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

17–25 March 2009

ICES Headquarters, Copenhagen

International Council for the Exploration of the Sea

Conseil International pour l'Exploration de la Mer

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Executive Summary

The ICES herring assessment working group (HAWG) met for 7 days in March 2009 to assess the status of 7 herring stocks and 3 sprat stocks. The working group conducted update assessments for North Sea, Western Baltic and West of Scotland herring stocks and for North Sea sprat. Moreover, the group performed an assessment for Celtic Sea and Division VIIj herring which is presented as an update.

The SSB of **North Sea autumn spawning herring** in autumn 2008 was estimated at 1.0 million t, and is expected to remain below B_{pa} (1.3 million t) in 2009. F_{2-6} in 2008 was estimated at 0.24, above the target F_{2-6} of 0.14. The year classes since 2002 are estimated to be among the weakest since the late 1970s. Best estimates of catches in 2008 were 257 900 t, a decrease from 406 900 t in 2007. The **Western Baltic spring spawning** stock's SSB has been rather stable over the last decade, although the most recent value is in the lower quartile of all observations. Fishing mortality has also been stable in the same period but is larger than any proxy of $F_{msy.}$ Recruitment has declined consistently since 2003 and the estimated number of 0-ringers in 2008 is the lowest observed value. The 2003 year class year class has been the largest component of the SSB for the last three years and has supported the stock during this period. However, this year class will pass out of the stock in the next two years, whilst its place will be taken by the sequence of poor year classes: a continuation of the decline in SSB can therefore be expected in the short and medium term. The **Celtic Sea autumn and winter spawning** stock has increased in size and SSB is now above B_{pa} and mean F_{2-5} has declined to the lowest estimate observed. Catch in 2008/2009 decreased to lowest in the series (5 800 t). Two strong and two weak year classes have recruited recently. In recent years the assessment was considered as indicative of trends. In 2009 HAWG puts forward an analytical assessment for this stock, which is considered by the WG to be stable enough to provide the basis for advice. **West of Scotland autumn spanwing** stock's SSB (in 2009) is 1.8 times B_{lim}. The stock is currently fluctuating at a low level and is being exploited close to F_{msy}. Recruitment has been low since 1998. Catch in 2008 was 16 000 t, a decrease from 29 000 t in 2007. **The WG evaluated the recently agreed management plan for this stock (slightly changed from the proposed plan) and found no substantive differences from the earlier evaluations of medium term risks of SSB<Blim, indicating that advice could be based on the agreed plan. West of Ireland (Division VIaS and VIIb,c) autumn- and winter/spring-spawning** stock cannot be assessed analytically because no tuning data are available. However, there are indications that the stock is at a historically low level. Though current levels of SSB and F are not precisely known, there are no sign of stock recovery. Catch in 2008 was 13 300 t, a decrease from 18 000 t in 2007. **Irish Sea autumn spawning** herring SSB has been relatively stable for the last 10 years, and fishing mortality does not appear to be increasing above the recent average. Catches (4 900 t in 2008) have been close to TAC level in recent years and the main fishing activity has not varied considerably. An increase in effort on the Mourne spawning component has been noted in the past three years. There is some evidence of increased recruitment in the stock in most recent years. Catches of the **Clyde spring spawning** stock were 676 t in 2008, but no information is available to perform an assessment.

Survey trends indicate that the stock size of **North Sea Sprat** has varied around an average level with no trend. There is no analytical assessment for this stock. The recruits account for a large proportion of the stock, and the fishery in a given year is very dependent on that year's incoming year class. The state of the stock is uncertain, and catches in 2008 were 61 100 t, declining from 81 000 t in 2007. The new data avail-

able for **sprat in Division IIIa** were too sparse to perform an assessment. The total landings decreased from 15 700 t in 2007 to 9 100 t in 2008. **Sprat in VIId,e** catch was somewhat higher than the recent average (3 300 t in 2008). No assessment of this stock was possible.

The group answered one *ad hoc* request, for updated advice for western Baltic spring spawning herring

The working group also commented on the quality and availability of data, the problems with estimating the amounts of discarded fish, the use of the data system INTERCATCH, changes in mean weights of the stocks considered by the group and recent meetings and reports of relevance to HAWG.

1 Introduction

1.1 Participants

Steven Beggs	UK/Northern Ireland
Stijn Bierman	The Netherlands
Massimiliano Cardinale	Sweden
Maurice Clarke (Co-Chair)	Ireland
Lotte Worsøe Clausen	Denmark
Mark Dickey-Collas	The Netherlands
Afra Egan	Ireland
Christina Frisk	Denmark
Tomas Gröhsler (Co-Chair)	Germany
Joachim Gröger	Germany
Clementine Harma	Ireland
Niels Hintzen	The Netherlands
Cecilie Kvamme	Norway
Henrik Mosegaard	Denmark
Peter Munk	Denmark
Mark Payne	Denmark
Beatriz Roel	UK/England & Wales
Norbert Rohlf	Germany
Barbara Schoute	ICES Secretariat
John Simmonds	UK/Scotland
Dankert Skagen	Norway
Else Torstensen	Norway
Yves Verin	France

Contact details for each participant are given in Annex 1.

1.2 Terms of Reference

2008/2/ACOM03 The **Herring Assessment Working Group for the Area South of 62ºN** [HAWG] (Co-Chairs: Tomas Gröhsler, Germany and Maurice Clarke, Ireland) will meet at ICES Headquarters, 17–25 March 2009 to:

a) compile the catch data of North Sea and Western Baltic herring on 17–18 March

b) address generic ToRs for Fish Stock Assessment Working Groups 19–25 March (see table below).

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

Fish Stock	Stock Name	Stock Co-ord.	Assesss. Coord. 1	Assess. Coord. 1	Advice
her-3a22	Herring in Division IIIa and Subdivisions 22–24 (Western Baltic Spring spawners)	Denmark	Germany	Denmark	Advice
her-47d3	Herring in Subarea IV and Division IIIa and VIId (North Sea Autumn spawners)	Germany	NL	UK (Scotland)	Advice
her-irls	Herring in Division VIIa South of 52° 30′ N and VIIg,h,j,k (Celtic Sea and	Ireland	Ireland		Same advice as last

	South of Ireland)				year
her-irlw	Herring in Divisions VIa (South) and VIIb,c	Ireland	Ireland		Same advice as last year
her-nirs	Herring in Division VIIa North of 52° 30′ N (Irish Sea)	UK (Northern Ireland)	UK (Northern Ireland)		Same advice as last year
her-vian	Herring in Division VIa (North)	UK (Scotland)	UK S		Advice
spr-nsea	Sprat in Subarea IV (North Sea)	Denmark	Denmark	Norway	Advice

HAWG will report by 30 March 2009 for the attention of ACOM.

1.3 Working Group's response to ad hoc requests

1.3.1 EU Baltic Pelagic HCR Special request

a) *For WBSS herring advice provided in 2008 on the request EC-DG FISH 27.03.2007-021 should be updated as necessary.*

b) *Following recommendations in this advice, results from the benchmark assessment carried out in March 2008 should be taken into account and advice management options be developed in light of the multi-fleet fisheries on this stock.*

c) *In addition, mixing with NSAS herring in IIIa should be taken into account*

d) *Advice should be provided for a fixed allocation of catch options between Div. IIIa and SD 22-24.*

Response

Advice for 2010

– An option realizing the advised HCR in 2008 has been included as a scenario in the Western Baltic spring spawning herring (WBSS) advice for 2010 according to the following rule:

  - Target fishing mortality is 0.25,
  - This results in a TAC (IIIa + SD 22-24) change larger than 15%, thus the TAC change was restricted to + 15% (**value**).

