.59	0.92	183.4	27.3
4	649.83	126.93	0.99	195.3	27.9
5	377.64	77.29	0.98	204.7	28.4
6	442.14	93.44	1.00	211.3	28.9
7	83.10	18.06	0.97	217.3	29.4
8	22.56	4.86	1.00	215.3	29.1
9+	2.09	0.46	1.00	220.0	30.0
Immature	89	12		137.9	25.1
Mature	1935	387		200.1	28.2
Total	2024	399	0.96	197.4	28.0

Table 6.2.5. Herring in 6.a (North). Estimates of abundance and SSB for the time series of acoustic surveys in the historically surveyed area of 6.a (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	-	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
2013	-	136931	319711	599897	161597	69341	60566	24302	37398	256 089
2014	1031086	243227	217650	469032	519032	143402	30318	18677	11449	272 000
2015	0	121640	324964	649835	377636	442135	83103	22556	2086	387 000

Table 6.2.6 Herring in 6.a (North). 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	4511.46
2	40867	23013	24469	95288	36554	82176	37854	55810	74167	35252	22960.61
3	40779	25229	24922	18710	40193	30398	30899	34966	34571	93910	21825.16
4	74279	28212	23733	10978	6007	21272	9219	31657	31905	25078	51420.22
5	26520	37517	21817	13269	7433	5376	7508	23118	22872	13364	15504.75
6	13305	13533	33869	14801	8101	4205	2501	17500	14372	7529	9002.21
7	9878	7581	6351	19186	10515	8805	4700	10331	8641	3251	3897.69
8	21456	6892	4317	4711	12158	7971	8458	5213	2825	1257	1835.56
9	5522	4456	5511	3740	10206	9787	31108	9883	3327	1089	576.39

	year							
age	2001	2002	2003	2004	2005	2006	2007	2008
1	147.07	992.20	56.11	0.00	182.50	132.46	130.75	0.00
2	83318.40	38481.61	33331.96	7235.79	9632.71	6691.49	34326.00	7898.43
3	15368.56	93975.05	46865.58	23483.32	23236.71	9186.07	17754.83	13039.08
4	9569.99	9014.40	53766.66	29421.79	20602.39	13644.88	6555.14	5427.59
5	25175.08	18113.71	7462.98	48394.28	10237.93	41067.79	14264.99	3219.52
6	9544.89	28016.08	4344.55	4151.94	9783.17	27781.86	30566.16	5688.56
7	6813.78	9040.10	12818.38	8100.36	1014.99	20972.98	21517.07	14832.27
8	4741.98	1547.87	9187.62	9023.67	1194.95	3041.71	13585.45	8142.31
9	1028.78	1422.68	1407.96	4265.93	1430.76	5088.99	4242.60	8968.60

	year						
age	2009	2010	2011	2012	2013	2014	2015
1	1923.62	10074.12	1667.19	979.53	0.00	0.00	231.18
2	11508.54	20339.85	40587.92	14952.63	13681.14	8705.73	10854.96
3	10475.63	16331.31	15782.93	46647.39	18181.74	15144.82	13937.56
4	16586.96	9957.96	10333.90	9704.45	53116.88	21063.66	15716.6
5	8332.17	14608.15	7190.29	8097.30	11681.99	42229.47	19386.7
6	5688.68	6322.33	5071.43	6311.66	7093.01	7130.95	21621.33
7	7514.70	4322.24	3164.16	3873.67	5098.64	2944.09	6397.35
8	11793.98	5388.91	2611.38	1129.80	4324.63	2854.21	1932.73
9	9443.85	13199.28	7225.68	4013.80	5031.77	3511.43	1250.55

Table 6.2.7 Herring in 6.a (North). 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
1	0.089	0.083	0.106	0.081	0.089	0.097	0.076	0.0834	0.0490	0.1066	0.0609
2	0.128	0.142	0.142	0.134	0.136	0.138	0.130	0.1373	0.1398	0.1464	0.1448
3	0.158	0.167	0.181	0.178	0.177	0.159	0.158	0.1637	0.1628	0.1625	0.1593
4	0.197	0.190	0.191	0.210	0.205	0.182	0.175	0.1829	0.1828	0.1728	0.1690
5	0.206	0.195	0.198	0.230	0.222	0.199	0.191	0.2014	0.1922	0.1595	0.1852
6	0.228	0.201	0.214	0.233	0.223	0.218	0.210	0.2147	0.1959	0.1780	0.1997
7	0.223	0.244	0.208	0.262	0.219	0.227	0.225	0.2394	0.2047	0.1863	0.1942
8	0.262	0.234	0.227	0.247	0.238	0.212	0.223	0.2812	0.2245	0.2449	0.1854
9	0.263	0.266	0.277	0.291	0.263	0.199	0.226	0.2526	0.2716	0.2802	0.2938

age \ year	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
1	0.0000	0.1084	0.0908	0.1152	0.0000	0.1121	0.0818	0.0613	0.0725	0.0000
2	0.1541	0.1327	0.1580	0.1667	0.1705	0.1726	0.1549	0.1550	0.1469	0.1441
3	0.1732	0.1632	0.1676	0.1881	0.2060	0.2141	0.1883	0.1894	0.1894	0.1746
4	0.1948	0.1845	0.1929	0.1968	0.2310	0.2379	0.2129	0.2178	0.2076	0.1965
5	0.2160	0.2108	0.2076	0.2105	0.2309	0.2457	0.2337	0.2340	0.2161	0.2020
6	0.2197	0.2258	0.2251	0.2214	0.2489	0.2535	0.2394	0.2388	0.2261	0.2124
7	0.1986	0.2341	0.2443	0.2161	0.2529	0.2599	0.2369	0.2470	0.2408	0.2304
8	0.1885	0.2556	0.2615	0.2618	0.2840	0.2549	0.2400	0.2463	0.2817	0.2343
9	0.3030	0.2496	0.2750	0.3030	0.2877	0.2730	0.2549	0.2522	0.2467	0.2476

age \ year	2014	2015
1	0.0000	0.0769
2	0.1451	0.1425
3	0.1877	0.1795
4	0.2030	0.2059
5	0.2279	0.2136
6	0.2449	0.2307
7	0.2608	0.2386
8	0.2614	0.2454
9	0.2835	0.2685

Table 6.2.8 Herring in 6.a (North). Weights at age in the stock.

Units : kg

year

age	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

year

age	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

year

age	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

year

age	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

year

age	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
1	0.0751	0.075	0.0750	0.055	0.059	0.068	0.057	0.066	0.06366667	0.064
2	0.1296	0.135	0.1675	0.172	0.151	0.162	0.132	0.150	0.15500000	0.108
3	0.1538	0.166	0.1830	0.191	0.206	0.194	0.160	0.183	0.16500000	0.158
4	0.1665	0.185	0.1914	0.208	0.223	0.227	0.208	0.189	0.20200000	0.180
5	0.1802	0.192	0.1951	0.214	0.233	0.239	0.236	0.206	0.21000000	0.206
6	0.1911	0.204	0.1951	0.214	0.231	0.248	0.245	0.217	0.23600000	0.214
7	0.2125	0.211	0.2021	0.221	0.232	0.258	0.238	0.214	0.24300000	0.231
8	0.2030	0.224	0.2034	0.224	0.232	0.226	0.222	0.218	0.24500000	0.244
9	0.2284	0.231	0.2138	0.238	0.238	0.212	0.253	0.215	0.25400000	0.264

year

age	2015
1	0.065
2	0.155
3	0.183
4	0.195
5	0.204
6	0.211
7	0.217
8	0.215
9	0.220

Table 6.2.9 Herring in 6.a (North). Proportion mature.

Units : NA

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

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

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

age	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
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	0.000	0.000
2	0.92	0.76	0.83	0.84	0.81	1.00	0.98	0.70	0.79	0.46	0.85	0.52	0.178	0.580
3	1.00	1.00	0.97	1.00	0.97	1.00	1.00	1.00	1.00	0.92	1.00	0.81	0.730	0.920
4	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.99	0.990	0.990
5	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.98	1.000	0.980
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	1.000	1.000
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	1.000	0.970
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	1.000	1.000
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	1.000	1.000

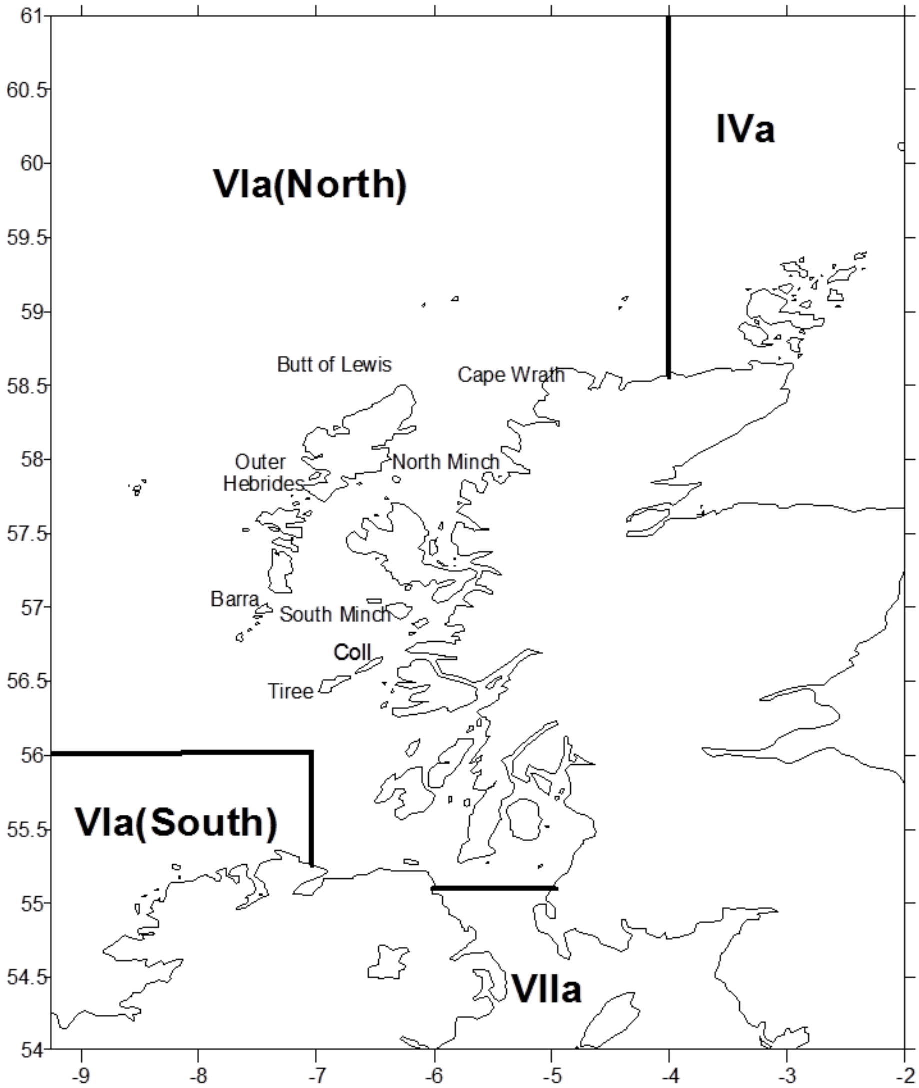


Figure 6.2.1. Location of ICES area 6.a (North) and adjacent areas, with place names.

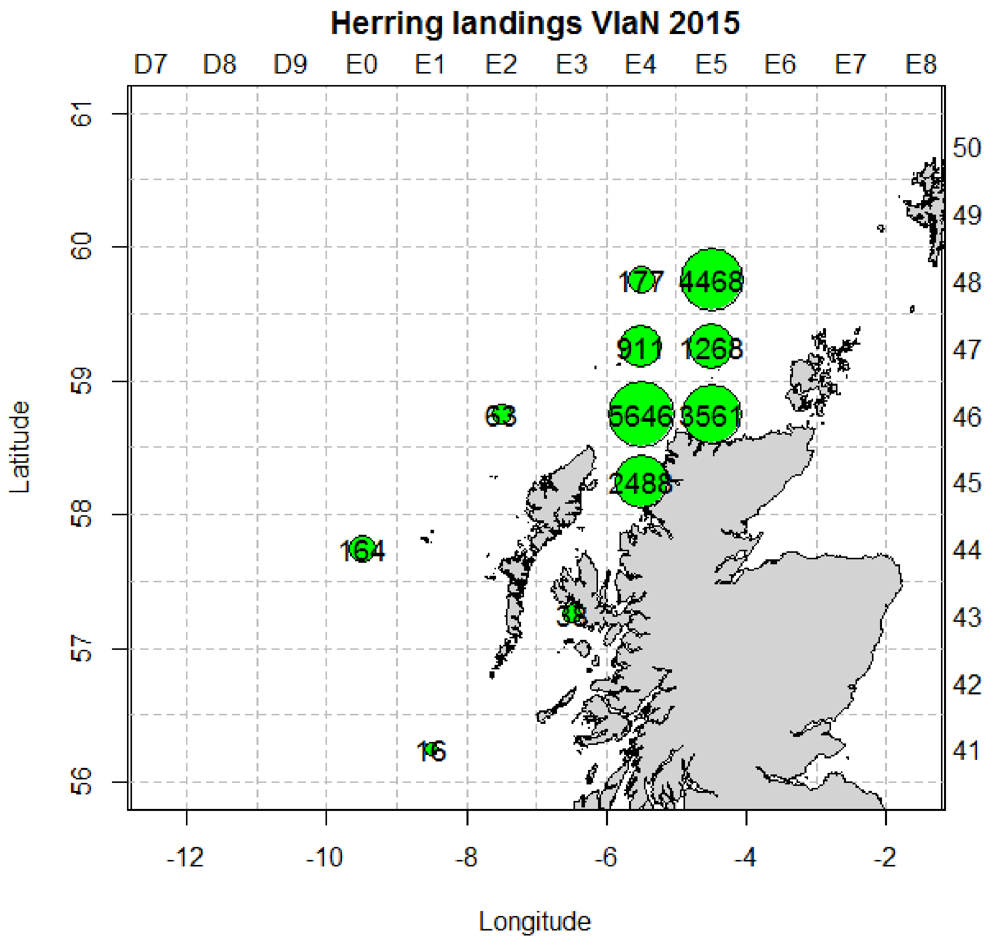


Figure 6.2.2. Herring in 6.a (North). Herring catches in tonnes in all quarters in 2015 by statistical rectangle. WG estimates (apart from Scotland as only the official data by rectangle is available).

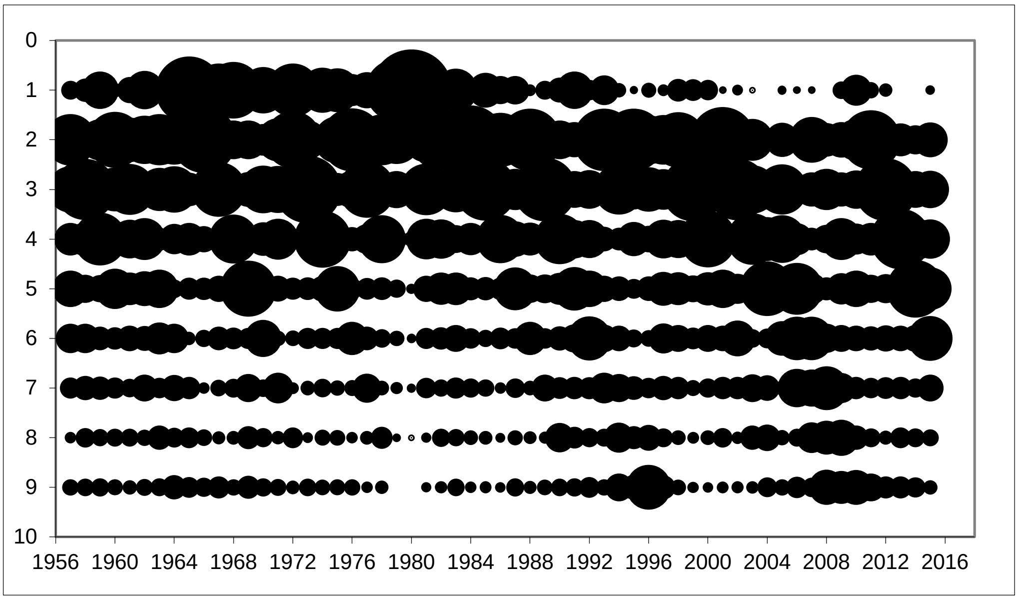


Figure 6.2.3. Herring in 6.a (North). Mean standardised catch numbers-at-age standardised by year for the fishery, 1957 to 2015.

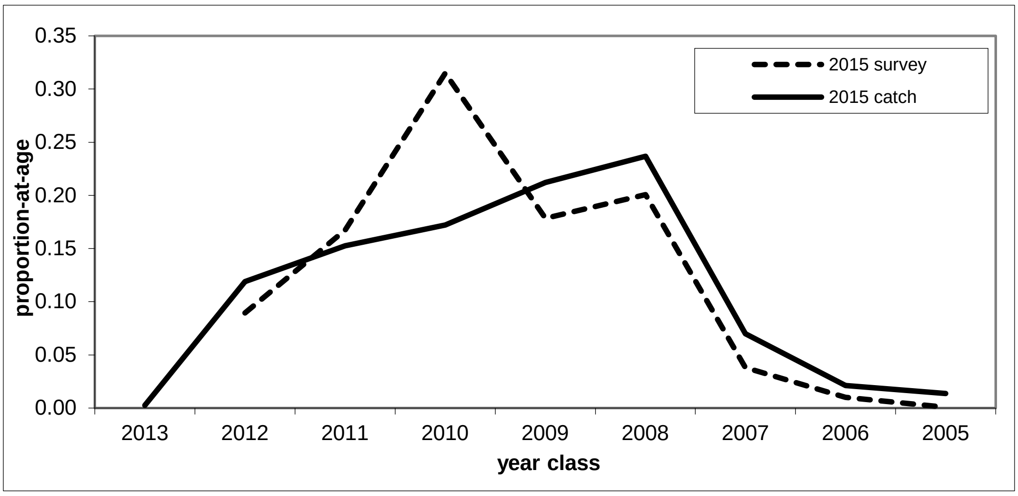


Figure 6.2.4. Herring in 6.a (North). Comparison of the proportions-at-age, by year class, in the 2014 acoustic survey (MSHAS_N) and the 2015 catch.

7 Herring in Division 7.a North (Irish Sea)

This section is under preparation. Please see the advice for herring in Division 7.a North (Irish Sea) here:

http://www.ices.dk/sites/pub/Publication%20Reports/Advice/2016/2016/her-nirs.pdf

8 Sprat in the North Sea

8.1 The Fishery

8.1.1 ACOM advice applicable to 2015 and 2016

There have never been any explicit management objectives for this stock. Last year, the advised TAC for July 2015 to June 2016 was set to 506 000 t. The 2016 herring by-catch quota was 13 382 t.

8.1.2 Catches in 2015

Catch statistics for 1996–2015 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 catch tables for the North Sea (Table 8.1.1–8.1.2). The WG estimate of total catches for the North Sea in 2015 were 290 380 t (total official catches mounted to 299 193 t). This is a 182% increase compared to 2014, and 77% above the average for the time series. The Danish catches represent 93% of the total catches.

The spatial distribution of landings was similar to 2014 (Figure 8.1.1). As in previous years, only small catches were landed in the first and second quarter of 2015 (Table 8.1.2).

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 second quarter or July in the EU and the Norwegian zone. There is also a maximum vessel quota of 550 t when fishing in the EU-zone. A herring by-catch of up to 10% in biomass is allowed in Norwegian sprat catches. Most sprat catches are taken in an industrial fishery where catches are limited by herring by-catch quantities. 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 4.c. This led to the introduction of a closed area (sprat box) to ensure that sprat catches were not taken close to the Danish west coast where there large bycatches were expected.

STECF evaluated the effectiveness of the sprat box in 2007 (STECF, 2007). The Committee concluded that the position of the sprat box may be sub-optimal in relation to the distribution of herring and sprat. However, the conclusion was based on the assumption that the distribution pattern shown in International Trawl Surveys (IBTS Q3) provided an unbiased estimate of the distribution of sprat and herring and the species composition in commercial trawl hauls: 'It should be borne in mind that these results are derived from the IBTS survey and therefore are the catches of a demersal trawl using GOV gear. However, it is not clear whether this method can reliably describe the distribution and abundance of sprat, which is a pelagic species. Furthermore, the question of how the IBTS catches relate to catches in the actual fishery is unclear.' (STECF, 2007, p. 110).

To estimate whether the distribution of sprat and herring in surveys are mirrored in their distribution in commercial catches and whether there is a significant difference in bycatch of herring inside and outside the box, an experimental fishery was conducted in the months of July, August, September and October in 2013, 2014 and 2015.

8.1.3.1 Material and Methods

14 vessels participated in sprat fishery in the area where 12 of the vessels were conducting the fishery with pair trawling and two were fishing alone. To ensure comparable temporal coverage inside and outside the box, a trip within the box must be followed by at least one trip outside the box. Up to two trips within the box could be carried out before making trips outside the box. Samples were collected in ports and transported to DTU Aqua, where they were sorted by species. All fish were length measured (to nearest mm), weighed (gram) and aged following the species specific protocol.

Two aspects of catch composition were analysed, the weight of herring in the sample relative to the weight of sprat and the number of herring in the sample relative to the weight of sprat. These two parameters were analysed to investigate whether there were significant differences between samples taken inside the sprat box and in an area adjacent to the sprat box (Figures 8.1.2 – 8.1.4). Only commercial samples taken from industrial fishing targeting sprat were included and samples taken outside the box and the adjacent areas were excluded from statistical analyses. For comparison with the commercial samples, the identical parameters were derived from IBTS Q3 hauls in the box and in the adjacent area. Both sets of data were log-transformed and analysed using ANOVA and a mixed model. The ANOVA analysed the effects of year, month and inside/outside the box and their crossed effects. The mixed model analysed the effect of month and inside/outside the box assuming the combined effect of year and statistical rectangle to be normally distributed with a common mean and variance parameter. In the analyses of survey data, month was not included in the analyses as the survey covered approximately one month. There were two observations where no herring were found in the commercial samples, and these were not included in further analyses.

Following this analysis, the weight of herring in the commercial samples relative to the weight of sprat and the number of herring in the commercial sample relative to the weight of sprat were compared to the corresponding average values for each rectangle from survey catches.

8.1.3.2 Results

The sample coverage improved markedly from 2013 to 2015 (Table 8.1.3) both in numbers and in spatial coverage (Figures 8.1.2–4). The number of herring per kg of sprat did not differ significantly between samples taken inside and outside the box (P(Anova) = 0.1074, P(mixed model) = 0.1140) and no significant cross effects with box were found ($P > 0.20$ in all cases).

The weight of herring per kg sprat differed significantly between the box and the adjacent area when using the mixed model ($P = 0.0005$), and ANOVA ($P = 0.0106$). Both models had residuals which did not differ significantly from a normal distribution ($P > 0.05$).The estimated effects of being inside the box in the two models were -0.37 (std = 0.15) and -0.39 (std = 0.15) for the ANOVA and mixed model, respectively, corresponding to 31% and 32% less herring per kg sprat inside the box, respectively. When performing the test for each year separately, the difference was still significant for 2015 but not for the other years ($P > 0.10$ in both models). However, the differences retained the same direction in all years (higher percentage of herring outside the box) (table 8.1.4).

The estimated difference in the number of herring per kg sprat was -0.60 (std = 0.18) and -0.64 (std = 0.18) when estimated in the ANOVA and mixed model, respectively, corresponding to 45% and 47% less herring per kg sprat inside the box, respectively.

8.1.3.3 Conclusion

There was no evidence of a higher proportion of herring in catches taken inside the sprat box compared to samples taken outside the box. In fact, the proportion of herring in commercial samples taken inside the box was lower than outside the box in each year and across years, this difference was significant in both models.

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 Norwegian catches were mainly taken by purse seiners, and the catches taken by trawlers were low. In the last years, the trawlers' 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 was conducted with an extremely low by-catch of herring in 2015. The total amount of herring caught as by-catch in the sprat fishery has mostly been less than 10% except in 2012 (11%) and 2008 (11%). In 2013–2014, it was 8%. However, in 2015 it was the lowest ever observed (> 2%).

The estimated quarterly landings at age in numbers for the period 1974–2014 are presented in Table 8.2.2. In 2015, one-year old sprat contributed 65% of the total landings, which is similar to 2013 (70%) and 2014 (73%) and above the average contribution (60% since 1996, range: 27–94%). 2-year olds contributed 24% in 2015 compared with 20% of the total landings in 2013 and 5% in 2014. 0-year olds contributed 9% of the total landings, which is similar to the 7% in 2013 but below the 2014 value of 20%.

There was no substantial change in mean-weight-at-age (kg) in the landings in 2015 (quarter 4) compared to the previous years. The mean-weight-at-age of the 1+ year olds has shown a gradual increase since 2010 (Table 8.2.3 and Figure 8.6.2).

Denmark, Norway and Sweden provided age data of commercial landings in 2015 (Table 8.2.4). All the quarters were covered. The sample data were used to raise the landings data from the North Sea. The landings by the Netherlands, Sweden, UK-England, Germany, Belgium and France were minor and unsampled. The sampling level (no. samples per 2000 t landed) in 2012–2013 (2.2), 2014 (1.8) and 2015 (1.5) was greatly improved compared to 2007–2011 (0.8 samples for 2007–2010, and 1.2 for 2011) because of the newly implemented sampling programme for collecting haul based samples from the Danish sprat fishery. In 2015, 4.c had only 0.5 samples per 2000 t, whereas 4.b had 1.5. The required sampling level in the EU directive for the collection of fisheries data (Commission Regulation 1639/2001) is 1 sample per 2000 tonnes (see also the Stock Annex).

The number of samples, both length and age-length 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

8.3.1.1.1 IBTS Q1 (February) and Q3

Sprat of age 1 and 2 were mostly found in the central and south-west (Figures 8.3.1a-c), which represents a shift from last year when the age 1 and 2 were mostly found in the south-east. 3+-age groups were also found most abundantly in the central and south-western part of the North Sea. Table 8.3.1 gives the time series of IBTS indices by age (values used are based on a stratified mean, see Stock Annex and ICES, 2013. IBTS Q1 data from 1974–2015 were updated in 2016. The index for IBTS Q1 1-year olds in 2016 was the highest just below the average in the time series. There is no indication of an upward or downward trend in any of the IBTS time-series.

IBTS Q3 survey indices were also used in the assessment. These indices from 1991–2015 were also updated in 2016.

8.3.2 Acoustic Survey (HERAS)

Total abundance in 2015 was estimated by WGIPS (ICES, 2014a)(see section 1.4.2) to be 58 711 million individuals and the biomass 712 000 tonnes (Table 8.3.2). This is a 33% decrease in terms of abundance and a 2% decrease in terms of biomass when compared to last year but a 232% increase in terms of abundance and a 314% increase in terms of biomass when compared to 2013 (ICES, 2014a).

Figure 8.3.1 compares the three survey indices for 1-year-olds, and Figures 8.3.2–5 show external and internal consistency of the survey indices.

8.4 Mean weights-at-age and maturity-at-age

Mean weights-at-age in catches and maturity are given in Tables 8.2.3 and 8.6.1.

Proportion mature fish was derived from the first quarter IBTS, following the benchmark procedure. Annual varying maturity ogives were used after 1994 (Table 8.6.1). More details about the maturity staging are given in Section 4.5.3.2 in the WKSPRAT report (ICES, 2013). Proportion mature for age-1 in the 2016 IBTS Q1 (0.33) was below that of 2015 (0.47) and 2014 (0.47), but high as in 2013 (0.21).

8.5 Recruitment

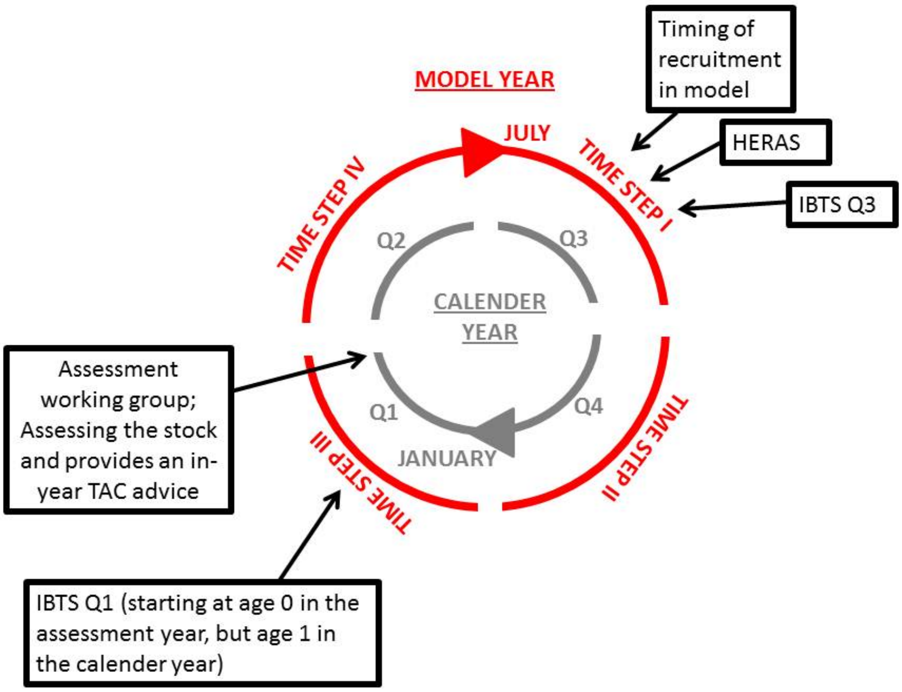
The IBTS Q1 (February) 1-group index (Table 8.3.1) is used as a recruitment index for this stock. The incoming 1-group in 2016 (2015 year class) was estimated to 74% of the long term average.

8.6 Stock Assessment

The stock assessment was benchmarked in February 2013 (ICES, 2013).

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 1 July. 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

Information on catch data is provided in Tables 8.1.1–2 and in Figures 8.1.13 and 8.6.1. Sampling effort is presented in Table 8.2.5 and Figure 8.2.1.

The age distribution of quarterly catches of less than 5000 tonnes was very poorly estimated: less than five 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.

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). In the end, catches are raised to match the total ICES landings in 2015 as the official catches in some cases include bycatch of e.g. herring.

As the model describes the development in the stock based on years from 1 July to 30 June, an assumption is required on the catches taken in the second half of the assessment year (i.e. January to June 2016). As stated in the Stock Annex, the catch taken in this period is estimated from the average fraction of total catches taken in January to June over the past three years. In this case, this average was 16%, corresponding to an assumed catch of 47 881 t from January to June 2016.

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 (Tables 8.3.1–3), IBTS Q1 (1975–present), IBTS Q3 (1991–present) and HERAS (Q3) (2003–present). 0-group (young-of-the-year) sprat is unlikely to be fully recruited by the time of IBTS Q3 and HERAS, and for this reason this age group was excluded from runs. Internal consistency in survey data and external consistency between surveys are presented in Figures 8.3.3–7. During the update of survey data input, an error was detected in the 2015 IBTS Q3 for age 3+. This error was corrected in 2016.

8.6.1.4 Natural mortality

Natural mortalities are derived from the 2015 key run of the multispecies model described in the WGSAM reports (ICES, 2014b; ICES, 2016) similar to the 2014 assessment. Variable mortality is applied up till 2013, and after this the average mortality for 2011–2013 is used. Natural mortalities used in the model are given in Table 8.6.2.

8.6.1.5 Proportion mature

Proportion mature fish was derived from the first quarter IBTS. Annual varying maturity ogives were used after 1994 (Table 8.6.1). More details about the maturity staging are given in Section 4.5.3.2 in the WKSPRAT report (ICES, 2013). The 2015 value of 0.33 was below the long-term average of 0.41.

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 between IBTS Q1, IBTS Q3 and HERAS 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 (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). The CV of survey observations are in general low to medium. There were no obvious patterns in the residuals, apart from a series of strong negative residuals of the youngest age in IBTS Q1 in the years 1974 to 1982 (Figures 8.6.3–4). Presumably, this was 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. Therefore, the IBTS Q1 for this age group was excluded for the period 1974–1982. Common CVs were estimated for the groups: 0 to 3-year olds in IBTS Q1 and 2 and 3-year olds 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 and Tables 8.6.4–5. From these figures it is apparent that recent high catch levels have occurred simultaneously with extremely high SSBs and recruitment.

8.7 Reference points

A B_{lim} of 90 000 t (Figure 8.7.1) and B_{pa} of 142 000 t were agreed at the most recent benchmark. 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

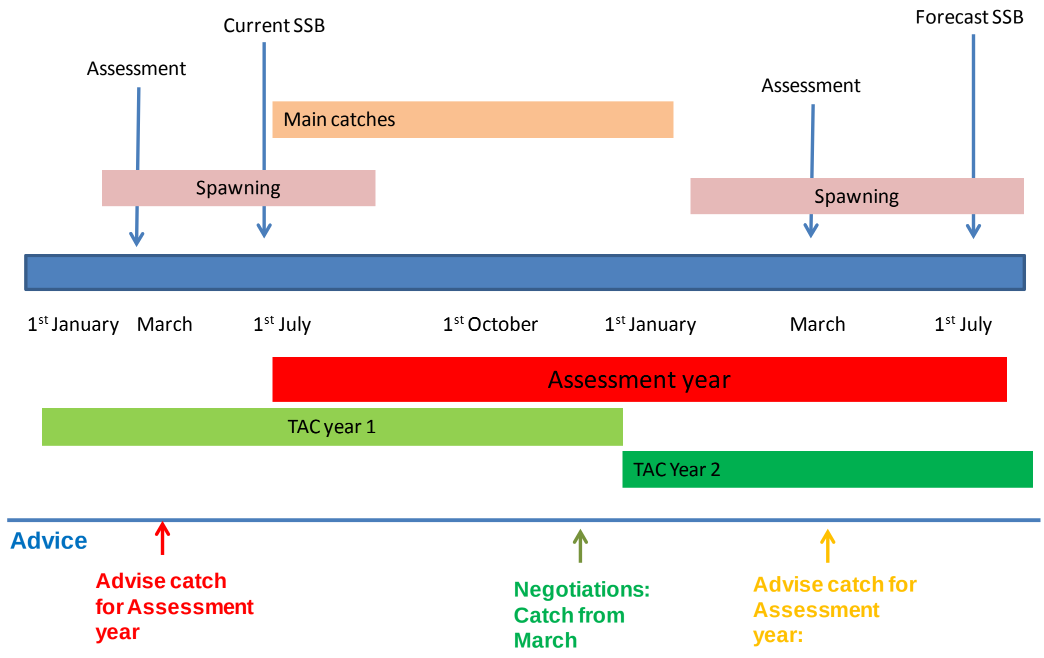
The sprat stock appears to be abundant judged both by surveys individually and by the assessment performed. The stock appears to have been well above B_{pa} since 2008 and has currently exhibited two years of extremely high recruitment and SSB more than twice the B_{pa}, the highest since 1976. Fishing mortality has been below the long term average (0.4–0.9) in the past three years but has increased in 2015 to 1.3.

A stock summary from the assessment output can be found in Table 8.6.5 and Figure 8.6.8.

8.9 Short-term projections

The sprat stock forecast is used to evaluate the escapement strategy used for short-lived species like North Sea sprat. Management strategy evaluations for this stock were made in autumn 2013 and presented at the WKMSYREF2 meeting in January 2014 (ICES, 2014c). These evaluations clearly show that the current management strategy ($B_{escapement}$) is not precautionary unless an additional constraint is imposed on the fishing mortality (referred to as F_{cap}). In 2014 a value of 0.7 was proposed as an optimal F_{cap} value (according to F_{MSY} criteria), which is a revision of the 2013 value equal to 1.2. This means, that the fishing mortality (F_{bar}(1–2)) derived from the $B_{escapement}$ strategy, should not exceed 0.7.

Since the catch projections are now based on an assessment year which runs from 1 July to 30 June each year rather than the traditional TAC years of 1 January to 31 December the following figure (see below) illustrates the timing of steps in the process in relation to the spawning and fisheries of North Sea sprat.



SSB in 2016 is expected to be above the long term average and above B_{pa}. Using the input and assumptions detailed above, the projection for an F = 0 is an SSB in July 2016 of 286 000 t (Table 8.9.2). The F_{MSY} approach prescribes the use of an F value of 0.7 (F_{cap}, see explanation above) and results in a TAC advice of 126 000 t (July 2016–June 2017), which is anticipated to result in an SSB of 206 000 t in July 2017, well above B_{pa}.

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 (ICES, 2013). A complete overview of the choices made during the benchmark can be found in the WKSPRAT report (ICES, 2013) and these are also described in the North Sea Sprat Stock Annex. The 2016 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 may be due to low sampling effort in several years in spite of substantial catches taken. The CVs of F, SSB and recruitment are in general low (see Table 8.6.3 and Figure 8.6.5). 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 CV of survey observations are in general lower (Table 8.6.3).

8.11 Management Considerations

A management plan needs to be developed.

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 13 832 t of juvenile herring in 2016. It is important to continue monitoring bycatch of juvenile herring to ensure compliance with this allocation. Management of this stock should consider management advice given for herring in Subarea 4, Division 7.d, and Division 3.a.

8.11.1 Stock units

North Sea sprat is considered an independent stock. This is discussed in WKSPRAT report (ICES, 2013). 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 sprat in such areas is an issue of ecological concern.

There is a necessity to determine whether the sprat in the North Sea (area 4) constitute a stock or whether they encompass one or both of the adjoining populations of sprat (i.e. 3.a or 7 (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, including sprat, have recruited strongly in recent years (e.g. sandeel, Norway pout). This is in contrast to a previous period of poor recruitment. The implications of the environmental change for sprat and the influence of the sprat fishery on 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.

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 in the WKSPRAT report (ICES, 2013).

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. Landings (' 000 t) 1996–2015. See HAWG 2006 (ICES, 2006) for earlier data. Catch in fjords of western Norway excluded. 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. The 4.b catches for 2000–2007 divided by 4.bW and 4.bE can be found in HAWG 2008 (ICES, 2008).

Country	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Division 4.a																				
Denmark	0.3			0.7		0.1	1.1		*		*	0.8	*	*					*	*
Norway														*		*				
Sweden						0.1														
UK (Scotland)																0.5				
Germany																				*
Netherlands																				*
Total	0.3			0.7		0.2	1.1		*		*	0.8	*	*		0.5			*	*
Division 4.b																				
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	44.7	121.3	234.4
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	*	8.9	0.3
Sweden	0.5		1.7	2.1		1.4				*				0.3	0.6	1.1	1.8	0.1	3.9	5.5
UK(Scotland)				1.4								0.1		2.5	1.1	1.9	0.7			
UK(Engl.&Wales)														*						
Germany																3.3	0.5	0.6	1.5	3.1
Netherlands																1.1	2.7	0.4	2.4	1.2
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	45.8	138.0	244.6
Division 4.c																				
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	15.4	2.2	34.0
Norway		0.1	16.0	5.7	1.8	3.6					9.0	2.9		1.8	3.2	9.9	3.0	1.7	0.1	8.8
Sweden														0.6	0.6	0.2	0.4	1.3		1.2
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	*	*	*

Country	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Germany																*	*	1.0		0.6
Netherlands				0.2												4.2	1.0	0.7	*	1.2
Belgium																*		*	*	*
France																				*
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	20.1	2.3	45.8
			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	60.2	123.5	268.4
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	1.7	9.0	9.1
Sweden	0.5		1.7	2.1		1.5				*				0.9	1.2	1.2	2.2	1.4	3.9	6.8
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	1.6	1.5	3.7
Netherlands				0.2												5.3	3.7	1.1	2.4	2.4
Belgium																*		*	*	*
France																				*
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	65.9	140.4	290.4

* < 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 HAWG 2007 (ICES, 2007). The 4.b catches for 2000–2007 divided by 4.bW and 4.bE can be found in HAWG 2008 (ICES, 2008).

Year	Quarter	Area				Total
		4.aW	4.aE	4.b	4.c	
2000	1			18 126	28 063	46 189
	2			1 722	45	1 767
	3			131 306	1 216	132 522
	4			12 680	2 718	15 398
	Total			163 834	32 042	195 876
2001	1	115		40 903	9 716	50 734
	2			1 071		1 071
	3			44 174	481	44 655
	4	79		65 102	8 538	73 719
	Total	194		151 249	18 735	170 177
2002	1	1 136		2 182	2 790	6 108
	2			435	93	528
	3			70 504	647	71 151
	4			52 942	12 911	65 853
	Total	1 136		126 063	16 441	143 640
2003	1			11 458	7 727	19 185
	2			625	26	652
	3			56 207	165	56 372
	4			84 629	15 651	100 280
	Total			152 919	23 570	176 489
2004	1			827	1 831	2 657
	2	7		260	16	283

Year	Quarter	Area				Total
		4.aW	4.aE	4.b	4.c	
2008	1			2 872	43	2 915
	2			52	*	52
	3			21 787		21 787
	4			27 994	8 334	36 329
	Total			52 706	8 377	61 083
2009	1			36	1 268	1 304
	2			2 526	1	2 527
	3		22	41 513		41 535
	4			78 373	9 336	87 709
	Total		22	122 448	10 604	133 075
2010	1			10 976	17 072	28 048
	2			3 235	3	3 238
	3			14 220		14 220
	4			62 006	35 973	97 979
	Total			90 437	53 048	143 485
2011	1			3 747	21 039	24 786
	2			2 067	3	2 070
	3			22 309	451	22 761
	4	8		70 256	13 759	84 023
	Total	8		98 380	35 252	133 640
2012	1			81	1 649	1 730
	2			2 924	0	2 924

Year	Quarter	Area				Total
		4.aW	4.aE	4.b	4.c	
	3			54 161	496	54 657
	4			120 685	15 937	136 622
	Total	7		175 932	18 280	194 219
2005	1			11 538	2 457	13 995
	2			2 515	123	2 638
	3			107 530		107 530
	4			82 474	1 033	83 507
	Total			204 057	3 613	207 670
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
2007	1			582	247	829
	2			241	3	244
	3			16 603		16 603
	4	769		41 850	23 531	66 150
	Total	769		59 276	23 781	83 826

Year	Quarter	Area				Total
		4.aW	4.aE	4.b	4.c	
	3			26 779	307	27 086
	4			47 765	6 060	53 825
	Total			77 549	8 016	85 565
2013	1			1 281	3 158	4 438
	2			32	0	32
	3			25 577	720	26 297
	4			18 892	16 276	35 167
	Total			45 781	20 154	65 934
2014	1			59	125	184
	2			11 631	3	11 635
	3	1		88 457	1 428	89 885
	4	7		37 851	822	38 681
	Total	8		137 999	2 378	140 384
2015	1		*	14 816	16 972	31 788
	2			16 843	107	16 949
	3			124 512	335	124 847
	4	25		88 395	28 375	116 795
	Total	25	*	244 566	45 789	290 380

* < 0.5 t

Table 8.1.3. Numbers of samples taken inside the box and outside the box by year.

YEAR	INSIDE	OUTSIDE
2013	5	25
2014	69	68
2015	151	211

Table 8.1.4. Average percentage of herring in catches. Values are given where at least 5 samples were analysed.

	2014		**2015**	
	inside	outside	inside	outside
July	15.3%	26.5%	1.1%	1.8%
August	10.9%	11.7%	0.7%	1.2%
September	11.6%	14.9%	1.5%	2.4%
October	8.2%	7.2%	2.9%	3.0%

Table 8.2.1. North Sea sprat. Species composition in Danish sprat fishery in tonnes and percentage of the total catch in the North Sea.

	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	1 187	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	1 141	170 862
Tonnes	2002	140 568	16 644	2 078	2 537	27	715	0	4 102	801	167 471
Tonnes	2003	172 456	10 244	718	1 106	15	799	11	5 357	3 504	194 210
Tonnes	2004	179 944	10 144	474	334	0	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	234 251
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	112 395	4 410	11	119	2	18	0	1 236	577	118 769
Tonnes	2011	109 376	8 073	35	191	0	127	0	1 881	345	120 026
Tonnes	2012	67 263	8 573	2	354	0	246	0	93	411	76 943
Tonnes	2013	55 792	5 176	47	445	0	277	2	1	369	62 109
Tonnes	2014	123 180	11 402	0	897	0	70	16	16	1 700	137 280
Tonnes	2015	265 356	4 568	5	1 809	0	527	0	147	3 311	275 723
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	94.6	3.7	0.0	0.1	0.0	0.0	0.0	1.0	0.5	100.0
Percent	2011	91.1	6.7	0.0	0.2	0.0	0.1	0.0	1.6	0.3	100.0
Percent	2012	87.4	11.1	0.0	0.5	0.0	0.3	0.0	0.1	0.5	100.0
Percent	2013	89.8	8.3	0.1	0.7	0.0	0.4	0.0	0.0	0.6	100.0
Percent	2014	89.7	8.3	0.0	0.7	0.0	0.1	0.0	0.0	1.2	100.0
Percent	2015	96.2	1.7	0.0	0.7	0.0	0.2	0.0	0.1	1.2	100.0

Table 8.2.2. North Sea sprat. Catch in numbers by age (1000's) by quarter and year. (Calendar year)

Year	Quarter	Age-0	Age-1	Age-2	Age-3	Age-4
1988	Q1	0	493 180	688 667	23 432	3 157
	Q2	0	72 029	111 595	3 987	781
	Q3	0	1 586 856	4 134 647	9 609	0
	Q4	0	23 940	85 397	910	0
1989	Q1	0	1 822 864	688 151	35 173	0
	Q2	0	38 434	14 712	1 195	0
	Q3	12 416	1 349 973	3 441 515	971	0
	Q4	674	48 312	75 260	53	0
1990	Q1	0	500 283	243 280	48 737	14 638
	Q2	0	34 285	23 249	6 770	2 271
	Q3	0	2 107 664	1 548 789	449 802	167 844
	Q4	0	1 674 087	1 230 181	357 271	133 316
1991	Q1	0	50 269	3 312	689	103
	Q2	0	32 873	3 114	450	69
	Q3	39 075	1 582 926	1 968 851	33 462	844
	Q4	1 358 716	2 738 086	585 720	12 904	370
1992	Q1	0	8 192	3 674	123	8
	Q2	0	415 567	186 393	6 232	390
	Q3	17 469	8 903 703	1 139 117	143 169	14 295
	Q4	178 160	1 120 582	138 127	17 884	1 902
2002	Q1	0	323 605	70 070	13 307	791
	Q2	0	23 206	5 025	954	57
	Q3	72 234	6 240 286	393 859	40 131	3 446
	Q4	480 139	4 192 059	902 086	193 376	10 170
2003	Q1	0	1 595 254	1 150 283	106 446	3 660
	Q2	0	67 395	38 384	3 408	121
	Q3	0	3 773 602	536 016	39 557	13 331
	Q4	411 438	7 597 795	1 040 850	47 583	30 233
2004	Q1	0	132 197	22 821	1 347	76
	Q2	0	29 872	5 157	304	17
	Q3	330 650	3 616 036	790 575	46 831	3 599
	Q4	21 362 903	4 845 166	372 609	33 761	1 849
2005	Q1	0	3 214 471	218 695	9 249	305
	Q2	0	690 733	41 135	1 703	54
	Q3	0	12 371 678	222 757	34 807	1 169
	Q4	905 687	7 636 106	193 874	15 025	595
2006	Q1	0	675 765	5 164 658	136 240	5 908
	Q2	0	11 341	59 145	1 469	65
	Q3	0	2 354 139	1 164 248	196 933	3 705
	Q4	0	1 589 716	922 747	98 174	2 439

Year	Quarter	Age-0	Age-1	Age-2	Age-3	Age-4
1993	Q1	0	2 330 690	1 439 234	194 770	8 536
	Q2	0	788 283	382 178	53 291	2 798
	Q3	0	2 861 064	4 943 973	194 177	24 607
	Q4	2 048 272	4 728 377	1 288 186	35 809	2 506
1994	Q1	0	2 327 734	2 074 998	320 669	33 962
	Q2	0	2 427 321	1 081 474	157 150	7 661
	Q3	0	29 911 167	550 021	27 189	375
	Q4	1 891 731	5 127 983	1 436 318	133 383	5 555
1995	Q1	0	421 834	1 895 084	608 541	16 521
	Q2	0	530 161	358 121	116 385	4 436
	Q3	208 386	19 738 855	3 119 870	499 613	3 712
	Q4	731 010	7 327 987	3 289 073	669 519	13 910
1996	Q1	0	5 784 702	1 613 377	375 365	21 893
	Q2	0	356 707	106 061	25 043	1 625
	Q3	107 253	127 719	381 423	137 974	27 334
	Q4	880 333	660 293	2 178 394	774 114	181 774
1997	Q1	0	1 530 663	515 776	60 268	7 729
	Q2	0	264 007	89 901	14 984	1 470
	Q3	44 531	1 640 137	521 235	74 525	27 396
	Q4	107 553	3 494 688	1 265 240	200 795	85 539
1998	Q1	0	674 134	508 613	70 038	13 829
	Q2	0	83 006	58 156	6 706	1 092

Year	Quarter	Age-0	Age-1	Age-2	Age-3	Age-4
2007	Q1	0	188 409	112 126	21 465	1 057
	Q2	0	12 611	7 505	1 437	71
	Q3	0	791 996	370 110	83 329	3 360
	Q4	570 769	3 607 022	1 587 098	207 134	16 190
2008	Q1	0	275 013	212 650	8 983	1 280
	Q2	0	4 661	3 355	217	36
	Q3	11 226	374 967	1 350 863	273 722	23 195
	Q4	471 069	1 457 841	1 154 410	243 032	40 973
2009	Q1	0	274 316	32 208	1 962	129
	Q2	0	302 545	35 522	2 163	143
	Q3	0	4 428 777	185 438	18 651	853
	Q4	221 908	7 851 426	562 588	93 691	4 255
2010	Q1	0	43 328	3 230 747	475 426	71 299
	Q2	0	6 548	342 686	39 999	8 396
	Q3	12 808	1 429 681	433 709	7 880	1 438
	Q4	344 087	3 395 699	3 034 682	825 848	970 833
2011	Q1	0	190 971	1 981 930	704 501	91 150
	Q2	0	90 971	174 916	55 063	6 773
	Q3	2 669	1 410 307	959 871	206 730	28 765
	Q4	366 915	4 094 960	2 652 433	752 025	214 962
2012	Q1	0	101 747	41 459	5 929	697
	Q2	0	191 599	78 071	11 165	1 313

Year	Quarter	Age-0	Age-1	Age-2	Age-3	Age-4
	Q3	620 081	3 588 086	1 619 886	172 387	4 584
	Q4	1 015 745	3 531 232	1 518 689	410 014	0
1999	Q1	0	1 038 772	2 189 060	159 850	33 261
	Q2	0	134 048	226 782	18 915	4 103
	Q3	211 127	13 970 676	458 334	88 243	686
	Q4	85 617	1 934 117	362 667	21 842	111
2000	Q1	0	2 068 324	2 972 728	652 986	240 495
	Q2	0	55 868	110 058	37 736	21 766
	Q3	1 671	9 463 341	1 526 772	84 078	5 227
	Q4	2 432	722 669	421 757	38 132	2 148
2001	Q1	0	756 085	2 938 300	1 259 571	168 402
	Q2	0	10 921	35 795	12 415	1 222
	Q3	330 710	2 999 048	731 582	61 006	0
	Q4	731 508	4 466 857	1 535 060	134 942	0

Year	Quarter	Age-0	Age-1	Age-2	Age-3	Age-4
	Q3	16 927	2 207 305	609 219	68 208	16 287
	Q4	111 565	3 503 253	1 603 395	239 132	17 808
2013	Q1	0	118 913	500 345	54 490	4 178
	Q2	0	902	3 798	474	40
	Q3	25 538	2 263 365	330 826	58 469	9 576
	Q4	401 216	2 382 055	507 642	154 932	59 316
2014	Q1	0	7 600	516	66	64
	Q2	0	1 497 692	101 690	13 015	12 598
	Q3	2 123 129	8 292 983	608 778	56 122	50 202
	Q4	1 523 128	3 754 357	323 800	73 041	22 923
2015	Q1	0	611 726	3 106 692	276 572	13 721
	Q2	0	1 551 688	1 017 081	15 535	204
	Q3	2 490 966	10 322 443	2 457 770	102 266	23 836
	Q4	1 220 084	11 560 204	1 159 903	37 905	16 079

Table 8.2.3. North Sea sprat. Mean weight at age (kg) by quarter and year. (Calendar year)

Year	Quarter	Age-0	Age-1	Age-2	Age-3	Age-4
1974	Q1		0.005953	0.012854	0.017806	0.024999
	Q2		0.005546	0.011308	0.014707	0.023244
	Q3	0.007115	0.00886	0.013422	0.023148	0.026301
	Q4	0.005724	0.008422	0.013785	0.020402	0.025486
1975	Q1		0.003458	0.007102	0.012549	0.019671
	Q2		0.006092	0.009241	0.011088	0.017475
	Q3	0.007115	0.008472	0.013583	0.017937	0.020004
	Q4	0.005928	0.01052	0.016703	0.020838	0.020437
1976	Q1		0.003506	0.009773	0.014807	0.018884
	Q2		0.006176	0.009881	0.013213	0.015831
	Q3	0.003265	0.006809	0.012884	0.014423	0.018191
	Q4	0.003526	0.008306	0.015142	0.01901	0.018466
1977	Q1		0.003634	0.006314	0.010283	0.012952
	Q2		0.003901	0.006241	0.008346	0.009999
	Q3	0.006456	0.008326	0.012426	0.018034	0.016847
	Q4	0.00668	0.010536	0.014313	0.019706	0.016364
1978	Q1		0.003021	0.008346	0.012507	0.016517
	Q2		0.004944	0.00791	0.010578	0.012674
	Q3	0.004891	0.005969	0.011498	0.013582	0.019515
	Q4	0.004693	0.010137	0.016293	0.020106	0.022087
1979	Q1		0.002196	0.007216	0.010489	0.0146
	Q2		0.004063	0.0065	0.008692	0.010414
	Q3	0.007115	0.005577	0.006793	0.01647	0.007835
	Q4	0.003639	0.009961	0.014813	0.018366	0.009894
1980	Q1		0.002197	0.007293	0.0124	0.016323
	Q2		0.004919	0.007869	0.010523	0.012608
	Q3	0.007115	0.005985	0.007818	0.009816	0.011043
	Q4	0.005142	0.005796	0.00785	0.009713	0.010668
1981	Q1		0.003085	0.007593	0.01248	0.016103
	Q2		0.004735	0.00558	0.007625	0.009494
	Q3	0.006912	0.009281	0.012042	0.014347	0.017009
	Q4	0.005142	0.011266	0.014743	0.019207	0.023807
1982	Q1		0.003701	0.008436	0.015486	0.019244
	Q2		0.005507	0.008811	0.011782	0.014116
	Q3	0.006901	0.007327	0.010603	0.01652	0.020027
	Q4	0.008773	0.011151	0.014464	0.021113	0.023851
1983	Q1		0.009546	0.015997	0.021841	0.026272
	Q2		0.009789	0.015661	0.020942	0.025091
	Q3	0.008423	0.01177	0.015375	0.019306	0.021718
	Q4	0.007938	0.012843	0.017098	0.02121	0.018108
1984	Q1		0.00478	0.011143	0.015442	0.018733
	Q2		0.006728	0.010765	0.014394	0.016496
	Q3	0.007528	0.010519	0.013741	0.017255	0.018007
	Q4	0.004948	0.012412	0.017589	0.016068	0.018127

Table 8.2.3. (cont.) North Sea sprat. Mean weight at age (kg) by quarter and year. (Calendar year)

Year	Quarter	Age-0	Age-1	Age-2	Age-3	Age-4
1985	Q1		0.009292	0.013534	0.019686	0.019686
	Q2		0.009292	0.013534	0.019686	0.019686
	Q3	0.007115	0.009292	0.013534	0.019686	0.019686
	Q4	0.005142	0.009292	0.013534	0.019686	0.019686
1986	Q1		0.007258	0.00988	0.016584	0.016584
	Q2		0.007258	0.00988	0.016584	0.016584
	Q3	0.007115	0.007258	0.00988	0.016584	0.016584
	Q4	0.005142	0.007258	0.00988	0.016584	0.016584
1987	Q1		0.008761	0.014681	0.020044	0.018733
	Q2		0.008828	0.014124	0.018887	0.016496
	Q3	0.007115	0.009206	0.012646	0.014801	0.018007
	Q4	0.005799	0.009296	0.011176	0.016135	0.018127
1988	Q1		0.008337	0.013971	0.019075	0.018733
	Q2		0.008689	0.013901	0.018588	0.016496
	Q3	0.007115	0.011925	0.014068	0.018104	0.018007
	Q4	0.005142	0.010985	0.014878	0.01841	0.018127
1989	Q1		0.006577	0.011021	0.015047	0.018733
	Q2		0.006786	0.010856	0.014517	0.016496
	Q3	0.005501	0.008423	0.009751	0.018461	0.018007
	Q4	0.004559	0.007692	0.010418	0.012891	0.018127
1990	Q1		0.007415	0.012427	0.016966	0.020408
	Q2		0.007703	0.012323	0.016479	0.019744
	Q3	0.007115	0.008992	0.011747	0.014751	0.016593
	Q4	0.005142	0.008833	0.011964	0.014804	0.016259
1991	Q1		0.004562	0.01082	0.013801	0.017319
	Q2		0.004792	0.007666	0.010251	0.012283
	Q3	0.012675	0.014371	0.015385	0.017269	0.018943
	Q4	0.003714	0.011909	0.016946	0.018066	0.020771
1992	Q1		0.004471	0.007493	0.01023	0.012305
	Q2		0.004563	0.0073	0.009761	0.011695
	Q3	0.008282	0.009893	0.012284	0.014353	0.017807
	Q4	0.006681	0.011437	0.014612	0.016164	0.017393
1993	Q1		0.003364	0.009103	0.01351	0.017633
	Q2		0.004338	0.00694	0.00928	0.011119
	Q3	0.007115	0.010853	0.012203	0.012474	0.017853
	Q4	0.007566	0.010649	0.01347	0.016441	0.017654
1994	Q1		0.002718	0.008346	0.011369	0.015351
	Q2		0.004369	0.00699	0.009347	0.011199
	Q3	0.007115	0.006338	0.00847	0.009733	0.014094
	Q4	0.008741	0.010274	0.012483	0.015304	0.017145
1995	Q1		0.003318	0.008251	0.010122	0.01495
	Q2		0.00486	0.007775	0.010397	0.012457
	Q3	0.002779	0.008008	0.010971	0.011702	0.018007
	Q4	0.005092	0.009736	0.013118	0.015428	0.017

Table 8.2.3. (cont.) North Sea sprat. Mean weight at age (kg) by quarter and year. (Calendar year)

Year	Quarter	Age-0	Age-1	Age-2	Age-3	Age-4
1996	Q1		0.007444	0.011167	0.012889	0.015444
	Q2		0.007088	0.011339	0.015163	0.018168
	Q3	0.007422	0.01037	0.013546	0.01701	0.019135
	Q4	0.006186	0.010456	0.014605	0.016411	0.019345
1997	Q1		0.005604	0.009392	0.012823	0.015424
	Q2		0.005932	0.009491	0.012691	0.015206
	Q3	0.00831	0.011611	0.015168	0.019046	0.021426
	Q4	0.003464	0.011389	0.015643	0.018844	0.021859
1998	Q1		0.008832	0.014801	0.020208	0.024307
	Q2		0.009043	0.014468	0.019346	0.02318
	Q3	0.005643	0.013941	0.016117	0.017338	0.020284
	Q4	0.00664	0.012016	0.015042	0.01823	0.020252
1999	Q1		0.00429	0.007466	0.010226	0.011339
	Q2		0.004558	0.007292	0.009751	0.011683
	Q3	0.007115	0.009725	0.011621	0.011735	0.013638
	Q4	0.003709	0.010175	0.012755	0.015839	0.013712
2000	Q1		0.003544	0.008627	0.010862	0.011541
	Q2		0.004901	0.007841	0.010486	0.012563
	Q3	0.00881	0.011903	0.014222	0.015713	0.015745
	Q4	0.009355	0.011973	0.014618	0.015758	0.015849
2001	Q1		0.004397	0.009765	0.012648	0.01482
	Q2		0.005723	0.009157	0.012244	0.014671
	Q3	0.007475	0.010445	0.013644	0.017133	0.018007
	Q4	0.004884	0.010751	0.01332	0.017189	0.018127
2002	Q1		0.011187	0.018747	0.025596	0.030787
	Q2		0.009937	0.015899	0.02126	0.025473
	Q3	0.007149	0.010414	0.013722	0.015286	0.016072
	Q4	0.006408	0.011521	0.013412	0.014268	0.015723
2003	Q1		0.004402	0.008511	0.010406	0.011861
	Q2		0.004816	0.007705	0.010304	0.012345
	Q3	0.007115	0.012657	0.0145	0.018719	0.019314
	Q4	0.006866	0.010895	0.014017	0.014721	0.015256
2004	Q1		0.009729	0.016304	0.02226	0.026775
	Q2		0.007607	0.01217	0.016274	0.019499
	Q3	0.008663	0.011171	0.01366	0.014211	0.016819
	Q4	0.004143	0.009141	0.011321	0.014193	0.019042
2005	Q1		0.00339	0.006821	0.007912	0.013494
	Q2		0.00346	0.005535	0.007402	0.008869
	Q3	0.007115	0.00849	0.011568	0.011601	0.017268
	Q4	0.006467	0.010009	0.010948	0.011499	0.017912
2006	Q1		0.00575	0.007732	0.009738	0.010753
	Q2		0.004722	0.007555	0.010103	0.012104
	Q3	0.007115	0.010445	0.011785	0.013184	0.011648
	Q4	0.005142	0.008982	0.012166	0.015054	0.016534

Table 8.2.3. (cont.) North Sea sprat. Mean weight at age (kg) by quarter and year. (Calendar year)

Year	Quarter	Age-0	Age-1	Age-2	Age-3	Age-4
2007	Q1		0.00918	0.015384	0.021004	0.025265
	Q2		0.008414	0.013461	0.018	0.021567
	Q3	0.007115	0.012442	0.013618	0.014343	0.015153
	Q4	0.006192	0.010095	0.012729	0.014914	0.015657
2008	Q1		0.004643	0.007403	0.010125	0.014564
	Q2		0.004723	0.007557	0.010105	0.012107
	Q3	0.008433	0.009856	0.011086	0.012731	0.012988
	Q4	0.005292	0.009311	0.013152	0.01425	0.020143
2009	Q1		0.00858	0.014378	0.01963	0.023612
	Q2		0.007288	0.01166	0.015592	0.018682
	Q3	0.007115	0.00908	0.011801	0.013906	0.017654
	Q4	0.004639	0.009536	0.013137	0.016431	0.018342
2010	Q1		0.00435	0.007669	0.010253	0.013326
	Q2		0.004845	0.007751	0.010365	0.012419
	Q3	0.006815	0.007898	0.009344	0.013557	0.015594
	Q4	0.004482	0.009103	0.01114	0.01314	0.017319
2011	Q1		0.005373	0.007357	0.009542	0.013151
	Q2		0.0045	0.0072	0.009628	0.011535
	Q3	0.005165	0.008287	0.010046	0.013455	0.015423
	Q4	0.004396	0.008888	0.011448	0.014137	0.017203
2012	Q1		0.009602	0.01609	0.021968	0.026424
	Q2		0.008008	0.012811	0.017131	0.020526
	Q3	0.008531	0.008494	0.010352	0.013519	0.016777
	Q4	0.007249	0.008677	0.011985	0.015054	0.017578
2013	Q1		0.003871	0.006698	0.010697	0.013658
	Q2		0.004323	0.006916	0.009248	0.01108
	Q3	0.006135	0.009579	0.012025	0.014621	0.018215
	Q4	0.004394	0.009908	0.012666	0.014675	0.018061
2014	Q1		0.014844	0.024875	0.033962	0.040851
	Q2		0.008588	0.013739	0.018372	0.022013
	Q3	0.008594	0.008508	0.010178	0.015429	0.019534
	Q4	0.00726	0.007699	0.011341	0.012554	0.018182
2015	Q1		0.004633	0.008003	0.011562	0.013196
	Q2		0.005803	0.007538	0.008863	0.011339
	Q3	0.007113	0.007909	0.010018	0.014043	0.016025
	Q4	0.007138	0.008247	0.010218	0.014023	0.016367

Table 8.2.4. North Sea sprat. Sampling for biological parameters in 2015. This table only shows age-length samples, and therefore the number of samples may differ from Table 8.2.5.

Country	Quarter	Landings ('000 tonnes)	No. samples	No. measured	No. aged
Denmark	1	22.69	13	1 356	494
	2	16.94	9	951	297
	3	118.08	134	13 811	4 751
	4	110.69	27	2 741	893
	Total	268.40	183	18 859	6 435
Norway	1	9.06	7	700	235
	2				
	3				
	4				
	Total	9.06	7	700	235
All countries	1	31.79	20	2 056	729
	2	16.95	9	951	297
	3	124.85	134	13 811	4 751
	4	116.79	27	2 741	893
Total North Sea		290.38	190	19 559	6 670

Table 8.2.5. North Sea sprat. Number of biological samples taken from 1991 and onward. The number of samples may 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	Quarter 1	Quarter 2	Quarter 3	Quarter 4
1991	10	0	5	31
1992	2	4	38	20
1993	16	2	15	29
1994	13	1	21	29
1995	11	2	16	29
1996	13	2	1	8
1997	4	1	2	16
1998	2	1	16	14
1999	5	1	22	8
2000	14	0	21	8
2001	13	1	2	6
2002	2	0	9	32
2003	11	4	11	26
2004	3	1	12	21
2005	10	4	22	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	13	2	23	52
2012	3	1	33	86
2013	9	0	31	23
2014	0	1	99	14
2015	13	9	134	27

Table 8.3.1. North Sea sprat. Abundance indices by age from IBTS Q1 (Feb) from 1972–2015 as calculated by the stratified method (see Stock Annex, WKSPRAT ICES, 2013). Data from 1974–2014 were updated in 2015.

Year	Age				
	1	2	3	4+	Total
1972	467.25	531.95	53.80	6.81	1 059.81
1973	255.91	206.75	26.07	0.16	488.90
1974	1 178.64	2 008.10	257.81	76.02	3 520.56
1975	96.65	1 567.44	747.15	22.84	2 434.08
1976	863.93	433.09	192.26	3.09	1 492.38
1977	141.86	2 559.19	230.25	19.74	2 951.04
1978	987.54	486.59	227.12	6.96	1 708.21
1979	429.51	212.18	150.98	5.49	798.15
1980	336.85	849.58	31.61	2.85	1 220.89
1981	624.72	817.55	144.51	9.31	1 596.08
1982	119.84	311.95	80.45	3.69	515.94
1983	143.00	453.27	127.60	7.89	731.75
1984	233.76	329.00	39.61	6.49	608.86
1985	376.10	195.48	26.76	4.16	602.49
1986	44.19	73.54	22.01	1.48	141.21
1987	542.24	66.28	19.14	2.16	629.82
1988	98.61	884.07	61.80	6.99	1 051.46
1989	2 314.22	476.29	271.85	7.12	3 069.48
1990	234.94	451.98	102.16	30.28	819.37
1991	676.78	93.38	23.33	2.75	796.24
1992	1 060.78	297.69	43.25	7.77	1 409.48
1993	1 066.83	568.53	118.42	6.41	1 760.19
1994	2 428.36	938.16	92.16	4.10	3 462.77
1995	1 224.89	1 036.40	87.33	3.28	2 351.90
1996	186.13	383.53	146.84	19.03	735.53
1997	591.86	411.96	179.54	17.77	1 201.13
1998	1 171.05	1 456.51	305.91	19.13	2 952.60
1999	2 534.53	562.10	80.35	5.27	3 182.25
2000	1 058.01	860.09	278.32	45.18	2 241.61
2001	883.06	1 057.04	185.54	17.90	2 143.53
2002	896.13	642.52	69.76	8.26	1 616.66
2003	1 818.25	344.39	33.60	2.68	2 198.92
2004	1 593.78	495.63	78.23	5.03	2 172.67
2005	3 059.03	269.39	36.47	0.87	3 365.77
2006	426.01	1 174.00	93.78	5.08	1 698.86
2007	1 053.59	1 341.38	275.18	11.19	2 681.33
2008	1 427.99	766.97	96.68	6.85	2 298.49
2009	3 140.10	451.31	25.53	2.77	3 619.72
2010	2 101.85	1 736.00	156.14	25.48	4 019.48
2011	646.57	966.59	734.01	132.34	2 479.50
2012	2 481.94	1 995.87	429.47	30.58	4 937.86

Year	Age				
	1	2	3	4+	Total
2013	709.56	1 303.67	453.65	59.46	2 526.34
2014	2 963.62	1 029.25	230.15	29.67	4 252.70
2015	3 218.27	2 912.03	479.29	32.44	6 642.03
2016*	826.02	1 469.57	388.88	23.68	2 708.14

* Preliminary

Table 8.3.2. North Sea sprat. Time-series of sprat abundance and biomass (ICES areas 4.a-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. The model use data from 2003 and onward.

	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
2013	454	9,332	6,273	1,600	17,660	2	71	74	25	172
2014	5,828	58,405	20,164	3,823	88,219	9	429	228	62	728
2015	198	26,241	22,474	9,799	58,711	0	239	312	161	712

*re-calculated using FishFrame

Table 8.3.3. North Sea sprat. Abundance indices by age from IBTS Q3 from 1991–2015 as calculated by the stratified method (see Stock Annex, WKSPRAT ICES, 2013). Data from 1991–2014 updated in 2015.

Year	Age					
	0	1	2	3	4+	Total
1991	0.00	196.33	78.74	32.50	0.45	308.02
1992	20.36	2 430.01	2 024.16	120.25	21.31	4 616.09
1993	7.46	1 423.79	1 540.57	317.35	13.41	3 302.58
1994	3.49	2 441.07	333.21	80.24	7.05	2 865.05
1995	0.00	729.86	2 067.47	1 064.51	12.82	3 874.66
1996	1.51	310.54	734.58	315.55	44.04	1 406.23
1997	15.70	4 527.79	1 278.58	237.42	28.24	6 087.72
1998	193.63	2 020.65	1 122.15	146.22	4.82	3 487.46
1999	1 754.76	7 982.21	918.38	61.66	0.12	10 717.12
2000	27.96	2 535.90	1 561.27	42.31	3.29	4 170.73
2001	51.83	2 310.04	1 495.48	116.37	0.75	3 974.47
2002	103.68	4 248.45	1 153.75	112.07	11.60	5 629.54
2003	11.07	1 619.47	303.27	13.41	0.54	1 947.76
2004	4 279.64	3 061.32	840.65	106.76	2.16	8 290.54
2005	0.64	8 273.86	438.34	64.28	25.89	8 803.00
2006	0.05	1 446.66	1 913.58	85.74	2.41	3 448.43
2007	42.73	1 435.51	1 122.14	223.09	4.55	2 828.01
2008	95.18	1 806.34	977.72	123.95	2.89	3 006.09
2009	496.67	9 424.91	2 186.34	262.98	8.74	12 379.64
2010	19.32	3 967.83	3 076.58	179.98	3.67	7 247.38
2011	3.44	10 660.13	3 788.89	1 052.66	63.67	15 568.79
2012	0.06	2 761.31	2 896.50	416.86	31.88	6 106.61
2013	0.04	3 508.33	3 143.59	359.82	46.85	7 058.64
2014	870.06	10 316.05	1 741.91	72.06	1.12	13 001.20
2015	27.60	9 351.69	4 948.41	409.25	0.55	14 737.50

Table 8.6.1. North Sea sprat. Maturity at age input (from IBTS Q1). (Calendar 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	0.517681	0.954882	1
2013	0	0.211287	0.806729	0.980479
2014	0	0.465547	0.867485	0.808139
2015	0	0.467141	0.953112	0.998317
2016	0	0.331436	0.916164	0.968765

Table 8.6.2. North Sea sprat. Natural mortality input (years refer to the model year). From multi-species SMS (WKSAM: ICES, 2015) 2015 key run (years and age refer to the model year. For example 2012 refers to the model year July 2012 to June 2013, and S1-S4 refers to the model seasons).

Year	Season	Age 0	Age 1	Age 2	Age 3
1974	S1	0.463	0.375	0.288	0.122
	S2	0.289	0.247	0.209	0.149
	S3	0.314	0.165	0.129	0.129
	S4	0.394	0.334	0.199	0.199
1975	S1	0.509	0.478	0.349	0.169
	S2	0.484	0.306	0.273	0.221
	S3	0.27	0.17	0.154	0.154
	S4	0.346	0.295	0.243	0.243
1976	S1	0.387	0.342	0.282	0.203
	S2	0.532	0.31	0.283	0.241
	S3	0.313	0.206	0.183	0.183
	S4	0.398	0.261	0.258	0.258
1977	S1	0.359	0.333	0.293	0.226
	S2	0.616	0.33	0.309	0.26
	S3	0.398	0.221	0.2	0.2
	S4	0.405	0.304	0.301	0.301
1978	S1	0.31	0.289	0.251	0.201
	S2	0.488	0.277	0.259	0.227
	S3	0.285	0.183	0.167	0.167
	S4	0.326	0.252	0.249	0.249
1979	S1	0.377	0.342	0.286	0.2
	S2	0.461	0.268	0.247	0.208
	S3	0.352	0.186	0.167	0.167
	S4	0.437	0.267	0.263	0.263
1980	S1	0.6	0.592	0.438	0.242
	S2	0.666	0.497	0.415	0.303
	S3	0.422	0.286	0.26	0.26
	S4	0.437	0.315	0.311	0.311
1981	S1	0.583	0.54	0.479	0.21
	S2	0.656	0.419	0.385	0.228
	S3	0.325	0.218	0.192	0.192
	S4	0.362	0.297	0.237	0.237
1982	S1	0.648	0.571	0.502	0.227
	S2	0.662	0.457	0.417	0.257
	S3	0.335	0.232	0.195	0.195
	S4	0.355	0.303	0.247	0.247
1983	S1	0.658	0.545	0.423	0.187
	S2	0.603	0.371	0.309	0.188
	S3	0.276	0.182	0.139	0.139
	S4	0.304	0.237	0.205	0.205
1984	S1	0.717	0.583	0.395	0.203
	S2	0.756	0.489	0.381	0.259

Year	Season	Age 0	Age 1	Age 2	Age 3
	S3	0.358	0.234	0.203	0.203
	S4	0.334	0.289	0.252	0.252
1985	S1	0.754	0.73	0.438	0.202
	S2	0.707	0.491	0.34	0.218
	S3	0.367	0.188	0.163	0.163
	S4	0.358	0.234	0.231	0.231
1986	S1	0.548	0.523	0.395	0.196
	S2	0.865	0.573	0.441	0.226
	S3	0.357	0.206	0.183	0.183
	S4	0.326	0.287	0.241	0.241
1987	S1	0.709	0.6	0.537	0.231
	S2	1.06	0.7	0.634	0.294
	S3	0.445	0.28	0.239	0.239
	S4	0.385	0.346	0.297	0.297
1988	S1	0.609	0.559	0.429	0.204
	S2	0.909	0.585	0.459	0.232
	S3	0.405	0.195	0.169	0.169
	S4	0.363	0.308	0.277	0.277
1989	S1	0.627	0.572	0.416	0.243
	S2	0.961	0.604	0.493	0.307
	S3	0.415	0.272	0.239	0.239
	S4	0.364	0.295	0.291	0.291
1990	S1	0.6	0.502	0.406	0.211
	S2	0.837	0.544	0.449	0.241
	S3	0.336	0.217	0.186	0.186
	S4	0.317	0.285	0.252	0.252
1991	S1	0.595	0.541	0.393	0.204
	S2	0.787	0.543	0.404	0.225
	S3	0.297	0.197	0.168	0.168
	S4	0.296	0.249	0.222	0.222
1992	S1	0.526	0.423	0.309	0.176
	S2	0.711	0.46	0.344	0.203
	S3	0.281	0.178	0.152	0.152
	S4	0.282	0.246	0.221	0.221
1993	S1	0.41	0.373	0.281	0.169
	S2	0.618	0.408	0.318	0.202
	S3	0.251	0.18	0.149	0.149
	S4	0.254	0.22	0.203	0.203
1994	S1	0.371	0.328	0.254	0.169
	S2	0.528	0.33	0.261	0.181
	S3	0.22	0.157	0.138	0.138
	S4	0.231	0.201	0.186	0.186
1995	S1	0.494	0.444	0.313	0.182
	S2	0.667	0.394	0.314	0.212
	S3	0.281	0.201	0.17	0.17

Year	Season	Age 0	Age 1	Age 2	Age 3
	S4	0.291	0.247	0.231	0.231
1996	S1	0.401	0.347	0.285	0.168
	S2	0.476	0.328	0.246	0.179
	S3	0.182	0.146	0.13	0.13
	S4	0.196	0.16	0.148	0.148
1997	S1	0.447	0.353	0.244	0.156
	S2	0.624	0.387	0.281	0.191
	S3	0.233	0.164	0.142	0.142
	S4	0.222	0.19	0.188	0.188
1998	S1	0.376	0.349	0.249	0.165
	S2	0.617	0.361	0.268	0.182
	S3	0.25	0.161	0.13	0.13
	S4	0.265	0.225	0.222	0.222
1999	S1	0.421	0.322	0.243	0.152
	S2	0.594	0.303	0.232	0.143
	S3	0.219	0.141	0.118	0.118
	S4	0.227	0.189	0.187	0.187
2000	S1	0.439	0.351	0.264	0.167
	S2	0.619	0.359	0.28	0.186
	S3	0.265	0.173	0.149	0.149
	S4	0.257	0.221	0.219	0.219
2001	S1	0.397	0.353	0.271	0.179
	S2	0.619	0.363	0.286	0.196
	S3	0.254	0.179	0.156	0.156
	S4	0.243	0.21	0.208	0.208
2002	S1	0.472	0.376	0.292	0.205
	S2	0.606	0.394	0.317	0.23
	S3	0.26	0.216	0.175	0.175
	S4	0.288	0.257	0.254	0.254
2003	S1	0.411	0.387	0.292	0.212
	S2	0.64	0.324	0.288	0.214
	S3	0.25	0.202	0.156	0.156
	S4	0.3	0.27	0.259	0.259
2004	S1	0.403	0.298	0.23	0.175
	S2	0.63	0.306	0.243	0.187
	S3	0.208	0.158	0.122	0.122
	S4	0.249	0.223	0.213	0.213
2005	S1	0.468	0.334	0.249	0.166
	S2	0.527	0.305	0.205	0.149
	S3	0.189	0.146	0.107	0.107
	S4	0.243	0.205	0.203	0.203
2006	S1	0.43	0.38	0.209	0.16
	S2	0.58	0.378	0.22	0.171
	S3	0.199	0.153	0.116	0.116
	S4	0.242	0.203	0.201	0.201

Year	Season	Age 0	Age 1	Age 2	Age 3
2007	S1	0.431	0.367	0.217	0.155
	S2	0.557	0.352	0.217	0.159
	S3	0.209	0.142	0.11	0.11
	S4	0.234	0.193	0.191	0.191
2008	S1	0.437	0.267	0.216	0.141
	S2	0.66	0.282	0.161	0.157
	S3	0.18	0.135	0.108	0.108
	S4	0.203	0.176	0.174	0.174
2009	S1	0.506	0.263	0.21	0.128
	S2	0.64	0.265	0.142	0.138
	S3	0.158	0.118	0.1	0.1
	S4	0.172	0.142	0.14	0.14
2010	S1	0.513	0.319	0.225	0.128
	S2	0.787	0.364	0.159	0.156
	S3	0.226	0.139	0.116	0.116
	S4	0.239	0.178	0.177	0.177
2011	S1	0.632	0.45	0.321	0.156
	S2	0.941	0.529	0.2	0.197
	S3	0.257	0.192	0.144	0.144
	S4	0.31	0.252	0.249	0.249
2012	S1	0.623	0.478	0.175	0.173
	S2	0.819	0.505	0.201	0.198
	S3	0.22	0.175	0.133	0.133
	S4	0.282	0.218	0.216	0.216
2013	S1	0.417	0.373	0.129	0.128
	S2	0.59	0.401	0.152	0.148
	S3	0.234	0.168	0.131	0.131
	S4	0.277	0.216	0.214	0.214
2014*	S1	0.557	0.434	0.208	0.152
	S2	0.783	0.478	0.184	0.181
	S3	0.237	0.178	0.136	0.136
	S4	0.29	0.229	0.227	0.227
2015*	S1	0.557	0.434	0.208	0.152
	S2	0.783	0.478	0.184	0.181
	S3	0.237	0.178	0.136	0.136
	S4	0.29	0.229	0.227	0.227

***Average of 2011–2013**

Table 8.6.3. North Sea sprat. Assessment diagnostics.

objective function (negative log likelihood): 473.013

Number of parameters: 143

Maximum gradient: 3.4694e–005

Akaike information criterion (AIC): 1232.03

Number of observations used in the likelihood:

CATCH	CPUE	S/R	STOMACH	SUM
672	274	42	0	988

objective function weight:

CATCH	CPUE	S/R
1.00	1.00	0.10

unweighted objective function contributions (total):

CATCH	CPUE	S/R	STOM	STOM N.	PENALTY	SUM
493.1	19.9	2.0	0.0	0.0	0.0	471

unweighted objective function contributions (per observation):

CATCH	CPUE	S/R	STOMACHS
0.73	0.07	0.05	0.00

contribution by fleet:

IBTS Q1	total: -18.045	mean: -0.113
IBTS Q3	total: 11.959	mean: 0.159
Acoustic	total: -13.819	mean: -0.354

Table 8.6.3 (continued). North Sea sprat. Assessment diagnostics.

F, season effect:

----

age: 0

1974–1995: 0.023 0.116 0.494 0.250

1996–2015: 0.056 0.672 0.497 0.250

age: 1

1974–1995: 0.695 0.829 0.616 0.250

1996–2015: 2.384 5.725 0.559 0.250

age: 2

1974–1995: 0.787 1.228 0.574 0.250

1996–2015: 2.552 13.311 0.565 0.250

age: 3

1974–1995: 0.661 1.787 0.752 0.250

1996–2015: 2.588 17.467 0.641 0.250

F, age effect:

	0	1	2	3
1974–1995:	0.023	0.250	0.429	0.429
1996–2015:	0.006	0.046	0.056	0.056

Exploitation pattern (scaled to mean F=1)

		0	1	2	3
1974–1995	season 1:	0.001	0.192	0.372	0.312
	season 2:	0.003	0.229	0.580	0.844
	season 3:	0.012	0.170	0.271	0.355
	season 4:	0.006	0.069	0.118	0.118
1996–2015	season 1:	0.001	0.163	0.213	0.216
	season 2:	0.006	0.390	1.111	1.458
	season 3:	0.005	0.038	0.047	0.053
	season 4:	0.002	0.017	0.021	0.021

Table 8.6.3 (continued). North Sea sprat. Assessment diagnostics.

sqrt(catch variance) ~ CV:

----

	season			
age	1	2	3	4
0	1.414	1.414	1.414	1.414
1	0.933	0.798	1.414	0.806
2	1.186	1.368	1.414	1.414
3	1.186	1.368	1.414	1.414

Survey catchability:

----

	age 0	age 1	age 2	age 3
IBTS Q1	0.243	1.047	2.286	2.286
IBTS Q3		1.172	3.796	3.796
Acoustic		0.862	1.906	2.455

sqrt(Survey variance) ~ CV:

----

	age 0	age 1	age 2	age 3
IBTS Q1	0.54	0.54	0.54	0.54
IBTS Q3		0.77	0.52	0.90
Acoustic		0.47	0.41	0.41

Recruit-SSB		alfa	beta	recruit s2	recruit s
Sprat	Hockey stick -break.:	1858.235	9.000e+004	0.334	0.578

Table 8.6.4. North Sea Sprat. Assessment output: Stock numbers (thousands). Age 0 at start of 2nd half-year, age 1+ at start of 1st half-year (years and age refer to the model year. For example 2012 refers to the model year July 2012 to June 2013).

Year/Age	Age 0	Age 1	Age 2	Age 3+
1974	267080000	109932000	7139390	401942
1975	465477000	60792500	19706400	977509
1976	206181000	88803400	4221590	410667
1977	241335000	39469200	14521800	408603
1978	236288000	39358400	4184040	573371
1979	208493000	55675900	4879010	198488
1980	266783000	39746600	7784220	305040
1981	103166000	30926300	3017760	318937
1982	67455100	14547700	2658740	124764
1983	78079600	9017650	1930890	280144
1984	44202600	12072600	909871	102062
1985	27783000	4989690	1330870	83610
1986	159582000	3046070	387113	65699
1987	130034000	19366000	421728	60642
1988	253745000	9620950	2356270	65864
1989	99207900	25632200	1528190	436198
1990	161587000	9288020	4243430	451586
1991	229066000	19813400	694956	119857
1992	225625000	31538100	2899530	109077
1993	229763000	36669400	5155690	387530
1994	114425000	47693500	3498210	195306
1995	72663500	29015100	8941920	415966
1996	106483000	12451500	3186640	508626
1997	125901000	30082300	3095540	637422
1998	155195000	27172500	6838390	640231
1999	128168000	33737600	3996070	467840
2000	109246000	29438500	8229030	714126
2001	94090700	22240500	5243280	838325
2002	134243000	20381700	3043480	298690
2003	103554000	25845000	2210350	122262
2004	227768000	20621700	4019540	176765
2005	88093300	50006900	2345330	120658
2006	103130000	20903300	10086300	275497
2007	85078600	23834600	3284330	882341
2008	167515000	19990600	3308910	218402
2009	139533000	37568100	4295600	380191
2010	194144000	31530100	10196400	780925
2011	187892000	32909300	7415580	1981480
2012	183675000	21852700	4694410	1102930
2013	383420000	26001300	3345640	849789
2014	502730000	83567300	6367550	1234990
2015	250819000	77008400	14752300	1343120
2016		38238500	9839450	1326890

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. All estimates are for July – June. For example 2012 refers to the model year 2012/2013.

Year	Recruits (million)	TSB (tonnes)	SSB (tonnes)	Yield (tonnes)	Mean F ages 1–2
1974	267080	2969950	491616	379747	0.915
1975	465477	4096090	458498	637282	2.107
1976	206181	1337230	301061	557359	1.083
1977	241335	2075230	296770	318769	1.667
1978	236288	1446500	145487	378632	1.700
1979	208493	1822190	158368	368667	1.403
1980	266783	2190780	153030	300239	1.342
1981	103166	1040680	153479	203897	1.426
1982	67455	602328	70013	123379	0.702
1983	78080	792735	74405	85168	1.436
1984	44203	470293	64502	85617	0.959
1985	27783	262671	36047	40922	1.356
1986	159582	1156870	13410	15687	0.583
1987	130034	1105210	78776	37551	0.289
1988	253745	1945420	76741	95972	0.289
1989	99208	784436	109191	51943	0.091
1990	161587	1284560	83854	67386	1.887
1991	229066	3202060	128268	114872	0.660
1992	225625	2217290	160372	148236	0.767
1993	229763	2092530	222413	209193	1.775
1994	114425	1144050	52434	313687	1.005
1995	72664	537644	174733	387626	1.399
1996	106483	965169	130722	84573	0.671
1997	125901	1444600	250311	104797	0.665
1998	155195	1375460	240588	172063	1.369
1999	128168	1287520	187936	215412	0.763
2000	109246	1440840	240842	195170	1.060
2001	94091	1016910	109349	131538	1.483
2002	134243	1218280	151555	157248	1.633
2003	103554	1095740	77245	159515	1.157
2004	227768	2260270	168198	207779	1.970
2005	88093	1076820	144771	232048	1.028
2006	103130	1071260	151237	74648	1.249
2007	85079	955363	235763	85080	1.537
2008	167515	1648760	139589	63623	1.129
2009	139533	1385060	176313	162714	0.853
2010	194144	1678960	257542	126077	0.750
2011	187892	1345320	238991	119083	0.869
2012	183675	1812320	93414	86196	0.858
2013	383420	2652090	160972	81268	0.442
2014	502730	5115310	414827	192679	0.713

Year	Recruits (million)	TSB (tonnes)	SSB (tonnes)	Yield (tonnes)	Mean F ages 1–2
2015	250819	2559330	355782	275150	1.265
2016			208904		
arith. mean	175207	1618622	177635	186869	1.102
geo. mean	149714				

Table 8.9.1. North Sea Sprat. Input to forecast (years and age refer to the model year. For example 2015 refers to the model year July 2015 to June 2016, and Q1-Q4 refers to the model quarters).

Age	Age 0	Age 1	Age 2	Age 3
Stock numbers (2016)	153211	38238.5	9839.45	1326.89
Exploitation pattern Q1	0.000543	0.172774	0.226353	0.229595
Exploitation pattern Q2	0.006483	0.41481	1.180845	1.549544
Exploitation pattern Q3	0.004787	0.040488	0.05014	0.056827
Exploitation pattern Q4	0.00134	0.010072	0.012331	0.012331
Weight in the stock Q1	7.276667	8.663333	10.73333	15.4
Weight in the catch Q1	7.276667	8.663333	10.73333	15.4
Weight in the catch Q2	6.24	8.566667	11.3	14.6
Weight in the catch Q3	6.036667	10.33667	14.7	17.36667
Weight in the catch Q4	6.886667	10.28667	13.43333	16.16667
Proportion mature (2016)	0	0.421375	0.912254	0.925074
Proportion mature (2017)	0	0.437425	0.894967	0.957509
Natural mortality Q1	0.510333	0.413667	0.181667	0.144
Natural mortality Q2	0.718667	0.452333	0.173333	0.17
Natural mortality Q3	0.236	0.174667	0.134333	0.134333
Natural mortality Q4	0.285667	0.224667	0.222667	0.222667

Table 8.9.2. Sprat North Sea. Short-term predictions options table. Basis: Fsq = F (July 2015–June 2016) = 1.226; Yield (2015) = 275; Recruitment (2015) = 251; Recruitment (2016) = geometric mean (GM 1995–2015) = 153 billion; SSB (2016) = 255.

Rationale	Wanted catch* (July 2016–June 2017)	Basis	F (July 2016–June 2017)	SSB* (July 2017)	% SSB change**	% TAC change***
MSY approach	126	F_{cap}	0.7	206	-19%	-54%
Zero catch	0	F = 0	0	286	12%	-100%
Other options	23	$F_{2015–2016}$ × 0.08	0.1	271	6%	-92%
	43	$F_{2015–2016}$ × 0.16	0.2	257	1%	-84%
	62	$F_{2015–2016}$ × 0.24	0.3	245	-4%	-77%
	80	$F_{2015–2016}$ × 0.33	0.4	234	-8%	-71%
	96	$F_{2015–2016}$ × 0.41	0.5	224	-12%	-65%
	112	$F_{2015–2016}$ × 0.49	0.6	215	-16%	-59%
	126	$F_{2015–2016}$ × 0.57	0.7	206	-19%	-54%
	139	$F_{2015–2016}$ × 0.65	0.8	199	-22%	-50%
	245	$F_{2015–2016}$ × 1.64 ($B_{escapement}$)	2.01	142	-44%	-11%

*Weights in thousand tonnes.

**SSB in July 2016

*** Advised TAC in July 2017 relative to advised TAC in July 2016

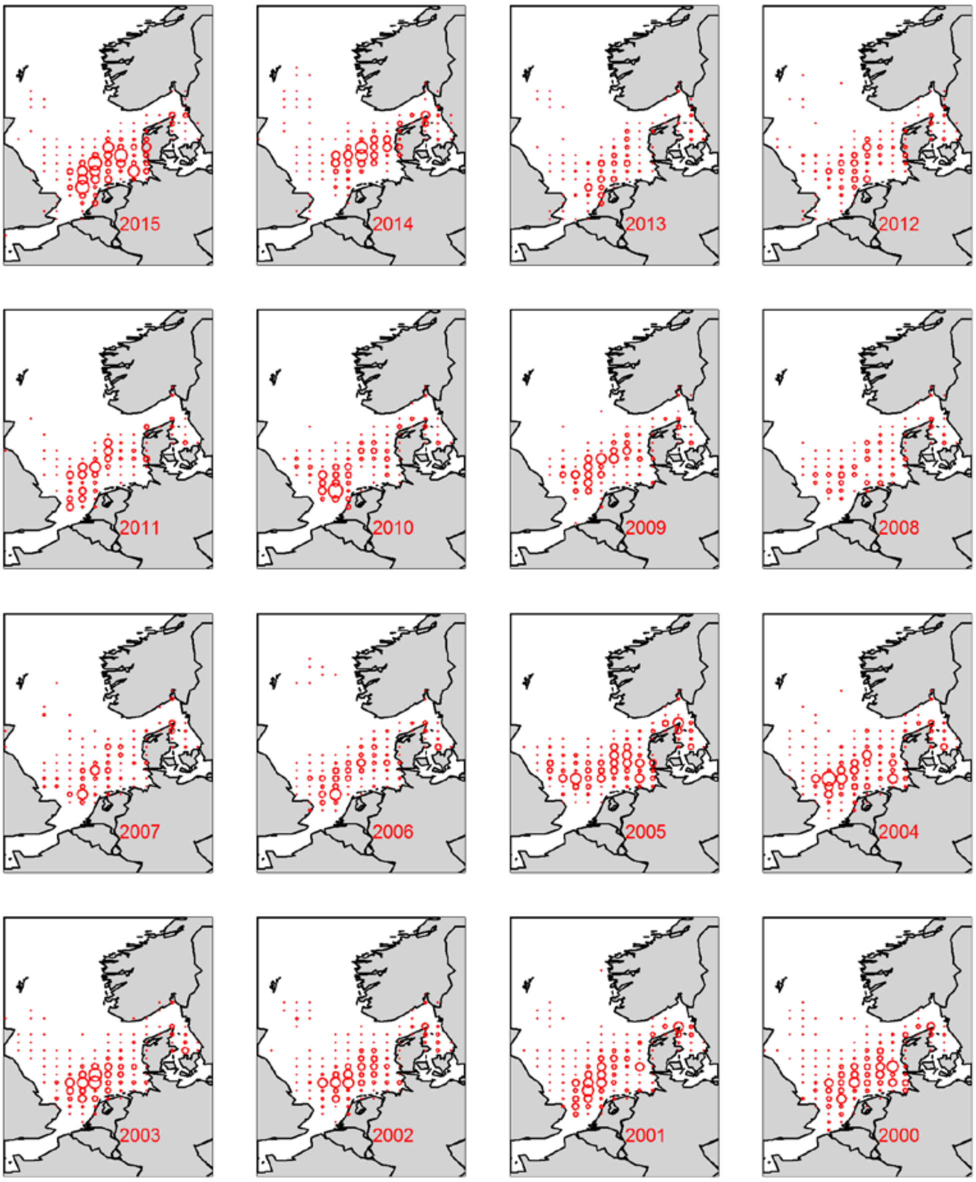


Figure 8.1.1. North Sea sprat and 3.a sprat. Sprat catches in the North Sea and Div. 3.a (in tonnes) for each year 2000–2015 by statistical rectangle.

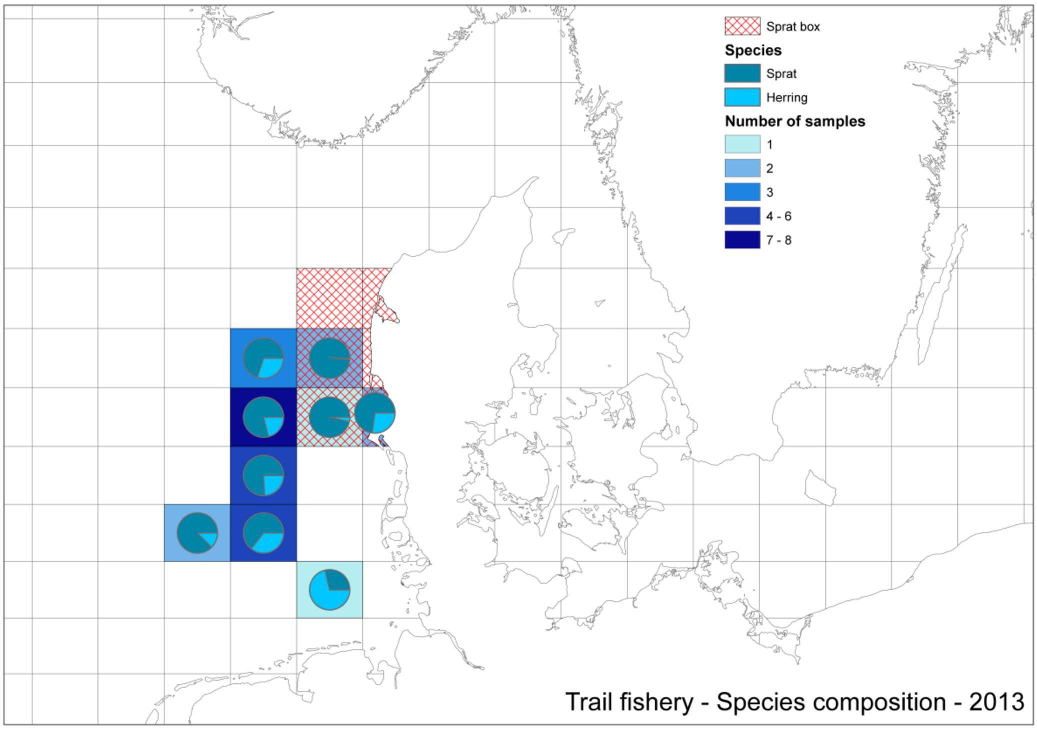


Figure 8.1.2. Species composition in the sprat fishery in 2013. Colours indicate number of samples pr. rectangle; red area indicates the sprat box.

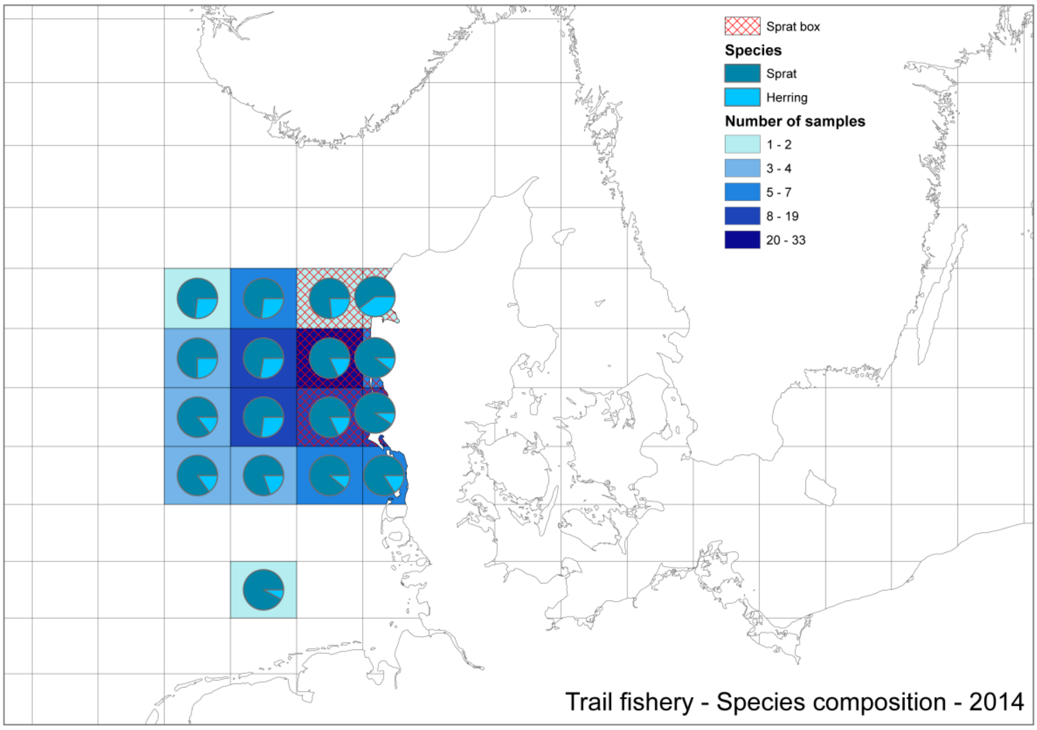


Figure 8.1.3. Species composition in the sprat fishery in 2014. Colours indicate number of samples pr. rectangle; red area indicates the sprat box.

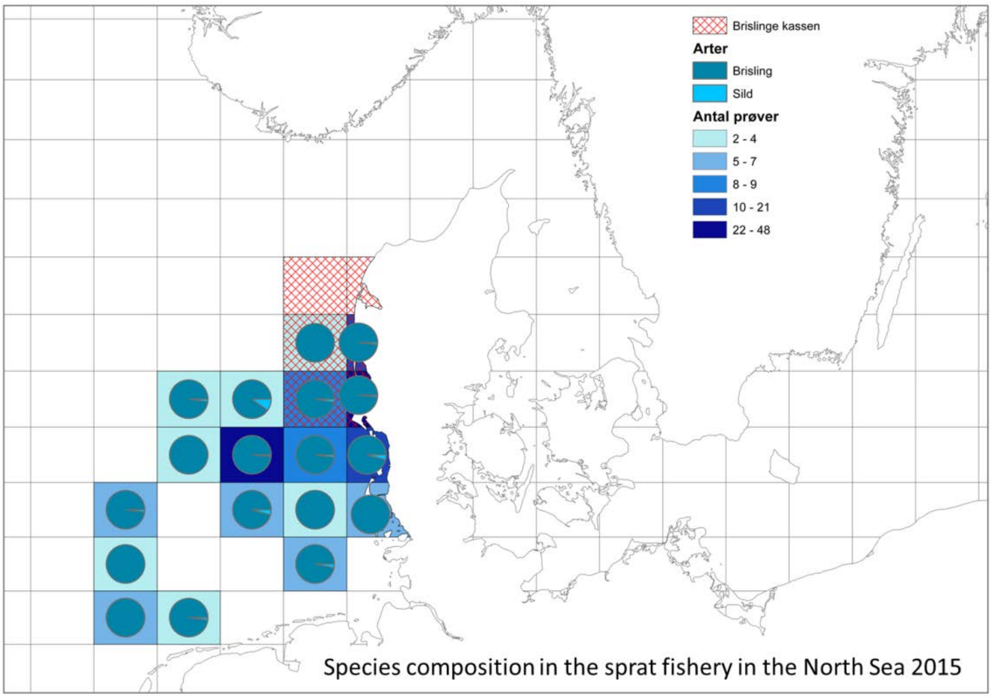


Figure 8.1.4. Species composition in the sprat fishery in 2015. Colours indicate number of samples pr. rectangle; red area indicates the sprat box.

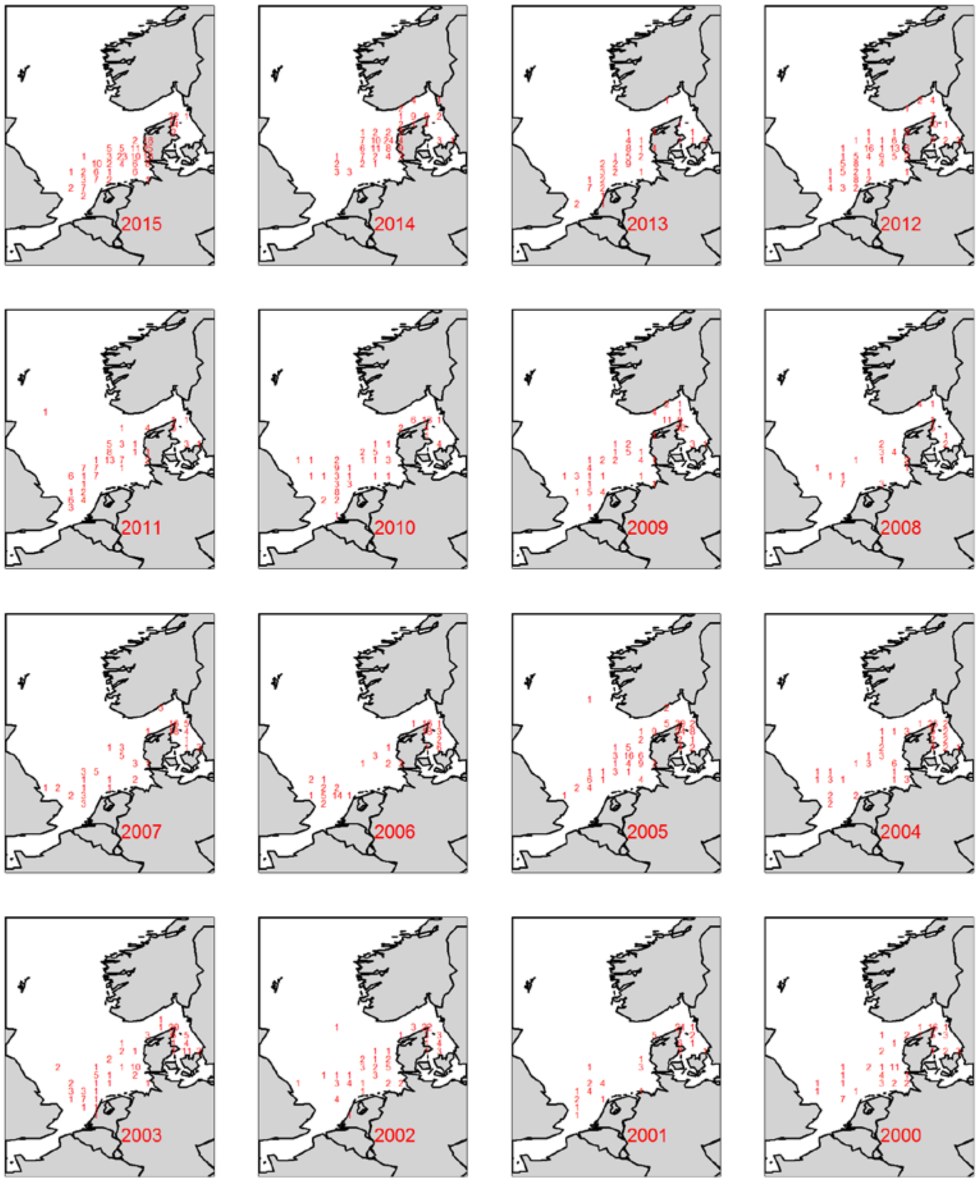


Figure 8.2.1. North Sea sprat and 3.a sprat. Number of samples taken in the North Sea and Div. 3.a for each year 2000–2015 by statistical rectangle.

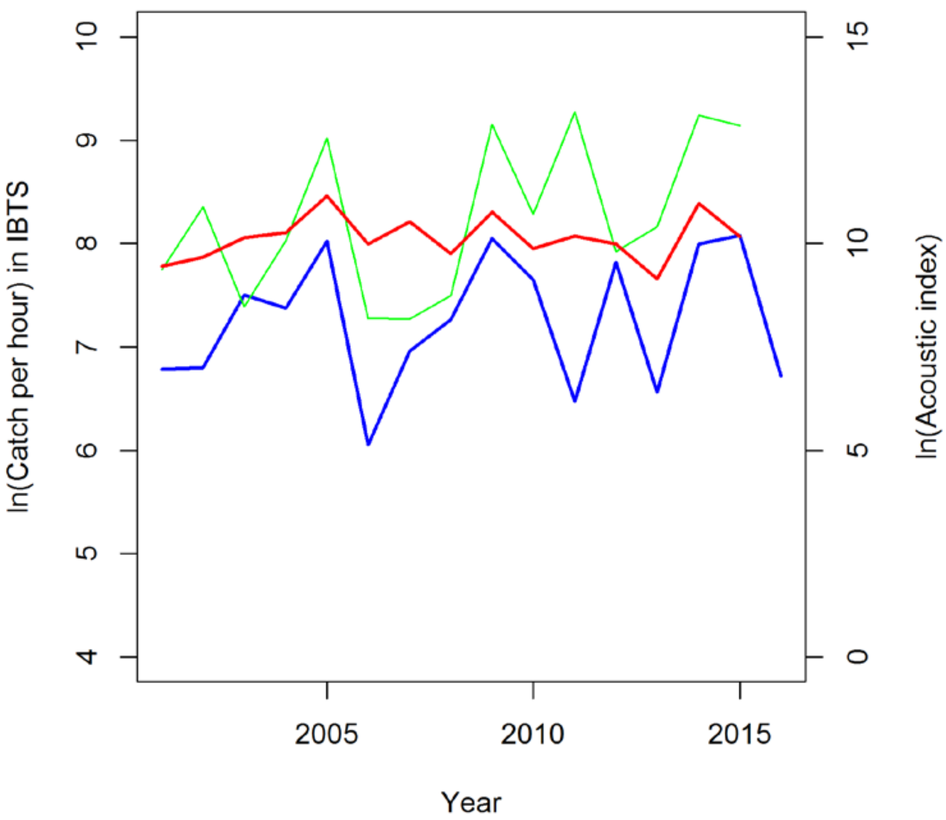


Figure 8.3.1. North Sea sprat. Mean IBTS catch rate of 1-year olds in quarters 1 (blue) and 3 (green) and in HERAS (red).

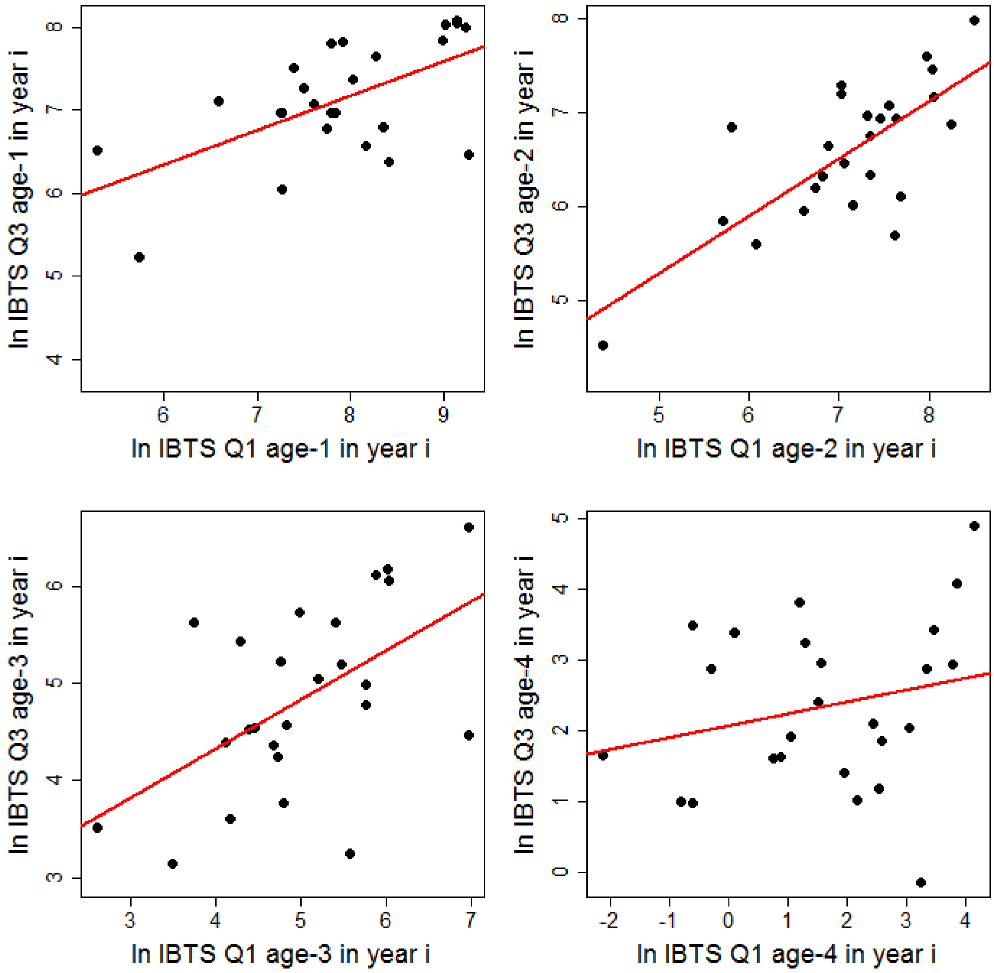


Figure 8.3.2a. North Sea sprat. External consistency between the IBTS Q1 and Q3 surveys. Red number inside the graphs are R^2. (Quarter (Q) and age refer to the calendar year)

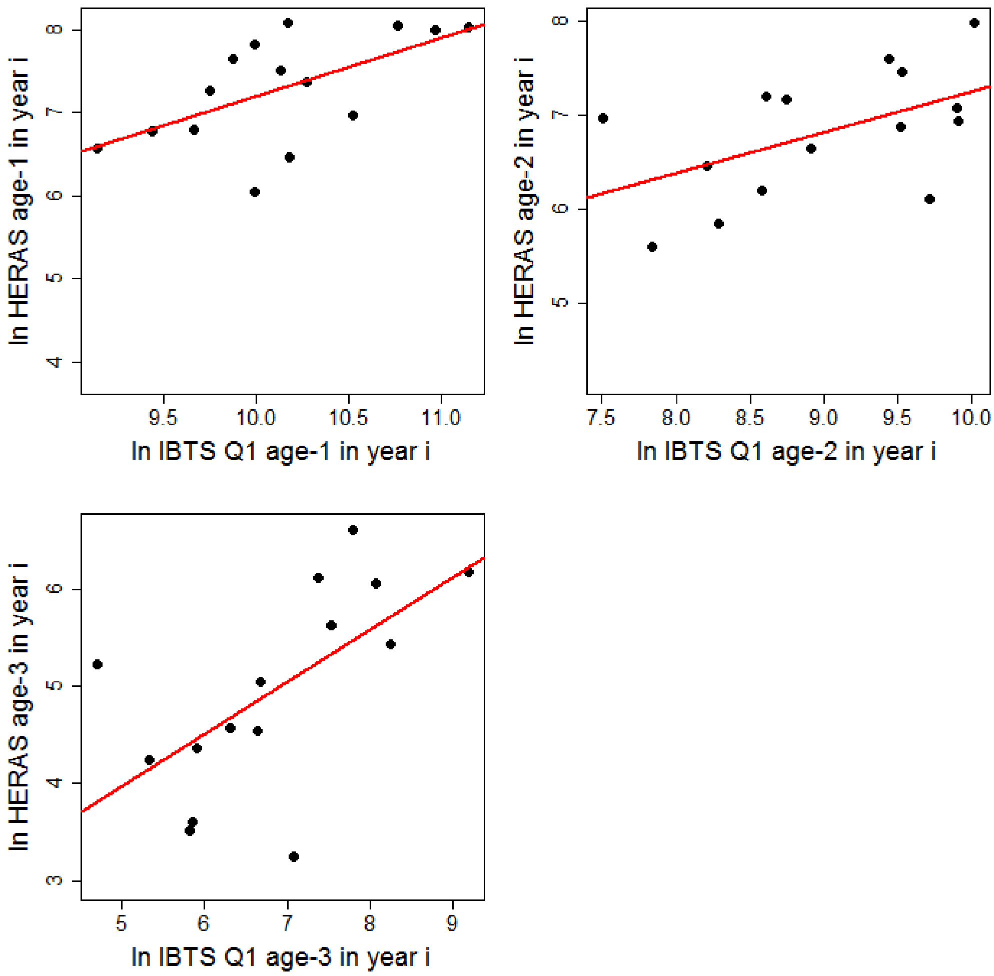


Figure 8.3.2b. North Sea sprat. External consistency between the IBTS Q1 and HERAS. Red number inside the graphs are R2. (Quarter (Q) and age refer to the calendar year)

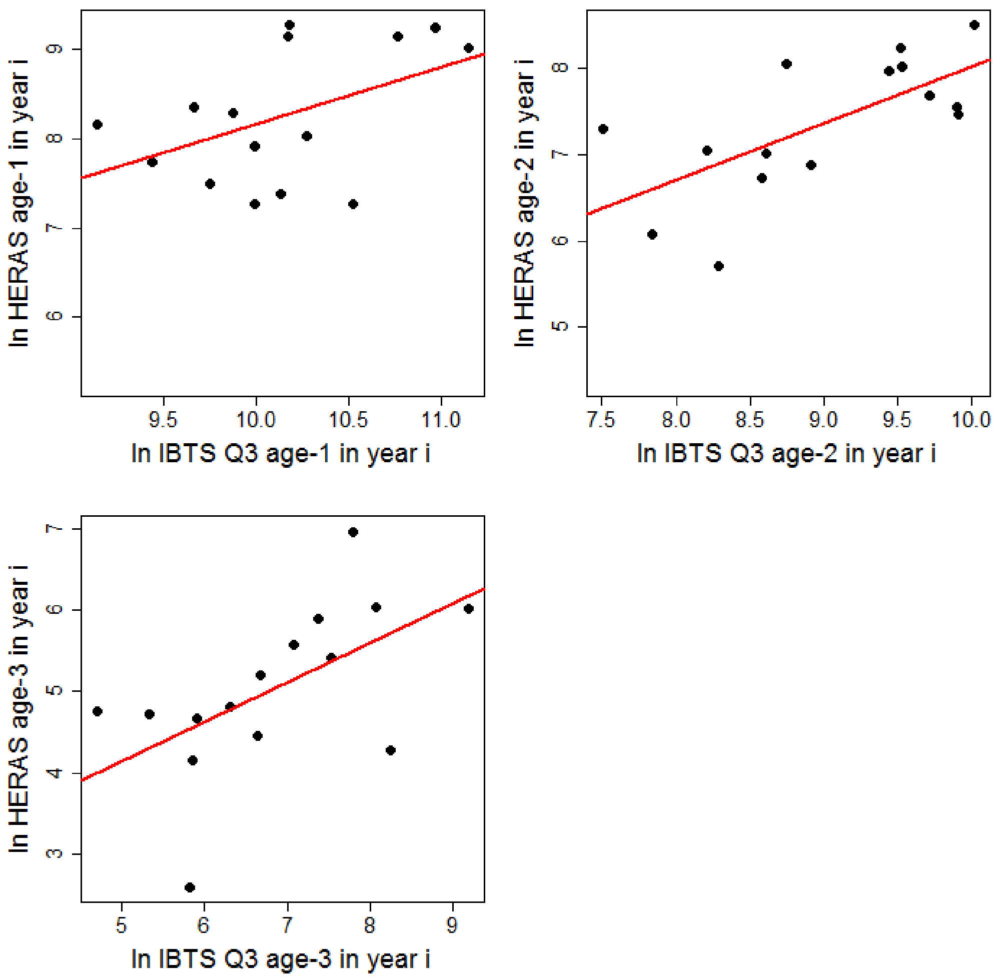


Figure 8.3.2c. North Sea sprat. External consistency between the IBTS Q3 and HERAS. Red number inside the graphs are R^2. (Quarter (Q) and age refer to the calendar year)

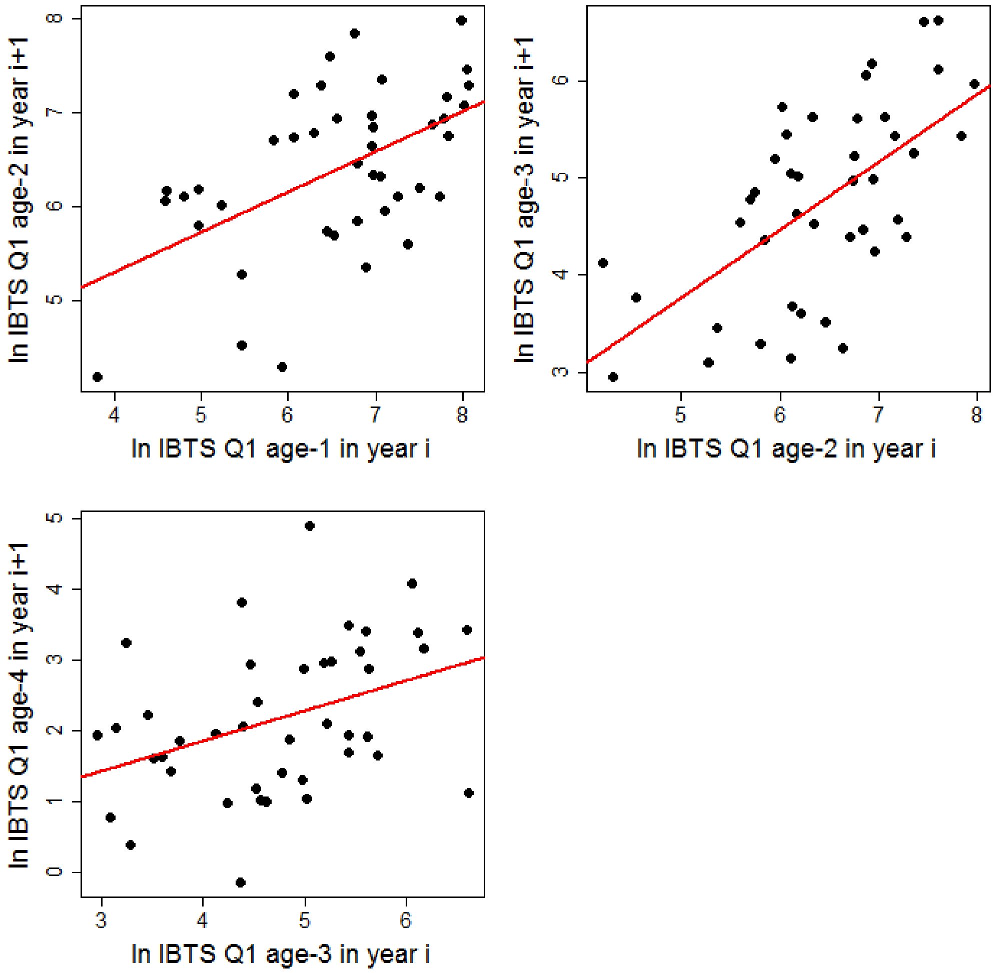


Figure 8.3.3. North Sea sprat. Internal consistency in the IBTS Q1 survey. Red number inside the graphs are R^2. (Quarter (Q) and age refer to the calendar year)

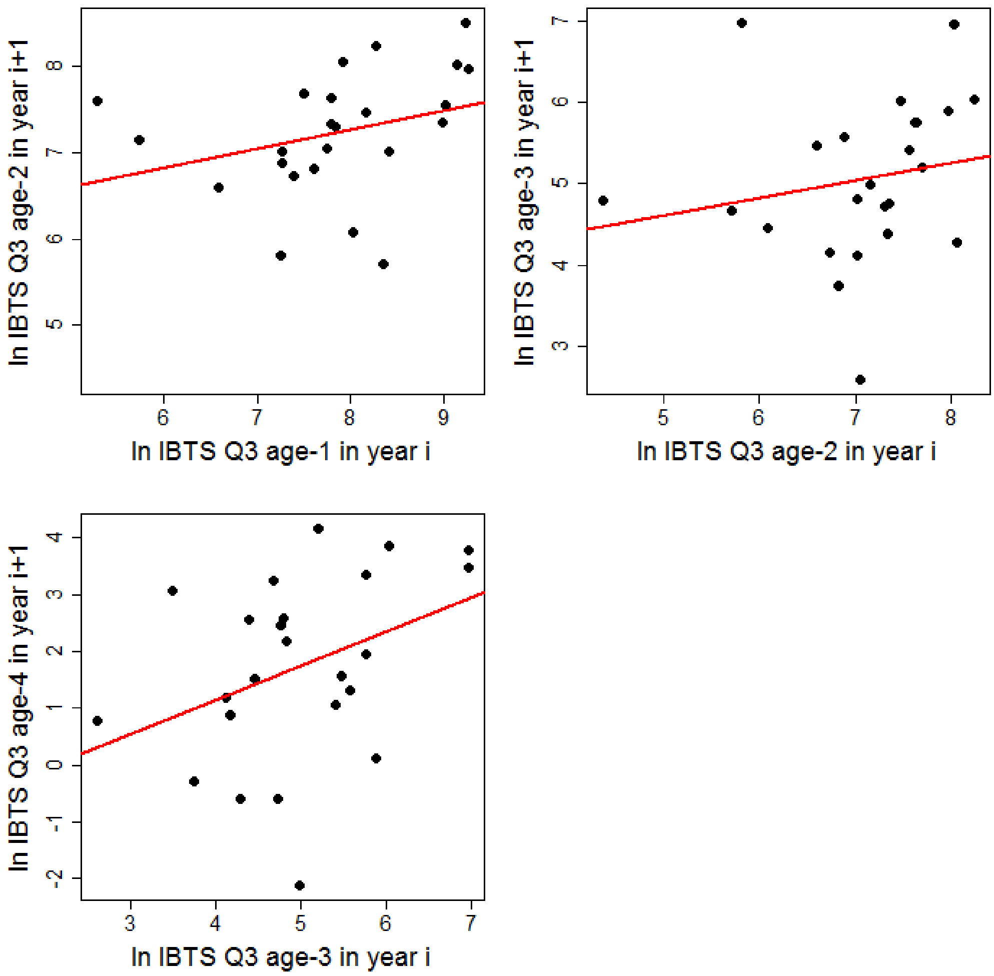


Figure 8.3.4. North Sea sprat. Internal consistency in the IBTS Q3 survey. Red number inside the graphs are R^2. (Quarter (Q) and age refer to the calendar year)

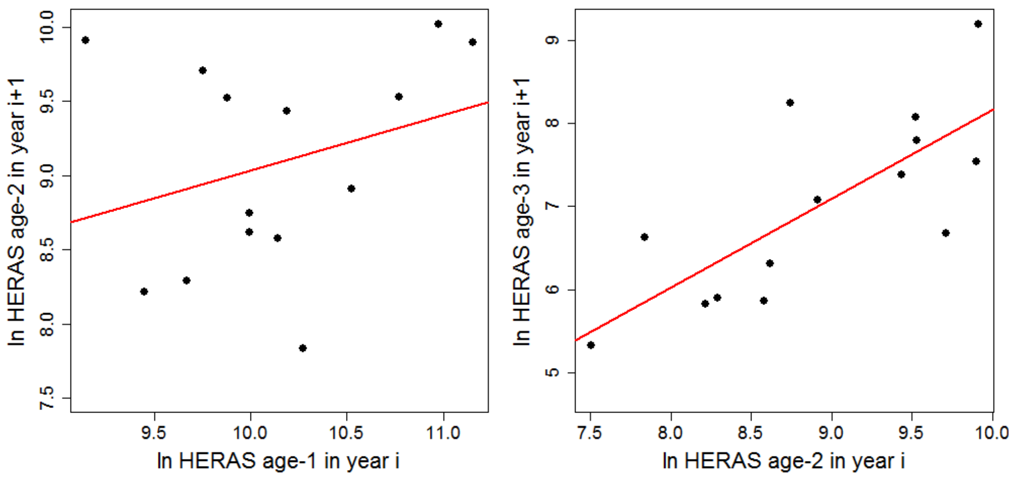


Figure 8.3.5. North Sea sprat. Internal consistency in the HERAS (acoustic) survey. Red number inside the graphs are R^2. (Quarter (Q) and age refer to the calendar year)

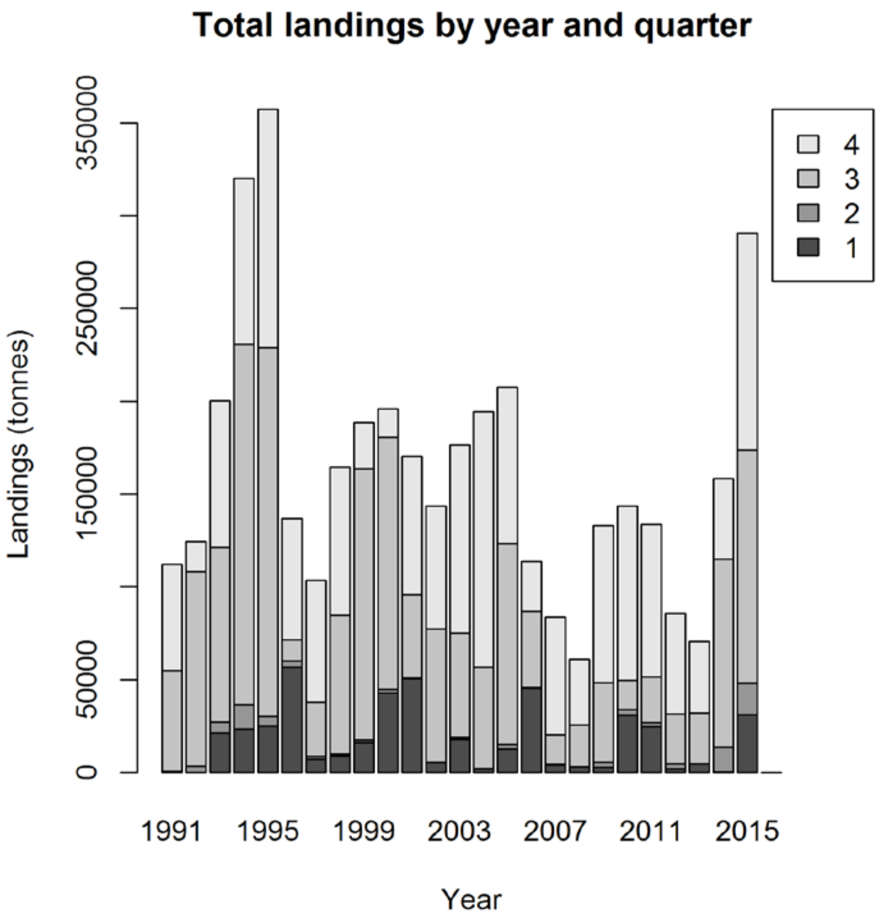


Figure 8.6.1. North Sea sprat. Quarterly distribution of Danish catches (Calendar year).

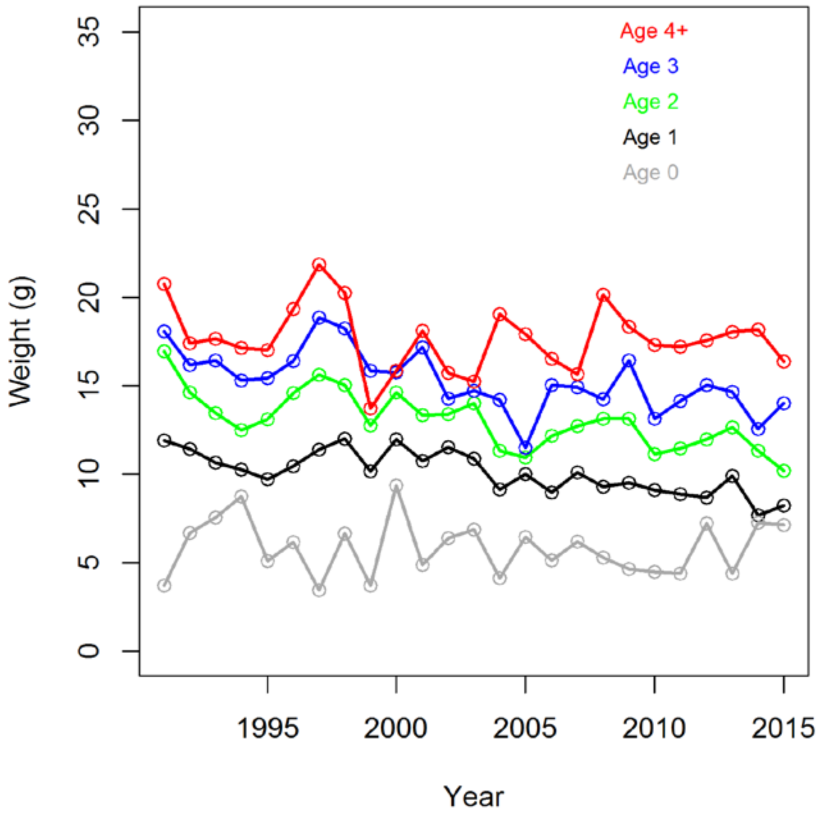


Figure 8.6.2. North Sea sprat. Mean weight at age in quarter 4 (Calender year).

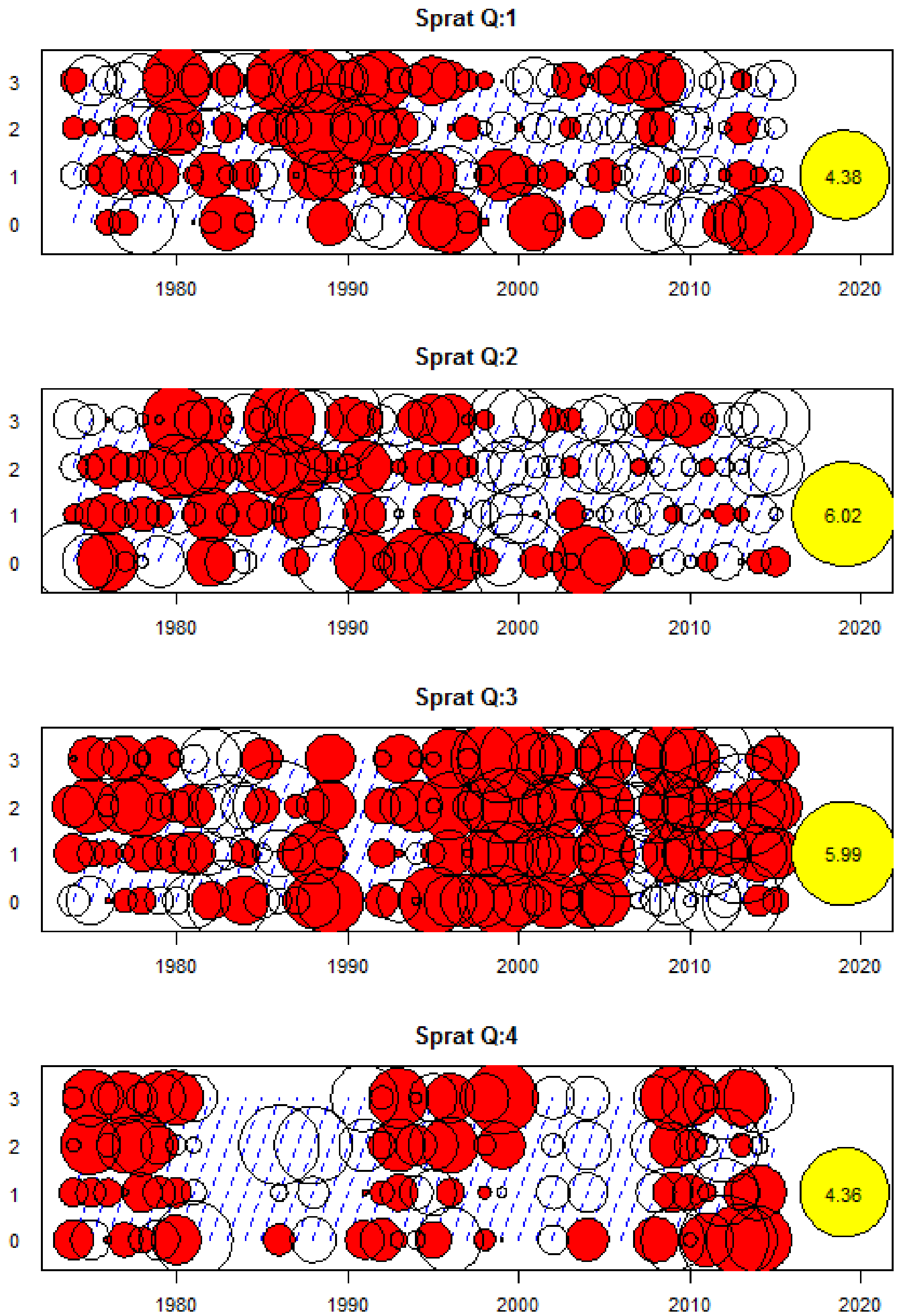


Figure 8.6.3. North Sea sprat. Catch residuals by age. (Model year)

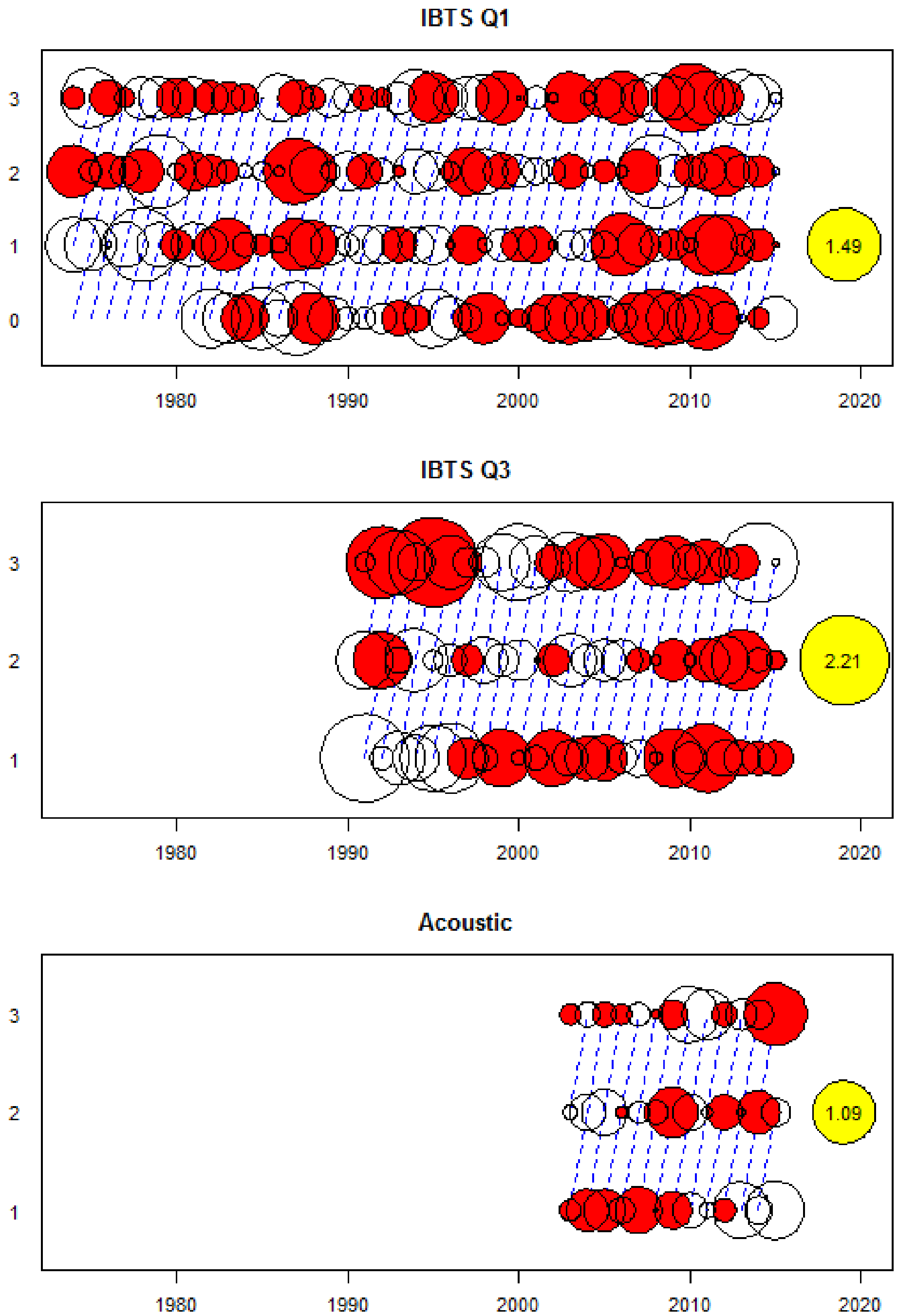


Figure 8.6.4. North Sea sprat. Survey residuals by age. (Model year)

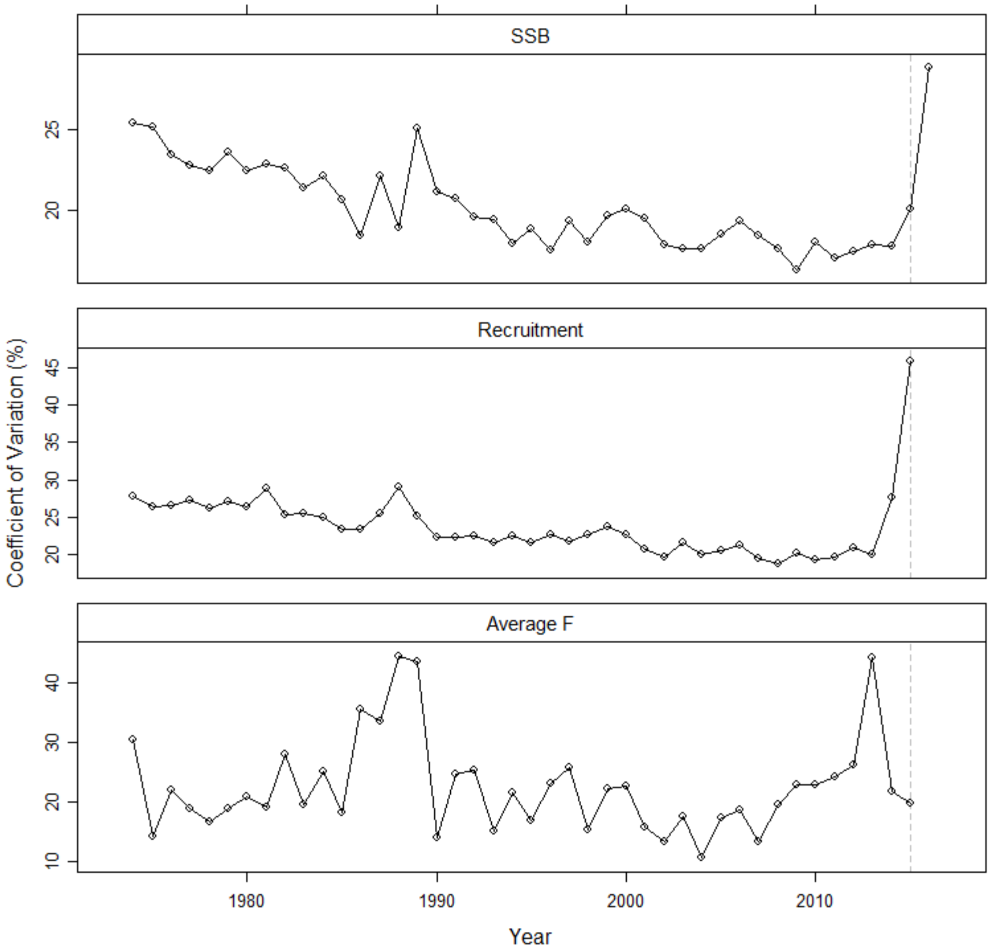


Figure 8.6.5. North Sea sprat. Coefficients of variance (Model year)

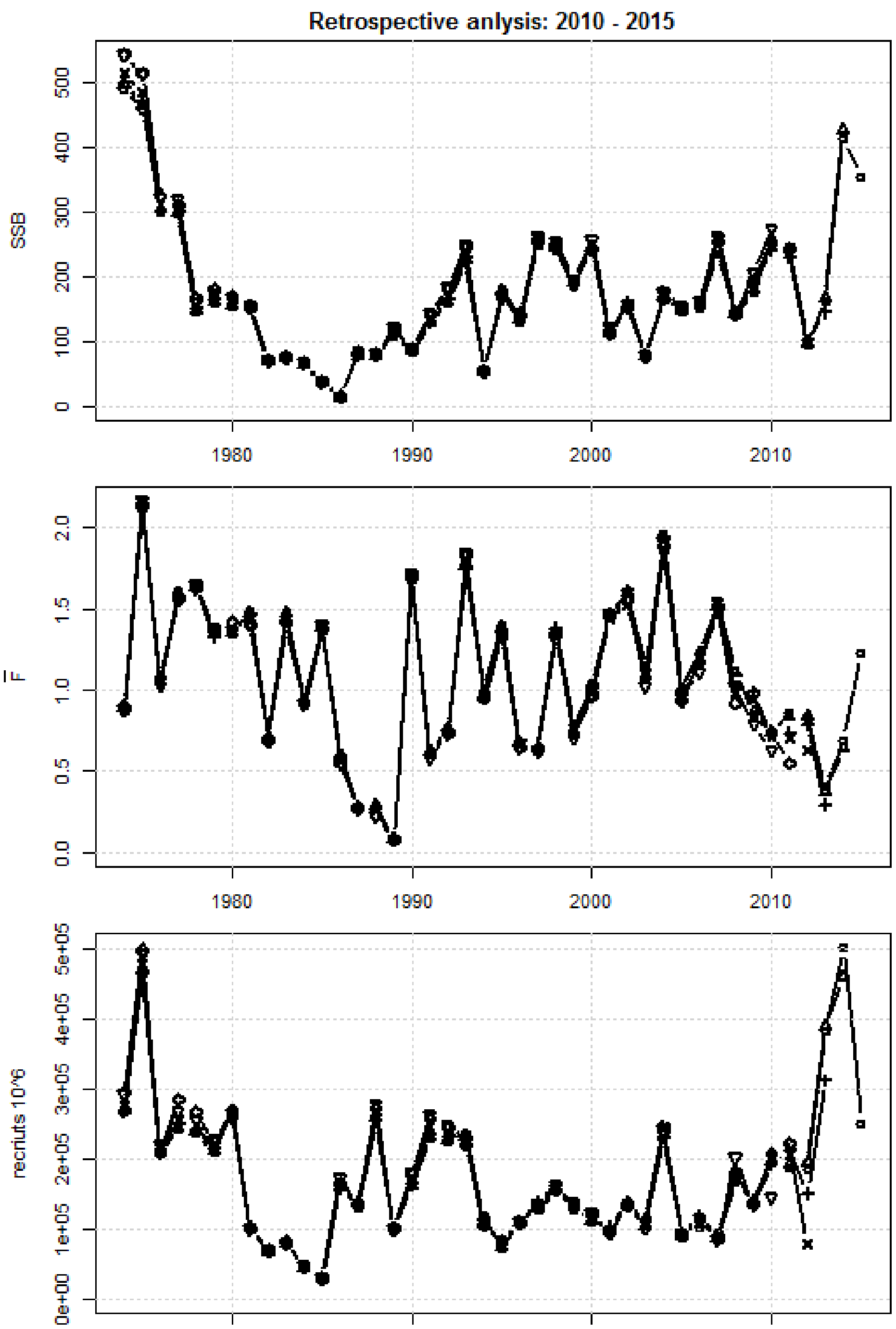


Figure 8.6.6. North Sea sprat. Retrospective analysis (Model year)

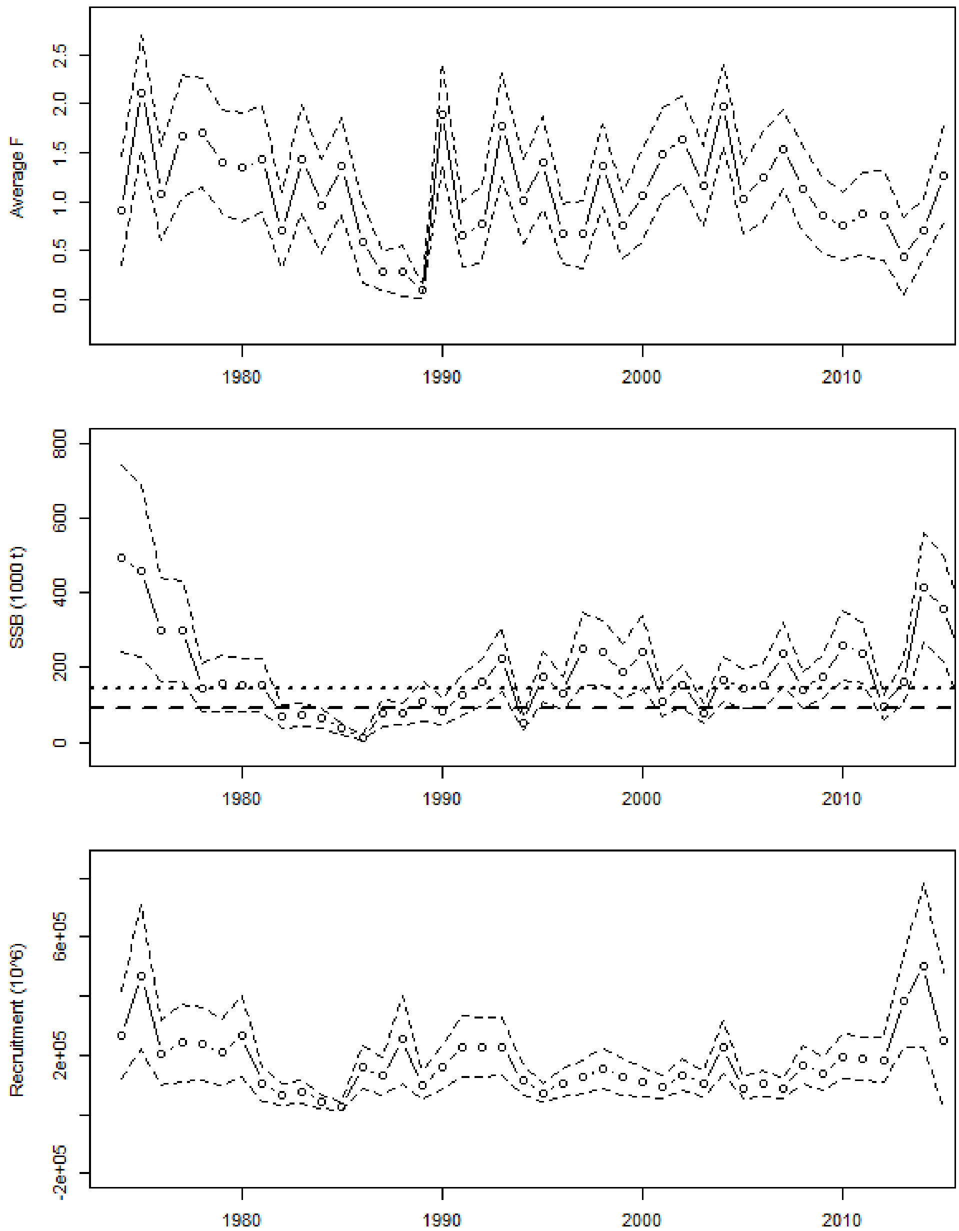


Figure 8.6.7. North Sea sprat. Temporal development in Mean F, SSB and recruitment. Hatched lines are 95% confidence intervals (Model year).

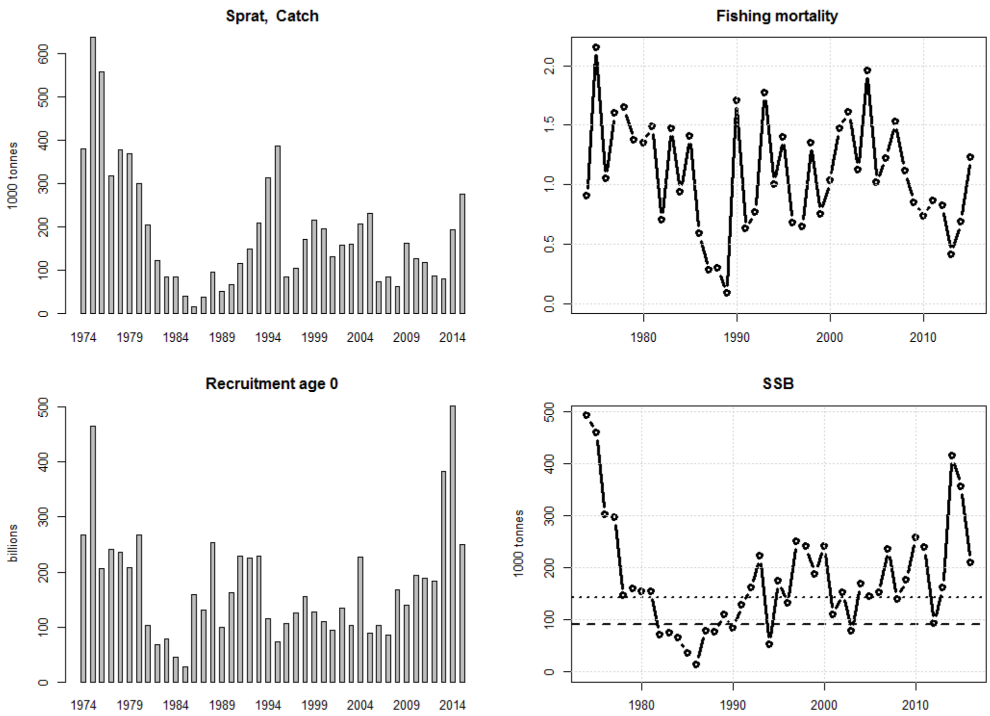


Figure 8.6.8. North Sea sprat. Assessment summary (years and age refer to the model year. For example 2012 refers to the model year July 2012 to June 2013).

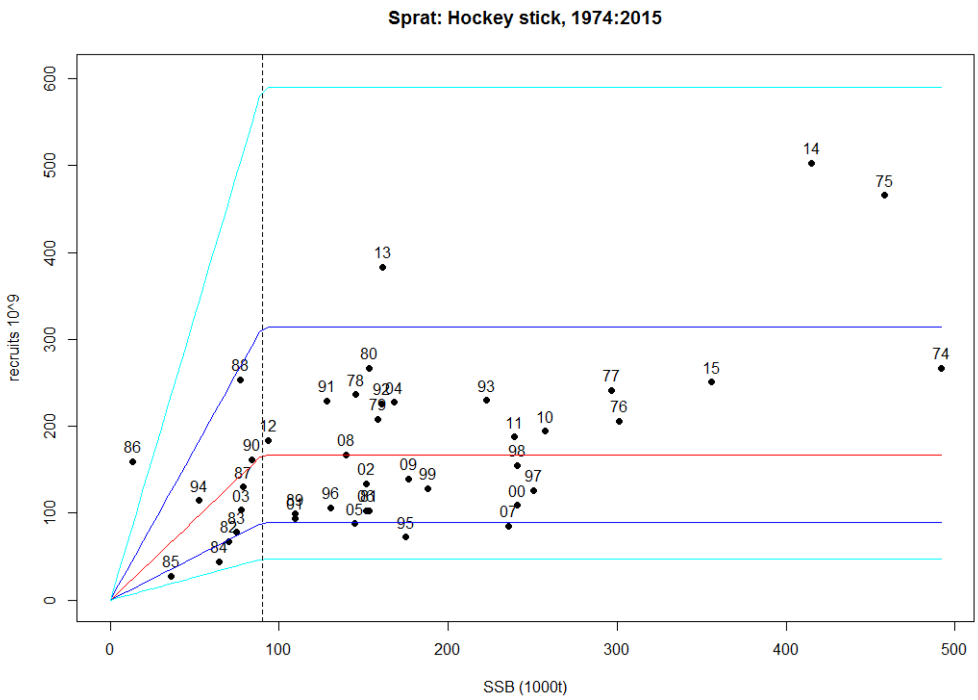


Figure 8.7.1. North Sea sprat. Stock-recruitment relationship (years and age refer to the model year. For example 2012 refers to the model year July 2012 to June 2013).

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9 Sprat in Division 3.a

9.1 The Fishery

9.1.1 ICES advice applicable for 2015 and 2016

In 2015, the TAC for sprat was set at 33 280 t and the by-catch of herring in both the industrial and sprat fishery was limited to 6659 t. The advice in 2015 (for 1 July 2015–30 June 2016) was for a severe reduction in TAC to just 8144 t. Also for 2016, the TAC for sprat is set at 33 280 t and the herring by-catch limit 6659 t.

Sprat is mainly 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, Sweden and Denmark: respectively max 10%, 10% and 50% by-catch of herring in weight). Now with the implementation of the landing obligation, this rule has disappeared for the EU countries. The fishery is still regulated by the herring by-catch TAC and the Danish fishery has implemented a self-regulation rule in relation to the catch-composition of the sprat fishery.

9.1.2 Landings

The total landings in 2014 and 2015 (18 537 t and 13 276 t, respectively) are above average landings in the last 10 years (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). The official and ICES catches often differ considerably for this stock as official landings often include bycatch of other species.

There were sprat landings in all quarters (Table 9.1.2). In 2015 the proportion of total landings from the 3rd and 4th quarters (85%) continued to be substantially above the long term average (67%). 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 3.a.

The Danish sprat fishery consists of trawlers using a 16 mm mesh size in the codend and all landings are used for fishmeal and oil production. In Sweden there is a pelagic trawl fishery 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 3.a 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 4, Division 7.d, and Division 3.a.

Most sprat catches are taken in a small-meshed industrial fishery where catches are limited by herring by-catch restrictions.

In Norway, there is a minimum catch size for sprat within the 4 nautical mile limit from the coast. In 2015, this was increased from 9 to 10 cm.

9.1.5 Changes in fishing technology and fishing patterns

No changes in fishing technology and fishing patterns for the sprat fisheries in 3.a have been reported for 2015.

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 2013 the 1- and 2-year-olds contributed only 43% of the total landings in numbers, reflecting the low incoming year classes (1-year-olds) seen both in 2012 and 2013 surveys (see Table 9.2.1). In 2014 and 2015, 91% and 83% of the catch consisted of 1-year olds, in accordance with the high acoustic index of 1-year olds.

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 were raised using a combination of Danish, Norwegian and Swedish samples, without any differentiation in types of fleets. Details on the sampling for biological data per country and quarter are shown in Table 9.2.3.

The species composition of the Danish sprat fishery is given in Table 9.2.4.

9.3 Fishery-independent information

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 3.a (highlighted by WKSPRAT (ICES CM 2013/ACOM:48)) is 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 3.a since 2000, and from 2006 also split by age (see Table 9.3.1). At the time of the surveys in 2015, sprat were once again mainly found in Kattegat (94.5%). The 2015 abundance was estimated to be 1386 million individuals, an increase compared to 533 and 913 million individuals in 2013 and 2014 but still below long term average. The biomass was estimated to be 18 500 tonnes, similar to the estimated biomass in 2013. By far the majority of sprat were 1 group, in accordance with the catches in IBTS Q3.

9.3.2 IBTS (1st and 3rd Quarter)

The IBTS Q1 (February) sprat indices for 1984–2016 are presented in Table 9.3.2. The preliminary IBTS index for 1-groups 2016 was 2.6 times the long term mean and 9.9 times the recent averages for the period 2011–15. The high catch of the 2014 year class was sustained in the 2015 IBTS Q3 (Table 9.3.3).

9.3.3 Survey consistency

The estimation of average catch at age in the IBTS was explored in WKSPRAT (ICES CM 2013/ACOM:48), 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 WKSPRAT: ICES CM 2013/ACOM:48).

9.4 Mean weight-at-age and length-at-maturity

Data on maturity by age, mean weight- and length-at-age during the 2015 HERAS are presented in Table 5.12 in the WGIPS report (ICES CM 2016/SSGIEOM:05).

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 2015 at 59% of the total index, was substantially higher than in recent years (19, 16 and 7% in 2014, 2013 and 2012, respectively) with the exception of 2015 (74%). The procedure for the survey did not differ from previous years.

9.6 Stock Assessment

9.6.1 Stock Assessment

The stock is assessed using the ICES data limited stock approach (Category 3/4 DLS: ICES CM 2012/ACOM 68) with input from three surveys. Together, this provides an index of the sprat which will be age 1 and 2 in the beginning of July.

9.6.2 State of the Stock

The total stock size indices for the most recent three years indicate a rising stock size. The low proportion of older fish in the catches in the most recent years indicates strong incoming recruitment.

9.7 Short term projections

The IBTS Q1 age 1 is used 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 provide in year advice for 3.a 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.

9.7.1 Method

The method, as identified in WKSPRAT is detailed in the Stock annex.

9.7.2 Results

The anomalies in each of the survey indices are seen in Figure 9.7.1 and the total index anomaly in Figure 9.7.2. Further, the proportion of all commercial catches (in biomass) consisting of fish with more than 2 winter rings is given in Figure 9.7.3. Applying the rule stated in the stock annex, the catch multiplier is estimated at 1.2 (without cap: 6.3). This value was driven by the positive anomaly of all surveys. Applying the benchmarked method results in a TAC advice of 9773 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 (WKSPRAT ICES CM 2013/ACOM:48).

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 the last three years, the sprat fisheries have not been limited by the sprat quota, as this has been substantially above the advised TAC.

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 (WGSAM: ICES CM 2011/SSGSUE:10). It is considered that there are fewer predator populations in 3.a 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 may be possible to estimate average predation consumption.

A major source of uncertainty with 3.a sprats is the extent to which these fish derive from migrations of fish from the North Sea stock into 3.a.

9.12 Changes in the environment

Temperatures in the Skagerrak area were relatively stable from the 1920s to the late 1980s and early 1990s when there was an increase (Johannesen *et al*., 2012). This elevated temperature (both in the summer and winter) has remained elevated and reasonably stable.

Table 9.1.1 Division 3.a sprat. Catches in ('000 t) 1996–2015. (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.

Year	Skagerrak					Kattegat			Div. 3.a total
	Denmark	Sweden	Norway	Germany	**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
2013	0.3	0.7	0.9		1.9	1.6	0.4	2.0	3.9
2014	12.0	1.1	0.3	*	13.3	4.7	0.5	5.2	18.5
2015	7.5	0.9	0.3		8.7	4.2	0.4	4.6	13.3

*** < 50 t**

Table 9.1.2. Division 3.a sprat. Catches of sprat ('000 t) by quarter by countries, 2003–2015. (Data provided by the Working Group members).

	Quarter	Denmark	Norway	Sweden	Total
2003	1	3.54	0.10	1.67	5.30
	2	0.59		0.80	1.40
	3	1.00		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		1.35	4.46
	2	0.64		0.87	1.51
	3	3.70		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		1.68	8.15
	2	4.65		0.07	4.72
	3	18.61	0.71	0.81	20.13
	4	2.13		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		0.16	0.32
	3	1.34		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		0.59	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		0.35	1.02
	3	0.45		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			0.30
	3	3.20		0.10	3.30
	4	1.20	0.24	1.20	2.64
	Total	6.90	0.64	1.70	9.24

	Quarter	Denmark	Norway	Sweden	Germany	Total
2010	1	1.45	0.05	0.02		1.51
	2	0.64		0.01		0.65
	3	3.38		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		0.02		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		0.09		0.91
	3	1.63				1.63
	4	1.54	0.46	1.19		3.19
	Total	8.43	0.48	1.50		10.42
2013	1	0.97	0.12	0.32		1.42
	2	0.43		0.01		0.44
	3	0.21	*			0.21
	4	0.25	0.74	0.70		1.68
	Total	1.86	0.86	1.03		3.75
2014	1	0.34	0.14	0.04		0.52
	2	1.41		0.00		1.41
	3	9.25	*	0.37		9.62
	4	5.74	0.12	1.12	0.05	7.03
	Total	16.75	0.26	1.53	0.05	18.58
2015	1	1.08	0.12	0.37		1.56
	2	0.53		0.09		0.62
	3	6.50	*	0.03		6.53
	4	3.55	0.18	0.84		4.57
	Total	11.66	0.30	1.32		13.27

*** < 5 t**

Table 9.2.1. Division 3.a sprat. Landed numbers (millions) of sprat by age groups in 2004–2015 (based on Danish, Norwegian and Swedish sampling). The landed numbers in 1996–2003 can be found in 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	15.1	2026.3
	4	19.1	234.8	11.0	2.8	0.7	268.5
	Total	62.5	5434.7	311.7	38.8	25.5	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	10.9	2.0	83.9
	Total	5.2	406.9	590.7	136.1	46.9	1185.8
2007	1	0.0	62.1	18.7	40.2	3.5	124.5
	2	0.0	4.8	1.6	4.5	0.4	11.3
	3	0.0	799.2	65.8	24.0	3.5	892.5
	4	26.3	257.0	17.6	9.1	1.9	311.9
	Total	26.3	1123.1	103.7	77.7	9.3	1340.1
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	188.3	59.9	44.2	402.4
	4	2.0	8.2	20.9	15.8	17.1	64.0
	Total	3.2	382.8	421.9	155.7	91.5	1055.2
2011	1	0.0	167.8	29.2	1.9	8.7	207.6
	2	0.0	44.1	7.7	0.5	2.3	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	761.7	215.4	8.1	28.5	1013.8

	Quarter	Age					Total
		0	1	2	3	4+	
2012	1	0.0	44.6	236.4	82.7	33.2	396.9
	2	0.0	10.6	80.6	21.5	8.0	120.7
	3	0.0	82.5	59.2	7.6	14.0	163.4
	4	0.0	133.6	95.9	12.4	22.6	264.5
	Total	0.0	271.3	472.1	124.2	77.8	945.5
2013	1	0.0	17.2	13.5	36.5	39.1	106.4
	2	0.0	5.6	5.5	17.8	18.1	47.0
	3	0.0	10.1	1.8	5.9	6.0	23.7
	4	0.0	54.5	9.7	31.8	32.3	128.3
	Total	0.0	87.3	30.5	92.0	95.6	305.4
2014	1	0.0	139.1	1.1	1.8	3.5	145.4
	2	0.0	625.0	3.6	3.5	4.7	636.8
	3	6.7	1021.7	38.5	1.4	2.5	1070.8
	4	599.9	621.1	48.7	2.7	7.3	1279.8
	Total	606.7	2406.9	91.9	9.4	18.0	3132.9
2015	1	0.0	60.5	98.1	19.0	3.8	181.3
	2	0.0	28.7	51.2	8.1	1.5	89.5
	3	6.4	846.2	9.2	0.9	0.5	863.1
	4	0.0	398.9	19.9	3.8	4.0	426.7
	Total	6.4	1334.3	178.4	31.7	9.8	1560.5

Table 9.2.2. Division 3.a sprat. Quarterly mean weight-at-age (g) in the landings for the years 2004–2015 (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		4.9	11.5	13.4	14.0
	2		5.1	9.6	12.5	14.7
	3		11.5	14.2	15.5	16.7
	4	3.9	11.8	15.5	16.0	17.1
Weighted mean		3.9	7.8	12.8	13.8	14.5
2005	1		2.9	11.1	12.7	14.6
	2		4.5	9.7	12.1	13.3
	3	7.7	11.2	13.6	14.4	22.6
	4	7.5	13.2	15.9	17.4	18.1
Weighted mean		7.7	6.4	12.3	13.6	19.4
2006	1		5.2	10.9	14.3	15.1
	2		5.3	10.0	13.0	15.3
	3		12.0	16.7	19.6	20.4
	4	6.0	15.7	17.4	19.6	21.0
Weighted mean		6.0	5.7	12.4	15.3	16.1
2007	1		3.6	9.3	12.9	13.4
	2		5.2	9.9	12.9	15.2
	3		11.8	13.0	15.0	15.2
	4	8.7	12.4	15.4	19.6	20.4
Weighted mean		8.7	11.5	12.7	14.4	15.5
2008	1		5.8	11.8	15.3	18.3
	2		6.2	11.8	15.4	18.1
	3	3.6	5.1	11.2	14.0	14.5
	4	3.5	7.0	9.5	11.0	12.0
Weighted mean		3.5	6.8	11.3	14.8	17.5
2009	1		3.8	7.8	8.2	9.9
	2		4.1	7.7	10.0	11.8
	3		11.7	13.7	13.9	13.4
	4	5.7	11.8	14.6	15.8	15.1
Weighted mean		5.7	6.4	9.3	10.2	11.6
2010	1		5.0	10.2	13.2	15.8
	2		5.3	10.0	13.0	15.3
	3	6.6	10.3	11.3	13.0	14.8
	4	6.6	11.9	13.9	16.0	18.4
Weighted mean		6.6	6.7	10.8	13.4	15.7

Year	Age					
	Quarter	0	1	2	3	4+
2011	1		6.7	13.6	17.7	21.2
	2		6.9	13.1	17.0	20.0
	3		9.4	10.7	11.1	15.7
	4		13.0	16.0	13.0	19.1
Weighted mean			9.5	13.0	13.5	19.6
2012	1		3.6	9.4	11.9	16.1
	2		4.6	8.8	11.4	13.4
	3	5.8	10.0	14.3	16.5	18.8
	4	5.2	10.4	14.0	16.3	17.8
Weighted mean		5.5	9.0	10.9	12.5	16.8
2013	1		6.2	11.6	15.2	18.1
	2		6.3	12.0	15.5	18.3
	3		7.8	11.1	12.8	14.5
	4		8.2	11.0	12.7	13.9
Weighted mean			7.6	11.4	14.2	16.5
2014	1		2.5	5.0	6.5	7.7
	2		2.0	10.3	14.4	16.0
	3	5.7	8.9	12.9	16.4	16.8
	4	2.1	8.0	13.7	16.1	16.1
Weighted mean		2.1	6.5	13.1	13.7	14.6
2015	1		3.1	9.0	10.3	11.6
	2		4.3	8.1	10.5	12.4
	3	6.9	7.8	10.8	13.2	14.2
	4	7.2	10.3	14.3	15.8	18.6
Weighted mean		6.9	8.3	9.4	11.1	14.7

Table 9.2.3 Division 3.a sprat. Sampling commercial landings for biological samples in 2015.

Country	Quarter	Landings (tonnes)	No. samples	No. meas.	No. aged	Samples per 1000 t
Denmark	1	1 075	7	557	50	7
	2	532				
	3	6 501	30	2 913	649	5
	4	3 548	11	902	312	3
	Total	11 656	48	4 372	1 011	4
Norway	1	116				
	2					
	3	2				
	4	180	2	66	66	11
	Total	298	2	66	66	7
Sweden	1	366	1	14	14	3
	2	87				
	3	27				
	4	841	15	1 108	1 105	18
	Total	1 321	16	1 122	1 119	12
Denmark		11 656	48	4 372	1 011	4
Norway		298	2	66	66	7
Sweden		1 321	16	1 122	1 119	12
	Total	13 276	66	5 560	2 196	5

Table 9.2.4. Sprat in Division 3.a. Species composition in Danish sprat fishery in tonnes and percentage of the total catch in the North Sea. Data is reported for 1998–2015.

	Year	Sprat	Herring	Horse mack.	Whiting	Haddock	Mackerel	Cod	Sandeel	Other	Total
Tonnes	1998	9 143	3 385	230	467	54	0	49	7	2 866	16 202
Tonnes	1999	16 603	8 470	138	1 026	210	5	75	3 337	2 896	32 760
Tonnes	2000	12 578	8 034	5	1 062	308	8	52	13	3 556	25 617
Tonnes	2001	18 236	8 196	75	1 266	50	13	35	4 281	1 271	33 423
Tonnes	2002	11 451	12 982	21	1 164	3	6	30	606	2 280	28 541
Tonnes	2003	8 182	4 928	340	252	4	4	4	1	567	14 282
Tonnes	2004	13 374	4 620	97	976	18	24	27	116	2 155	21 408
Tonnes	2005	30 157	6 171	244	871	63	18	20	746	1 758	40 047
Tonnes	2006	6 814	2 852	215	276	13	3	45	1	232	10 451
Tonnes	2007	7 116	2 043	34	190	31	8	4	1	469	9 896
Tonnes	2008	4 805	1 948	14	285			11	462	39	7 563
Tonnes	2009	4 839	3 016	37	169	15	0	1	53	47	8 177
Tonnes	2010	2 851	2 134	25	142	6	1	2	135	171	5 466
Tonnes	2011	4 754	2 461	0	43	0	7	1	141	40	7 447
Tonnes	2012	5 707	5 495	9	149	7	10	5	0	228	11 610
Tonnes	2013	1 143	1 751	2	46		0	1	1	27	2 971
Tonnes	2014	16 751	3 777	5	343	1	20	5	12	888	21 801
Tonnes	2015	11 448	5 831	0	565		29	8	1	154	18 036
Percent	1998	56%	21%	1%	3%	0%	0%	0%	0%	18%	100%
Percent	1999	51%	26%	0%	3%	1%	0%	0%	10%	9%	100%
Percent	2000	49%	31%	0%	4%	1%	0%	0%	0%	14%	100%
Percent	2001	55%	25%	0%	4%	0%	0%	0%	13%	4%	100%
Percent	2002	40%	45%	0%	4%	0%	0%	0%	2%	8%	100%
Percent	2003	57%	35%	2%	2%	0%	0%	0%	0%	4%	100%
Percent	2004	62%	22%	0%	5%	0%	0%	0%	1%	10%	100%
Percent	2005	75%	15%	1%	2%	0%	0%	0%	2%	4%	100%
Percent	2006	65%	27%	2%	3%	0%	0%	0%	0%	2%	100%
Percent	2007	72%	21%	0%	2%	0%	0%	0%	0%	5%	100%
Percent	2008	64%	26%	0%	4%	0%	0%	0%	6%	1%	100%
Percent	2009	59%	37%	0%	2%	0%	0%	0%	1%	1%	100%
Percent	2010	52%	39%	0%	3%	0%	0%	0%	2%	3%	100%
Percent	2011	64%	33%	0%	1%	0%	0%	0%	2%	1%	100%
Percent	2012	49%	47%	0%	1%	0%	0%	0%	0%	2%	100%
Percent	2013	38%	59%	0%	2%	0%	0%	0%	0%	1%	100%
Percent	2014	77%	17%	0%	2%	0%	0%	0%	0%	4%	100%
Percent	2015	63%	32%	0%	3%	0%	0%	0%	0%	1%	100%

Table 9.3.1. Division 3.a sprat. HERAS indices of sprat per age group 2000–2015. * These figures should be uploaded from FishFrame.

	Abundance (million)					Biomass (1000 t)				
	Age					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
2013	1.4	14.5	68.8	448.6	533.3	0.0	0.2	1.2	9.6	10.9
2014	29.6	614.5	109.8	159.4	913.3	0.1	4.8	1.8	3.4	10.1
2015	0.3	840.8	202.0	342.6	1 385.8	0.0	9.6	2.7	6.2	18.5

Table 9.3.2. Division 3.a sprat. IBTSQ1 (February) indices of sprat per age group 1984–2016.

Year	No Rect	No hauls	Age Group					Total
			1	2	3	4	5+	
1984	15	38	5 675.45	868.88	205.10	79.08	63.57	6 892.08
1985	14	32	2 157.76	2 347.02	392.78	139.74	51.24	5 088.54
1986	16	41	628.64	1 979.24	2 034.98	144.19	37.53	4 824.58
1987	16	50	2 735.92	2 845.93	3 003.22	2 582.24	156.64	11 323.95
1988	14	38	914.47	5 262.55	1 485.07	2 088.05	453.13	10 203.26
1989	16	43	413.94	911.28	988.95	554.53	135.79	3 004.48
1990	16	44	481.02	223.89	64.93	61.11	45.69	876.65
1991	17	40	492.50	726.82	698.11	128.36	375.44	2 421.23
1992	18	46	5 993.64	598.71	263.97	202.90	76.04	7 135.25
1993	18	46	1 589.92	4 168.61	907.43	199.32	239.64	7 104.92
1994	18	48	1 788.86	715.84	1 050.87	312.65	70.11	3 938.32
1995	18	48	2 204.07	1 769.53	35.19	44.96	4.23	4 057.98
1996	17	49	199.30	5 515.42	692.78	111.98	173.75	6 693.23
1997	18	46	232.65	391.23	1 239.13	139.14	134.51	2 136.67
1998	17	44	72.25	1 585.22	619.76	1 617.71	521.52	4 416.46
1999	17	46	4 534.96	355.24	249.86	44.25	313.52	5 497.83
2000	17	45	292.32	737.80	59.69	51.79	23.21	1 164.80
2001	17	45	6 539.48	1 144.34	676.71	92.37	45.87	8 498.77
2002	17	45	1 180.52	1 035.71	89.96	58.85	12.93	2 377.96
2003	17	46	461.66	1 247.15	1 171.77	382.08	122.99	3 385.65
2004	17	46	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	17	46	774.11	306.63	250.81	42.08	13.74	1 387.37
2008	17	46	150.60	981.90	132.46	228.32	107.60	1 600.87
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
2014	18	44	518.18	229.09	308.53	1 340.84	364.72	2 761.36
2015	18	47	957.73	206.94	21.87	8.74	83.51	1 278.79
2016*	18	49	4208.38	2216.26	416.80	117.81	141.30	7 100.55

*** Preliminary**

Table 9.3.3. Division 3.a sprat. IBTS Q3 indices of sprat per age group 1991–2015. * No survey

Year	Age Group						Total
	0	1	2	3	4	5+	
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	0.61	849.82	4 639.73	1 839.29	184.31	115.51	7 629.27
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
2013	5.06	356.27	967.29	2 192.62	1 130.27	457.09	5 108.60
2014	4.06	30 111.50	831.07	503.50	249.93	184.78	31 884.84
2015	0.58	16 064.67	2 110.62	415.73	218.26	163.57	18 973.43

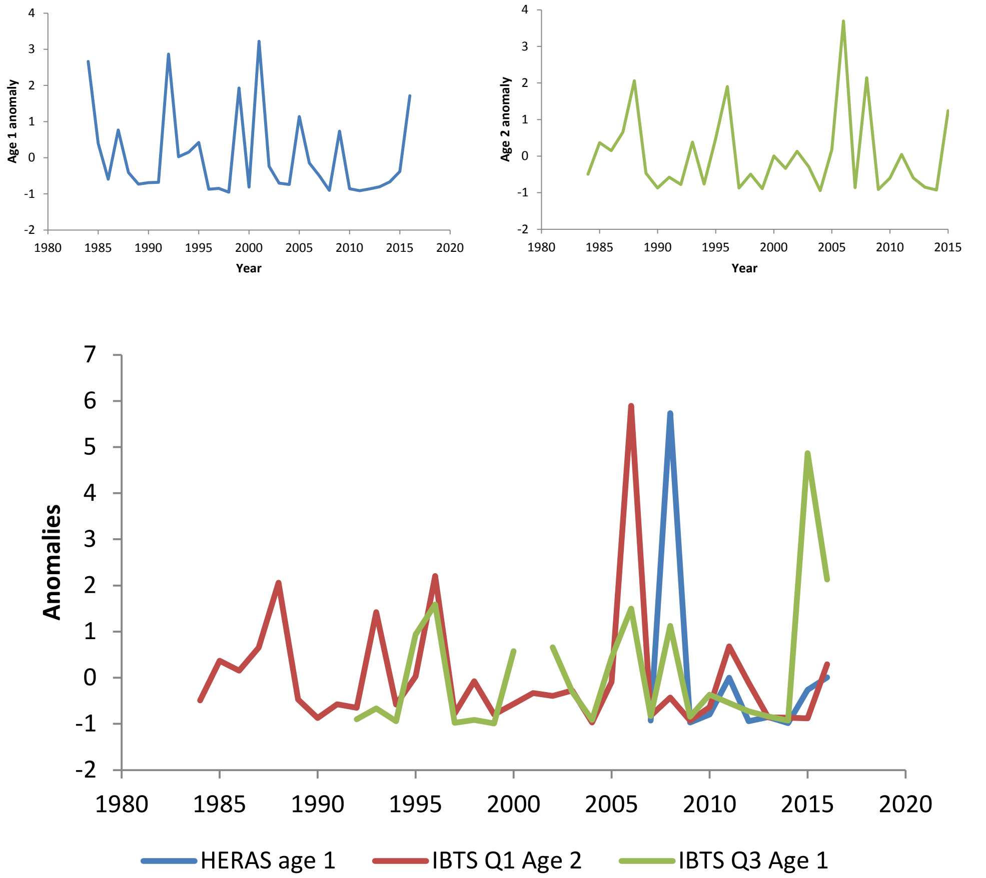

Figure 9.7.1. Division 3.a sprat. Survey index anomalies for surveys used for ages 1 (left) and 2 (right) winter ringers and for each survey (lower).

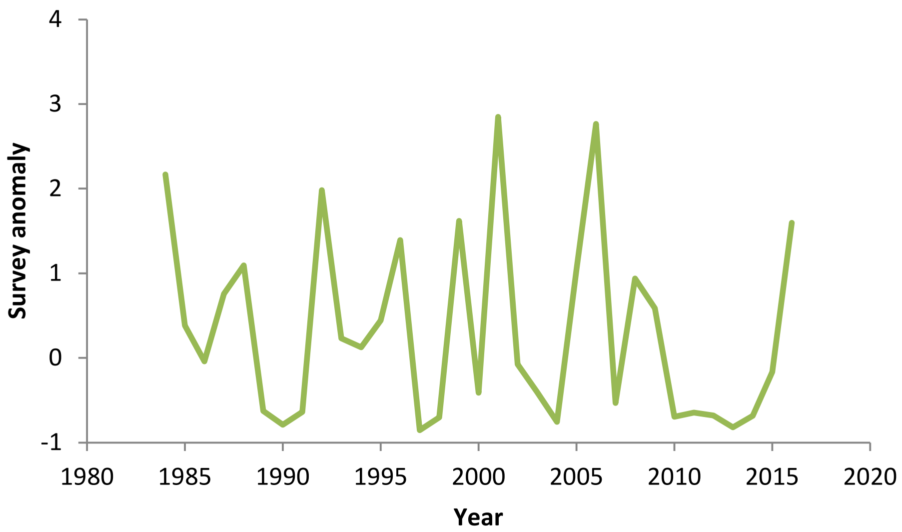

Figure 9.7.2. Division 3.a sprat. Survey index anomalies for total index.

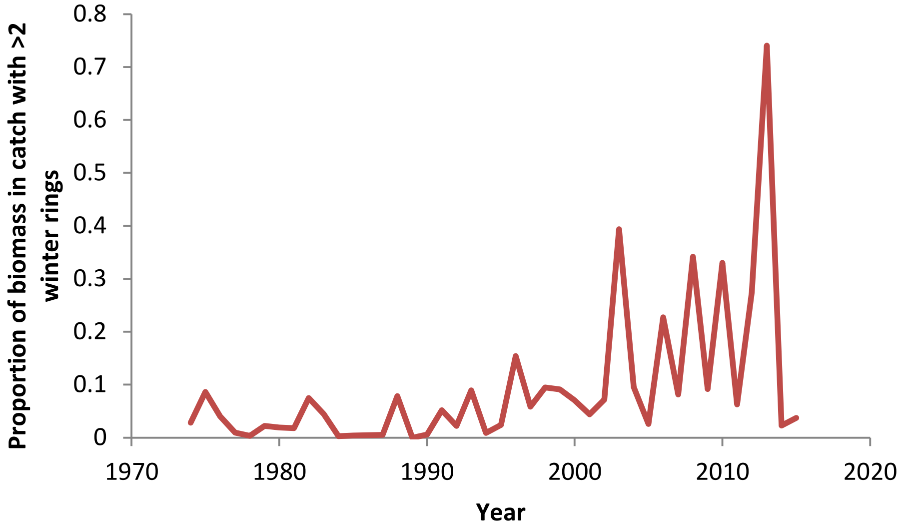

Figure 9.7.3. Division 3.a sprat. The proportion of all commercial catches (in biomass) consisting of fish with more than 2 winter rings.