  The resulting SSB in 2011 is indicated to be below Btrig [C] 110 000 t therefore this option was not used as a basis for advice.

– Results from the benchmark assessment carried out in March 2008 have been taken into account in the advice. Like earlier years, advice options are routinely given in light of the multi-fleet fisheries:

North Sea	Fleet A	Directed herring fisheries with purse-seiners and trawlers. Bycatches in industrial fisheries by Norway are included.
	Fleet B	Herring taken as bycatch under EU regulations.
Division IIIa	Fleet C	Directed herring fisheries with purse-seiners and trawlers
	Fleet D	Bycatches of herring caught in the small-mesh fisheries
Subdivision 22-24	Fleet F	All herring fisheries in Subdivisions 22–24

– In addition, mixing with the North Sea Autumn Spawning (NSAS) herring in IIIa is routinely taken into account. For 2009, the expected catch of WBSS in IIIa was calculated assuming the same WBSS proportions in the catch of each fleet in 2009 as that in 2008 neglecting the small amount of about 120 t WBSS taken in Division IVaE by the A-fleet.

Allocating catches between areas

– The ICES advice for the area is used in a TAC management system dividing Division IIIa from SD 22-24. The ICES short-term forecast assumes a ratio of catches over the two management areas based on recent landings. For the 2010 advice, based on the 2008 catches, a 47 : 53 ratio between IIIa : SD 22-24 catches is used. The historical allocation pattern is close to 50/50 between Division IIIa and SD 22-24 as a result of informal allocation.

Considering the spatial distribution of the different life-stages over the seasons, ICES recommends that a specific rule be incorporated in the management plan for WBSS determining a fixed allocation. Other way round...The allocation of the TACs between the two areas should match the one used in the ICES forecast... Using a different allocation corrupts the power of the prediction of the forecast.

Source of information

ICES 2008. Report of the Workshop on Herring Management Plans (WKHMP), 4–8 February, ICES Headquarters Copenhagen. ICES CM 2008/ACOM: 27. 2 pp.

1.4 Reviews of groups or work important for the WG

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

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

HAWG was informed about the WGCHAIRS meeting in January 2009. The presentation focused on the following main outcome relevant for HAWG:

Reviews of EG reports: There is still a need to clarify the role of reviewers for stock assessment updates. The reviewers only need to determine that the assessment follows the rules given in the stock annex. The reviews should not act like a benchmark. There is a need to "caveat" reviews that are appended to WG reports to indicate that they are constructive feedback from peers, but that they are not necessarily superior to the Expert Group in terms of insights or validity.

Draft Advice: According to Council decision, it is the responsibility of ADGs to draft advice in order to facilitate integration. However, EG ToRs should be constructed to respond to requests for advice. If EGs prepare concise and focused text, tabular material, and figures that respond to ToRs, their work will have a clear impact on advice. Information like: Impact of fisheries on the ecosystems, Regulations and their effects, Changes in fishing technology and fishing patterns, Impact of the environment on the fish stock etc. should only be given in the advice, when any of this information was used in the assessment. A new SUBFORMAT for 2010 or later is proposed and under discussion.

Enhanced Integration and the ecosystem approach: Benchmark workshops are a mechanism to enhance integration and the ecosystem approach. EGs are asked to provide a list of stocks to be benchmarked in 2010, including a list of the criteria set up by the Benchmark Workshop Planning Group (PGBWK) (ICES CM 2008/ACOM:62). Regional ecosystem descriptions should be maintained even if this needs to be done ad hoc in 2009. They should be taken into account in future advice to the extent this is scientifically justified.

Working documents: An archiving system for these documents would be good, this works on SharePoint. The ICES Secretariat is looking at a way to keep up a longer time period for availability of these documents.

Planning Group on Commercial Catch, Discards and Biological Sampling (PGCCDBS): HAWG is asked to nominate one contact person, which should

- compile data issues addressed during our meeting that could possibly compromise the quality of the assessment,
- be responsible for communicating this message to relevant groups that deal with data collection (RCM & PGCCDBS) personally or through the ICES secretariat.

This would also mean that the nominated member should/has to participate in all relevant data collection meetings (RCM & PGCCDBS).

1.4.2 Planning Group of International Pelagic Surveys [PGIPS]

The **Planning Group for Pelagic Surveys** (PGIPS, formerly PGHERS) has met in January 2009 (ICES 2009/LRC:02) to co-ordinate acoustic and larvae surveys in the North Sea, the Malin Shelf and the Western Baltic; to combine recent survey results for assessment purposes and to elucidate parameters influencing these calculations.

Review of larvae surveys in 2008/2009: Six survey metiers were covered in the North Sea. Larvae abundance has increased in all observed areas, with the exception of the Buchan area. The Multiplicative Larval Abundance Index indicates that the SSB has increased compared to last year.

Workshop on the Identification of clupeid larvae (WKIDCL): A workshop should take place in Hamburg, Germany, from 1-3 September 2009 to review available information on the identification of clupeid fish larvae; to identify sources of misidentification of clupeid larvae and to establish an agreed identification key for participants in clupeid larvae surveys, e.g. for the IHLS in the North Sea, the Irish Sea, the IBTS (MIK index), the Rügen HLS and the Norwegian Spring Spawning herring larvae surveys.

North Sea, West of Scotland and Malin Shelf summer acoustic surveys in 2008: Eight acoustic surveys were carried out during late June and July 2008 covering the

North Sea, West of Scotland and the Malin Shelf area. The estimate of North Sea autumn spawning herring spawning stock is at 1.8 million tonnes. This is slightly higher than the previous year (1.2 million tonnes). The West of Scotland estimates of SSB are 788 000 tonnes. This is the second highest estimate in the time series. The survey did not detect many immature fish this year.

For the first time, a synoptic survey of what is currently considered the Malin Shelf population of herring was carried out. This provided an estimate comprising four stocks to the west of the British Isles: the West of Scotland herring stock in Division VIaN; the Clyde stock; the stock in Division VIaS and VIIb, c and the Irish Sea stock. The Malin Shelf estimate of SSB was 826 000 tonnes and is largely dominated by the west of Scotland estimate.

Sprat: In most recent years, there is a downward trend in North Sea sprat. In 2008, the total biomass was estimates to 270 000 tonnes, which is a reduction by 25 % when compared to last year. The majority of the stock consists of mature fish. The sprat stock is dominated by 1- and 2-year old fish representing more than 95 % of the biomass.

In Division IIIa, sprat was abundant in the Kattegat only. No sprat was observed in the Skagerrak area. The biomass has significantly decreased to 12 000 tonnes.

Western Baltic acoustic surveys in 2008: A joint German-Danish acoustic survey was carried in the Western Baltic in October 2008. The estimate of Western Baltic spring spawning herring is about 124 000 tonnes in Subdivisions 22–24 and is dominated by young herring as in former years. The present overall estimates are low both in terms of abundance and biomass, when compared to the long term mean. The estimated total sprat stock is around 60 000 tonnes and indications are found for a weak upcoming year class.

1.4.3 Work on Multi-annual Management of pelagic stocks in the Baltic [WKMAMPEL]

The ICES Workshop on Multi-annual management of Pelagic Fish Stocks in the Baltic [WKMAMPEL] met in February 2009 in response to an EC request to develop a multi-annual plan for the management of the pelagic fish stocks in the Baltic Sea. The Western Baltic Spring Spawning, and specifically the fishery on this stock in SD 22-24 was considered as part of this process.