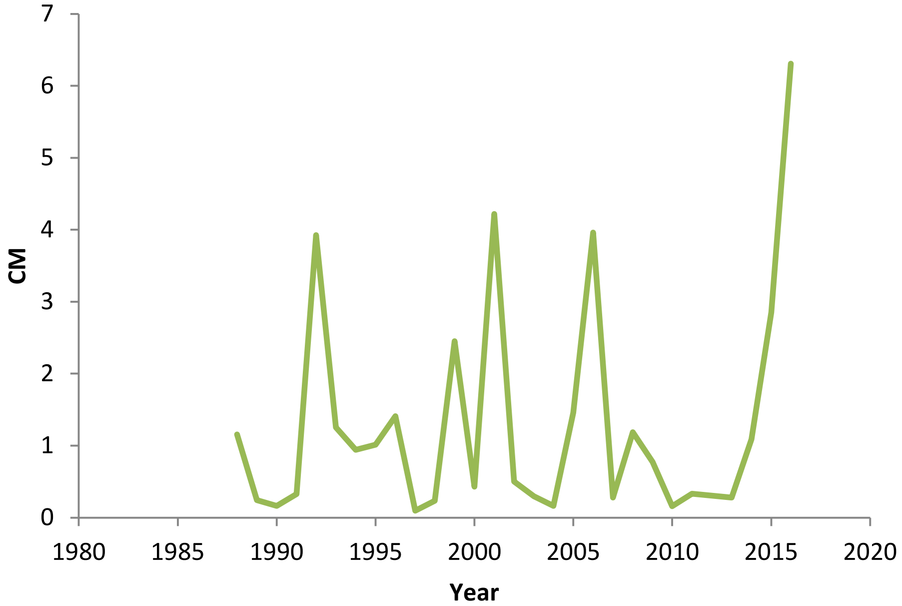

Figure 9.7.4. Division 3.a sprat. Catch multiplier estimated.

10 Sprat in the Celtic Seas (subareas 6 and 7)

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 (6aN); in Donegal Bay (6aS); Galway Bay and in the Shannon Estuary (7.b); in various bays in 7.j; in 7.aS; in the Irish Sea and in the English Channel (7.d–e). A map of these areas is provided in Figure 10.1.

The stock structure of sprat populations in this ecoregion is not clear. In 2014, HAWG presented an update of the available data on these sprat populations, in a single chapter. However, HAWG does not necessarily advocate that 6 and 7 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 2016 and 2017

ICES analysed data for sprat in the Celtic Sea and West of Scotland. 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 2017. The TAC for the English Channel (7.d and 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 10.1.1–10.1.8 and in figures 10.2.1–10.2.8.

Division 6.a (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 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 continuing into January. Landings were high in the early part of the time series peaking with average annual landings of ~ 7000 t in the period 1972 to 1978 (Figure 10.2.1). Landings were low for a period after this until a second peak in the period 1995 to 2000 where landings averaged just around 4600 tonnes annually. In 2005 to 2009 the fishery was virtually absent but has slowly picked up again since 2010. In 2013 landings reached 968 tonnes, lower than in 2012, and landings in 2014 and 2015 increased again to 1540 t and 1060 t respectively.

Division 7.a

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 (figures 10.2.2–3). 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 7.aN or 7.aS. Very high catches in 7.aS were reported in 2012 (Table 10.1.3) with a decrease in 2013 and only 16 t reported in 2014. In 2015 the catches raised again to over 3000 t. Despite the high catches registered in some years, those figures should be interpreted with caution because they may be over-estimated. No landings from 7.aN were reported in 2013 (Table 10.1.2), however there have been reported landings of 522 t in 2014 and 771 t in 2015. With the exception of the last two years, recent Irish landings are mainly from 7.aS, predominantly from Waterford Harbour.

Divisions 7.b–c (West of Ireland)

Sporadic fisheries have taken place, mainly in Galway Bay and the Mouth of the Shannon. The highest recorded landings were in 1980 and 1981 during the winter of 1980/1981, when over 5000 t were landed by Irish boats (Table 10.1.4, 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 in 2000. Irish data may be underestimated, due to difficulties in quantifying the landings from vessels of less than 10 m length.

Divisions 7.g–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 7.g and 7.j are similar, though the 7.j landings have been higher. Landings for 7.g and 7.j 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 (Table 10.1.7). The average catches in the last 10 years were equal to 2308 t. Irish data may be underestimated, due to difficulties in quantifying the landings from vessels of less than 10 m length.

Divisions 7.d–e (English Channel)

Total landings from the international sprat fishery are available since 1950 (see Figure 10.2.5). Sprat landings prior to 1985 in 7.d–e were extracted from official catch statistics dataset (STATLANT27, Historical Nominal Catches 1950–2010, Official Nominal Catches 2006–2013), 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 1970s and 1980s 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 7.e, where in the last 10 years 99% 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 Ecoregion 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 other small 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, but based on a limited number of samples available to the working group this is estimated to be less than 1% of the catch.

In the English Channel the primary gear used for sprat is midwater trawl. Within that gear type three vessels under 15 m have actively target sprat and have been responsible for the majority of landings (since 2003 they took on average 96% of the total landings). In the most recent year only one of the vessels have been targeting sprat. Sprat is also caught by driftnet, fixed nets, lines and pots and 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 7.d–e, English Channel. No other 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 fish meal and oil. It is not clear whether bycatches 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 (6a)

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 6.a 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. A total of 8 landings were sampled in 2012 and a further 5 landings in 2013. 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 was used to calculate sprat biomass. Biomass estimates for Celtic Sea Sprat for the period November 1991 to October 2014 are shown in Figure 10.3.1 and Table 10.3.1. However, the survey results prior to 2002 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 up to 2009 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. In 2013 the survey was cancelled due to technical problems. It is anticipated the survey will continue in the future.

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. Not updated in 2013 or 2014.

Northern Ireland Groundfish Survey

The Agri-Food and Biosciences Institute of Northern Ireland (AFBINI) groundfish survey of ICES Division 7.aN are carried out in March and October at standard stations between 53° 20'N and 54° 45'N (see Stock Annex 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 the Stock Annex for a description of the survey). While targeting herring, a sprat biomass is also calculated. The annual calculated biomass from 1998–2014 is shown in Figure 10.3.4 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 95 000 t in 2010. Recent estimates suggest an increase with 2014 being the second highest estimate in the time series, followed by a decline in the final year of the survey. Spatial distribution of sprat at the time of the survey is shown in Figure 10.3.5. Further work is required to investigate the utility of this survey for measuring sprat biomass in this area.

PELTIC Acoustic Survey

An autumn Pelagic survey of the Celtic Sea (PELTIC) provided autumn biomass estimates for sprat from 2013–2015 (ICES, 2015). Basic survey design was comparable with the FSP survey although the coverage by PELTIC was extended further offshore and further west, including the waters north of the Cornish Peninsula (Figure 10.3.6, ICES 2015/SSGIEOM:05).

The survey estimates for 2013–2014 were similar, while a decrease in biomass of about 23% was observed in 2015 (Table 10.3.3) for the Western English Channel.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.

FSP Acoustic Survey off the western English Channel

In October 2011 and 2012, two Fisheries Science Partnership (FSP) surveys were conducted 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.

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

Biological information from trawl catches carried out during the FSP acoustic survey where sampling information was available, 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 undersampled 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 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 maturity at age

No data on mean weight at age or maturity at age in the catch are available.

10.5 Recruitment

The various ground fish and acoustic surveys may provide an index of sprat recruitment in this ecoregion. However further work is required.

10.6 Stock Assessment

Sprat in the English Channel (Division 7.d–e)

An analytical assessment was carried out for sprat in the English Channel at WKSPRAT 2013 and requires further development prior to its acceptance.

10.6.1 Data exploration

Landings Per Unit of Effort

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 and updated in 2015 (Table and Figure 10.6.1). The lpue was based on data from a minimum of two < 15 m vessels that target sprat in the area for the whole time series until 2014; in 2015 only one vessel contributes to the LPUE which was therefore considered less reliable for providing advice and not used for this purpose. The vessels used in the index account for on average 95% of total landings for the area. The index includes searching time and time at sea with zero returns which are appropriate given sprat shoaling behavior. The sprat fishing season runs from August to March the following year. The lpue was computed from August to March the following year for consistency with the fishing season that starts when sprat appears on the grounds. If there were no landings in August or March, the effort in those months was excluded from the computation.

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.

Sprat landings and effort data are available by ICES rectangle for the entire English Channel and for vessels operating a variety of gears both demersal and pelagic. The current lpue index uses data from a minimum of two vessels that target sprat. If an lpue index of abundance was to be derived based on landings from the entire English Channel and from the entire pelagic fleet effort should be standardized. Generalized linear models (GLMs; Nelder and Wedderburn, 1972) are frequently used to standardise catch and effort data. Results for English Channel sprat lpue index was presented this year.

Biomass Index

A pelagic survey was undertaken in Autumn in the western English Channel and Eastern Celtic Sea to acoustically asses the biomass of the small pelagic fish community within this area (divisions 7.e–g). This survey, conducted from the RV Cefas Endeavour, is divided into three geographically separated strata: the western English Channel, the Isles of Scilly and the Bristol Channel (Figure 10.6.2).

Calibrated acoustic data were collected during daylight hours only over three frequencies (38, 120, 200 kHz) from transducers mounted on a lowered drop keel at 8.2 m below the surface. Pulse duration was set to 0.516 m s for all three frequencies and the ping rate was set to 0.6 s-1 as the depth did not exceed 100 m. Data from 38 kHz was used to determine target species abundance for all swimbladder fish. To distinguish between organisms with different acoustic properties (echotypes) a multifrequency algorithm was developed, principally based on a threshold applied to the summed backscatter of the three frequencies, eventually resulting in separate echograms for each of the echotypes.

Sprat was in general the dominant small pelagic species in the trawl samples, with highest densities in the eastern parts of the western Channel and the Bristol Channel. As in previous two years, large schools in the Bristol Channel appeared to consist mainly of juvenile sprat, whereas those in the English Channel also included larger size classes. See WD 01 for considerations on Sprat distribution and composition in the area. For more details on the survey design please refer to ICES 2015/SSGIEOM:05.

The biomass index from the PELTIC acoustic survey was used to provide advice on sprat in Division 7.d–e. The index was also used to provide an indication of the current harvest rate. The lpue information, on the other hand, were used to give a general indication of the stock development over time, but were not considered robust enough to base the advice on, due to the marked reduction in the number of fishing vessels operating in the area.

10.7 State of the Stock

Sprat in the English Channel (Division 7.d–e)

The lpue index presented (Table 10.6.1) shows an increasing trend since 2009, however the number of vessels contributing to this index has decreased and is considered less informative for management and is no longer the basis for the advice. A short time-series of biomass estimates from the PELTIC survey was presented (Table 10.3.3), although it only focuses on the 7.e area it shows a drop in biomass in the most recent year compared to the previous two years.

CATCH ADVICE

Catch advice in 2016 is based on the acoustic estimates. Discards occur but are believed to be negligible, therefore the advice is for catch. The 2015 advice was based on category 3.2 (WKLIFE 2012) according to the data and analyses available. Those are three acoustic surveys (2013 and 2015) carried out in area 7.e which includes the area where the fishery takes place and a time-series of lpue (1988–2015). Data presented in 2016 showed a drop in biomass for both the indices. ICES advice is for no more than 3678 tonnes.

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

N/A

10.11 Management Considerations

Sprat in the English Channel (Division 7.d–e)

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 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 7.d–e, English Channel, which has not been fully utilized.

Sprat annual landings from 7.d–e over the past 20 years have been 2926 tonnes on average. The 2015 annual landings of 3003 t constitute 16% of the 2015 acoustic estimate of sprat biomass when considering the Lyme Bay area only (23 451 t), while it is 6% when considering the entire surveyed area, estimated to be 60 011 t.

The high LPUE values in the last few years suggested that a large component of the stock was available to the fishery in Lyme Bay, and as a consequence the exploitation rate increased. The drop in the last year, could in part be due to the availability of sprat, Figure 10.11.1 shows that in 2015 a higher proportion of sprat was found outside the Lyme Bay area, and therefore not accessible to the fishery (see WD 01 for details).

The exploitation rate, ranging between 16% (in the worst case scenario) and 6%, suggests that the fishery is not having a detriment impact on English Channel sprat (Table 10.11.1).

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, and in general of other pelagic species, taken by seabirds in the Celtic Seas Ecoregion.

The Celtic Seas Ecoregion 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 Ecoregion. Landings of sprat, 1985–2015 6a. Irish data may be underestimated, due to difficulties in quantifying the landings from vessels of less than 10 m length.

Country	Denmark	Faeroe Islands	Ireland	Norway	UK - Eng+Wales+N.Irl.	UK - 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	3 864	4 378
1989	0	0	147	0	0	1 146	1 293
1990	0	0	800	0	0	813	1 613
1991	0	0	151	0	0	1 526	1 677
1992	28	0	360	0	0	1 555	1 943
1993	22	0	2 350	0	0	2 230	4 602
1994	0	0	39	0	0	1 491	1 530
1995	241	0	0	0	0	4 124	4 365
1996	0	0	269	0	0	2 350	2 619
1997	0	0	1 596	0	0	5 313	6 909
1998	40	0	94	0	0	3 467	3 601
1999	0	0	2 533	0	310	8 161	11 004
2000	0	0	3 447	0	0	4 238	7 685
2001	0	0	4	0	98	1 294	1 396
2002	0	0	1 333	0	0	2 657	3 990
2003	887	0	1 060	0	0	2 593	4 540
2004	0	0	97	0	0	1 416	1 513
2005	0	252	1 134	0	13	0	1 399
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	468	0	248	507	1 223
2012	0	0	113	0	0	1 688	1 801
2013	0	0	487	0	0	968	1 455
2014	0	0	3	0	0	1 540	1 543
2015	0	0	1305	0	0	1 060	2 365

Table 10.1.2 Sprat in the Celtic Seas Ecoregion. Irish landings of sprat, 1985–2015 from 7.aN. Irish data may be underestimated, due to difficulties in quantifying the landings from vessels of less than 10 m length.

Country	Ireland	Isle of Man	UK - Eng+Wales+N.Irl.	UK - Scotland	Total
1985	668	0	20	0	688
1986	1 152	1	6	0	1 159
1987	41	0	0	0	41
1988	0	0	4	6	10
1989	0	0	1	0	1
1990	0	0	0	0	0
1991	0	0	3	0	3
1992	0	0	0	0	0
1993	0	0	0	0	0
1994	0	0	0	0	0
1995	0	0	30	0	30
1996	0	0	0	0	0
1997	0	0	2	0	2
1998	0	0	3	0	3
1999	0	0	146	0	146
2000	0	0	371	0	371
2001	0	0	269	3	272
2002	0	0	306	0	306
2003	0	0	592	0	592
2004	0	0	134	0	134
2005	0	0	591	0	591
2006	0	0	563	0	563
2007	0	0	0	0	0
2008	0	0	2	0	2
2009	0	0	0	0	0
2010	0	0	0	0	0
2011	0	0	0	0	0
2012	0	0	0	0	0
2013	0	0	0	0	0
2014	522	0	0	0	522
2015	771	0	0	0	771

Table 10.1.3 Sprat in the Celtic Seas Ecoregion. Irish landings of sprat, 1985–2015 from 7.aS. Irish data may be underestimated, due to difficulties in quantifying the landings from vessels of less than 10 m length.

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	3 103
2004	408
2005	361
2006	114
2007	0
2008	102
2009	0
2010	433
2011	1 696
2012	6 948
2013	3 082
2014	16
2015	3 659

Table 10.1.4. Sprat in the Celtic Seas Ecoregion. Landings of sprat, 1985–2015 7.b–c. Irish data may be underestimated, due to difficulties in quantifying the landings from vessels of less than 10 m length.

Country	Ireland
1985	0
1986	0
1987	100
1988	0
1989	0
1990	400
1991	40
1992	50
1993	3
1994	145
1995	150
1996	21
1997	28
1998	331
1999	5
2000	698
2001	138
2002	11
2003	38
2004	68
2005	260
2006	40
2007	32
2008	1
2009	238
2010	0
2011	4
2012	23
2013	237
2014	0
2015	250

Table 10.1.5 Sprat in the Celtic Seas Ecoregion. Landings of sprat, 1985–2015 7.d–e.

Country	Denmark	France	Netherlands	UK - Eng+Wales+N.Irl.	UK - Scotland	Total
1985	0	14	0	3 771	0	3 785
1986	15	0	0	1 163	0	1 178
1987	250	23	0	2 441	0	2 714
1988	2 529	2	1	2 944	0	5 476
1989	2 092	10	0	1 520	0	3 622
1990	608	79	0	1 562	0	2 249
1991	0	0	0	2 567	0	2 567
1992	5 389	35	0	1 791	0	7 215
1993	0	3	0	1 798	0	1 801
1994	3 572	1	0	3 176	40	6 789
1995	2 084	0	0	1 516	0	3 600
1996	0	2	0	1 789	0	1 791
1997	1 245	1	0	1 621	0	2 867
1998	3 741	0	0	1 973	0	5 714
1999	3 064	0	1	3 558	0	6 623
2000	0	1	1	1 693	0	1 695
2001	0	0	0	1 349	0	1 349
2002	0	0	0	1 196	0	1 196
2003	0	2	72	1 368	0	1 442
2004	0	6	0	0 836	0	0 842
2005	0	0	0	1 635	0	1 635
2006	0	7	0	1 969	0	1 976
2007	0	0	0	2 706	0	2 706
2008	0	0	0	3 367	0	3 367
2009	0	2	0	2 773	0	2 775
2010	0	2	0	4 408	0	4 410
2011	0	1	37	3 138	0	3 176
2012	6	2	8	4 458	0	4 474
2013	0	0	0	3 793	0	3 793
2014	45	0	275	3 358	0	3 678
2015	0	1	346	2 657	0	3 003

Table 10.1.6 Sprat in the Celtic Seas Ecoregion. Landings of sprat, 1985–2015 7.f.

Country	Netherlands	UK - Eng+Wales+N.Irl.	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	1	1
2012	0	2	2
2013	0	2	2
2014	0	1	1
2015	0	0	0

Table 10.1.7 Sprat in the Celtic Seas Ecoregion. Landings of sprat, 1985–2015 7.g–k. Irish data may be underestimated due to difficulties in quantifying the landings from vessels of less than 10 m length.

Country	Denmark	France	Ireland	Netherlands	Spain	UK - Eng+Wales+N.Irl.	Total
1985	0	0	3 245	0	0	0	3 245
1986	538	0	3 032	0	0	2	3 572
1987	0	1	2 089	0	0	0	2 090
1988	0	0	703	1	0	0	704
1989	0	0	1 016	0	0	0	1 016
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	3 924	0	0	0	3 924
1997	0	0	461	0	0	6	467
1998	0	0	1 146	0	0	0	1 146
1999	0	0	3 263	0	0	0	3 263
2000	0	0	1 764	0	0	0	1 764
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	3 523	0	0	0	3 523
2005	0	0	4 173	0	0	0	4 173
2006	0	0	768	0	0	0	768
2007	0	0	3 380	0	1	0	3 381
2008	0	0	1 358	0	0	0	1 358
2009	0	0	3 431	0	0	0	3 431
2010	0	0	2 436	0	0	0	2 436
2011	0	0	1 767	0	0	12	1 779
2012	0	0	2 642	0	0	0	2 642
2013	0	0	1 648	0	0	0	1 648
2014	0	0	2 311	0	0	0	2 311
2015	0	0	3 322	0	0	0	3 322

Table 10.1.8 Sprat in the Celtic Seas Ecoregion. Landings of sprat, 1985–2015. Total Landings, divisions 6 and 7. Irish data may be underestimated, due to difficulties in quantifying the landings from vessels of less than 10 m length.

Country	Denmark	Faeroe Islands	France	Ireland	Isle of Man	Netherlands	Norway	Spain	UK - England & Wales	UK - Scotland	Un. Sov. Soc. Rep.	Total
1985	0	0	14	3 964	0	273	557	0	3 791	2 946	0	11 545
1986	553	0	0	4 532	1	0	0	0	1 173	520	0	6 779
1987	519	0	24	2 230	0	0	0	0	2 441	582	0	5 796
1988	2 893	0	2	853	0	2	0	0	2 948	3 870	0	10 568
1989	2 092	0	10	1 163	0	0	0	0	1 521	1 146	0	5 932
1990	608	0	79	1 325	0	0	0	0	1 562	813	0	4 387
1991	0	0	0	205	0	0	0	0	2 571	1 526	0	4 302
1992	5 417	0	35	508	0	0	0	0	1 791	1 555	0	9 306
1993	22	0	3	2 353	0	0	0	0	1 798	2 230	0	6 406
1994	3 572	0	1	232	0	0	0	0	3 178	1 531	0	8 514
1995	2 575	0	0	799	0	0	0	0	1 546	4 124	0	9 044
1996	0	0	2	4 214	0	0	0	0	1 789	2 350	0	8 355
1997	1 245	0	1	2 085	0	0	0	0	1 629	5 313	0	10 273
1998	3 781	0	0	1 578	0	0	0	0	2 027	3 467	0	10 853
1999	3 064	0	0	5 826	0	1	0	0	4 014	8 161	0	21 066
2000	0	0	1	6 032	0	1	0	0	2 064	4 238	0	12 336
2001	0	0	0	455	0	0	0	0	1 716	1 297	0	3 468
2002	0	0	0	1 729	0	0	0	0	1 502	2 657	0	5 888
2003	887	0	2	4 948	0	72	0	0	1 960	2 593	0	10 462
2004	0	0	6	4 096	0	0	0	0	970	1 416	0	6 488
2005	0	252	0	5 928	0	0	0	0	2 239	0	0	8 419
2006	0	0	7	1 523	0	0	0	0	2 532	0	0	4 062
2007	0	0	0	3 745	0	0	0	1	2 708	14	0	6 468
2008	0	0	0	2 353	0	0	0	0	3 369	0	0	5 722
2009	0	0	2	3 773	0	0	0	0	2 774	70	0	6 619
2010	0	0	2	3 200	0	0	0	0	4 415	537	0	8 154
2011	0	0	1	3 935	0	37	0	0	3 399	507.3	0	7 879
2012	6	0	2	9 726	0	8	0	0	4 460	1 688	0	15 890
2013	0	0	0	5 453	0	0	0	0	3 795	968	0	10 217
2014	45	0	0	2 852	0	275	0	0	3 359	1 540	0	8 070
2015	0	0	1	9 307	0	346	0	0	2 657	1 060	1	13 371

Table 10.3.1. Sprat in the Celtic Seas Ecoregion. Sprat biomass by year in the Celtic Sea (Source: MI Celtic Sea Herring Acoustic Survey, ICES, 2016).

Year	Biomass (t)
Nov/Dec-91	36 880
Jan-92	15 420
Jan-92	5 150
Nov-92	27 320
Jan-93	18 420
Nov-93	95 870
Jan-94	8 035
Nov-95	75 440
2002	20 600
2003	1 395
2004	14 675
2005	29 019
2008	5 493
2009	16 229
2011	31 593
2012	35 100
2013	44 685
2014	33 728
2015	83 779

Table 10.3.2. Sprat in the Celtic Seas Ecoregion. Annual sprat biomass in ICES Subdivision 7.a (Source: AFBI annual herring acoustic survey).

	Sprat & 0-group herring			Sprat
Year	Biomass (t)	CV	% 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	95	162,600
2013	255,300	0.09	77	197,500
2014	393,000	0.1	93	367,100
2015	237,000	0.09	84	199,100

Table 10.3.3. Sprat in 7.d–e. Annual sprat biomass in ICES Subdivision 7.e (Source: Cefas annual pelagic acoustic survey).

Survey	Area	Season	2011	2012	2013	2014	2015
Partial	Lyme Bay*	Oct	33,861	24,246	69,865	62,946	23,451
FSP	Lyme Bay**	Oct	33,861	27,971			
PELTIC	W Eng Ch	May	85,358				
PELTIC	W Eng Ch	Oct			75,546	77,800	60,011

Table 10.6.1. Sprat in 7.d–e. Landings per unit effort (lpue) for 3 vessels that target sprat. The year refers to the start of the season 1 August year (y) to 31 March in year (y+1).

Year	HAWG 2015	HAWG 2016
1988	283	283
1989	668	682
1990	429	429
1991	528	528
1992	422	422
1993	630	630
1994	742	747
1995	599	599
1996	803	803
1997	868	868
1998	736	736
1999	970	970
2000	631	683
2001	508	521
2002	598	644
2003	352	375
2004	588	588
2005	1 050	1 050
2006	992	992
2007	1 050	1 050
2008	1 029	1 029
2009	773	773
2010	1 527	1 527
2011	1 042	1 042
2012	1 904	1 904
2013	1 933	1 933
2014	2 413	2 405
2015*		2 221

***The estimate in 2015 is provisional.**

Table 10.11.1. Sprat in 7.d–e. Catch/survey biomass ratio estimates from acoustic survey in 7.e.

Survey	Area	Season	2011	2012	2013	2014	2015
Partial	Lyme Bay	Oct	9%	18%	5%	6%	16%
PELTIC	W Eng Ch	May	4%				
FSP	Lyme Bay	Oct	9%	16%			
PELTIC	W Eng Ch	Oct			5%	5%	6%

Figure 10.1. Sprat in the Celtic Seas Ecoregion. Map showing areas mentioned in the text.

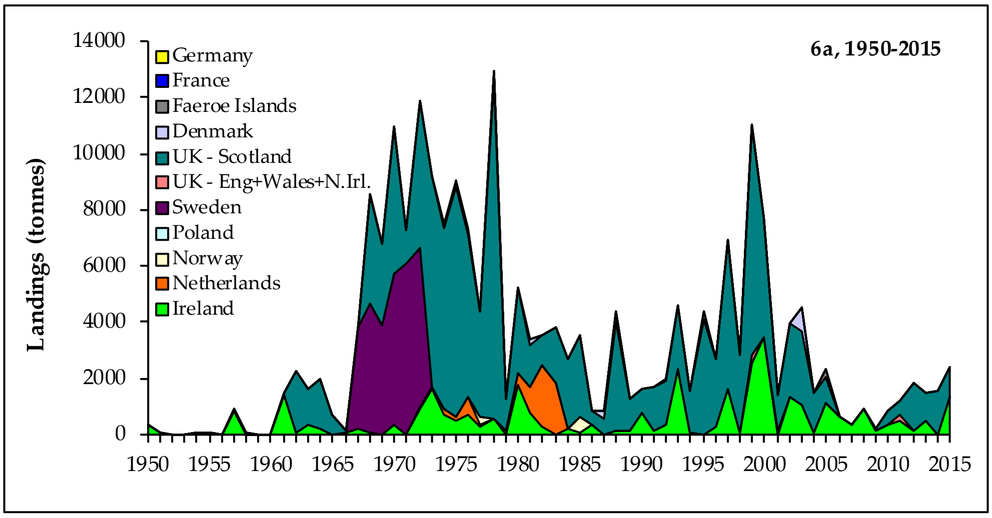

Figure 10.2.1. Sprat in the Celtic Seas Ecoregion. Landings of sprat 1950–2015 ICES Subdivision 6.a.

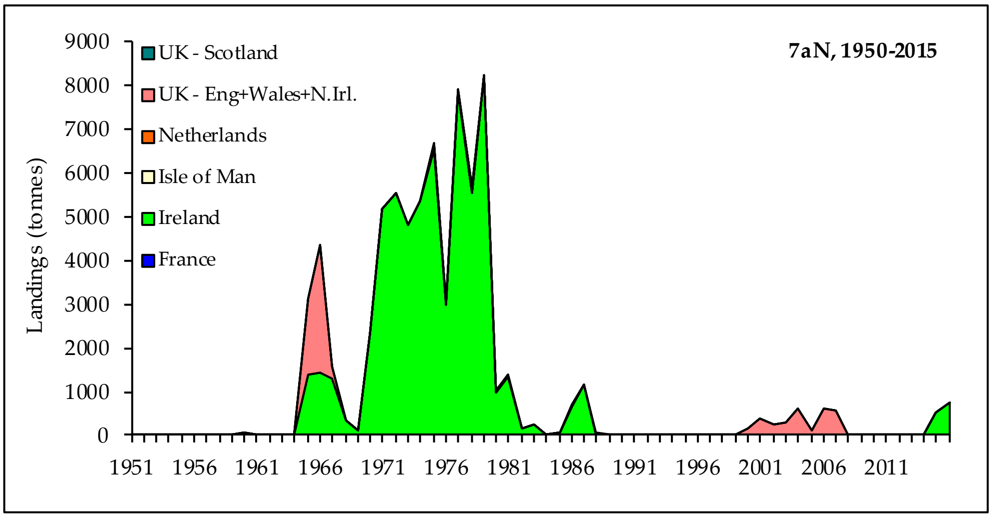

Figure 10.2.2. Sprat in the Celtic Seas Ecoregion. Landings of sprat 1950–2015 ICES Subdivision 7.aN. Note: Irish landings from 1973–1995 may be from 7.aN or 7.aS.

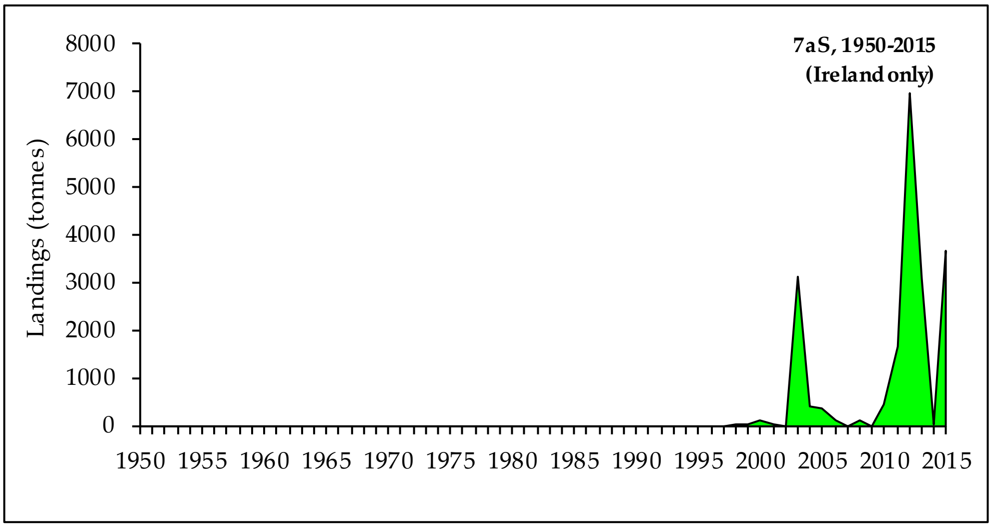

Figure 10.2.3. Sprat in the Celtic Seas Ecoregion. Landings of sprat 1950–2015 ICES Subdivision 7.aS.

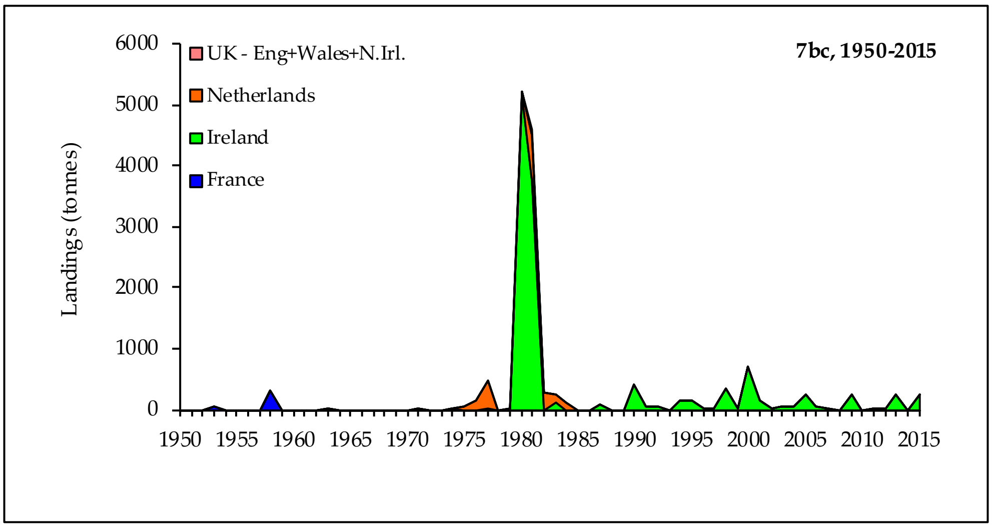

Figure 10.2.4. Sprat in the Celtic Seas Ecoregion. Landings of sprat 1950–2015 ICES Subdivisions 7.b–c.

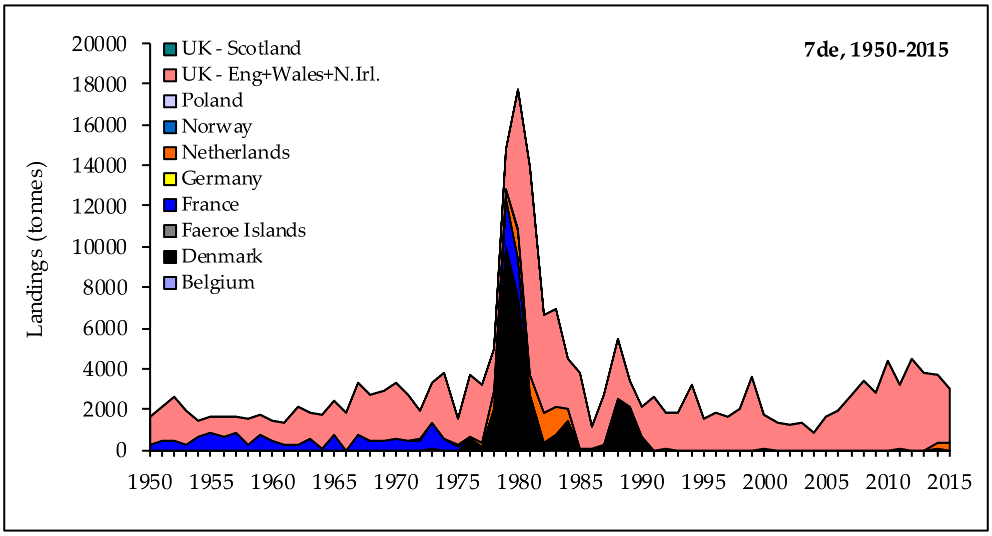

Figure 10.2.5. Sprat in the Celtic Seas Ecoregion. Landings of sprat 1950–2015 ICES Subdivisions 7.d–e.

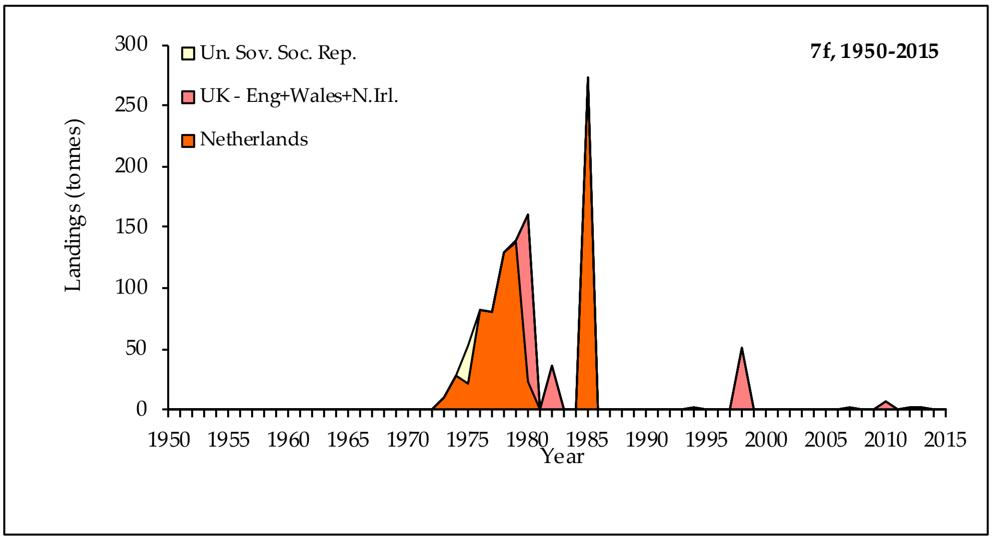

Figure 10.2.6. Sprat in the Celtic Seas Ecoregion. Landings of sprat 1950–2015 ICES Subdivision 7.f.

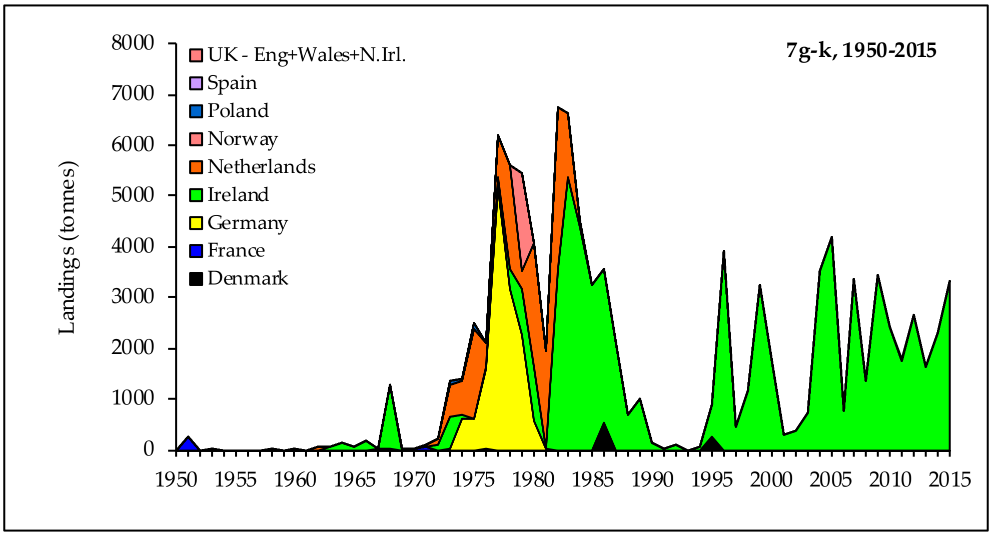

Figure 10.2.7. Sprat in the Celtic Seas Ecoregion. Landings of sprat 1950–2015 ICES Subdivisions 7.g–k.

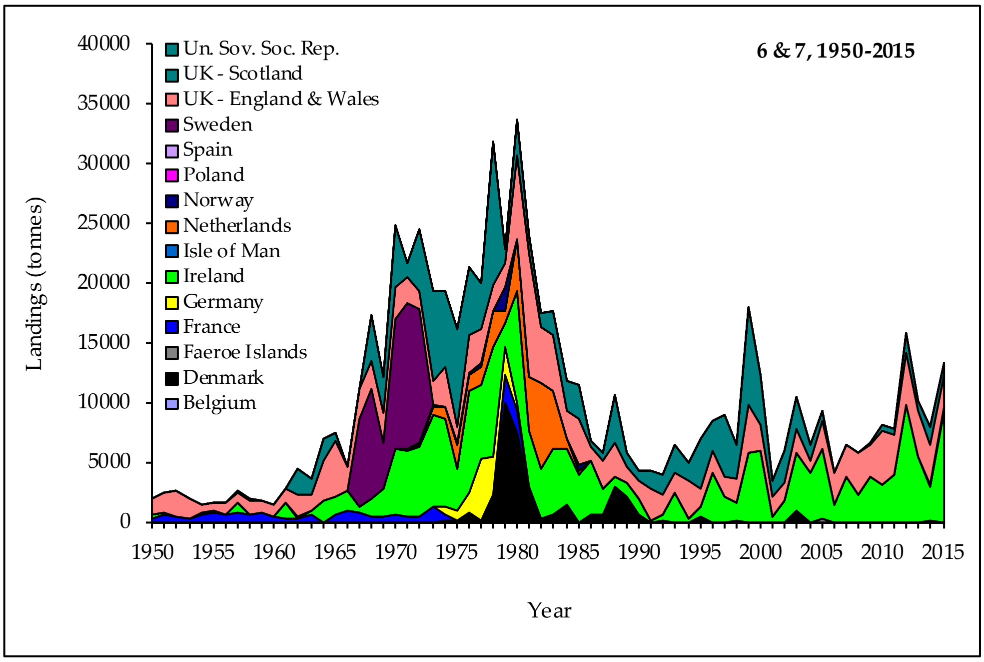

Figure 10.2.8. Sprat in the Celtic Seas Ecoregion. Landings of sprat 1950–2015 ICES divisions 6 and 7 (Celtic Seas Ecoregion).

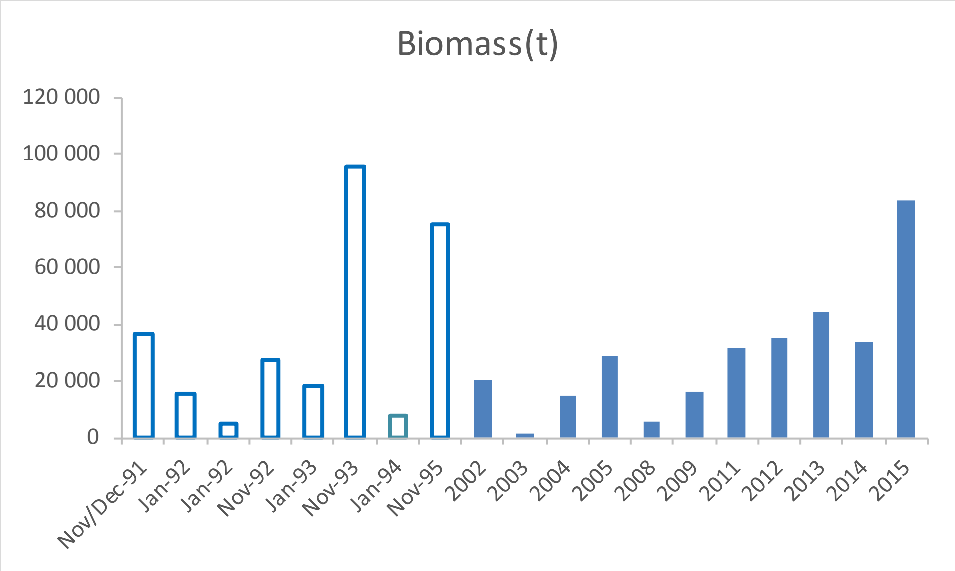

Figure 10.3.1. Sprat in the Celtic Seas Ecoregion. Estimated sprat biomass in the Celtic Sea. (Source: MI Celtic Sea Herring Acoustic Survey). Solid bars correspond to the period where the surveys are considered consistent.

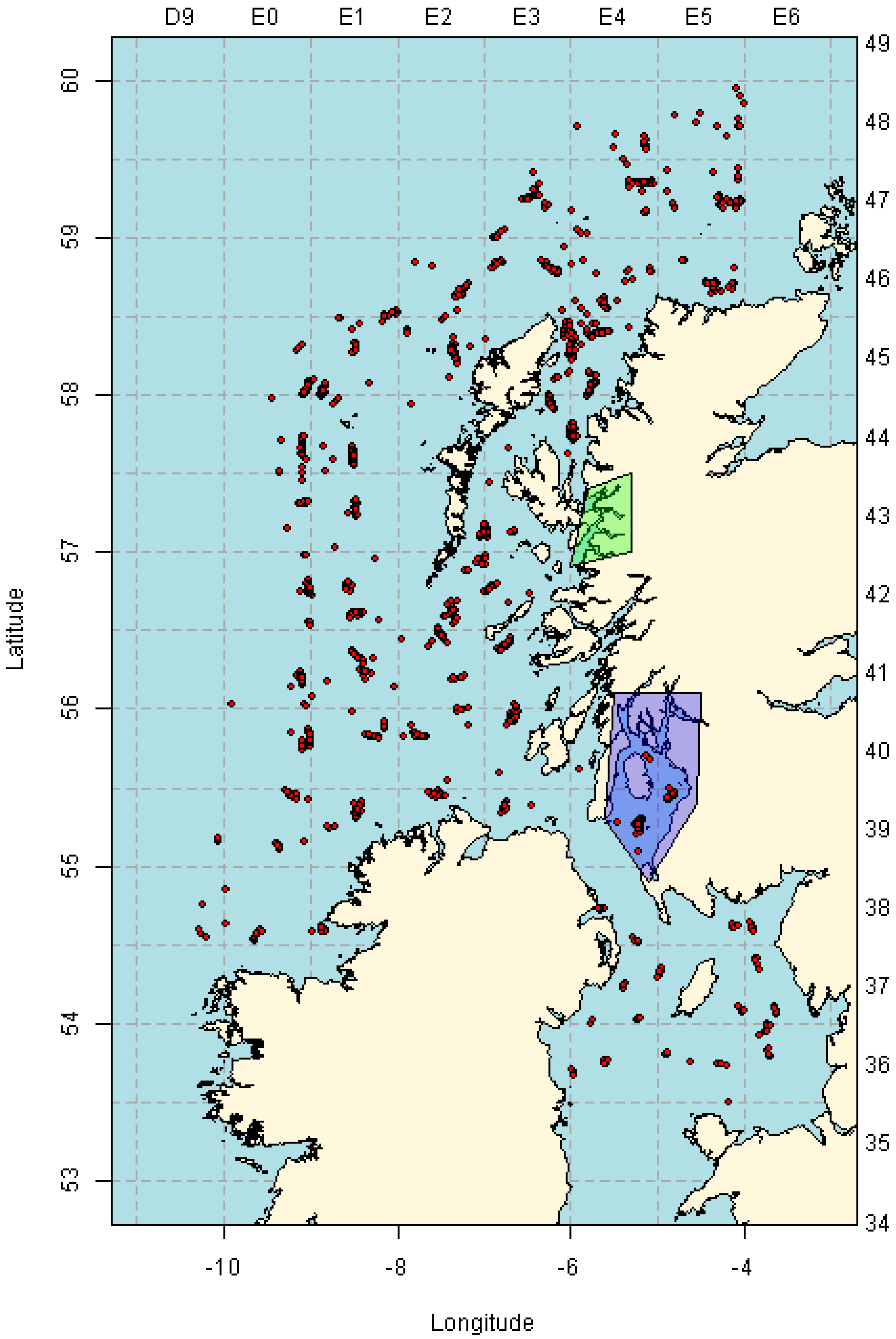

Figure 10.3.2: Extent of Scottish surveys that may provide information about sprat in 6.a. In purple is the extent of the Clyde Herring and Sprat Acoustic Surveys carried out in July between 1985 and 1989 and again in October 2012. In green is the extent of the Sea Lochs Surveys carried out annually 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.

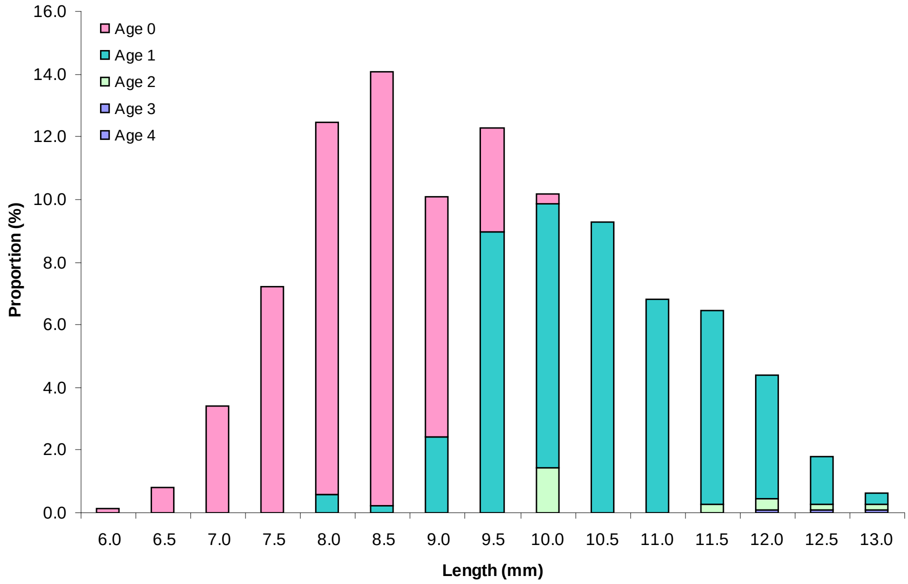

Figure 10.3.3. Length and age of sprat caught in the October 2012 Clyde Herring and Sprat Acoustic Survey. Data from six hauls were combined giving equal weight to the age and length distribution in each haul. 1442 sprat were measured and 182 were aged.

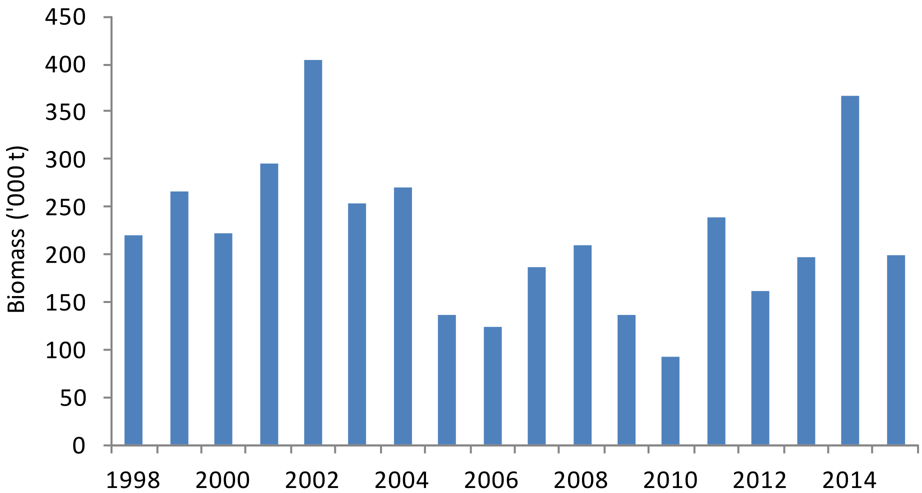

Figure 10.3.4. Sprat in the Celtic Seas Ecoregion. Annual sprat biomass in ICES Subdivision 7.aN.

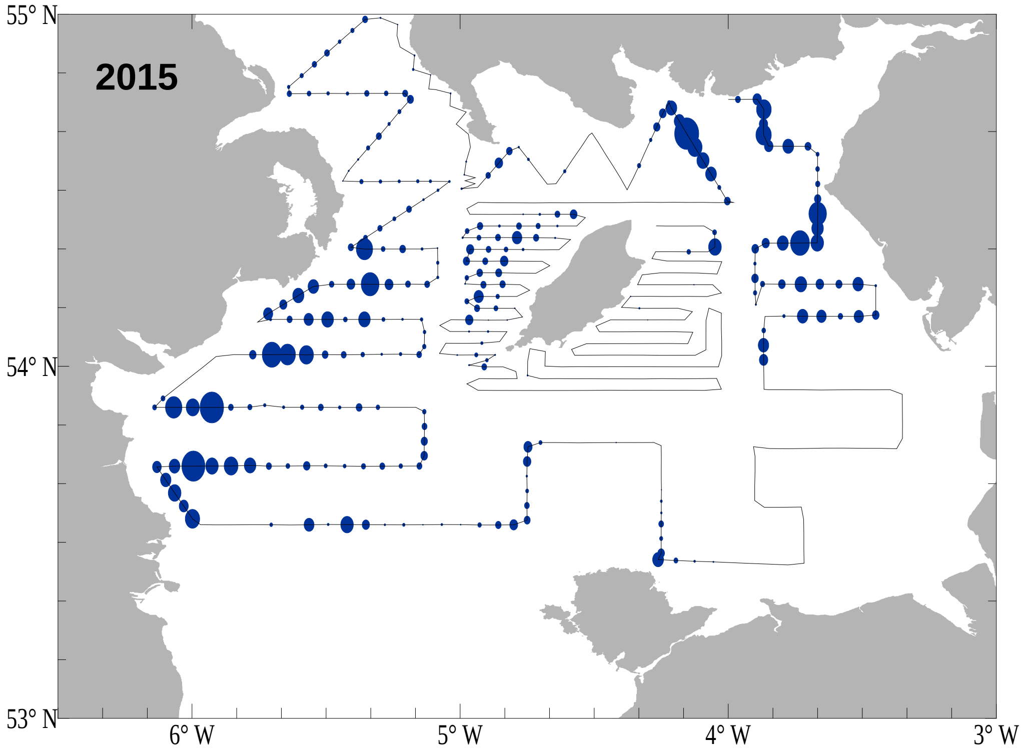

Figure 10.3.5. Sprat in the Celtic Seas Ecoregion. Sprat acoustic densities in ICES Subdivision 7.aN. Size of elipses is proportional to square root of the fish density (t n.mile^{-2}) per 15-minute interval) for the UK (NI). September 2015 acoustic survey (AC(7.aN)) . Maximum density was 470 t n.mile^{-2}.

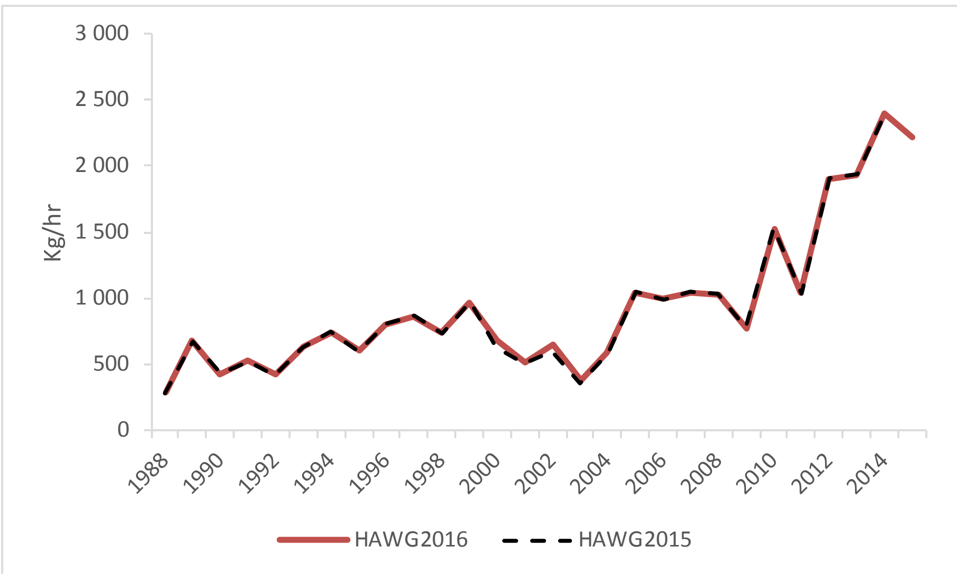

Figure 10.6.1. Sprat in 7.d–e. Lpue (kg/hr). Comparison between the series presented in 2015 and the updated series in 2016. Note that the 2015 season lpue is provisional because the season runs from 1 August to 31 March the following year.

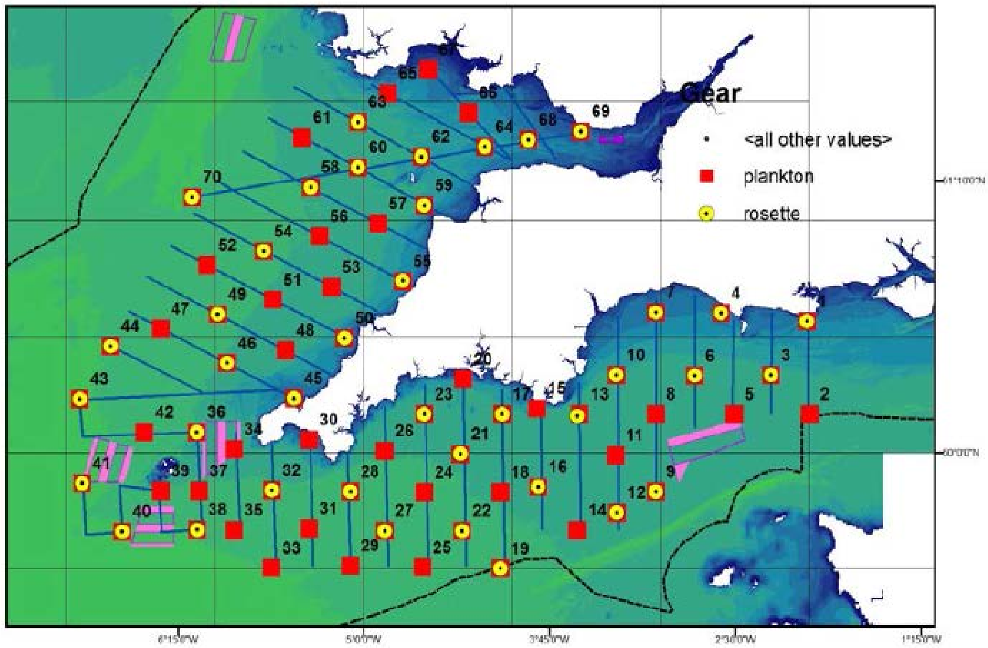

Figure 10.6.2. Sprat in 7.d–e. Survey design with acoustic transects (blue lines), zooplankton stations (red squares) and oceanographic stations (yellow circles).

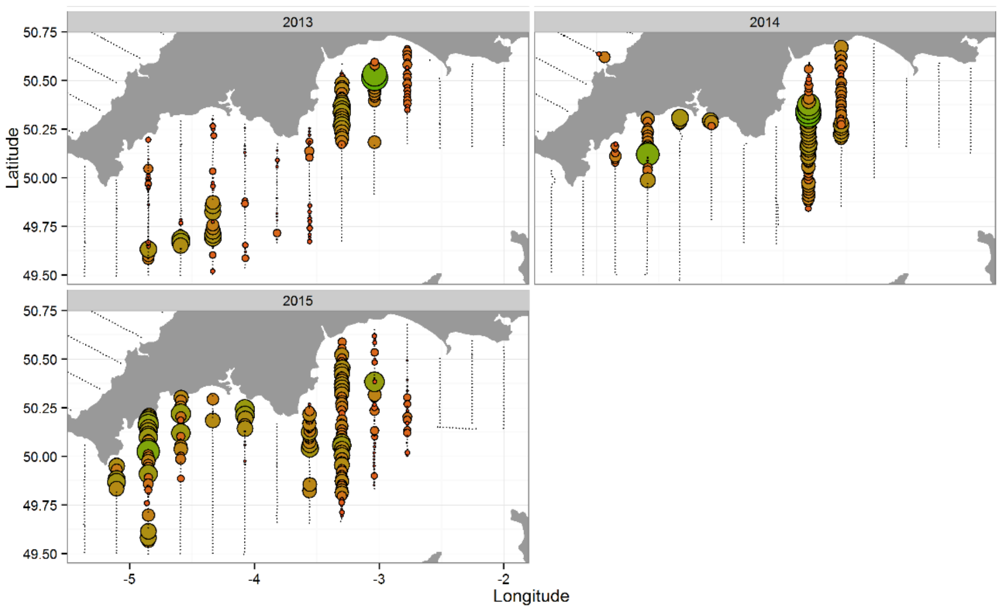

Figure 10.11.1. Acoustic backscatter attributed to sprat per 1 nmi equidistant sampling unit (EDSU) in the western Channel during October.

11 Sandeel in Division 3.a and Subarea 4

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, 2009), it was suggested that the North Sea should be divided into seven sandeel assessment areas as shown in Figure 11.1.1. On this basis the benchmark assessment (ICES, 2010) decided to make area specific assessments from 2010 onwards. Currently fishing takes place in five out of these seven areas (samdeel area (SA) 1–4 and 6). Analytical stock assessments are currently carried out in SA 1–3, whereas SA 4 is managed under the ICES approach for data limited stocks (Category 3).

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 and is still used to assess sandeel in SAs 1, 2 and 3.

Further information on the stock areas and assessment model can be found in the Stock Annex and in the benchmark report (ICES, 2010).

The sandeel assessment will be benchmarked in 2016 with data evaluation workshop in June and benchmark meeting in October-November.

11.1 General

11.1.1 Ecosystem aspects

Sandeel in the North Sea can be divided into a number of more or less 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, 2007; ICES, 2008a). Since 2010 this has been accounted for by dividing the North Sea and 3a into seven management areas.

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, 2007). During the last ten years, the number of Danish vessels participating in the North Sea sandeel fishery has been stable with around 100 active vessels.

The same tendency was seen for the Norwegian vessels fishing sandeel until 2005. In 2006 only six Norwegian vessels were allowed to participate in an experimental sandeel fishery in the Norwegian EEZ compared to 53 in 2002. In 2008, 42 vessels participated in the sandeel fishery, and 29 vessels participated in 2015. From 2002 to 2014 the average GRT per trip in the Norwegian fleet increased from 269 to 1150 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 current 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 2015 was opened 1 April and practically ended in early June. In NEEZ the fishery opened 15 April and ended 23 June.

11.1.3 ICES Advice

ICES advised that the fishery in 2015 should be allowed only if the analytical stock assessment indicated that the stock would be above B_{pa} by 2016 (Escapement strategy). This approach resulted in an advised TAC in 2015 of 133 000 t in SA 1, 29 000 t in SA 2 and 370 000 t in SA 3. A monitoring TAC of 5000 was advised for SA 4 based on the approach for data limited stocks.

11.1.4 Norwegian advice

Based on a recommendation from the Norwegian Institute for Marine Research, an opening TAC of 100 000 tonnes for 2015 was given, and as the acoustic survey estimates of age 1 were only medium high the TAC was not increased. Fishery was allowed in the subareas 1b, 2b, 3a, 3b and 4a (Norwegian sandeel management areas).

11.1.5 Management

Norwegian sandeel management plan

An Area Based Sandeel Management Plan for the Norwegian EZZ was fully implemented in 2011, but was also partly used in 2010. Based on historical fishing patterns and local stock developments, six areas are defined, each consisting of "a" and "b" subareas (Figure 11.1.5). A national evaluation of the management plan was carried out in March 2014, and the evaluation panel concluded that the main principles of the management plan should continue for at least three additional. In the new management plan, the number of management areas is reduced to five by combining area 4 and 5 as no evident difference in the growth pattern was found between these two areas. In addition, it was decided to keep subarea 3b open for fishery every season (as long as the biomass is above a critical biomass in area 3). Area 3 consists of several not trawlable areas, which seem to function as natural protection areas for sandeel. In addition, some borders were slightly changed. The new management areas are shown in Figure 11.1.5. The main objective of the Plan is to rebuild the spawning stocks in all five areas and thereby enhance the total recruitment and catch potential. Acoustic surveys and catch information (when 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, one of the adjacent subareas can be opened for fishery. The subsequent year, if the state of the spawning stock is still strong, the other subarea will be opened. Prior to the fishing season, 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 sandeel. Based on this updated survey information, the TAC within the current year can be increased and new areas (subareas) can be opened.

Closed periods

From 2005 to 2007, the fishery in the Norwegian EEZ opened 1 April and closed again 23 June. In 2008, the ordinary fishery was stopped 2 June, and only a restricted fishery with five vessels continued. No fishery was allowed in 2009. From 2010 to 2014 the fishing season was 23 April–23 June, and in 2015 from 15 April to 23 June in the Norwegian EEZ.

Since 2005, Danish vessels have not been allowed to fish sandeel before 31 March.

Closed areas

The Norwegian EEZ was only open for an exploratory fishery in 2006 based on the results of a three week RTM fishery. In 2007, no regular 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 five 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, the Norwegian management subareas 1b, 2b and 3b were open in 2010 and 2012, and the subareas 1a, 2a and 3a were open in 2011. In 2013, subareas 2a and 3a were open. An exploratory fishery (with a quota of 2000 t) was carried out in subarea 5a between 15 May and 23 June 2012. In 2013, five vessels were allowed to fish in subarea 4a. In 2014, the subareas 2a, 3b, 3c and 4b were open for fishery. In the period 23 April–15 May, five vessels were allowed to fish in subarea 4a, but no vessel had catches in this subarea. In 2015, fishery was allowed in the subareas 2b, 3a, 3b and 4a (only five vessels) until 15 May. From 15 May, subareas 1b, 2b, 3a, 3b and 4a were open.

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. Note that a limited fishery for stock monitoring purposes occurs in May-June in this area.

11.1.6 Catch

Adjustment of official catches

The 2014 official Danish catches by rectangles (based on logbooks) showed that a series of rectangles (41F1, 41F2, 41F3 and 41F4) in the southern part of SA 3, which previously had supported small catches, had been very productive in this year. These rectangles are characterized by an almost complete lack of recorded fishing grounds and historically quite low catches. VMS data indicate fishing activity (speed 2–4 knots) just north of the southern border of SA 3, in areas with no recorded fishing ground, though one of the rectangles, 41F4, contains the northernmost tip of a fishing ground which is located in 40F4. Historically, there has been a very good correlation between the summed catch in the rectangles 41F1, 41F2, 41F3 and 41F4 and that in 40F4 throughout the period when this information has been reported. However, the large catch in 2014 in these four rectangles was not accompanied by a large catch in 40F4. The recorded change in fishing pattern is assumed to be due to a substantial reporting of SA 1 catches to SA 3 in rectangles 41F1, 41F2, 41F3 and 41F4. International catches in these rectangles (40 682 t) are allocated to SA 1 for assessment purposes and effort data were adjusted accordingly (see below). The catch and effort data for 2014 presented in this report have all been adjusted unless specifically stated. More details on the analysis can be found in WD1, Annex 4.

In 2015, the Danish regulation did not allow fishing in several stock areas on a single fishing trip. This eliminated the misreporting issue for Danish catches. However, German and Swedish catches were still high in the four rectangles, and an analysis of Swedish VMS for the years 2012 to 2015 indicated that misreporting had also occurred of Swedish catches in 2014 and 2015 (see WD2, Annex 4). Because of this, the working group decided to keep the practice from last year's assessment and reallocate reported catches (14 781 t) from rectangles 41F1, 41F2, 41F3 and 41F4 to SA 1.

Catch and trends in catches

Catch statistics for Division 3 are given by country in Table 11.1.1. Catch statistics and effort by assessment area are given in Tables 11.1.2–11.1.7. Figure 11.1.1 shows the areas for which catches are tabulated.

The sandeel fishery developed during the 1970s, and catches peaked in 1997 and 1998 with more than 1 million t. Since 1983 the total catches have fluctuated between 1.2 million t (1997) and 101 000 t (2012) (Figure 11.1.3). Total catches in 2015 amounted to 307 000 t.

Spatial distribution of catches

Yearly catches for the period 2000–2015 distributed by ICES rectangle are shown in Figure 11.1.2 (with no spatial adjustment of official catches distribution in 2014 and 2015). The spatial distribution is variable from one year to the next, however with common characteristic. The Dogger Bank area includes the most important fishing banks for SA 1 sandeel. The fishery in the Norwegian EEZ (SA 3) has varied over time, primarily as a result of changes in regulations and very low abundance of sandeel on the northern fishing grounds.

Figure 11.1.3 and Table 11.1.2 show catch weight by area. There are large differences in the regional patterns of the catches. SAs 1 and 3 have always been the most important with regard to sandeel catches. On average, these two areas together have contributed ~85% of the total sandeel catches in the period since 1983.

The third most important area for the sandeel fishery is SA 2. In the period since 2003 catches from this area contributed 10% of the total catches on average. Only a monitoring fishery (5000 t) was permitted in SA 2 in 2014.

SA 4 has contributed about 5% of the total catches since 1994, but there have been a few outstanding years with particular high catches (1994, 1996 and 2003 contributing 19, 17 and 20% of the total catches, respectively). Only a monitoring fishery (5000 t) was permitted in SA 4 in 2014 and 2015.

Several banks in the northern areas of Norwegian EEZ have not provided catches for the last 8–12 years. From 2001 to 2008, almost all catches from the Norwegian EEZ came from the Vestbank area (management area 3 in Figure 11.1.5). From 2010, catches have been mainly taken from the Norwegian management areas 1, 2 and 3.

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.

Effect of country on CPUE

Individual Norwegian logbook records have been included in the dataset used to estimate effort since 2011. A correction factor significantly different from zero was estimated and used to standardise Norwegian effort to Danish levels in 2011 and 2013 (i.e. one Norwegian fishing day corrected for vessel size counted as 0.61 and 0.44 Standardised Fishing Days in 2011 and 2013, respectively). In 2012, the difference was not statistically significant and no standardization for country effects was performed. In 2015, there was no spatial overlap between logbook records, and hence, no correction factor was estimated. As more data is added in the coming years, the estimation of correction factors should be revisited.

Estimating effort by area in 2014

When estimating effort by area, it was assumed that CPUE records are biased due to substantial reporting of SA 1 catches in SA 3 in rectangles 41F1, 41F2, 41F3 and 41F4. Catches in these rectangles are allocated to SA 1. The studies of VMS tracks suggest that the fishing days reported in these squares are not actual fishing days and this effort is therefore not used in the summation of total effort. In 2015, the Danish and Norwegian CPUE records are assumed to be accurate, and hence the effort estimated necessary to catch the apparently misallocated catches was reallocated to SA 1 together with the catches.

The lack of reliable CPUE data by trip and square from 2014 invalidates the benchmarked method to estimate effort standardised by vessel size which uses an annual estimate of the effect of vessel size on CPUE. Instead, the average effect of vessel size in the years 2004–2013 was used to estimate standardised fishing days. Further, the lack of spatial overlap between Norwegian and Danish vessels means that it is not possible to estimate the 2014 standardisation between countries which is necessary due to the difference in the reporting of days (fishing days or days since leaving harbour) and hence the 2013 value was used (0.43). Standardised fishing days for each area was estimated as

$$E_{200GRT} = \frac{C_T}{C_{DK} + C_{NO}} \left(\sum_{GRT} E_{DK,GRT} \left(\frac{GRT}{200}\right)^{0.453} + \sum_{GRT} 0.43 E_{NO,GRT} \left(\frac{GRT}{200}\right)^{0.453} \right)$$

Where C_T is the total international catch in the area in 2014 after allocating the catches in the rectangles 41F1, 41F2, 41F3 and 41F4 to SA 1, C_{DK} is the total Danish catch derived from log books and reallocating the catches in the rectangles 41F1, 41F2, 41F3 and 41F4 to SA 1 C_{NO} is the Norwegian catch derived from logbooks, GRT is gross register tonnage of the vessel size class, $E_{DK,GRT}$ is the sum of fishing days reported by Danish vessels in the GRT size class disregarding all days reported in rectangles 41F1, 41F2, 41F3 and 41F4, $E_{NO,GRT}$ is the sum of fishing days reported by Norwegian vessels in the GRT size class (Norwegian vessels did not report catches in rectangles 41F1, 41F2, 41F3 and 41F4).

11.1.7 Sampling the catch

Sampling activity for commercial catches is shown in Table 11.1.8. Self-sampling and scientific sampling from landings have given a rather high number of samples in total in 2015.

11.1.7.1 Survey indices

Abundance of sandeel is monitored by a Danish dredge survey (covering SA 1–3) and a Scottish dredge survey (SA 4) in December. See the Stock Annex for more details. An acoustic survey was carried out in Norwegian EEZ in April/May following the standard procedures described in the benchmark report (ICES, 2010a).

The Danish dredge survey in 2015 was carried out as planned and nearly all planed positions were covered in accordance with the survey protocol without notable problems related to weather or other potentially obstructive factors. All data were included in the estimated dredge index by area. Figure 11.1.4 shows the time series of average CPUE per rectangle and year.

11.1.8 Natural mortality

Values of natural mortality are obtained from a multispecies model where predation mortality is estimated (ICES, 2008b). The same values are used for the assessments of sandeel in SA 1, 2 and 3.

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 Sandeel in SA 1

11.2.1 Catch data

Total catch weight by year for SA 1 is given in Tables 11.1.2–11.1.4. Catch numbers at age by half-year is given in Table 11.2.1.

In 2015, the proportion 1-group was 90% (Figure 11.2.1).

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 11.2.2 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 11.2.2. Mean weight at age in the first half year was decreasing in 2010–2012 and has been increasing slightly since 2013. The second half year shows a more variable mean weight, most likely due to limited sampling.

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 11.2.3). Maturity in 2016 (based on maturity of 0-group in the December 2015 dredge survey) is around average for age 1 and 2, while the proportion mature for age is lower.

11.2.4 Effort and research vessel data

Trends in overall effort and CPUE

Table 11.1.5–11.1.7 and Figure 11.2.3 show the trends in the international effort over years measured as number of fishing days standardized to a 200 GRT vessel. The standardization includes just the effect of vessel size, and does not take changes in efficiency into account. Total international standardized effort peaked in 2001, after which substantial effort reduction has taken place. Effort in 2015 is less than the average effort for the full time series.

The average CPUE in the period 1994 to 2002 was around 60 t^{-day}. In 2003, CPUE declined to the all-time lowest at 21 t^{-day}. Since 2004, the CPUE has increased and reached the all-time highest (101 t^{-day}) in 2010 followed by progressively lower CPUEs ending with CPUEs in 2014 below long term average. CPUE in 2015 was higher than average.

Tuning series used in the assessments

No commercial tuning series are used in the present assessment.

CPUE data from the dredge survey (Table 11.2.4) in 2015 show the lowest observed index for age 0 and a lower than average index for the 1-group.

The internal consistency, i.e. the ability of the survey to follow cohorts, (Figure 11.2.4) shows a low correlation between the 0-group and 1-group.

11.2.5 Data analysis

Following the Benchmark assessment (ICES, 2010a) the SMS-effort model was used to estimate fishing mortalities and stock numbers at age by half year, using data from 1983 to 2015. 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 11.2.5. The seasonal effect on the relation between effort and F ("F, Season effect" in the table) is rather constant over the three year ranges used. The "age selection" ("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 assessment period, to a fishery targeting age 1+ in a similar way.

The CV of the dredge survey ("sqrt (Survey variance) ~CV" in the table) is low (0.3) for age 0 and high (1.35) for age 1. SMS uses a lower boundary of 0.3 for CV of survey indices, which is met by this assessment. Due to the low "internal consistency" for this survey (Figure 11.2.4), the low CV for age 1 might be a result of a rather poor fit for other data sources, such that the model obtain the lowest fit for a good fit to data for the 0-group survey index. The survey residual plot (Figure 11.2.5) shows no bias for the 0-group, while clusters of residuals are observed for the 1 group.

The model CV of catch at age ("sqrt(catch variance) ~CV", in Table 11.2.5 is low (0.373) for age 1 and age 2 in the first half of the year and high (> 0.70) for the remaining ages and season combinations. The catch at age residuals (Figure 11.2.6) show no alarming patterns, except for a cluster of negative residuals (observed catch is less than model catch) for age 4+ in 2005–2011.

The CV of the fitted Stock recruitment relationship (Table 11.2.5) is high (0.845), which is also indicated by the stock recruitment plot (Figure 11.2.7). The high CV of recruitment is probably due to biological characteristic of the stock and not so much due to the quality of the assessment. The *a priori* weight on likelihood contributions from SSR-R observations is therefore set low (0.05 in "objective function weight" in Table 11.2.5) such that SSB-R estimates do not contribute much to the overall likelihood and model fit.

The retrospective analysis (Figure 11.2.8) shows very consistent assessment results from one year to the next. This is partly due to the assumed robust relationship between effort and F, which is rather insensitive to removal of a few years.

Uncertainties of the estimated SSB, F and recruitment (Figure 11.2.9) are in general small. For F, uncertainties are lowest for the most recent years, which are not normally seen. This is due to the model fit where the most recent effort values estimate F with a small error (Figure 11.2.11), while older observations have a larger difference between effort and F. The overall pattern with a lower F:effort ratio for older data indicates that the model assumption of no efficiency creeping is violated.

11.2.6 Final assessment

The output from the assessment is presented in Tables 11.2.6 (fishing mortality at age by year), 11.2.7 (fishing mortality at age by half year), 11.2.8 (stock numbers at age) and 11.2.9 (stock summary).

11.2.7 Historic Stock Trends

The stock summary (Figure 11.2.12 and Table 11.2.9) shows that SSB have been at or below B_{lim} from 2000 to 2002 and again in 2004 and 2006. Since 2007, SSB has been above B_{lim} but below B_{pa} in 2010 and 2013–2015. SSB is estimated below B_{pa} in 2016. $F_{(1-2)}$ is estimated to have been below the long-time average since 2006. Recruitment in 2015 is estimated to the second lowest observed in the time series.

11.2.8 Short-term forecasts

Input

Input to the short term forecast is given in Table 11.2.10. Stock numbers in the TAC year are taken from the assessment for age 1 and older. Recruitment in 2016 is the geometric mean of the recruitment 1983–2014 (194 billion at age 0). The exploitation pattern and F_{sq} is taken from the assessment values in 2015. However, as the SMS-model assumes a fixed exploitation pattern since 1999, the choice of years is not critical. Mean weight at age in the catch and in the sea is the average value for the years 2013–2015. The maturity estimate in 2016 is obtained from the dredge survey in December 2015. For 2017 the long term average proportion mature is applied. Natural mortality is the fixed M as applied in the assessment. The Stock Annex gives more details about the forecast methodology.

Output

The short term forecast (Table 11.2.11) shows that a zero TAC in 2016 will leave SSB below the MSY $B_{trigger}$ of 215 000 t in 2017. The TAC according to the escapement strategy is therefore 0 in 2016. A monitoring TAC at 5000 t in 2016 will lead to an SSB in 2017 of 187 000 t.

11.2.9 Biological reference points

B_{lim} is set at 160 000 t and B_{pa} at 215 000 t. MSY $B_{trigger}$ is set at B_{pa}.

Further information about biological reference points for sandeel in 3 can be found in the Stock Annex.

11.2.9.1 Quality of the assessment

The quality of the present assessment has improved compared to the combined assessment for the whole of the North Sea previously presented by ICES before 2010. This is mainly due to the fact that the present division of stock assessment areas better reflects the spatial stock structure and dynamics of sandeel. Addition of fishery independent data from the dredge survey has also improved the quality of the assessment. Application of the 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, gives rather narrow confidence limits for the model estimates of F, SSB and recruitment, but a poorer fit for the oldest data.

The model uses effort as basis for the calculation of F. The total international effort is derived from Danish and Norwegian (since 2011) CPUE and total international catches. Danish catches are by far the largest in the area, but effort data from the other countries could improve the quality of the assessment.

Abundance of the 1-group, which in most years dominates the catches, is estimated on the basis of the 0-group index from the dredge survey in December of the preceding year. The model estimates a low variance on the survey index for age 0, however there is a poor internal correlation between age 0 and age 1. This might indicate that the low variance of the 0-group index is more a result of an overall poor fit for all data sources, rather than a very precise survey.

11.2.9.2 Status of the Stock

Recruitment in 2014 at around long term average and an F below average in 2015 have resulted in SSB above B_{pa} in 2016. The very low recruitment in 2015 will lead to an SSB below B_{pa} in 2017, even with no fishery in 2016.

11.2.10 Management Considerations

A management plan needs to be developed. The ICES approach for MSY based management of a short-lived species such as sandeel is the so-called escapement strategy, i.e. to maintain SSB above MSY $B_{trigger}$ after the fishery has taken place. Management strategy evaluations presented at the ICES WKMSYREF2 meeting in 2014 (ICES, 2014a) indicated that the escapement-strategy is not sustainable for short-lived species, unless the strategy is combined with a ceiling (F_{cap}) on the fishing mortality. This means that if the TAC that comes out of the Escapement-strategy corresponds to an F_{bar} that exceeds F_{cap}, then the Escapement-strategy should be disqualified and the TAC is instead determined based on a fishing mortality corresponding to F_{cap}. A preliminary attempt to establish an optimal F_{cap} for SA 1 (in accordance with the concepts of a conventional management strategy evaluation and a selection criteria of 0.05 probability of SSB < B_{lim}), suggested an F_{cap} of 0.6 (preliminary value; not benchmarked yet).

Based on the misreporting of catches as observed in 2014, management measures to avoid area misreporting (only one fishing area per trip) have been mandatory for the Danish fishery since 2015. There are strong indications of area misreporting for other nations in 2015, and similar management measures as used for the Danish fishery seems to be necessary for other nations as well.

Self-sampling on board the commercial vessels for biological data should be mandatory for all nations utilising a monitoring TAC. Today samples are only obtained from the Danish fishery.

11.3 Sandeel in SA 2

11.3.1 Catch data

Total catch weight by year for SA 2 is given in Tables 11.1.2–11.1.4. Catch numbers at age by half-year is given in Table 11.3.1.

The proportion of the 1-group in the catch has decreased since 2013 (Figure 11.3.1).

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 11.3.2 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 11.3.2.

11.3.3 Maturity

Currently, there is not a sufficiently long dredge survey time-series in SA 2. Therefore means of the maturity estimates from SA 1 in the period 2005–2010 are used for the entire time series in SA 2 (Table 11.3.3.).

11.3.4 Effort and research vessel data

Trends in overall effort and CPUE

Table 11.1.5–11.1.7 and Figure 11.3.3 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 3240 days in 1985 to 136 days in 2007. In 2015, effort remained considerably lower – 573 days - than the long term average of 1443 days. CPUE in 2015 was around the long term average.

Tuning series used in the assessments

No commercial tuning series are used in the present assessment.

A dredge survey in SA 2 (Table 11.3.4) was initiated in 2010. The survey in 2012 did not cover SA 2, so the time series is still short (five years) for assessment purposes. However, as there is a strong correlation between recruitments estimated for SA 1 and SA 2 (Figure 11.3.4), the catch rate indices of age group 0 from SA 1 (Table 11.2.4) was used to calibrate the assessment of SA 2.

Details about the dredge survey are given in the Stock Annex and the benchmark report (ICES, 2010a).

The SA 2 survey was applied in an exploratory assessment this year.

11.3.5 Data analysis

The diagnostics output from SMS-effort are shown in Table 11.3.5. The seasonal effect on the relation between effort and F ("F, Season effect" in the table) is rather constant over the two year ranges used. 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 relatively higher for the most recent period 1999–2015.

The CV of the dredge survey (Table 11.3.4) is low and at the lower boundary (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 11.3.5) shows no bias for this time series.

The model CV of catch at age 1 and 2 is medium (0.436) in the first half of the year and high for the remaining ages and season combinations. The residual plots for catch at age (Figure 11.3.6) 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 most ages in the first half-year.

The CV of the fitted Stock recruitment relationship (Table 11.3.4) is high (0.97) which is also indicated by the stock recruitment plot (Figure 11.3.7). The high CV of recruitment is probably due to the biological characteristics of the stock and less due to the quality of the assessment.

The retrospective analysis (Figure 11.3.8) shows 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.

Uncertainties of the estimated SSB, F and recruitment (Figure 11.3.9) are in general moderate, which gives moderate confidence limits on estimated values (Figure 11.3.10).

The plot of standardized fishing effort and estimated F (Figure 11.3.11) shows a good relationship between effort and F as specified by the model. As the model assumes a different efficiency and catchability for the two periods 1983–1998, 1999–2015, 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 an effort unit in the most recent years. This indicates technical creep, i.e. a standard 200 GT vessel has become more efficient over time, which is not fully taken into account by splitting the time series into two periods.

11.3.6 Explorative analysis

An explorative assessment was made using the short survey time series for SA 2 (Table 11.3.4) as the only survey index. The assessment results are practically identical; however a slightly higher recruitment in 2015 and a slightly lower recruitment in 2014 are obtained with the SA 2 survey. The CV of the 2015 year-class is estimated to be 108% using the SA 2 indices, while the default configuration had a CV at 38%, showing a higher uncertainty using the SA 2 survey.

Using the assessment result for the forecast, a zero TAC in 2016 will result in an SSB of 61 kt when the SA 2 survey is used, whereas the default model gives 56 kt (both below B_{lim} = 70 kt).

Due to the short time series and the more uncertain estimate of the 2015 year class, it was decided to maintain the SA 1 survey for the SA 2 assessment.

11.3.7 Final assessment

The output from the assessment is presented in Tables 11.3.6 (fishing mortality at age by year), 11.3.7 (fishing mortality at age by half year), 11.3.8 (stock numbers at age) and 11.3.9 (stock summary).

11.3.8 Historic Stock Trends

The stock summary (Figure 11.3.12 and Table 11.3.9) show that recruitment has been highly variable and with a weak decreasing trend over the full time series. SSB has decreased considerably from 1999 to 2002 after which SSB has remained at a relatively lower level. $F_{(1-2)}$ is estimated to have been below the long-term average since 2005.

SSB in 2016 is below B_{pa} and recruitment in 2015 is estimated to be the second lowest in the time series.

11.3.9 Short-term forecasts

Input

Input to the short term forecast is given in Table 11.3.10. Stock numbers for age 1 and older in the TAC year are taken from the assessment. Recruitment in 2016 is the geometric mean of the recruitment 1983–2014 (39 billion at age 0). The exploitation pattern and F_{sq} is taken from the assessment values in 2015. As the SMS-model assumes a fixed exploitation pattern since 1999, the choice of year is not critical. Mean weight at age in the catch and in the sea is the average value for the years 2013–2015. Natural mortality and proportion mature are the fixed values applied in the assessment.

Output

The short term forecast (Table 11.3.11) shows that a zero TAC in 2016 will leave SSB below MSY $B_{trigger}$ of 100 000 t in 2017. The TAC according to the escapement strategy is therefore 0 in 2016. A monitoring TAC at 5000 t in 2016 will lead to an SSB in 2017 at 53 000 t.

11.3.10 Biological reference points

B_{lim} is set at 70 000 t and B_{pa} at 100 000 t. MSY $B_{trigger}$ is set at B_{pa}.

Further information about biological reference points can be found in the Stock Annex.

11.3.11 Quality of the assessment

There is only five years of fishery independent data available from the dredge survey in December covering the main fishing banks in SA 2. The present use of data from the dredge survey in SA 1 improves the quality of the assessment, but the newly established survey should be continued. An explorative assessment this year, using the SA 2 index, gave similar assessment results, but the uncertainty of the recruitment in the most recent years was considerably higher using the SA 2 index.

The model uses effort as basis for the calculation of F. The total international effort is derived from Danish CPUE and total international catches. Danish catches are by far the largest in the area, but effort by the individual countries would improve the quality of the assessment.

11.3.12 Status of the Stock

A low F since 2006 in combination with a moderate recruitment have given an increasing SSB since the historical low values in 2001 and 2004. SSB in 2016 is estimated lower than B_{pa}. Recruitment in 2015 is estimated well below average.

11.3.13 Management considerations

A management plan needs to be developed. The ICES approach for MSY based management of a short-lived species such 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. Management strategy evaluations presented at the ICES WKMSYREF2 meeting in 2014 (ICES, 2014a) supported this conclusion, by establishing that the escapement-strategy is not sustainable for short-lived species, unless the strategy is combined with a ceiling (F_{cap}) on the fishing mortality.

This means that if the TAC that results from the Escapement-strategy corresponds to an F_{bar} that exceeds F_{cap}, then the Escapement-strategy should be disqualified and the TAC is instead determined based on a fishing mortality corresponding to F_{cap}. A preliminary attempt to establish an optimal F_{cap} for SA 2 (in accordance with the concepts of a conventional management strategy evaluation and a selection criteria of 0.05 probability of SSB < B_{lim}), indicated that an F of 0.4 is close to the F_{cap} for this area (preliminary F_{cap} = 0.4; not benchmarked).

Self-sampling on board the commercial vessels for biological data should be mandatory for all nations utilising a monitoring TAC. Today samples are only obtained from the Danish fishery.

11.4 Sandeel in SA 3

11.4.1 Catch data

Total catch weight by year for SA 3 is given in Tables 11.1.2–11.1.4. Catch numbers at age by half-year is given in Table 11.4.1.

The proportions of age groups in the 2013–2015 catches are quite similar with approximately 65% 1-group (Figure 11.4.1).

11.4.2 Weight at age

The mean weights at age observed in the catch are given in Table 11.4.2 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 11.4.2. Mean weight of age 1–4 in the first half-year has increased since 2013 and is now around long term average.

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 11.4.3). Based on the dredge survey of December 2015 the proportion mature at age in 2016 is close to the average.

11.4.4 Effort and research vessel data

Trends in overall effort and CPUE

Tables 11.1.5–11.1.7 and Figure 11.4.3 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 peaked in 1998 (12 176 days), and declined thereafter to less than 2000 days since 2005.

Tuning series used in the assessments

A time series of stratified catch rates (Table 11.4.4) from the dredge survey was used to calibrate the assessment. This survey covers mainly the southern part of SA 3 (Figure 11.1.4).

In 2015 data form the dredge survey show the highest index for the age-1 in the time series (Table 11.4.4). The index is highly influenced by two positions (six hauls) that had very high and consistent catch rates in ICES rectangle 43F4: A high 0-group index was observed in the same rectangle in 2015. Catch rates of both 0- and 1-groups were low outside rectangle 43F4 in 2015 (Figure 11.1.4).

In 2014, 13 new positions were included in the survey in SA 3. Only two of the new positions were taken in squares not included before – 42F5 and 42F6. All the new positions have been included in the survey index since 2014 (Table 11.4.4) for assessment purposes, to obtain a better spatial coverage.

The estimated 1-goup index for 2015 (7112) is seven times higher than the maximum value in the preceding period. The 0-group index is low.

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 11.4.4) shows high consistency for both age 0 vs. age 1 and age 1 vs. age 2.

Details about the dredge survey are given in the Stock Annex and the benchmark report (ICES, 2010a).

11.4.5 Norwegian Acoustic Survey

A Norwegian Acoustic survey in Norwegian EEZ has been conducted in April-May since 2007 allowing a preliminary analysis of the potential use of this survey in the assessment in SA 3. The survey design is stratified systematically with parallel or zigzag transects. The starting position in each stratum is random. By using multi frequency acoustic, the sandeel schools are identified and the average nautical area scattering coefficient (NASC) classified as sandeel is calculated by stratum (Figure 11.1.5). 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 11.1.5) 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 11.4.12. The 1-group index in 2015 is around average, which is in contrast to the very high index from the dredge survey.

11.4.6 Data Analysis

The diagnostics output from SMS-effort model is shown in Table 11.4.5. 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. In the period 1989–1998, the relative fishing pressure in the first half-year was much higher than in the periods before and after.

This is also reflected in the "Exploitation pattern" where the period 1989–1998 had a relatively low fishing pressure in the second half-year.

The CV of the dredge survey (Table 11.4.5) is low (0.30) for age 0 and high (1.09) for age 1, showing an overall medium consistency between the results from the dredge survey and the overall model results. Last year the CV for age 0 was 0.48. The reduction from 0.48 to 0.30 might be a result of an additional data year with consistent data, or might be a "flip" to a new state, dominated by the 0-group in absence of a clear signal from other data sources. The survey residuals (Figure 11.4.5) plot shows a series of positive residuals from 2007–2011 for the 1 group and as expected a very high residual in 2015, while the residuals for the 0-group are more randomly distributed.