Management plans for this stock have previously been examined by the WKHMP working group in February 2008. These simulations suggested that a target F (“A” parameter in a harvest control rule) should be set no higher than 0.25. Exploration of different juvenile selection patterns indicated that at high fishing mortalities the proportion of simulations falling below Bim increased with increasing juvenile selection. Limitations on the year-to-year variation in TAC (“B” parameter) were recommended to be 15%. WKHMP was unable to make a specific recommendation on the level of the trigger biomass (“C” parameter).

These evaluations were based on population parameters from the 2007 stock assessment. The stock was the subject of a benchmark assessment in March 2008, which improved the quality of the assessment, although the overall perception of the development of the stock changed little. Work performed by ICES in August 2008 updated the results of WKHMP to incorporate the results of the benchmark assessment. The new simulations differed little from those presented in WKHMP and ICES concluded that the conclusions drawn by WKHMP were not changed by the benchmark assessment process.

Both WKHMP and WKMAMPEL highlighted several concerns about the appropriateness of the tools employed to assess the proposed management plans, noting the inherent complexity of the Western Baltic Spring Spawning population and associated fishery. WKHMP and WKMAMPEL recommended that further work be performed to develop tools appropriate for this system. Work is currently ongoing, through the "JAKFISH" and "GAP" EU projects, to develop such tools. This work is expected to run for the duration of the JAKFISH project (until 2011). Additionally, careful scientific evaluations by the ICES quality assurance system and by the ICES Advisory Committee will be required. It is therefore expected that it will take at least 1-2 years before such work could be completed and implemented.

1.4.4 Linking Herring 2009 [ICES/PICES/GLOBEC sponsored symposium]

The Linking Herring symposium was organized to link our understanding of herring biology, population dynamics and exploitation in the context of ecosystem complexity. It is beyond argument that herring play a pivotal role in shaping the structure and dynamics of many boreal continental-shelf ecosystems. Thus, in moving to an ecosystem approach to fisheries management, the time seemed right for ICES to hold another herring symposium. Since the last ICES symposia on herring in the 1960s (ICES Herring Symposium, 1961; Biology of Early Stages and Recruitment Mechanisms of Herring, 1968), many of the former paradigms have been rejected and substantial progress has been made by striking out along new avenues. The symposium covered new research from both the ICES and PICES community.

The symposium took place from the 26th to the 29th August 2008, at the National University of Ireland, Galway, Ireland. The conference was co-sponsored by Marine Institute (Ireland), Institute of Marine Research (Norway), ICES, the Irish Tourist Board, PICES and Wageningen IMARES (The Netherlands) and supported by GLOBEC. In total there were 80 presentations, 64 oral and 16 posters. These studied the Atlantic (NE and NW), Pacific (NE and NW), Baltic and Arctic herrings. Delegates, numbering 100 in total, attended from Ireland, UK, Norway, Denmark, Italy, France, the Netherlands, Germany, Canada, USA, Russia, Latvia, Iceland and Poland. The local organisation was lead by Maurice Clarke (Marine Institute) and Patricia Walsh (National University of Ireland, Galway).

According to expectations, Linking Herring was an exciting symposium that successfully described the state of the art in herring science and management. However, it showed that there are still huge challenges ahead, particularly in understanding the role of herring within the ecosystem approach and how to translate this into actual management measures. With herring, fixed rules appear to be few, and any current paradigm is likely to shift in future. Exploiting herring in a sustainable manner may never be possible as its populations naturally come and go, even without exploitation. The example of Norwegian spring-spawning herring shows us that the choices of individuals belonging to a highly plastic species results in populations that adapt and vary over time. Our most important task is to ensure that any assumptions underlying the management advice reflect this feature of plasticity, even if we don't understand its genetic and phenotypic origin completely.

1.4.5 Study Group on the Evaluation of Assessment and Management Strategies of the Western Herring Stocks [SGHERWAY]

The ICES Study Group on the evaluation of assessment and management strategies of the western herring stocks [SGHERWAY] met in early December 2008 to consider issues surrounding the assessment and management of the herring stocks to the west of the British Isles.

SGHERWAY arose out of the EU funded project WESTHER which evaluated the uncertain stock identity of herring stocks to the west of the British Isles. Its results suggested a rearrangement of the stocks as they are currently assessed. SGHERWAY recognises the need to provide sound management advice for the western herring areas, and in particular the importance of ensuring as far as possible that there is no depletion of local components. Currently it is unclear what management regime would provide the most cost effective method for successful management and what data would be needed to support this management.

SGHERWAY considered that it is necessary to move towards management for this area through a series of iterations involving the following steps: (I) Investigation of a combined assessment of the three currently assessed stocks, VIaN, VIaS/VIIbc and VIIaN (to be called the Malin Shelf stock), including an investigation of the utility of a combined acoustic survey; (II) Examination of alternative management strategies based on their ability to deliver protection to local populations and provide cost effective information applicable for management of the new proposed stock unit of herring to the west of the British Isles (Malin Shelf); (III) Amendment of existing, or development of new, cost effective assessment and data collection schemes which will be required to support this management.

In December 2008, SGHERWAY was able to address the first of the two steps above. During the meeting the majority of the data required to perform a combined assessment of the three herring stocks were compiled and a combined assessment carried out using FLICA with the VIaN survey as the tuning index. This combined assessment gave a lower catchability than the current VIaN assessment, suggesting that the inclusion of additional catch from the VIaS/VIIb c and VIIaN stocks was an improvement. However, the retrospective pattern was very poor. This may be as a result of the partial coverage of the single tuning index used. In most years this survey does not extend as far as VIaS/VIIbc or VIIaN. Another possibility is that the selection pattern assumed for the fishery may not represent the combined fishery. The development of a time series of a synoptic acoustic survey of the Malin and Hebrides shelf areas will enable survey coverage to be extended to the whole sea area in which mixing of the various western herring stocks is thought to occur, and a more apposite tuning index to be developed. The first such synoptic survey was carried out in 2008. The area was surveyed in June/July 2008 by vessels from Scotland, Northern Ireland and the Republic of Ireland. The three survey estimates were combined in the same manner as the surveys in the North Sea. The Malin Shelf estimate of SSB was 826,000 tonnes and 4,007 million fish. This is largely dominated by the VIaN estimate.

A previously defined model was available to suffice as a good starting point to evaluate alternative management strategies for the metapopulations west of the British Isles. The simulations were run under a number of F and mixing settings. The model supplied allowed the study of some aspects of the dynamics of a fishery operating on mixed populations. In particular, the model allowed investigation of the effects of a sudden increase in catchability in one of the populations. However, shifts in fishing effort which should have an impact on all populations caught were not investigated. To be fully able to evaluate alternative management strategies for herring stocks west of the British Isles, it is recommended to adapt the model setup to coincide more with reality. Therefore, the model should be adjusted to a year-by-year evaluation platform, where management rules can be incorporated and fed back into the biological part of the model as well.

1.4.6 Planning Group on Commercial Catch, Discards and biological Sampling [PGCCDBS]

Contact persons as link between AWG and PGCCDBS

PGCCDBS considered that the system of contact persons providing a link between ICES stock assessment Working Groups and PGCCDBS was insufficiently developed in 2008 to evaluate the success of this initiative. Furthermore, there did not appear to be a well-defined protocol for contacts officers to provide feedback from AWGs (assessment working groups). The PGCCDBS defined a suitable contact person profile to be:

- An active member of the relevant assessment group and the benchmark WKs related to the AWG stocks
- A participant of PGCCDBS or close contact with an attendee of that group.
- A participant of relevant regional coordinating meeting (RCM) or close contact with attendee of that group.

In order for the contact person to function effectively, PGCCDBS envisaged that the role should include the following tasks;

- Contact all stock coordinators (and assessors) that the HAWG represents in order to identify issues relevant to PGCCDBS.
- Ensure that all issues relevant to PGCCDBS and RCM's are entered in the table - "Stock Data Problems Relevant to Data Collection" (see below text table) and that this is included in the report of the AWG.
- In completing the form, the contact person should, where possible, indicate the course of action that they feel is required in order to address the issues identified.
- Provide feedback from PGCCDBS and RCMs to HAWG.

HAWG 2009 appointed Lotte Worsøe Clausen (DTU Aqua) as contact person for the PGCCDBS.

Quality Assurance Framework (QAF)

The development of a Quality Assurance Framework (QAF) and associated data catalogue to strengthen link between AWGs and PGCCDBS by automating the reporting of data usage by the AWGs, reducing demands on already reduced WG time was continued. The ICES AMAWGC meeting in 2008 supported the development of a data catalogue to manage sampling meta-information so that the sampling summaries can be generated automatically. This should, at the same time, also suit the needs of STECF-SGRN when evaluating the compliance of Member States with the DCR (data collection regulation) and their National Programmes. The PGCCDBS worked on the outline of such a catalogue intersessionally and a first draft was presented at the meeting in March 2009. The implementation of the catalogue is planned to be tested by table templates which are to be supplied to selected stock coordinators.

Consequence of the new DCF sampling schemes

PGCCDBS recommended that Member States evaluate potential changes to the continuity of their stock assessment fishery data sets caused by the new DCF sampling schemes from 2009 onwards. A suitable approach could be developed around the framework for bias and precision evaluation developed by WKACCU and COST.

The evaluations should be supplied to ICES stock managers when Member States provide national assessment data for 2009, so that the assessment Working Groups can be made aware of features of the data that could explain unusual assessment model results, or to allow them to carry out sensitivity tests.

One of the new subjects within the current DCF is the obligation for MS to collect data for a list of ecosystem indicators. This list encompasses indicators like e.g. mean maximum length of the fish, distribution of fishing activities and discard rates of commercially exploited species (2008/949/EC, Appendix XIII). For the latter, PGCCDBS received a request from DG MARE, via ICES, to explain the process of building up a time series for this indicator.

PGCCDBS recommended that an additional Term of Reference should be provided to ICES stock assessment Working Groups from 2010 onwards to report on the impact of the new DCF sampling requirements on the quality and continuity of data sets used for assessments.

1.4.7 FRS project on factors affecting overwinter survival of larvae in the northern North Sea

The North Sea herring stock has experienced a succession of poor recruitments by the 2002, 2003, 2004, 2005, 2006 and 2007 year classes – amongst the lowest since the collapse of the stock during the mid-1970s. This has occurred despite the presence of the highest spawning-stock biomass (SSB) since 1973. In more recent years (2005-2007), the SSB has begun to decline, and fishers, managers and scientists have expressed concern for the future state of the herring stock. As a consequence, ICES advised large cuts in total allowable catches. ICES also convened the Study Group on Recruitment Variability in North Sea Planktivorous Fish (SGRECVAP), which met in January 2006 and May 2007 to consider the possible causes of the recruitment failure.

The SGRECVAP (ICES 2006a) found little or no evidence of impaired egg production by herring, or egg hatching success, from 2002 onwards. However, there was clear evidence of a large increase in mortality between the early larval phase (September/October), and the late larval phase (February the following year). The SG also noted that a similar phenomenon appeared to have occurred during the development of year classes 1988, 1989 and 1990, when the spawning biomass was also close to the recent historical maximum.

The 2006 SG noted evidence for significant changes in the transport of larvae, and in the plankton community of the North Sea, correlated with warming of the region especially since 2001. In 2007 the SG determined that hydrographic changes in the North Sea may have resulted in changes in frontal development and it is conceivable that these factors could have affected the feeding conditions of herring larvae and hence their growth and survival. The 2007 SG also determined that the timing of the changes in the plankton community was similar to those in the recruitment/survival patterns of the herring larvae (i.e., the late 1980s and around 2000).

In a search for evidence to support the empirical relationships between plankton and herring larvae survival noted by the SG, we examined the archived collections of larval herring from the Scottish MIKT surveys in the north-western North Sea which are carried out in February each year. Specimens from surveys between 1995 and 2007 collected in a standard sampling area off the east coast of Scotland were dissected to expose the gut contents, which were identified and enumerated.

Alongside the gut contents analysis, results from a bio-physical model were used to simulate year-to-year changes in the transport of herring larvae produced in September at spawning grounds around Orkney, Shetland and off the east coast of Scotland, to the sampling area in February of the following year. Using these results we were able to estimate the survival of the population of larvae in the February sampling area during their over-winter drift period.

The composition of the gut contents of larvae indicated which plankton species were being eaten immediately prior to capture in February each year. The copepods *Paracalanus sp.* and *Pseudocalanus sp.* were consistently important components of the diet, but there were no clear trends in diet composition that could be related to survival.

Plankton abundance in the water, estimated from monitoring data collected weekly off Stonehaven on the east coast of Scotland, showed marked trends in species composition, but these were not obviously related to the diet of the herring larvae.

Two intestinal parasites were found in the gut contents of the larvae. One (larvae of a tetraphyllidean cestode) was a benign parasite that is progressively accumulated with feeding but is relatively harmless to the larvae. We deduced that we can use the incidence of this parasite as an index of the cumulative feeding history of the larvae. We found that the prevalence of tetraphyllideans in the gut contents varied significantly between years and was positively correlated with feeding success. High feeding success, indicated by high prevalence of tetraphyllideans, influenced survival by offsetting the effect of the second parasite type. We conclude that variability in cumulative food intake over the life span up to February is a significant determinant of variability in survival.

The other parasite (a digenean trematode species) is also obtained from eating infected plankton, but is harmful to the larvae. In years when tetraphyllideans were rare in the gut contents, indicating poor feeding conditions, there was a negative relationship between the more harmful digenean parasite and survival. We conclude that the benefits of good feeding conditions outweigh the detrimental effects of the digenean parasite on survival. However, when feeding conditions are poor, incidence of the digenean parasite further exacerbates the impact on survival.

Our data indicate that the survival of herring larvae in the north-western North Sea has increased since 2004, in marked contrast to the well documented continued decline in survival in the North Sea as a whole. Hence, the overall decline in North Sea herring recruitment must be caused by factors which are primarily operating in the central or southern North Sea, not in the northern North Sea. Our results attribute the improved survival in the north-western North Sea to increased food consumption, presumably due to improved plankton abundance. However, we cannot use our results to say that, conversely, the impaired survival in other parts of the North Sea must be necessarily due to poor feeding conditions. We recommend a similar study on archived samples of herring larvae from the surveys in the central and southern North Sea.