The model CV of catch at age is medium-high (0.686) for age 1 and age 2 in the first half of the year (Table 11.4.5). For the older ages and for all ages in the second half year, the CVs are very high. Compared to last year, the fit of catches is poorer, probably due to the higher weight (lower CV) on the 0-group survey index. The catch residual plots for catch at age (Figure 11.4.6) confirm that the fits are generally very poor except for age 1 and 2 in the first half year. There is a tendency for cluster of negative or positive residuals for all ages.

The CV of the fitted stock recruitment relationship (Table 11.4.5) is high (0.99), which is also indicated by the stock recruitment plot (Figure 11.4.7). The high CV of recruitment is probably due to the biological characteristics of the stock and less due to the quality of the assessment. The *a priori* weight on likelihood contributions from SSR-R observations is therefore set low (0.01 in "objective function weight" in Table 11.4.5) such that SSB-R estimates do not contribute much to the overall model likelihood and fit.

The retrospective analysis (Figure 11.4.8) shows consistent assessment results from one year to the next. This is probably due to the assumed relationship between effort and F, which is insensitive to addition of a few years. The estimate of recruitment in 2013–2014 was decreased compared to the most recent assessment.

Uncertainties of the estimated SSB, F and recruitment (Figure 11.4.9) are in general medium, which gives wide confidence limits (Figure 11.4.10) on output variables. In this year's assessment the CV of the most recent recruitment is lower than last year which is in accordance with the lower estimated CV of the dredge survey 0-group index. Please note that the confidence limits in Figure 11.4.10 assume a normally distributed F, SSB and recruitment, where an assumption of a log-normal distribution would probably be more correct.

The plot of standardized fishing effort and estimated F (Figure 11.4.11) shows a moderate relation between effort and F as assumed by the model specification. As the model assumes a different catchability at age for the three periods 1983–1988, 1989–1998 and 1999–2015, and as the seasonal distribution of the fishery is variable from one period 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 generally lower than effort on the plot, while the opposite is the case for the remaining periods, corresponding to a technical creep over time, not fully taken into account by the three periods.

11.4.6.1 Explorative assessment using the Norwegian Acoustic Survey

As done last year, an explorative assessment was attempted in which the Norwegian acoustic survey was included together with the dredge survey.

Diagnostics (table 11.4.13) are quite similar to the default assessments; however the CV of the 0-group index from the dredge survey is not estimated to the lower bound (0.30) as in the default assessment, probably because the additional survey data makes it impossible to fit one time series only to "perfection". The acoustic data fits reasonably well into the model (CV of the acoustic survey is 0.58 for ages 1 and 2. The pattern of acoustic residuals appears random (and therefore fine) (Figure 11.4.13) and catch residuals (Figure 11.4.14) are similar to residuals from the default assessment.

When comparing assessment results with and without the acoustic survey, stock dynamics (Figure 11.4.17) are similar; however, the use of the acoustic survey gives an approximately 30% lower SSB in the years 2015–2016.

11.4.6.2 Choice of assessment for advice

The dredge survey effort increased considerably in 2014 and 2015 in Norwegian NEEZ. In 2012 and 2013 only six dredge stations were carried out in Norwegian waters, whereas 25 stations were carried out in 2014 and 2015. However, only two of the new positions were in ICES rectangles not included before – 42F5 and 42F6. All the new positions were included in the survey index for 2014 in last year's assessment to obtain a better spatial coverage. Excluding the new positions would result in a 10% decrease in the index for the age-0 and an increase of 10% for the age-1, in 2014.

In 2014, data from the dredge survey showed the highest index for the age-0 in the time series (Table 11.4.4). The overall index was highly influenced by two positions (six hauls) in ICES rectangle 43F3 with consistently very high catch rates, but high catch rates are also found in other areas of SA 3 (Figure 11.1.4). In 2015 the same two positions had a very high catch of age 1, but in contrast to the situation in 2014, no other stations had high catches in 2015. Therefore the historic high age 1 index for 2015 is mainly driven by catch rates from the two stations.

One of the two stations in rectangle 43F3 was added in 2014, but as the CPUE from the "old" and the "new" stations are similar (both very high), and as the dredge index is calculated on the basis of average CPUE per rectangle, the addition of the new stations since 2014 will not bias the assessment result.

Last year there was also concern about the dredge survey index. The very high (660 kt) TAC suggested for 2015 on the basis of mainly the high 0-group index in 2014 was downscaled to 370 kt due to uncertainties around the survey index and a high forecast F estimated by the escapement strategy.

The Norwegian acoustic survey shows a 1-group index in 2015 around average, which is in contrast to the historic high index from the dredge survey. The acoustic survey covers just the Norwegian EEZ of SA 3, but this part has historically included most of the catches from SA 3. The dredge survey has a more complete coverage of SA 3. The acoustic survey showed high sandeel densities in the area where the dredge survey had the very high catch rates.

The very high 1-group index from the dredge survey in 2015 resulted in a high SSB in 2015 and a historic high estimate of SSB in 2016 when using the benchmark settings. Such high biomasses were not observed in fisheries in the EU zone of SA 3 in 2014 and 2015, where the quota uptake was low. The Norwegian fleet landed the national quota of 100 kt in 2015. However, neither the feedback from the fishing organizations nor the acoustic survey supported a historical high abundance of sandeel in SA 3 in 2015.

Last year, explorative assessments were made a) using dredge survey with only the old stations, b) using the dredge survey with all stations, and c) using both the dredge survey with all stations and the acoustic survey. They all gave similar results in both the historical assessment and forecast (666 kt, 660 kt and 669 kt, respectively, with the escapement strategy).

The "change in state" for the default assessment where the CV of the dredge survey 0-group index changed from 0.45 in last year's assessment to 0.30 in this year's assessment might be a result of the very high 0-group index in 2014 followed by the very high 1-group index in 2015. However, it could also be seen as a false signal, where fitting one data series (the 0-group index) to perfection (reach lower CV bound set at 0.3) is the "best" signal found in data. When both the dredge and the acoustic indices are used, the CV for the 0-group dredge survey (0.47) "flips" back to last year's value (0.49).

Both model diagnostics and the record high estimated SSB in 2016 for the default assessment indicates that the addition of the acoustic survey will improve the assessment quality. However, the high catch rates for the two dredge survey stations in 2014 (age 0) and 2015 (age 1) show a consistent signal and the high local density was confirmed from the acoustic survey. The problem seems to be the way the individual survey catch rates are combined into a year index used for assessment. This in combination with the present management system with closed and open areas in Norwegian EEZ, exclusive national fishing access to the national EEZs and an apparent stationary stock after the larvae period suggest a more comprehensive analysis is needed and not just a quick fix of adding another survey. These issues will be included in the planned benchmark June-November 2016. Therefore, it was decided to use assessment method as outlined in the Stock Annex as "final assessment" used for the advice.

11.4.7 Final assessment

The output from the final assessment is presented in Tables 11.4.6 (fishing mortality at age), 11.4.7 (fishing mortality at age by half year), 4.11.8 (stock numbers at age) and 4.11.9 (Stock summary).

11.4.8 Historic Stock Trends

SSB has been at or below B_{lim} from 2000 to 2007 after which SSB increased to above B_{pa} in 2010. This was followed by SSB below B_{lim} in 2013–2014 (Figure 11.4.16 and Table 11.4.17). High recruitments in 2013 and 2014, both produced by an SSB below approximately half of B_{lim}, have resulted in SSB above B_{pa} in 2016.

The estimated recruitment in 2014 is the second highest in the time series, whereas the recruitment in 2015 is estimated as the lowest short-term forecast.

11.4.9 Short-term forecasts

Input

Input to the short term forecast is given in Table 11.4.11. Stock numbers in the TAC year are taken from the assessment for age 1 and older. Recruitment in 2016 is the geometric mean of the recruitment 1983–2014 (93 billion at age 0). The exploitation pattern and F_{sq} is taken from the assessment values in 2015. As the SMS-model assumes a fixed exploitation pattern since 1999, the choice of year is not critical. Mean weight at age in the catch and in the sea is the average value for the years 2013–2015.

Proportion mature in 2016 is estimated from the dredge survey in December 2015. For 2017, 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 escapement strategy provides a TAC of 123 kt, corresponding to F = 0.407 (Table 11.4.19).

Concern about the use of an unbound forecast F in the escapement strategy has previously been raised. Management strategy evaluations presented at the ICES WKMSYREF2 meeting in 2014 (ICES, 2014a) concluded that the escapement-strategy is not sustainable for short-lived species, unless the strategy is combined with a ceiling (F_{cap}) on the fishing mortality. This means that if the TAC that comes out of the Escapement-strategy corresponds to an F_{bar} that exceeds F_{cap}, then the Escapement-strategy should be disqualified and the TAC is instead determined based on a fishing mortality corresponding to F_{cap}. A preliminary estimate of F_{cap} = 0.8 for SA 3 sandeel was suggested in the HAWG 2014 report (ICES, 2014b). A more comprehensive model study, based on the same approach as was used for the WKMSYREF2 study (ICES, 2014a), estimated that an F_{cap} > 0.9 for SA 3 sandeel is not precautionary (Mosegaard *et al.*, 2014).

11.4.10 Biological reference points

B_{lim} is set at 100 000 t and B_{pa} is estimated to 195 000 t. MSY $B_{trigger}$ is set at B_{pa}. Further information about biological reference points can be found in the Stock Annex.

11.4.11 Quality of the assessment

Catches of sandeel in the Northern North Sea (mainly SA 3 sandeel) have decreased far more than sandeel from SA 1. This heterogeneity is one of the reasons for the present area specific assessments. While the quality (based on confidence limits of SSB and F) of the SA 1 assessment is high, the quality of the SA 3 assessment is lower. This is partly due to quality of input to the assessment. Norwegian effort data with the right resolution have only been available in recent years, and the relationship between Norwegian and Danish CPUEs is not well known. Area misreporting in 2014 and 2015 and the following reallocation of catches and effort might also have increased the uncertainty.

The dredge survey covered mainly the southern part of SA 3. A northerly extension of the survey and 13 new stations since 2014 has increased the coverage of the survey. The 2014 and 2015 assessment results are robust to the inclusion of new stations in the survey. The assessment results this year with a very high 2014 year-class are highly dependent on CPUE from the dredge survey from two stations in rectangle 42F3. This might have biased the assessment (overestimated the stock size) but it was not possible this year to suggest a better method for calculating the survey index, taking the very heterogeneous distribution of both stock and fishery into account. This will be part of the benchmark, June-November 2016, for the stock.

Application of the new statistical assessment model SMS-effort since 2010 resulted in less 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 and a more appropriate stock definition. However, very different regulation in the EU EEZ and the Norwegian EEZ (Norwegian EEZ has been closed in some years and partially open in others) conflicts with the assumption of a homogeneous stock distribution taken for cohort models such as SMS.

11.4.12 Status of the Stock

The SSB has increased from half of B_{lim} in 2013–2014 to above B_{pa} in 2016, due to high recruitment in 2013 and 2014. Recruitment estimate for 2015 is uncertain but is estimated to be very low.

11.4.13 Management Considerations

A management plan needs to be developed for SA 3 sandeel. SA 3 comprises both Norwegian and EU EEZ, and currently there is no agreement between the parties on management of the stock. The EU fishery is managed on the basis of the ICES advice, 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 SA 3 sandeel is considered uncertain, it is considered adequate as the basis for TAC advice.

Based on the misreporting of catches as observed in 2014, management measures to avoid area misreporting (only one fishing area per trip) have been mandatory for the Danish fishery since 2015. There are strong indications of area misreporting for other nations in 2015, and similar management measures as used for the Danish fishery seems to be necessary for other nations as well.

11.5 Sandeel in SA 4

11.5.1 Catch data

Total catch weight by year for SA 4 is given in Tables 11.1.2–11.1.4.

Catch numbers at age by half year is given in Table 11.5.1.

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 11.5.2 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 11.5.1.

11.5.3 Effort and research vessel data

Trends in overall effort and CPUE

Tables 11.1.5–11.1.7 and Figure 11.5.2 show the trends in the international effort over years measured as number of fishing days standardized to a 200 GRT vessel. The standardization includes just the effect of vessel size, and does not take changes in efficiency into account. The figure also shows the development in CPUE, which shows large fluctuations in recent years with very high CPUEs in 2009 and 2014. However, in recent years, very low effort and catches have been taken in the area and the uncertainty in the estimated mean CPUE and catch at age is presumably large.

Abundance indices

The Marine Scotland Science (MSS) sandeel survey of SA4, off the north eastern coast of the UK, was established in 2008 to complement the Danish dredge survey of SAs 1–3. The survey is targeted on the banks that were historically fished off the Firth of Forth and around Turbot bank, and the survey takes place in late November or early December to coincide with the Danish sampling.

Dredge hauls encompassing the major Firth of Banks banks were taken at eight stations in 1999–2003; three stations on the Wee Bankie, three on Marr Bank and two on Berwick Bank. In 2008–2015, additional stations were sampled over Berwick Bank and around the Wee Bankie grounds. During 2008–2013, and in 2015, the Turbot bank and/or nearby patches of sandeel habitat have also been surveyed. The survey in 2015 (see WD3, Annex 4) sampled from four stations on Wee Bankie, two on Marr Bank and four on Berwick Bank. Five stations over Turbot Bank were dredged for the first time since 2012. Where possible, five tows of 10 minute duration were made per station, although, due to poor weather, on some days this was reduced to two.

The CPUE from the survey areas is presented in Table 11.5.3. As only sandeels ≥ 8.5 cm TL are fully selected by the gear and many 0-group are typically below this length, age 1 catches are generally higher than age 0 for a given year-class, although this was not the case for the 2012 and 2013 year-classes. Nevertheless, catch rates at age 1 were significantly correlated with age 0 and similarly for catch rates of age 1 and 2 ($P < 0.05$, Figure 11.5.3).

The 2014 year-class signal remained dominant in all hauls at all stations (Table 2a and b) with age-1 CPUE values comparable to those in 2010. This year's recruiting 0-group CPUE was low, similar to that observed throughout 2010–2013.

Stock status

An index of abundance was estimated as the average of the anomaly of the index of 0- and 1-year olds. Both 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. This resulted in a catch multiplier CM of:

$$CM_y = \frac{(1 + \bar{I}_y)}{(1 + (\bar{I}_{y-1} + \bar{I}_{y-2} + \bar{I}_{y-3} + \bar{I}_{y-4})/4)}$$

Where y indicates year = 2015. The method is similar to the methods used for sprat in 3a, and differs slightly from that used for long-lived species (see ICES, 2013 for discussion). As the precautionary buffer of 20% was applied in 2014, is was not applied again this year.

If the index $\bar{I}$ exceeds 0.2 or falls below –0.2, it is replaced by a cap of 0.2 and –0.2, respectively, so the minimum and maximum value of CM are 0.8 and 1.2.

The catch multiplier is used to estimate next year's TAC as

$$TAC_y = CM(C_{y-1}+C_{y-2}+C_{y-3})/3$$

Applying the rule, the catch multiplier is estimated at 2.59, which is then replaced by a catch multiplier of 1.2. As the average catch over the last three years is 4678 t, the TAC using this method will be 5614 t.

To produce an analytical assessment for SA 4, information on older age groups is needed in addition to the dredge survey information. The low and variable catchability of older age classes in the dredge renders the assessments completely dependent on information of 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 ICES, 2010b). Based on past average sandeel tonnes per haul (commercially around 55 t) and the fact that it would be preferable to sample no more than once every three hauls in order to reduce correlation, a monitoring catch obtaining a minimum of 30 samples would be of the order of 5000 t. This monitoring TAC should over time result in an analytical assessment for SA 4. It is considered that the suggested TAC by the catch multiplier rule (5614 t) will be sufficient to achieve the samples to produce an analytical assessment in the near future.

11.6 Sandeel in SA 5

11.6.1 Catch data

Total catch weight by year for SA 5 is given in Tables 11.1.2–11.1.4. No landings from this area have been taken since 2007. Acoustic surveys have been carried out since 2005 on Vikingbanken, which is the main sandeel ground in SA5. The survey estimates show a low biomass of sandeel on Vikingbanken.

11.7 Sandeel in SA 6

11.7.1 Catch data

Total catch weight by year for SA 6 is given in Tables 11.1.2–11.1.4.

11.8 Sandeel in SA 7

11.8.1 Catch data

Total catch weight by year for SA 7 is given in Tables 11.1.2–11.1.4 No catches from this area have been taken since 2003.

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Table 11.1.1. Sandeel. Catches ('000 t), 1955–2015. (Data provided by Working Group Members).

Year	Denmark	Germany	Faroes	Ireland	Nether-lands	Norway	Sweden	UK	Lithu-ania	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	-	-	-	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	-	-	-	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	0.2	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	-	-	12.2	0.2	37	-	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	-	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	-	-	160.7	-	9.7	-	824.8
1997	831.8	-	11.2	-	-	350.1	-	24.6	-	1217.8
1998	628.2	-	11	-	+	343.3	8.6	23.8	-	1014.8

Year	Denmark	Germany	Faroes	Ireland	Nether-lands	Norway	Sweden	UK	Lithu-ania	Total
1999	511.3	-	13.2	0.4	+	187.6	23.2	11.5	-	747.1
2000	557.3	-	-	-	+	119	28.6	10.8	-	715.7
2001	650.0	-	-	-	-	183	50	1.3	-	884.3
2002	659.5	-	-	-	-	176	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	2	-	-	51.1	7.9	1	-	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	352.9
2010	285.9	13	-	-	-	78	32.7	4	0.6	414.2
2011	278.5	9.8	-	-	-	109	32.7	6.1	1.7	437.8
2012	51.5	1.7	-	-	-	42.5	5.7	-	-	101.4
2013	208.7	7.9	-	-	0.4	30.446	26.8	2.436	1.3	278.0
2014	156.3	5.1	-	-	-	82.5	18.8	+	0.8	263.8
2015	162.9	9.1	-	-	-	100.9	32.9	1.6	-	307.3

Table 11.1.2. Sandeel. Total catch (tonnes) by area as estimated by ICES.

	SA 1	SA 2	SA 3	SA 4	SA 5	SA 6	SA 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	205853	49766	449847	158690	2762	3748	0	870666
1995	408676	59847	267559	52591	152274	1830	0	942776
1996	279863	62121	295489	158490	27571	1263	0	824796
1997	424701	100918	617570	58446	11689	2372	2143	1217839
1998	373369	69461	504251	58746	2952	941	5121	1014841
1999	423993	31646	233419	53334	145	132	4415	747083
2000	363606	52299	255908	37792	324	684	4350	714963
2001	522337	58758	252293	47918	1678	306	971	884260
2002	611064	36974	195957	12761	8	2386	453	859604
2003	150708	56304	62455	64048	44	900	260	334718
2004	206752	71085	88011	6882	0	573	0	373302
2005	105337	43395	26093	1557	0	259	0	176640
2006	238293	35435	18828	86	0	161	0	292802
2007	109067	5891	114231	11	4	652	0	229855
2008	235031	12709	98456	1168	0	472	0	347836
2009	309709	9578	33376	0	0	260	0	352922
2010	298514	30738	84524	275	0	132	0	414183
2011	311811	29848	95347	272	0	484	0	437761
2012	45998	8246	43074	2585	0	211	0	99904
2013	210056	23534	39084	5225	0	90	0	277989
2014	99234	8929	142608	4414	0	79	0	255184
2015	163429	20993	118538	4384	0	229	0	307344
arith. mean	313058	55833	215532	31712	7111	1050	537	624625

Table 11.1.3. Sandeel. Total catch (tonnes) by area, first half year as estimated by ICES.

	SA 1	SA 2	SA 3	SA 4	SA 5	SA 6	SA 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	187429	23063	394012	147019	2759	3222	0	757503
1995	371069	25246	243035	52497	152269	1829	0	845945
1996	244749	45417	141395	48496	14551	1168	0	495777
1997	343868	51719	522528	47668	9349	2194	1714	979040
1998	355798	43302	380105	57212	2851	939	4472	844679
1999	390079	22687	104421	51179	145	21	2152	570684
2000	323082	36537	247478	37792	308	683	3788	649668
2001	356820	33591	82467	47492	1678	57	735	522841
2002	606623	21669	194623	12761	8	2386	101	838171
2003	128742	46653	27890	62578	44	848	187	266941
2004	191182	52934	68404	6860	0	571	0	319951
2005	102115	33548	24957	1557	0	259	0	162434
2006	233953	22080	15767	55	0	160	0	272015
2007	109061	5891	114230	11	4	651	0	229848
2008	231731	9487	98333	1168	0	471	0	341189
2009	292985	9235	22058	0	0	259	0	324538
2010	294655	21875	81892	275	0	132	0	398830
2011	308904	28279	95341	272	0	484	0	433278
2012	45996	8222	41930	2585	0	0	0	98733
2013	207846	13943	38756	5225	0	90	0	265860
2014	94333	8924	140192	4414	0	0	0	247863
2015	163428	20944	117824	4384	0	0	0	306579
arith. mean	281932	40865	169594	26396	6477	803	398	526465

Table 11.1.4. Sandeel. Total catch (tonnes) by area, second half year as estimated by ICES.

	SA 1	SA 2	SA 3	SA 4	SA 5	SA 6	SA 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	18423	26703	55836	11671	3	526	0	113163
1995	37607	34601	24524	94	5	1	0	96831
1996	35113	16704	154093	109994	13020	95	0	329019
1997	80832	49198	95041	10779	2340	179	429	238799
1998	17571	26159	124146	1533	101	1	649	170162
1999	33913	8959	128998	2154	0	111	2263	176399
2000	40524	15763	8430	0	15	1	562	65295
2001	165517	25167	169825	426	0	248	236	361419
2002	4441	15306	1334	0	0	0	352	21433
2003	21966	9651	34565	1469	0	52	73	67777
2004	15569	18151	19607	22	0	2	0	53351
2005	3222	9847	1136	0	0	0	0	14206
2006	4341	13355	3060	30	0	0	0	20787
2007	6	0	0	0	0	1	0	7
2008	3300	3223	124	0	0	0	0	6647
2009	16724	342	11318	0	0	0	0	28384
2010	3859	8863	2631	0	0	0	0	15353
2011	2908	1569	6	0	0	0	0	4483
2012	2	24	1144	0	0	0	0	1171
2013	2210	9591	328	0	0	0	0	12128
2014	4901	5	2415	0	0	0	0	7321
2015	1	49	714	0	0	0	0	764
arith. mean	31126	14967	45938	5316	634	41	138	98160

Table 11.1.5. Sandeel. Effort (days fishing for a standard 200 GT vessel) by area, as estimated by ICES.

	SA 1	SA 2	SA 3	SA 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	3361	880	7726	1586	13552
1995	5983	1199	4993	422	12597
1996	5291	1364	7620	1427	15702
1997	5475	2206	11163	636	19480
1998	6771	1876	12102	626	21375
1999	8526	892	6860	803	17080
2000	6883	1262	5504	409	14057
2001	10559	1540	5955	666	18720
2002	8229	1235	3970	143	13577
2003	6186	2037	2776	1146	12145
2004	6987	2382	3158	212	12739
2005	2948	1164	795	88	4995
2006	4314	1016	566	2	5897
2007	1772	136	2068	1	3977
2008	2930	303	1894	8	5134
2009	4196	219	647	0	5062
2010	2962	522	2237	4	5726
2011	3449	759	686	16	4910
2012	644	266	741	75	1725
2013	3905	677	1298	44	5924
2014	2365	237	1803	58	4463
2015	2252	573	1534	48	4406
arith. mean	5792	1443	4780	364	12380

Table 11.1.6. Sandeel. Effort (days fishing for a standard 200 GT vessel) by area, first half year as estimated by ICES.

	SA 1	SA 2	SA 3	SA 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	3001	401	6679	1408	11489
1995	5335	569	4483	420	10807
1996	4596	889	3897	503	9884
1997	4058	883	8493	501	13935
1998	6243	964	7888	590	15686
1999	7470	634	3058	803	11965
2000	5965	772	5289	409	12434
2001	7702	908	2266	652	11528
2002	8042	597	3873	143	12654
2003	5347	1568	1462	1071	9448
2004	6540	1667	2370	211	10787
2005	2901	860	760	88	4609
2006	4184	625	498	2	5309
2007	1772	136	2068	1	3977
2008	2853	208	1886	8	4954
2009	3992	213	473	0	4678
2010	2856	341	2161	4	5361
2011	3413	678	686	16	4792
2012	644	266	718	75	1702
2013	3858	356	1271	44	5529
2014	2299	237	1739	58	4333
2015	2252	573	1512	48	4385
arith. mean	5069	1017	3578	302	9966

Table 11.1.7. Sandeel. Effort (days fishing for a standard 200 GT vessel) by area, second half year as estimated by ICES.

	SA 1	SA 2	SA 3	SA 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	360	479	1047	178	2064
1995	648	630	510	1	1790
1996	695	475	3723	924	5818
1997	1417	1323	2670	135	5545
1998	528	911	4214	36	5690
1999	1055	258	3802	0	5115
2000	918	491	215	0	1623
2001	2857	632	3689	13	7192
2002	187	638	97	0	923
2003	838	469	1314	75	2697
2004	447	715	789	2	1952
2005	47	304	34	0	385
2006	130	391	67	0	587
2007	0	0	0	0	0
2008	77	95	7	0	180
2009	203	6	174	0	384
2010	107	182	76	0	364
2011	36	81	0	0	118
2012	0	0	23	0	23
2013	48	321	27	0	395
2014	66	0	64	0	130
2015	0	0	22	0	22
arith. mean	723	426	1202	62	2414

Table 11.1.8. Sandeel. Number of samples from commercial catches by year and area.

	SA 1	SA 2	SA 3	SA 4	SA 5	SA 6	All
1983	73	21	15	0	0	0	109
1984	116	15	31	0	2	0	164
1985	97	26	9	19	2	0	153
1986	28	2	39	1	0	0	70
1987	63	6	65	1	0	0	135
1988	40	4	76	0	0	0	120
1989	38	7	47	0	0	1	93
1990	2	1	39	0	0	2	44
1991	25	9	53	1	0	0	88
1992	54	19	49	4	0	7	133
1993	21	17	112	15	0	7	172
1994	20	9	79	15	0	4	127
1995	42	15	74	7	7	2	147
1996	39	15	164	27	19	1	265
1997	37	24	180	25	8	3	277
1998	62	14	204	7	0	2	289
1999	258	32	65	44	0	1	400
2000	102	16	79	59	0	2	258
2001	211	9	68	90	1	1	380
2002	289	28	120	62	0	1	500
2003	261	65	64	160	0	2	552
2004	446	66	182	47	0	1	742
2005	306	41	49	30	0	1	427
2006	539	27	112	2	0	2	682
2007	287	17	265	0	0	1	570
2008	291	11	164	1	0	0	467
2009	303	7	126	0	0	1	437
2010	172	28	279	1	0	3	483
2011	161	50	27	4	0	4	246
2012	220	64	79	21	0	12	396
2013	295	24	234	5	0	3	561
2014	143	52	110	18	0	5	328
2015	311	63	100	38	0	4	516
Sum	5352	804	3359	704	39	73	10331

Table 11.2.1. Sandeel SA 1. Catch at age numbers (million) by half year.

	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	371	0	413	0	3321	0	127	0
2013	3	18149	263	7916	61	2188	25	4309	17
2014	926	8986	131	3372	98	403	23	361	25
2015	0	25399	0	1904	0	566	0	164	0
arith. mean	3337	24859	1863	9293	605	2318	196	713	37

Table 11.2.2. Sandeel SA 1. Individual mean weight (gram) at age in the catch and in the sea.

	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	4.1	6.4	8.9	9.5	13.4	11.3	16.8	14.5	21.3
2013	2.4	4.7	5.0	6.5	7.5	10.0	9.4	11.3	11.9
2014	2.8	4.7	5.9	7.1	9.0	9.5	11.3	11.7	14.3
2015	3.2	5.4	6.7	8.2	10.1	10.4	12.6	13.7	16.0
arith. mean	3.0	5.7	6.9	9.7	10.3	12.5	13.0	15.6	17.0

Table 11.2.3. Sandeel SA 1. Proportion mature.

	Age 1	Age 2	Age 3	Age 4
1983-2004	0.02	0.83	1.00	1
2005	0.06	0.98	1.00	1
2006	0.01	0.90	1.00	1
2007	0.01	0.94	1.00	1
2008	0.02	0.97	1.00	1
2009	0.00	0.61	1.00	1
2010	0.01	0.56	1.00	1
2011	0.00	0.58	1.00	1
2012	0.03	0.77	1.00	1
2013	0.01	0.85	1.00	1
2014	0.00	0.70	1.00	1
2015	0.07	0.87	0.98	1
2016	0.03	0.88	0.87	1

Table 11.2.4. Sandeel SA 1. Dredge survey indices (number/hour).

Year	Age 0	Age 1	Age 2
2004	960	148	2.4
2005	2141	49	8.1
2006	1496	241	1.5
2007	3449	107	11.1
2008	458	348	19.3
2009	3755	74	30.2
2010	423	2015	73.9
2011	661	950	653.8
2012	2069	215	19.1
2013	847	258	17.0
2014	1744	73	19.5
2015	320	229	10.4

Table 11.2.5. Sandeel SA 1. SMS settings and statistics.

```
Date: 01/22/16  Start time:07:56:26 run time:0 seconds

 objective function (negative log likelihood):  39.051
 Number of parameters: 58
 Maximum gradient: 5.21999e-005
 Akaike information criterion (AIC):   194.102
 Number of observations used in the likelihood:
                            Catch    CPUE     S/R Stomach     Sum
                             297      24      33       0      354

 objective function weight:
                          Catch  CPUE   S/R
                          1.00  1.00  0.05

 unweighted objective function contributions (total):
                Catch    CPUE    S/R   Stom.  Stom N.  Penalty    Sum
               42.8    -4.3    11.1     0.0     0.0      0.00      50


 unweighted objective function contributions (per observation):
                Catch   CPUE     S/R   Stomachs
                 0.14   -0.18    0.34    0.00


 contribution by fleet:
 ----------------------
 Dredge survey 2004-2015     total:  -4.333   mean:  -0.181

 F, season effect:
 -----------------
 age: 0
     1983-1988:   0.000 1.000
     1989-1998:   0.000 1.000
     1999-2015:   0.000 1.000
 age: 1 - 4
     1983-1988:   0.504 0.500
     1989-1998:   0.477 0.500
     1999-2015:   0.369 0.500

 F, age effect:
 --------------
                0      1      2      3      4
 1983-1988:  0.018  0.191  0.814  1.315  1.315
 1989-1998:  0.027  0.433  0.645  0.730  0.730
 1999-2015:  0.027  0.733  1.018  0.758  0.758


 Exploitation pattern (scaled to mean F=1)
 -----------------------------------------
                        0      1      2      3      4
 1983-1988 season 1:      0  0.294  1.254  2.026  2.026
           season 2:  0.016  0.086  0.365  0.590  0.590

 1989-1998 season 1:      0  0.765  1.140  1.291  1.291
           season 2:  0.005  0.038  0.057  0.064  0.064

 1999-2015 season 1:      0  0.703  0.976  0.727  0.727
           season 2:  0.010  0.134  0.187  0.139  0.139
```

```
sqrt(catch variance) ~ CV:
 --------------------------

              season
 ----------------------
 age        1       2

  0               1.125
  1       0.373   0.690
  2       0.373   0.690
  3       0.703   1.256
  4       0.703   1.256


 Survey catchability:
 --------------------
                               age 0    age 1
  Dredge survey 2004-2015       2.018    1.359

 sqrt(Survey variance) ~ CV:
 ---------------------------
                               age 0    age 1
  Dredge survey 2004-2015        0.30     0.95

 Recruit-SSB             alfa      beta       recruit s2     recruit s
 Area-1             1213.700   1.600e+005   0.721          0.849
```

Table 11.2.6. Sandeel SA 1. Annual fishing mortality (F) at age.

	Age 0	Age 1	Age 2	Age 3	Age 4	Avg. 1-2
1983	0.009	0.243	0.973	1.557	1.558	0.608
1984	0.010	0.275	1.101	1.760	1.760	0.688
1985	0.009	0.279	1.114	1.777	1.777	0.697
1986	0.003	0.213	0.842	1.335	1.333	0.527
1987	0.005	0.148	0.594	0.952	0.952	0.371
1988	0.004	0.214	0.850	1.349	1.347	0.532
1989	0.003	0.701	0.979	1.092	1.089	0.840
1990	0.005	0.638	0.892	0.997	0.996	0.765
1991	0.013	0.492	0.697	0.788	0.788	0.595
1992	0.009	0.725	1.017	1.140	1.138	0.871
1993	0.004	0.295	0.415	0.465	0.465	0.355
1994	0.003	0.273	0.383	0.429	0.428	0.328
1995	0.006	0.483	0.678	0.759	0.758	0.580
1996	0.006	0.424	0.596	0.669	0.668	0.510
1997	0.012	0.419	0.594	0.672	0.673	0.506
1998	0.005	0.551	0.772	0.862	0.861	0.661
1999	0.011	1.107	1.454	1.083	1.082	1.280
2000	0.010	0.897	1.179	0.877	0.877	1.038
2001	0.030	1.347	1.791	1.345	1.347	1.569
2002	0.002	1.078	1.403	1.040	1.038	1.240
2003	0.009	0.808	1.061	0.789	0.789	0.934
2004	0.005	0.917	1.197	0.888	0.886	1.057
2005	0.000	0.395	0.514	0.378	0.377	0.455
2006	0.001	0.574	0.748	0.552	0.550	0.661
2007	0.000	0.240	0.311	0.228	0.228	0.275
2008	0.001	0.392	0.511	0.376	0.375	0.452
2009	0.002	0.557	0.727	0.537	0.536	0.642
2010	0.001	0.396	0.516	0.380	0.379	0.456
2011	0.000	0.462	0.601	0.442	0.441	0.531
2012	0.000	0.088	0.114	0.083	0.083	0.101
2013	0.000	0.516	0.671	0.494	0.492	0.594
2014	0.001	0.317	0.413	0.304	0.303	0.365
2015	0.000	0.334	0.433	0.318	0.317	0.384
arith. mean	0.005	0.509	0.792	0.810	0.809	0.651

Table 11.2.7. Sandeel SA 1. Fishing mortality (F) at 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	0.161	0.047	0.686	0.200	1.108	0.323	1.108	0.323
1984	0.010	0.183	0.053	0.779	0.225	1.258	0.363	1.258	0.363
1985	0.009	0.190	0.047	0.807	0.201	1.304	0.324	1.304	0.324
1986	0.003	0.155	0.018	0.660	0.077	1.066	0.124	1.066	0.124
1987	0.005	0.099	0.027	0.422	0.113	0.682	0.183	0.682	0.183
1988	0.004	0.156	0.019	0.663	0.083	1.071	0.133	1.071	0.133
1989	0.003	0.540	0.027	0.806	0.040	0.912	0.045	0.912	0.045
1990	0.005	0.478	0.044	0.712	0.065	0.806	0.074	0.806	0.074
1991	0.013	0.321	0.106	0.479	0.158	0.542	0.179	0.542	0.179
1992	0.009	0.529	0.074	0.788	0.110	0.892	0.124	0.892	0.124
1993	0.004	0.211	0.033	0.315	0.049	0.356	0.055	0.356	0.055
1994	0.003	0.198	0.025	0.296	0.037	0.335	0.042	0.335	0.042
1995	0.006	0.353	0.045	0.526	0.067	0.595	0.076	0.595	0.076
1996	0.006	0.304	0.048	0.453	0.072	0.513	0.081	0.513	0.081
1997	0.012	0.268	0.098	0.400	0.146	0.453	0.166	0.453	0.166
1998	0.005	0.413	0.037	0.615	0.055	0.696	0.062	0.696	0.062
1999	0.011	0.790	0.151	1.098	0.210	0.817	0.156	0.817	0.156
2000	0.010	0.631	0.131	0.876	0.183	0.653	0.136	0.653	0.136
2001	0.030	0.815	0.409	1.132	0.568	0.843	0.423	0.843	0.423
2002	0.002	0.851	0.027	1.182	0.037	0.880	0.028	0.880	0.028
2003	0.009	0.566	0.120	0.786	0.167	0.585	0.124	0.585	0.124
2004	0.005	0.692	0.064	0.961	0.089	0.715	0.066	0.715	0.066
2005	0.000	0.307	0.007	0.426	0.009	0.317	0.007	0.317	0.007
2006	0.001	0.443	0.019	0.615	0.026	0.458	0.019	0.458	0.019
2007	0.000	0.187	0.000	0.260	0.000	0.194	0.000	0.194	0.000
2008	0.001	0.302	0.011	0.419	0.015	0.312	0.011	0.312	0.011
2009	0.002	0.422	0.029	0.587	0.040	0.437	0.030	0.437	0.030
2010	0.001	0.302	0.015	0.420	0.021	0.312	0.016	0.312	0.016
2011	0.000	0.361	0.005	0.501	0.007	0.373	0.005	0.373	0.005
2012	0.000	0.068	0.000	0.095	0.000	0.070	0.000	0.070	0.000
2013	0.000	0.408	0.000	0.567	0.000	0.422	0.000	0.422	0.000
2014	0.001	0.243	0.009	0.338	0.013	0.251	0.010	0.251	0.010
2015	0.000	0.262	0.000	0.364	0.000	0.271	0.000	0.271	0.000
arith. mean	0.005	0.370	0.053	0.607	0.093	0.621	0.103	0.621	0.103

Table 11.2.8. Sandeel SA 1. Stock numbers (millions). Age 0 at start of 2nd half-year, age 1+ at start of the year.

	Age 0	Age 1	Age 2	Age 3	Age 4
1983	566232	17121	53030	2662	263
1984	148192	214869	4915	9252	356
1985	973215	56172	60010	763	964
1986	145440	369294	15671	9266	176
1987	72777	55496	109786	3172	1456
1988	348962	27724	17298	27191	1000
1989	171706	133121	8225	3472	4289
1990	257018	65525	26681	1494	1544
1991	315373	97877	13751	5191	652
1992	78354	119171	22562	3077	1446
1993	327187	29727	23057	3889	840
1994	475475	124767	8233	6783	1599
1995	110344	181491	35273	2497	2936
1996	710362	42014	43105	8252	1438
1997	104625	270366	10444	10794	2727
1998	173604	39573	66243	2559	3722
1999	238583	66170	8925	14348	1527
2000	394019	90353	9125	1022	3050
2001	562278	149430	14899	1339	966
2002	30824	208975	15533	1152	335
2003	218706	11780	30716	1943	307
2004	98746	83013	2098	5015	564
2005	222859	37633	13780	311	1299
2006	129499	85289	9721	3772	609
2007	284099	49517	19008	2168	1385
2008	92839	108780	14511	6200	1506
2009	634468	35519	28121	3976	2848
2010	47929	242420	7994	6357	2205
2011	63840	18331	62380	2177	3157
2012	188200	24435	4493	15873	1895
2013	95347	72060	8068	1729	8426
2014	264706	36508	16936	1937	3488
2015	37025	101284	10023	5045	2172
2016		14177	27551	2948	2823

Table 11.2.9. Sandeel SA 1. Estimated recruitment, total stock biomass (TBS), spawning stock biomass (SSB), catch weight (Yield) and average fishing mortality.

	Recruits (million)	TSB (tonnes)	SSB (tonnes)	Yield (tonnes)	Mean F_{1-2}
1983	566232	665059	482224	349232	0.608
1984	148192	1366770	198091	467609	0.688
1985	973215	935658	530629	424114	0.697
1986	145440	2322940	302138	382735	0.527
1987	72777	1605400	1084670	357671	0.371
1988	348962	769134	622311	398271	0.532
1989	171706	771906	227360	445695	0.840
1990	257018	656707	336684	283040	0.765
1991	315373	1120220	303095	347096	0.595
1992	78354	1276900	361327	564298	0.871
1993	327187	542869	288575	124082	0.355
1994	475475	864654	187669	209538	0.328
1995	110344	1870520	449237	410513	0.580
1996	710362	706602	420394	298702	0.510
1997	104625	2197650	256788	431808	0.506
1998	173604	910839	567415	371117	0.661
1999	238583	584843	227864	427691	1.280
2000	394019	685659	123585	284521	1.038
2001	562278	829098	148659	513068	1.569
2002	30824	1376870	136644	596049	1.240
2003	218706	268535	192780	121863	0.934
2004	98746	476988	70699	195274	1.057
2005	222859	383987	152661	100835	0.455
2006	129499	645666	142255	231448	0.661
2007	284099	503622	220795	108600	0.275
2008	92839	945584	272458	237447	0.452
2009	634468	565681	245407	291247	0.642
2010	47929	1746960	196346	300954	0.456
2011	63840	714308	392437	311542	0.531
2012	188200	405541	244261	45642	0.101
2013	95347	502481	160734	209416	0.594
2014	264706	351330	142851	79237	0.365
2015	37025	716016	191471	162054	0.384
2016			271006		
arith. mean	260086	917788	298574	305528	0.651
geo. mean	194636				

Arith. mean for the period 1983–2015
Geo. mean for the period 1983–2014

Table 11.2.10. Sandeel SA 1. Input to forecast.

	Age 0	Age 1	Age 2	Age 3	Age 4
Stock numbers(2016)	194636	14177	27551	2948	2823
Exploitation pattern 1st half		0.262	0.364	0.271	0.271
Exploitation pattern 2nd half	0.000	0.000	0.000	0.000	0.000
Weight in the stock 1st half		4.95	7.26	9.98	12.25
Weight in the catch 1st half		4.95	7.26	9.98	12.25
weight in the catch 2nd half	2.80	5.86	8.85	11.09	14.07
Proportion mature(2016)	0.00	0.03	0.88	0.87	1.00
Proportion mature(2017)	0.00	0.02	0.82	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 11.2.11. Sandeel SA 1. Short term forecast (000 tonnes).

Basis: F_{sq}=F(2015)=0.313; Yield(2015)=162; Recruitment(2015)=37; Recruitment(2016)=geometric mean (GM 83-14)=195 billion; SSB(2016)=238

F multiplier	Basis	F(2016)	Catch (2016)	SSB (2017)	%SSB change*	%TAC change**
0	F=0	0.000	0.001	190	-20 %	-100 %
0.06	Fsq*0.06	0.018	5.025	187	-22 %	-97 %
0.25	Fsq*0.25	0.078	21.323	176	-26 %	-87 %
0.5	Fsq*0.5	0.156	41.072	162	-32 %	-75 %
0.75	Fsq*0.75	0.235	59.370	150	-37 %	-63 %
1	Fsq*1	0.313	76.330	139	-42 %	-53 %
1.25	Fsq*1.25	0.391	92.056	129	-46 %	-43 %
1.5	Fsq*1.5	0.469	106.642	119	-50 %	-34 %
1.75	Fsq*1.75	0.547	120.176	110	-54 %	-26 %
2	Fsq*2	0.626	132.740	102	-57 %	-18 %
No conversion for calculation of MSY catch		NA	NA	NA		

***SSB in 2017 relative to SSB in 2016**

****TAC in 2016 relative to catches in 2015**

Table 11.3.1. Sandeel SA 2. Catch at age numbers (million) by half year.

	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	1	146	0	270	1	40	0
2013	0	760	749	227	110	230	89	61	35
2014	0	489	1	439	0	38	0	23	0
2015	0	265	0	589	1	521	1	188	0
arith. mean	408	2314	873	1363	310	461	122	182	45

Table 11.3.2. Sandeel SA 2. Individual mean weight (gram) at age in the catch and in the sea.

	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	3.2	8.0	7.0	11.0	10.0	12.0	12.4	13.3	15.1
2012	3.4	9.5	6.8	13.2	9.4	14.7	11.7	16.2	14.2
2013	4.4	8.6	8.7	12.7	11.5	15.6	14.3	15.5	15.3
2014	2.5	7.3	5.0	10.2	6.9	13.0	8.6	15.7	10.4
2015	4.7	8.8	9.6	13.1	13.3	15.0	16.5	16.5	20.0
arith. mean	3.7	7.6	8.6	12.2	12.0	15.0	14.7	17.5	18.3

Table 11.3.3. Sandeel SA 2. Proportion mature.

	Age 1	Age 2	Age 3	Age 4
1983–2016	0.02	0.83	1	1

Table 11.3.4. Sandeel SA 2. Dredge survey indices (number/hour). Not used for default assessment.

Year	Age 0	Age 1	Age 2
2010	7	156	11.0
2011	11	22	33.6
2012	NA	NA	NA
2013	202	63	18.4
2014	86	57	34.2
2015	27	10	19.6

Table 11.3.5. Sandeel SA 2. SMS settings and statistics.

```
Date: 01/22/16  Start time:08:05:25 run time:0 seconds

 objective function (negative log likelihood):  91.7612
 Number of parameters: 51
 Maximum gradient: 5.08777e-005
 Akaike information criterion (AIC):   285.522
 Number of observations used in the likelihood:
                            Catch    CPUE     S/R Stomach     Sum
                             297      12      33       0     342

 objective function weight:
                          Catch  CPUE   S/R
                          1.00  1.00  0.10

 unweighted objective function contributions (total):
                Catch    CPUE    S/R   Stom.  Stom N.  Penalty    Sum
              100.7   -10.5    15.4     0.0     0.0      0.00     106


 unweighted objective function contributions (per observation):
                Catch   CPUE     S/R   Stomachs
               0.34   -0.87    0.47    0.00


 contribution by fleet:
 ----------------------
 Dredge survey 2004-2015     total: -10.456   mean:  -0.871

 F, season effect:
 -----------------
 age: 0
     1983-1998:   0.000 1.000
     1999-2015:   0.000 1.000
 age: 1 - 4
     1983-1998:   0.540 0.500
     1999-2015:   0.360 0.500

 F, age effect:
 --------------
                0      1      2      3      4
 1983-1998:  0.013  0.181  0.450  0.440  0.440
 1999-2015:  0.001  0.220  0.481  0.386  0.386


 Exploitation pattern (scaled to mean F=1)
 -----------------------------------------
                        0      1      2      3      4
 1983-1998 season 1:      0  0.475  1.176  1.151  1.151
           season 2:  0.014  0.100  0.249  0.243  0.243

 1999-2015 season 1:      0  0.401  0.877  0.704  0.704
           season 2:  0.002  0.227  0.495  0.397  0.397
```

```
sqrt(catch variance) ~ CV:
 --------------------------

              season
 ----------------------
 age        1       2

  0               2.128
  1       0.436   0.892
  2       0.436   0.892
  3       1.104   1.126
  4       1.104   1.126


 Survey catchability:
 --------------------
                               age 0
  Dredge survey 2004-2015       9.389

 sqrt(Survey variance) ~ CV:
 ---------------------------
                               age 0
  Dredge survey 2004-2015        0.30

 Recruit-SSB            alfa      beta       recruit s2     recruit s
 Area-2              566.568   7.000e+004   0.938          0.969
```

Table 11.3.6. Sandeel SA 2. Annual fishing mortality (F) at age.

	Age 0	Age 1	Age 2	Age 3	Age 4	Avg. 1–2
1983	0.005	0.257	0.598	0.583	0.582	0.427
1984	0.010	0.198	0.471	0.465	0.467	0.334
1985	0.011	0.354	0.829	0.812	0.812	0.591
1986	0.008	0.210	0.496	0.487	0.487	0.353
1987	0.007	0.114	0.271	0.269	0.270	0.192
1988	0.006	0.335	0.779	0.757	0.756	0.557
1989	0.003	0.337	0.778	0.754	0.753	0.558
1990	0.001	0.367	0.845	0.817	0.814	0.606
1991	0.011	0.227	0.539	0.532	0.533	0.383
1992	0.004	0.184	0.430	0.419	0.419	0.307
1993	0.006	0.186	0.437	0.429	0.429	0.312
1994	0.006	0.083	0.199	0.199	0.200	0.141
1995	0.008	0.114	0.274	0.274	0.275	0.194
1996	0.006	0.143	0.339	0.333	0.334	0.241
1997	0.017	0.201	0.485	0.488	0.491	0.343
1998	0.012	0.183	0.437	0.435	0.437	0.310
1999	0.001	0.171	0.356	0.289	0.289	0.264
2000	0.001	0.238	0.500	0.408	0.410	0.369
2001	0.001	0.288	0.609	0.498	0.500	0.449
2002	0.001	0.227	0.483	0.399	0.402	0.355
2003	0.001	0.393	0.815	0.657	0.658	0.604
2004	0.002	0.454	0.949	0.769	0.771	0.701
2005	0.001	0.224	0.466	0.376	0.377	0.345
2006	0.001	0.191	0.403	0.329	0.330	0.297
2007	0.000	0.027	0.056	0.044	0.044	0.042
2008	0.000	0.058	0.121	0.098	0.098	0.089
2009	0.000	0.044	0.090	0.071	0.071	0.067
2010	0.000	0.099	0.208	0.169	0.170	0.154
2011	0.000	0.150	0.308	0.245	0.245	0.229
2012	0.000	0.054	0.109	0.086	0.086	0.081
2013	0.001	0.125	0.266	0.219	0.220	0.196
2014	0.000	0.048	0.097	0.077	0.077	0.073
2015	0.000	0.115	0.234	0.185	0.185	0.175
arith. mean	0.004	0.194	0.433	0.393	0.394	0.313

Table 11.3.7. Sandeel SA 2. Fishing mortality (F) at 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	0.178	0.038	0.440	0.093	0.431	0.091	0.431	0.091
1984	0.010	0.112	0.071	0.276	0.176	0.270	0.172	0.270	0.172
1985	0.011	0.229	0.078	0.568	0.192	0.556	0.188	0.556	0.188
1986	0.008	0.131	0.055	0.324	0.137	0.317	0.134	0.317	0.134
1987	0.007	0.061	0.046	0.151	0.114	0.148	0.111	0.148	0.111
1988	0.006	0.239	0.039	0.592	0.097	0.579	0.095	0.579	0.095
1989	0.003	0.250	0.023	0.619	0.058	0.606	0.056	0.606	0.056
1990	0.001	0.283	0.009	0.701	0.023	0.686	0.023	0.686	0.023
1991	0.011	0.130	0.077	0.323	0.192	0.316	0.188	0.316	0.188
1992	0.004	0.127	0.027	0.315	0.067	0.309	0.066	0.309	0.066
1993	0.006	0.119	0.043	0.295	0.106	0.289	0.104	0.289	0.104
1994	0.006	0.039	0.043	0.096	0.106	0.094	0.104	0.094	0.104
1995	0.008	0.055	0.056	0.136	0.140	0.133	0.137	0.133	0.137
1996	0.006	0.086	0.043	0.213	0.105	0.208	0.103	0.208	0.103
1997	0.017	0.085	0.118	0.211	0.294	0.207	0.287	0.207	0.287
1998	0.012	0.093	0.082	0.231	0.202	0.226	0.198	0.226	0.198
1999	0.001	0.099	0.056	0.216	0.122	0.174	0.098	0.174	0.098
2000	0.001	0.121	0.106	0.264	0.233	0.212	0.187	0.212	0.187
2001	0.001	0.142	0.137	0.310	0.299	0.249	0.240	0.249	0.240
2002	0.001	0.093	0.138	0.204	0.302	0.164	0.243	0.164	0.243
2003	0.001	0.245	0.102	0.535	0.222	0.430	0.178	0.430	0.178
2004	0.002	0.261	0.155	0.569	0.339	0.457	0.272	0.457	0.272
2005	0.001	0.134	0.066	0.294	0.144	0.236	0.116	0.236	0.116
2006	0.001	0.098	0.085	0.213	0.185	0.171	0.149	0.171	0.149
2007	0.000	0.021	0.000	0.046	0.000	0.037	0.000	0.037	0.000
2008	0.000	0.033	0.021	0.071	0.045	0.057	0.036	0.057	0.036
2009	0.000	0.033	0.001	0.073	0.003	0.058	0.002	0.058	0.002
2010	0.000	0.053	0.039	0.116	0.086	0.093	0.069	0.093	0.069
2011	0.000	0.106	0.018	0.232	0.038	0.186	0.031	0.186	0.031
2012	0.000	0.042	0.000	0.091	0.000	0.073	0.000	0.073	0.000
2013	0.001	0.056	0.070	0.122	0.152	0.098	0.122	0.098	0.122
2014	0.000	0.037	0.000	0.081	0.000	0.065	0.000	0.065	0.000
2015	0.000	0.090	0.000	0.196	0.000	0.157	0.000	0.157	0.000
arith. mean	0.004	0.118	0.056	0.277	0.129	0.251	0.115	0.251	0.115

Table 11.3.8. Sandeel SA 2. Stock numbers (millions). Age 0 at start of 2nd half-year, age 1+ at start of the year.

	Age 0	Age 1	Age 2	Age 3	Age 4
1983	120164	3967	10971	684	47
1984	35178	45764	1131	2724	220
1985	231198	13334	13477	304	961
1986	37338	87548	3467	2665	314
1987	18419	14184	25697	926	966
1988	112320	7006	4506	8345	755
1989	62659	42768	1876	957	2357
1990	82303	23912	11505	403	891
1991	94953	31471	6310	2360	332
1992	31919	35957	9037	1596	828
1993	124732	12174	10892	2609	856
1994	63947	47467	3660	3085	1197
1995	22537	24335	15462	1265	1800
1996	199505	8560	7695	4964	1214
1997	3109	75927	2661	2368	2310
1998	13311	1170	21888	679	1475
1999	39949	5038	347	6007	734
2000	10513	15288	1525	105	2614
2001	105003	4021	4305	393	961
2002	6643	40149	1075	991	433
2003	60508	2540	11256	274	486
2004	24532	23144	635	2233	215
2005	44921	9378	5398	108	601
2006	29011	17188	2713	1475	261
2007	68809	11098	5062	771	643
2008	18866	26346	3840	2045	703
2009	97604	7222	8831	1447	1281
2010	12232	37371	2466	3465	1326
2011	15884	4681	12039	852	2086
2012	52774	6081	1462	3889	1233
2013	27600	20207	2062	565	2436
2014	27020	10560	6301	664	1261
2015	7997	10346	3597	2459	938
2016		3062	3343	1252	1488

Table 11.3.9. Sandeel SA 2. Estimated recruitment, total stock biomass (TBS), spawning stock biomass (SSB), catch weight (Yield) and average fishing mortality.

	Recruits (million)	TSB (tonnes)	SSB (tonnes)	Yield (tonnes)	Mean $F_{1\text{-}2}$
1983	120164	141647	101515	74481	0.427
1984	35178	305095	55992	63046	0.334
1985	231198	231388	136525	96645	0.591
1986	37338	562280	81810	93146	0.353
1987	18419	396883	268206	53284	0.192
1988	112320	228563	190959	120382	0.557
1989	62659	257997	80482	109703	0.558
1990	82303	264239	145100	100917	0.606
1991	94953	402338	137791	107795	0.383
1992	31919	419395	150629	69825	0.307
1993	124732	341343	211031	59652	0.312
1994	63947	503300	135042	50656	0.141
1995	22537	455399	228959	60138	0.194
1996	199505	316938	202891	80012	0.241
1997	3109	650718	101589	102726	0.343
1998	13311	346937	285733	68953	0.310
1999	39949	173299	116689	32108	0.264
2000	10513	230398	70863	52228	0.369
2001	105003	131332	78574	56934	0.449
2002	6643	310933	37731	35494	0.355
2003	60508	155833	112722	55924	0.604
2004	24532	215593	42888	71413	0.701
2005	44921	127270	52380	41420	0.345
2006	29011	197633	48923	35351	0.297
2007	68809	188821	81871	5911	0.042
2008	18866	269174	79244	13064	0.089
2009	97604	176495	112492	10240	0.067
2010	12232	323261	85361	31747	0.154
2011	15884	208090	148742	29807	0.229
2012	52774	154253	94356	8098	0.081
2013	27600	245811	71780	23534	0.196
2014	27020	170259	83434	8928	0.073
2015	7997	190255	93118	20992	0.175
2016			80118		
arith. mean	57681	281611	117810	55896	0.313
geo. mean	39194				

Arith. mean for the period 1983–2015
Geo. mean for the period 1983–2014

Table 11.3.10. Sandeel SA 2. Input to forecast.

	Age 0	Age 1	Age 2	Age 3	Age 4
Stock numbers(2016)	39194	3062	3343	1252	1488
Exploitation pattern 1st half		0.090	0.196	0.157	0.157
Exploitation pattern 2nd half	0.000	0.000	0.000	0.000	0.000
Weight in the stock 1st half		8.23	12.00	14.51	15.92
Weight in the catch 1st half		8.23	12.00	14.51	15.92
weight in the catch 2nd half	3.84	7.75	10.57	13.14	15.24
Proportion mature(2016)	0.00	0.02	0.83	1.00	1.00
Proportion mature(2017)	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 11.3.11. Sandeel SA 2. Short term forecast (000 tonnes).

Basis: F_{sq}=F(2015)=0.143; Yield(2015)=21; Recruitment(2015)=8; Recruitment(2016)=geometric mean (GM 83-14)=39 billion; SSB(2016)=76

F multiplier	Basis	F(2016)	Catches (2016)	SSB (2017)	%SSB change*	%TAC change**
0	F=0	0.000	0.001	56	-25 %	-100 %
0.37	Monitoring TAC	0.053	5.000	53	-30 %	-76 %
0.25	Fsq*0.25	0.036	3.400	54	-28 %	-84 %
0.5	Fsq*0.5	0.071	6.669	52	-31 %	-68 %
0.75	Fsq*0.75	0.107	9.815	50	-33 %	-53 %
No conversion for calculation of MSY catch		NA	NA	NA		

***SSB in 2017 relative to SSB in 2016**

****TAC in 2016 relative to catches in 2015**

Table 11.4.1. Sandeel SA 3. Catch at age numbers (million) by half year.

	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	164	5	289	50	1214	5	382	10
2013	0	4653	18	1143	6	115	1	72	1
2014	300	7826	140	4285	28	943	3	414	4
2015	0	8027	42	2479	8	1007	1	112	2
arith. mean	6612	16104	1866	4021	191	705	55	225	23

Table 11.4.2. Sandeel SA 3. Individual mean weight (gram) at age in the catch and in the sea.

	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	3.8	7.3	9.2	13.8	15.5	22.5	19.2	30.1	21.6
2013	3.9	5.9	9.5	7.6	16.3	12.3	20.0	14.8	22.7
2014	3.0	7.7	7.4	11.8	12.6	13.2	15.4	18.5	17.5
2015	4.7	8.0	11.6	12.6	19.8	19.3	24.3	29.5	27.6
arith. mean	3.9	6.3	9.4	12.5	17.2	19.3	20.8	25.3	23.3

Table 11.4.3. Sandeel SA 3. Proportion mature.

	Age 1	Age 2	Age 3	Age 4
1983–2004	0.05	0.77	1	1
2005	0.12	0.96	1	1
2006	0.08	0.78	1	1
2007	0.02	0.80	1	1
2008	0.03	0.69	1	1
2009	0.01	0.48	1	1
2010	0.04	0.92	1	1
2011	0.04	0.92	1	1
2012	0.01	0.70	1	1
2013	0.04	0.88	1	1
2014	0.02	0.25	1	1
2015	0.00	0.94	1	1
2016	0.02	0.87	1	1

Table 11.4.4. Sandeel SA 3. Dredge survey indices (number/hour).

Year	Age 0	Age 1	Age 2
2004	85	24	0.8
2005	379	45	1.3
2006	904	59	2.3
2007	426	216	8.0
2008	1125	311	123.3
2009	550	1109	45.2
2010	40	416	62.7
2011	75	48	941.0
2012	1174	11	7.3
2013	1781	77	3.3
2014	3032	223	18.1
2015	118	7112	584.9

Table 11.4.5. Sandeel SA 3. SMS settings and statistics.

```
Date: 01/22/16  Start time:08:09:45 run time:1 seconds

 objective function (negative log likelihood):  139.203
 Number of parameters: 57
 Maximum gradient: 6.97409e-005
 Akaike information criterion (AIC):   392.405
 Number of observations used in the likelihood:
                            Catch    CPUE     S/R Stomach     Sum
                             297      24      33       0      354

 objective function weight:
                          Catch  CPUE   S/R
                          1.00  1.00  0.01

 unweighted objective function contributions (total):
                Catch    CPUE    S/R   Stom.  Stom N.  Penalty    Sum
              141.9    -2.8    16.6     0.0     0.0      0.00     156


 unweighted objective function contributions (per observation):
                Catch   CPUE     S/R   Stomachs
               0.48   -0.12    0.50    0.00


 contribution by fleet:
 ----------------------
 Dredge survey 2004-2014     total:  -2.840   mean:  -0.118

 F, season effect:
 -----------------
 age: 0
     1983-1988:   0.000 1.000
     1989-1998:   0.000 1.000
     1999-2015:   0.000 1.000
 age: 1 - 4
     1983-1988:   0.879 0.500
     1989-1998:   1.172 0.500
     1999-2015:   0.789 0.500

 F, age effect:
 --------------
                0      1      2      3      4
 1983-1988:  0.041  0.284  0.594  1.009  1.009
 1989-1998:  0.225  0.363  0.276  0.241  0.241
 1999-2015:  0.015  0.423  0.437  0.322  0.322


 Exploitation pattern (scaled to mean F=1)
 -----------------------------------------
                        0      1      2      3      4
 1983-1988 season 1:      0  0.523  1.096  1.861  1.861
           season 2:  0.035  0.123  0.258  0.437  0.437

 1989-1998 season 1:      0  1.064  0.811  0.706  0.706
           season 2:  0.088  0.071  0.054  0.047  0.047

 1999-2015 season 1:      0  0.550  0.569  0.419  0.419
           season 2:  0.032  0.433  0.448  0.330  0.330
```

```
sqrt(catch variance) ~ CV:
 --------------------------

              season
 ----------------------
 age        1       2

  0               1.855
  1       0.686   1.048
  2       0.686   1.048
  3       0.969   1.513
  4       0.969   1.513


 Survey catchability:
 --------------------
                                age 0    age 1
  Dredge survey 2004-2014       1.915    1.915

 sqrt(Survey variance) ~ CV:
 ---------------------------
                                age 0    age 1
  Dredge survey 2004-2014        0.30     1.09

 Recruit-SSB            alfa      beta       recruit s2     recruit s
 Area-3             1085.139   1.000e+005   1.006          1.003
```

Table 11.4.6. Sandeel SA 3. Annual fishing mortality (F) at age.

	Age 0	Age 1	Age 2	Age 3	Age 4	Avg. 1–2
1983	0.015	0.334	0.661	1.110	1.110	0.498
1984	0.016	0.355	0.702	1.178	1.177	0.528
1985	0.014	0.191	0.381	0.646	0.647	0.286
1986	0.044	0.690	1.367	2.298	2.299	1.028
1987	0.002	0.631	1.225	2.014	2.010	0.928
1988	0.036	0.946	1.854	3.077	3.075	1.400
1989	0.086	1.340	0.976	0.842	0.841	1.158
1990	0.120	0.696	0.504	0.437	0.437	0.600
1991	0.088	0.889	0.644	0.556	0.555	0.767
1992	0.041	0.570	0.411	0.354	0.353	0.491
1993	0.145	0.783	0.568	0.493	0.493	0.676
1994	0.056	0.883	0.639	0.551	0.549	0.761
1995	0.027	0.591	0.426	0.366	0.365	0.509
1996	0.199	0.628	0.457	0.399	0.400	0.543
1997	0.143	1.162	0.846	0.731	0.730	1.004
1998	0.226	1.143	0.833	0.723	0.723	0.988
1999	0.044	1.449	1.447	1.082	1.086	1.448
2000	0.003	1.647	1.618	1.189	1.186	1.632
2001	0.043	1.186	1.188	0.892	0.897	1.187
2002	0.001	1.215	1.189	0.871	0.868	1.202
2003	0.015	0.632	0.627	0.466	0.467	0.629
2004	0.009	0.850	0.834	0.614	0.613	0.842
2005	0.000	0.248	0.241	0.175	0.175	0.245
2006	0.001	0.169	0.164	0.120	0.119	0.167
2007	0.000	0.655	0.637	0.464	0.462	0.646
2008	0.000	0.599	0.583	0.424	0.423	0.591
2009	0.002	0.174	0.170	0.125	0.125	0.172
2010	0.001	0.693	0.675	0.493	0.491	0.684
2011	0.000	0.221	0.214	0.155	0.155	0.217
2012	0.000	0.231	0.224	0.162	0.162	0.227
2013	0.000	0.406	0.394	0.286	0.285	0.400
2014	0.000	0.553	0.537	0.391	0.390	0.545
2015	0.000	0.482	0.468	0.340	0.339	0.475
arith. mean	0.042	0.704	0.718	0.728	0.727	0.711

Table 11.4.7. Sandeel SA 3. Fishing mortality (F) at 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	0.229	0.054	0.480	0.113	0.814	0.191	0.814	0.191
1984	0.016	0.245	0.055	0.513	0.115	0.870	0.196	0.870	0.196
1985	0.014	0.120	0.048	0.252	0.100	0.427	0.169	0.427	0.169
1986	0.044	0.450	0.152	0.942	0.319	1.600	0.541	1.600	0.541
1987	0.002	0.496	0.007	1.040	0.015	1.765	0.025	1.765	0.025
1988	0.036	0.675	0.126	1.414	0.263	2.399	0.447	2.399	0.447
1989	0.086	1.042	0.069	0.794	0.053	0.691	0.046	0.691	0.046
1990	0.120	0.490	0.097	0.374	0.074	0.325	0.064	0.325	0.064
1991	0.088	0.664	0.071	0.506	0.054	0.441	0.047	0.441	0.047
1992	0.041	0.430	0.033	0.328	0.025	0.285	0.022	0.285	0.022
1993	0.145	0.548	0.117	0.417	0.089	0.363	0.078	0.363	0.078
1994	0.056	0.677	0.045	0.515	0.034	0.449	0.030	0.449	0.030
1995	0.027	0.454	0.022	0.346	0.017	0.301	0.015	0.301	0.015
1996	0.199	0.395	0.161	0.301	0.123	0.262	0.107	0.262	0.107
1997	0.143	0.860	0.115	0.655	0.088	0.571	0.077	0.571	0.077
1998	0.226	0.799	0.182	0.609	0.139	0.530	0.121	0.530	0.121
1999	0.044	0.769	0.606	0.795	0.626	0.586	0.461	0.586	0.461
2000	0.003	1.330	0.034	1.375	0.035	1.013	0.026	1.013	0.026
2001	0.043	0.570	0.588	0.589	0.608	0.434	0.448	0.434	0.448
2002	0.001	0.974	0.015	1.007	0.016	0.742	0.012	0.742	0.012
2003	0.015	0.368	0.209	0.380	0.216	0.280	0.159	0.280	0.159
2004	0.009	0.596	0.126	0.616	0.130	0.454	0.096	0.454	0.096
2005	0.000	0.191	0.005	0.198	0.006	0.146	0.004	0.146	0.004
2006	0.001	0.125	0.011	0.129	0.011	0.095	0.008	0.095	0.008
2007	0.000	0.520	0.000	0.538	0.000	0.396	0.000	0.396	0.000
2008	0.000	0.474	0.001	0.490	0.001	0.361	0.001	0.361	0.001
2009	0.002	0.119	0.028	0.123	0.029	0.091	0.021	0.091	0.021
2010	0.001	0.543	0.012	0.562	0.013	0.414	0.009	0.414	0.009
2011	0.000	0.173	0.000	0.178	0.000	0.131	0.000	0.131	0.000
2012	0.000	0.181	0.000	0.187	0.000	0.138	0.000	0.138	0.000
2013	0.000	0.320	0.000	0.330	0.000	0.243	0.000	0.243	0.000
2014	0.000	0.437	0.000	0.452	0.000	0.333	0.000	0.333	0.000
2015	0.000	0.380	0.000	0.393	0.000	0.290	0.000	0.290	0.000
arith. mean	0.042	0.504	0.091	0.540	0.100	0.553	0.104	0.553	0.104

Table 11.4.8. Sandeel SA 3. Stock numbers (millions). Age 0 at start of 2nd half-year, age 1+ at start of the year.

	Age 0	Age 1	Age 2	Age 3	Age 4
1983	87531	20050	6507	179	10
1984	45266	33000	5341	1522	35
1985	291712	17059	8643	1206	272
1986	373974	110173	5098	2573	415
1987	93985	137054	21330	611	179
1988	302441	35912	29282	3143	67
1989	102662	111689	5702	2317	95
1990	177139	36069	12996	1035	586
1991	96352	60159	7087	3516	564
1992	233258	33771	10189	1712	1276
1993	209163	85723	7512	3030	1133
1994	141910	69254	15581	1915	1372
1995	155188	51374	11893	3804	1049
1996	940878	57820	11279	3502	1809
1997	64022	295140	11724	3126	1887
1998	94696	21248	39319	2359	1350
1999	114488	28934	2815	7879	995
2000	70713	41936	2587	288	1585
2001	75749	27008	3788	267	347
2002	15405	27783	3000	484	132
2003	41826	5892	3651	456	148
2004	14516	15771	1170	851	199
2005	34640	5507	2709	235	309
2006	90084	13258	1599	935	243
2007	54142	34466	4091	588	543
2008	112357	20731	7242	1011	393
2009	100063	43017	4555	1875	501
2010	7926	38236	13130	1656	1085
2011	10964	3032	7754	3128	924
2012	120198	4198	902	2745	1817
2013	164531	46023	1239	317	2047
2014	334728	62998	11817	377	972
2015	14262	128165	14379	3182	504
2016		5461	30972	4107	1405

Table 11.4.9. Sandeel SA 3. Estimated recruitment, total stock biomass (TBS), spawning stock biomass (SSB), Catchs weight (Yield) and average fishing mortality.

	Recruits (million)	TSB (tonnes)	SSB (tonnes)	Yield (tonnes)	Mean F_{1-2}
1983	87531	200132	73863	105946	0.498
1984	45266	281482	89425	123635	0.528
1985	291712	247508	131518	59083	0.286
1986	373974	763217	157665	420341	1.028
1987	93985	1075310	277054	403908	0.928
1988	302441	670498	390192	391081	1.400
1989	102662	809360	135313	481893	1.158
1990	177139	426229	194334	219183	0.600
1991	96352	644288	196285	368105	0.767
1992	233258	368008	164682	195700	0.491
1993	209163	723632	193398	263954	0.676
1994	141910	659082	239552	444119	0.761
1995	155188	490670	181268	218922	0.509
1996	940878	768450	296559	247397	0.543
1997	64022	1694050	236264	604159	1.004
1998	94696	562892	370516	499333	0.988
1999	114488	379414	169227	223160	1.448
2000	70713	348916	71454	242732	1.632
2001	75749	232962	58907	245290	1.187
2002	15405	228398	45162	209302	1.202
2003	41826	95548	54610	58942	0.629
2004	14516	122809	26267	79234	0.842
2005	34640	95944	57397	29677	0.245
2006	90084	130966	44190	18863	0.167
2007	54142	316133	73157	113232	0.646
2008	112357	275643	109878	94491	0.591
2009	100063	338602	66233	33350	0.172
2010	7926	522231	276323	80576	0.684
2011	10964	213554	184335	94750	0.217
2012	120198	159524	125395	45111	0.227
2013	164531	316027	53333	39082	0.400
2014	334728	649093	67390	133413	0.545
2015	14262	1277680	246485	118541	0.475
2016			487486		
arith. mean	145054	487523	163092	209288	0.711
geo. mean	92506				

Arith. mean for the period 1983–2015
Geo. mean for the period 1983–2014

Table 11.4.10. Sandeel SA 3. Input to forecast.

	Age 0	Age 1	Age 2	Age 3	Age 4
Stock numbers(2016)	92506	5461	30972	4107	1405
Exploitation pattern 1st half		0.380	0.393	0.290	0.290
Exploitation pattern 2nd half	0.000	0.000	0.000	0.000	0.000
Weight in the stock 1st half		7.21	10.67	14.91	20.91
Weight in the catch 1st half		7.21	10.67	14.91	20.91
weight in the catch 2nd half	3.89	9.50	16.24	19.88	22.59
Proportion mature(2016)	0.00	0.02	0.87	1.00	1.00
Proportion mature(2017)	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 11.4.11. Sandeel SA 3. Short term forecast (000 tonnes).

Basis: F_{sq}=F(2015)=0.387; Yield(2015)=119; Recruitment(2015)=14; Recruitment(2016)=geometric mean (GM 83-14)=93 billion; SSB(2016)=379

F multiplier	Basis	F(2016)	Catch (2016)	SSB (2017)	%SSB change*	%TAC change**
0.000	F=0	0.000	0.001	282	-26 %	-100 %
0.250	Fsq*0.25	0.097	33.463	258	-32 %	-72 %
0.500	Fsq*0.5	0.193	64.143	236	-38 %	-46 %
0.750	Fsq*0.75	0.290	92.280	217	-43 %	-22 %
1.000	Fsq*1	0.387	118.097	198	-48 %	0 %
1.250	Fsq*1.25	0.483	141.794	182	-52 %	20 %
1.500	Fsq*1.5	0.580	163.553	167	-56 %	38 %
1.750	Fsq*1.75	0.677	183.543	154	-59 %	55 %
2.000	Fsq*2	0.773	201.914	141	-63 %	70 %
1.051	MSY	0.407	123.135	195	-49 %	4 %

***SSB in 2017 relative to SSB in 2016**

****TAC in 2016 relative to catches in 2015**

Table 11.4.12. Sandeel SA 3. Acoustic survey indices (billions of individuals).

Survey.year	Age.1	Age.2	Age.3	Age.4
2007	16.10	3.92	1.00	0.34
2008	3.30	4.15	0.21	0.05
2009	12.70	4.30	0.87	0.12
2010	16.60	9.68	1.58	0.97
2011	0.41	8.70	0.99	0.37
2012	0.89	0.37	3.31	0.66
2013	2.63	0.33	0.10	0.70
2014	23.60	2.06	0.18	2.68
2015	9.65	1.89	0.67	0.94

Table 11.4.13. Sandeel SA 3. Explorative run with Norwegian acoustic survey. SMS settings and statistics.

```
Date: 01/22/16  Start time:08:12:14 run time:1 seconds

 objective function (negative log likelihood):  146.14
 Number of parameters: 62
 Maximum gradient: 7.85359e-005
 Akaike information criterion (AIC):   416.281
 Number of observations used in the likelihood:
                             Catch    CPUE     S/R Stomach     Sum
                              297      60      33       0     390

 objective function weight:
                           Catch  CPUE   S/R
                           1.00  1.00  0.01

 unweighted objective function contributions (total):
                 Catch    CPUE    S/R   Stom.  Stom N.  Penalty    Sum
               139.2     6.8    16.5     0.0     0.0      0.00     162


 unweighted objective function contributions (per observation):
                 Catch   CPUE     S/R   Stomachs
                0.47    0.11    0.50    0.00


 contribution by fleet:
 ----------------------
 Dredge survey 2004-2015     total:   3.493   mean:   0.146
 Acoustic                    total:   3.320   mean:   0.092

 F, season effect:
 -----------------
 age: 0
     1983-1988:   0.000 1.000
     1989-1998:   0.000 1.000
     1999-2015:   0.000 1.000
 age: 1 - 4
     1983-1988:   0.876 0.500
     1989-1998:   1.168 0.500
     1999-2015:   0.813 0.500

 F, age effect:
 --------------
                0      1      2      3      4
 1983-1988:  0.041  0.283  0.592  1.016  1.016
 1989-1998:  0.226  0.361  0.277  0.238  0.238
 1999-2015:  0.014  0.412  0.431  0.296  0.296


 Exploitation pattern (scaled to mean F=1)
 -----------------------------------------
                        0      1      2      3      4
 1983-1988 season 1:      0  0.524  1.094  1.880  1.880
           season 2:  0.036  0.124  0.258  0.443  0.443

 1989-1998 season 1:      0  1.060  0.814  0.698  0.698
           season 2:  0.089  0.071  0.054  0.047  0.047

 1999-2015 season 1:      0  0.554  0.580  0.398  0.398
           season 2:  0.030  0.423  0.443  0.305  0.305
```

```
sqrt(catch variance) ~ CV:
 --------------------------

              season
 ----------------------
 age        1       2

  0               1.853
  1       0.654   1.036
  2       0.654   1.036
  3       0.984   1.521
  4       0.984   1.521


 Survey catchability:
 --------------------
                                age 0   age 1   age 2   age 3   age 4
  Dredge survey 2004-2015       2.064    2.064
  Acoustic                               0.338   0.779   0.669   0.669

 sqrt(Survey variance) ~ CV:
 ---------------------------
                                age 0   age 1   age 2   age 3   age 4
  Dredge survey 2004-2015        0.47     1.06
  Acoustic                                0.58   0.58    0.76    0.76

 Recruit-SSB            alfa      beta       recruit s2     recruit s
 Area-3             1062.088   1.000e+005   0.999           0.999
```

Table 11.4.14. Sandeel SA 3. Explorative run with Norwegian acoustic survey. Annual fishing mortality (F) at age.

	Age 0	Age 1	Age 2	Age 3	Age 4	Avg. 1–2
1983	0.015	0.333	0.656	1.115	1.115	0.495
1984	0.016	0.354	0.697	1.183	1.182	0.525
1985	0.014	0.190	0.378	0.649	0.650	0.284
1986	0.044	0.687	1.358	2.309	2.310	1.022
1987	0.002	0.629	1.216	2.022	2.018	0.922
1988	0.036	0.942	1.841	3.091	3.089	1.392
1989	0.086	1.329	0.976	0.830	0.828	1.153
1990	0.121	0.690	0.504	0.430	0.430	0.597
1991	0.089	0.882	0.644	0.548	0.547	0.763
1992	0.041	0.565	0.411	0.349	0.348	0.488
1993	0.146	0.777	0.568	0.486	0.485	0.673
1994	0.056	0.876	0.639	0.542	0.541	0.757
1995	0.027	0.586	0.426	0.361	0.360	0.506
1996	0.200	0.623	0.457	0.393	0.394	0.540
1997	0.144	1.153	0.846	0.721	0.719	0.999
1998	0.227	1.134	0.833	0.712	0.712	0.983
1999	0.041	1.439	1.454	1.014	1.018	1.447
2000	0.002	1.651	1.641	1.127	1.124	1.646
2001	0.040	1.176	1.192	0.835	0.839	1.184
2002	0.001	1.218	1.206	0.825	0.823	1.212
2003	0.014	0.629	0.631	0.438	0.438	0.630
2004	0.009	0.849	0.844	0.579	0.579	0.847
2005	0.000	0.249	0.245	0.166	0.166	0.247
2006	0.001	0.169	0.167	0.113	0.113	0.168
2007	0.000	0.657	0.647	0.440	0.438	0.652
2008	0.000	0.601	0.592	0.402	0.401	0.596
2009	0.002	0.174	0.172	0.118	0.118	0.173
2010	0.001	0.695	0.685	0.467	0.465	0.690
2011	0.000	0.221	0.217	0.147	0.146	0.219
2012	0.000	0.232	0.227	0.154	0.153	0.229
2013	0.000	0.407	0.400	0.271	0.271	0.404
2014	0.000	0.554	0.545	0.371	0.369	0.550
2015	0.000	0.483	0.475	0.323	0.321	0.479
arith. mean	0.042	0.702	0.721	0.713	0.712	0.711

Table 11.4.15. Sandeel SA 3. Explorative run with Norwegian acoustic survey. Fishing mortality (F) at 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	0.228	0.054	0.476	0.112	0.818	0.193	0.818	0.193
1984	0.016	0.244	0.055	0.509	0.115	0.874	0.197	0.874	0.197
1985	0.014	0.120	0.048	0.250	0.099	0.429	0.171	0.429	0.171
1986	0.044	0.448	0.152	0.935	0.317	1.606	0.545	1.606	0.545
1987	0.002	0.494	0.007	1.032	0.015	1.772	0.026	1.772	0.026
1988	0.036	0.672	0.125	1.403	0.262	2.409	0.450	2.409	0.450
1989	0.086	1.033	0.069	0.793	0.053	0.680	0.045	0.680	0.045
1990	0.121	0.486	0.096	0.373	0.074	0.320	0.063	0.320	0.063
1991	0.089	0.659	0.071	0.506	0.055	0.434	0.047	0.434	0.047
1992	0.041	0.426	0.033	0.327	0.025	0.281	0.022	0.281	0.022
1993	0.146	0.543	0.117	0.417	0.090	0.358	0.077	0.358	0.077
1994	0.056	0.671	0.045	0.515	0.035	0.442	0.030	0.442	0.030
1995	0.027	0.450	0.022	0.346	0.017	0.297	0.014	0.297	0.014
1996	0.200	0.391	0.160	0.301	0.123	0.258	0.105	0.258	0.105
1997	0.144	0.853	0.115	0.655	0.088	0.562	0.076	0.562	0.076
1998	0.227	0.792	0.181	0.608	0.139	0.522	0.119	0.522	0.119
1999	0.041	0.771	0.590	0.807	0.617	0.555	0.424	0.555	0.424
2000	0.002	1.334	0.033	1.396	0.035	0.960	0.024	0.960	0.024
2001	0.040	0.572	0.572	0.598	0.599	0.411	0.412	0.411	0.412
2002	0.001	0.977	0.015	1.023	0.016	0.703	0.011	0.703	0.011
2003	0.014	0.369	0.204	0.386	0.213	0.265	0.147	0.265	0.147
2004	0.009	0.598	0.122	0.626	0.128	0.430	0.088	0.430	0.088
2005	0.000	0.192	0.005	0.201	0.006	0.138	0.004	0.138	0.004
2006	0.001	0.126	0.010	0.131	0.011	0.090	0.007	0.090	0.007
2007	0.000	0.522	0.000	0.546	0.000	0.375	0.000	0.375	0.000
2008	0.000	0.476	0.001	0.498	0.001	0.342	0.001	0.342	0.001
2009	0.002	0.119	0.027	0.125	0.028	0.086	0.019	0.086	0.019
2010	0.001	0.545	0.012	0.571	0.012	0.392	0.008	0.392	0.008
2011	0.000	0.173	0.000	0.181	0.000	0.125	0.000	0.125	0.000
2012	0.000	0.181	0.000	0.190	0.000	0.130	0.000	0.130	0.000
2013	0.000	0.321	0.000	0.336	0.000	0.231	0.000	0.231	0.000
2014	0.000	0.439	0.000	0.459	0.000	0.316	0.000	0.316	0.000
2015	0.000	0.381	0.000	0.399	0.000	0.274	0.000	0.274	0.000
arith. mean	0.042	0.503	0.089	0.543	0.100	0.542	0.101	0.542	0.101

Table 11.4.16. Sandeel SA 3. Explorative run with Norwegian acoustic survey. Stock numbers (millions). Age 0 at start of 2nd half-year, age 1+ at start of the year.

	Age 0	Age 1	Age 2	Age 3	Age 4
1983	89443	20337	6486	179	9
1984	45026	33720	5423	1524	35
1985	295045	16968	8841	1230	271
1986	368446	111432	5074	2639	420
1987	92110	135027	21617	614	181
1988	302849	35196	28908	3211	67
1989	101685	111839	5604	2315	95
1990	181797	35711	13134	1017	592
1991	94733	61703	7050	3553	564
1992	235116	33189	10514	1703	1297
1993	213018	86388	7411	3127	1143
1994	145184	70479	15786	1889	1416
1995	150137	52544	12176	3855	1063
1996	935450	55930	11582	3585	1842
1997	62626	293144	11389	3209	1939
1998	93798	20769	39366	2292	1400
1999	113310	28627	2774	7888	1000
2000	72178	41637	2594	282	1699
2001	77036	27572	3749	262	388
2002	15479	28342	3105	479	148
2003	40206	5921	3715	465	157
2004	17264	15177	1180	863	211
2005	31578	6554	2611	235	327
2006	101343	12087	1902	899	253
2007	59225	38776	3729	698	534
2008	109796	22677	8135	914	436
2009	163843	42037	4975	2090	492
2010	8173	62616	12836	1806	1186
2011	10524	3127	12681	3032	1032
2012	71626	4029	930	4477	1837
2013	125716	27425	1188	325	2841
2014	228418	48136	7035	359	1320
2015	13273	87460	10972	1881	641
2016		5082	21110	3115	981

Table 11.4.17. Sandeel SA 3. Explorative run with Norwegian acoustic survey. Estimated recruitment, total stock biomass (TBS), spawning stock biomass (SSB), catch weight (Yield) and average fishing mortality.

	Recruits (million)	TSB (tonnes)	SSB (tonnes)	Yield (tonnes)	Mean F_{1-2}
1983	89443	201473	73724	105946	0.495
1984	45026	286610	90461	123635	0.525
1985	295045	250052	133980	59083	0.284
1986	368446	771824	159602	420341	1.022
1987	92110	1067780	279523	403908	0.922
1988	302849	663380	388034	391081	1.392
1989	101685	808905	134289	481893	1.153
1990	181797	425815	195423	219183	0.597
1991	94733	656050	197266	368105	0.763
1992	235116	368794	167715	195700	0.488
1993	213018	728014	194237	263954	0.673
1994	145184	669059	242316	444119	0.757
1995	150137	501296	184816	218922	0.506
1996	935450	760839	302306	247397	0.540
1997	62626	1682820	235446	604159	0.999
1998	93798	561056	370848	499333	0.983
1999	113310	376990	169059	223160	1.447
2000	72178	349188	73645	242732	1.646
2001	77036	236856	59518	245290	1.184
2002	15479	233610	46562	209302	1.212
2003	40206	97017	55729	58942	0.630
2004	17264	119479	26465	79234	0.847
2005	31578	102732	57243	29677	0.247
2006	101343	126540	46196	18863	0.168
2007	59225	342581	71773	113232	0.652
2008	109796	300601	118303	94491	0.596
2009	163843	341013	72276	33350	0.173
2010	8173	674118	283266	80576	0.690
2011	10524	277980	243157	94750	0.219
2012	71626	198184	165161	45111	0.229
2013	125716	217371	60418	39082	0.404
2014	228418	484143	57251	133413	0.550
2015	13273	889673	185109	118541	0.479
2016			339023		
arith. mean	141377	477935	161181	209288	0.711
geo. mean	91196				

Arith. mean for the period 1983–2015
Geo. mean for the period 1983–2014

Table 11.4.18. Sandeel SA 3. Explorative run with Norwegian acoustic survey. Input to forecast.

	Age 0	Age 1	Age 2	Age 3	Age 4
Stock numbers(2016)	91196	5082	21110	3115	981
Exploitation pattern 1st half		0.381	0.399	0.274	0.274
Exploitation pattern 2nd half	0.000	0.000	0.000	0.000	0.000
Weight in the stock 1st half		7.21	10.67	14.91	20.91
Weight in the catch 1st half		7.21	10.67	14.91	20.91
weight in the catch 2nd half	3.89	9.50	16.24	19.88	22.59
Proportion mature(2016)	0.00	0.02	0.87	1.00	1.00
Proportion mature(2017)	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 11.4.19. Sandeel SA 3. Explorative run with Norwegian acoustic survey. Short term forecast (000 tonnes).

Basis: Fsq=F(2015)=0.39; Yield(2015)=119; Recruitment(2015)=13; Recruitment(2016)=geometric mean (GM 83-14)=91 billion; SSB(2016)=264

F multiplier	Basis	F(2016)	Catch (2016)	SSB (2017)	%SSB change*	%TAC change**
0	F=0	0	0	203	-23 %	-100 %
1.640	MSY quota set by the default assessment	0.640	123	116	-56 %	5 %
0.250	Fsq*0.25	0.098	23.891	186	-29 %	-80 %
0.500	Fsq*0.5	0.195	45.784	171	-35 %	-61 %
0.750	Fsq*0.75	0.293	65.856	157	-40 %	-44 %
1.000	Fsq*1	0.390	84.266	144	-45 %	-29 %
1.250	Fsq*1.25	0.488	101.158	133	-50 %	-15 %
1.500	Fsq*1.5	0.585	116.666	122	-54 %	-2 %
1.750	Fsq*1.75	0.683	130.908	112	-57 %	10 %
2.000	Fsq*2	0.781	143.995	104	-61 %	21 %
0.118	MSY	0.046	11.543	195	-26 %	-90 %

***SSB in 2017 relative to SSB in 2016**

****TAC in 2016 relative to catches in 2015**

Table 11.5.1. Sandeel SA 4. Catch numbers (millions) by half-year.

Year	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
1982	0	328	0	36	0	19	0	11	0
1983	0	16	0	257	0	7	0	3	0
1984	0	295	0	16	0	52	0	2	0
1985	6	958	2	1180	4	357	2	171	0
1986	10	1719	10	187	1	14	0	0	0
1987	2	633	22	302	1	11	0	4	0
1988	15	29	1	75	0	4	0	0	0
1989	0	555	0	22	0	33	0	0	0
1990	63	174	10	142	2	21	0	6	0
1991	2410	1088	2233	421	67	63	22	22	0
1992	5	6526	151	1112	15	112	6	70	1
1993	674	1235	149	6337	381	1861	122	534	39
1994	0	1070	256	1522	62	5144	257	2092	159
1995	4	2690	4	1229	1	529	0	30	0
1996	2666	754	2584	2536	3461	476	227	130	1110
1997	0	2879	1369	291	35	1683	43	413	10
1998	0	2159	61	3766	97	235	6	130	3
1999	0	1472	86	1137	46	1543	47	252	11
2000	0	6537	0	376	0	323	0	297	0
2001	0	2048	64	4961	20	601	1	377	0
2002	0	337	0	807	0	511	0	101	0
2003	145	4322	148	1002	10	2721	5	1253	1
2004	0	920	4	220	1	45	0	82	0
2005	0	49	0	145	0	32	0	17	0
2006	0	8	0	1	0	0	0	0	0
2007	0	2	0	0	0	0	0	0	0
2008	0	200	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	83	0	40	0	196	0	3	0
2013	0	182	0	100	0	71	0	133	0
2014	0	346	0	54	0	15	0	47	0
2015	0	864	0	29	0	9	0	14	0

Table 11.5.2. Sandeel SA 4. Individual mean weight (g) at age in the catch and in the sea.