1.5 Commercial catch data collation, sampling, and terminology

1.5.1 Commercial catch and sampling: data collation and handling

Input spreadsheet and initial data processing

Since 1999 (catch data 1998), the working group members have used a spreadsheet to provide all necessary landing and sampling data. The current version used for reporting the 2008 catch data was v1.6.4. These data were then further processed with the SALLOC-application (Patterson, 1998). This program gives the needed standard outputs on sampling status and biological parameters. It also clearly documents any decisions made by the species co-ordinators for filling in missing data and raising the catch information of one nation/quarter/area with information from another data set. This allows recalculation of data in the future, or storage and analyses in other tools like InterCatch (see section 1.5.4), choosing the same (subjective) decisions currently made by the WG. Ideally, all data for the various areas should be provided on the standard spreadsheet and processed similarly, resulting in a single output file for all stocks covered by this working group. National catch data submission was due to 23 February 2009. Some nations failed to deliver their data in time, but provided them the week after. All but one nation submitted catch and sampling data via the official exchange spreadsheets, and some of them loaded data into the InterCatch database.

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

1.5.2 Sampling

Quality of sampling for the whole area

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

Area	Official catch (t)	Sampled catch (t)	Age readings	Age readings per 1000 t
IVa(E)	19462	16854	370	19
IVa(W)	124563	106188	5553	45
IVb	57362	31261	1213	21
IVc	2087	185	75	36
VIId	24422	18616	1452	59
VIIa(N)	4895	4895	938	192
VIa(N)	25216	9837	757	30
IIIa	38200	38200	7499	196
Celtic Sea,VIIj	5794	5794	3779	652
VIaS, VIIb,c	10237	10237	3653	353

The EU sampling regime

HAWG has recommended for years that sampling of commercial catches should be improved for most of the stocks. The EU directive for the collection of fisheries data was implemented in 2002 for all EU member states (Commission Regulation 1639/2001). The provisions in the "data directive" define specific sampling levels per 1000 tons catch. The definitions applicable for herring and the area covered by HAWG are given below:

AREA	SAMPLING LEVEL PER 1000 t CATCH		
Baltic area (IIIa (S) and IIIb-c)	*1 sample of which*	*100 fish measured and*	*50 aged*
Skagerrak (IIIa (N))	*1 sample*	*100 fish measured*	*100 aged*
North Sea (IV and VIId):	*1 sample*	*50 fish measured*	*25 aged*
NE Atlantic and Western Channel ICES sub-areas II, V, VI, VII (excluding d) VIII, IX, X, XII, XIV	*1 sample*	*50 fish measured*	*25 aged*

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

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

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

1.5.3 Terminology

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

1.5.4 Intercatch

InterCatch is a web-based system for handling fish stock assessment data. National fish stock catches are imported to InterCatch. Stock coordinators then allocate sampled catches to unsampled catches, aggregate to stock level and download the output. The InterCatch stock output can then be used as input for the assessment models." Stock coordinators used InterCatch for the first time at the 2007 Herring Assessment Working Group. Comparisons between InterCatch and conventional used systems (e.g., Salloc and spreadsheets) were carried out annually since 2007. For the most recent year, the maximum discrepancies between the systems are presented in Table 1.5.2. These are in general very small. However, at the area level, some year-classes show much larger variances. The reasons for these discrepancies have to be elucidated in more detail during an intersessional cooperation between stock-coordinators and ICES InterCatch team.

In principle, the stock coordinators found that InterCatch is a helpful tool that it has the potential to reduce errors and work load of the stock coordinators. Many improvements have been implemented. However, in terms of practical use, there are still problems. The output files from InterCatch still not do supply the WG with the same information as the conventional systems. Especially for the WBSS and NSAS there is no information on CATON and CANUM for Div. IIIa available. Consequently, InterCatch could not be used for the stocks in the Baltic Sea. InterCatch can not be used solely unless this output is produced. Thus the system is regarded as an additional back-up and archiving system, which implies an extra workload for Stock-coordinators and data submitters. This may sum to several men-weeks a year.

1.6 Methods Used

1.6.1 ICA

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

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

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. Last year's assessment, the FLICA package was adjusted to provide raw parameter estimates together with the variance-covariance matrix as standard output from ICA. With this information, the standard diagnostics of ICA were replaced with diagnostics generated within FLR. The WG decided to show results of catchability models and regression residuals as they are actually fitted. Thus, observed indices are treated as dependent variables and VPA estimates of SSB or numbers at age are considered predictor variables. This enhances the visual judgment of the quality of model fit, even though the nature of the data would suggest a reversal of predictor and dependent variables. It may be sensible to take this into account in the way the catchability models are fitted, but this would require changes in the ICA code itself. In addition, a Q-Q plot to show the distribution of the log residuals as compared to a normal distribution was added to the diagnostics output.

This year new diagnostic plots were developed. In particular, plots showing the contribution to the sum of squares (SSQ) of the tuning indices and the catch by age, year and cohort provide a detailed representation of how the model is fitting the data.

1.6.3 MFSP, MSYPR and MFDP

Short-term predictions for the North Sea used MFSP / MSYPR that was developed three years ago in the HAWG (Skagen; WD to HAWG 2003). Other short-term predictions were carried out using the MFDP v.1a software.

1.6.4 STPR used for medium term projections NS herring and VIa (north) herring

Medium term projections were performed with the STPR3 software, supplemented with a version (S3S) made to ease screening over ranges of model parameter choices. The software documentation is available from ICES or as a report (Skagen, 2003). The simulation framework covers alternative scenarios for future recruitment, weight and maturity at age, assessment error, discarding and other unaccounted mortality. The harvest rules can be examined with respect to error in future assessments by assuming that the stock numbers at age, and hence the SSB on which managers make their decisions, deviates from the real state of the stock. STPR3 does this by a simple stochastic multiplier on the stock numbers as seen by decision makers. Likewise, discrepancy between the decided TAC and the catch actually taken is simulated by a common implementation multiplier. This may account for bias due to misreporting etc. Uncertainty due to measurement (i.e. sampling of the catch derivation of CPUE) estimation within the assessment process, model mis-specification and implementation error were not explicitly modelled but assigned a combined assessment error. However, varying feedback between the assessment process and the management decision making process was not included. Feedback can cause bias in the assessment to affect the management and thus the stock which in turn affects bias in the assessment.

The simple approach in STPR allows for some evaluation of the robustness of a harvest rule to such errors, but does not pretend to foresee how these errors will appear in the future. However, to be feasible, one would assume that the harvest rule still should lead to a precautionary management if these errors have an order of magnitude that has been experienced in the past. It may be noted that previous implementation error that has not been accounted for, although it will have influenced the perception of the stock in the past. Hence, implementation error should only cover cases where it may be different from what it was in the past or already documented and explicitly included in past data.

1.6.5 Management simulations

F-PRESS (Fisheries Projection and Evaluation by Stochastic Simulation) is a stochastic simulation tool which can be used to develop probabilistic assessment advice or to evaluate management strategies and harvest control rules (HCRs). F-PRESS is written and runs in R and is designed to be easy to edit by end users to suit their requirements. A description of this tool can be found in the SGMAS report (ICES CM 2006, ACFM:15). Preliminary simulations for Celtic Sea herring were carried out using this tool. These simulations were used to test the medium term behaviour of the stock in a stochastic framework, assuming a range of constant catch strategies.

1.6.6 Separable VPA

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

1.7 Discarding and unaccounted mortality by Pelagic fishing Vessels

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

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

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

In the area considered by HAWG, four nations reported discards from their fleets in 2008. From those, Scotland, Germany and Sweden incorporated discards in the assessment data. The discard figures were raised to national landings (based on the spatial and temporal distribution of the fleet by metier), and used in the assessment of North Sea autumn spawning (see Section 2.3) and VIaN (see Section 5.1.3) herring. For the Netherlands, the estimates of herring discards of approximately 970 tonnes (CV=35%) in 2008 (from a fleet whose total landings is over 300 000 tonnes of fish per year in the ICES area) were not sampled at a high enough resolution to allocate the catch in individual stocks (Helmond & van Overzee WD03; Borges *et al*. 2008).