Year	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
1982	3.98	5.51	9.03	9.96	16.15	13.74	18.82	16.40	25.47
1983	3.98	5.51	9.03	9.96	16.15	13.74	18.82	16.90	25.47
1984	3.98	5.53	9.03	11.34	16.15	13.91	18.82	17.23	25.47
1985	3.03	5.64	13.23	13.03	27.84	27.28	36.20	43.33	51.91
1986	3.03	5.64	13.23	13.05	27.84	27.27	18.82	16.30	25.47
1987	3.03	5.64	13.23	12.75	27.84	24.82	18.82	41.79	25.47
1988	3.03	5.64	13.23	13.05	27.84	27.30	36.20	42.20	44.00
1989	5.00	6.19	8.90	13.98	16.00	16.30	18.82	18.01	25.47
1990	3.01	4.03	12.81	12.50	24.72	15.57	31.87	19.42	38.58
1991	2.61	8.06	7.50	16.34	13.60	17.27	12.00	18.14	44.00
1992	3.40	7.40	9.43	13.71	16.61	17.56	20.04	22.97	22.58
1993	2.95	7.36	6.70	11.85	11.99	14.87	13.97	20.09	18.90
1994	3.81	10.87	8.65	11.08	15.46	14.70	18.02	20.51	24.39
1995	4.45	8.42	10.09	15.69	18.05	19.10	21.03	15.52	28.46
1996	6.32	5.30	7.31	12.87	13.12	18.58	18.01	23.02	22.32
1997	3.06	6.69	6.95	7.46	12.43	11.15	14.49	18.06	19.61
1998	2.64	6.06	5.99	10.37	10.71	13.60	12.48	14.57	16.88
1999	3.18	6.07	7.23	10.82	12.93	16.12	15.06	20.16	20.39
2000	3.98	3.87	9.03	8.02	16.15	13.20	18.82	17.29	25.47
2001	1.84	3.40	4.17	5.99	7.47	9.03	8.70	14.23	11.77
2002	3.98	3.75	9.03	5.94	16.15	9.51	18.82	17.93	25.47
2003	3.63	4.60	5.60	6.59	6.20	8.13	7.82	10.91	10.12
2004	1.44	4.01	3.26	7.40	5.83	9.28	6.79	13.75	9.19
2005	3.98	4.25	9.03	6.10	16.15	8.59	18.82	10.98	25.47
2006	NA	5.47	NA	10.00	NA	14.30	NA	18.09	NA
2007	3.98	4.83	9.03	8.84	16.15	12.65	18.82	16.00	25.47
2008	3.98	4.75	9.03	8.70	16.15	12.44	18.82	15.74	25.47
2009	3.98	5.82	9.03	10.65	16.15	15.24	18.82	19.28	25.47
2010	3.98	5.12	9.03	9.37	16.15	13.40	18.82	16.95	25.47
2011	3.98	4.86	9.03	8.89	16.15	12.72	18.82	16.09	25.47
2012	3.98	4.02	9.03	8.18	16.15	9.63	18.82	12.19	25.47
2013	3.98	5.28	9.03	9.34	16.15	14.74	18.82	17.11	25.47
2014	3.98	7.10	9.03	12.43	16.15	17.21	18.82	19.97	25.47
2015	3.98	4.36	9.03	9.52	16.15	11.36	18.82	16.25	25.47

Table 11.5.3. Sandeel SA 4. Average dredge survey CPUE by age for a) SA 4 and b) Firth of Forth.

a) SA 4

Year	Age.0	Age.1	Age.2
2008	52	24	18
2009	832	87	38
2010	147	1032	67
2011	89	165	407
2012	95	135	23
2013	62	85	35
2014*	445	43	12
2015	136	1044	14

***Adverse weather conditions in 2014 precluded any sampling of SA4 stations outside the Firth of Forth region, hence CPUE estimates are identical.**

b) Firth of Forth

Year	Age.0	Age.1	Age.2
1999			301
2000	586	3170	258
2001	48	2656	1561
2002	243	404	916
2003	580		
NA			
2008	68	24	24
2009	1023	174	56
2010	186	1244	78
2011	119	220	534
2012	122	178	30
2013	82	89	45
2014	445	43	12
2015	151	1126	13

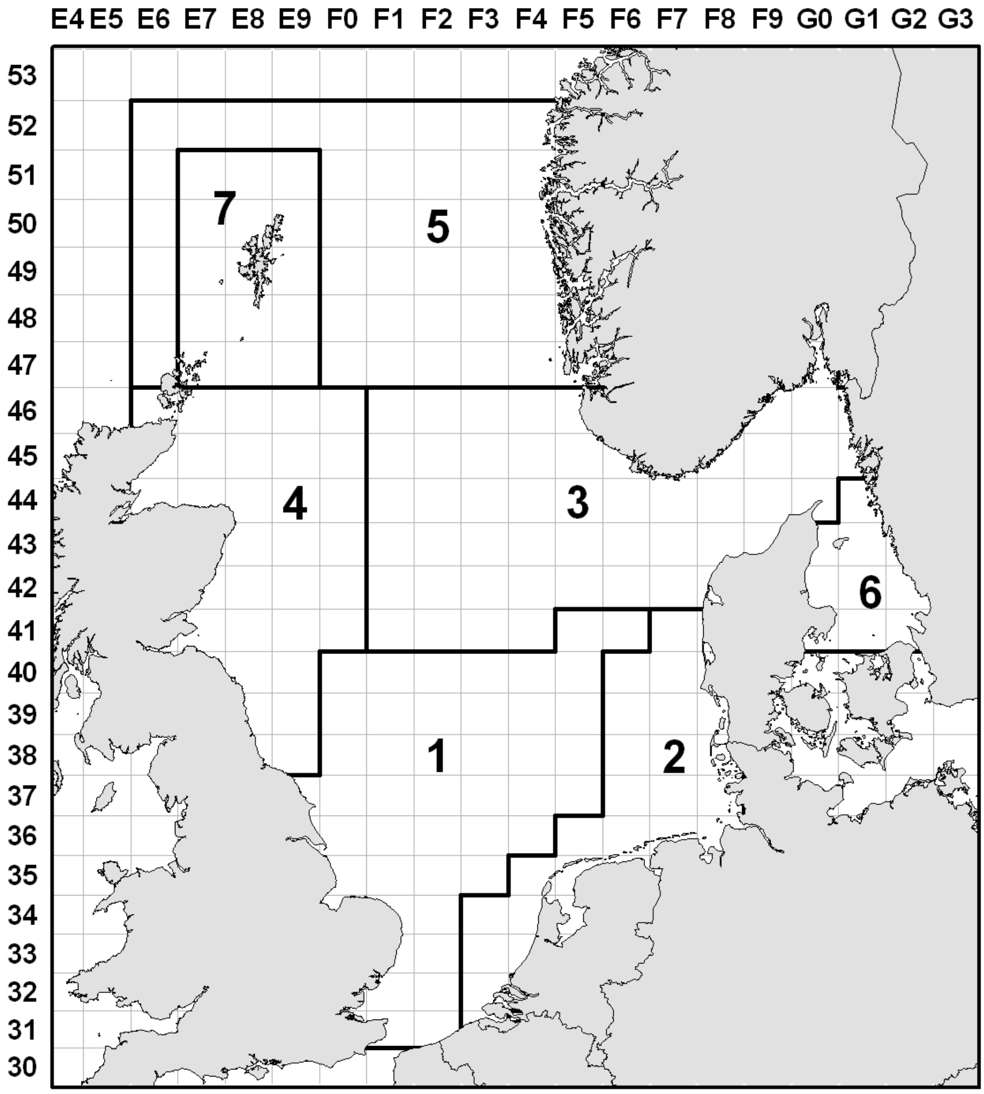


Figure 11.1.1. Sandeel in ICES Division 4 and 3a. Sandeel management areas.

Figure 11.1.2. Sandeel in ICES Division 4 and 3a. Catches ICES rectangles 2000–2015. Area of the circles is proportional to catch by rectangle.

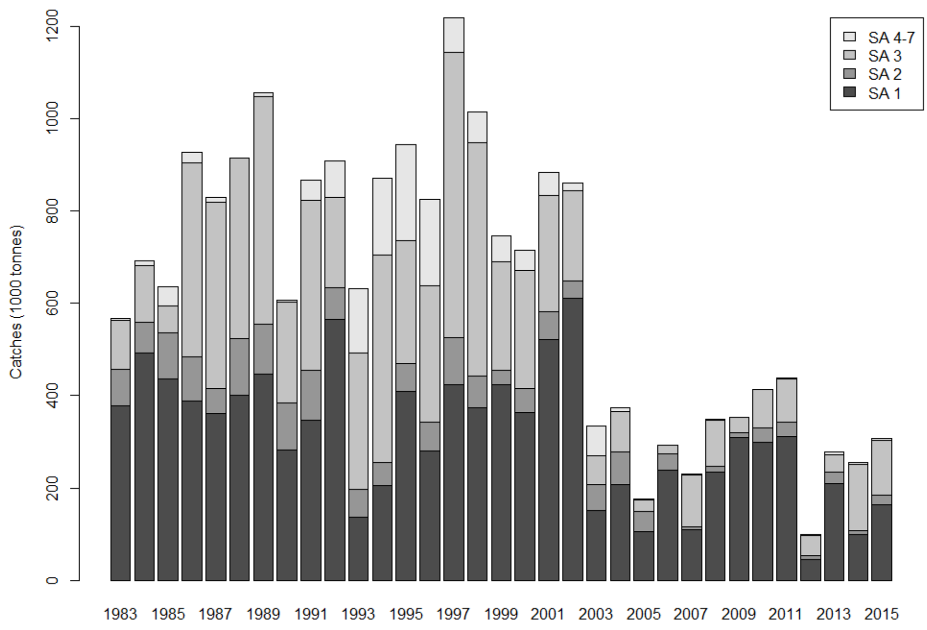


Figure 11.1.3. Sandeel in ICES Division 4 and 3a. Total catch by year and area.

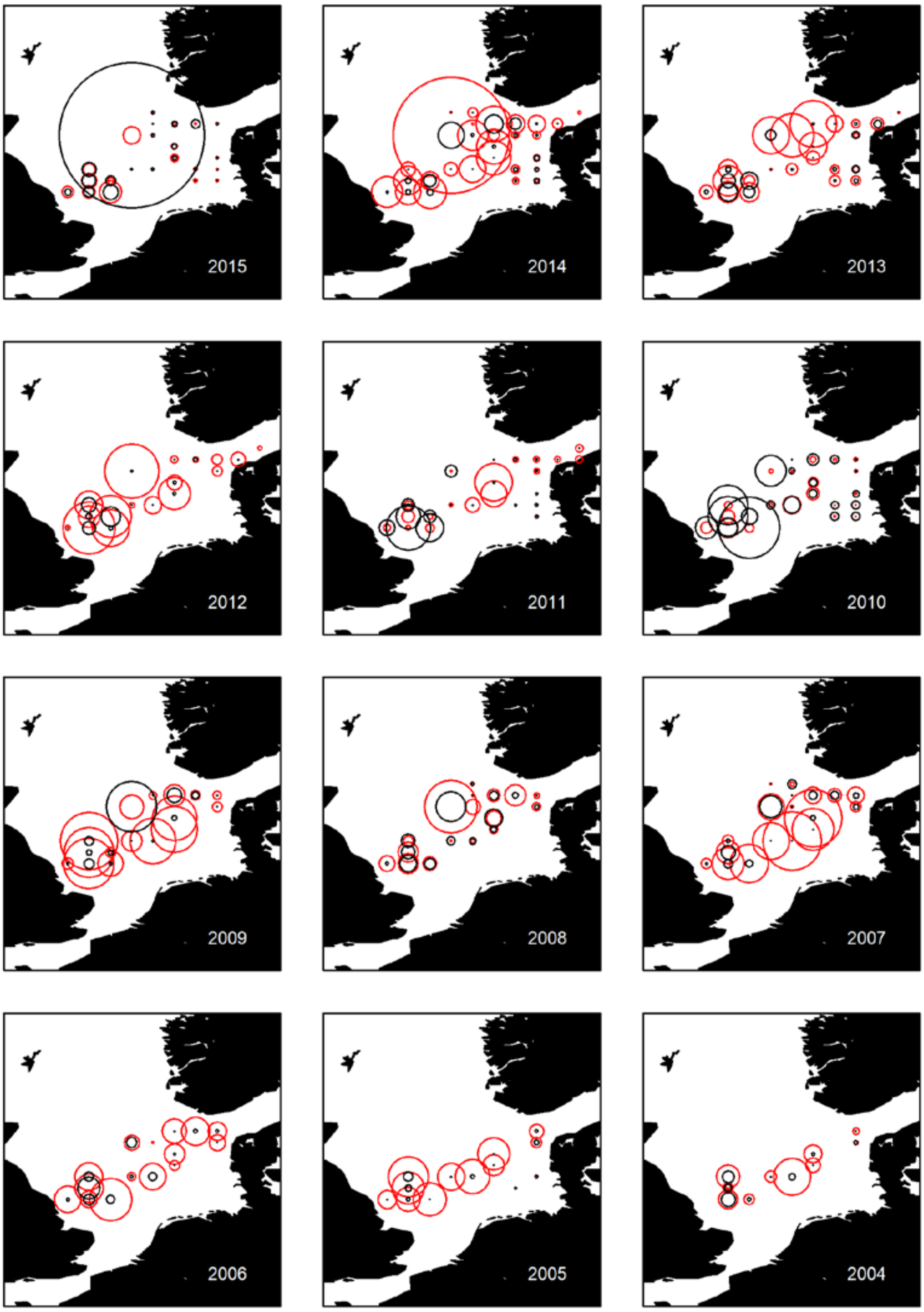


Figure 11.1.4. Sandeel in ICES Division 4 and 3a. Danish survey indices by year and ICES rectangles. Red circles: 0-group, black circles: 1-group. Area of the circles is proportional to catch numbers by rectangle.

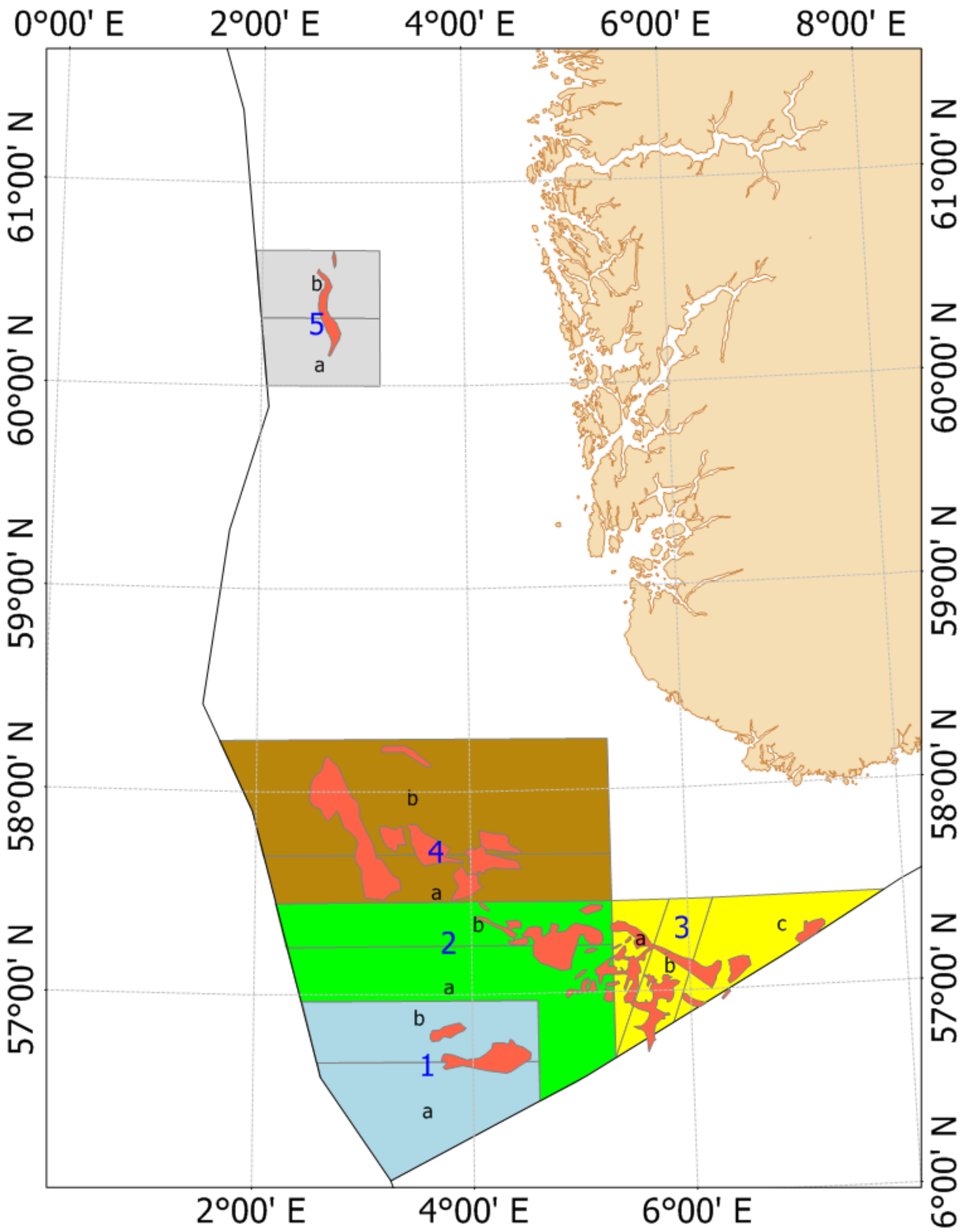


Figure 11.1.5. Sandeel in ICES Division 4 and 3a. Norwegian sandeel management areas. There are 6 main areas consisting of subareas a and b. Sub SA 3 consist of three subareas a, b, and c.

Figure 11.2.1. Sandeel SA 1. Catch numbers, proportion at age.

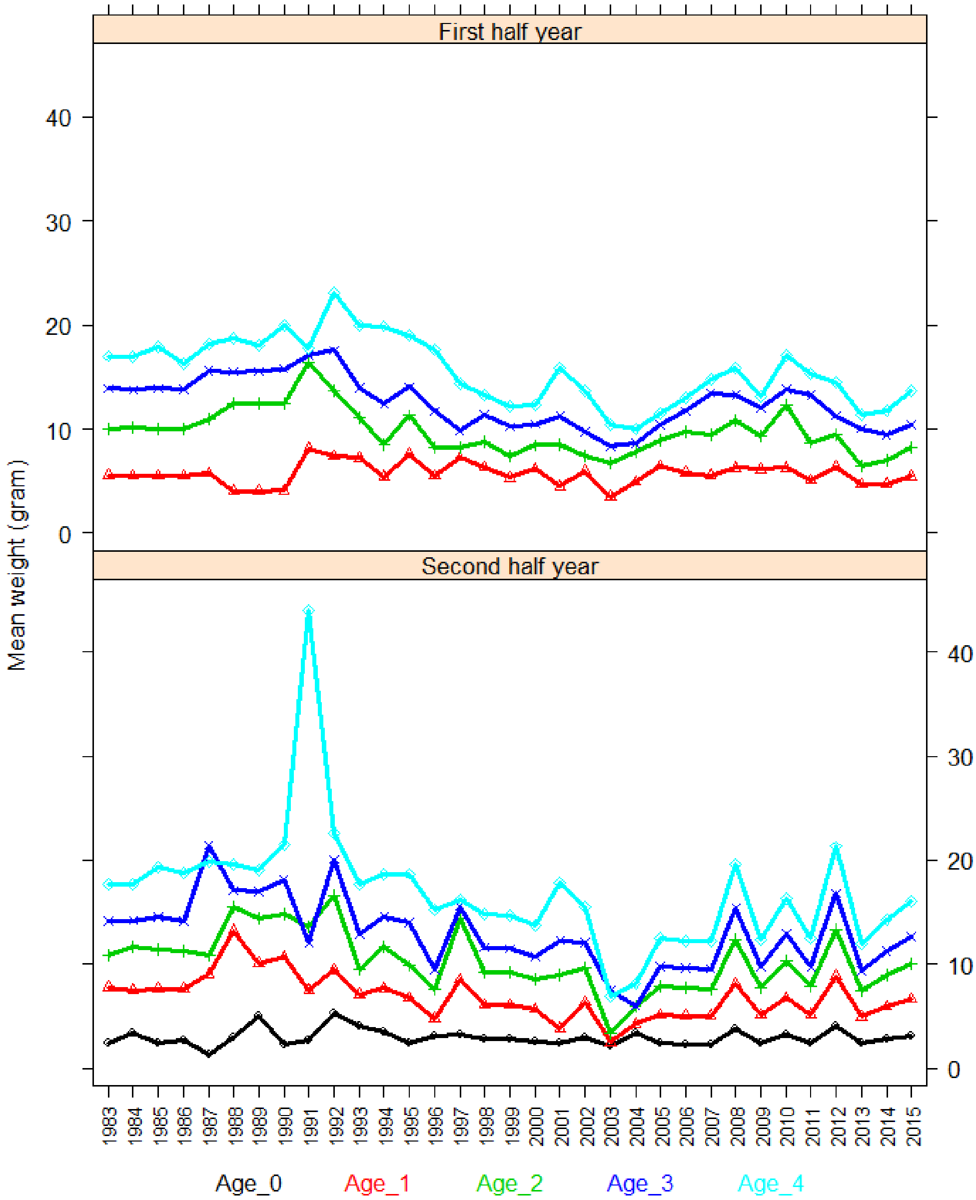


Figure 11.2.2. Sandeel SA 1. Mean weight at age in the first half year (age 1–4+) and second half year (age 0–4+).

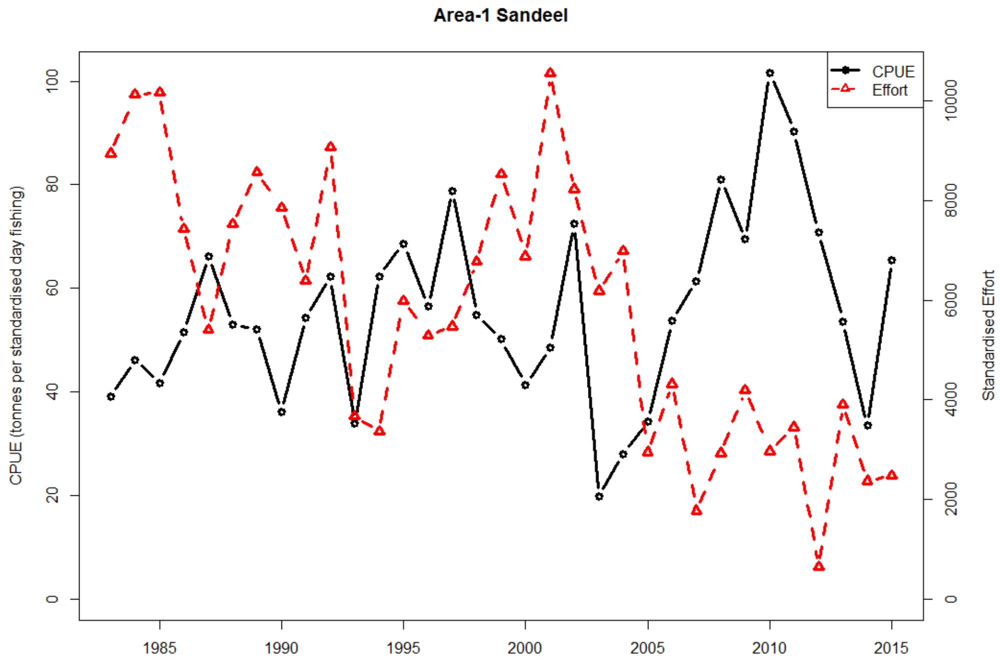


Figure 11.2.3. Sandeel SA 1. CPUE and effort.

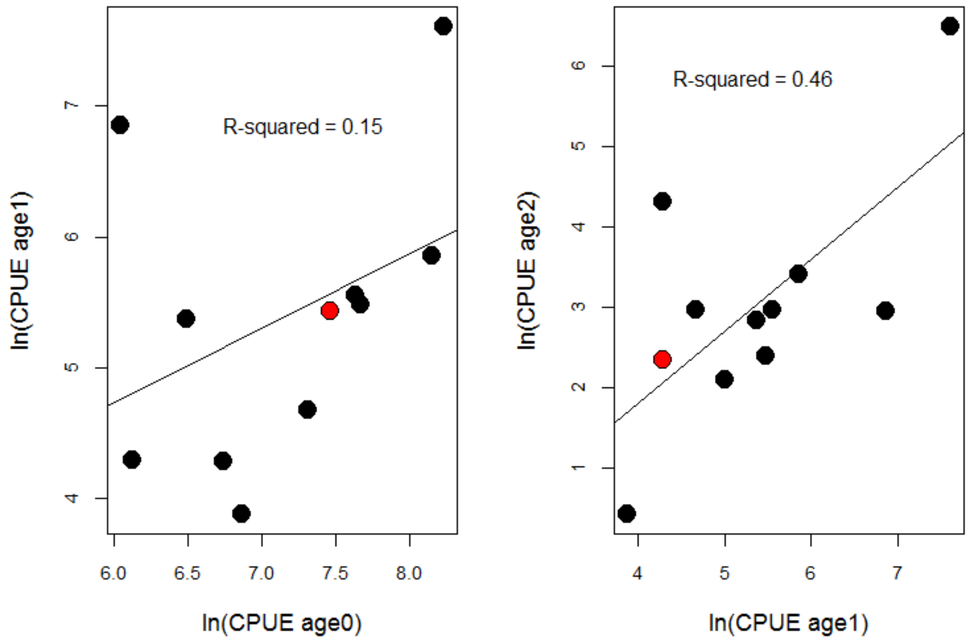


Figure 11.2.4. Sandeel SA 1. Internal consistency by age of the dredge survey. Red dot indicates the most recent data point.

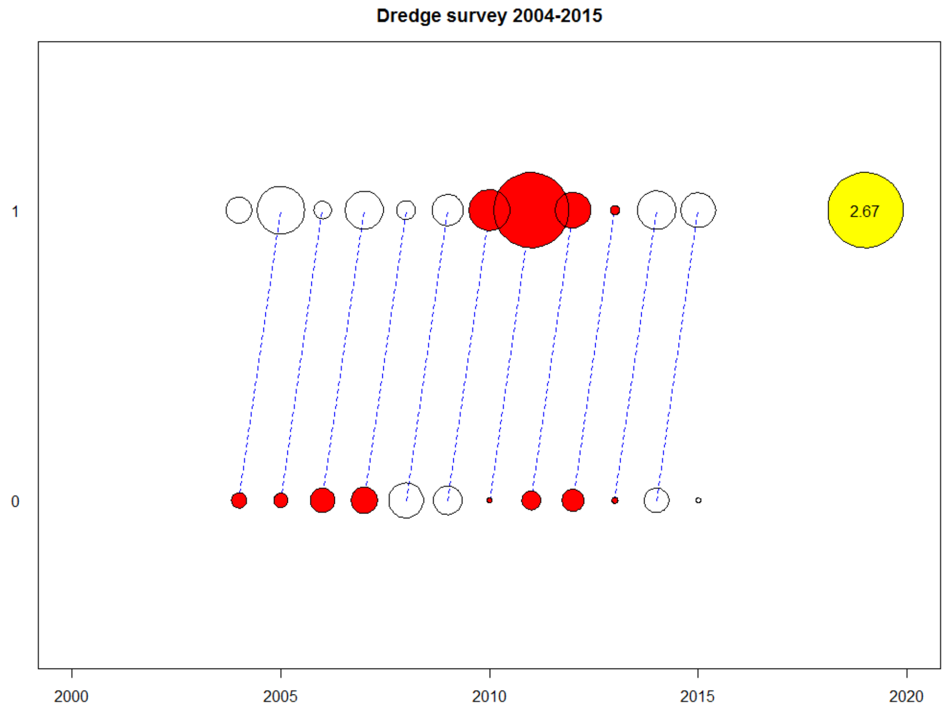


Figure 11.2.5. Sandeel SA 1. Survey CPUE at age residuals (log(observed CPUE)- log(expected CPUE). Red dots indicate a positive residual.

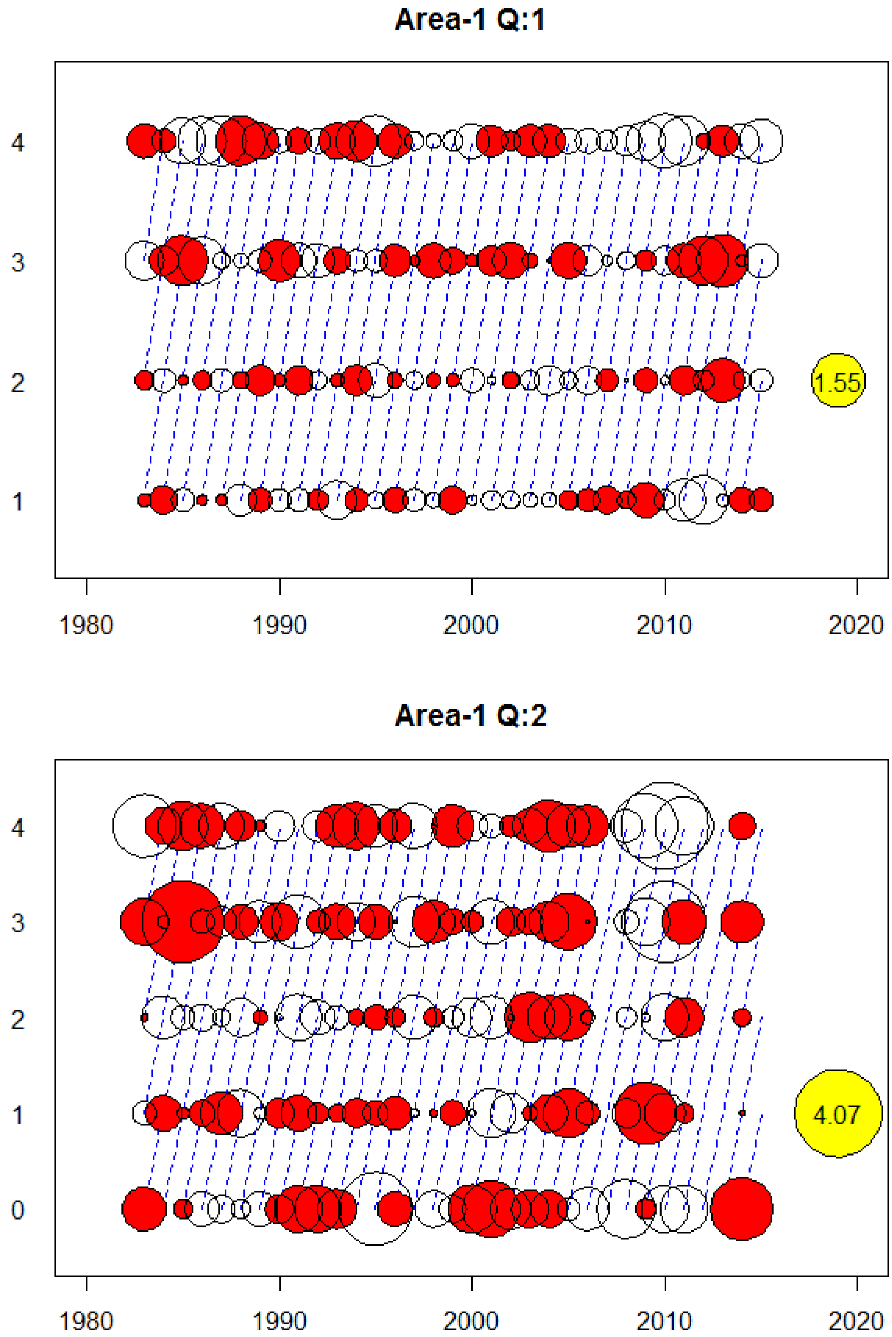


Figure 11.2.6. Sandeel SA 1. Catch at age residuals (log(observed CPUE)- log(expected CPUE). Red dots indicate a positive residual.

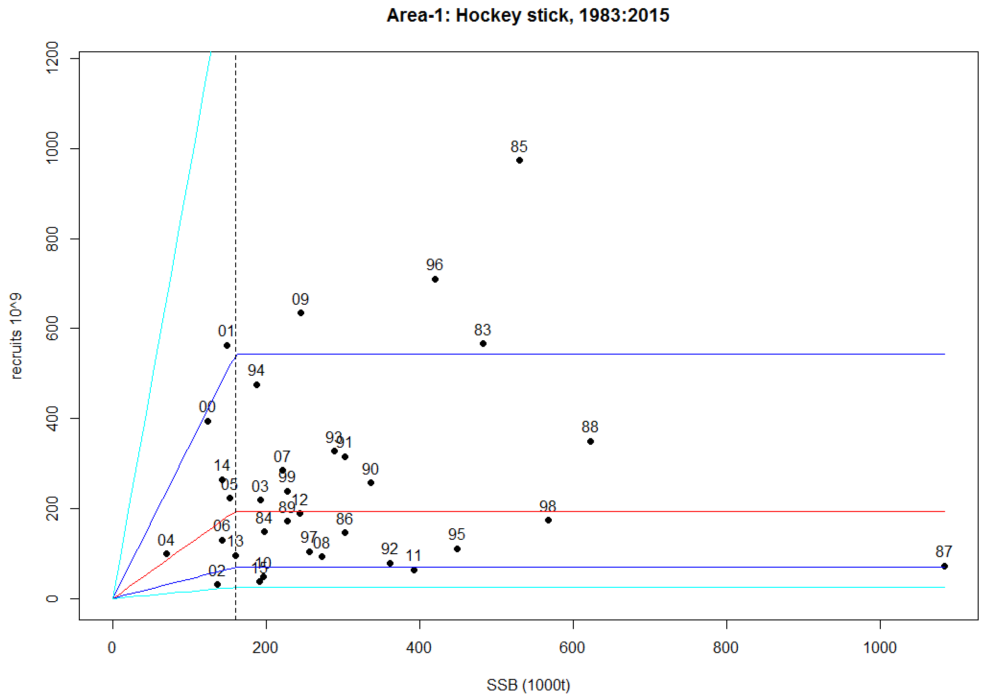


Figure 11.2.7. Sandeel SA 1. Estimated stock recruitment relation. Red line = median of the expected recruitment, Dark blue lines = one standard deviation, Light blue lines = 2 standard deviations. The area within the light blue lines can be seen as the 95% confidence interval of recruitment. Years shown in red are not used in the fit.

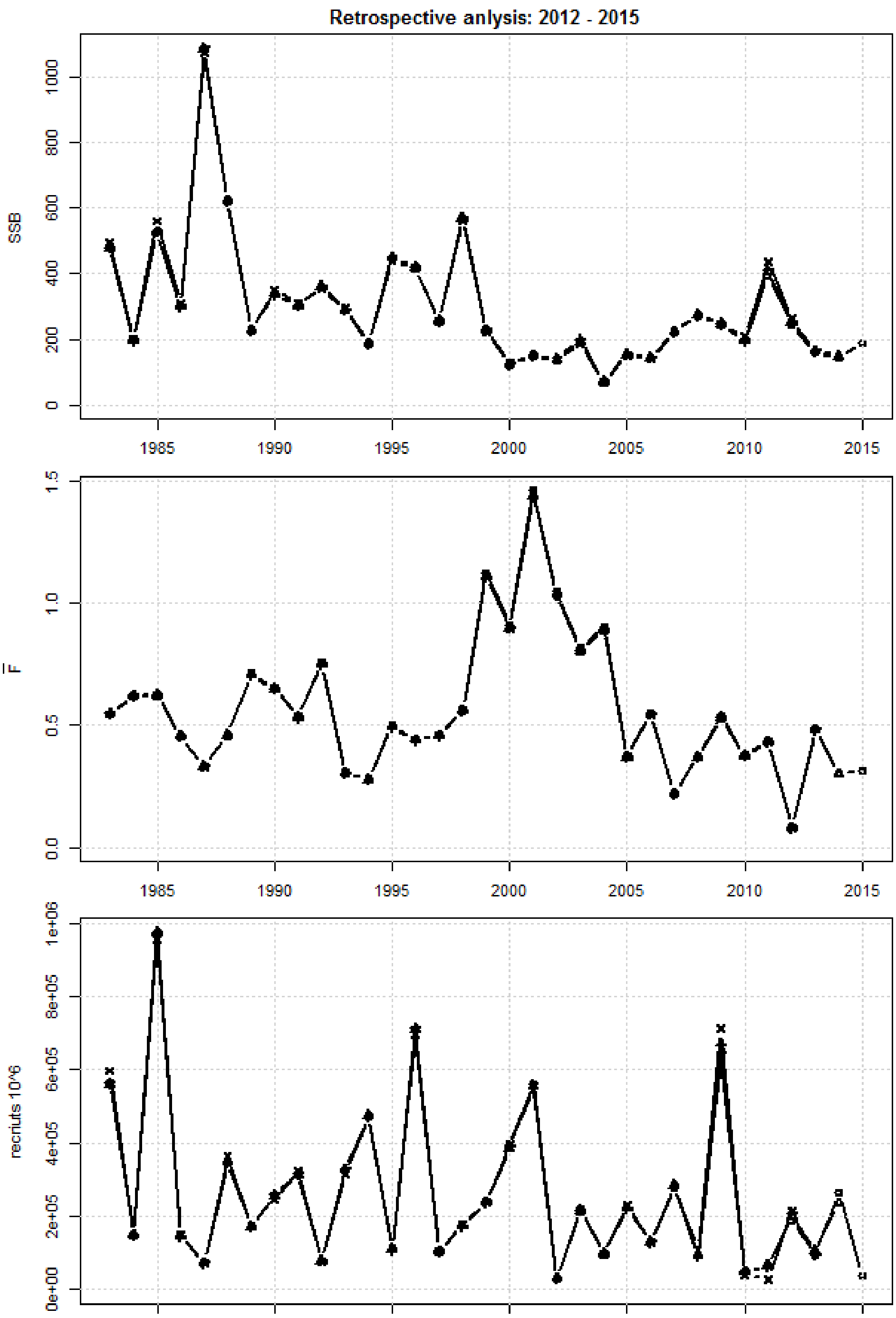


Figure 11.2.8. Sandeel SA 1. Retrospective analysis.

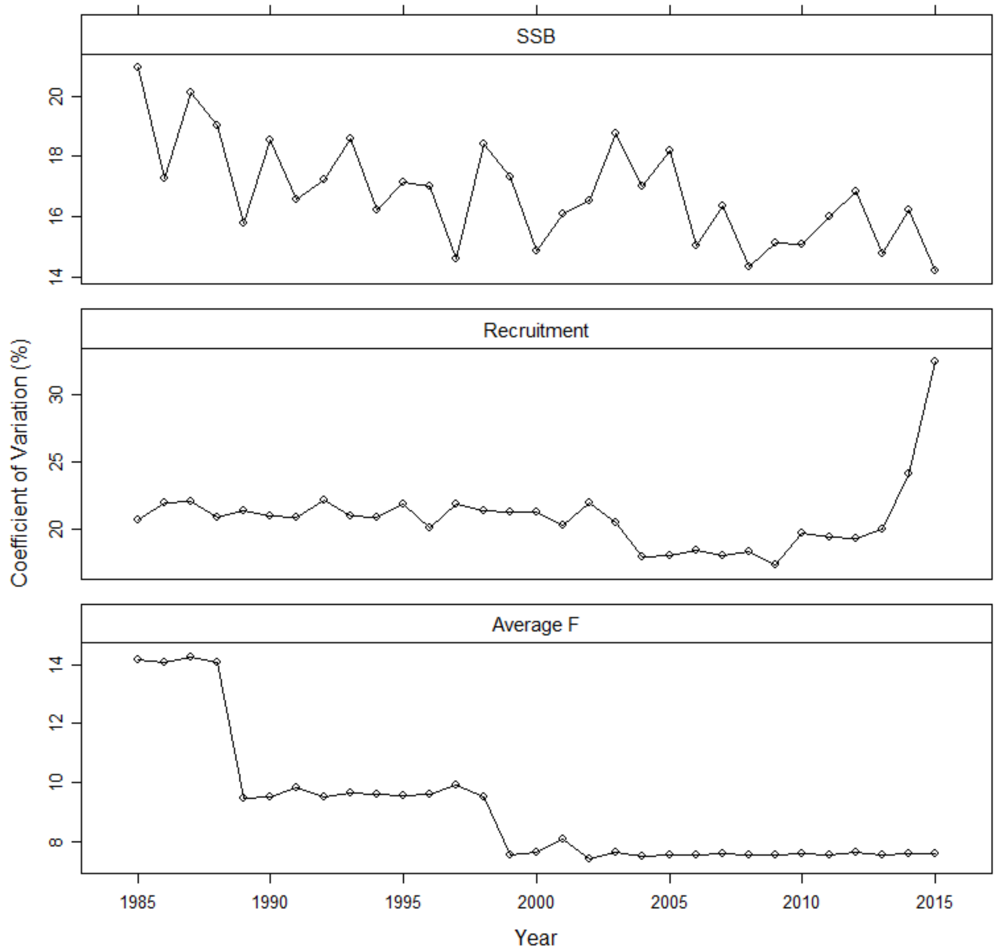


Figure 11.2.9. Sandeel SA 1. Uncertainties of model output estimated from parameter uncertainties derived from the Hessian matrix and the delta method.

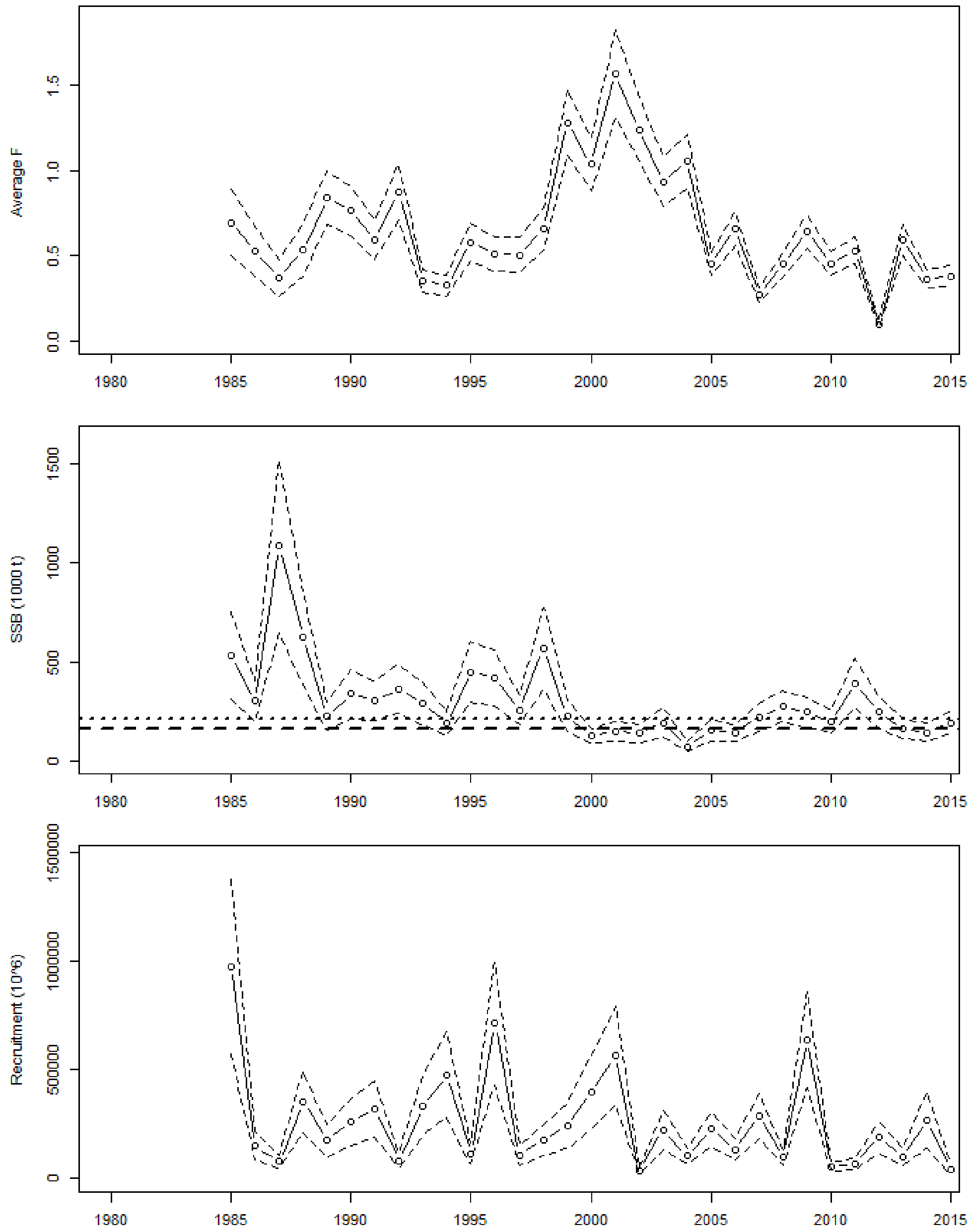


Figure 11.2.10. Sandeel SA 1. Model output (mean F, SSB and Recruitment) with mean values and plus/minus 2 * standard deviation.

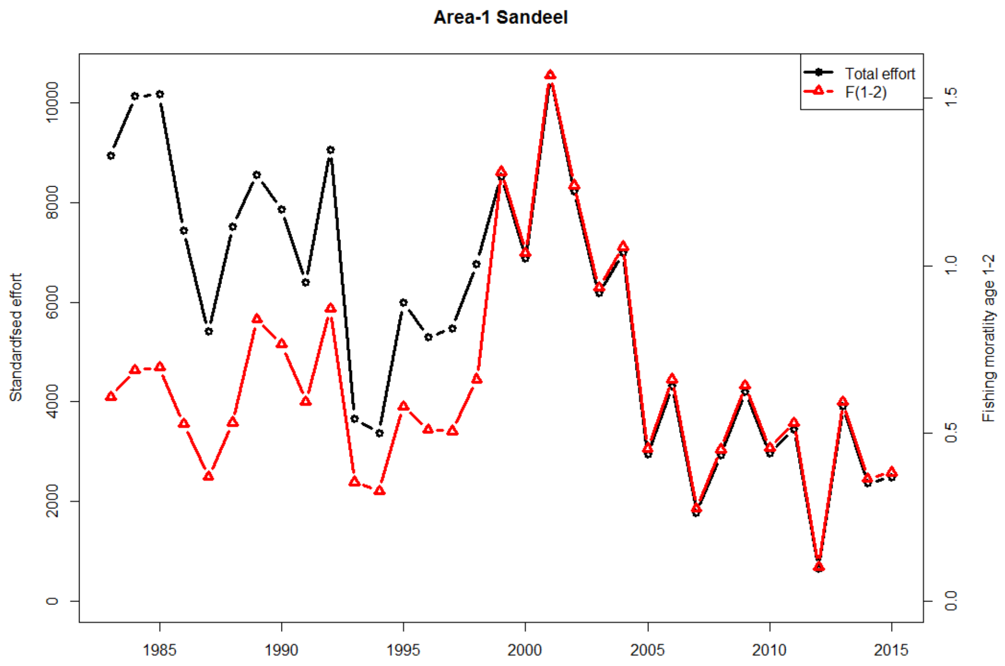


Figure 11.2.11. Sandeel SA 1. Total effort (days fishing for a standard 200 GT vessel) and estimated average Fishing mortality.

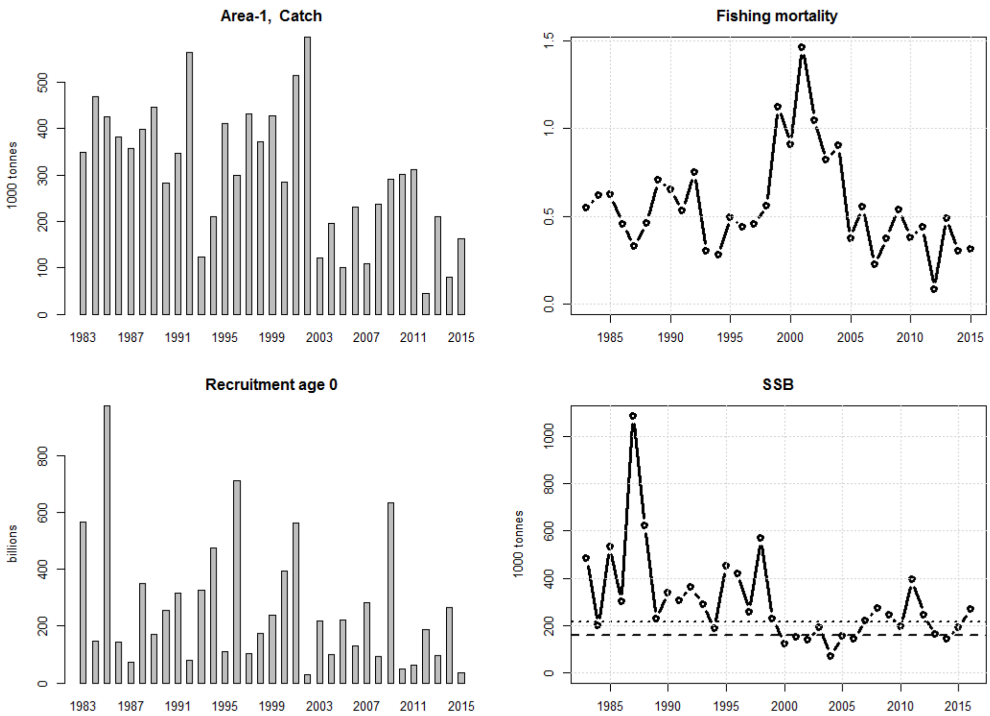


Figure 11.2.12. Sandeel SA 1. Stock summary.

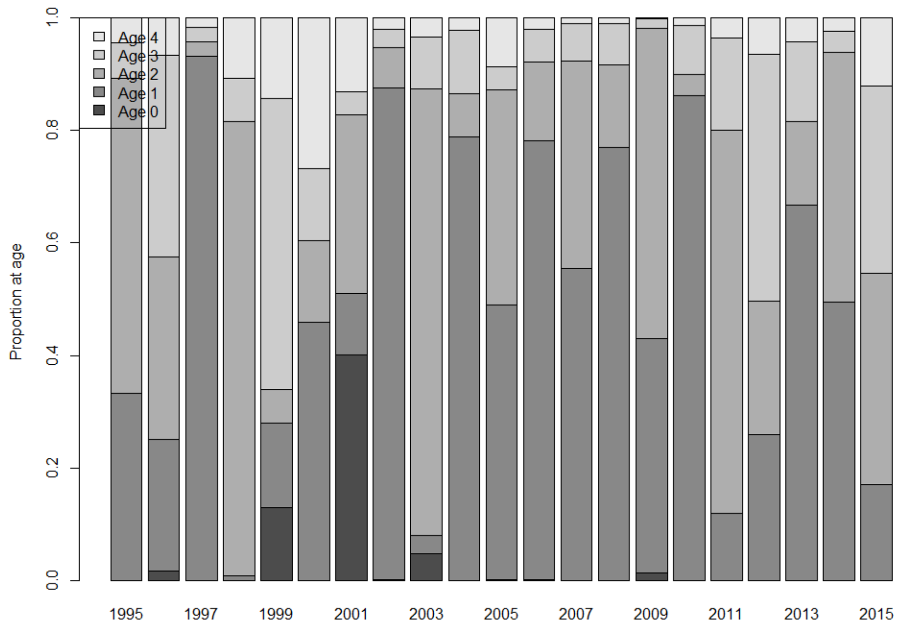


Figure 11.3.1. Sandeel SA 2. Catch numbers, proportion at age.

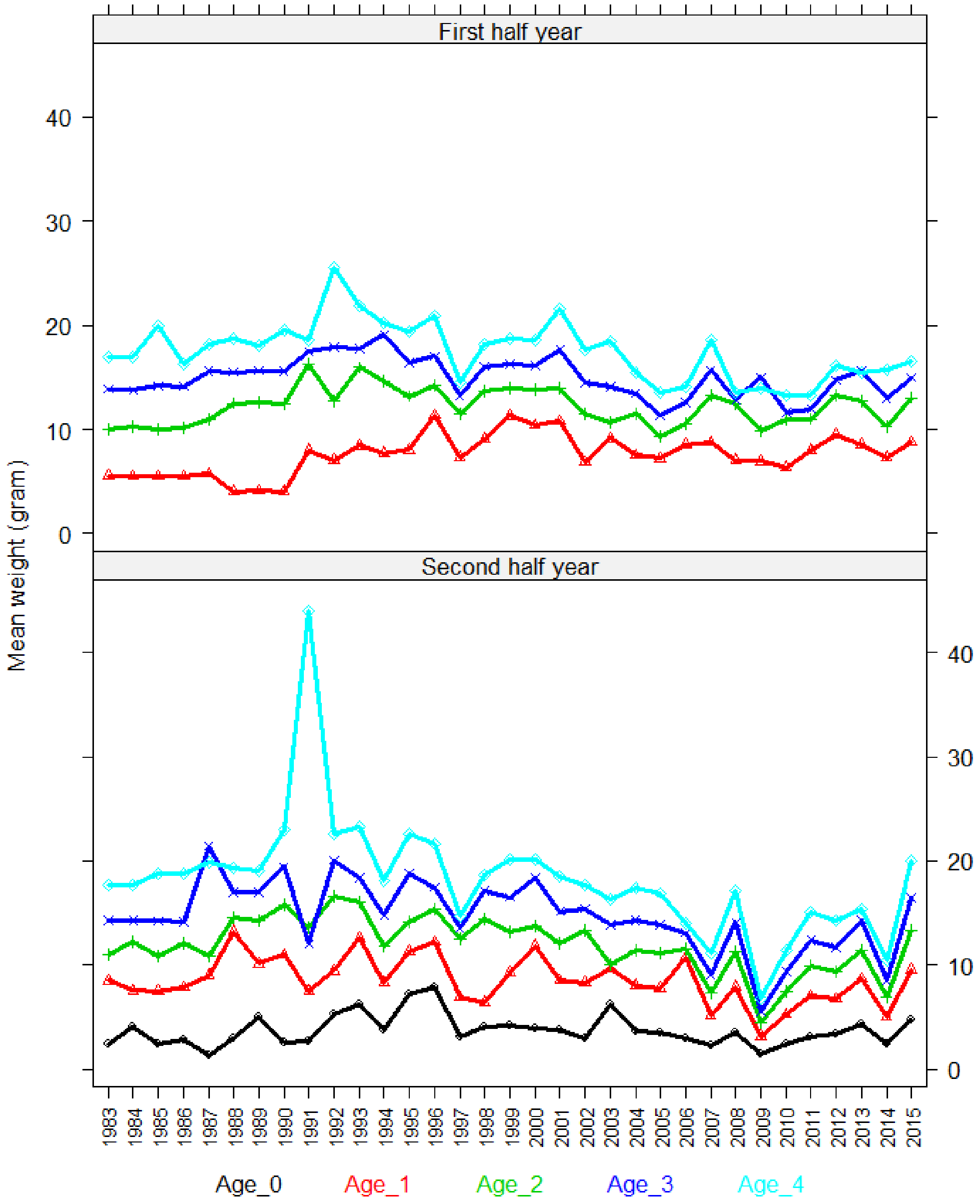


Figure 11.3.2. Sandeel SA 2. Mean weight at age in the first half year (age 1-4+) and second half year (age 0-4+).

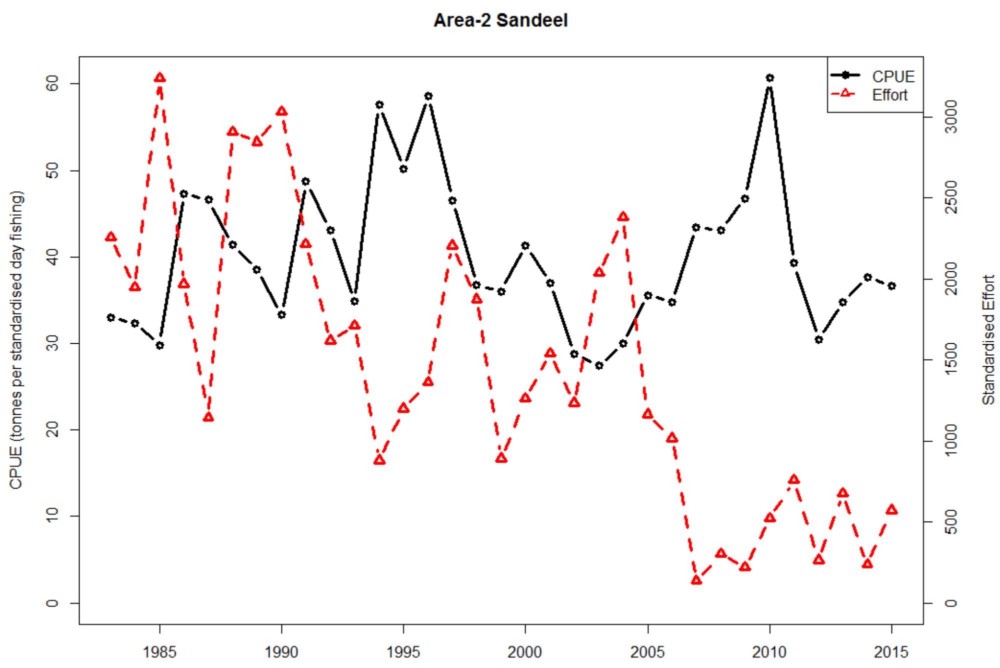


Figure 11.3.3. Sandeel SA 2. CPUE and effort.

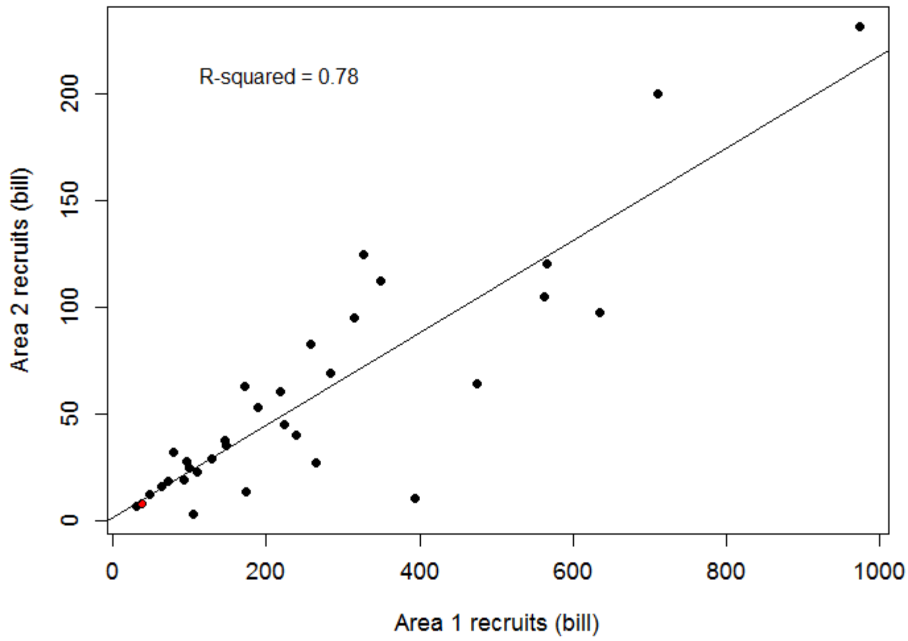


Figure 11.3.4. Sandeel SA 2. Consistency of recruitment estimates in SA 1 and SA 2. Last year is shown in red.

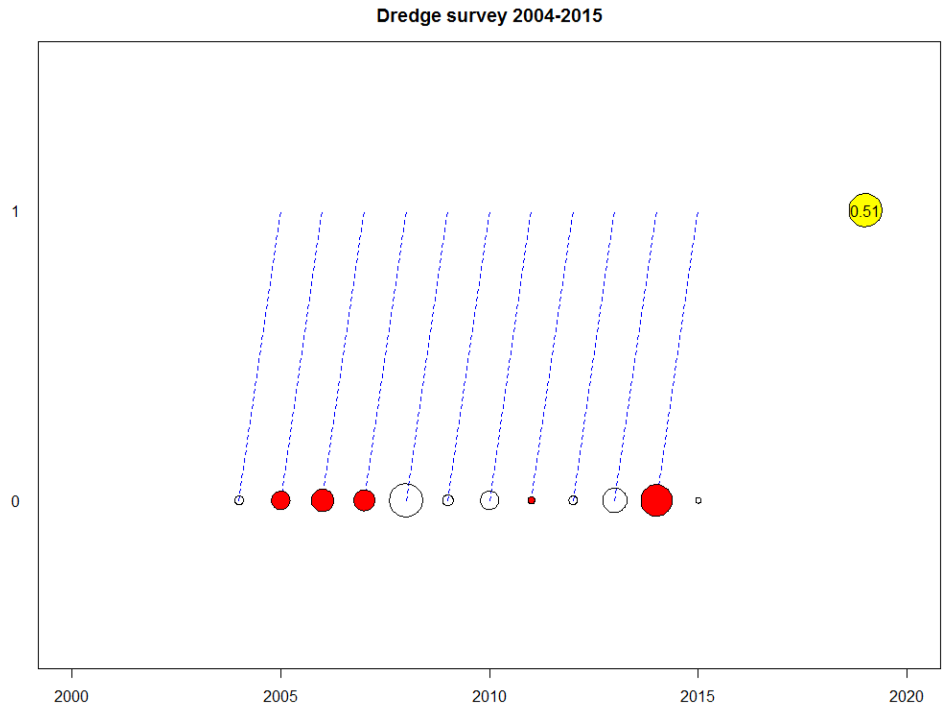


Figure 11.3.5. Sandeel SA 2. Survey CPUE at age residuals (log(observed CPUE)- log(expected CPUE). Red dots indicate a positive residual.

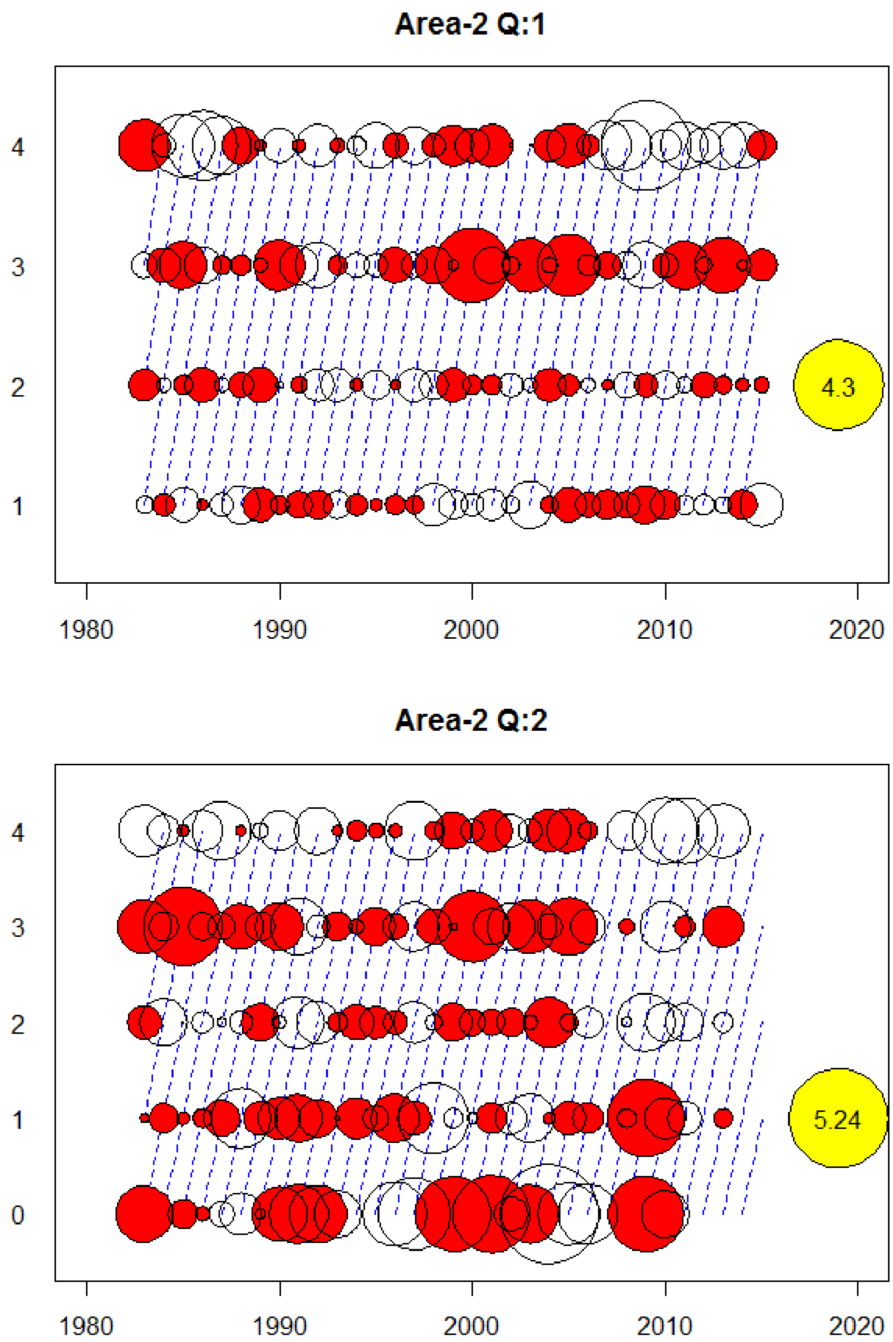


Figure 11.3.6. Sandeel SA 2. Catch at age residuals (log(observed CPUE)- log(expected CPUE). Red dots indicate a positive residual.

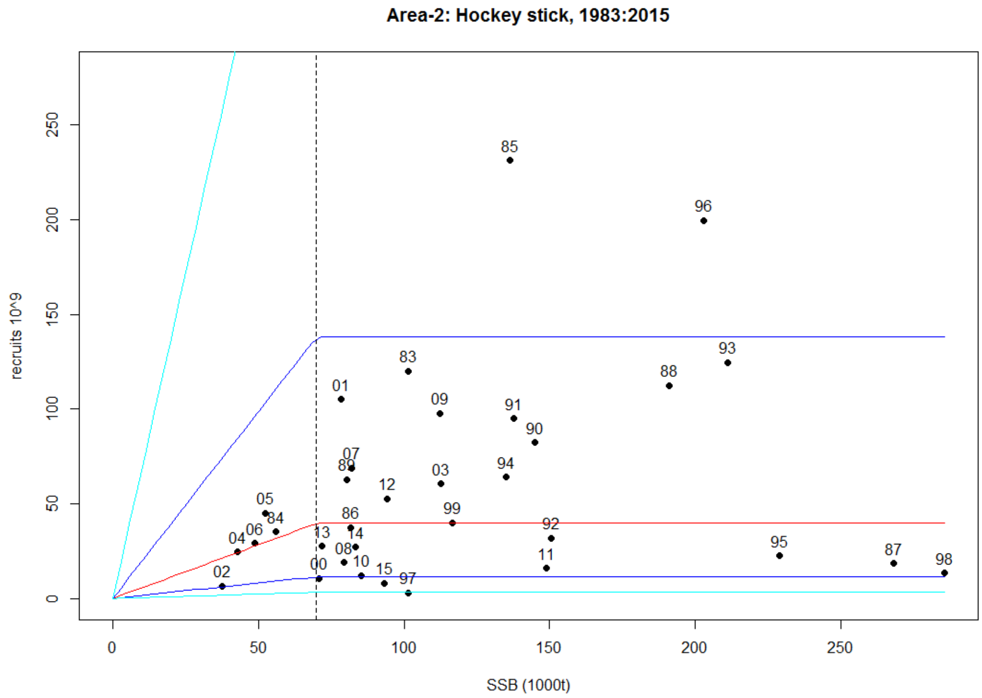


Figure 11.3.7. Sandeel SA 2. Estimated stock recruitment relation. Red line = median of the expected recruitment, Dark blue lines = one standard deviation, Light blue lines = 2 standard deviations. The area within the light blue lines can be seen as the 95% confidence interval of recruitment. Years shown in red are not used in the fit.

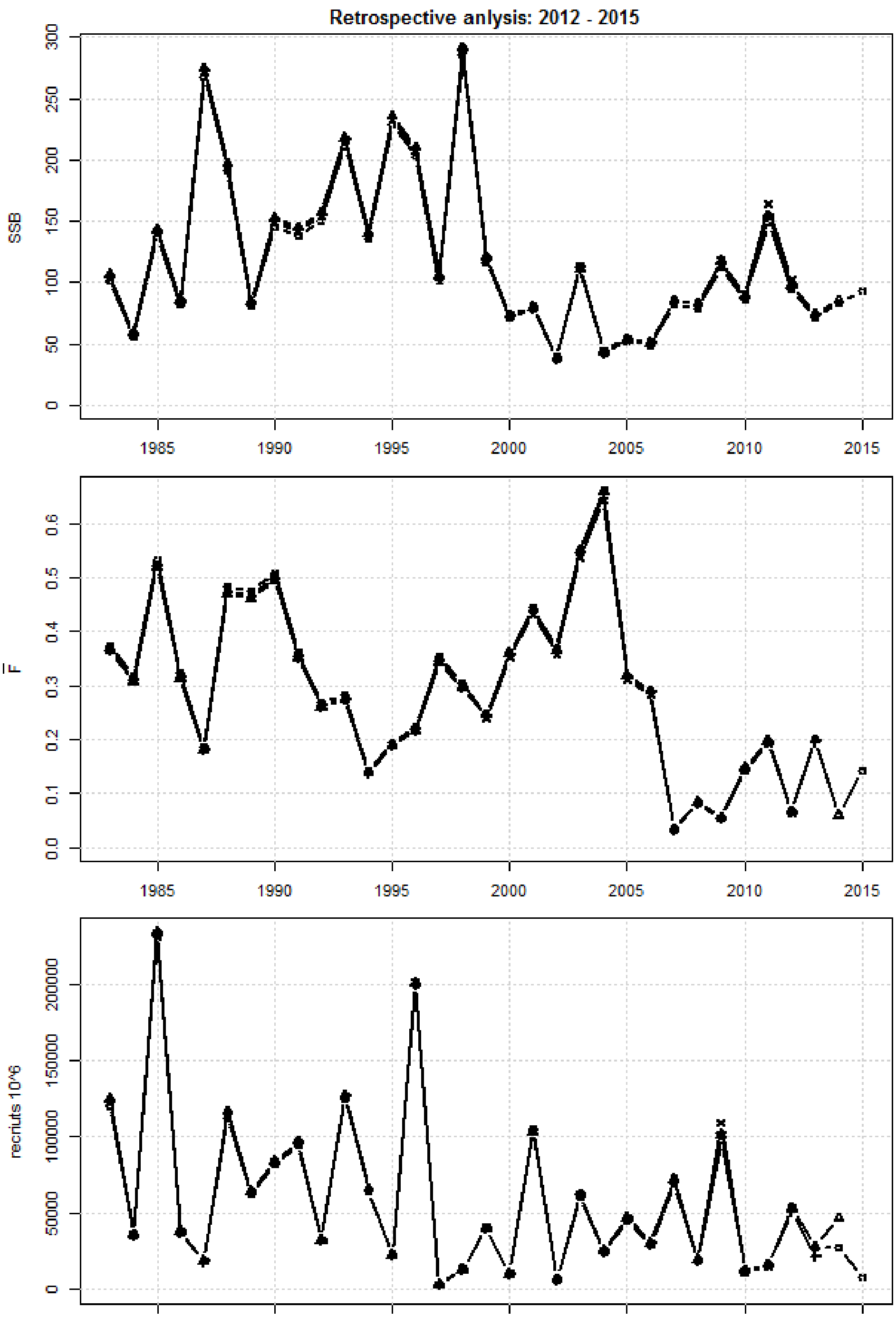


Figure 11.3.8. Sandeel SA 2. Retrospective analysis.

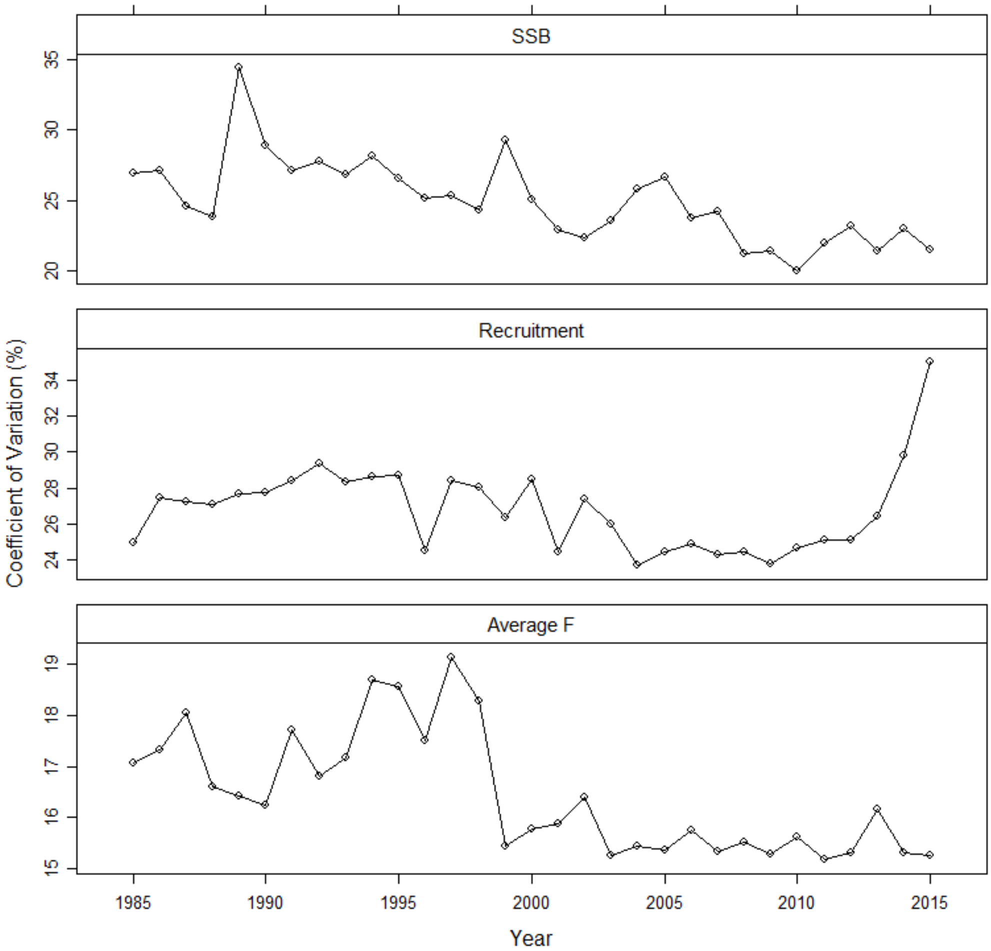


Figure 11.3.9. Sandeel SA 2. Uncertainties of model output estimated from parameter uncertainties derived from the Hessian matrix and the delta method.

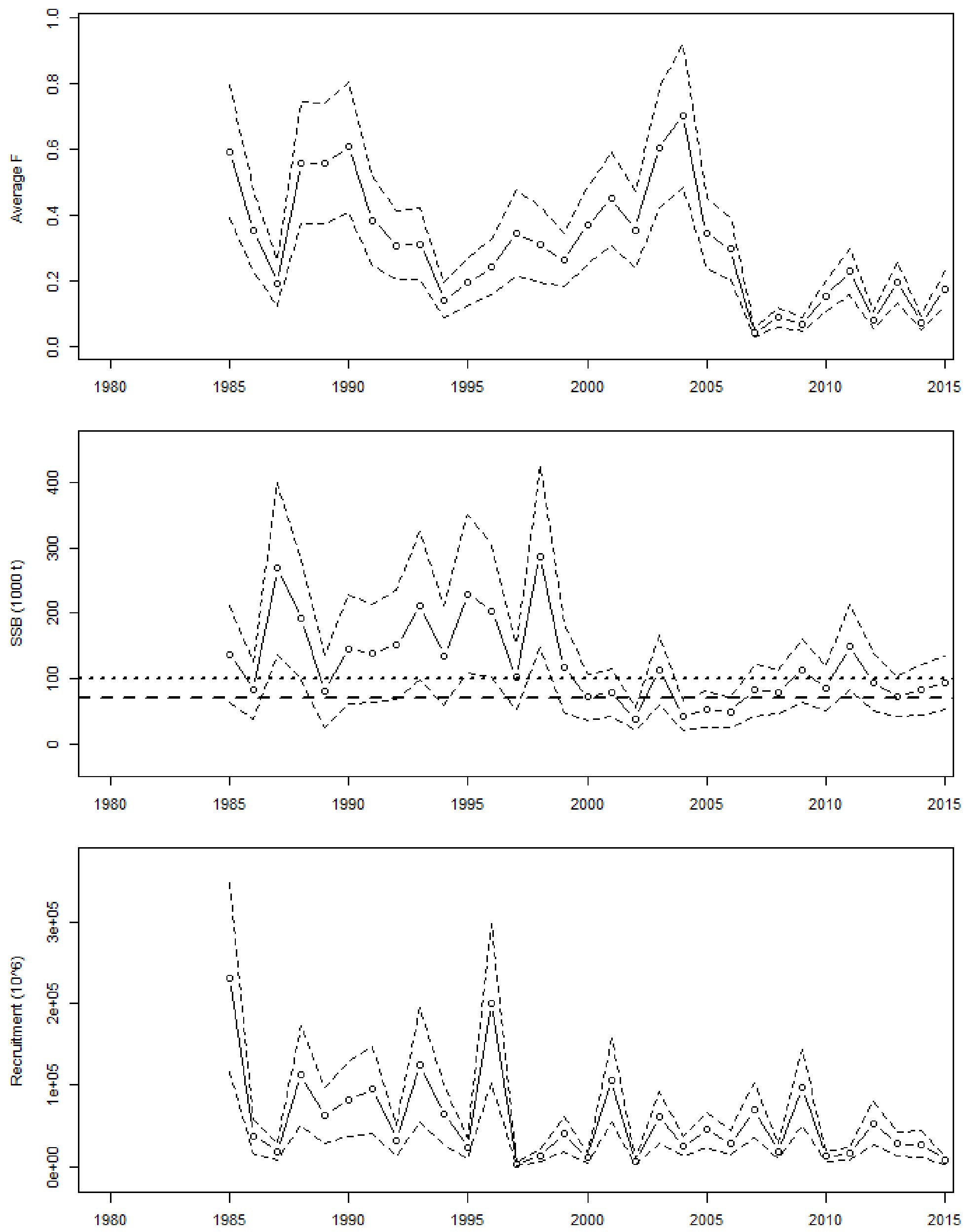


Figure 11.3.10. Sandeel SA 2. Model output (mean F, SSB and Recruitment) with mean values and plus/minus 2 * standard deviation.

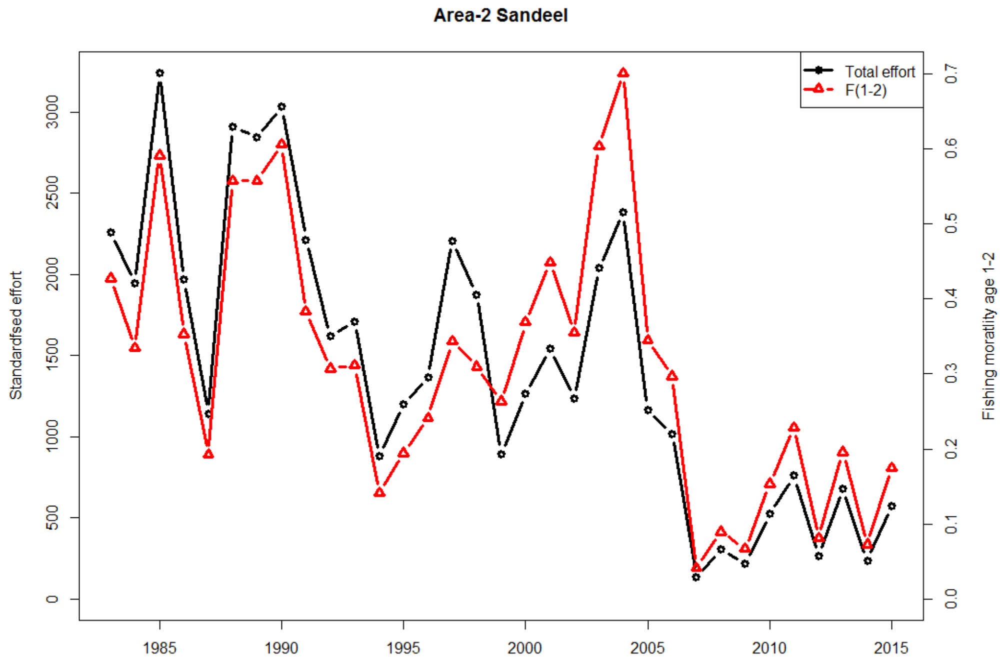


Figure 11.3.11. Sandeel SA 2. Total effort (days fishing for a standard 200 GT vessel) and estimated average Fishing mortality.

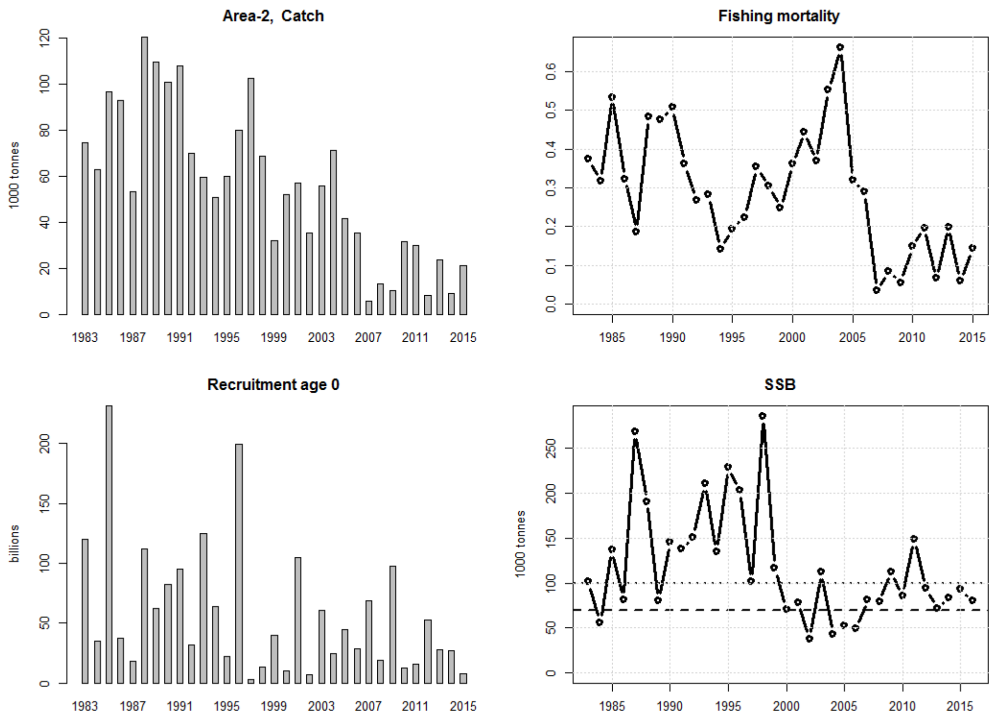


Figure 11.3.12. Sandeel SA 2. Stock summary.

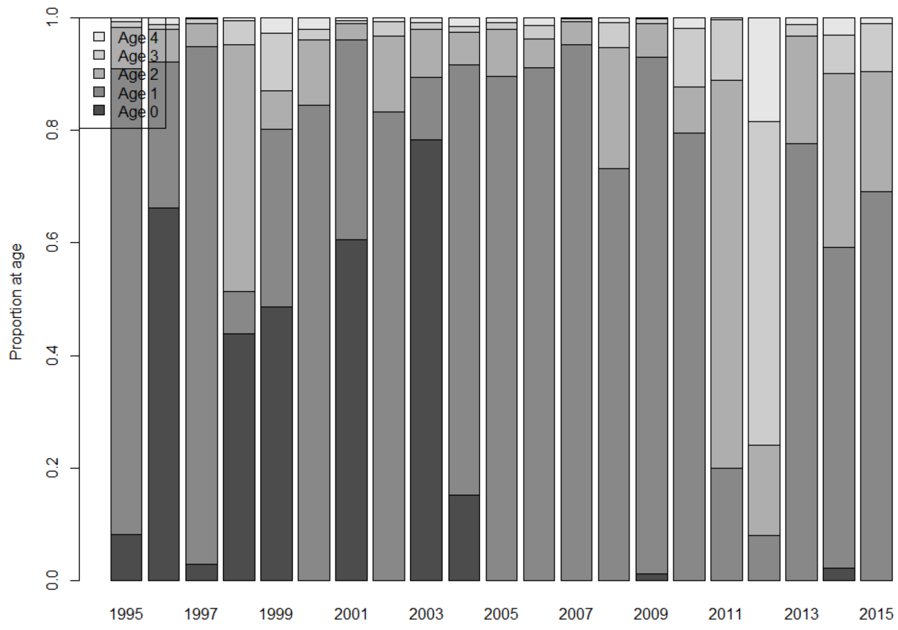


Figure 11.4.1. Sandeel SA 3. Catch numbers, proportion at age.

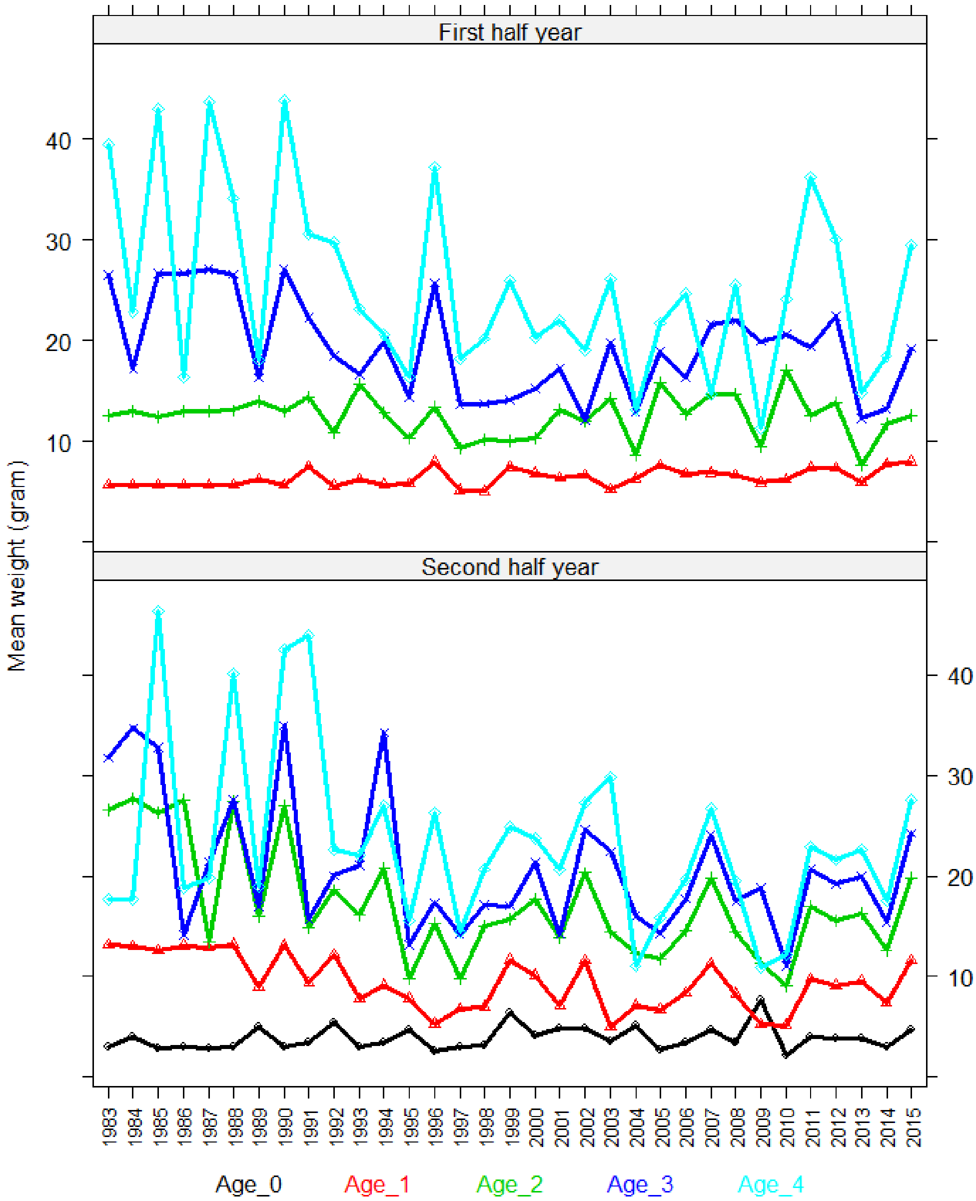


Figure 11.4.2. Sandeel SA 3. Mean weight at age in the first half year (age 1–4+) and second half year (age 0-4+).

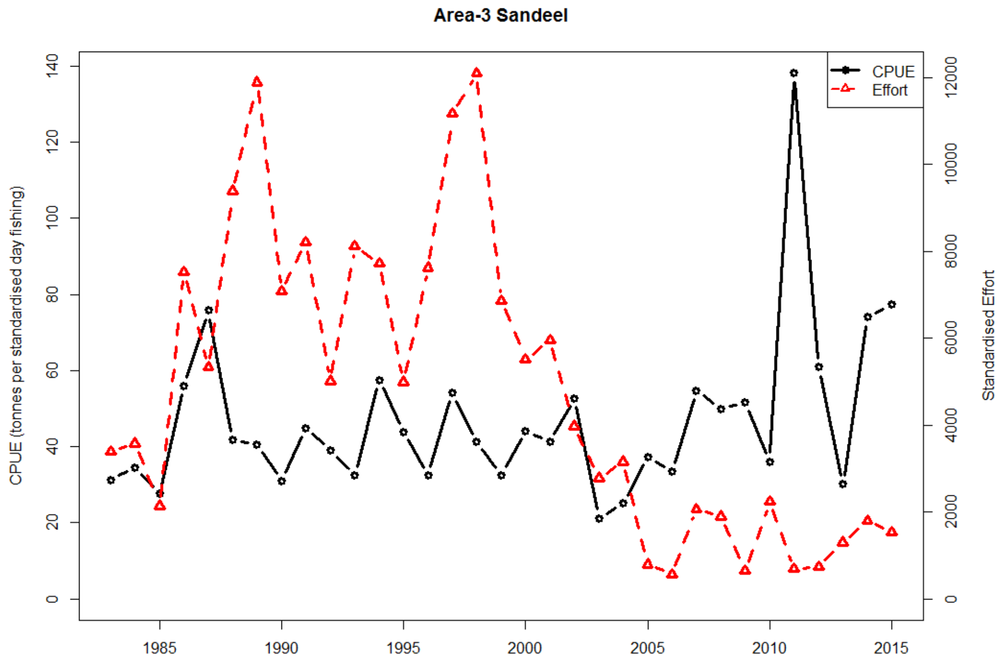


Figure 11.4.3. Sandeel SA 3. CPUE and effort.

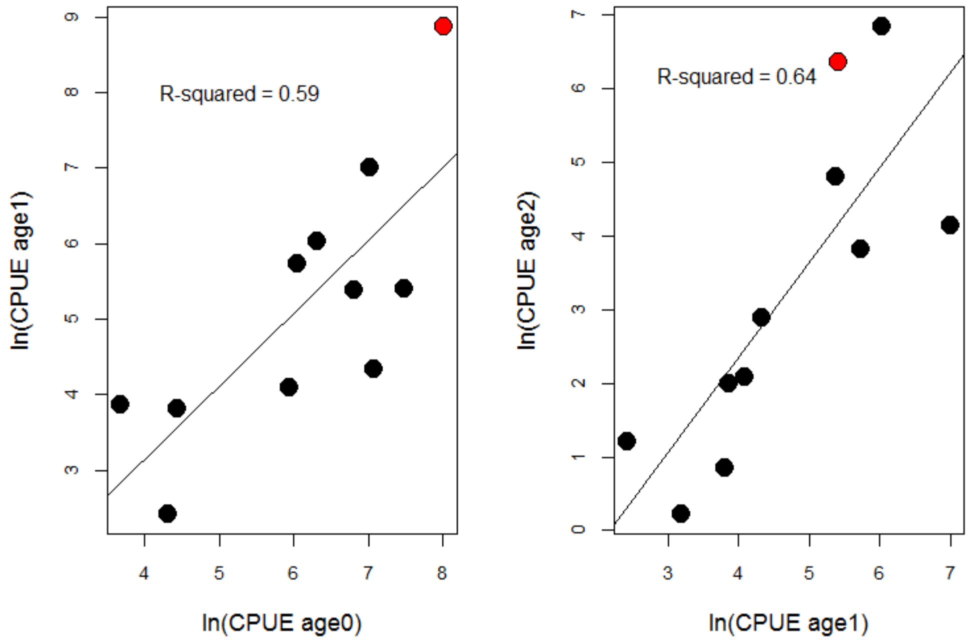


Figure 11.4.4. Sandeel SA 3. Internal consistency by age of the dredge survey. Red dot indicates the most recent data point.