In the Dutch fleet there appears to be no size selection for landed herring compared to discarded herring (Figure 1.7.1).

No other nations reported on discards of herring in the pelagic fisheries, either because they did not occur, catches were not sampled for discards or there were difficulties with raising procedures (ICES, 2007/ACFM:06). No discard estimates for the total international catch were calculated, on a basis that some of the coverage is still not high enough. There were no other studies on unaccounted fishing mortality in herring presented to HAWG.

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

Conclusion

HAWG has no evidence that discarding of herring is a major problem at present for the estimation of population dynamics of herring, for the conservation of the stocks covered by HAWG, or for the ecosystem as a whole.

1.8 Ecosystem considerations, sprat and herring

Analysis of trends in weight at age and large climatic oscillation in herring stocks

Time series of weight-at-age for North Sea, Western Scotland, Western Baltic, Irish Sea, Celtic Sea and North West of Ireland herring were collected from ICES (2008) last assessment report. A clustering (median linkage ordination analysis) analysis was performed in order to identify groups of different stocks that showed similar trends over time.

Trends in weight at age are shown in Figure 1.8.1.The Irish and Celtic Sea stocks (cluster similarity > 90%) showed a significant decline (Pearson correlation analysis, P-value < 0.001) in the average mean weight at age from 1970 and the trend amplified after 1985 when the values become lower than the long-term mean limit of 0.17 kg. The North West of Ireland stock and the North Sea herring showed also a significant long-term decline in mean weight at age (Pearson correlation analysis, P-value < 0.05). On the contrary, weight at age increased significantly since 1972 for the Western Scotland (Pearson correlation analysis, P-value < 0.05). Western Baltic stock exhibited smaller weight at age compared to other stocks (long-term mean around 0.10 kg) and a stable trend over time, with a small decline occurring between 1998 and 2002. However, the time series is too short (1991-2008) to allow for any conclusion on the long term trend for this stock.

A principal components analysis (PCA) was applied to the time series of weight at age. Western Baltic herring was excluded as the time series is relatively short compared to the other stocks. The first PCA component (PCA1) explained 61% of the year variability of stock weight at age (Figure 1.8.2).

Monthly values of AMO (Atlantic Multidecadal Oscillation) index (Enfiled *et al*. 2001; Rayner *et al*. 2003) were obtained from AMO official web site (http://www.cdc.noaa.gov/data/timeseries/AMO). The time series are calculated from the Kaplan sea surface temperature (SST) dataset which is updated monthly. AMO is basically considered as an index of the long term trend of the North Atlantic temperatures.

First, a cross-correlation function was applied to the untransformed data of PCA1 and the yearly median of the AMO data set (AMOA). A significant correlation was evident at different lags with the largest correlation observed at lag 0 (1.8.3a). However, both time series exhibited a strong trend during the time period analysed (Figure 1.8.2). Therefore, both PCA1 and AMOA were detrended applying the following formula:

$\mu = x - (a + b \cdot t)$

where x is the average, t is the time and a and b are the parameters estimated directly from the data. The cross-correlation function was then re-applied on the detrended data. The results showed that after detrending, the relationship between PCA1 and AMOM was not significant (Figure 1.8.3b).

HAWG concluded that the possible link between trends in weight-at-age and climate conditions should be investigated at a finer spatial scale, using stock specific time series of monthly SST in assumed key-periods for growth and condition of herring stocks.

1.9 Pelagic Regional Advisory Council [Pelagic RAC]

Members of HAWG have attended meetings of the Pelagic RAC since its inauguration in 2005. HAWG considers the views of the Pelagic RAC as important, and welcomes the formation of this forum to give stakeholders a role in the advisory process. HAWG notes that the Pelagic RAC also has special representation by non-EU countries, notably from Norway.

Most relevant documents from the Pelagic RAC to ICES and the European Commission about herring assessment and management were available to HAWG.

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

Assessment Working Group (AWG) recommendations

The Group reviewed AWG reports with respect to recommendations addressed to PGCCDBS and processed these for either further action/other groups (like RCM, LM). The relevant recommendations for HAWG and the PGCCDBS response is listed in the below table.

Recommendation	addressed to
HAWG recommends that all metiers with substantial catch should be sampled (including by-catches in the small meshed fishery)	This is a matter for the relevant RCM's, to address when considering the harmonization and coordination of National Programmes. ACOM members (Norway) also need to consider this when setting annual sampling programmes.
HAWG encourages further examination of the observed internannual variability in maturity ogive using appropriate scientific methodology	Handled by WKMOG. A Workshop on Sexual Maturity Staging of Herring and Sprat [WKMSHS] (Chairs: Jonna Tomkiewicz and Cindy van Damme/Gerd Kraus) is planned for 2009
HAWG recommends a workshop on the identification of clupeid fish larvae to ensure data quality. This WS should especially deal with possible sources of misidentification of sprat, herring and other clupeid larvae	This recommendation was also referred to PGIPS, and PGCCDBS was of the opinion that PGIPS was the appropriate group to assess this request.

Stock Data Problems Relevant to Data Collection

HAWG identified the following issues for further discussion by the PGCCDBS in relation to stock data problems relevant to data collection:

Request for guidance on the sampling of landings of flagged vessels landing into different states under the DCF.

HAWG found that there are no formal agreements or procedures on the exchange of data collected from samples from vessels landing abroad, e.g. how do you exchange, and at what level, the information from English catch sampled when landed in The Netherlands? Upon requesting clarification from colleagues involved in the DCF and PGCCDBS, none was forthcoming. HAWG decided that in the absence of guidance, they would suggest that this should be resolved on a case by case basis, but preferred to receive guidance from PGCCDBS. HAWG perceive that problems associated with the handling and exchange of data from sampling foreign vessels are likely to increase in frequency as the EU moves towards collecting data by fleet and metier rather than by nation.

As shown by the project EMAS and the ICES study group on market sampling methodology (ICES 1999 and 2000), individual National laboratories have different sampling procedures therefore, it would not be appropriate to raise samples obtained in the context of a particular sampling strategy by means of procedures conceived for a different strategy In the case of English flagged vessels landing in the Netherlands, it was agreed that the numbers and weights at age profiles per area and quarter obtained from raw data by the institute sampling at the port of landing would be submitted to the other institute who would be responsible for determining the best estimate of the age composition of the catch for their own flagged vessels. Crucially activities should not be replicated. Given results from the studies above, the quality of the data submitted would be considered acceptable as long as the standard protocols of the sampling institute were documented and followed. Due to language problems, these protocols may not be readily available to the receiving institutes.

Stock	Description of Data Problem	How to Be addressed?	By who
North Sea herring	Guidance on the sampling of landings of flagged vessels landing into different states under the DCF.	PGCCDBS, North Sea RCM, Western RCM	PGCCDBS, North Sea RCM, Western RCM
All stocks	Spatial data and information on sampling coverage and precision needs to be provided and if possible used in the assessment.	PGCCDBS should formulate data requirements	PGCCDBS and in turn the DCF

1.11 Stock overview

Analytical assessment could be carried out for four of these eleven stocks. 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 is the largest stock assessed by this WG. It has experienced very low spawning stock biomass levels in the late 1970s when the fishery was closed for a number of years. This stock began to recover until the mid-1990s, when it appeared to decrease again rapidly. A management scheme was adopted to halt this decline. Given this, ICES advises on the basis of the agreed EU–Norway management plan. Based on the most recent estimates of SSB and fishing mortality, ICES classifies the stock as being at risk of having reduced reproductive capacity and harvested sustainably. The SSB in autumn 2008 was estimated at 1.0 million t, and is expected to remain below B_{pa} (1.3 million t) in 2009. F_{2-6} in 2008 was estimated at 0.24, above the target F_{2-6} of 0.14. The year classes since 2002 are estimated to be among the weakest since the late 1970s. Following the agreed management plan implies catches of 164 300 t for fleet A and 10 400 t for fleet B in 2010 in the North Sea which is expected to lead to SSB of 1.21 million tonnes in 2011.

Western Baltic Spring Spawners (WBSS) 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 Sub-Divisions 22, 23 and 24. Within the northern area, the stock mixes with North Sea autumn spawners. An analytical assessment demonstrates that the SBB has been stable over the last decade, although the most recent value is in the lower quartile of all observations. Fishing mortality has also been stable in the same period but is larger than any proxy of F_{msy}. Recruitment has declined consistently since 2003 and the estimated number of 0-ringers in 2008 is the lowest observed value. These poor year classes have not had a dramatic effect on the spawning stock biomass as yet, due to the comparatively large size and good growth of the 2003 year class. This year class has been the largest component of the SSB for the last three years (2006-2008) and has supported the stock during this period. However, this year class is now in decline, and will pass out of the stock in the next two years, whilst its place will be taken by the sequence of poor year classes: a continuation of the decline in SSB can therefore be expected in the short and medium term.

Celtic Sea herring: The herring fisheries to the south of Ireland in the Celtic Sea and in Division VIIj have been considered to exploit the same stock. For the purpose of stock assessment and management, these areas have been combined since 1982. The fishery in the eastern part of the Celtic Sea was closed in the early eighties due to poor recruitment. In recent years the assessment has been presented as indicative of trends. In 2009 HAWG put forward an analytical assessment for this stock. The assessment showed SSB being above B_{pa} and mean F_{2-5} to be declining. Overall recruitment is around long term mean. The stock is recovering. However it is still very dependent on the strength of the incoming year class, which is poorly estimated.

West of Scotland herring: 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, but in 2004 and 2005 misreporting increased again. In the absence of precautionary reference points the state of the stock cannot be evaluated. An analytical assessment shows that SSB (in 2009) is 1.8 times Blim. ICES considers that the stock is currently fluctuating at a low level and is being exploited close to F_{msy}. Recruitment has been low since 1998.

Herring in VIa south and VIIbc are considered to consist of a mixture of autumn- and winter/spring-spawning fish. The winter/spring-spawning component is distributed in the northern part of the area. The main decline in the overall stock since 1998 appears to have taken place on the autumn-spawning component, and this is particularly evident on the traditional spawning grounds in VIIb. However, there are indications that the stock is on a historically low level. The current levels of SSB and F are not precisely known, as there is no tuned assessment available for this stock. There are no sign of stock recovery in VIaS herring.

Irish Sea autumn spawning herring comprises of two spawning groups (Manx and Mourne). This stock complex experienced a very low biomass level in the late 1970s with an increase in the mid-1980s after the introduction of quotas. The stock then declined from the late 1980s to its present level. During this time period the contribution of the Mourne spawning component declined. 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. It seems likely that the stock has been relatively stable for the last 10 years, and that fishing mortality does not appear to be increasing above the recent average. The catches have been close to TAC levels in recent years and the main fishing activity has not varied considerably. An increase in activity on the Mourne spawning area has been observed since 2006. There is some evidence of increased recruitment in the stock in most recent years.

North Sea Sprat is a short-lived species. The recruits account for a large proportion of the stock, and the fishery in a given year is very dependent on that year's incoming year class. The size of the stock has been variable with a large biomass in the early 90's followed by a sharp decline. The state of the stock is uncertain. Survey trends indicate the stock size has varied around an average level with no trend. There is no analytical assessment for this stock.

1.12 Structure of the report

The report below further details in each chapter the available information on the catch, fisheries and biology of the stocks and then the stock assessments, the projections, the quality of the assessments and management considerations for each stock. This information and analyses are given in chapters for each of the seven major stocks considered by HAWG. Despite this structure, it is important to realise that there are many links between the stocks and/or areas. (e.g. North Sea and herring caught in IIIa; VIaN herring and the North Sea; VIaS, VIIbc, Irish Sea and VIaN herringand Celtic Sea and Irish Sea herring).

In 2009 HAWG carried out one three assessments: western Baltic spring spawning herring. North Sea autumn spawning herring and VIaN autumn spawning herring. These were update assessments in 2009. Based on improved data availability the Celtic Sea autumn and winter spawning stock assessment was accepted by the group as an improved update of the benchmark assessment conducted in 2007. Irish Sea herring and North Sea sprat were all exploratory assessments. One stock with poor data (IIIa sprat) is described in Section 9. Two stocks, with very poor data (no catch at age sampling) and no current ongoing research are described in Section 10. These are Clyde herring and sprat in the English Channel.

1.13 Recommendations

Please see Annex 2.

Table 1.5.1 Available disaggregated data for the HAWG per March 2009. X: Multiple spreadsheets (usually .xls); W: WG-data national input spreadsheets (xls); D: Disfad inputs and Alloc-outputs (ascii/txt); I: Intercatch input