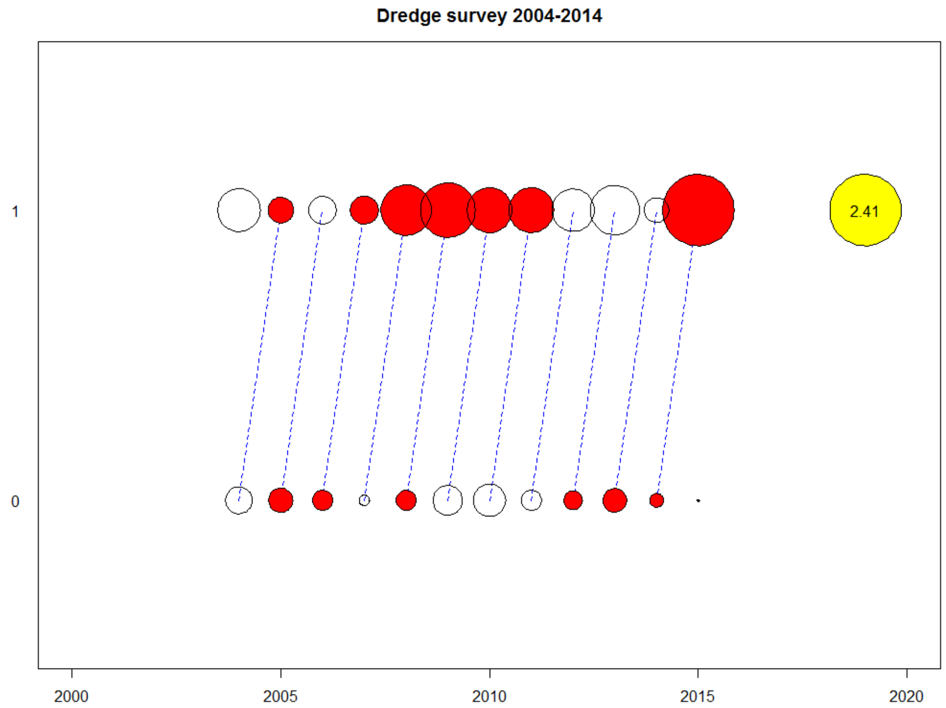


Figure 11.4.5. Sandeel SA 3. Survey CPUE at age residuals (log(observed CPUE)- log(expected CPUE). Red dots indicate a positive residual.

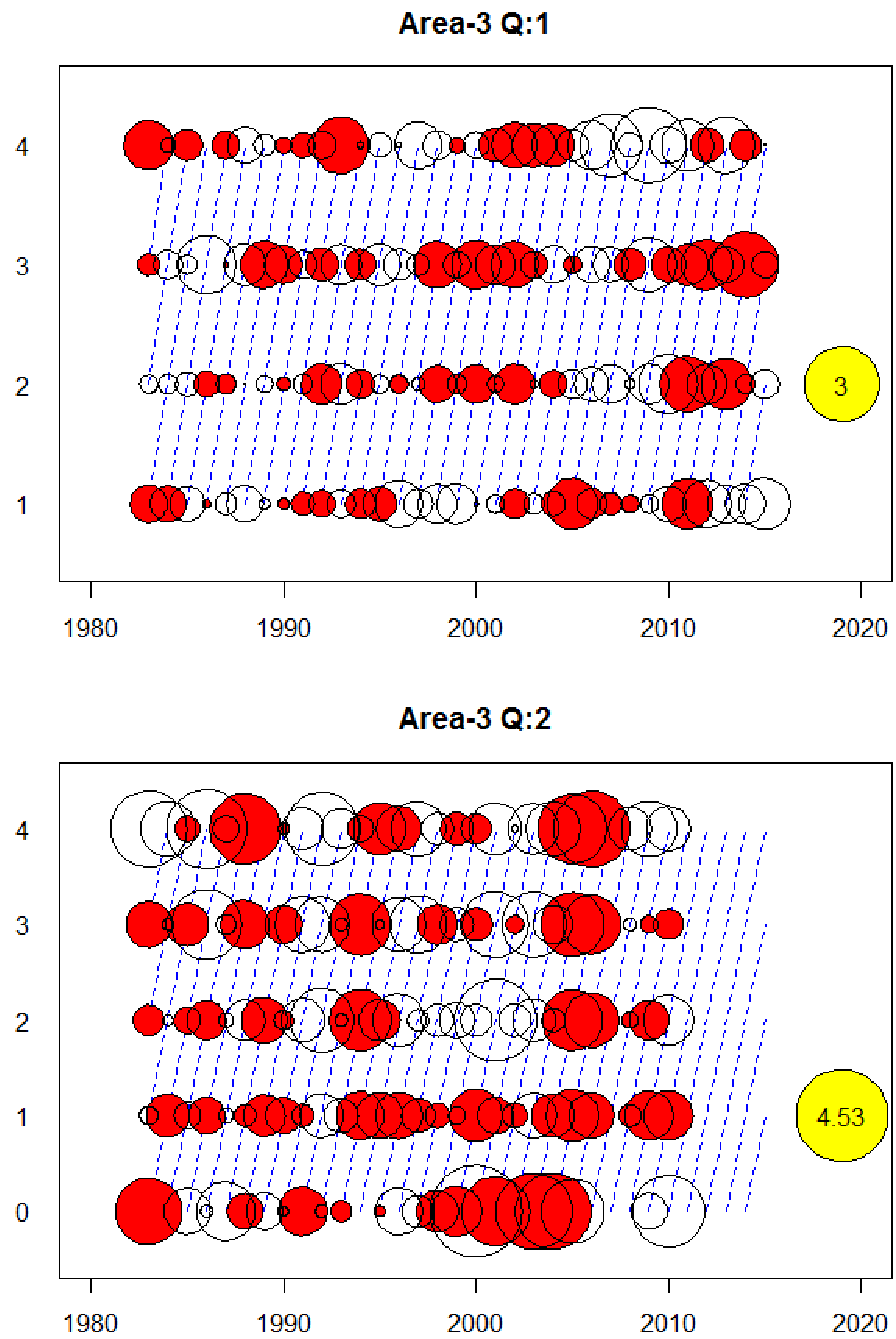


Figure 11.4.6. Sandeel SA 3. Catch at age residuals (log(observed CPUE)- log(expected CPUE). Red dots indicate a positive residual.

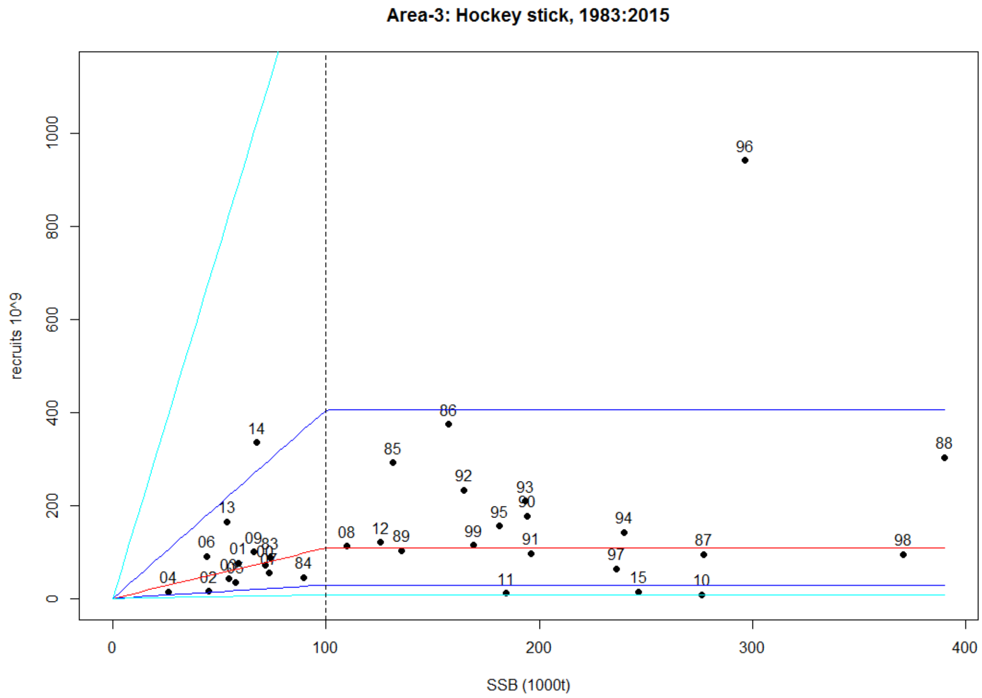


Figure 11.4.7. Sandeel SA 3. Estimated stock recruitment relation. Red line = median of the expected recruitment, Dark blue lines = one standard deviation, Light blue lines = 2 standard deviations. The area within the light blue lines can be seen as the 95% confidence interval of recruitment. Years shown in red are not used in the fit.

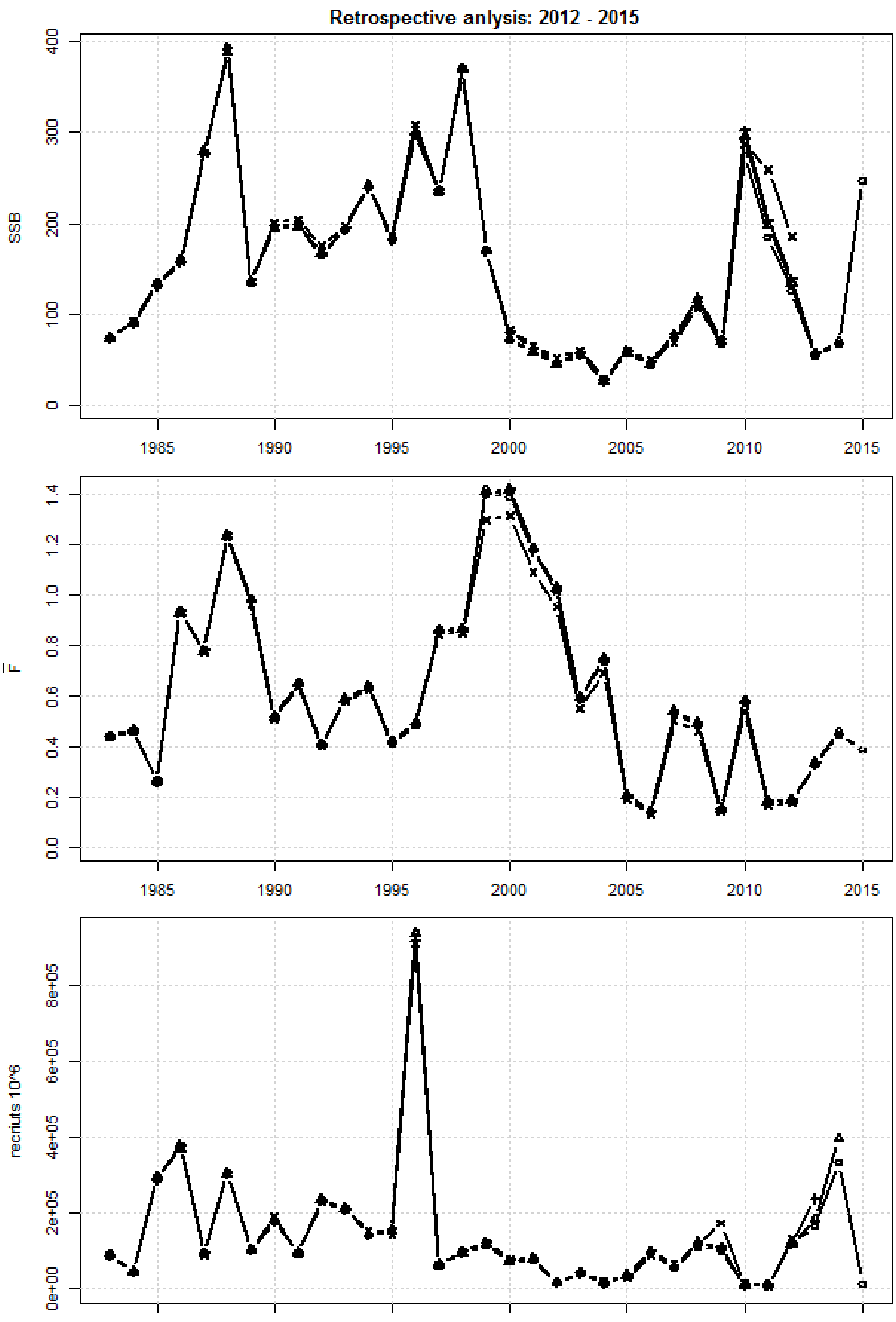


Figure 11.4.8. Sandeel SA 3. Retrospective analysis.

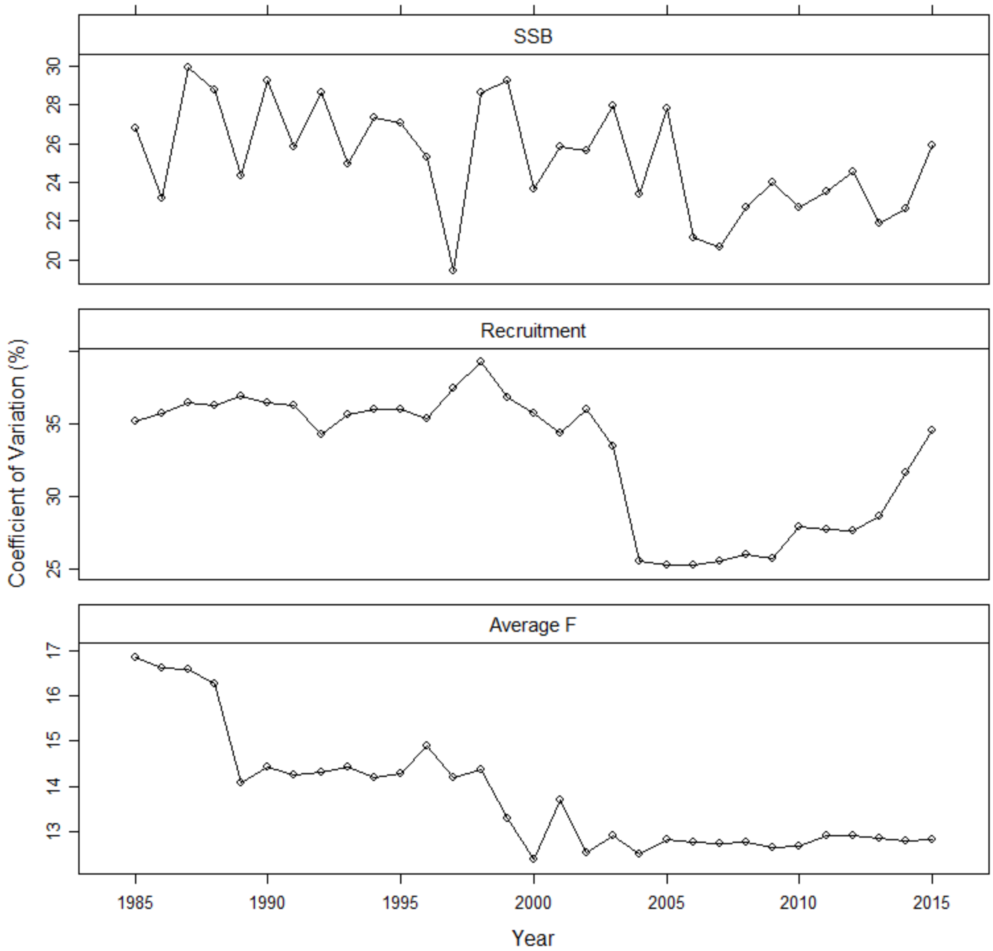


Figure 11.4.9. Sandeel SA 3. Uncertainties of model output estimated from parameter uncertainties derived from the Hessian matrix and the delta method.

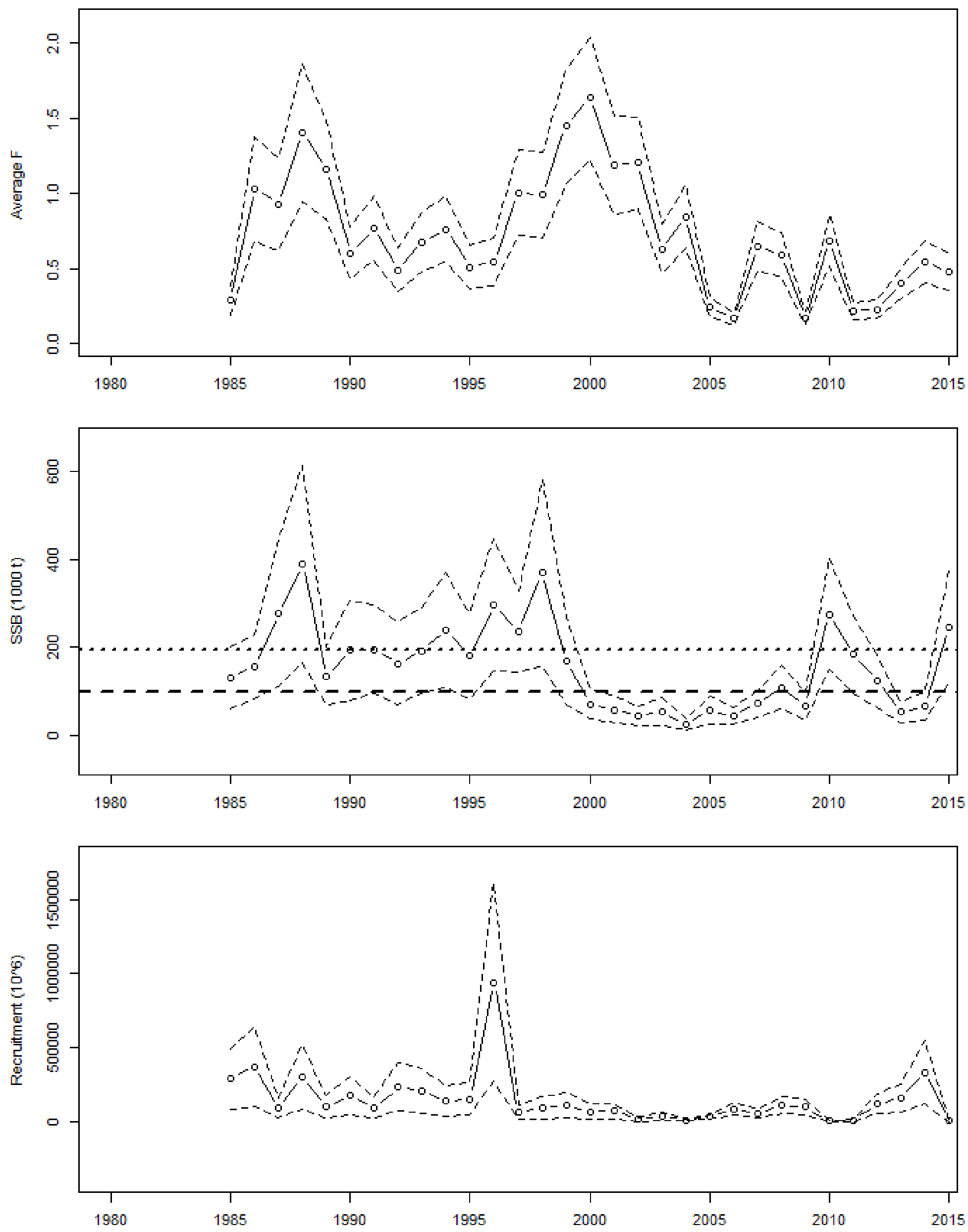


Figure 11.4.10. Sandeel SA 3. Model output (mean F, SSB and Recruitment) with mean values and plus/minus 2 * standard deviation.

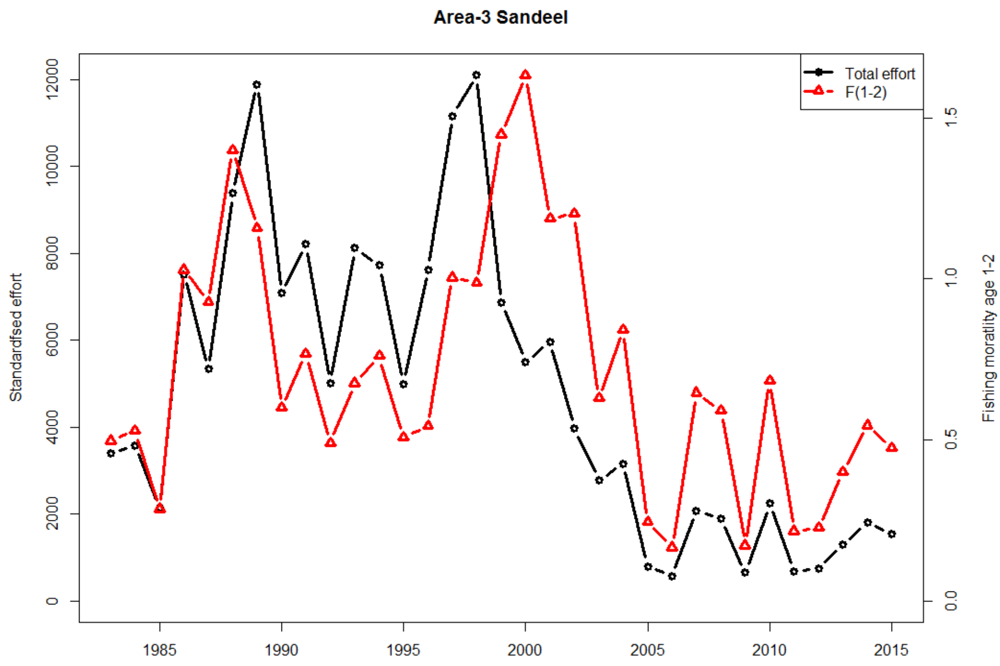


Figure 11.4.11. Sandeel SA 3. Total effort (days fishing for a standard 200 GT vessel) and estimated average Fishing mortality.

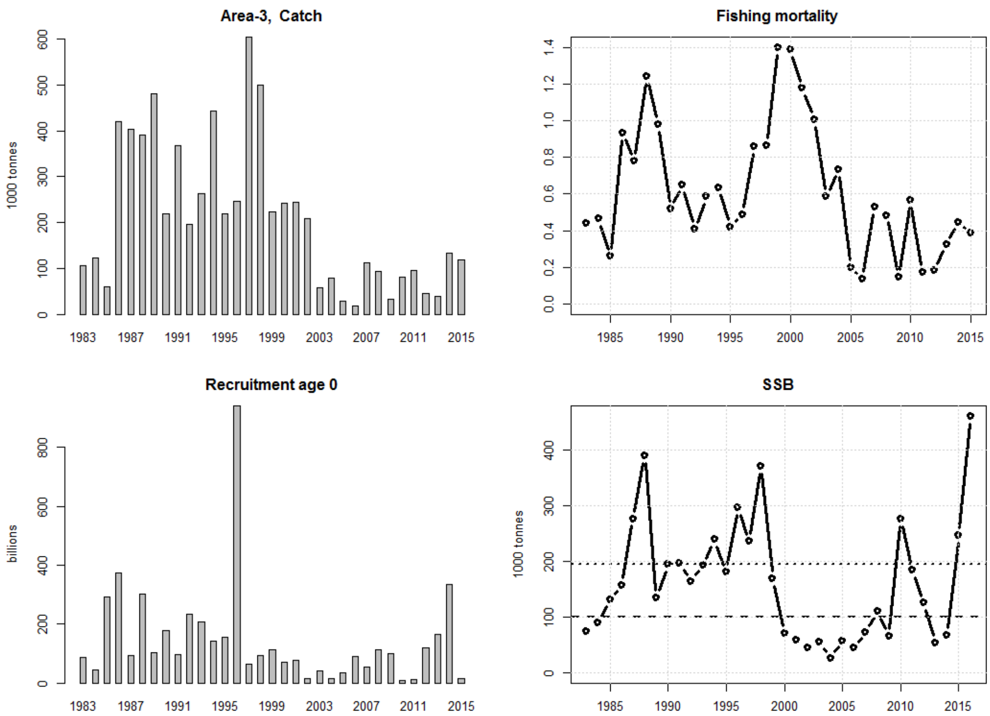


Figure 11.4.12. Sandeel SA 3. Stock summary.

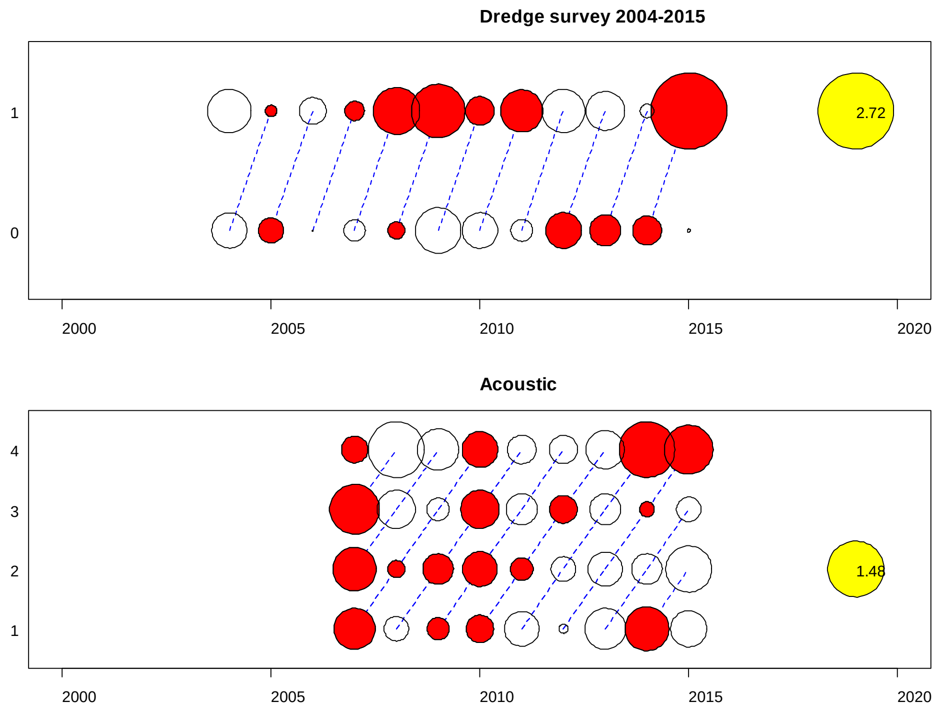
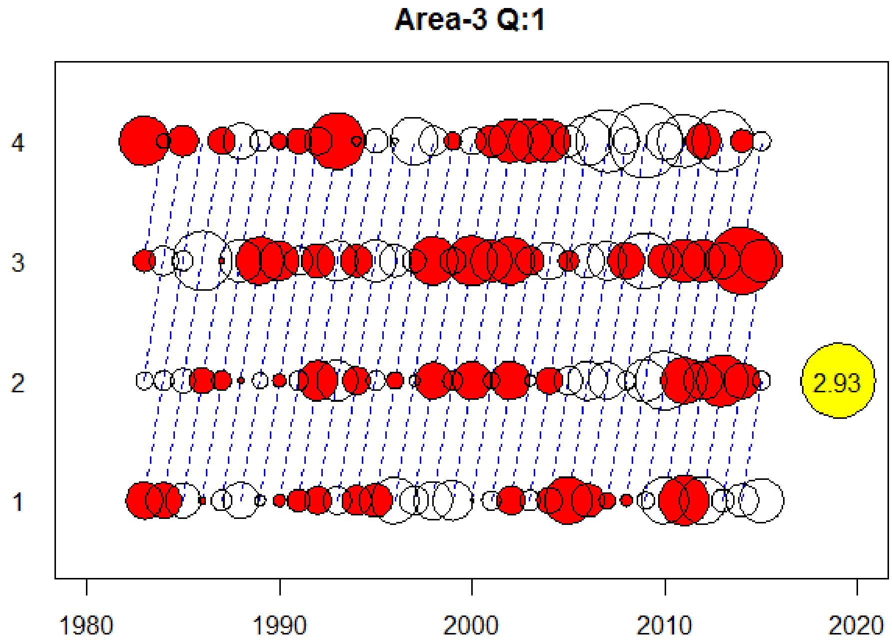


Figure 11.4.13. Sandeel SA 3. Explorative run with Norwegian acoustic survey. Survey CPUE at age residuals (log(observed CPUE)- log(expected CPUE). Red dots indicate a positive residual.



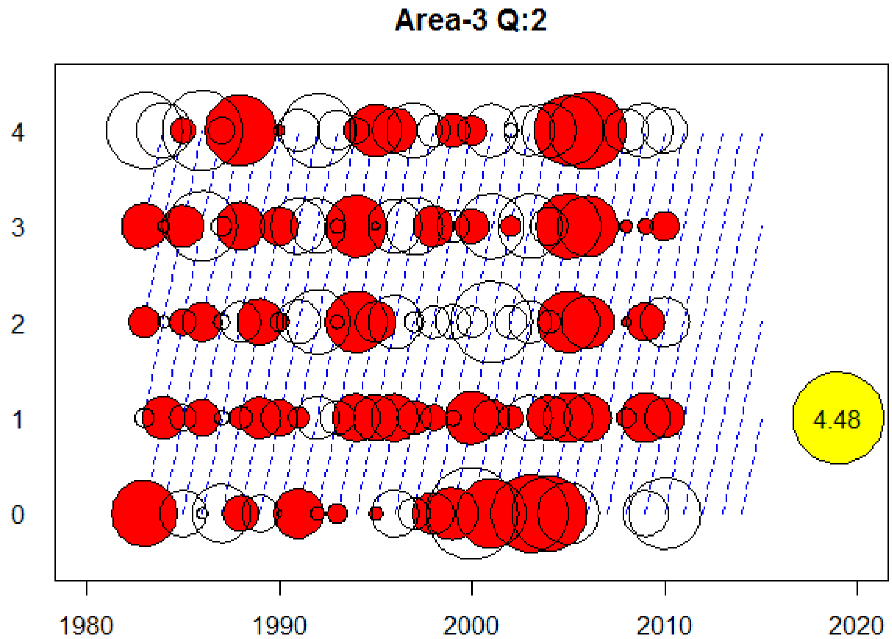


Figure 11.4.14. Sandeel SA 3. Explorative run with Norwegian acoustic survey. Catch at age residuals (log(observed CPUE)- log(expected CPUE). Red dots indicate a positive residual.

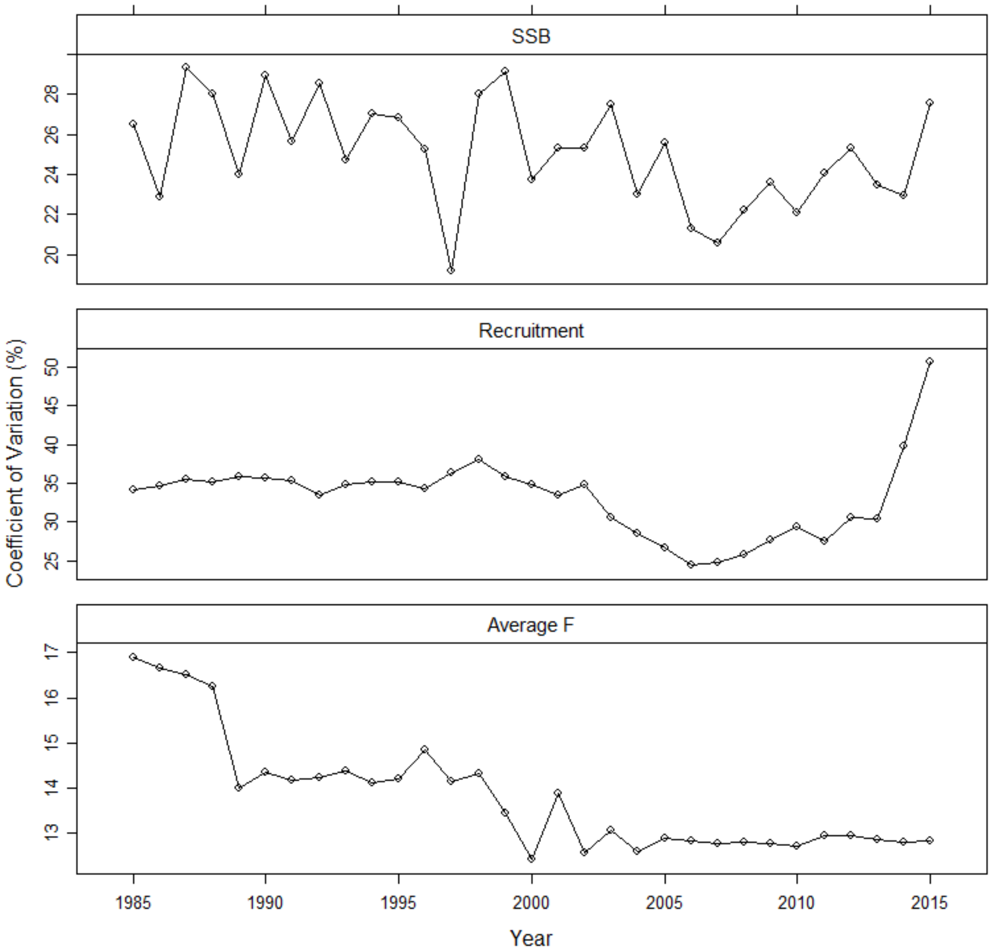


Figure 11.4.15. Sandeel SA 3. Explorative run with Norwegian acoustic survey. Uncertainties of model output estimated from parameter uncertainties derived from the Hessian matrix and the delta method.

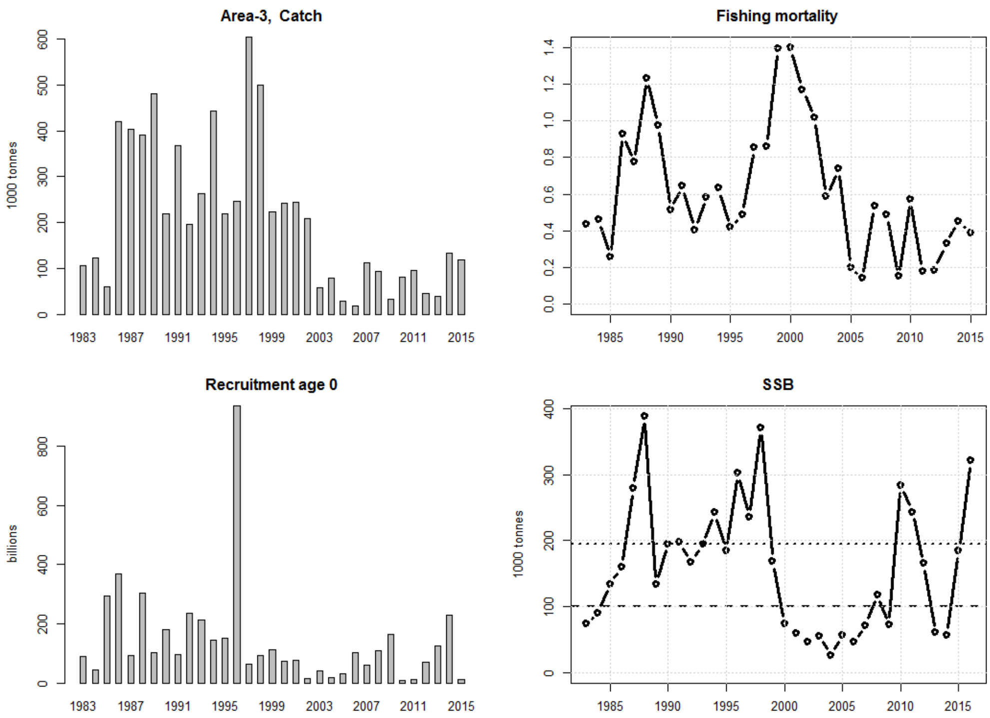


Figure 11.4.16. Sandeel SA 3. Explorative run with Norwegian acoustic survey. Stock summary.

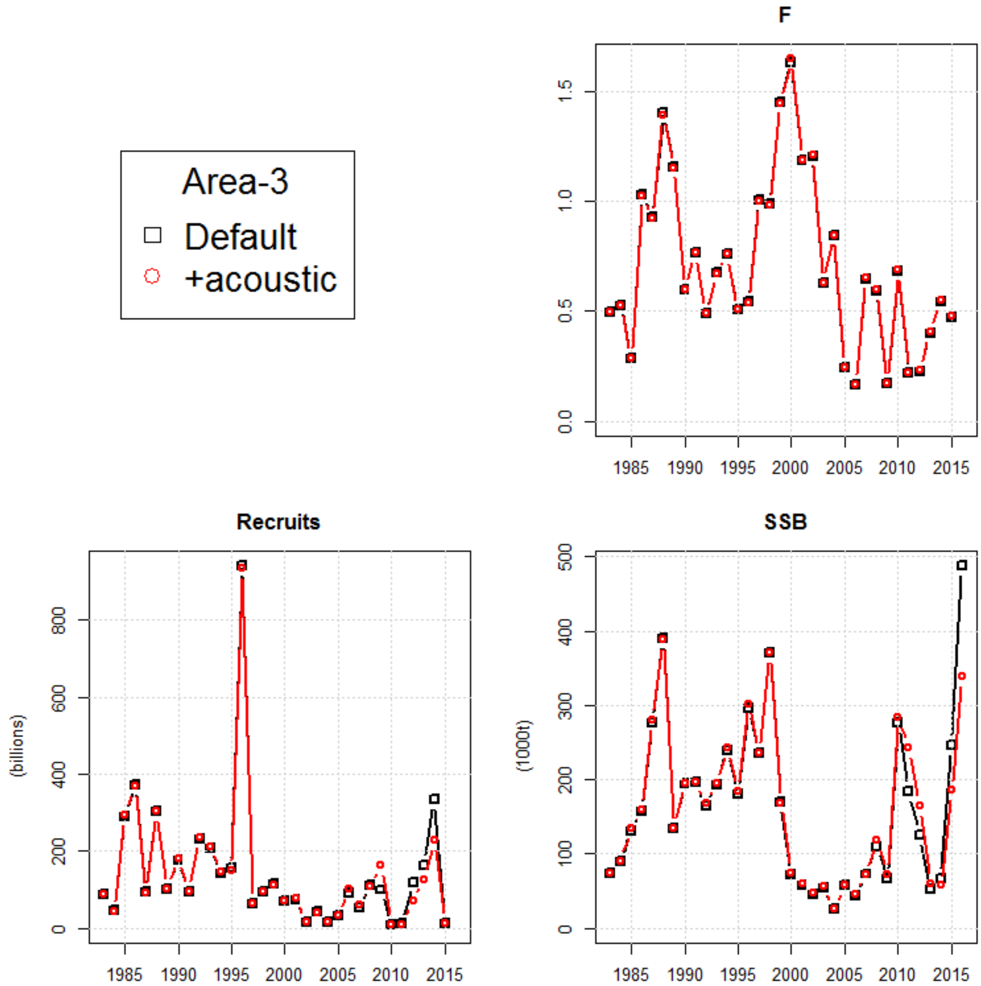


Figure 11.4.17. Sandeel SA 3. Explorative run with Norwegian acoustic survey. Stock summary comparison.

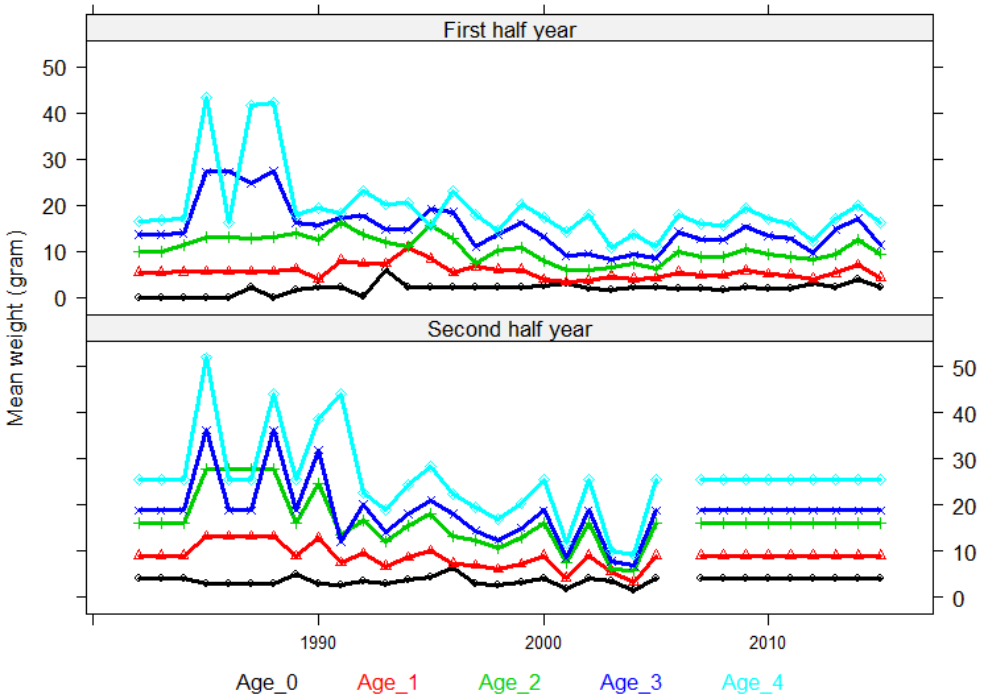


Figure 11.5.1. Sandeel SA 4. Individual mean weights (g) at age in 1st (upper) and 2nd (lower) half-year.

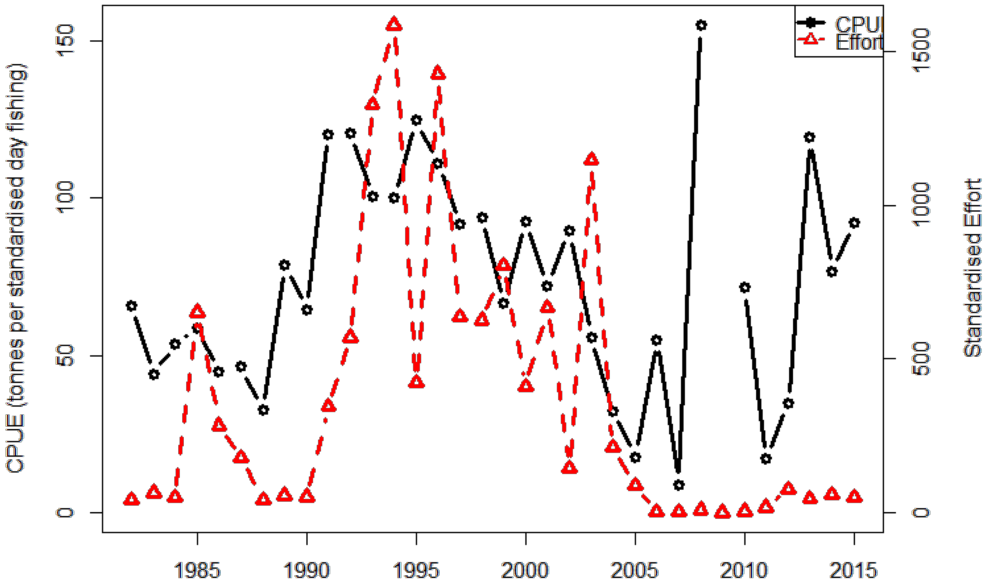


Figure 11.5.2. Sandeel SA 4. Effort (days fishing for a standard 200GT vessel) and CPUE(tonnes per standard fishing day).

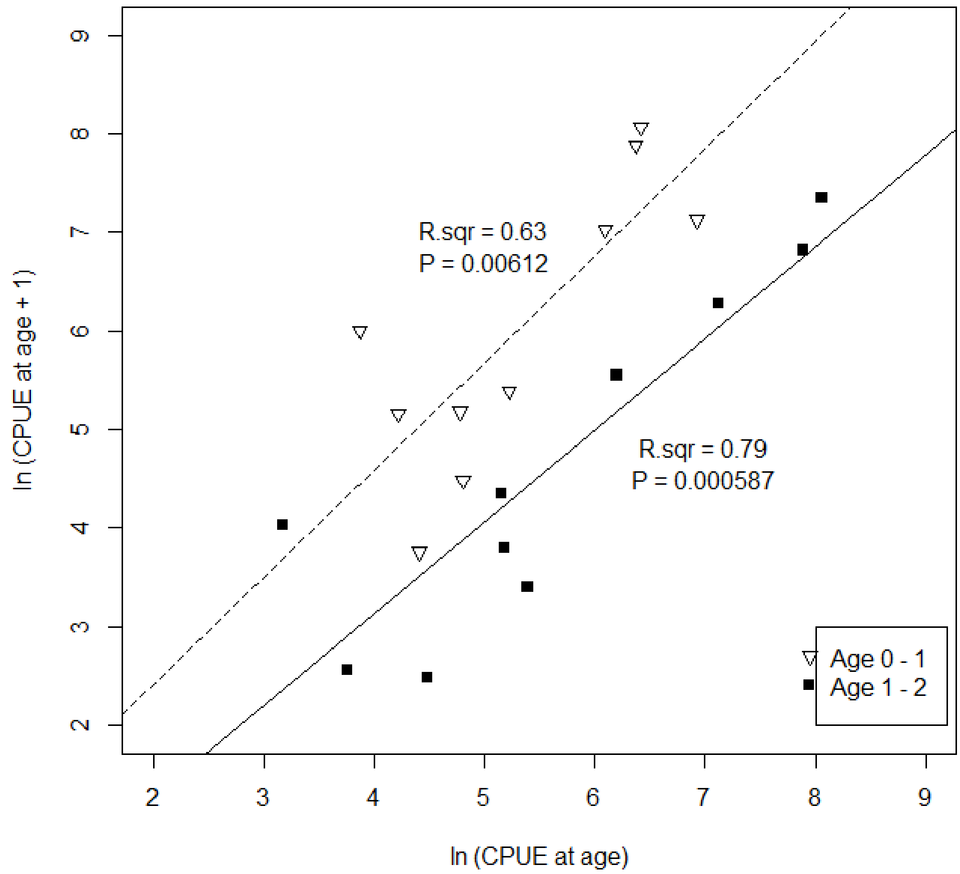


Figure 11.5.3. Sandeel SA 4. Internal consistency plot. Average dredge CPUE of consecutive ages from the same year-class for Firth of Forth samples.

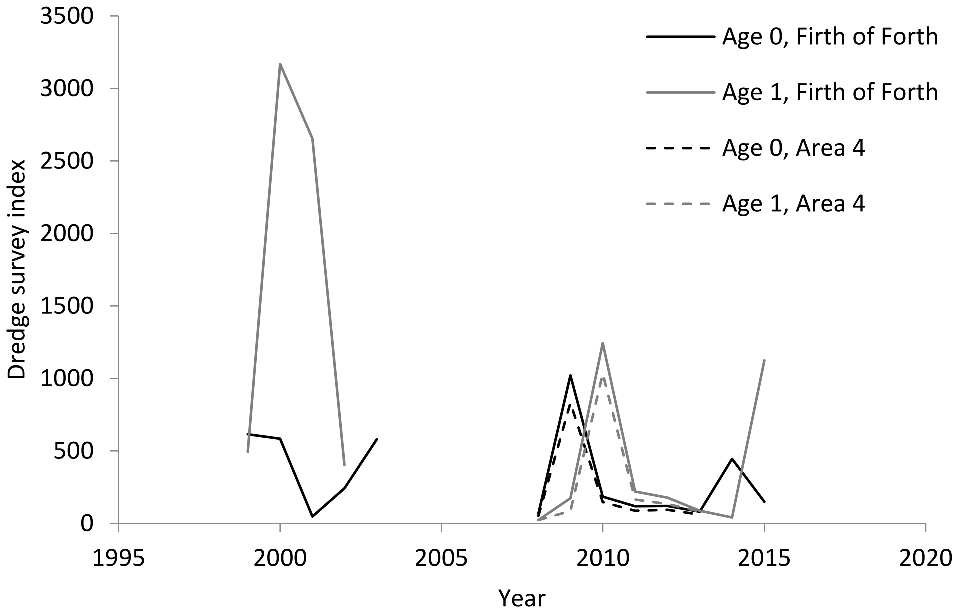


Figure 11.5.4. Sandeel SA 4. Dredge survey CPUE for SA 4 and Firth of Forth.

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 6.aN (Section 5.11 in ICES 2005a), herring in 7.e–f and herring in the Bay of Biscay (Subarea 8). In this section only the time 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 TAC has been 583 t in 2015. No catches are reported in 2015 (Table 12.1).

Division 7.e–f

Figure 12.1 shows the time series of landings over the period 1974–2015 in Division 7.e and 7.f. Data are taken from the ICES historical and official nominal databases and adjusted, where possible, with data supplied by working group members.

Since 1999, landings in Division 7.e are stable and have fluctuated between 5 and 800 t except in 2008 where they reached more than 1000 t (Figure 12.1).

In Division 7.f, 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 (Figure 12.1).

Subarea 8 (Bay of Biscay)

In the Bay of Biscay, French landings peaked at 1700 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 8000 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, 1959–2015. Spring and autumn-spawners combined.

Year	**1959**	**1960**	**1961**	**1962**	**1963**	**1964**	**1965**	**1966**	**1967**	**1968**	**1969**	**1970**	**1971**	**1972**
All Catches														
Total	10 530	15 680	10 848	3 989	7 073	14 509	15 096	9 807	7 929	9 433	10 594	7 763	4 088	4 226

Year	**1973**	**1974**	**1975**	**1976**	**1977**	**1978**	**1979**	**1980**	**1981**	**1982**	**1983**	**1984**	**1985**	**1986**
All Catches														
Total	4 715	4 061	3 664	4 139	4 847	3 862	1 951	2 081	2 135	4 021	4 361	5 770	4 800	4 650

Year	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**
Scotland	2 895	1 568	2 135	2 184	713	929	852	608	392	598	371	779	16	1	78
Other UK	-	-	-	-	-	-	1	-	194	127	475	310	240	0	392
Unallocated*	278	110	208	75	18	-	-	-	-	-	-	-	-	-	-
Discards	4394	2454	**	**	**	**	**	**	**	-	-	-	-	-	-
Agreed TAC	3 500	3 200	3 200	2 600	2 900	2 300	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000
Total	3 612	1 923	2 343	2 259	731	929	853	608	586	725	846	1089	256	1	480

Year	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
Scotland	46	88	-	-	+	163	54	266	-	90	119	21	0	0
Other UK	335	240	-	318	512	458	622	488	301	111	184	-	-	-
Unallocated*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Discards	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Agreed TAC	1 000	1 000	1 000	1 000	1 000	800	800	800	720	720	720	648	648	583
Total	381	328	0	318	512	621	676	754	301	201	303	21	0	0

*** Calculated from estimates of weight per box and in some years estimated by-catch in the sprat fishery.**

**** Reported to be at a low level, assumed to be zero, for 1989–1995.**

Table 12.2. Stocks with limited data. Landings of herring in divisions 7.e and 7.f. Source: ICES official landings database 2006–2014, national databases and ICES preliminary catch statistics 2015.

Division	Country	2008	2009	2010	2011	2012	2013	2014	2015*
7.e	UK (Eng,Wal,NI,Scot,Guernsey)	78	130	185	218	162	274	435	268
7.e	Denmark	-	-	0	-	-	-	-	-
7.e	France	499	489	493	486	278	7	314	3
7.e	Germany, Fed. Rep. Of	-	-	0	-	-	-	-	-
7.e	Netherlands	433	-	2	6	-	-	4	0
	Total	**1 010**	**619**	**678**	**710**	**440**	**275**	**753**	**271**

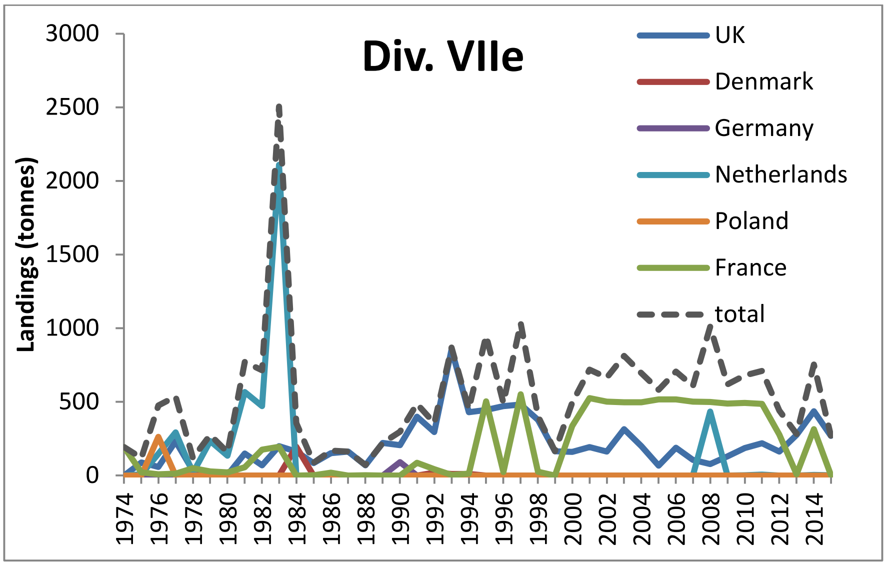
Division	Country	2008	2009	2010	2011	2012	2013	2014	2015*
7.f	UK (Eng, Wal, Scot, NI)	29	8	23	78	113	136	20	111
7.f	Belgium	-	-	-	-	-	-	-	-
7.f	France	-	-	-	26	-	-	-	-
7.f	Netherlands	-	-	-	-	-	-	-	-
7.f	Poland	-	-	-	-	-	-	-	-
	Total	**29**	**8**	**23**	**104**	**113**	**136**	**20**	**111**

*** Preliminary data**

Table 12.3. Stocks with limited data. Landings of herring in Subarea 8.

Country	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015*
France	15	14	6	12	12	34	50	82	22	7	5	5
Netherlands	1426	28	12	24	24	68	502	222	-	-	-	-
Portugal	-	-	-	.	.	-	-	-	-	-	-	-
Spain	0	50	214	120	131	55	38	54	2	-	-	-
UK	0	0	0	0	0	-	-	-	-	-	-	-
	1411	92	232	156	167	157	590	358	24	7	5	5

*** Preliminary data**



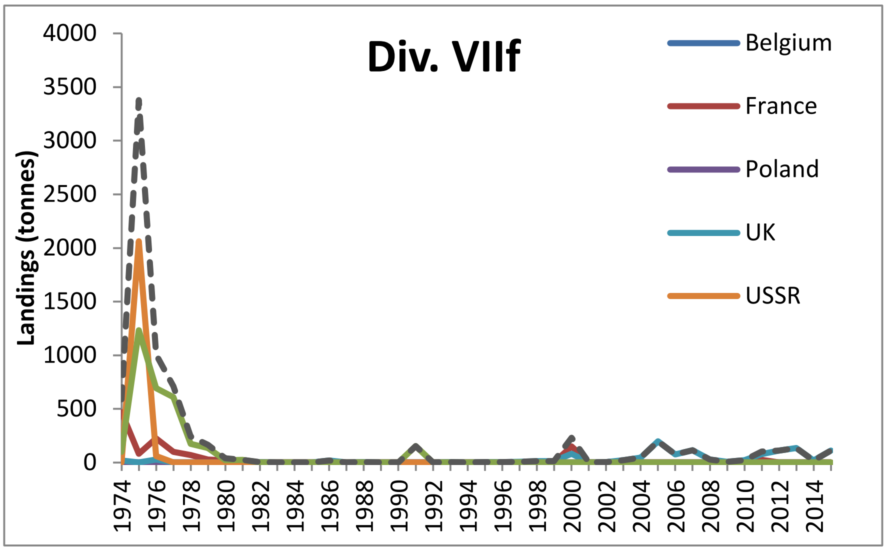


Figure 12.1. Stocks with limited data. Landings over time of herring in divisions 7.e (upper panel) and 7.f (lower panel).

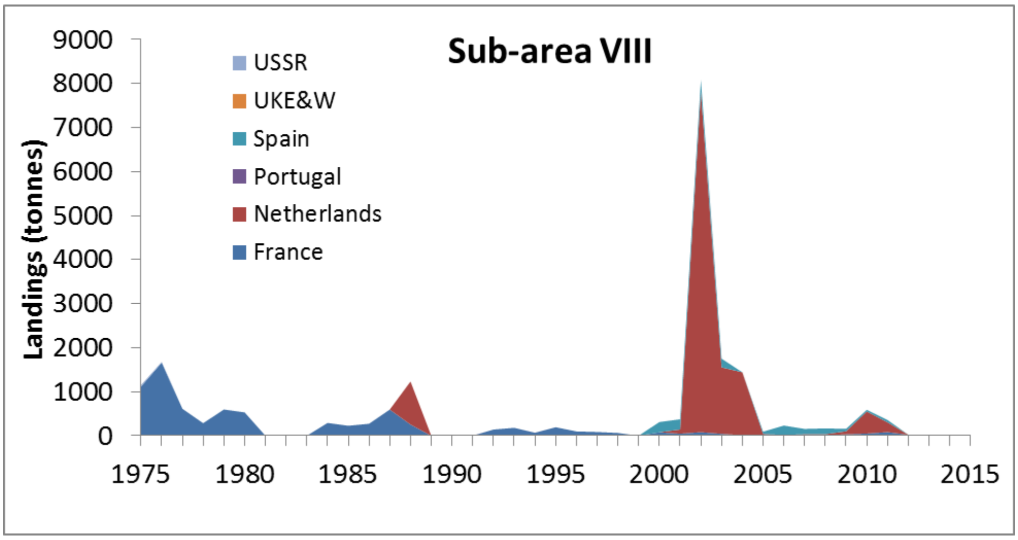


Figure 12.2. Stocks with limited data. Landings over time of herring in Subarea 8.

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Annex 1 List of Participants

HAWG 2016, 29 March–7 April 2016, ICES HQ

Member	Institute	Email	Telephone	Street	Post Code	PO Box
Andrew Campbell	Marine Institute	andrew.campbell@marine.ie		Rinville, Oranmore, Co. Galway, Ireland		
Anna Rindorf	DTU Aqua - National Institute of Aquatic Resources	ar@aqua.dtu.dk	+45 35 88 33 78	Jægersborg Allé 1, Charlottenlund, Denmark	2920	
Anne Cooper	ICES Secretariat	anne.cooper@ices.dk				
Bastian Huwer (Chair-invited member)	DTU Aqua - National Institute of Aquatic Resources	bhu@aqua.dtu.dk		Marine Living Resources, Charlottenlund Slot Jægersborg Allé 1, Charlottenlund, Denmark		
Cecilie Kvamme	Institute of Marine Research	cecilie.kvamme@imr.no	+47 454 49 350	Nordnes, Bergen, Norway	5817	1870
Claus Reedtz Sparrevohn	Danish Pelagic Producers' Organisation	crs@pelagisk.dk	+45	Willemoesvej 2, Hirtshals, Denmark	9850	
Cindy van Damme (Chair-invited member, via Skype for Business)	IMARES, part of Wageningen UR	Cindy.vandamme@wur.nl		Haringkade 1 Ijmuiden, Netherlands		
Espen Johnsen (via Skype for Business)	Institute of Marine Research	espen.johnsen@imr.no	+47 55 23 53 55	Nordnes, Bergen, Norway	5817	1870
Henrik Mosegaard	DTU Aqua - National Institute of Aquatic Resources	hm@aqua.dtu.dk	+45 35 88 34 61	Marine Living Resources, Charlottenlund Slot Jægersborg Allé 1, Charlottenlund, Denmark	2920	
Lars O. Mortensen	DTU Aqua - National Institute of Aquatic Resources	laomo@aqua.dtu.dk		Charlottenlund Slot Jægersborg Allé 1, Charlottenlund, Denmark	2920	
Lisa Readdy	Centre for Environment Fisheries and Aquaculture Science (Cefas), Lowestoft Laboratory	lisa.readdy@cefas.co.uk	+44 1502 52 4319	Pakefield Road, Lowestoft, Suffolk, UK	NR33 0HT	

Member	Institute	Email	Telephone	Street	Post Code	PO Box
Lotte Worsøe Clausen	DTU Aqua - National Institute of Aquatic Resources, Section for Fisheries Advice	law@aqua.dtu.dk	+45 21362804	Charlottenlund Slot Jægersborg Allé 1, Charlottenlund, Denmark	2920	
Marc Hufnagl (Chair-invted member)	Mathematical Modelling and Fisheries Science Institute for Hydrobiology and Fisheries Science University of Hamburg	marc.hufnagl@uni-hamburg.de		Olbersweg 24 Hamburg Germany	22767	
Martin Pastoors	Pelagic Freezer Trawler Association	mpastoors@pelagicfish.eu		Louis Braillelaan 80 Zoetermeer The Netherlands	2719 EK	
Maurice Clarke	Marine Institute	maurice.clarke@marine.ie	+353 91387200	Rinville, Oranmore, Co. Galway, Ireland		
Mike O'Malley	Marine Scotland Science, Marine Laboratory	Mike.O'Malley@scotland.gsi.gov.uk	+44	375 Victoria Road, Aberdeen, UK	AB11 9DB	
Niels Hintzen (Chair)	Wageningen IMARES	niels.hintzen@wur.nl	+31 317 487 090	Haringkade 1 Ijmuiden, Netherlands	1970 AB	68
Norbert Rohlf	Thünen Institute of Sea Fisheries	norbert.rohlf@thuenen.de	+49 40 38905 166	Palmaille 9, Hamburg, Germany	22767	
Piera Carpi	Centre for Environment Fisheries and Aquaculture Science (Cefas), Lowestoft Laboratory	piera.carpi@cefas.co.uk		Pakefield Road, Lowestoft, Suffolk, UK	NR33 0HT	
Pieter-Jan Schön	Agri-food and Biosciences Institute (AFBI)	pieter-jan.schon@afbini.gov.uk	+44 28 90255015	AFBI Headquarters, 18a Newforge Lane, Belfast, UK	BT9 5PX	
Richard Nash	Institute of Marine Research	Richard.Nash@imr.no	+47 48036416	Nordnesgatan 33, Nordnes, Bergen, Norway	5817	1870
Sascha Fassler	Wageningen IMARES	sascha.fassler@wur.nl	+31 317 48 7474	Ijmuiden, Netherlands	1970 AB	Box 68
Susan Mærsk Lusseau	Marine Scotland Science, Marine Laboratory	s.lusseau@marlab.ac.uk	+44	375 Victoria Road, Aberdeen, UK	AB11 9DB	

Member	Institute	Email	Telephone	Street	Post Code	PO Box
Tomas Gröhsler	Thünen Institute, Baltic Sea Fisheries	tomas.groehsler@ti.bund.de	+49 381 811 6104	Alter Hafen Süd 2, Rostock, Germany	18069	
Valerio Bartolino	Swedish University of Agricultural Sciences, Institute of Marine Research	valerio.bartolino@slu.se	+46 7612 68049	Turistgatan 5, Lysekil, Sweden	453 30	

Annex 2 Recommendations

RECOMMENDATION	FOR FOLLOW UP BY:
WGSAM are asked to forward results from updated key runs to the relevant assessment working group chairs together with a detailed description of the causes for any differences between the new key run and the previous key run immediately following the WGSAM meeting where these are agreed. This will allow the assessment working group to consider well before the assessment working group meeting whether an update of reference points is likely to be required as a result of the new key run. In addition, HAWG request the who-eats-whom and abundance output files from the previous and current key run.	WGSAM
It is recommended to the ICES Secretariat to get access to the annual EU FIDES database (containing quota changes and catch per year) to have the ability to check quota uptake and inter-species transfers relevant for short time forecasting.	ICES Secretariat
HAWG recommends to WKLIFE to investigate data limited advice procedures for short lived species.	WKLIFE
HAWG recommends to WGIPS to deliver on an annual basis the requested features and estimates of acoustic survey results, model fitting process and uncertainties herein (Table 1.2.2, Section 1.2.2, HAWG 2016).	WGIPS
HAWG recommends that WGFAST and WGIPS have an active role in developing the 6.a–7.b–c herring industry acoustic survey that is being planned for 2016 under the auspices of the PELAC (Pelagic Advisory Council). The inclusion of industry acoustic surveys into the data sources for expert groups is an important new development that would benefit from expertise on acoustics and survey design. A review of the foreseen 2016 industry acoustic survey in the 2017 is needed to assess the quality of the survey for further inclusion in the ICES advisory system. It is envisaged that WGIPS and WGFAST would be involved in this review process.	WGIPS, WGFAST
HAWG considers that every effort be made to maintain the existing time series (to maintain catchability) of the CSHAS survey, while ensuring a full coverage of the stock.	
To investigate the potential of the MSHAS/Boarfish survey conducted in June/July as, and coordinated by WGIPS, as an additional abundance index for Celtic Sea herring and Celtic Sea sprat, and whether amendments would be required before this survey could be operational for that purpose.	
To investigate the potential of the PELTIC survey conducted in October as, and coordinated by WGIPS, as an additional abundance index for Western Channel sprat, and whether amendments would be required before this survey could be operational for that purpose.	

Annex 3 ToRs for next meeting

HAWG – Herring Assessment Working Group for the Area South of 62°N

2016/2/ACOMXX The **Herring Assessment Working Group for the Area South of 62ºN** (HAWG), chaired by Niels Hintzen, NL will meet at ICES Headquarters, 29 March to 7 April 2017, and at ICES Headquarters in the third week of January 2017 to:

a) compile the catch data of North Sea and Western Baltic herring on 29-30 March

b) address generic ToRs for Regional and Species Working Groups 31 March–7 April

The assessments will be carried out on the basis of the Stock Annex. The assessments must be available for audit on the first day of the meeting.

Material and data relevant for the meeting must be available to the group no later than XX March 2017 according to the Data Call 2017.

HAWG will report by XX February 2017 (on sandeel), and by XX April 2017 (all stocks except sandeel) for the attention of ACOM and WKIrish.

Annex 4 Working Documents

WD 01 Estimation of total catches and effort by area in 2014. *By A. Rindorf 2015. Working document to HAWG 2015*

WD 02 Landings per unit effort and spatial distribution of the Swedish North Sea sandeel fishery. *By Patrik Johnsson and Valerio Bartolino, February 2016. Working document to HAWG 2016.*

WD 03 Marine Scotland Science sandeel dredge survey indices for SA4. *By J. Clarke, P. Boulcott & P.J. Wright.*

WD 04 Results of an Independent Observer Study of the Celtic Sea Herring Fishery, 2015. *By Pinfield, R. and Berrow, S. 2015.*

WD 05 Celtic Sea herring acoustic survey 2015, Trial adaptive mini surveys in the Celtic Sea 2015. *By Ciaran O'Donnell.*

WD 06 The Sprat Box Evaluation. *By Anna Rindorf and Lotte Worsøe Clausen, DTU Aqua, March 2016.*

WD 07 German Herring fisheries & stock assessment data in the Western Baltic in 2015. *Compiled by Tomas Gröhsler.*

WD 08 Investigating change in fishing selectivity of the pelagic fleet targeting herring.

WD 09 HAWG request to WGSAM

Working document 1 – Estimation of total catches and effort by area in 2014

By A. Rindorf 2015. Working document to HAWG 2015

Investigating the 2014 reported catches by ICES rectangle, it seemed that a series of rectangles (41F1, 41F2, 41F3 and 41F4) which previously had not supported large catches had been very productive (fig. 1). These rectangles are characterized by an almost complete lack of know fishing grounds and historically quite low catches. One of the rectangles, 41F4, contains the northernmost tip of a fishing ground which is located in 40F4. Historically, there has been a very good correlation between the summed catch in the rectangles 41F1, 41F2, 41F3 and 41F4 and that in 40F4 throughout the period where this information has been reported (fig. 2). However, the large catch in 2014 in these four squares was not accompanied by a large catch in 40F4 (fig. 2).

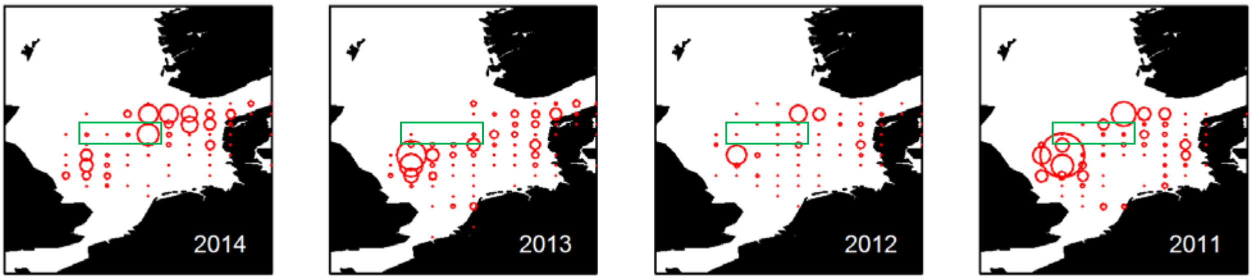


Fig. 1. Catches by square in 2011-2014. Green rectangle indicates the squares 41F1, 41F2, 41F3 and 41F4.

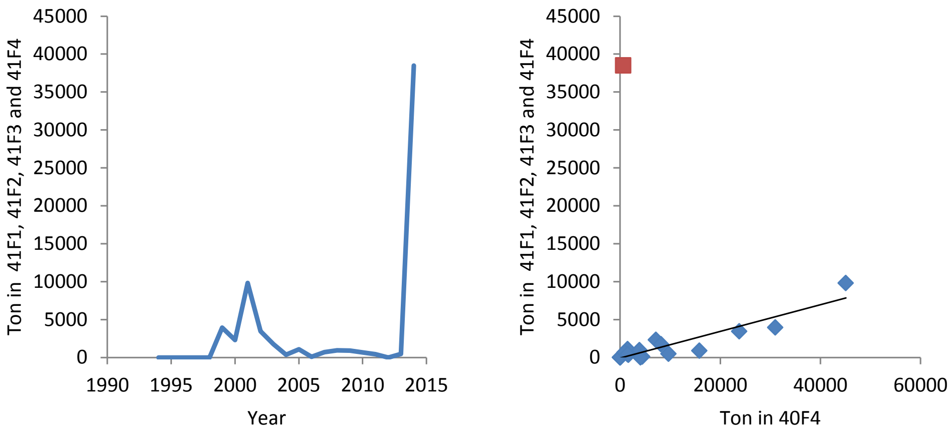


Fig. 2. Summed catch in rectangles 41F1, 41F2, 42F3 and 41F4 as a function of year (left) and catch in rectangle 40F4 (right). Right panel: Blue diamonds: years 1994-2013, red square: 2014, line: regression of years 1994-2013.

This apparent change in catches close to the border between areas 1 and 3 together with the knowledge that a more restrictive TAC was advised for area 1 than area 3 in 2014 meant a more detailed investigation of the origin of the reported catches using

Danish logbooks and VMS data. Fig. 3 shows the fishing locations in the four rectangles determined from VMS points with a vessel speed of 2-4 knots. The vast majority of the VMS points in 41F4 are located outside the known fishing ground. Further, where VMS points on known fishing grounds tend to form distinct patterns (lines or aggregations), those in 41F4 have no consistent pattern. A complementary analyses was performed to determine whether the total number fishing days reported in areas 1, 2 and 3 in any year was related to the sum of VMS points characterized as fishing. Fishing days and VMS points were highly correlated for the years 2005-2013 (fig. 4 left). However, in 2014, the number of reported fishing days was substantially higher than would be expected from VMS points. This difference was diminished if effort in rectangles 41F1-F4 was removed from the data in 2014, though the point was still further from the linear relationship than any other point in the time series (fig. 4 right).

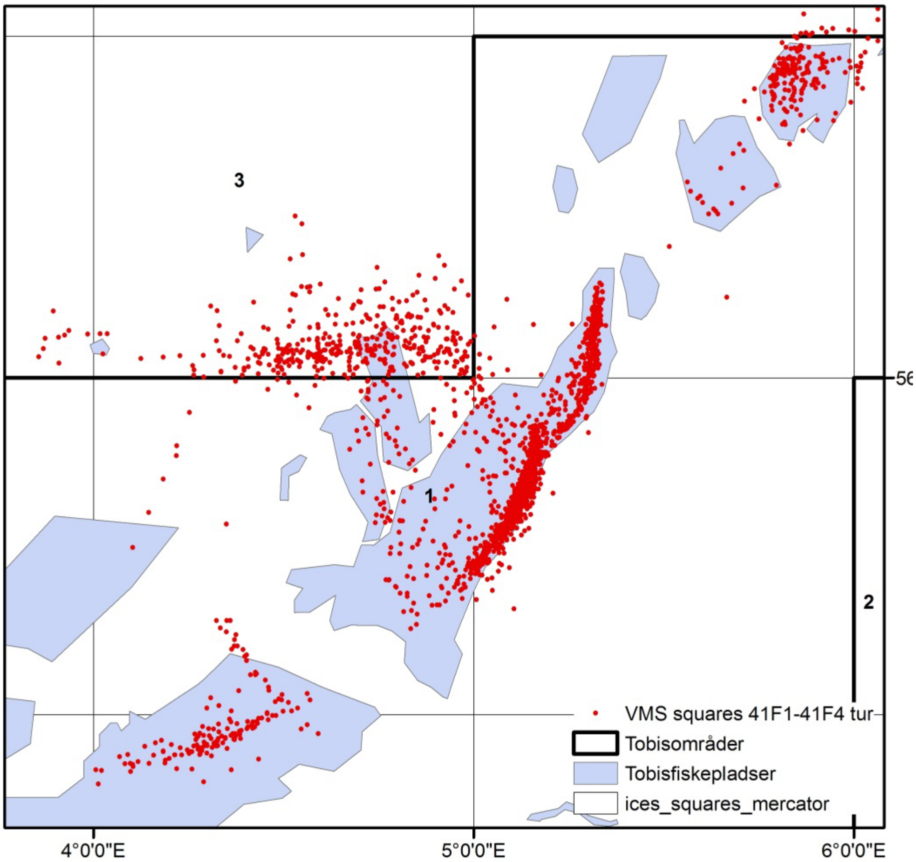
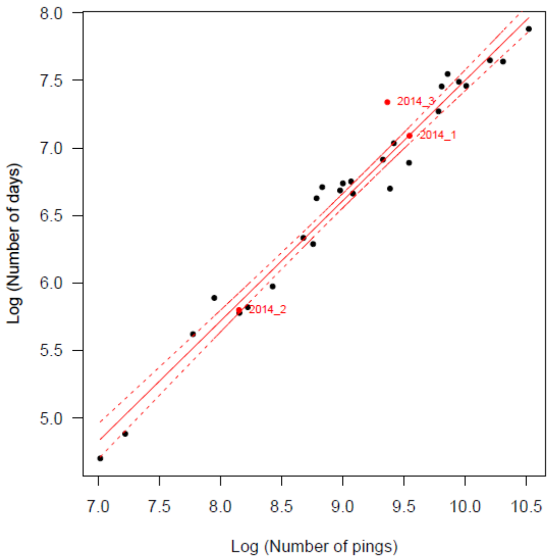


Fig. 3. VMS points of vessels reporting catch in 41F1-41F4 in rectangles 41F4 (top left), 40F4 (bottom left), 41F5 (top right) and 40F5 (bottom right).



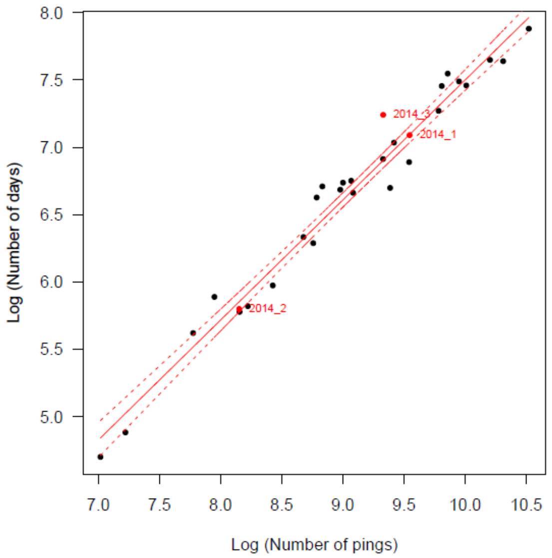


Fig. 4. Effort in reported fishing days as a function of VMS points. With (left) and without (right) 41F1-F4.

To investigate where catches reported in 41F1-F4 could be derived from, the VMS points from trips reporting catches in these squares were investigated (fig. 5). The vast majority of these points are located in area 1, including the Dogger bank area. For comparison, fig. 6 shows VMS points of trips where catches were reported to come from area 1.

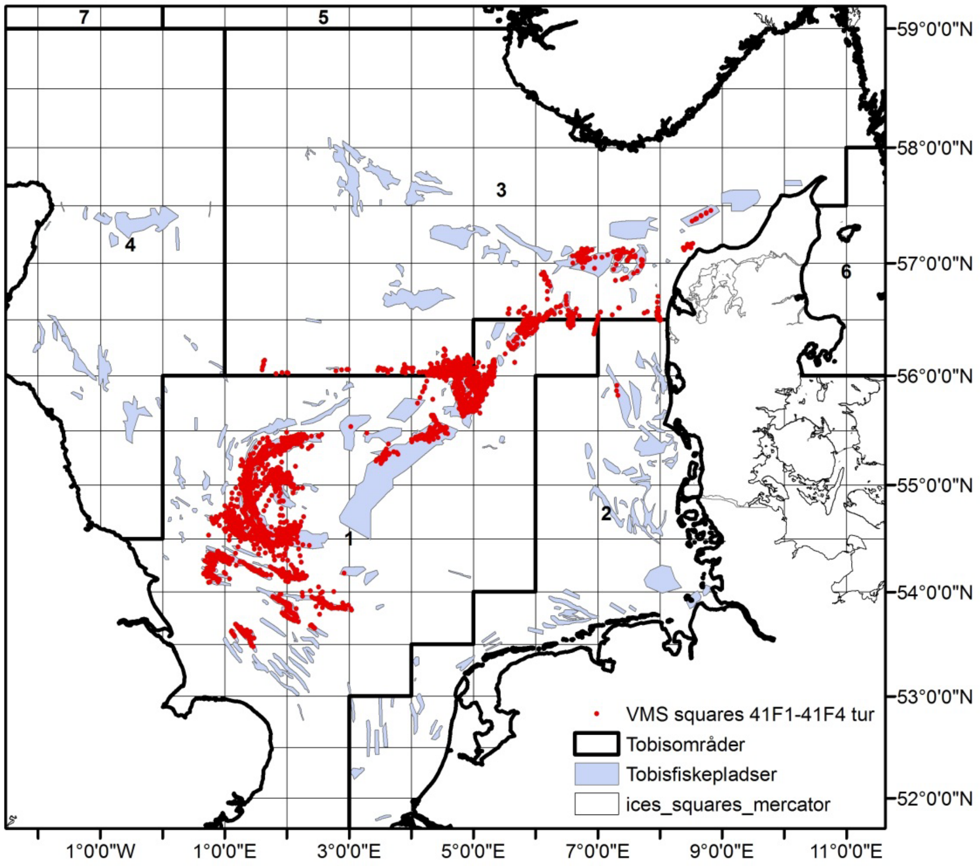


Fig. 5. VMS points characterized as fishing on trips reporting catches in 41F1-41F4.

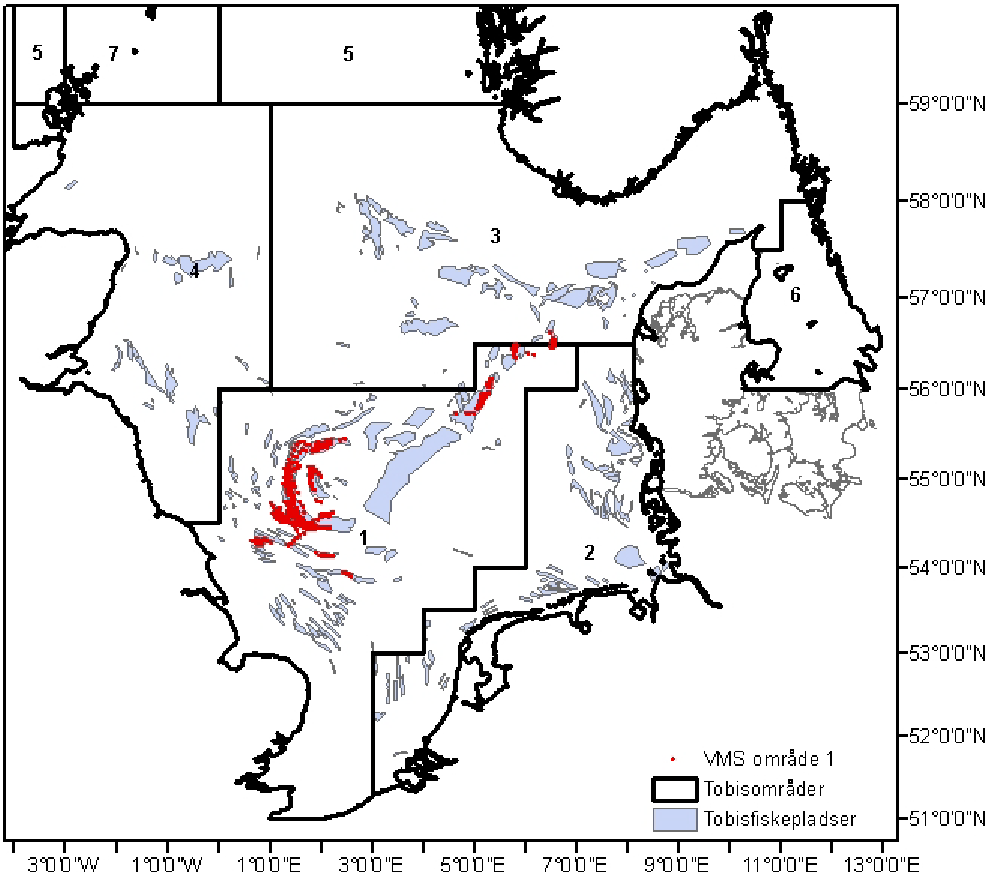


Fig. 6. VMS points characterized as fishing on trips reporting catches only in area 1.

Finally, the estimated CPUEs based on trips fishing in only one area was compared to that from trips fishing in both areas 1 and 3 (table 1). Catch rates based on fishing in only one area follows the expected pattern that CPUE in area 1 should be higher than in area 3 (fishing rates in area 3 are app. 35% of area 1) to make fishing attractive to fishers as area 1 fishing grounds are further from port than area 3 fishing grounds. However, catch rates derived from trips fishing in both area 1 and 3 show fishing rates in area 3 which are 12 times that in area 1.

Table 1. Estimated CPUEs based on trips fishing in only one area compared to that from trips fishing in both areas 1 and 3.

Fishing area	CPUE Area 1	CPUE Area 3
1 only	6,477	
3 only		2,285
1 and 3	5,192	64,316

Based on this evidence, it was concluded that catches reported in rectangles 41F1-41F4 are likely to have been taken in area 1. Hence, all international catches from these rectangles were added to the catches in area 1 and not included in the catch in area 3. As evident from figure 4, this did not completely remove the apparent overestimation of fishing in area 3, and hence the resulting estimate of catches in area 1 should be considered a minimum estimate and those of area 3 a maximum estimate. Effort in area 1 seemed to be accurately estimated whereas effort in area 3 derived from reported fishing days was an overestimate.

Revised estimate of effort

When estimating effort by area, it is assumed that CPUE records are biased due to substantial reporting of area 1 catches in area 3 in rectangles 41F1, 41F2, 41F3 and 41F4. Catches in these rectangles are allocated to area 1. The studies of VMS tracks suggest that the fishing days reported in these squares are not actual fishing days and this effort is therefore not used in the summation of total effort.

The lack of reliable CPUE data invalidates the benchmarked method to estimate effort standardised by vessel size which uses an annual estimate of the effect of vessel size on CPUE. Instead, the average effect of vessel size in the years 2004-2013 was used to estimate standardised fishing days (table 2, fig. 7).

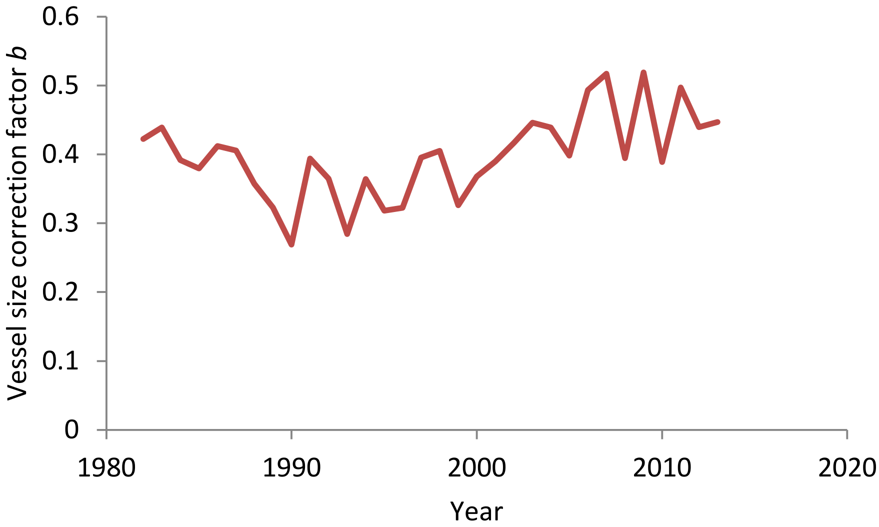


Fig. 7. Estimated vessel size correction factors for the years 1983-2013

Table 2. Estimated vessel size correction factors for the years 2004-2013

Year	Vessel effect
2004	0.439
2005	0.398
2006	0.494
2007	0.517
2008	0.394
2009	0.519
2010	0.389
2011	0.497
2012	0.439
2013	0.447
Average	0.453

Further, the lack og spatial overlap between Norwegian and Danish vessels means that it is not possible to estimate the 2014 standardisation between countries which is necessary due to the difference in the reporting of days (fishing days or days since leaving harbour) and hence the 2013 value was used (0.43). Standardised fishing days for each area was estimated as

$$E_{200GRT} = \frac{C_T}{C_{DK} + C_{NO}} \left(\sum_{GRT} E_{DK,GRT} \left(\frac{GRT}{200}\right)^{0.453} + \sum_{GRT} 0.43 E_{NO,GRT} \left(\frac{GRT}{200}\right)^{0.453} \right)$$

Where C_T is the total international catch in the area in 2014 after allocating the catches in in the rectangles 41F1, 41F2, 41F3 and 41F4 to area 1, C_{DK} is the total Danish catch derived from log books and reallocating the catches in in the rectangles 41F1, 41F2, 41F3 and 41F4 to area 1 C_{NO} is the Norwegian catch derived from logbooks, GRT is gross register tonnage of the vessel size class, $E_{DK,GRT}$ is the sum of fishing days reported by Danish vessels in the GRT size class disregarding all days reported in rectangles 41F1, 41F2, 41F3 and 41F4, $E_{NO,GRT}$ is the sum of fishing days reported by Norwegian vessels in the GRT size class (Norwegian vessels did not report catches in rectangles 41F1, 41F2, 41F3 and 41F4).

A second method to estimate 2014 standardised effort was also investigated. This method used the sum of VMS pings from designated fishing in 2013 and 2014 (disregarding pings from rectangles 41F1, 41F2, 41F3 and 41F4 in 2014), P_{2013} and P_{2014} , respectively, to derive an index of 2014 effort as:

$$\epsilon_{200GRT,2014} = \frac{P_{2014}}{P_{2013}} E_{200GRT,2013}$$

This index assumes that the size distribution of fishing days across fishing vessels and the ratio of Danish to Norwegian effort is identical in the two years, and hence was used for comparison only.

Working document 2 – Landings per unit effort and spatial distribution of the Swedish North Sea sandeel fishery

By Patrik Johnsson and Valerio Bartolino, February 2016. Working document to HAWG 2016.

Fishermen logbook information from 2012 - 2015 is analyzed to investigate potential misreporting in the Swedish North Sea sandeel fishery. Positional data from the Vessel Monitioring System (VMS) is used to map the distribution of fishing events. Landings per unit effort (LPUE) are calculated as landed quantity (kg) of sandeel divided by haul duration (hours). Fishermen report information on individual hauls and since the introduction of the electronic logbook (2011-2012) both start and stop times of fishing events are reported. The VMS data from the self reported haul events show a good resemblance to speed filtered VMS data (see map in figure 1). Therefore LPUE is calculated directly from the logbook information rather than counting VMS –pings.

Result

Swedish sandeel fishery contributes only to a small part of the total fishery with 5 – 10% of total landings. Approximately ten vessels are involved and they make in total 30 – 50 trips per year and typically around 10 hauls per trip.

Average LPUE (mean and median) is aggregated over each fishing area and grouped by the area combinations visited each trip. All vessels are grouped without any vessel standardization. All multiple fishing area trips are grouped into one category "1234" (see table 1).

The main part of their effort is located in fishing area 1. LPUE in fishing area 1 varies the least with trip combinations. Fishing areas 2 and 4 are seldom visited, only very few, short duration hauls but very large catches / LPUE are consistently reported.

LPUE in fishing area 3 are reported to be higher when the area is fished during multiple area trips and such difference appears larger in most recent years with estimated mean LPUE from area 3 almost five times larger when associated to trips visiting multiple areas than in single area trips.

These results are not conclusive evidence of misreporting, LPUE might differ between areas and areas might be visited differently during the fishing season leading to different LPUE in the same area. (Neither is the vessel effect fully investigated). However the spatial distribution of the fishing effort during multiple area trips (see figure 1) suggest that particularly area 2 and 4 are visited in an apparently non-random way, close to the borders of area 1.

In 2015, the fishery has given particular attention to the rectangle 41F4 (area 3) which appears visited systematically during trips where most of the fishing time is spent in area1. Not surprisingly, of the 50 hauls with reported largest catch during 2015, 54% of them come from rectangle 41F4 during multi-area trips. Figure 2 presents VMS positions from the 10 trips with the highest catch.

Further a particularly striking example is shown in figure 3, where four vessels catch exactly the same amount of sandeel in single one hour hauls in all three areas 2, 3 and 4 respectively during a multi area trips. These events must be considered extremely unlikely to happen by chance alone.

In conclusion the specific landings of individual hauls might be questionable and fishing effort might be a more robust way to partition landings across different subareas.

Table 1. Aggregated landings per unit effort of Sandeel (in kg / hour) grouped by year, fishing area and the trip-level combination of fishing areas. Value for fishing areas visited during single vs multi area trips are highlighted by colors.

Sandeel fishing area	Fishing area trip	Year	LPUE (mean)	LPUE (median)	Mean haul duration (h)	Number of hauls
1	1	2012	16 256	7 500	4.1	47
1	1234	2012	16 974	12 500	4.4	38
2	1234	2012	21 000	16 500	1.2	6
3	1234	2012	19 000	14 000	1.1	7
4	1234	2012	32 571	18 000	1.0	7
3	3	2012	17 346	7 917	5.1	13
1	1	2013	10 161	6 364	6.1	283
1	1234	2013	9 227	7 000	6.2	220
2	1234	2013	53 922	43 500	2.0	10
3	1234	2013	18 564	13 750	4.0	22
3	3	2013	9 087	5 000	4.4	11
1	1234	2014	4 496	2 500	6.5	220
2	1234	2014	31 000	31 000	2.0	2
3	1234	2014	40 000	27 500	4.5	107
4	1234	2014	100 000	100 000	1.0	1
3	3	2014	14 992	7 619	4.5	24
1	1234	2015	9 039	5 000	5.9	361
2	1234	2015	57 167	48 250	2.1	8
3	1234	2015	64 757	50 000	3.4	131
4	1234	2015	52 667	52 667	6.5	2
3	3	2015	13 277	7 000	5.5	11

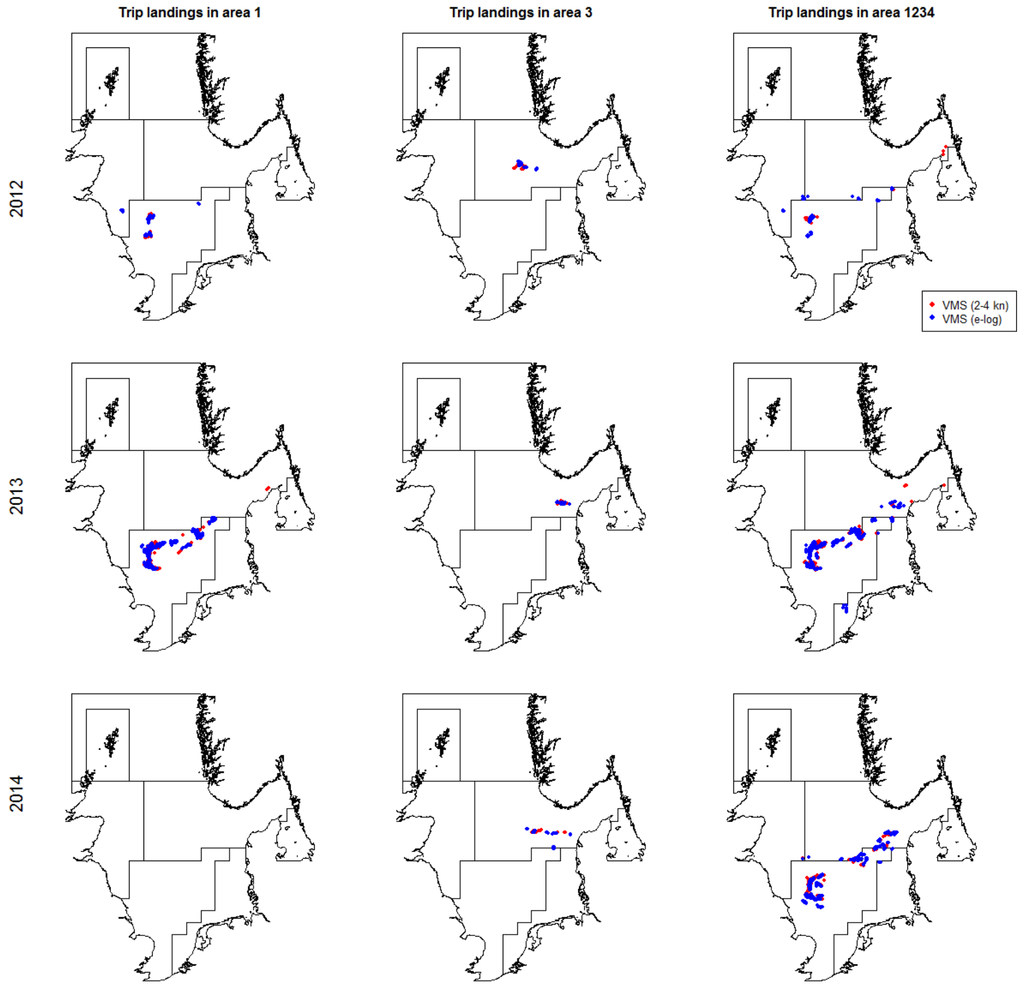


Figure 1. Spatial distribution of Sandeel fishery (2012-2014). Fishing trips are grouped according to the combination of visited fishing areas. Blue dots denote the VMS signals within reported setting / hauling times and red dots are VMS signals filtered by the speed interval 2-4 knots.

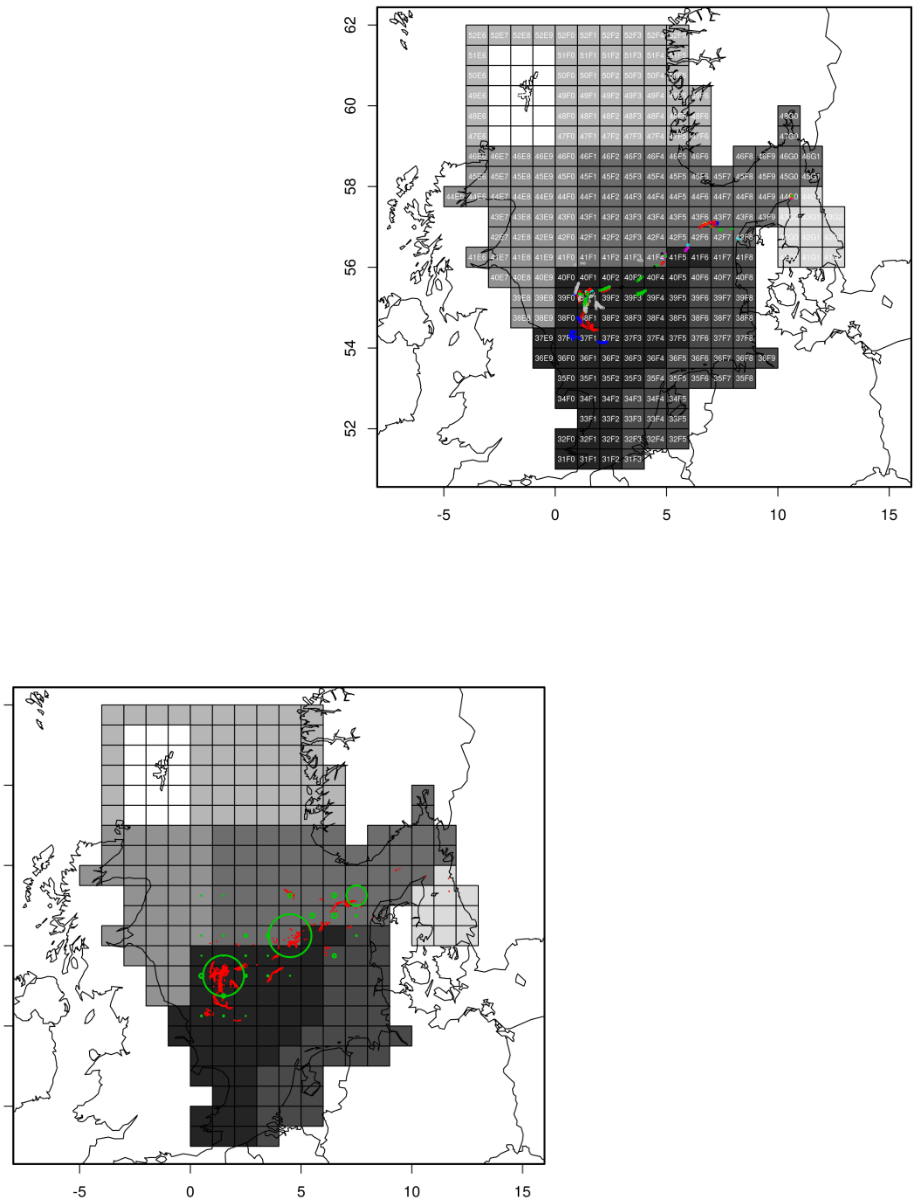


Figure 2. (Left panel) VMS positions from 2015 (red dots) with aggregated catch amount (green bubbles) by rectangle from logbook. (Right panel) VMS positions of the top 10 trips with highest catch which visited multiple areas within a trip during 2015.

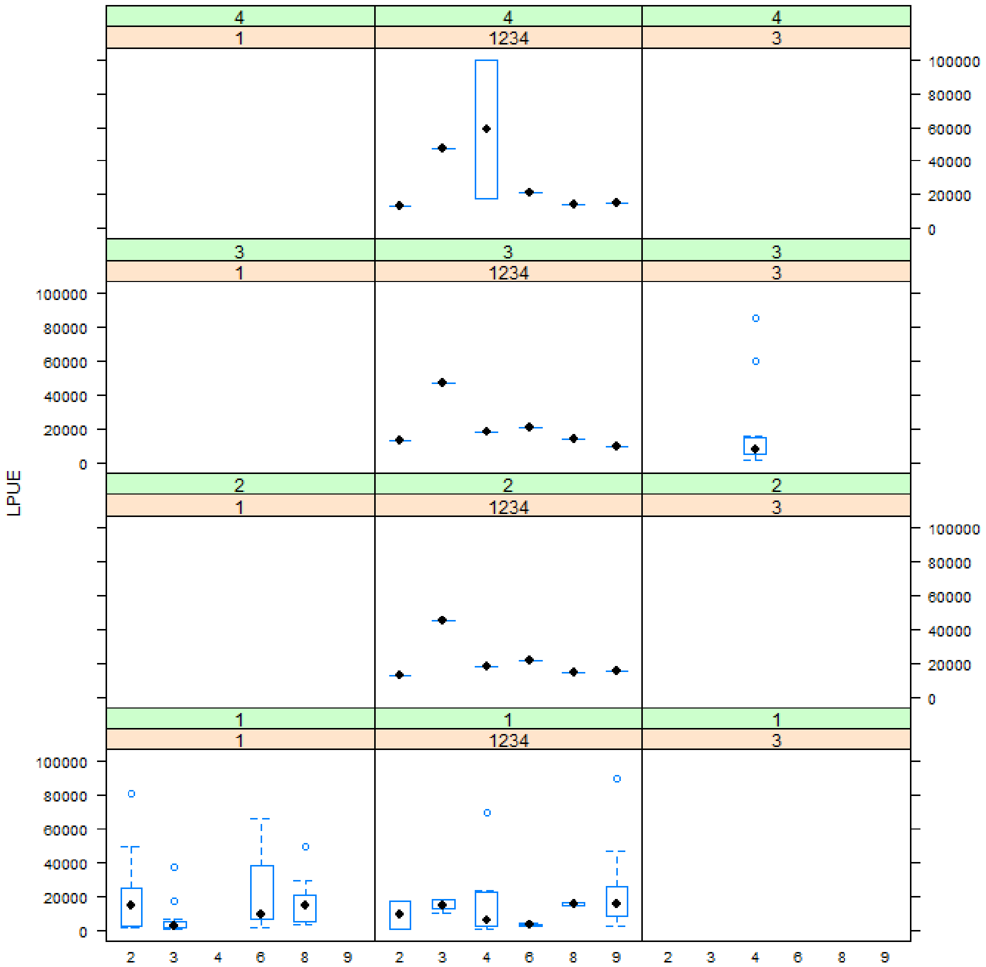


Figure 3. Boxplots of LPUE (kg/h) by fishing area of anonymized vessels during 2012, grouped by trip type (single or multiple area trips).

Working document 3 - Marine Scotland Science sandeel dredge survey indices for SA4

*By J. Clarke, P. Boulcott & P.J. Wright**

*corresponding author *P.Boulcott@marlab.ac.uk*

Introduction

The Marine Scotland Science (MSS) sandeel survey of SA4, off the north east UK coast, was established in 2008 to complement the Danish dredge survey of areas 1 – 3. The survey is targeted at historically fished banks off the Firth of Forth and around Turbot bank and takes place in late November or early December to coincide with the Danish sampling. This report presents the results from this survey for the years 2008 - 15 and compares the Firth of Forth banks with data from the same stations sampled during research surveys conducted in October-November between 1999 and 2003.

Methods

Dredge hauls encompassing the major Firth of Banks banks were taken at 8 stations in 1999 – 2003; 3 stations on the Wee Bankie, 3 on Marr Bank and 2 on Berwick Bank. In 2008 – 2015, additional stations were sampled over Berwick Bank and around the Wee Bankie grounds. During 2008 – 2013, and in 2015, the Turbot bank and/or nearby patches of sandeel habitat have also been surveyed. The survey in 2015 sampled from 4 stations on Wee Bankie, 2 on Marr Bank and 4 on Berwick Bank. 5 stations over Turbot Bank were dredged for the first time since 2012. Where possible 5 tows of 10 minute duration were made per station, although due to poor weather on some days this was reduced to 2. All captured sandeels were measured and a length stratified sample was aged to produce average age length keys for Firth of Forth and Turbot bank grounds. Numbers caught were converted to numbers per area swept and then raised to numbers per hour based on the average area swept in 1 hour. Average CPUE for SA4 was calculated using the same averaging used in the Danish surveys (Christensen, Appendix A, WKSAN 2010) in order to enable comparison.

Results

The total numbers of hauls by sandeel bank 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. As only sandeels ≥ 8.5 cm TL are fully selected by the gear and many 0-group are typically below this length, age 1 catches are generally higher than age 0 for a given year-class, although this was not the case for the 2012 and 2013 year-classes. Nevertheless, catch rates at age 1 were significantly correlated with age 0 and similarly for catch rates of age 1 and 2 ($P < 0.05$, Figure 1).

The 2014 year-class signal remained dominant in all hauls at all stations (Table 2 a & b) with age-1 CPUE values comparable to those in 2010. This year's recruiting 0-group CPUE was low, similar to that observed throughout 2010 – 2013.

Table 1. Scottish dredge survey. Number of hauls by sandeel bank and year

Bank	Year												
	1999	2000	2001	2002	2003	2008	2009	2010	2011	2012	2013	2014	2015
Wee Bankie	3	4	3	3	3	18	15	18	11	14	18	16	18
Marr Bank	4	5	3	3	3	8	8	9	7	7	13	10	6
Berwick Bank	2	5	0	2	2	6	8	8	6	6	17	14	20
Turbot Bank	0	0	0	0	0	3	15	16	17	20	6	0	16

Table 2. Average CPUE by age for a) SA4 and b) Firth of Forth

a)				b)		
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	95	135	23	122	178	30
2013	62	85	35	82	89	45
2014	445*	43*	12*	445	43	12
2015	136	1044	14	151	1126	13

*Adverse weather conditions in 2014 precluded any sampling of SA4 stations outside the Firth of Forth region, hence CPUE estimates are identical.

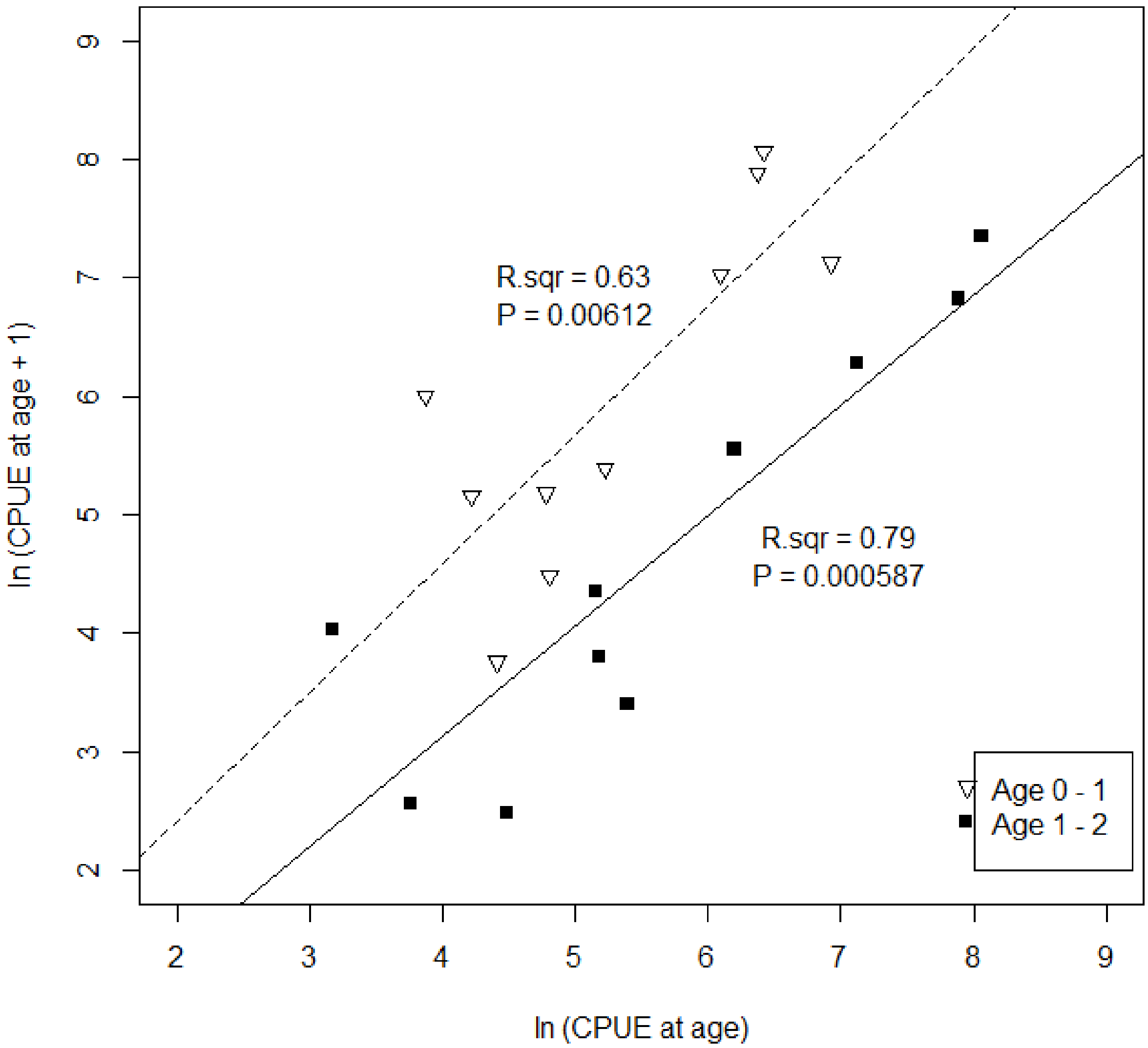


Figure 1. Internal consistency plot. Average CPUE of consecutive ages from the same year-class for Firth of Forth samples.

Working document 4 – Results of an Independent Observer Study of the Celtic Sea Herring Fishery, 2015.

By Pinfield, R. and Berrow, S. 2015

Results of an Independent Observer Study of the Celtic Sea Herring Fishery, 2015

Róisín Pinfield and Simon Berrow

IWDG Consulting
Irish Whale and Dolphin Group, Merchants Quay, Kilrush, Co Clare
http://consulting.iwdg.ie

Introduction

Herring (*Clupea harengus*) has been an important source of food and income for coastal communities in Ireland for generations and the Celtic Sea Herring fishery (CSH) is one of the most important fisheries in the country (Molloy 2006). The fishery developed in the 1950s, mainly from ports in Co. Waterford and expanded rapidly in Ireland in the 1960s following restrictions on foreign vessels fishing at the spawning grounds. The expansion of the fishery west to Castletownbere, Co. Cork and Dingle, Co. Kerry, combined with continued pressure from continental fleets led to concerns about over-fishing in the late 1960s, early 1970s. Landings peaked in 1969/70 at 44,000 tonnes and have since declined. During the 1980s and 1990s the Total Allowable Catch (TAC) was maintained at 20,000 tonnes but catches failed to reach this quota since 1997 and up to 2011. Following declining catches and unsuccessful management approaches, the Celtic Sea Herring Management Advisory Committee (CSHMAC) was formally established in 2005 and included representatives from the Irish South and West Fishermen's Organisation (IS&WFO), the Irish South and East Fishermen's Organisation (IS&EFO), the Irish Fish Producers Organisation (IFPO), the Killybegs Fishermen's Organisation (KFO) as well as processing interests and invited experts from the Marine Institute, Sea Fisheries Protection Authority and other relevant stakeholders including the Irish Whale and Dolphin Group (IWDG).

Celtic Sea Herring Fishery 2015

Standing Stock Biomass (SSB) and thus fishing quotas for this fishery have been steadily increasing over the last six years, however this year the adjusted Irish TAC in 2015 was set at 17,350 tonnes in 2015 which was a decrease of 17.4% or 3,660 tonnes on the TAC in 2014. The main fishery was allocated 84% or 14,574 tonnes of the Irish TAC , the sentinel 11% or 1,908 tonnes and 5% or 867 tonnes was allocated to the open fishery for vessels under 20m.

The CSHMAC has greatly assisted in the recovery of the herring stock in the Celtic Sea through recommending and implementing important conservation measures. The CSHMAC successfully attained Marine Stewardship Council (MSC) certification for this fishery in 2012. The MSC certifies fisheries that are seen to be sustainable, which is important to consumers enabling it to sell products into markets which require the MSC label. In order to maintain this certification and ensure management decisions are informed by robust science, it is important that data is collected on discarding rates and the potential impact of this fishery on non-target species. The IWDG were contracted by the CSHMAC to carry out an independent observer programme on-board participating MSC certified vessels during the 2015 autumn/winter fishery.

Methodology

Observers

Only experienced observers were used in this scheme. They required previous offshore experience on fishing or research vessels, experience in identification of cetacean species in Irish waters and a third level qualification in a marine related science. Observers were additionally required to hold a personal survival techniques certificate (STCW 95) and a current ENG 11 medical certificate. Observers were provided with personal protective equipment, identification keys for marine mammals and fish and data collection sheets for recording details of each fishing operation (see Appendices 1-4). Data sheets used for this project were used in previous bycatch studies conducted by the IWDG.

Observers recorded spatial and temporal data on fishing activities, estimated catches and discarding of targeted species and catches of non-target species. Observer estimates were carried out by visually estimating approximately how many fish boxes (40kg approx.) of each of the non-target fish species were pumped onboard. For estimates of large quantities of bycatch the observer consultated with the skipper or other fishermen on the deck. Observer estimates are in kilograms or tonnes. All values are estimates and should be treated as such. In addition, effort watches for marine mammals were carried out while onboard. Sightings of all marine megafauna (cetaceans, seals, sharks etc.) were identified to species level where possible. Species identifications were graded as definite, probable or possible. Where cetacean species identification could not be confirmed, sightings were downgraded according to criteria established for IWDG's cetacean sightings database (IWDG 2010).

Sampling Strategy

All vessels certified under MSC to fish for Celtic Sea herring were eligible for observer coverage. Where possible best efforts were made to exclude vessels that had collaborated with previous observer studies over the last year from having to participate in the present study. The CSHMAC informed the participating vessel owners that they would be required to accommodate an observer in the season if contacted. Observers were placed on each vessel and their partner vessel/s during the same fishing trip, in order to get complete coverage of the fishing activities during that trip. In some boat pairs, one vessel would always take the catch for both vessels and so only that vessel carried an observer. Where possible, observers were not placed on the same vessel twice.

Results

Observer Trips

A total of nine observer trips (8 main fishery, 1 sentinel fishery) were carried out resulting in 329.5 hours (322hrs main fishery, 7.5hrs sentinel fishery,) at sea over a seven week period from 19 October to 1 December, 2015. A total of 15 hauls were observed (12 main fishery, 3 sentinel fishery) during this period with towing duration ranging from 25 to 257 minutes.

Table 1. Trips sampled during the CSH fishery observer study in 2015

Trip No.	Fishery	Week	Vessel	Trip duration (hrs)	Observer
1	Main	5	A	35h00m	RP
2	Main	6	B	25h00m	JE
3	Main	6	B	24h30m	JE
4	Main	7	C	62h20m	AB
5	Main	7	D	35h50m	MQ
6	Main	7	E	35h50m	MM
7	Sentinel	3 of sentinel	F	07h40m	MQ
8	Main	10 reallocation	G	52h30m	JE
9	Main	10 reallocation	H	52h30m	MQ

An estimated 475 tonnes of herring from the main fishery and 1.32 tonnes from the sentinel fishery was retained during the nine fishing trips with observers (Table 2). A total of 6.7 tonnes (main) and 0.02 tonnes (sentinel) of herring were estimated to be discarded, which amounted to a discard rate of 1.4% and 1.5% of the total herring landings observed respectively. Of the 6.7

tonnes discarded for the main fishery, 3 tonne was slipped as the catch was considered too small, 2 tonne was slipped as the vessel was full and the remaining 1.7 tonnes was a comobination of minor amounts released during/after pumping operations.

Table 2. The amounts of herring retained and discarded per trip for the main and sentinel fisheries during the CSH fishery observer study in 2015

Trip No.	No. of tows	Herring retained (tonnes)	Herring discarded (tonnes)	Comments
Main Fishery				
1	2	100	5	1st tow; 3T (all catch) slipped as catch was too small. 2nd tow; 2T slipped, hold full. Partner not taking fish
2	2	65	0	
3	1	0	unknown	Codend snagged on ground, lost all catch
4	1	30	0.1	Shared an additional 15T with partner vessel
5	2	85	0.3	Slippage and rail dump
6	1	30	0.7	Slippage and rail dump
8	2	0	0	
9	1	165	0.6	
Sentinel Fishery				
7	3	1.3	0.02	Fish slipped out through scuppers during net haul

Non-target species were bycaught on seven of the nine trips surveyed (Table 3). Whiting (*Merlangius merlangus*) was the most frequently observed bycatch, recorded on six trips and totalled an estimated 4.8 tonnes with one tow accounting for approximately 2 tonnes. Other non-target fish species included; small amounts of haddock (*Melanogrammus aeglefinus*) (50.2kg), mackerel (*Scomber scombrus*) (45kg), Cod (*Gadus morhua*) (9kg) and Flounder (*Platichthys flesus*) (6kg). Grey gurnard (*Eutrigla gurnardus*) were also recorded as bycatch in two tows, a species which was also bycaught in the 2014 CSH observer study (McKeogh and Berrow, 2015). This species had not been recorded in previous studies which suggests that they are not a regular bycatch species in the fishery and the rate is not significant at a population level. A single blue shark

(*Prionace glauca*) was also recorded as bycatch. No seabirds were bycaught during this study.

Table 3. Non-target species caught during an observer study of the CSH fishery in 2015

Trip Number	1	2	3	4	5	6	7	8	9	Total
Whiting (kg)	20.2	600	0	800	2250	100	0	0	1000	**4770.2**
Haddock (kg)	0	0.2	0	0	0	50	0	0	0	**50.2**
Mackerel (kg)	1	0	0	0	0	0	0	44	0	**45**
Cod (kg)	0	0	0	0	0	0	0	0	9	**9**
Flounder (kg)	0	0	0	0	0	6	0	0	0	**6**
Grey Gurnard (kg)	0.4	0	0	0	0	12	0	0	0	**12.4**
Blue shark (No.)	1	0	0	0	0	0	0	0	0	**1**

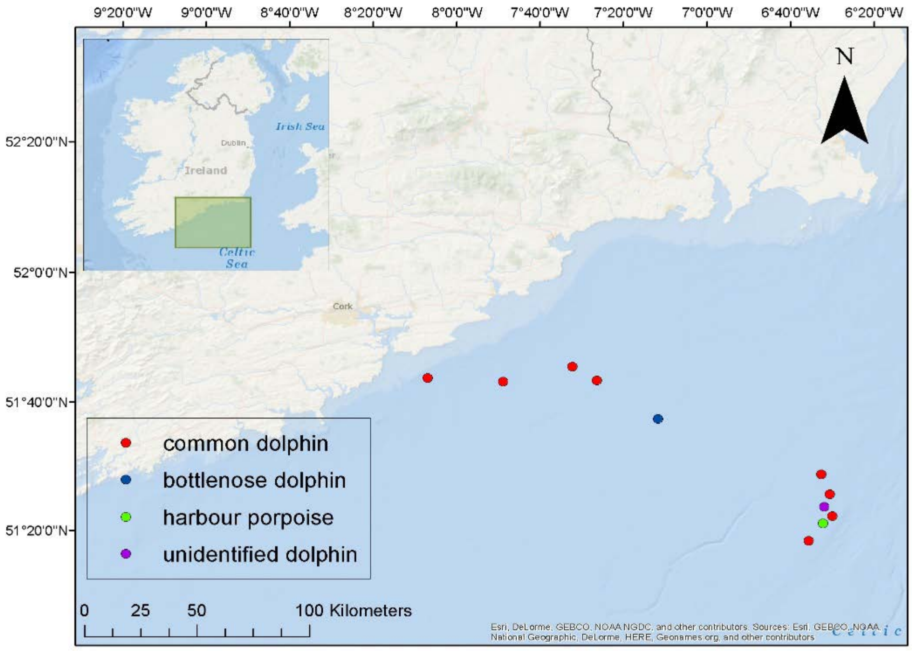
Marine Mammal Sightings

A total of 15 marine mammal sightings were reported during the study totalling an estimated 115 individuals (Table 4). These included one species of seal; grey seal (*Halichoerus grypus*) and four cetacean species; harbour porpoise (*Phocoena phocoena*), common dolphin (*Delphinus delphis*), bottlenose dolphin (*Tursiops truncatus*) and fin whale (*Balaenoptera physalus)*.

Table 4. Number of marine mammal sightings with estimates of group size during an observer study of the CSH fishery in 2015.
Sightings were graded as definite (d), probable (p) or possible(?)

Species	No. sightings	No. individuals	No. adults	No. juveniles	No. calves	Group size
Grey seal (d)	2	2	2	0	0	1
Harbour porpoise (p)	1	2	2	0	0	2
Common dolphin (d)	9	100	96	4	0	6-26
Bottlenose dolphin (d)	1	9	9	0	0	8-10
Fin whale (p)	1	1	1	0	0	1
Unidentified dolphin	1	1	1	0	0	1

Common dolphins were the most commonly sighted species (9 sightings) with a maximum group size of 26 (Table 4, Figure 1). There was 1 sighting of bottlenose dolphins which consisted of a relatively small group of up to 10 individuals and there was also 1 probable sighting of a harbour porpoise during heavy fog which made identification difficult. In addition, there was one distant sighting of an unidentified dolphin breaching, as it was approximately 2km away it made it difficult for the observer to identify to species level (Figure 1).



There were two grey seal sightings, one in the main fishery and one in the sentinel fishery. Both sightings were reported to be associated with fishing activities, in close proximity (<20m) to the nets while hauling.

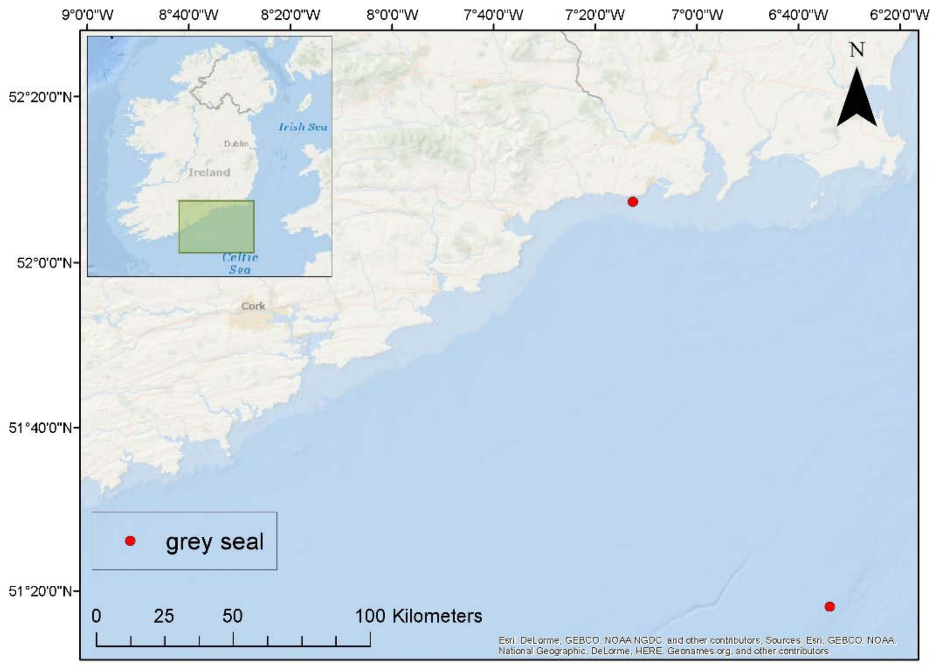


Figure 2. Grey seal sightings during the CSH fishery in 2015

800m away from the observer vessel, in close proximity to two other vessels. It then changed direction approximately 10 minutes later, travelling south past the observer vessel at approximately 700m away.

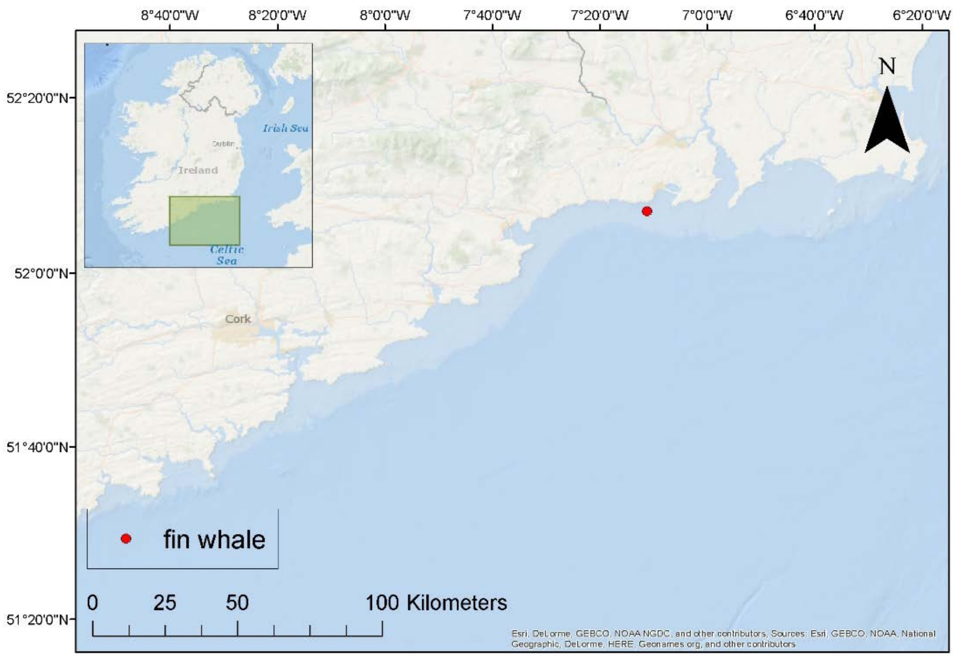


Figure 3. Fin whale sighting during the CSH fishery in 2015

Of the 13 cetacean sightings recorded, just one of them, the fin whale sighting, was recorded during fishing activities near other vessels in the area. All of the other sightings were during steaming or when the vessel was in the

CSH fishing grounds searching for fish. Eight of the sightings were of either common dolphins (n = 7) or bottlenose dolphins (n = 1) bowriding the vessel while in transit.

Other sightings of marine megafauna included; one sighting of a blue shark during fishing operations, one probable sighting of tope (*Galeorhinus galeus*) which appeared to be interested in rafting birds and one sighting of up to eight sharks also during fishing operations which included blue sharks, a porbeagle (*Lamna nasus*) and a possible thresher shark (*Alopias vulpinus*).

There was also one interesting sighting of a probable Long-eared owl (*Asio otus*) which perched on the bow of the observer vessel for a few minutes before being startedled and flying off.

Discussion

The observer study of the Celtic Sea herring fishery during 2015 undertaken by the IWDG was considered successful as nine observer trips out of a target of ten was achieved. During November and December many of the assigned vessels travelled to Killybegs to fish for mackerel in Scottish waters making it difficult to organise observer trips. In addition, four of the vessels assigned to take observers were not taking part in the fishery this year for various reasons and a further two more did not take fish onboard so the skipper of the partner vessel had to be contacted, this led to one vessel taking part in the observer programme two years in a row. Furthermore, stormy weather for the entire month of December meant conditions were not good enough for the sentinel boats to fish during this month, constraining the number of weeks available for deploying observers. In addition, only one of the two vessels from the sentinel fishery assigned to take observers in 2015 actually took part in the fishery, this again made it difficult to reach the target of 10 trips.

This is not an unusual issue with these types of studies, some recent observer schemes of pelagic fisheries, including the Celtic Sea herring fishery, have also found it difficult at times to source berths for observers for numerous reasons (McCarthy *et al.* 2010; Boyd *et al.* 2011; Lyne and Berrow 2012; McKeogh and Berrow 2015).

Bycatch

There was no cetacean bycatch reported during this study which was consistent with the five most recent surveys involving this particular fishery (McCarthy *et al.* 2011; Boyd *et al.* 2012; Lyne and Berrow 2012; McKeogh and Berrow 2014; McKeogh and Berrow 2015). This was also consistent with Berrow *et al.* (1998) who also reported no cetacean bycatch, in a more extensive study of this fishery in 1993/94. Although the results of this study are not definitive that no cetacean bycatch occurs in this fishery, it is likely that incidents are very rare and thus not significant at the population level.

There was no report of seal bycatch which has been recorded previously for this fishery, particularly for grey seals (Berrow *et al.* 1998; McKeogh and Berrow 2015). Though grey seal bycatch was not observed in 2015, it is important to note that observers did report two sightings of grey seals during net hauling within 20m of the vessel, with one individual coming to within 5-10m so the potential for bycatch during fishing operations remains and this study does not exclude that interactions with grey seal may have occurred during 2015 in either the main or sentinel fishery.

Bycatch of whiting has been recorded by previous studies of this fishery (Boyd *et al.,* 2012; Lyne and Berrow 2013; McKeogh and Berrow 2014, 2015) as well as during the present study but may be under recorded as it is difficult for observers to estimate accurately the amount of whiting in the catch due to the high rate of pumping fish from the net.

Overall there was minimal bycatch of any species recorded during the present study. No records of seabird bycatch were reported. Bycatch of gannets has been previously recorded in this fishery by McCarthy *et al.* (2011) and McKeogh and Berrow (2014; 2015) with most individuals released alive. This was positive as it shows that although bycatch of gannets occurs, many can be released alive if quick action is taken minimising the impact of bycatch on this species. Gannet populations have increased significantly in Ireland over the past 20-30 years with the colony on the Saltee Islands, Co. Wexford increasing by an estimated 76% to 1900 pairs (Mitchell *et al.* 2004).

Discard rate

A discard rate of 3.3% for herring reported in this study is similar to what was recorded in the previous observer study in the main fishery in 2014 (McKeogh and Berrow 2015). However, it should be noted that over half of this was due to the vessel being full or due to minor amounts being released during/after pumping operations. Boyd *et al.* (2012) also recorded some slippage in the fishery where errors in targeting and fishing on inconclusive marks lead to discarding of mixed catches of mackerel, sprat and herring. Similar studies in previous years (Lyne and Berrow 2012; McKeogh and Berrow 2013) found that discarding was less than 1% of catch.

Observer programmes

There have been a number of observer programmes of this fishery since 1993 with six since 2010 (Table 5). The largest study was carried out in 1993/94 when Berrow *et al.* (1998) carried out 85 days at sea and observed 78 tows which was around 7% of the total effort in this fishery during that season. No cetacean bycatch was recorded but four grey seals were caught and drowned in nets. Overall 1,270 tonnes of herring were observed caught with discarding estimated at 4.7%. Whiting was the most frequently discarded non-target fish species.

Five herring trips were monitored by McCarthy *et al.* (2011) during the 2010/11 season. During nine days at sea, eight tows were observed during which small quantities of fish were released due to a number of factors such as equipment failure, mixed catch of herring, mackerel and pilchard, holds being full and quota being filled. No bycatch or interactions with cetaceans were reported but three gannets were caught in one tow with one being released alive (McCarthy *et al.* 2011).

Boyd *et al*. (2012) recorded discarding during three fishing trips in the Celtic Sea during 2011/12 where eight hauls were observed and 155 tonnes of herring landed. No marine mammal bycatch occurred but two blue sharks were discarded. Only small numbers of whiting and mackerel were bycaught. During two of the trips around 10 tonnes of herring, sprat and mackerel were slipped or discarded (Boyd *et al*. 2012).

During the 2012/13 fishing season an observer study was carried out by Lyne and Berrow (2012). During 10 trips, 663 tonnes of herring were caught with a bycatch of just five blue sharks (one released alive), small amounts of whiting and blue whiting and a discard rate of just 0.7% (5 tonne) of the total herring landings observed. The results of an independent observer study in the 2013 season (McKeogh and Berrow, 2014) showed that discarding in this fishery was very low (<1%) and there was no significant bycatch of non-target species. The present study was broadly similar to results from these previous studies and was very similar to the results from the 2014 CSH fishery observer study (McKeogh and Berrow, 2015) which reported a 3.4% herring discard rate and showed no significant bycatch of non-target species.

Table 5. Summary of independent observer programmes of the Celtic Sea Herring fishery

Season	Number of tows	Total catch (tonnes)	Bycatch of ETP			Reference
			Marine Mammals	Seabirds	Other	
1993-94	78	1270	4 grey seals			Berrow *et al*. (1998)
2010-2011	8	?		3 gannets		McCarthy *et al*. (2011)
2011-2012	8	155			2 blue shark	Boyd *et al.* (2012)

2012-2013	13	663			3 blue shark	Lyne and Berrow (2012)
2013-2014	35	858		16 gannets	25 blue shark 1 Unid. shark 3 bluefin tuna	McKeogh and Berrow (2014)
2014	26	752	1	2 gannets 1 herring gull	1 bluefin tuna 1 blue shark 1 tope	McKeogh and Berrow (2015)
Total	**168**	**3698+**	**5**	**21 gannets** **1 herring gull**	**31 blue shark** **4 bluefin tuna** **1 tope**	

Recommendations

- If possible, vessels that are assigned to take observers during the fishery and subsequently drop out of the fishery should be replaced by other vessels. This would greatly improve the success of the project.

- Data on bycatch such as gender and length could not always be reported by observers as it was immediately discarded by the crew. This is valuable information that is being lost. It is important that in future observer studies, all bycatch be put aside for the observer to examine and record the necessary data before discarding it.

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Working document 5 – Celtic Sea herring acoustic survey 2015, Trial adaptive mini surveys in the Celtic Sea 2015.

By Ciaran O'Donnell

Introduction

The Celtic Sea herring acoustic survey has been undertaken annually since 1990. During this time survey design has been modified on several occasions in an attempt to provide a more consistent measure of the stock and reduce variability within the time series. Biotic and abiotic processes influencing stock distribution are dynamic and for a survey to be an effective means of measuring stock abundance over time then the design requires a degree of plasticity. Survey design has been modified to ensure it remains fit for purpose and has the ability to consistently track abundance from year to year. Past modifications include survey timing, geographical coverage and acoustic sampling effort (transect spacing). Changes were largely driven by fluctuations in stock abundance and more recently changes in offshore distribution. Acoustically derived abundance indices are inherently noisy but an effective survey design can reduce the level of uncertainty (Simmonds and MacLennan, 2005).

The stock is composed of autumn and winter spawning components with the latter dominating and spawning occurs from September to February. The survey has a three week window in which to best estimate the relative abundance of the stock as it migrates from offshore summer feeding areas to inshore spawning grounds. The annual timing of spawning migration is dynamic and likely driven by seasonal temperature and general condition arising from summer feeding success (Corten, 2000, Molloy, 2006, Varpe *et al.*, 2005, McManus *et al.*, 2016).

Since 2006 the survey has been fixed in time and the design more structured in geographical coverage and acoustic sampling effort (Figure 1). A need was identified within the survey to address concerns on how well the survey was performing and its ability to accurately track the stock during periods of low abundance, considering changes in distribution and where the geographically the stock is encountered during the survey.

Potential sources of error

Sources of error within acoustic surveys are well described (Simmonds and MacLennan, 2005). Here three potential sources of error are identified for further discussion.

Double counting

The survey design utilised from 2006-2014 used a combination of acoustic sampling effort to cover inshore waters out to c.15 nmi (Figure 2). Several small high intensity spawning box strata using 1 nmi spaced transects focused on known herring spawning grounds close inshore (O'Sullivan *et al*, 2013). Linking these strata was a broader strata with 2 nmi spaced transects.

The issue of double counting came to the fore in 2012 with a survey estimate of 246 000 t, an increase of 101% on the 2011 estimate of 122 000 t (O'Donnell *et. al*, 2012). A possible cause for the large increase in biomass was thought to be double counting of very high intensity herring echotraces close to the boundary of the 1 and 2 nmi strata. It was suggested that these fish had moved from one stratum into another and had been counted twice.

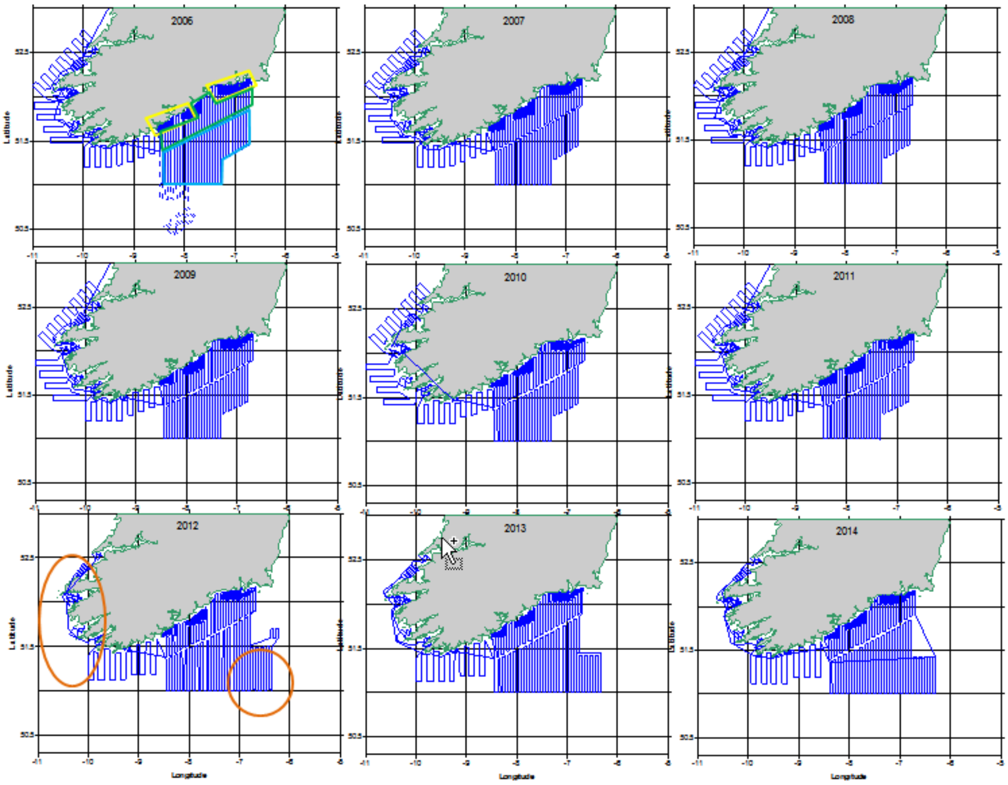

Figure 1. Survey design 2006-2014. Top left panel: Inshore spawning box strata (yellow) 1nmi transect spacing, inshore stratum (green box) 2nmi transect spacing, offshore strata (blue box) 2nmi spacing. In 2012-2014 survey effort (bottom left panel) was shifted from southwest to the southeast to ensure containment of the stock (circled orange).

Together the inshore strata accounted for 57% of the estimate of spawning stock biomass (SSB) in 2012. An exercise was undertaken during the HAWG 2013 to investigate this further (Nolan, 2013, unpublished data). The survey estimate was recalculated twice: once excluding every second (even number) transect and acoustic data from the stratum, and a second time omitting the inverse (odd number). However, it was not possible to determine if double counting was the issue as both recalculated estimates were within 5% of the original. The 2012 survey estimate remained in the assessment as a valid point in the index (ICES, 2013). In 2013 to address these concerns the order in which inshore strata were surveyed was adjusted to reduce the time lag (48 to 16 hrs) between neighbouring strata (ICES, 2014).

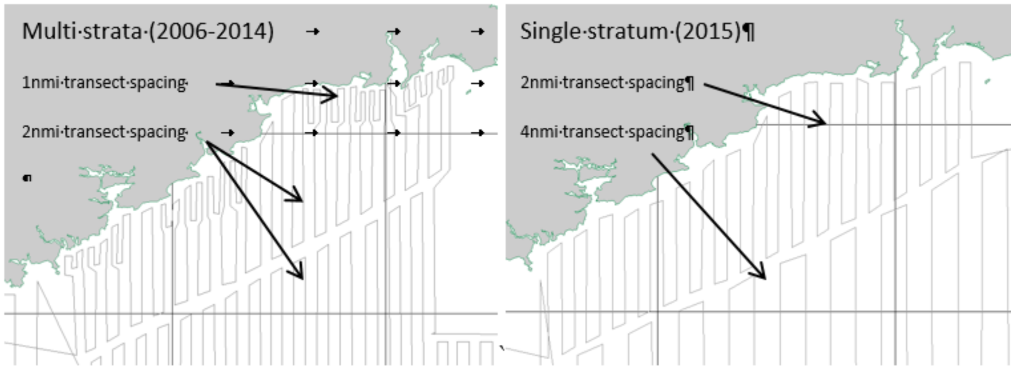

Figure 2. Inshore survey design using multiple strata (2006-2014); spawning boxes with 1 nmi transect spacing and surrounding strata using 2 nmi spacing. Right panel: Consolidated survey effort in 2015.

Stock distribution and the effect on abundance estimates

The surveys ability to track stock across years is considered most accurate during periods of high abundance and is poor during low abundance following a classic low biomass high variance scenario.

The survey is fixed in time and takes place during the first 3 weeks of October. The distribution of herring within the survey area varies annually and is categorised as either an offshore or inshore distribution (Figure 3). The timing of arrival of herring into the survey area varies annually by up to 3 weeks (O'Donnell *et al.*, 2013).

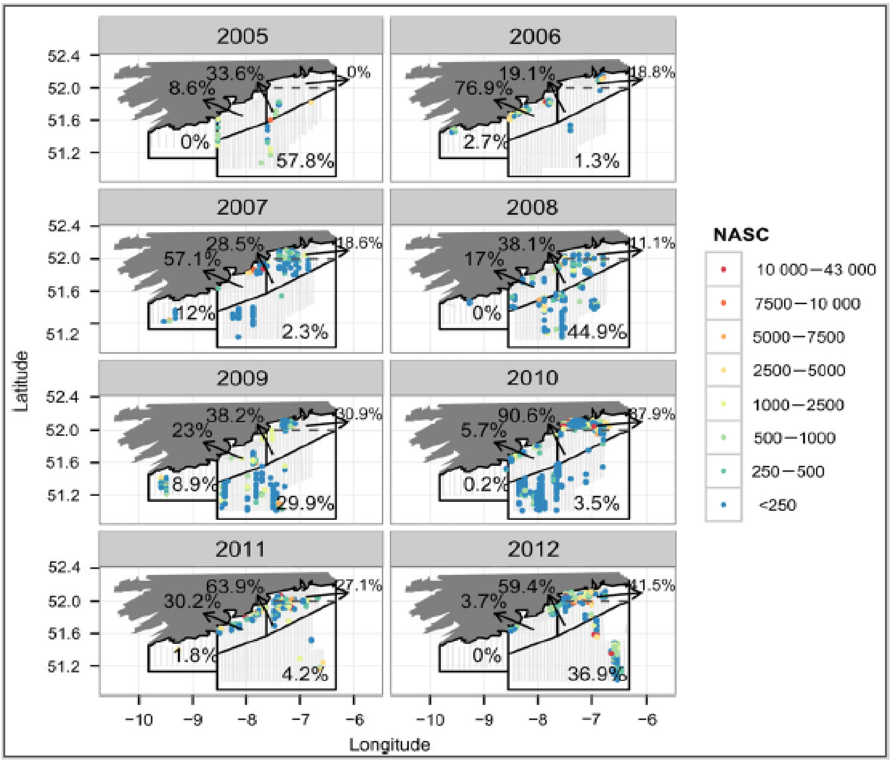

Figure 3. Herring NASC distribution from 2005 to 2012 (coloured points). The numbers give the percentage of NASC per area and year. Taken from Volkenandt *et al,* 2015.

As progressive waves of herring arrive in inshore herring shoals begin to spread out and are commonly observed in clusters of medium and high density running perpendicular to the shore. This type of distribution lends itself well to current surveying techniques as fish are encountered on multiple transects and in multiple strata. Inshore aggregations are considered both spatially and temporally stable. Prolonged poor weather or intensive fishing activities are the main disturbances causing larger shoals to break up into smaller more numerous aggregations.

In contrast, when the stock is located offshore the pattern of distribution is not as clearly defined. Pre-2008 the stock was primarily distributed around the Labadie Bank during the summer feeding phase. The migration pathway was relatively defined both through the fishery (catches) and from survey data with waves of herring moving northwards towards inshore spawning grounds. This pattern of distribution and migration lent itself well to the survey design in place during that time, with multiple aggregations encountered on multiple transects. From 2008 onwards the offshore distribution of the stock began to change shifting eastwards to the Celtic Deep away from traditional areas. By 2012 this shift was complete with almost all offshore catches and survey observations coming from east of 7° line of longitude (Figure 3). Survey design was modified in 2012 by adding a new stratum to ensure stock containment in the east.

Herring around the Celtic Deep tend to form single very large high density shoals that remain relatively stable both spatially and temporally. It is not clear if herring are now resident in this general area here during the feeding phase but it appears to be a regular staging post for onward spawning migration. Successive waves in inward migration are not as common as pre-2012. Pre-2014, a 2 nmi transect spacing was used for offshore strata and even with this degree of high resolution sampling effort it was possible to miss these aggregations either entirely or partially. In years where the latter occurred several individual herring echotraces made up the entire biomass leading to large uncertainties in the estimate. This hit/miss scenario causes high variance and does not provide an accurate measure of the stock.

In summary, when the stock is located inshore the survey is better able to track abundance due to how the fish behave (numerous well-spaced high density aggregations). In contrast, when the stock is located offshore and especially in the Celtic Deep area, the survey is poor at tracking abundance due to the way the herring aggregate and the described a hit/miss scenario. As a result the survey time series is composed of annual estimates of high and low confidence depending on where the fish were located during the survey leading to a saw tooth abundance index with variable precision (Table 1). Internal consistency of the survey as measured by the ability to track cohorts as they progress through the stock is considered as good when compared to catch data.

Table 1. Celtic Sea herring acoustic survey time series showing years where >50% of the survey biomass was located (Off= Offshore, In= Inshore). The 2015-16 estimate determined from adaptive mini surveys.

Season Age (Rings)	2005 2006	2006 2007	2007 2008	2008 2009	2009 2010	2010 2011	2011 2012	2012 2013	2013 2014	2014 2015	2015 2016
0	2	-	1	2	239	5	0.1	31	3.8	0	0
1	65	21	106	63	381	346	342	270	698	41	0
2	137	211	70	295	112	549	479	856	291	117	40
3	28	48	220	111	210	156	299	615	197	112	48
4	54	14	31	162	57	193	47	330	43.7	69	41
5	22	11	9	27	125	65	71	49	37.9	20	38
6	5	1	13	6	12	91	24	121	9.8	24	7
7	1	-	4	5	4	7	33	25	4.7	7	6
8	0	-	1	-	6	3	4	23	0	17	5
9	0	-	0	-	1	-	2	3	0.2	1	0
Abundance	312	305	454	671	1,147	1,414	1,300	2,322	1,286	408	184
SSB	33	36	46	93	91	122	122	246	71	48	24.7
CV	48	35	25	20	24	20	28	25	28	59.1	18.4
>50% biomass	Off	In	In	in	In	In	In	In	In	Off	Off

Changes in survey design 2015

Core survey

In 2015 inshore survey design was modified by consolidating several inshore strata into a single stratum with a uniform sampling effort of 2 nmi to reduce the possibility of double counting (Figure 2). For the offshore strata transect spacing was increased from 2 nmi to 4 nmi to allow time for an adaptive approach.

Adaptive surveying

Recouped time was allocated to adaptive sampling in high abundance areas identified during the co-occurring the fishery. Detailed real time information was available from the fleet during the co-occurring fishery on the location and size of offshore aggregations. Fishing effort was almost exclusively restricted to a single discrete location and was surveyed as a focus area.

Two locations were identified for fine spatial resolution adaptive surveys (Figure 4). In both instances these locations fell between core survey 4 nmi spaced transects. The 'Trench' ground is recognised as a traditional offshore area targeted for herring. The main bathymetric feature itself is a gully running of c.30 nmi in length from NE to SW. The gully ranges from 3-20m in depth with steep to gently sloping bathymetry. Herring were identified in one highly localised area (5 nmi^2) and this was the centre of focus. Two surveys were carried out (day/night).

The 'Smalls' grounds is the name given to the southwestern edge of the Celtic Deep focused primarily on the 100 m contour. The Smalls strata focused on a wider area (20 nmi^2) straddling the 100m depth contour of the western edge of the Celtic Deep. This area was identified as containing a single high density herring aggregation extending over 1.5 nmi along the 100m contour. Four replicate adaptive surveys were carried out over in this strata.

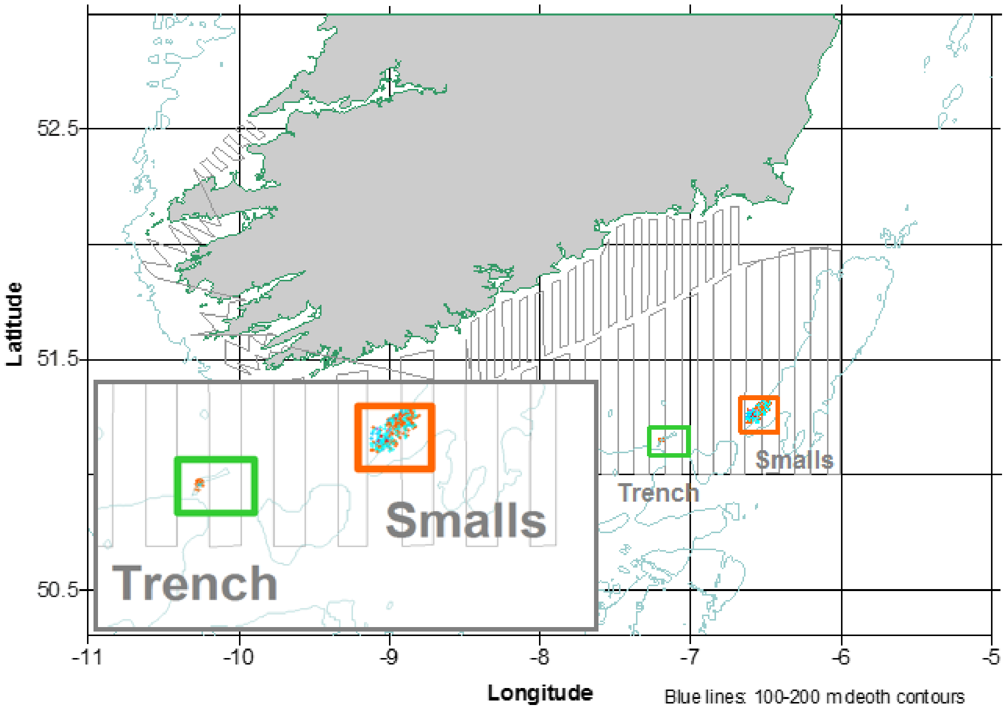

Figure 4. Adaptive survey focus areas of the 'Trench' fishing and the 'Smalls' grounds showing point positions of herring attributed echotraces. Note: position of echotraces relative to core survey transects (vertical grey lines).

A detailed description of data collection and analysis the methods are provided in the Celtic Sea herring survey report (O'Donnell *et al*, 2015) and summarised below:

Data collection

Each candidate area was scouted using Simrad SP70 long range low frequency omni sonar (range 20-30 kHz) to determine geographical extent of target aggregations. A survey plan was then designed with transects running perpendicular to the lines of bathymetry. Parallel transects were spaced at 300 m apart to ensure the full overlapping coverage of the Kongsberg EM2040 multibeam swath (300 kHz) in order that the full extent of the aggregation was contained. The EK60 and EM2040 multibeam systems were run in parallel to provide quantitative and spatial data respectively. Survey design followed methods described in Simmonds and MacLennan (2005) for adaptive surveys. EK60 settings were maintained from previous surveys in order to ensure comparability across surveys. Individual transects were run in parallel crossing the extent of the herring aggregation, the end point of each transect was determined when no further herring echotraces were observed for a further 100m.

Directed fishing trawls and in-trawl optics were used to determine echotrace identification and biological metrics as applied during routine surveying operations.

Data analysis

The elementary distance sampling unit (EDSU) applied during the core survey was 1 nmi. The choice of how long to make the EDSU is a balance between capturing the spatial structure of a population and reducing the correlation between successive samples (Simmonds and MacLennan, 2005). For the larger core survey an EDSU of 1 nmi was used, whereas for adaptive surveys used an EDSU of 0.05 nmi (100 m) was applied. This shorter EDSU was selected based on work carried out by Barbeaux, et al (2013) for surveying discreet aggregations of fish at high resolution.

Results

The Trench stratum was found to contain a low abundance of herring as compared to the larger Smalls stratum (Table 2).

Table 2. Adaptive survey results. (EDSU = 0.05 nmi)

Category Stratum	No. transects	No. schools	Def schools	Mix schools	Prob schools	% zeros	Def Biomass	Mix Biomass	Prob Biomass	Biomass ('000t)	SSB ('000t)	Abundance millions
Trench	7	69	69	0	0	0	0.9	0	0	0.9	0.9	7.4
Smalls	32	1166	1166	0	0	6	23.8	0	0	23.8	23.8	176.6
Total	39	1235	1235	0	0	5	24.7	0	0	24.7	24.7	184.0

Discussion and Conclusion

The adaptive survey biomass is presented as an alternative for 2015 as no herring were encountered during the core survey. The adaptive mini surveys are not considered suitable for inclusion into the time series due to the targeted nature of the survey design which is a step away from a random stratified survey methodology. Had offshore sampling effort (2 nmi transect spacing) remained unchanged in 2015 then it would be highly likely that the core survey estimate would have been similar to that presented here. However, this would be unrepresentative of the stock due to the points discussed here and further contributed to uncertainty in the index.

Having conducted this exercise we are in a better position to be aware of the limitations of the core survey design and to design a new approach to better track the stock offshore. Containment within the larger survey bounds is still an issue and is exacerbated in warmer years by the later arrival of fish and the resultant offshore distribution during the survey. Survey timing will also be considered as a means to ensure containment within the survey area.

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Working document 6 – The Sprat Box Evaluation.

By Anna Rindorf and Lotte Worsøe Clausen, DTU Aqua, March 2016

Introduction

STECF evaluated the effectiveness of the closed area (sprat box) for sprat fishery in the protection of young herring in 2007 (STECF 2007). The Committee concluded that the position of the sprat box may be sub-optimal in relation to the distribution of herring and sprat. However, the conclusion was based on the assumption that the distribution pattern shown in International Trawl Surveys (IBTS Q3) provided an unbiased estimate of the distribution of sprat and herring and the species composition in commercial trawl hauls: 'It should be borne in mind that these results are derived from the IBTS survey and therefore are the catches of a demersal trawl using GOV gear. However, it is not clear whether this method can reliably describe the distribution and abundance of sprat, which is a pelagic species. Furthermore, the question of how the IBTS catches relate to catches in the actual fishery is unclear.' (STECF 2007, p. 110).

Since then, ICES has examined the effectiveness of both trawl and acoustic surveys as indicators of sprat abundance and found that the two survey types provide consistent results which are also consistent through time (large cohorts are observed several times during their life span)(ICES 2012). Hence, the surveys should provide reliable estimates of the distribution of herring and sprat. However, the analyses of how the IBTS catches relate to catches in the commercial fishery remains unsolved due to lack of information from the closed area (as it is closed to the fishery) (STECF 2007). As described by STECF, an analysis of this problem directly from fisheries data would require age- and statistical rectangle- resolved data on the herring by-catch in the commercial sprat fishery.

Trial fishing to derive the necessary fisheries data

To estimate whether the distribution of sprat and herring in surveys are mirrored in their distribution in commercial catches, it is, as indicated by STECF, possible to use data collected outside the sprat box. However, historic sampling levels are unlikely to be sufficient to resolve age distribution of herring by-catch on a rectangle level. Further, even if this information had been available outside the sprat box, it would still remain an open question whether the relationship remained the same within the box. To enable an analysis with sufficient strength for conclusions, an experimental fishery was conducted in the months of July, August, September and October in 2013, 2014 and 2015.

In the event where there is a good correspondence between the commercial catch of the two species and their distribution in the IBTS survey conducted in the same period, two years of experimental fishing should be sufficient to evaluate the effectiveness of the closed area. A rather limited number of samples were obtained during the first two years of sampling, thus it was decided to recommend the extension of the trial period to include 2015 as well.

Material and Methods

The conditions for the vessels participating in the fishery were the following:

- The maximum number of vessels participating in the trial is 14 vessels.
- To ensure comparable temporal coverage inside and outside the box, a trip within the box must be followed by at least one trip outside the box. Up to two trips within the box can be carried out before trips outside the box. Fishing units should during a trip operate either inside or outside the box.
- In 2015, a further requirement was made for two selected pair trawlers (4 vessels) to perform a minimum of 5 trips inside and 5 outside the box during the months August – October to ensure a minimum of samples in both areas (inside and outside the box).
- Only units likely to perform a minimum of 5 trips inside and 5 trips within the North Sea outside the box during the months August - October were allowed to operate inside the box.
- From each trip, a sample of 5 kg was taken from the first haul conducted by the trip. This sample was analysed by DTU Aqua for estimation of species and age composition of herring and sprat.
- A monitoring programme was implemented with the aim of sampling for species composition at least 30% of landings from the vessels participating in the trial. For fishing units not participating in the experimental fishery standard monitoring was carried out.
- The overall length of the vessel allowed within the area did not exceed 24 m. All vessels participating in the experimental fishery had VMS and electronic logbook and haul by haul registration was conducted on all trips within or outside the sprat box. Vessels participating in the trial were not be allowed to discard or slip catches (this was only legal in 2013 and 2014) and all catches should be landed (mandatory in 2015). The vessels participating in the trial had derogation from by-catch rules in 2013 and 2014.

14 vessels are participated in sprat fishery in the area where 12 of the vessels were conducting the fishery with pair trawling and 2 were fishing alone.

Table 1 shows the number of trips conducted with Danish vessels with length less than 24 meters catching sprat in the North Sea and landing in the harbors Hvide Sande and Thyborøn in the months August- October in the time period 2008-2015. In case of pair trawling, the trip is only counted once.

	2008	2009	2010	2011	2012	2013	2014	2015
August	72	115	72	51	80	34	76	84
September	70	57	66	31	22	62	64	86
October	4	65	44	31	43	23	23	99
Total	146	237	182	113	145	119	163	269

Table 1. Historical number of trips in the North Sea by Danish vessels of relevant size.

Samples were collected in ports and transported to DTU Aqua, where they were sorted by species. All fish were length measured (to nearest mm), weighed (gram) and aged following the species specific protocol.

Data analyses

Two aspects of catch composition were analysed, the weight of herring in the sample relative to the weight of sprat and the number of herring in the sample relative to the weight of sprat. These two parameters were analysed to investigate whether there were significant differences between samples taken inside the sprat box and in an area adjacent to the sprat box (fig. 1). Only commercial samples taken from industrial fishing targeting sprat were included and samples taken outside the box or the adjacent areas were excluded from statistical analyses. For comparison with the commercial samples, the identical parameters were derived from IBTS Q3 hauls in the box and in the adjacent area. Both sets of data were log-transformed and analysed using anova and a mixed model. The anova analysed the effects of year, month and inside/outside the box and their crossed effects. The mixed model analysed the effect of month and inside/outside the box assuming the combined effect of year and statistical rectangle to be normal distributed with a common mean and variance parameter. In the analyses of survey data, month was not included in analyses as the survey covered approximately one month. There were two observations were no herring were found in the commercial samples, and these were not included in further analyses.

Following this analysis, the weight of herring in the commercial samples relative to the weight of sprat and the number of herring in the commercial sample relative to the weight of sprat were compared to the corresponding average values for each rectangle from survey catches.

Results

Sample coverage

The sample coverage improved markedly from 2013 to 2015 (Table 2) both in numbers and in spatial coverage (Figures 1 and 2).

Statistical Rectangle	2013				2014						2015					Total
	8	9	10	Total	6	7	8	9	10	Total	7	8	9	10	Total	
36F4												5			5	5
36F5												3			3	3
37F4													1	1	2	2
37F6						1				1						1
37F7		1		1								6	1		7	8
38F4													4	2	6	6
38F5		2		2												2
38F6	1	5		6								6			6	12
38F7											4				4	4
38F8											3	1	3		7	7
39F5							1	3		4		2		1	3	7
39F6	2	2	1	5		2	2			4	11	25		2	38	47
39F7						2		2	1	5			8	1	9	14
39F8						2	3	2		7	1	1	8	11	21	28
40F5							2		1	3		2	1	1	4	7
40F6	2	2	4	8		8	4	4	3	19			3		3	30
40F7			1	1		4	2	5	2	13	2		2	4	8	22
40F8		2		2		6	6	1		13	10	17	15	7	49	64
41F5						2	1			3						3
41F6	1	1	1	3		5	6	3	1	15						18
41F7		2		2		10	9	11	3	33	2			1	3	38
41F8						3	3			6	5	7	1	4	17	23
42F5							1			1						1
42F6						5				5						5
42F7					1		1			2						2
42F8							2			2						2
49F6							1			1						1
Total	6	17	7	30	1	50	44	31	11	137	38	75	47	35	195	362

Table 2. Numbers of samples taken inside the box (yellow) and outside the box by year and ICES statistical rectangle.

Obviously, the higher catches of sprat had an influence on the number of samples (the higher number of trips, the higher number of samples), although this did not explain fully the higher participation in the trial fishery in 2014 and 2015.

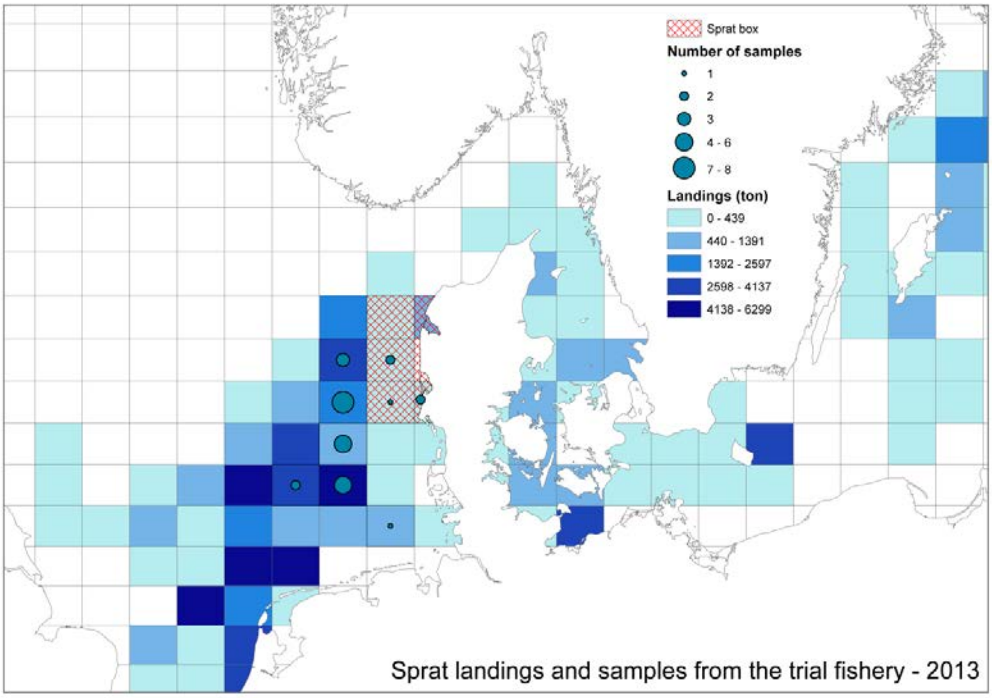


Figure 1. Sampling (circles) and landings (color-grade) in the Danish sprat fishery in 2013. Red hatching denotes the sprat box, black thick line denotes adjacent area.

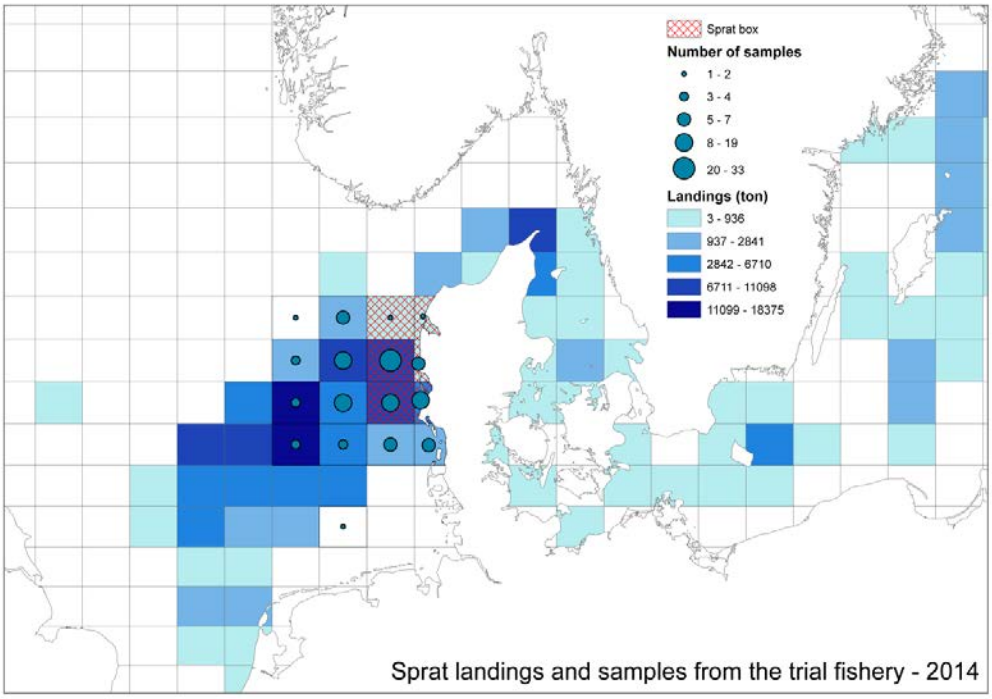


Figure 2. Sampling (circles) and landings (color-grade) in the Danish sprat fishery in 2014. Red hatching denotes the sprat box, black thick line denotes adjacent area.

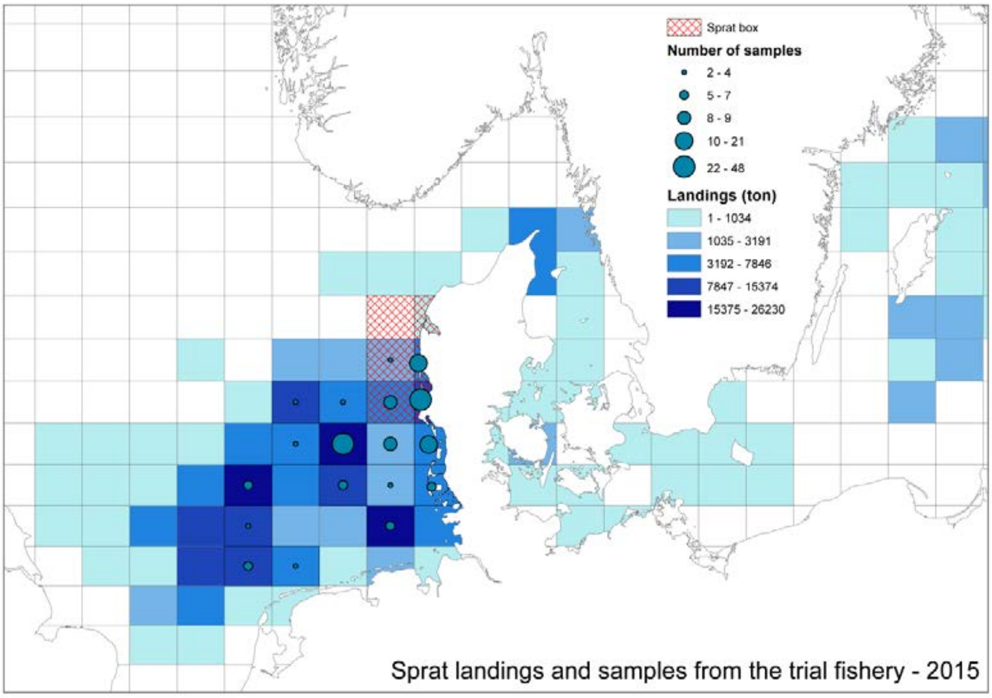


Figure 3. Sampling (circles) and landings (color-grade) in the Danish sprat fishery in 2015. Red hatching denotes the sprat box, black thick line denotes adjacent area.

Bycatch % of herring in the sprat box

Figures 4, 5 and 6 shows the species composition of the samples taken from the sprat fishery in 2013, 2014 and 2015, respectively.

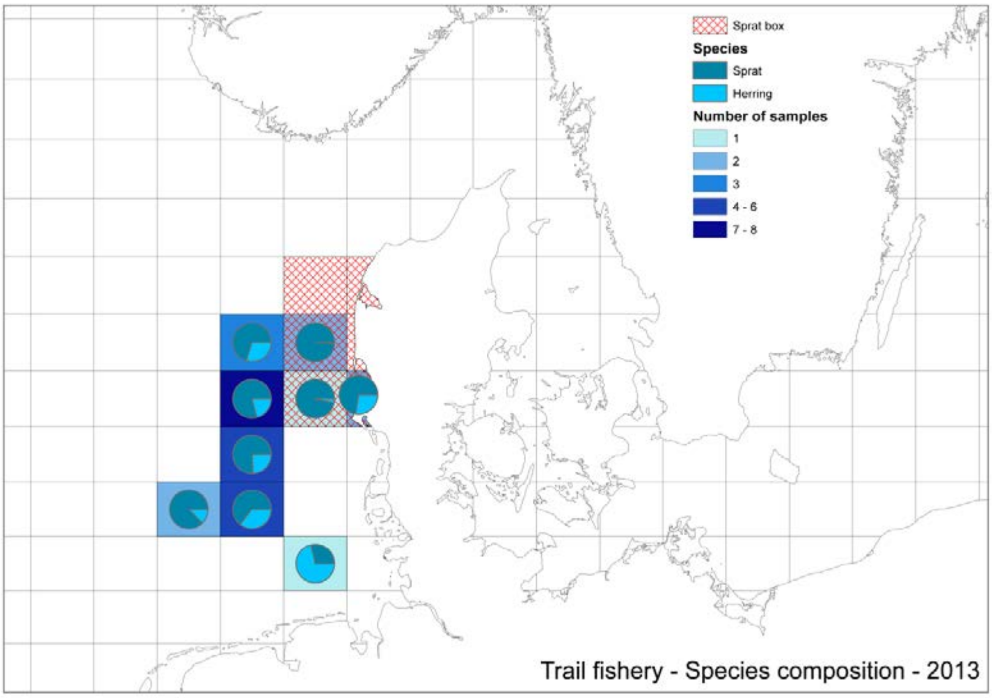


Figure 4. Species composition in the sprat fishery in 2013. Colors indicate number of samples pr. rectangle; red area indicates the sprat box.

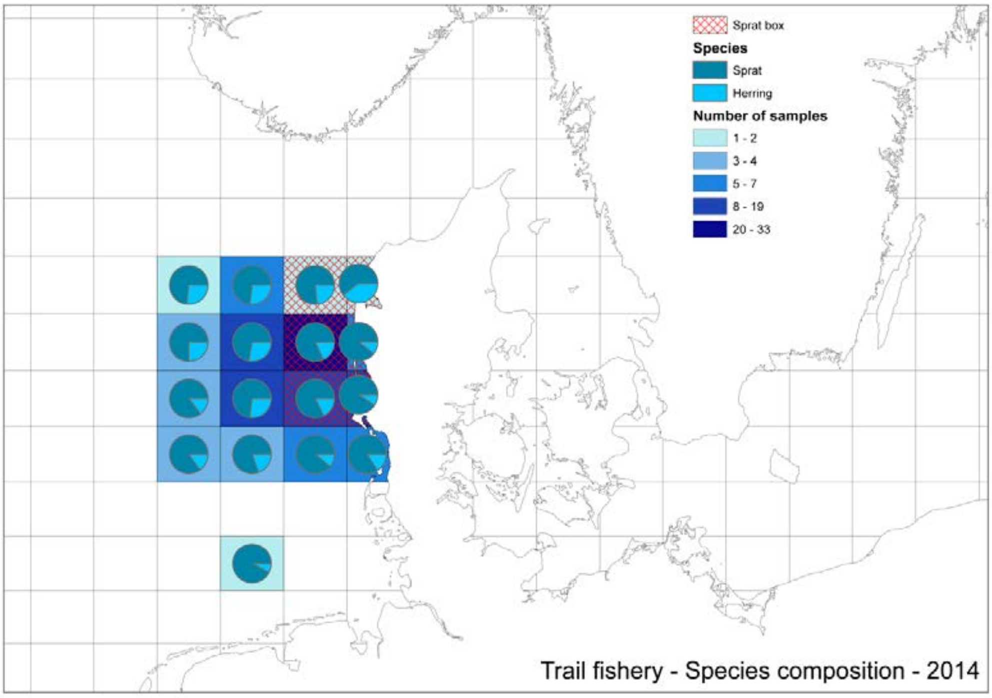


Figure 5. Species composition in the sprat fishery in 2014. Colors indicate number of samples pr. rectangle; red area indicates the sprat box.

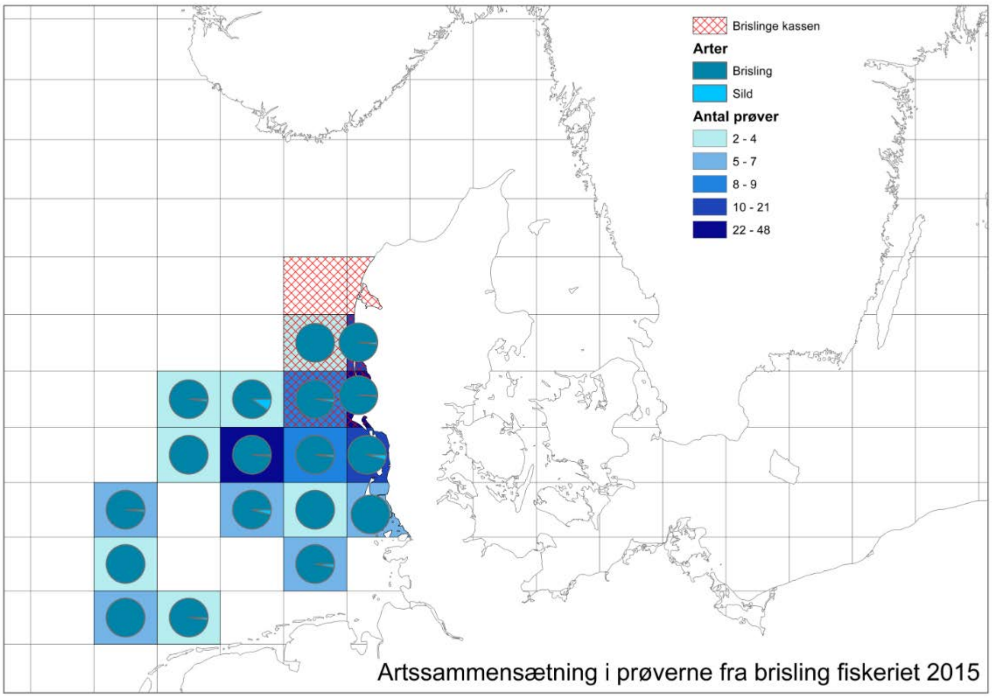


Figure 6. Species composition in the sprat fishery in 2015. Colors indicate number of samples pr. rectangle; red area indicates the sprat box.

Data analysis

The number of herring per kg of sprat did not differ significantly between samples taken inside and outside the box (P(Anova)=0.1074, P(mixed model)=0.1140) and no significant cross effects with box were found (P>0.20 in all cases).

The weight of herring per kg sprat differed significantly between the box and the adjacent area when using the mixed model (P=0.0005), and ANOVA (P=0.0106). Both models had residuals which did not differ significantly from a normal distribution (P>0.05).The estimated effects of being inside the box in the two models were -0.37 (std=0.15) and -0.39 (std=0.15) for the ANOVA and mixed model, respectively, corresponding to 31% and 32% less herring per kg sprat inside the box, respectively. When performing the test for each year separately, the difference was still significant for 2015 but not for the other years (P>0.10 in both models). However, the differences retained the same direction in all years (higher percentage of herring outside the box)(table 3).

The estimated difference in the number of herring per kg sprat was-0.60 (std=0.18) and -0.64 (std=0.18) when estimated in the ANOVA and mixed model, respectively, corresponding to 45% and 47% less herring per kg sprat inside the box, respectively.

Table 3. Average percentage of herring in catches. Values are given where at least 5 samples were analysed.

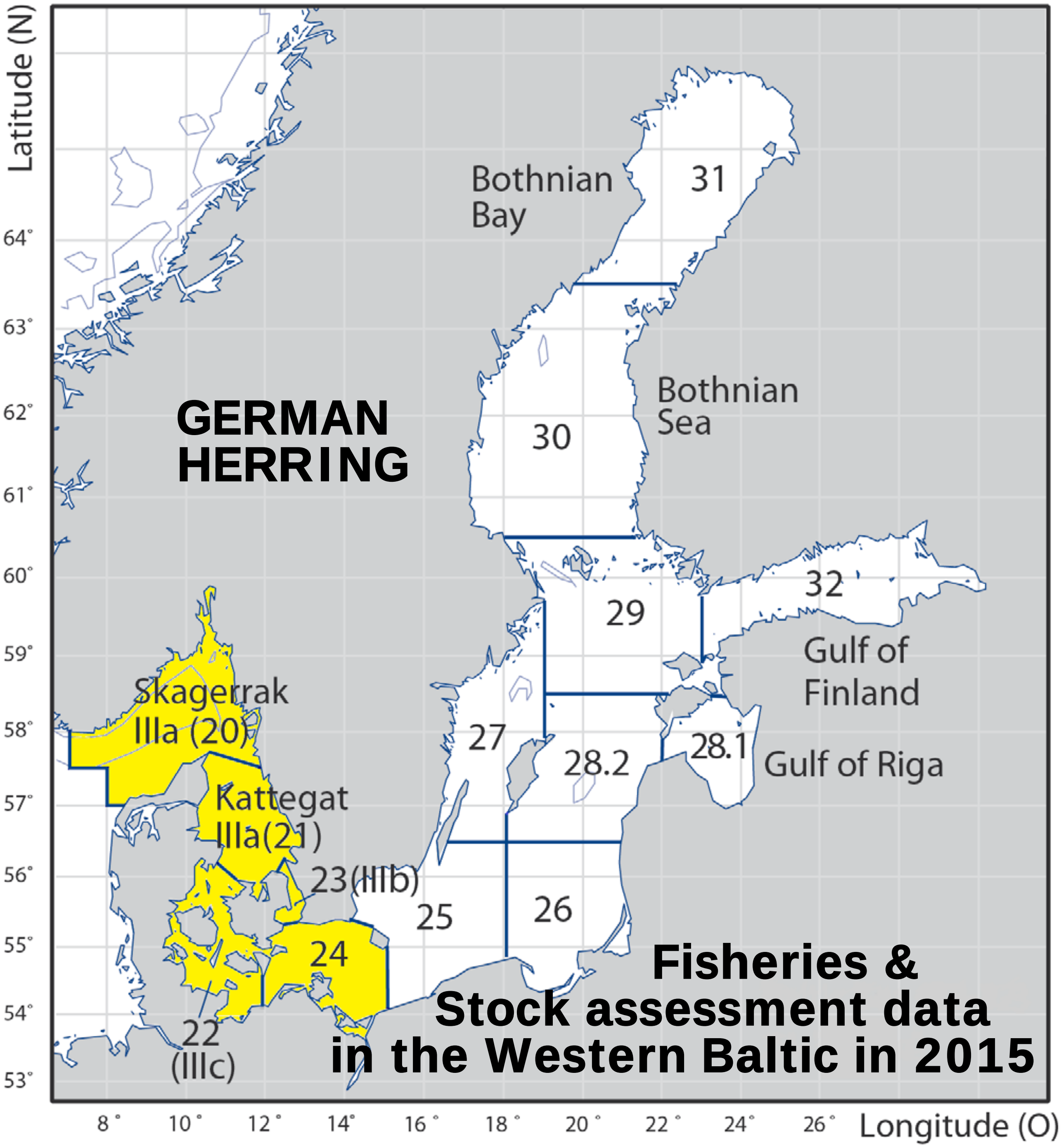
	2014		**2015**	
	inside	outside	inside	outside
July	15.3%	26.5%	1.1%	1.8%
August	10.9%	11.7%	0.7%	1.2%
September	11.6%	14.9%	1.5%	2.4%
October	8.2%	7.2%	2.9%	3.0%

Comparison with IBTS data

Analyses of IBTS data showed no significant difference between the number (P=0.7368 and P=0.8250) or weight of herring (P=0.4585 and P=0.5777) per kg sprat inside and outside the box when using ANOVA and the mixed model, respectively. However, the residuals, though appearing one topped and symmetrical, were not normal distributed in any of the cases, even when using a mixed model. There was no correlation between IBTS weight of herring (P=0. 9901 and P=0.9063) per kg sprat and those in commercial samples in the same rectangle in 2014 and 2015. 2013 had insufficient data to perform the test. On average across all samples, the weight of herring per kg sprat was significantly lower in the commercial samples than in the survey samples taken in the month overlapping the survey (P<0.0001, commercial weight of herring relative to sprat on average 1% of survey weight of herring relative to sprat).

Discussion

There was no evidence of a higher proportion of herring in catches taken inside the sprat box compared to samples taken outside the box. In fact, the proportion of herring in commercial samples taken inside the box was lower than outside the box in each year and across years, this difference was significant in both models. The fishery targets sprat in a way which ensures that the percentage of herring in the catches is only 1% of that in the IBTS on average. If there is a tempo-spatial correlation with IBTS, it was too weak to determine after three years of sampling, probably due to either the targeting behavior in the fishery or the low sampling effort of the IBTS.



compiled by Tomas Gröhsler
Thünen Institut of Baltic Sea Fisheries (TI-OF)
Germany

1 German herring fisheries in 2015

1.1 Fisheries

In 2015 the total German herring landings from the Western Baltic Sea in Subdivisions (SD) 22 and 24 amounted to 13,289 t, which represents an increase of 30 % compared to the landings in 2014 (10,241 t). This increase was caused by an increase of the TAC/quota and some further quota transfer to other countries around the Baltic Sea (German quota for SDs 22 and 24 in 2016: 12,259 t + quota-transfer of 1,216 t). The fishing activities in one of the main fishing areas, the Greifswald Bay (SD 24) could start earlier than in March due to mild winter conditions in January/February. The German fishery was forced to stop their activities in April 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
2013	195 (= 46 % of GER quota (>32 mm) of 421 t
2014	84 (= 27 % of GER quota (>32 mm) of 310 t
2015	128 (= 44 % of GER quota (>32 mm) of 289 t

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:

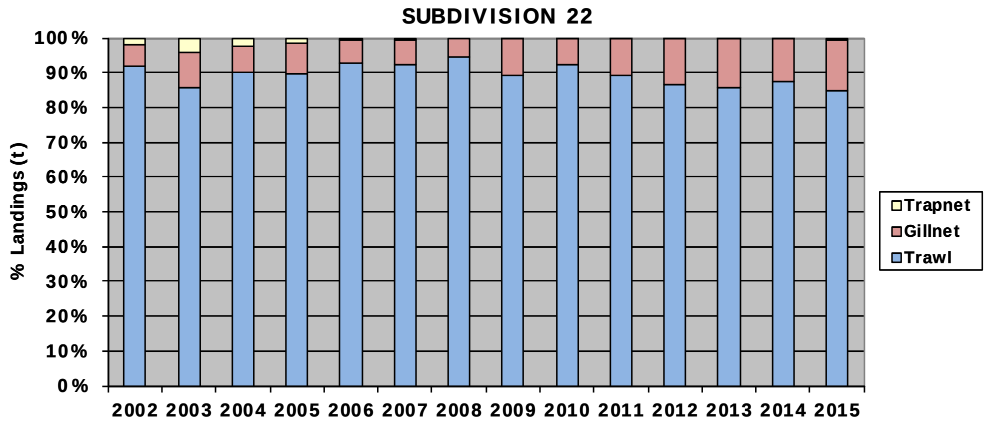
Quarter	Subdiv. 20 Skag./Katteg.	Subdiv. 22 (t)	Subdiv. 24 (t)	TOTAL (t)	TOTAL (%)
I		289.510	9,391.727 -99.063	**9,681.237** **-99.063**	**72.2** **-0.7**
II		39.882	1,493.838	**1,533.720**	**11.4**
III		1.088	0.338	**1.426**	**0.0**
IV	127.608	146.889	1,925.801	**2,200.298**	**16.4**
TOTAL	**127.608** **0.000**	**477.369** **0.000**	**12,811.704** **-99.063**	**13,416.681** **-99.063**	**100.0** **-0.7**

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)

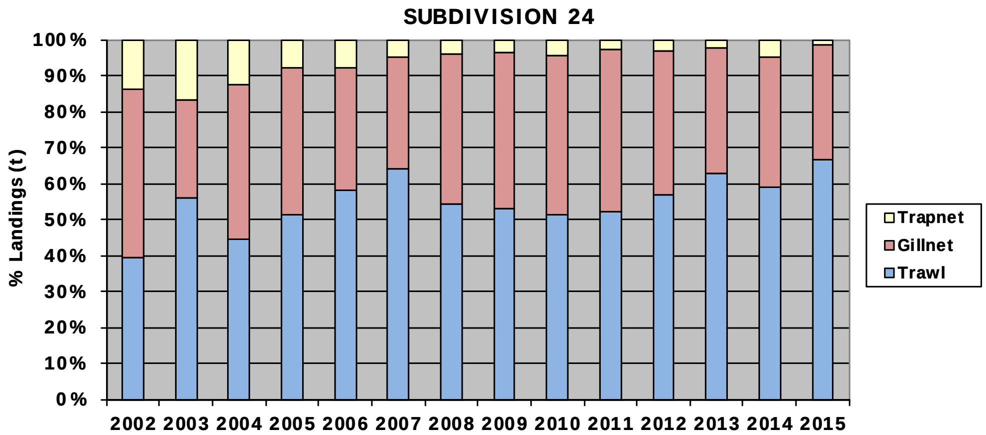
Landings = Total landings
-Landings = Fraction landed abroad

Just as in former years the main fishing season was during the first and second quarter. About 84 % of the herring in 2015 was caught between January and May (2014: 85 %, 2013: 98 %; 2012: 88 %, 2010-2011: 92%). As in last years, the main fishing area was located in Subdivision 24 (2015: 96 %, 2014: 93 %; 2013: 95 %, 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 %, fluctuated in 2008-2014 around 58-64 % (2008: 61 %; 2009: 59 %, 2010: 58 %, 2011: 58 %, 2012: 61 %, 2013: 64 %; 2014: 61 %) and now regain the record level of 67 %. The trawl fishery was mostly carried out in Subdivision 24 (2015: 96 %, 2014: 91 %; 2013: 94%, 2012: 90 %, 2011: 78 %, 2010: 78 %). 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 2002-2015 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%
2013	610.485	99.970	2.708	713.163	2013	85.6%	14.0%	0.4%
2014	572.074	80.422	2.660	655.156	2014	87.3%	12.3%	0.4%
2015	404.439	70.548	2.382	477.369	2015	84.7%	14.8%	0.5%



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%
2013	8,742.420	4,833.203	301.719	13,877.342	2013	63.0%	34.8%	2.2%
2014	5,656.314	3,482.558	447.064	9,585.936	2014	59.0%	36.3%	4.7%
2015	8,517.972	4,112.581	181.151	12,811.704	2015	66.5%	32.1%	1.4%



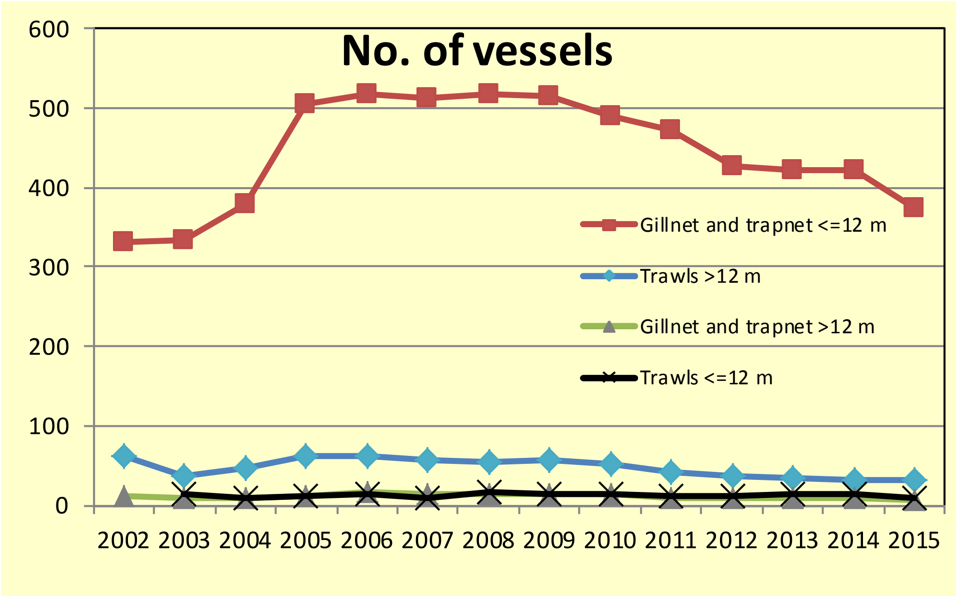
1.2 Fishing fleet

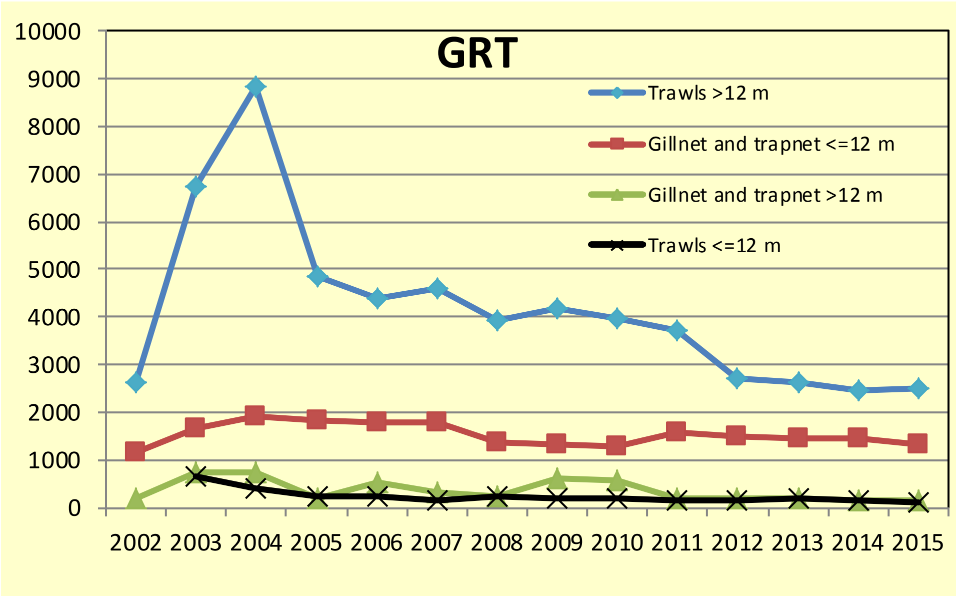
The German fishing fleet in the Baltic Sea consists of two parts where all catches for herring are taken in a directed fishery:

- 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 2008 until 2015 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
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**
2013	**Fixed gears (gillnet and trapnet)**	**<=12**	421	1,459	14,289
		>12	9	186	1,005
	Trawls	**<=12**	14	173	1,557
		>12	35	2,638	7,960
	TOTAL		**479**	**4,456**	**24,811**
2014	**Fixed gears (gillnet and trapnet)**	**<=12**	421	1,443	14,351
		>12	8	149	970
	Trawls	**<=12**	13	170	1,502
		>12	31	2,469	7,205
	TOTAL		**473**	**4,231**	**24,028**
2015	**Fixed gears (gillnet and trapnet)**	**<=12**	375	1,341	13,163
		>12	7	133	802
	Trawls	**<=12**	9	122	991
		>12	31	2,503	7,148
	TOTAL		**422**	**4,099**	**22,104**


No. of vessels
600
500
400
300
200
100
0
2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015
Gillnet and trapnet <=12 m
Trawls >12 m
Gillnet and trapnet >12 m
Trawls <=12 m


GRT
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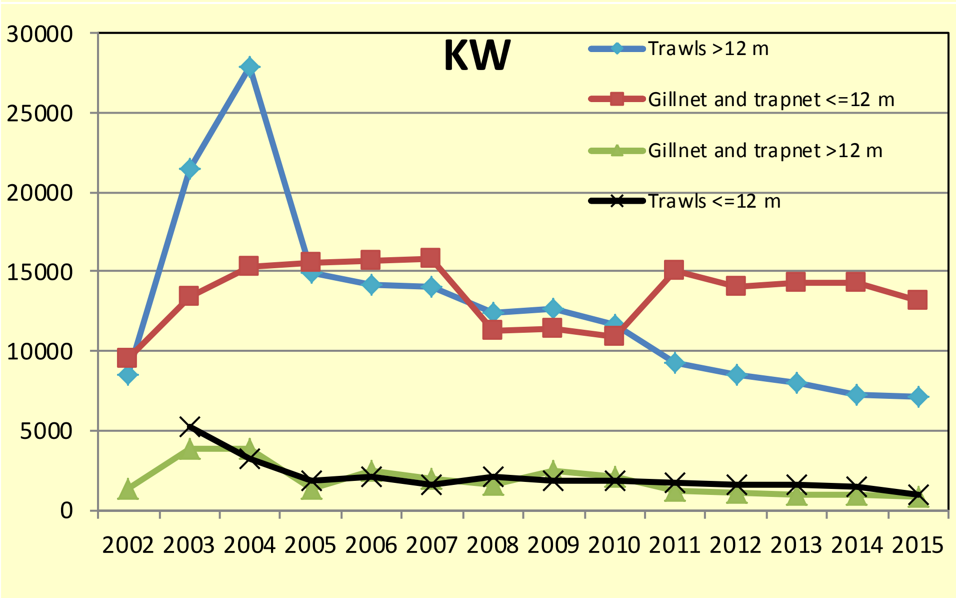
Trawls >12 m
Gillnet and trapnet <=12 m
Gillnet and trapnet >12 m
Trawls <=12 m


KW
30000
25000
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0
2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015
Trawls >12 m
Gillnet and trapnet <=12 m
Gillnet and trapnet >12 m
Trawls <=12 m

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 2015, are given below:

SD 22/Quarter I		Weight (kg)					Weight (%)			
	Sample No.	Herring	Sprat	Cod	Other	Total	Herring	Sprat	Cod	Other
January	1									
	2									
	3									
	Mean									
February	1									
	2									
	3									
	Mean									
March	1	10.8	5.8	0.2	6.2	22.9	46.9	25.3	0.7	27.1
	2									
	3									
	Mean	10.8	5.8	0.2	6.2	22.9	46.9	25.3	0.7	27.1
Q I	Mean	10.8	5.8	0.2	6.2	22.9	46.9	25.3	0.7	27.1

The results from the species composition of German trawl catches, which were sampled in **Subdivision 24** of quarter 1, 2 and 4 in 2015, are given below:

SD 24/Quarter I		Weight (kg)					Weight (%)			
	Sample No.	Herring	Sprat	Cod	Other	Total	Herring	Sprat	Cod	Other
January	1	65.4	0.1	0.0	0.0	65.5	99.9	0.1	0.0	0.0
	2									
	3									
	Mean	65.4	0.1	0.0	0.0	65.5	99.9	0.1	0.0	0.0
February	1	42.7	0.0	0.0	0.0	42.7	100.0	0.0	0.0	0.0
	2	63.3	0.3	0.0	0.0	63.6	99.5	0.5	0.0	0.0
	3									
	Mean	53.0	0.2	0.0	0.0	53.1	99.8	0.2	0.0	0.0
March	1	41.8	0.0	0.0	0.0	41.8	100.0	0.0	0.0	0.0
	2	59.3	0.0	0.0	0.0	59.3	100.0	0.0	0.0	0.0
	3									
	Mean	50.5	0.0	0.0	0.0	50.5	100.0	0.0	0.0	0.0
Q I	Mean	56.3	0.1	0.0	0.0	56.4	99.9	0.1	0.0	0.0

SD 24/Quarter II		Weight (kg)					Weight (%)			
	Sample No.	Herring	Sprat	Cod	Other	Total	Herring	Sprat	Cod	Other
April	1	58.5	0.6	0.0	0.0	59.0	99.0	1.0	0.0	0.0
	2	52.0	1.0	0.0	0.0	53.1	98.1	1.9	0.0	0.0
	3									
	Mean	55.2	0.8	0.0	0.0	56.1	98.5	1.5	0.0	0.0
May	1									
	2									
	Mean									
June	1									
	2									
	Mean									
Q II	Mean	55.2	0.8	0.0	0.0	56.1	98.5	1.5	0.0	0.0

SD 24/Quarter IV		Weight (kg)					Weight (%)			
	Sample No.	Herring	Sprat	Cod	Other	Total	Herring	Sprat	Cod	Other
Octob.	1									
	2									
	Mean									
Novemb.	1	63	0	0	0	63	100.0	0.0	0.0	0.0
	2	67	0	0	0	67	100.0	0.0	0.0	0.0
	3									
	Mean	65	0	0	0	65	100.0	0.0	0.0	0.0
Decemb.	1	60.580	0.419	0.000	0.000	60.999	99.3	0.7	0.0	0.0
	2									
	3									
	Mean	60.580	0.419	0.000	0.000	60.999	99.3	0.7	0.0	0.0
Q IV	Mean	62.984	0.210	0.000	0.000	63.193	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	1	**264**	46.9	124	-140
24	I	**5,776**	99.9	5,770	-6
	II	**839**	98.5	827	-13
	IV	**1,903**	99.7	1,897	-6

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 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 8,922 t – 164 t -> 1 % difference).

1.4 Logbook registered discards/BMS landings

No logbook registered discards or BMS landings (both new catch categories in 2015) of herring have been reported in the German herring fisheries in 2015 (no discards have been reported before 2015).

1.5 Central Baltic herring

In the western Baltic, the distribution areas of two stocks, the Western Baltic Spring Spawning herring (WBSSH) and the Central Baltic herring (CBH) overlap. German autumn acoustic survey (GERAS) results indicated in the recent years 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 (ICES, 2013). Accordingly, a stock separation function (SF) based on growth parameters in 2005 to 2010 has been developed to quantify the proportion of CBH and WBSSH in the area (Gröhsler et al., 2013, Gröhsler et al., 2016). The estimates of the growth parameters based on baseline samples of WBSSH and CBH support the applicability of SF in 2011-2015 (Oeberst et al., 2013, WD Oeberst et al., 2014, WD Oeberst et al., 2015; WD Oeberst et al., 2016). SF (slightly modified by commercial samples) was employed in the years 2005-2011 to identify the fraction of Central Baltic Herring in German commercial herring landings from SD 22 and 24 (WD Gröhsler et al., 2013). Results showed a rather low share of CBH in landings from all métiers but indicated that the actual degree of mixing might be underrepresented in commercial landings as German commercial fisheries target pre-spawning and spawning aggregations of WBSSH. The application of the present SF to commercial catch data in 2015, lead to similar results compared to 2005-2014. German gillnet catches in SD 22 and 24, mostly sampled at the spawning ground, consist of 100 % WBSSH. The amount of CBH in trapnet and trawl landings reached 5 % in numbers and 3 % or 2 % in biomass, respectively. As in the years before it was decided not to exclude CBH when compiling the assessment input data.

1.6 References

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2 Stock assessment data in 2015

2.1 Landings (tons) and sampling effort

Gear	Quarter	SKAGERRAK (DIVISION IIIaN/SD 20)				KATTEGAT (DIVISION IIIaS/SD21)			
		Landings (tons)	No. samples	No. measured	No. aged	Landings (tons)	No. samples	No. measured	No. aged
TRAWL	Q 1	no landings	-	-	-	no landings	-	-	-
	Q 2	no landings	-	-	-	no landings	-	-	-
	Q 3	no landings	-	-	-	no landings	-	-	-
	Q 4	127.608	0	0	0	no landings	-	-	-
	Total	127.608	0	0	0	0.000	0	0	0
GILLNET	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
TRAPNET	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
TOTAL	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	**0.000**	**0**	**0**	**0**	**0.000**	**0**	**0**	**0**
	Q 4	**127.608**	**0**	**0**	**0**	**0.000**	**0**	**0**	**0**
	Total	**127.608**	**0**	**0**	**0**	**0.000**	**0**	**0**	**0**

Gear	Quarter	SUBDIVISION 22				SUBDIVISION 24			
		Landings (tons)	No. samples	No. measured	No. aged	Landings (tons)	No. samples	No. measured	No. aged
TRAWL	Q 1	264.295	1	304	124	5,776.049	5	2,170	682
	Q 2	15.114	0	0	0	839.154	2	1,243	293
	Q 3	0.080	0	0	0	0.000	-	-	-
	Q 4	124.950	0	0	0	1,902.769	3	1,793	374
	Total	404.439	1	304	124	8,517.972	10	5,206	1,349
GILLNET	Q 1	25.180	1	309	53	3,486.516	12	4,085	674
	Q 2	24.453	0	0	0	602.957	4	1,385	216
	Q 3	0.643	0	0	0	0.338	0	0	0
	Q 4	20.272	0	0	0	22.770	0	0	0
	Total	70.548	1	309	53	4,112.581	16	5,470	890
TRAPNET	Q 1	0.035	1	358	86	129.162	1	459	110
	Q 2	0.315	0	0	0	51.727	1	632	106
	Q 3	0.365	0	0	0	0.000	-	-	-
	Q 4	1.667	1	590	94	0.262	0	0	0
	Total	2.382	2	948	180	181.151	2	1,091	216
TOTAL	Q 1	**289.510**	**3**	**971**	**263**	**9,391.727**	**18**	**6,714**	**1,466**
	Q 2	**39.882**	**0**	**0**	**0**	**1,493.838**	**7**	**3,260**	**615**
	Q 3	**1.088**	**0**	**0**	**0**	**0.338**	**0**	**0**	**0**
	Q 4	**146.889**	**1**	**590**	**94**	**1,925.801**	**3**	**1,793**	**374**
	Total	**477.369**	**4**	**1,561**	**357**	**12,811.704**	**28**	**11,767**	**2,455**

Gear	Quarter	TOTAL (DIV. IIIa & SUBDIV. 22+24)			
		Landings (tons)	No. samples	No. measured	No. aged
TRAWL	Q 1	6,040.344	6	2,474	806
	Q 2	854.268	2	1,243	293
	Q 3	0.080	0	0	0
	Q 4	2,155.327	3	1,793	374
	Total	9,050.019	11	5,510	1,473
GILLNET	Q 1	3,511.696	13	4,394	727
	Q 2	627.410	4	1,385	216
	Q 3	0.981	0	0	0
	Q 4	43.042	0	0	0
	Total	4,183.129	17	5,779	943
TRAPNET	Q 1	129.197	2	817	196
	Q 2	52.042	1	632	106
	Q 3	0.365	0	0	0
	Q 4	1.929	1	590	94
	Total	183.533	4	2,039	396
TOTAL	Q 1	9,681.237	21	7,685	1,729
	Q 2	1,533.720	7	3,260	615
	Q 3	1.426	0	0	0
	Q 4	2,200.298	4	2,383	468
	Total	13,416.681	32	13,328	2,812

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								0.003				0.050				0.053
	1					2.655	0.004	0.0000	0.015	1.378	0.243		0.228	4.033	0.247	0.0000	0.243
	2					3.687	0.035	0.0002	0.497	2.454	1.953		7.574	6.141	1.988	0.0002	8.072
	3					0.506	0.036	0.0002	0.286	6.776	1.984		4.349	7.282	2.020	0.0002	4.634
	4					0.152	0.061	0.0003	0.232	18.093	3.414		3.540	18.246	3.475	0.0003	3.772
	5					0.295	0.020	0.0001	0.086	8.984	1.094		1.314	9.279	1.113	0.0001	1.400
	6					0.049	0.007	0.0000	0.025	4.092	0.399		0.381	4.141	0.406	0.0000	0.406
	7					0.103	0.003	0.0000	0.016	1.800	0.144		0.238	1.904	0.147	0.0000	0.253
	8+					0.025	0.004	0.0000	0.010	2.425	0.209		0.149	2.450	0.213	0.0000	0.159
	Sum					7.473	0.170	0.0009	1.170	46.004	9.440		17.823	53.477	9.610	0.0009	18.993
	W-rings	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
GILLNET	0																
	1																
	2																
	3						0.0001	0.0000	0.000	0.037	0.002	0.0000	0.000	0.037	0.002	0.000	0.000
	4					0.000	0.012	0.0003	0.010	3.131	0.291	0.0002	0.011	3.132	0.302	0.000	0.021
	5					0.031	0.031	0.0008	0.025	6.992	0.758	0.0004	0.029	7.023	0.789	0.001	0.054
	6					0.044	0.035	0.0009	0.029	5.489	0.871	0.0005	0.033	5.533	0.907	0.001	0.062
	7					0.017	0.024	0.0006	0.020	1.370	0.583	0.0003	0.022	1.387	0.607	0.001	0.042
	8+					0.033	0.031	0.0008	0.026	1.528	0.775	0.0004	0.029	1.561	0.806	0.001	0.055
	Sum					0.126	0.133	0.0035	0.110	18.548	3.280	0.0018	0.124	18.673	3.413	0.005	0.234
	W-rings	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
TRAPNET	0																
	1								0.0001				0.0000				0.0001
	2						0.0008	0.0009	0.0039	0.012	0.124		0.0006	0.012	0.125	0.001	0.0046
	3					0.0000	0.0019	0.0022	0.0111	0.143	0.311		0.0017	0.143	0.313	0.002	0.0128
	4					0.0001	0.0012	0.0014	0.0028	0.537	0.198		0.0004	0.537	0.199	0.001	0.0032
	5					0.0000	0.0003	0.0003	0.0001	0.264	0.049		0.0000	0.264	0.049	0.000	0.0002
	6					0.0001	0.0000	0.0000	0.0001	0.065	0.004		0.0000	0.065	0.004	0.000	0.0002
	7					0.0000	0.0000	0.0000	0.0000	0.015	0.002		0.0000	0.015	0.002	0.000	0.0000
	8+					0.0000	0.0000	0.0000		0.025	0.007			0.025	0.007	0.000	
	Sum					0.0003	0.0042	0.0049	0.0182	1.061	0.696		0.0029	1.061	0.700	0.005	0.0211
	W-rings	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
TOTAL	0								0.003				0.050				0.053
	1					2.655	0.004	0.000	0.015	1.378	0.243		0.228	4.033	0.247	0.000	0.244
	2					3.6875	0.036	0.001	0.501	2.466	2.078		7.575	6.153	2.114	0.001	8.076
	3					0.506	0.038	0.002	0.297	6.956	2.298	0.000	4.351	7.462	2.336	0.002	4.647
	4					0.153	0.074	0.002	0.245	21.761	3.903	0.000	3.551	21.914	3.977	0.002	3.796
	5					0.326	0.051	0.001	0.112	16.241	1.901	0.000	1.342	16.567	1.951	0.002	1.454
	6					0.094	0.043	0.001	0.054	9.645	1.274	0.000	0.414	9.739	1.317	0.001	0.468
	7					0.120	0.026	0.001	0.035	3.186	0.729	0.000	0.260	3.306	0.755	0.001	0.295
	8+					0.058	0.035	0.001	0.036	3.979	0.991	0.000	0.179	4.037	1.026	0.001	0.215
	Sum					7.599	0.307	0.009	1.299	65.612	13.416	0.002	17.950	73.211	13.723	0.011	19.249

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	Gillnet	3	24	Gillnet	2
Gillnet	2	24	Gillnet	2	Gillnet	4	24	Gillnet	2
Trapn	2	24	Trapn	2	Trapn	4	22	Trapn	4
Trawl	3	24	Trawl	2					
Gillnet	3	24	Gillnet	2					
Trapn	3	24	Trapn	2					
Trawl	4	24	Trawl	4					
Gillnet	4	24	Gillnet	2					

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								14.2				14.2				14.2
	1					20.0	16.9	16.9	40.7	15.6	16.9		40.7	18.5	16.9	16.9	40.7
	2					32.8	50.5	50.5	84.2	45.0	50.5		84.2	37.7	50.5	50.5	84.2
	3					57.4	76.8	76.8	107.5	88.2	76.8		107.5	86.1	76.8	76.8	107.5
	4					76.2	94.7	94.7	129.1	114.1	94.7		129.1	113.7	94.7	94.7	129.1
	5					96.6	125.1	125.1	152.2	158.9	125.1		152.2	156.9	125.1	125.1	152.2
	6					119.9	155.4	155.4	173.0	179.4	155.4		173.0	178.7	155.4	155.4	173.0
	7					104.0	172.7	172.7	142.0	181.5	172.7		142.0	177.3	172.7	172.7	142.0
	8+					176.0	177.0	177.0	204.4	203.7	177.0		204.4	203.4	177.0	177.0	204.4
	Sum					35.4	88.9	88.9	106.8	125.6	88.9		106.8	113.0	88.9	88.9	106.8
	W-rings	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
GILLNET	0																
	1																
	2																
	3						136.7	136.7	136.7	139.6	136.7	136.7	136.7	139.6	136.7	136.7	136.7
	4					156.0	167.9	167.9	167.9	169.5	167.9	167.9	167.9	169.5	167.9	167.9	167.9
	5					189.4	179.9	179.9	179.9	184.9	179.9	179.9	179.9	184.9	179.9	179.9	179.9
	6					202.1	182.0	182.0	182.0	194.7	182.0	182.0	182.0	194.8	182.0	182.0	182.0
	7					196.3	187.2	187.2	187.2	196.5	187.2	187.2	187.2	196.5	187.2	187.2	187.2
	8+					209.5	193.3	193.3	193.3	209.2	193.3	193.3	193.3	209.3	193.3	193.3	193.3
	Sum					200.0	183.8	183.8	183.8	188.0	183.8	183.8	183.8	188.1	183.8	183.8	183.8
	W-rings	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
TRAPNET	0																
	1								37.5				37.5				37.5
	2						51.8	51.8	71.2	47.2	51.8		71.2	47.2	51.8	51.8	71.2
	3					84.6	73.8	73.8	91.9	82.0	73.8		91.9	82.0	73.8	73.8	91.9
	4					98.5	81.8	81.8	113.7	113.0	81.8		113.7	112.9	81.8	81.8	113.7
	5					114.4	81.2	81.2	134.1	140.6	81.2		134.1	140.6	81.2	81.2	134.1
	6					138.1	156.3	156.3	176.5	169.5	156.3		176.5	169.5	156.3	156.3	176.5
	7					151.1	158.1	158.1	162.5	188.0	158.1		162.5	188.0	158.1	158.1	162.5
	8+					160.0	168.6	168.6		207.9	168.6			207.9	168.6	168.6	
	Sum					116.7	74.3	74.3	91.5	121.8	74.3		91.5	121.8	74.3	74.3	91.5
	W-rings	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
TOTAL	0								14.2				14.2				14.2
	1					20.0	16.9	16.9	40.7	15.6	16.9		40.7	18.5	16.9	16.9	40.7
	2					32.8	50.6	51.6	84.1	45.0	50.6		84.2	37.7	50.6	51.6	84.2
	3					57.4	76.8	74.1	106.9	88.4	76.4	136.7	107.5	86.3	76.4	74.2	107.5
	4					76.5	106.1	97.0	130.5	122.0	99.5	167.9	129.2	121.7	99.6	102.3	129.3
	5					105.5	158.0	148.2	158.5	169.8	145.8	179.9	152.8	168.5	146.1	156.2	153.3
	6					158.9	177.5	180.3	177.8	188.1	173.6	182.0	173.7	187.8	173.7	180.8	174.2
	7					116.8	185.7	186.4	167.1	188.0	184.2	187.2	145.8	185.4	184.3	186.6	148.4
	8+					195.3	191.5	191.6	196.3	205.9	189.7	193.3	202.6	205.7	189.7	192.1	201.6
	Sum					38.1	129.8	116.9	113.1	143.1	111.3	183.8	107.3	132.2	111.8	127.9	107.7

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	Gillnet	3	24	Gillnet	2
Gillnet	2	24	Gillnet	2	Gillnet	4	24	Gillnet	2
Trapn	2	24	Trapn	2	Trapn	4	22	Trapn	4
Trawl	3	24	Trawl	2					
Gillnet	3	24	Gillnet	2					
Trapn	3	24	Trapn	2					
Trawl	4	24	Trawl	4					
Gillnet	4	24	Gillnet	2					

The overall mean weights in Quarter 4 of age 6 of 174.2 g drop to 148.4 g at age 7. This unexpected drop is caused by some contribution of CBH (see Section 1.5) at age 7 in quarter 4 trawl samples of SD 24 or trapnet samples of SD 22. The contribution of age 7 of quarter 4 to the overall abundance estimate of herring is less then 1 % (see Section 2.2).

2.4 Mean length (cm) in the catch

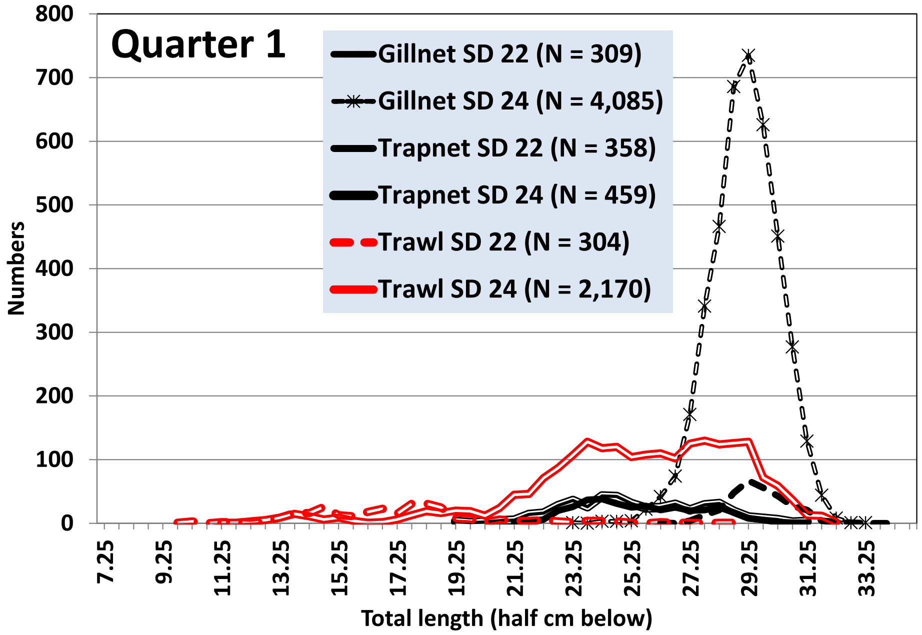
		SUBDIVISION 20				SUBDIVISION 22				SUBDIVISION 24				SUBDIVISIONS 22+24			
	W-rings	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
TRAWL	0								13.3				13.3				13.3
	1					14.9	14.4	14.4	18.8	14.0	14.4		18.8	14.6	14.4	14.4	18.8
	2					17.5	19.9	19.9	22.8	19.2	19.9		22.8	18.2	19.9	19.9	22.8
	3					20.8	22.8	22.8	24.3	23.4	22.8		24.3	23.2	22.8	22.8	24.3
	4					22.5	24.2	24.2	25.8	25.1	24.2		25.8	25.0	24.2	24.2	25.8
	5					24.3	26.3	26.3	27.3	27.6	26.3		27.3	27.5	26.3	26.3	27.3
	6					25.8	28.0	28.0	28.4	28.7	28.0		28.4	28.7	28.0	28.0	28.4
	7					24.3	29.0	29.0	26.2	28.8	29.0		26.2	28.5	29.0	29.0	26.2
	8+					28.3	29.5	29.5	30.1	29.9	29.5		30.1	29.9	29.5	29.5	30.1
	Sum					17.4	23.4	23.4	24.2	25.4	23.4		24.2	24.3	23.4	23.4	24.2
	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	26.3	26.3	26.1	26.3	26.3	26.3	26.1	26.3	26.3	26.3
	4					27.3	28.0	28.0	28.0	28.0	28.0	28.0	28.0	28.0	28.0	28.0	28.0
	5					28.9	28.8	28.8	28.8	28.9	28.8	28.8	28.8	28.9	28.8	28.8	28.8
	6					29.7	28.9	28.9	28.9	29.5	28.9	28.9	28.9	29.5	28.9	28.9	28.9
	7					29.4	29.2	29.2	29.2	29.6	29.2	29.2	29.2	29.6	29.2	29.2	29.2
	8+					30.2	29.7	29.7	29.7	30.4	29.7	29.7	29.7	30.4	29.7	29.7	29.7
	Sum					29.6	29.0	29.0	29.0	29.1	29.0	29.0	29.0	29.1	29.0	29.0	29.0
	W-rings	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
TRAPNET	0																
	1								18.3				18.3				18.3
	2						20.1	20.1	22.1	19.6	20.1		22.1	19.6	20.1	20.1	22.1
	3					23.4	22.5	22.5	23.9	22.9	22.5		23.9	22.9	22.5	22.5	23.9
	4					24.5	23.1	23.1	25.5	25.0	23.1		25.5	25.0	23.1	23.1	25.5
	5					25.6	23.0	23.0	27.2	26.6	23.0		27.2	26.5	23.0	23.0	27.2
	6					27.1	28.1	28.1	29.3	28.2	28.1		29.3	28.2	28.1	28.1	29.3
	7					28.1	28.3	28.3	28.8	29.3	28.3		28.8	29.3	28.3	28.3	28.8
	8+					28.4	28.6	28.6		30.4	28.6			30.4	28.6	28.6	
	Sum					25.6	22.4	22.4	23.8	25.4	22.4		23.8	25.4	22.4	22.4	23.8
	W-rings	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
TOTAL	0								13.3				13.3				13.3
	1					14.9	14.4	14.4	18.8	14.0	14.4		18.8	14.6	14.4	14.4	18.8
	2					17.5	19.9	20.1	22.8	19.2	19.9		22.8	18.2	19.9	20.1	22.8
	3					20.8	22.8	22.5	24.3	23.4	22.7	26.3	24.3	23.2	22.7	22.5	24.3
	4					22.5	24.8	24.0	25.9	25.5	24.4	28.0	25.8	25.5	24.5	24.3	25.8
	5					24.7	27.8	27.0	27.6	28.2	27.2	28.8	27.3	28.1	27.2	27.4	27.3
	6					27.6	28.8	28.9	28.7	29.2	28.6	28.9	28.4	29.2	28.6	28.9	28.4
	7					25.0	29.2	29.2	27.9	29.2	29.2	29.2	26.5	29.0	29.2	29.2	26.6
	8+					29.4	29.7	29.6	29.8	30.1	29.6	29.7	30.0	30.1	29.6	29.6	30.0
	Sum					17.6	25.8	25.0	24.6	26.5	24.7	29.0	24.3	25.5	24.7	25.6	24.3

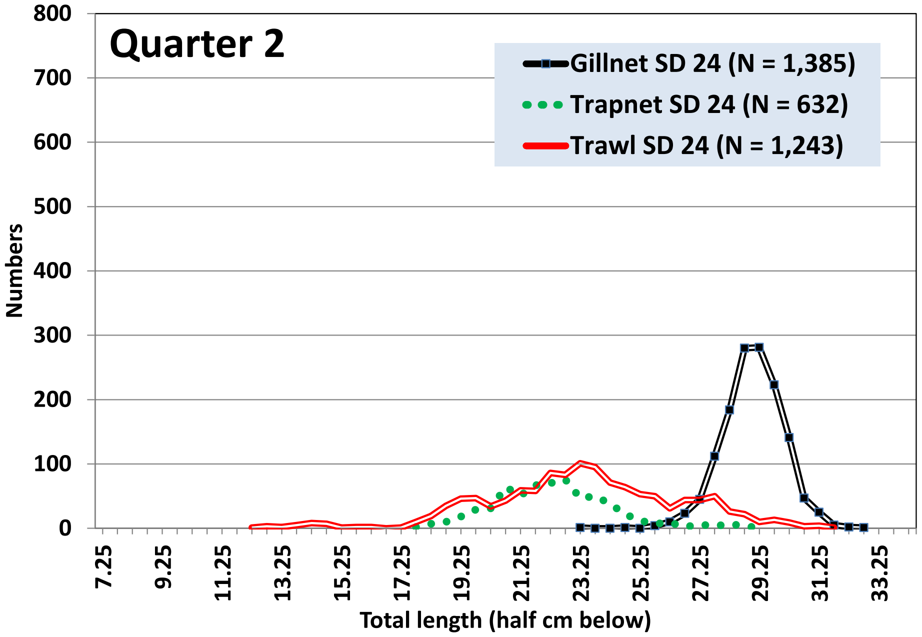
REPLACEMENT OF MISSING SAMPLES:

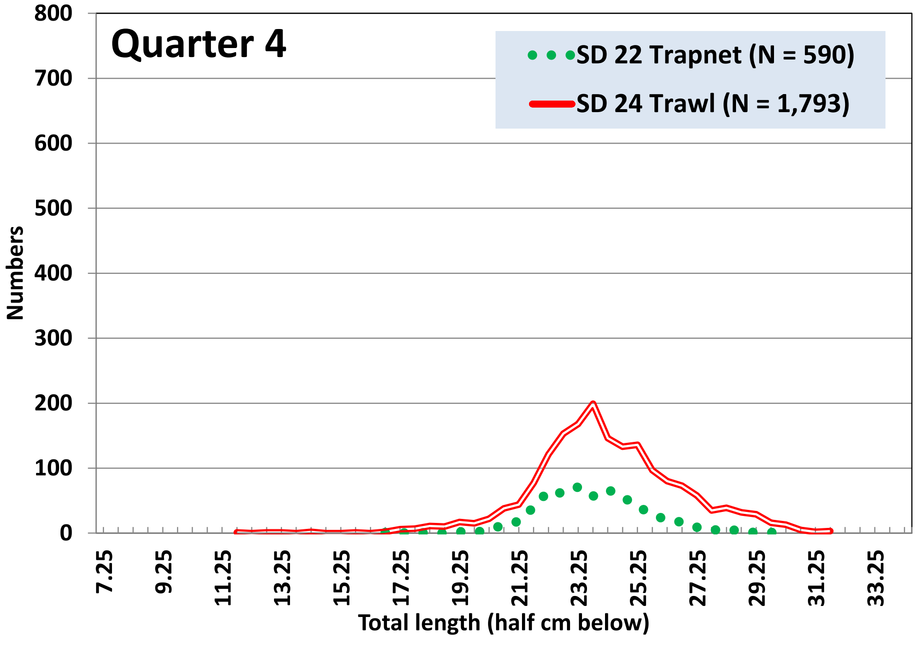
SUBDIVISION 22					SUBDIVISION 24				
Missing		Replacement by			Missing		Replacement by		
Gear	Quart.	Area	Gear	Quart.	Gear	Quart.	Area	Gear	Quart.
Trawl	2	24	Trawl	2	Gillnet	3	24	Gillnet	2
Gillnet	2	24	Gillnet	2	Gillnet	4	24	Gillnet	2
Trapn	2	24	Trapn	2	Trapn	4	22	Trapn	4
Trawl	3	24	Trawl	2					
Gillnet	3	24	Gillnet	2					
Trapn	3	24	Trapn	2					
Trawl	4	24	Trawl	4					
Gillnet	4	24	Gillnet	2					

The overall mean length in Quarter 4 of age 6 of 28.4 cm drops to 26.6 cm at age 7. This unexpected drop is caused by some contribution of CBH (see Section 1.5) at age 7 in quarter 4 trawl samples of SD 24 or trapnet samples of SD 22.

2.5 Sampled length distributions by Subdivision, quarter and type of gear







Investigating change in fishing selectivity of the pelagic fleet targeting herring

Introduction

Since 2015 there is a landing obligation for pelagic fisheries. It is yet unknown how the landing obligation has affected fisheries behaviour. Especially when a change has occurred that affects the selectivity of the fishing fleet, this must be communicated within assessment working groups as quickly as possible. Assessment models have the tendency to pick up changes in selection with marked delays. However, advice relies heavily upon estimates of most recent selectivity by the fishing fleet. It is therefore of upmost importance to detect changes in selectivity as soon as possible, outside of the regular assessment models.

At IMARES, a simple and easy to calculate set of spatial indicators was defined that would inform about a potential change in selectivity in pelagic fisheries. In total, a set of spatial indicator types were calculated for the acoustic survey on herring and for the Dutch fishing fleet during the same season. 1) centre of gravity, 2) dispersion (inertia), 3) isotropy (elongation), 4) collocation, 5) spreading area. Combining the two datasets allowed to calculate overlap (global index of collocation). To take irregular sampling into account, especially with respect to the trawler data, areas of influence around samples were computed and used as weighting factors. Five years of data were used to test whether the first 4 years differed from the last year (where the landing obligation was in place). Length-frequency distributions from market samples were added and compared over time, in relation to the 4 indicators from above.

Material and Methods

- Market sampling of all herring catches from pelagic freezer trawlers (2009-2015)
  - Length-frequency data from these samples
- Acoustic herring detections from HERAS (2011-2015)
- spatially resolved herring catch densities based on VMS data from pelagic freezer trawlers (2011-2015)
  - data from months June & July from these to align with the HERAS

Indicators of market sampling:
- Proportion of fish < 20cm
- Proportion of fish > 29cm
- Percentage of fishery catch per month

Area of influence:
The spatial area of influence of a sample location was defined as the area made up of the points in space that are closer to this sample than to others. It can be evaluated by overlying a very fine regular grid and counting grid points closer to the sample.

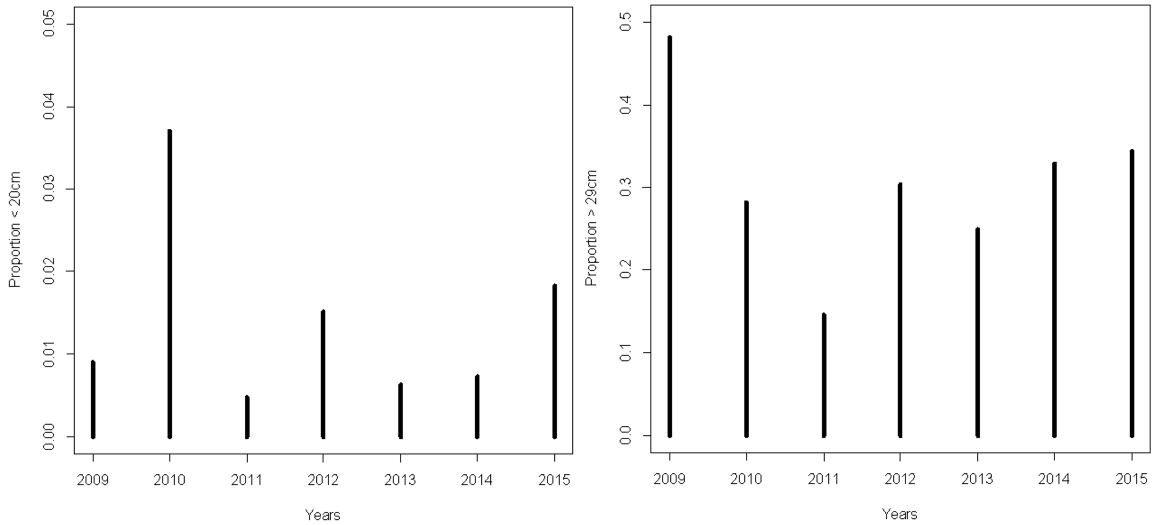
Spatial indicators:
1) centre of gravity
   The centre of gravity is the mean location of the observed population and therefore also the mean location of an individual fish density measure taken at random in the observed area.
2) dispersion (inertia)
   Inertia is the mean square distance between an individual fish density observation and the centre of gravity. It describes the dispersion (variance) of the population around its centre of gravity.
3) isotropy (elongation)
   In general, the dispersion of a population around its gravity centre is not necessarily identical in every direction of space (i.e. maximal isotropy). Therefore, in two dimensions, the total dispersion (inertia) of a population can be decomposed on its two principal axes. This “measure of elongation” can be represented conveniently on a map as a cross depicting the two principal directions.
4) collocation
   The global index of collocation looks at how geographically distinct two populations are by comparing the distance between their centres of gravity and the mean distance between individual density measurements taken at random and independently from each population. This

spatial index ranges between 0, in the extreme case where each population is concentrated on a single but different location (inertia = 0), and 1, where the two centre of gravities coincide and the inertias have any non-negative values.

5) Area occupation
Three types of area occupation indices were investigated: The positive area indicates the area of presence occupied by the population even when the density is low. The equivalent area is the area that would be covered by the population if all individuals had the same density, equal to the mean density per individual. The spreading area is a measure of how the population is distributed in space taking into account the variations in fish density.

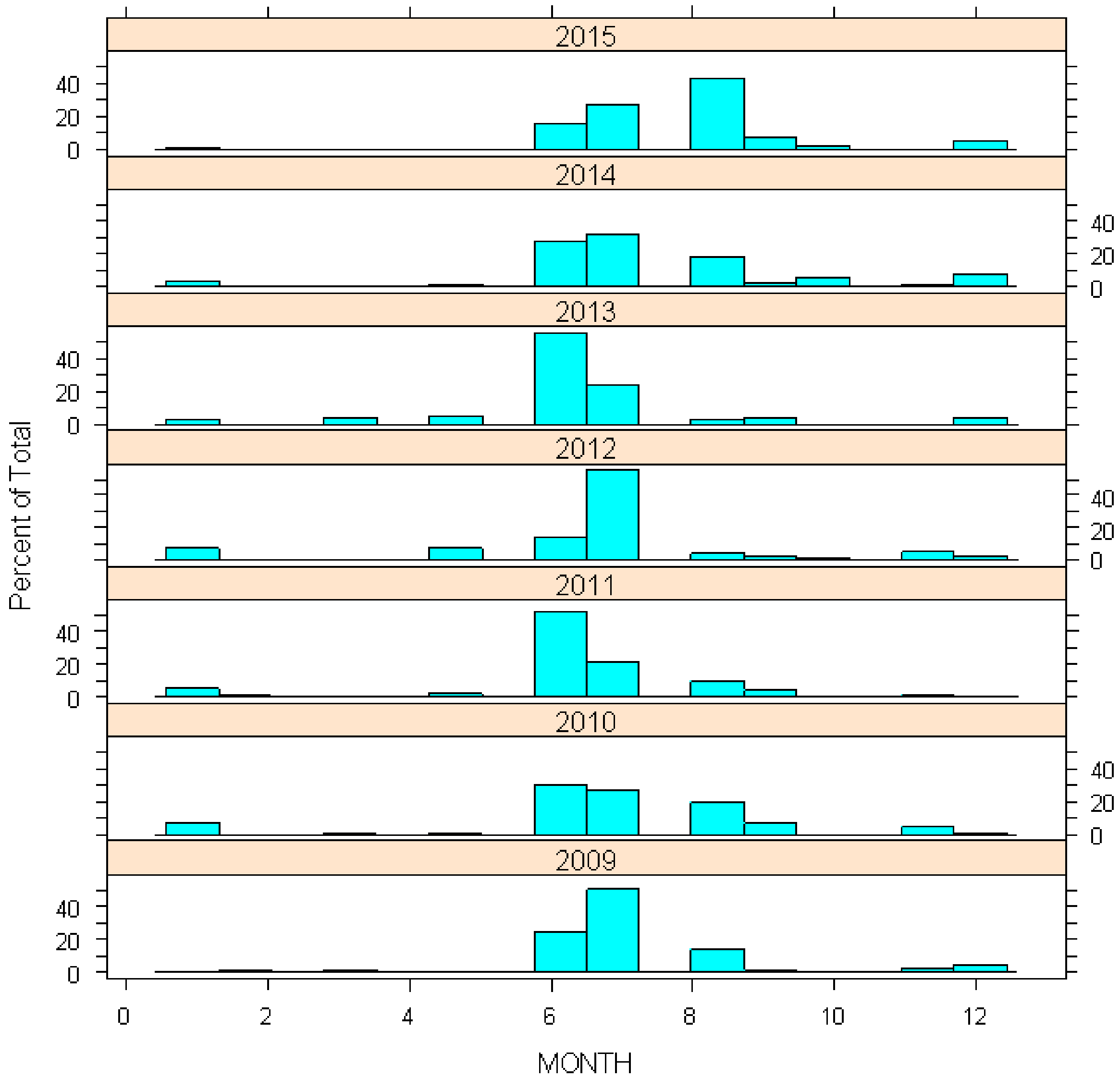
Results

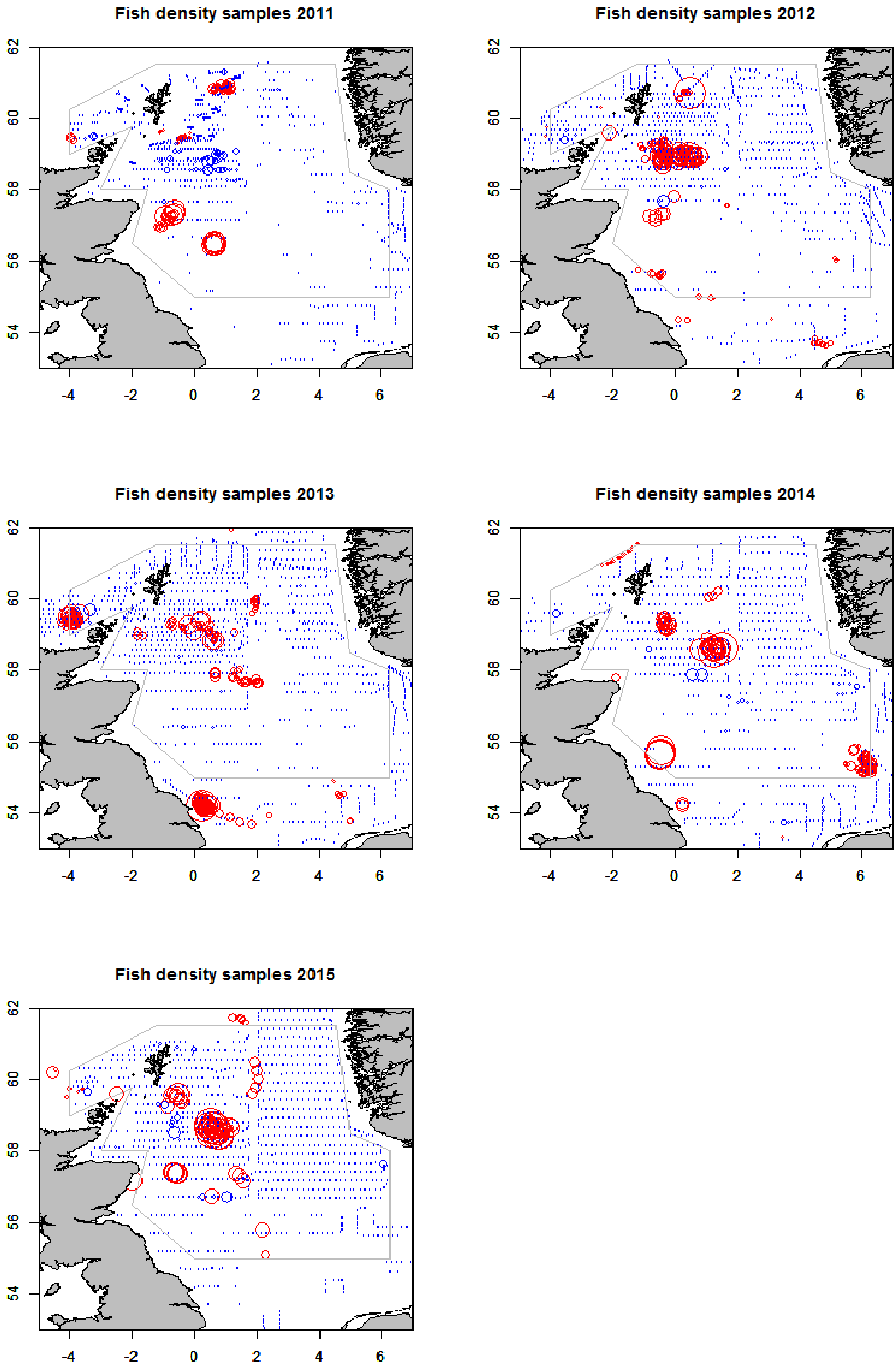
Results from the market samples, focussing on the proportion of fish <20cm or fish >29cm did not show any change in pattern compared to the period 2009-2014.



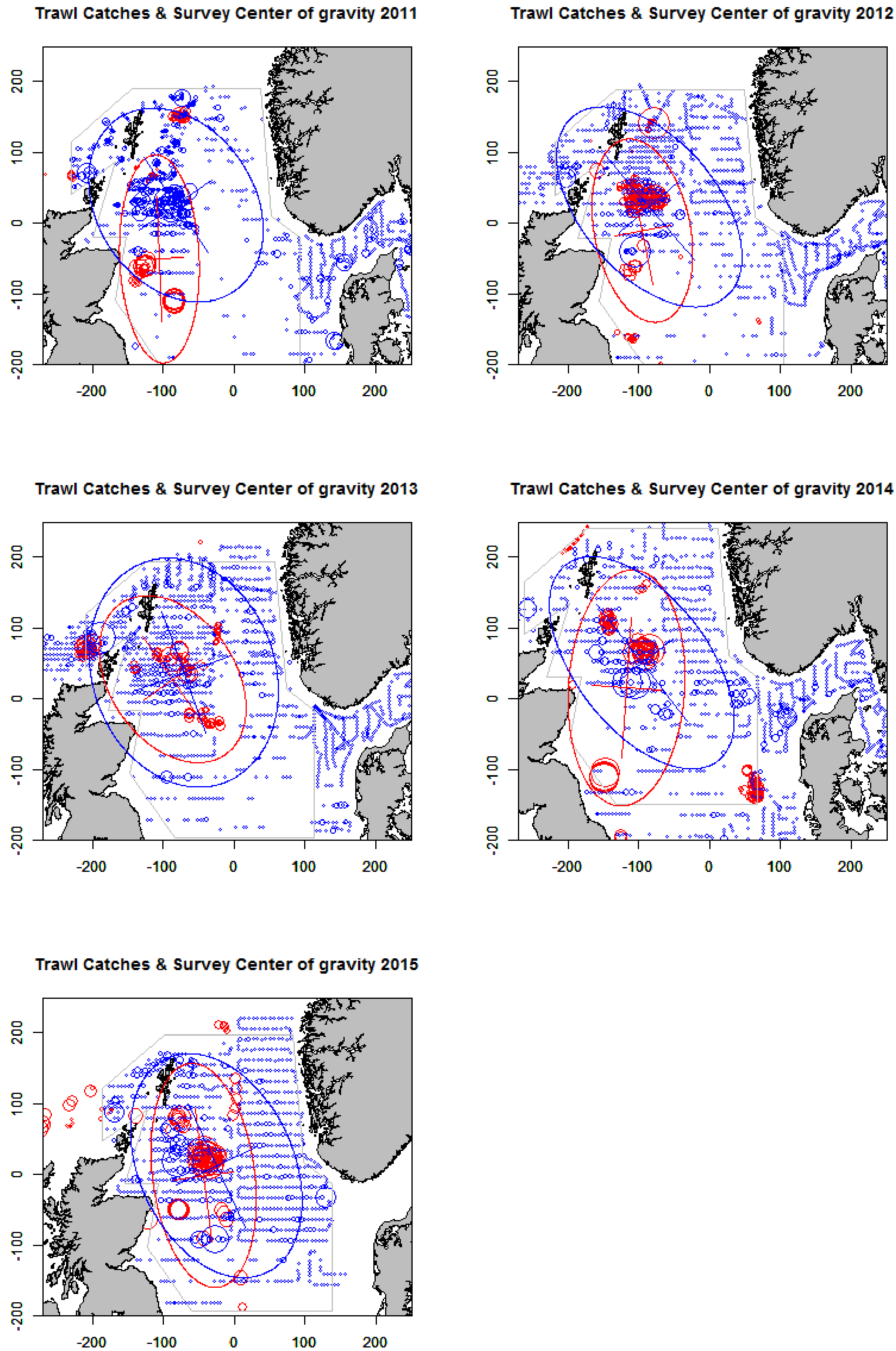
The proportion of the catch that was landed by month did show some larger parts coming from August but was not markedly different from 2014.

Results from the spatial indices analysis suggested that the location of trawl locations and quantities in 2015 was not different from those in the time before the introduction of the discard ban. To support this, the same result was observed in the results from the HERAS data. Collocation of both data sets was high and did not change over the whole time period (2011-2015). The only difference observed between 2015 and previous years was related to some of the measures of area occupation, which markedly increased for the trawler data in 2015.

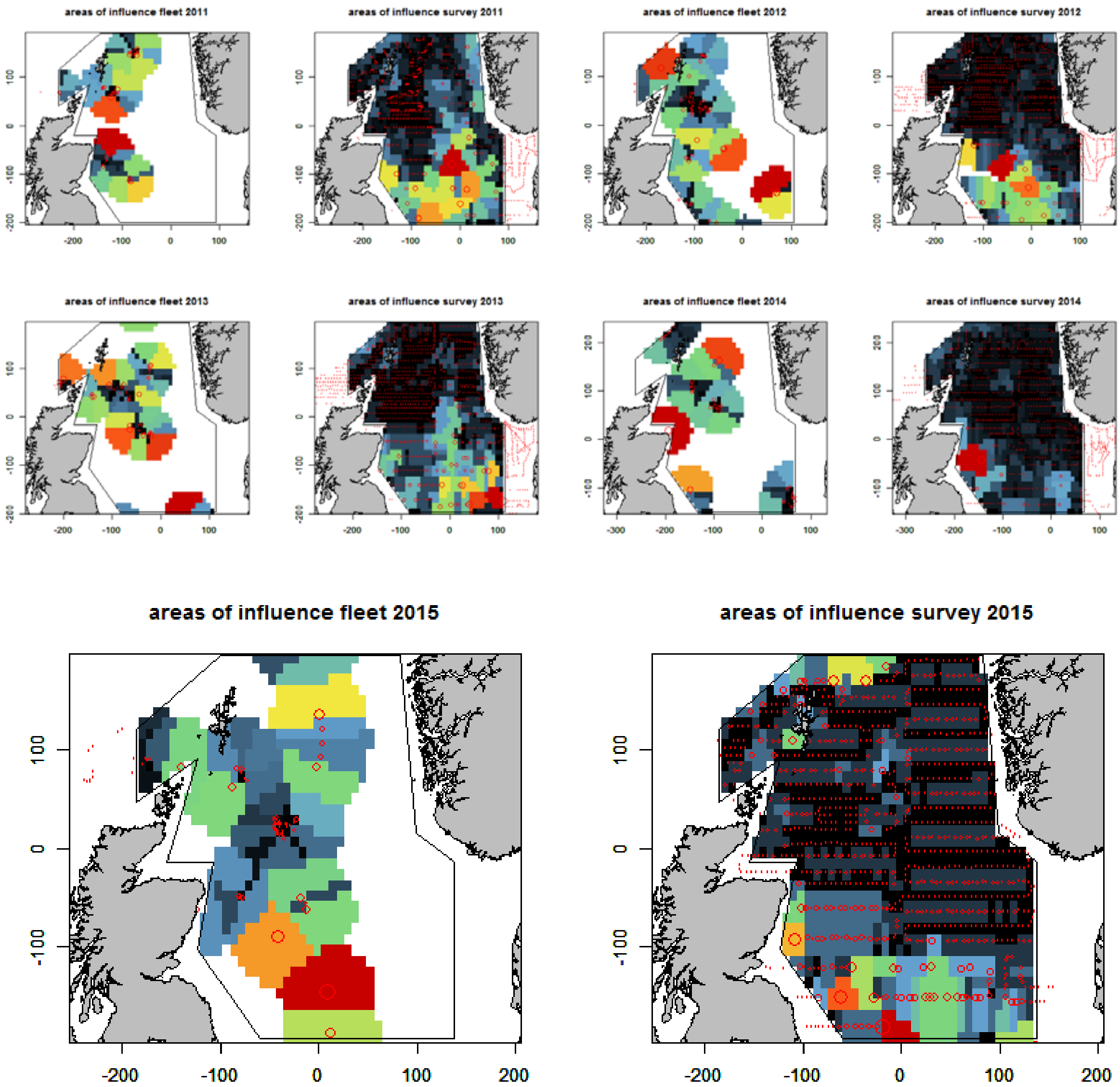

2015
2014
2013
2012
2011
2010
2009
Percent of Total
0
20
40
0
2
4
6
8
10
12
MONTH



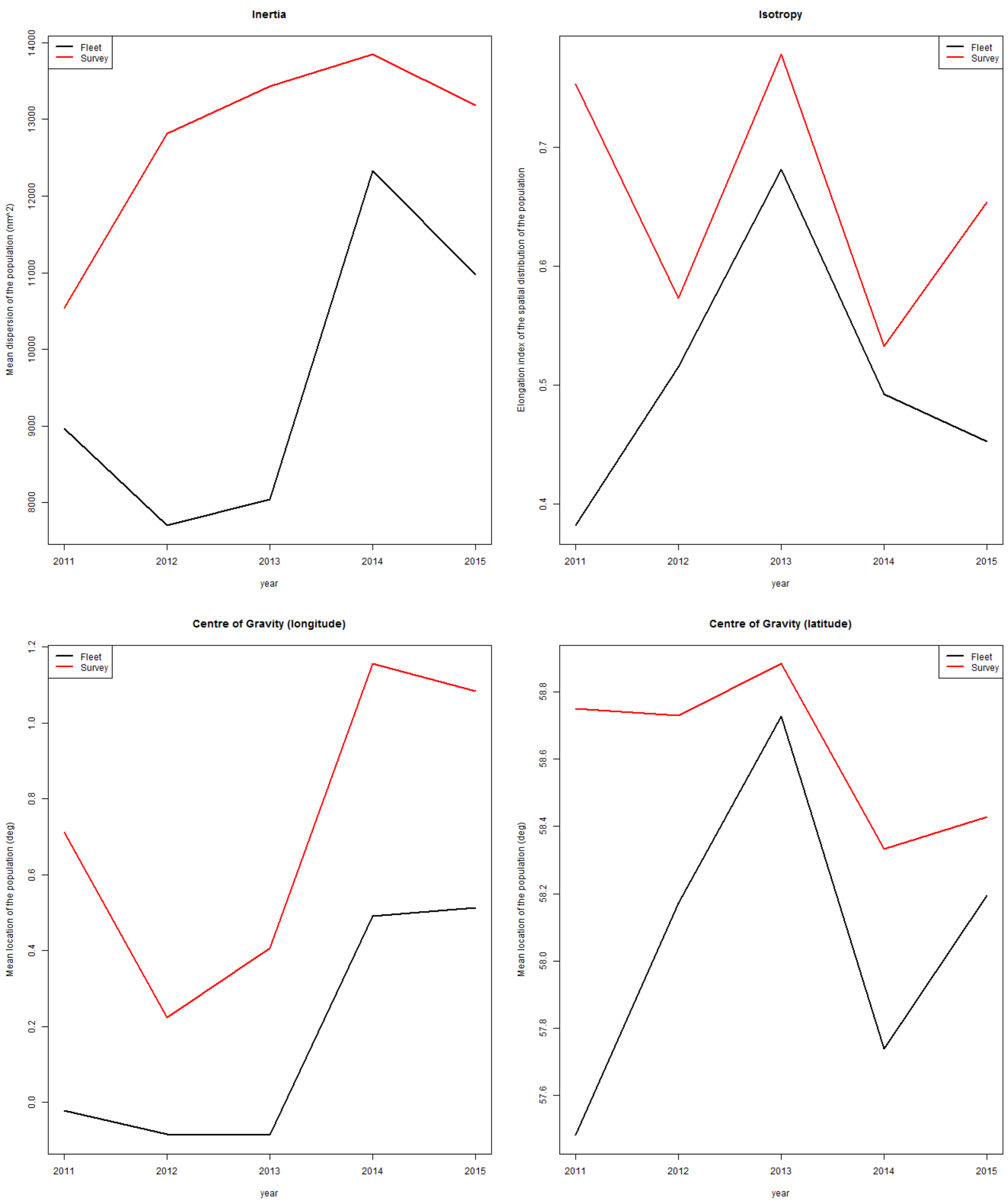
Distribution of herring density samples from the acoustic survey (blue; based on NASC) and pelagic trawlers (red; based on catch weight) from 2011-2015.



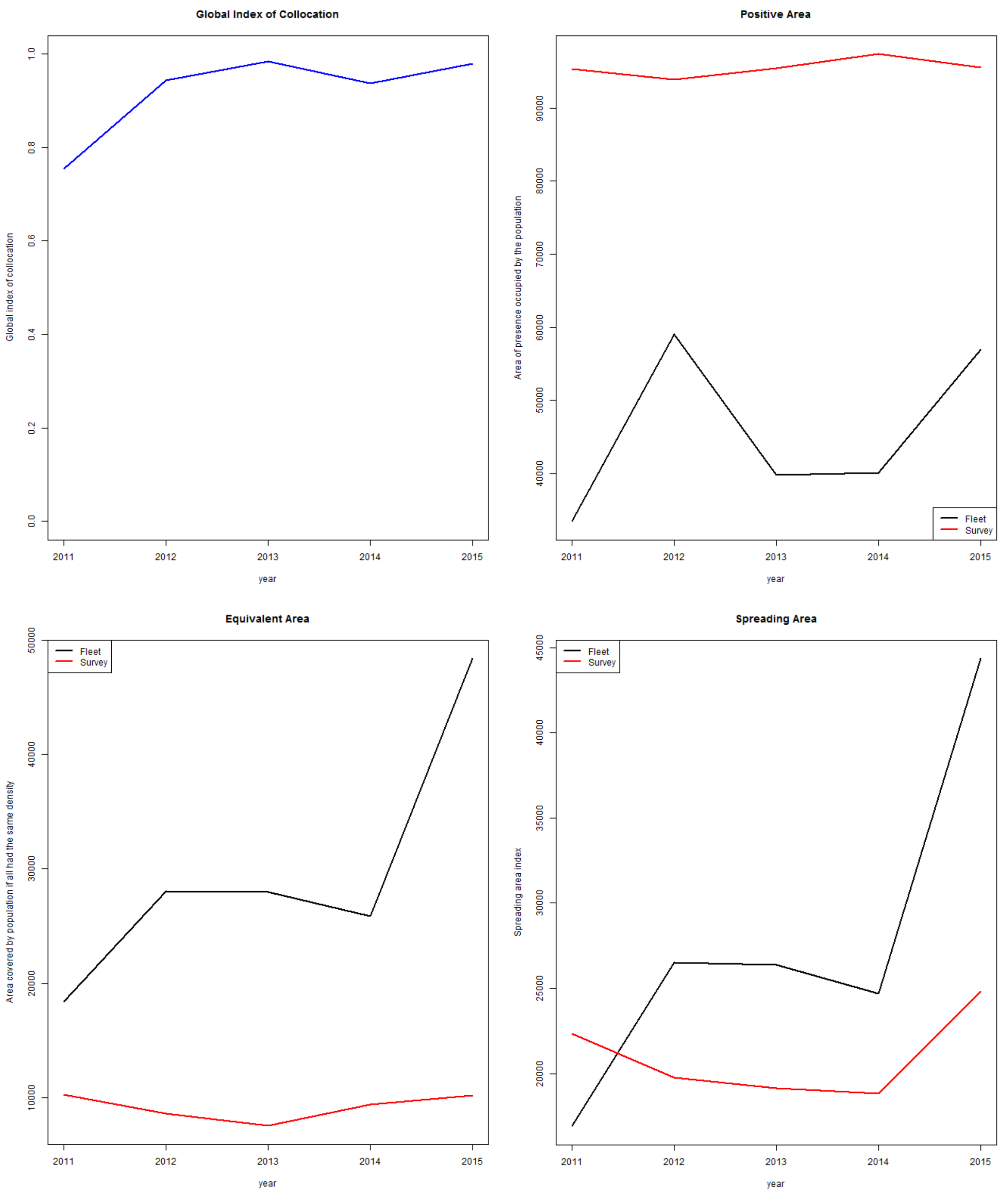
Centre of gravity, inertia and isotropy of herring density samples from the acoustic survey (blue; based on NASC) and pelagic trawlers (red; based on catch weight) from 2011-2015.



Areas of influence used for applying sampling weights to trawler and survey data from 2011-2015.



Spatial index values of herring density samples from the acoustic survey (red; based on NASC) and pelagic trawlers (black; based on catch weight) from 2011-2015.



Spatial index values of herring density samples from the acoustic survey (red; based on NASC) and pelagic trawlers (black; based on catch weight) from 2011-2015.

Discussion

The results currently available on the spatial distribution of the fishing fleet and the sampling of their catches does not indicate any change in fishing behaviour that could lead to a substantial change in selectivity which may not be picked up by assessment models.

Distribution of catch densities were similar to herring density distributions estimated by the acoustic survey throughout the years investigated (2011-2015), with no marked deviation in 2015. This means that trawlers targeted locations with a similar gravity centre as that of the wider herring population observed by the survey. The different patterns in isotropy values between the two data sets suggests a more narrower spread of trawling locations when compared to the whole herring population, suggesting focus on locations of highest density aggregations. Index of collocation between the two data sets was high over all years, suggesting similar sampling pattern of the fleet that is related to the gravity centre and spread of the population in a constant fashion.

A constantly higher positive area was observed for the survey area when compared to the constantly lower positive area for the trawler data. This simply confirms that more ground was covered with data points in the survey. While the equivalent area for the trawler data was higher (due to lower number of exclusively high density points), that value increased markedly in the last year (2015). This may suggest that the number and spread of catch density values were similar compared to previous years, but catches were proportionally higher. The same could be observed from the spreading area which also takes into account the variation in fish densities, suggesting that a similar variation was observed as in previous years. The Gini index (a measure of heterogeneity of the density distributions) also suggested that the trawler catch density data in 2015 was the most heterogeneous of all years analysed, represented by fewer but more high density values. These observations could be influenced by potential higher 2015 catches during the months analysed (June & July).

Observer trips executed on-board the freezer trawlers, 8 in 2015 that covered herring trips, did not observe any changes in fishing behaviour. Neither were discards observed in 2015 while in previous years a small proportion of the catch (~1-7 % in recent years) was discarded. Defining the exact BMS component of the catch is difficult BMS labelled fish at a vessel can be re-labelled when landing the fish.

1 Incoming request from HAWG

HAWG has recommended a comparison of the similarity of ecosystems across the HAWG stocks (Greater North Sea, Celtic Seas, Baltic Sea) in particular with respect to estimation of natural mortality (predator fields and dynamics). WGSAM decided to make a metanalysis of the level of M at age, the interannual variability and the degree to which different ages experience similar changes in natural mortality.

1.1 North Sea

Natural mortalities of North Sea herring from 1974 to 2013 are available from the 2015 SMS key run (chapter XX). Average M and standard deviation of M by age is given in table 1.1 and the correlation between annual values of different ages are given in table 1.2. The mean biomass of herring in the North Sea over the time period is 1.9 million ton, and the average total biomass of the main predators whiting, cod, saithe and hake is 1.2 million ton, and the average SSB is 0.5 million ton. This gives a ratio of herring to predator biomass of 1.6 when using total predator biomass and 3.7 when using spawning biomass only. There was a low but significant positive correlation between the average natural mortality of herring and both predator biomass and SSB (r^2=0.10 and 0.33, P=0.0414 and <0.0001, respectively).

Table 1.1. Average M, standard deviation of M, min and max M recorded for herring in the North Sea

Age	Average M	sd M	min M	max M
0*	0.79	0.08	0.64	0.94
1	0.65	0.09	0.48	0.87
2	0.36	0.05	0.27	0.48
3	0.33	0.04	0.24	0.39
4	0.30	0.04	0.23	0.36
5	0.28	0.04	0.22	0.35
6	0.27	0.04	0.21	0.35
7	0.25	0.04	0.19	0.33

* Age 0 M covers only 1/7 to 31/12.

Table 1.2. Correlation between natural mortality of different groups. Upper lines: correlation. Lower line: P(correlation=0)

AGE	1	2	3	4	5	6	7
0	0.56374	0.57676	0.55867	0.57905	0.58452	0.63028	0.62375
	0.0002	<.0001	0.0002	<.0001	<.0001	<.0001	<.0001
1		0.64966	0.46042	0.47129	0.41476	0.42473	0.32796
		<.0001	0.0028	0.0021	0.0078	0.0063	0.0388
2			0.87619	0.83452	0.78527	0.79292	0.71838
			<.0001	<.0001	<.0001	<.0001	<.0001
3				0.93645	0.90083	0.91255	0.84012
				<.0001	<.0001	<.0001	<.0001
4					0.96621	0.95217	0.87323
					<.0001	<.0001	<.0001
5						0.96802	0.92404
						<.0001	<.0001
6							0.94922
							<.0001

1.2 Baltic Sea

Natural mortalities of Baltic Sea herring from 1974 to 2011 are available from the 2012 SMS key run (WGSAM 2012). Average M and standard deviation of M by age is given in table 1.3 and the correlation between annual values of different ages are given in table 1.4. The mean biomass of herring in the Baltic Sea over the time period is 1.2 million ton, and the average total biomass of the main predator cod is 0.34 million ton, and the average SSB is 0.17 million ton. This gives a ratio of herring to predator biomass of 3.5 when using total predator biomass and 8.2 when using spawning biomass only. There was a low but significant positive correlation between the average natural mortality of herring and predator biomass but not when using SSB (r^2=0.11 and 0.02, P=0.0463 and 0.3611, respectively).

Table 1.3. Average M, standard deviation of M, min and max M recorded for herring in the Baltic Sea

AGE	AVERAGE M	SD M	MIN M	MAX M
0*	0.16	0.05	0.10	0.27
1	0.31	0.08	0.24	0.50
2	0.29	0.05	0.24	0.43
3	0.27	0.04	0.23	0.36
4	0.26	0.03	0.22	0.33
5	0.25	0.02	0.21	0.32

6	0.24	0.02	0.22	0.32
7	0.23	0.02	0.21	0.30

* Age 0 M covers only 1/7 to 31/12.

Table 1.4. Correlation between natural mortality of different groups. Upper lines: correlation. Lower line: P(correlation=0)

AGE	1	2	3	4	5	6	7
0	0.96512	0.81137	0.69393	0.44593	0.27756	0.06714	-0.22398
	<.0001	<.0001	<.0001	0.0050	0.0916	0.6888	0.1764
1		0.88227	0.78463	0.51868	0.39498	0.05111	-0.20895
		<.0001	<.0001	0.0008	0.0141	0.7606	0.2080
2			0.95261	0.70798	0.53082	0.19335	-0.06626
			<.0001	<.0001	0.0006	0.2448	0.6927
3				0.83547	0.68690	0.36261	0.12365
				<.0001	<.0001	0.0253	0.4595
4					0.76177	0.61485	0.47250
					<.0001	<.0001	0.0027
5						0.70101	0.63400
						<.0001	<.0001
6							0.81319
							<.0001

1.3 Georges Bank

Natural mortalities of Georges Bank herring from 1978 to 2007 are available from a multispecies statistical catch-at-age model (Curti, pers. comm). Average M and standard deviation of M by age is given in table 1.5 and the correlation between annual values of different ages are given in table 1.6. The mean biomass of herring over the time period is 0.069 million ton. Herring is consumed by a wide array of predators, but the average total biomass of the most dominant predator (cod) is 0.092 million ton. This gives a ratio of herring to predator biomass of 0.74.

Table 1.5. Average M, standard deviation of M, min and max M recorded for herring at Georges bank

AGE	AVERAGE M	SD M	MIN M	MAX M
1	0.52	0.20	0.27	0.91

2	0.49	0.24	0.23	1.01
3	0.35	0.18	0.18	0.83
4	0.27	0.14	0.15	0.65
5	0.22	0.11	0.14	0.58
6	0.18	0.09	0.11	0.45

Table 1.6. Correlation between natural mortality of different groups. Upper lines: correlation. Lower line: P(correlation=0)

Age	2	3	4	5	6
1	0.87756	0.78593	0.73756	0.71671	0.67765
	<.0001	<.0001	<.0001	<.0001	<.0001
2		0.94464	0.87334	0.82000	0.77209
		<.0001	<.0001	<.0001	<.0001
3			0.96772	0.91979	0.88025
			<.0001	<.0001	<.0001
4				0.97291	0.94025
				<.0001	<.0001
5					0.98034
					<.0001

1.4 Size spectra model results for the Celtic Sea and North Sea

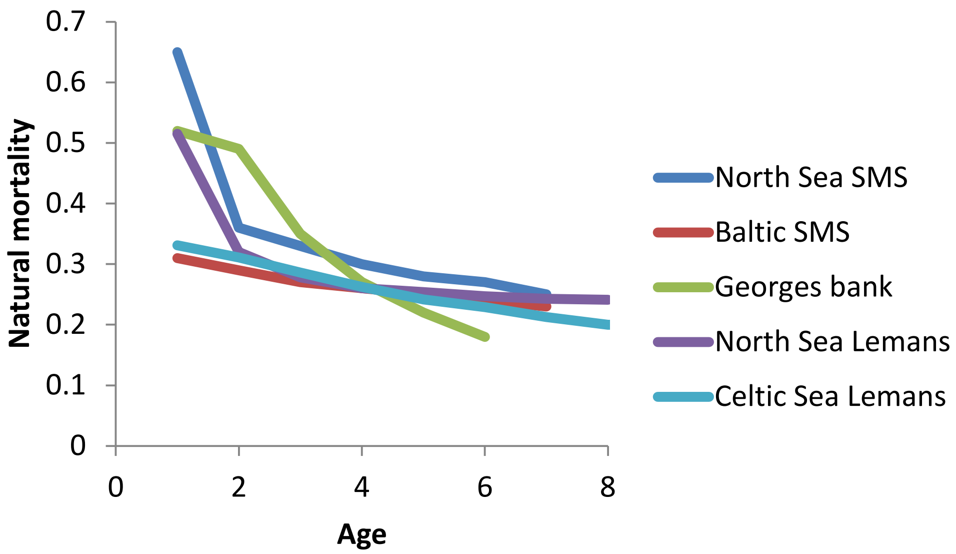
The values analysed for the North Sea, Baltic Sea and Georges Bank are all hindcasts of ecosystems where herring predators have been severely depleted during part of the time series. In a system where predator abundance was substantially higher, these natural mortalities may change substantially. To investigate this, we compared the natural mortalities from the 3 hindcast models with predictions from the Lemans model. This model predicts natural mortality at length, and these were transformed to natural mortality at age by using the weight at age of herring in each system (HAWG 2015), a length weight relationship and a smoothed relationship between length and natural mortality from model output.

1.5 Comparison across areas

In general, the hindcasted average natural mortalities were very similar over the three areas (fig. 1). In spite of herring being an important forage fish in all three areas, average natural mortality beyond age 3 was below 0.35 for all three stocks. The variability varied greatly between areas, with Georges Bank having the most (up to 4.6 times difference between the highest and lowest observed) and the North Sea the least variable natural mortalities for herring (less than 1.8 times difference between the highest and lowest observed). The change in Georges Bank mortalities were linked to a substantial decrease in the biomass of herring predators.

Given that the natural mortalities are very similar across stocks, it is probably a reasonable assumption that the natural mortalities do not vary greatly between areas unless the state of the predatory stocks varies greatly compared to the systems investigated here which all have exploited predator stocks. There was no link between natural mortality and e.g. the biomass of herring relative to that of predators and it was not possible to use very simple relationships with predator biomass to reliably predict annual variation in natural mortality.

Fig. xx. Natural mortality at age for different ecosystems from multispecies modelling based on statistical catch at age model hindcasts (North Sea SMS, Baltic Sea SMS and Georges Bank) and forward simulations in the Lemans model.



Annex 5 RG/ADG Sandeel Minutes Pertaining to ADG changes in the advice and assessments

San-ns4

Category 3 stock. HAWG found that the perception of the stock had not changed, due to the inherent variability in the data, even though there was a > 200% change in the survey index. HAWG agreed that the perception of the stock had not changed, and therefore, the advice should be the same catch value as for 2015. The ADG examined the indicator for this stock, the combined abundance index of ages 0 and 1 from the dredge survey of the Firth of Forth (ICES, 2012). The ADG concluded that this increase (2.56 between 2011–2014 (four-year average) and 2015), together with the trend in the index from 2013–2015 and the CPUE series from the fishery, was sufficient to indicate that stock status has changed. Therefore, the survey-adjusted status quo catch was adjusted for a revised catch advice value for 2016. The uncertainty cap was applied, but the precautionary buffer was not applied because it was applied in the past (and because the exploitation on the stock is considered to be very low), as per the ICES advice rule for category 3, 4, 5, and 6 stocks. Therefore, the advice is based on "the recent advised catch for 2015 of 5000 tonnes multiplied by 1.2, which is the uncertainty cap on the survey, for a total catch advice of no more than 6000 tonnes".

This is reflected in the catch options table in the published advice for 2016.

Table 6.3.40.2 Sandeel in the North Sea (SA 4). For stocks in ICES categories 3–6, one catch option is possible.

Index A (2015)		0.93
Index B (2011–2014)		0.38
Index ratio (A/B)		2.56
Uncertainty cap	Applied	1.2
Recent advised catch for 2015		5000 tonnes
Discard rate		Negligible
Precautionary buffer	Not applied	-
Catch advice*		6000 (tonnes)

* (Recent advised catch) × cap.

San-ns5

Category 5.3 stock (very low biomass, therefore, zero catch advice). The ADG agreed to provide multiyear advice for this stock with a non-standard advice text. The support for this non-standard text is as follows: this short-lived stock can be quite variable over time; therefore, it should be clearly communicated to clients in the advice statement that although ICES is giving advice for several years based on the history of this stock, due to the life-history of sandeel in this area the advice may change upon analysis of future data.

San-ns7

Category 5.3 stock (very low biomass, therefore, zero catch advice). The ADG agreed to provide multiyear advice for this stock with a non-standard advice text. The support for this non-standard text is as follows: this short-lived stock can be quite variable over time; therefore, it should be clearly communicated to clients in the advice statement that although ICES is giving advice for several years based on the history of this stock, due to the life-history of sandeel in this area the advice may change upon analysis of future data.

References

ICES. 2012. ICES Implementation of Advice for Data-limited Stocks in 2012 in its 2012 Advice. ICES CM 2012/ACOM 68. 42 pp.

Annex 6 Audits

All audits were conducted successfully.

Annex 7 Technical Minutes of the Review Group of Precautionary Approach Reference Points estimation

Review of ICES HAWG Report 2016

10 April 2016 – 10 June 2016

Reviewers: Chris Legault (chair)

Arni Magnusson

Colin Millar

Chair WG: Niels Hintzen (the Netherlands)

Secretariat: Cristina Morgado

1. General

The deadline for the review process of the stocks:

Herring in Division 3.a and Subdivisions 22 - 24 (Western Baltic spring spawners)

Herring in Subarea 4 and Divisions 3.a and 7.d (North Sea autumn spawners)

The Review Group considered estimation of PA reference points for the following stocks:

Herring in Divisions 6.a and 7.b-c

Herring in Division 3.a and Subdivisions 22 - 24

Herring in Division 7.a South of 52° 30"N and 7.g,h,j,k

Herring in Subarea 4 and Divisions 3.a and 7.d

2. Herring in Divisions 6.a and 7.b-c (report section 5)

General comments

According to the advice sheet, B_{lim}=250 kt and B_{pa}=410 kt. The basis of B_{lim} is the breakpoint in segmented regression stock-recruitment relationship, and the basis of Bpa is B_{lim} raised by assessment uncertainty.

According to the advice sheet, F_{lim} is not defined and F_{pa}=0.18. The basis of F_{pa} is stochastic simulations from Ricker stock-recruitment relationship.

The value supplied as F_{pa} is F_{p05}, an F that in long term simulations results in B falling below Blim 5% of the time. This is not the ICES definition of F_{pa} which is simply $F_{pa}=F_{lim}*\exp(-1.645\sigma_F)$, with σ_F is an estimate of the uncertainty of the estimate of log F in the terminal year.

The value of Flim was not defined in the advice sheet and not mentioned in the WG report, but is defined in the stock annex as Flim = 0.30. The method used in the stock annex follows the guidelines. If the assessment uncertainty in biomass was used to derive Fpa from Flim, this would result in Fpa=F_{lim}*exp(-1.645σ_B)=0.18., which is the same as F_{p05}.

Technical comments

	Basis of underlying limit refpt is clear	Right approach to derive PA refpt from limit refpt	PA refpt looks correct	Basis and value of σ is clear
B_{pa}	OK, B_{lim} is the breakpoint in a segmented regression stock-recruit fit (type 2)	Please state the equation B_{pa}=B_{lim}*exp(1.645σ_B) and the value of σ_B=0.30 in the refpt table of the advice sheet.	OK	Please state the value of σ_B in the refpt table of the advice sheet. Bpa = 410 kt implies σ_B=0.30
F_{pa}	Not defined, but is calculated in stock annex as F_{lim}=0.30	No, wrong approach was used. Please use and state the equation F_{pa}=F_{lim}*exp(-1.645σ_F) and the value of σ_F in the refpt table of the advice sheet.	Maybe, if Flim=0.30 (as stated in stock annex) and σ_F= σ_B=0.30.	Please state the value of σ_F in the refpt table of the advice sheet.

Conclusions

2 out of 8 cells are OK, the remaining 6 should be addressed.

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3. Herring in Division 3.a and Subdivisions 22 - 24 (report section 3)

General comments

According to the advice sheet, B_{lim}=90 and B_{pa}=110. The σ_B value used in these calculations is not clear, but the relationship B_{pa}=B_{lim}*exp(1.645σ_B) implies that a σ_B of around 0.12 is being used.

According to the advice sheet, F_{lim}=0.52 and F_{pa}=0.46. It appears that F_{pa} is estimated based on simulations, instead of the formula in the guidelines.

Technical comments

	Basis of underlying limit refpt is clear	Right approach to derive PA refpt from limit refpt	PA refpt looks correct	Basis and value of σ is clear
B_{pa}	OK, $B_{lim}=B_{loss}$ (type 5)	OK	Maybe, but what value for σ_B?	Was it 0.12?
F_{pa}	OK, F_{lim} is based on simulations (method a)	No, F_{pa} should be F_{lim}*exp(-1.645σ_F)	No, based on the wrong approach	No, σ_F was not used at all

Conclusions

3/8 cells in the above matrix are OK. The remaining 5 should be improved before the ADG meets.

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4. Herring in Division 7.a South of 52° 30"N and 7.g,h,j,k (report section 4)

General comments

According to the advice sheet, B_{lim}=33 kt and B_{pa}=54 kt. The basis of B_{lim} is B_{loss} and the basis of B_{pa} is B_{lim}*exp(1.645σ_B), where σ_B=0.30.

According to the advice sheet, F_{lim}=0.61 and F_{pa}=0.37. The basis of F_{lim} is the equilibrium F maintaining SSB > B_{lim} with 50% probability, and the basis of F_{pa} is F_{lim}*exp(-1.645σ_F), where σ_F=0.30.

Technical comments

	Basis of underlying limit refpt is clear	Right approach to derive PA refpt from limit refpt	PA refpt looks correct	Basis and value of σ is clear
B_{pa}	OK, B_{lim}=B_{loss} (type 5)	OK	OK	Please specify σ_B=0.30 with two significant digits.
F_{pa}	Basis of F_{lim} is stated in the wrong line. Suggest moving first half of F_{pa} basis sentence to the table cell above.	OK	OK	Please specify σ_F=0.30 with two significant digits.

Conclusions

5/8 cells in the above matrix are OK. The remaining 3 should be improved.

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5. Herring in Subarea 4 and Divisions 3.a and 7.d (report section 2)

General comments

According to the advice sheet, B_{lim}=800 kt and B_{pa}=1000 kt. The σ_B value used in these calculations is not clear, due to discrepancy between the stock annex and the advice sheet.

According to the advice sheet, F_{lim}=0.39 and F_{pa}=0.34. It appears that F_{pa} is estimated correctly from the WG report, however the advice sheet statement is incorrect.

The section would benefit from a little reordering. A logical ordering is F_{msy}, MSY $B_{trigger}$, B_{lim}, B_{pa}, F_{lim}, F_{pa}.

Due to a revision in natural mortality estimates, MSY reference points were recalculated for this stock. According to the advice sheet, MSY $B_{trigger}$ is not defined, but is given as 1500 kt in the WG report. According to the advice sheet, F_{msy}=0.33 (range: 0.24-0.34).

Technical comments

	Basis of underlying limit refpt is clear	Right approach to derive PA refpt from limit refpt	PA refpt looks correct	Basis and value of σ is clear
B_{pa}	OK, B_{lim}=breakpoint in segmented regression (type 2)	OK	B_{pa} seems too rounded. Give 2 sig. fig. What value for σ_B?	Value unclear, was it ≈ 0.20 (advice sheet), or ≈ 0.10 (report)?
F_{pa}	OK, F_{lim} is based on simulations (method a)	Technical basis in the advice sheet does not match the report.	OK	σ_F in advice sheet needs to match report.

Conclusions

4/8 cells in the above matrix are OK. The remaining 4 should be improved before the ADG meets.

The value of MSY $B_{trigger}$ and its basis should appear on the advice sheet. This should be improved before the ADG meets.