Stock	Catchyear	Format				Comments
		X	W	D	I	
Western Baltic Sea:						
IIIa and SD 22-24	1991-2000	X				raw data, provided by Jørgen Dalskov, Mar. 2001, splitting revised
(her_3a22)	1998	X				provided by Jørgen Dalskov, Mar. 2001, splitting revised
	1999	X				provided by Jørgen Dalskov, Mar. 2001, splitting revised, catch data re
	2000	X				provided by Jørgen Dalskov, Mar. 2001
	2001	X				provided by Jørgen Dalskov, Mar. 2002
	2002	X				provided by Jørgen Dalskov, Mar. 2003
	2003	X				provided by Jørgen Dalskov, Mar. 2004
	2004	X	W	D		provided by Lotte Worsøe Clausen, Mar. 2005
	2005	X	W	D		provided by Lotte Worsøe Clausen, Mar. 2006
	2006	X	W	D	(I)	provided by Mikael van Deurs, Mar. 2007
	2007	X	W	D	I	provided by Lotte Worsøe Clausen, Mar. 2008
	2008	X	W		I	provided by Lotte Worsøe Clausen, Mar. 2009
Celtic Sea and VIIj						
(her_irls)	1999	X				provided by Ciarán Kelly, Mar. 2000
	2000	X				provided by Ciarán Kelly, Mar. 2001
	2001			D		provided by Ciarán Kelly, Mar. 2002
	2002			D		provided by Ciarán Kelly, Mar. 2003
	2003			D		provided by Maurice Clarke, Mar. 2004
	2004			D		provided by Maurice Clarke, Mar. 2005
	2005			D		provided by Maurice Clarke, Mar. 2006
	2006			D	I	provided by Maurice Clarke, Mar. 2007
	2007		W		I	provided by Afra Egan, Mar. 2008
	2008		W		I	provided by Afra Egan, Mar. 2009
Clyde						
(her_clyd)	1999	X				provided by Mark Dickey-Collas, Mar. 2000
	2000-2003					included in VIaN
Irish Sea						
(her_nirs)	1988-2003	X				updated by SG HICS, March 2004
	1998	X				provided by Mark Dickey-Collas, Mar. 2000
	1999	X				provided by Mark Dickey-Collas, Mar. 2000
	2000	X	W			provided by Mark Dickey-Collas, Mar. 2001
	2001	X	W			provided by Mark Dickey-Collas, Mar. 2002
	2002	X	W			provided by Richard Nash, Mar. 2003
	2003	X	W			provided by Richard Nash, Mar. 2004
	2004	X	W			provided by Beatriz Roel, Mar. 2005
	2005		W			provided by Steven Beggs, Mar. 2006
	2006		W		I	provided by Steven Beggs, Mar. 2007
	2007		W		I	provided by Steven Beggs, Mar. 2008
	2008		W		I	provided by Steven Beggs, Mar. 2009
North Sea						
(her_47d3, her_nsea)	1991	X				provided by Yves Verin, Feb. 2001
	1992	X				provided by Yves Verin, Feb. 2001
	1993	X				provided by Yves Verin, Feb. 2001
	1994	X				provided by Yves Verin, Feb. 2001
	1995	X	W	D		provided by Yves Verin, Feb. 2001, updated Oct 2003
	1996	(X)	W	D		provided by Yves Verin, Feb. 2001, updated Oct 2003
	1997	(X)	W	D		provided by Yves Verin, Feb. 2001, updated Oct 2003
	1998	(X)	W	D		provided by Yves Verin, Mar. 2000, updated Oct 2003
	1999		W	D		provided by Christopher Zimmermann, Mar. 2000, updated Oct 2003
	2000		W	D		provided by Christopher Zimmermann, Mar. 2001, updated Oct 2003
	2001		W	D		provided by Christopher Zimmermann, Mar. 2002
	2002		W	D		provided by Christopher Zimmermann, Mar. 2003
	2003		W	D		provided by Christopher Zimmermann, Mar. 2004
	2004		W	D		provided by Christopher Zimmermann, Mar. 2005
	2005		W	D		provided by Christopher Zimmermann, Mar. 2006
	2006		W	D	I	provided by Norbert Rohlf, Mar. 2007
	2007		W	D	I	provided by Norbert Rohlf, Mar. 2008
	2008		W	D	I	provided by Norbert Rohlf, Mar. 2009
West of Scotland (VIa(N))						
(her_vian)	1957-1972	x				provided by John Simmonds, Mar. 2004
	1997	X				provided by Ken Patterson, Mar. 2002
	1998	X				provided by Ken Patterson, Mar. 2002
	1999		W	D		provided by Paul Fernandes, Mar. 2000, W included in North Sea
	2000		W	D		provided by Emma Hatfield, Mar. 2001, W included in North Sea
	2001		W	D		provided by Emma Hatfield, Mar. 2002, W included in North Sea
	2002		W	D		provided by Emma Hatfield, Mar. 2003, W included in North Sea
	2003		W	D		provided by Emma Hatfield, Mar. 2004, W included in North Sea
	2004		W	D		provided by John Simmonds, Mar. 2005, W included in North Sea
	2005		W	D		provided by Emma Hatfield, Mar. 2006, W included in North Sea
	2006		W	D		provided by Emma Hatfield, Mar. 2007
	2007		W	D	I	provided by Emma Hatfield, Mar. 2008
	2008		W	D	I	provided by Emma Hatfield, Mar. 2009
West of Ireland						
(her_irlw)	1999	X	(W)			provided by Ciaran Kelly, Mar. 2000
	2000	X	(W)			provided by Ciaran Kelly, Mar. 2001
	2001			D		provided by Ciaran Kelly, Mar. 2002
	2002			D		provided by Ciaran Kelly, Mar. 2003
	2003			D		provided by Maurice Clarke, Mar. 2004
	2004			D		provided by Maurice Clarke, Mar. 2005
	2005			D		provided by Afra Egan, Mar. 2006
	2006			D	I	provided by Afra Egan, Mar. 2007
	2007		W		I	provided by Afra Egan, Mar. 2008
	2008		W		I	provided by Afra Egan, Mar. 2009

Table 1.5.1: Available disaggregated data for the HAWG per March 2009. continued

Sprat in IIIa						
(spr_kask)	1999	X	(W)			provided by Else Torstensen, Mar. 2000
	2000	X	(W)			provided by Else Torstensen, Mar. 2001
	2001	X	(W)	D		provided by Lotte Askgaard Worsøe, Mar. 2002
	2002	X	(W)	D		provided by Lotte Worsøe Clausen, Mar. 2003
	2003	X	(W)	D		provided by Lotte Worsøe Clausen, Mar. 2004
	2004	X	(W)	D		provided by Lotte Worsøe Clausen, Mar. 2005
	2005	X	(W)	D		provided by Lotte Worsøe Clausen, Mar. 2006
	2006	X	(W)	D		provided by Mikael van Deurs, Mar. 2007
	2007	X	(W)	D		provided by Lotte Worsøe Clausen, Mar. 2008
	2008	X	(W)	D		provided by Lotte Worsøe Clausen, Mar. 2009
Sprat in the North Sea						
(spr_nsea)	1999	X	(W)			provided by Else Torstensen, Mar. 2000
	2000	X	(W)			provided by Else Torstensen, Mar. 2001
	2001	X	(W)	D		provided by Lotte Askgaard Worsøe, Mar. 2002
	2002	X	(W)	D		provided by Lotte Worsøe Clausen, Mar. 2003
	2003	X	(W)	D		provided by Lotte Worsøe Clausen, Mar. 2004
	2004	X	(W)	D		provided by Lotte Worsøe Clausen, Mar. 2005
	2005	X	(W)	D		provided by Lotte Worsøe Clausen, Mar. 2006
	2006	X	(W)	D		provided by Mikael van Deurs, Mar. 2007
	2007	X	(W)	D	I	provided by Lotte Worsøe Clausen, Mar. 2008
	2008	X	(W)	D	I	provided by Lotte Worsøe Clausen, Mar. 2009
Sprat in VIId & e						
(spr_ech)	1999	X	(W)			provided by Else Torstensen, Mar. 2000
	2000	X	(W)			provided by Else Torstensen, Mar. 2001
	2001	X	(W)	D		provided by Lotte Askgaard Worsøe, Mar. 2002
	2002	X	(W)	D		provided by Lotte Worsøe Clausen, Mar. 2003
	2003	X	(W)	D		provided by Lotte Worsøe Clausen, Mar. 2004
	2004	X	(W)	D		provided by Lotte Worsøe Clausen, Mar. 2005
	2005	X	(W)	D		provided by Lotte Worsøe Clausen, Mar. 2006
	2006	X	(W)	D		provided by Mikael van Deurs, Mar. 2007
	2007	X	(W)	D	I	provided by Else Torstensen, Mar. 2008
	2008	X	(W)	D	I	provided by Else Torstensen, Mar. 2009
National Data						
Germany: Western Balti	1991-2000	X				provided by Tomas Gröhsler, Mar. 2001 (with sampl
Germany: North Sea	1995-1998		W			provided by Christopher Zimmermann, Mar 2001 (w
Norway: Sprat	1995-1998		W			provided by Else Torstensen, Mar 2001 (without sam
Sweden	1990-2000		W			provided by Johan Modin, Mar 2001 (without samp
UK/England & Wales	1985-2000	X				database output provided by Marinelle Basson, Mar.
UK/Scotland	1990-1998		W			provided by Sandy Robb/Emma Hatfield, Mar. 2002

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

North Sea (47d3)

2008 age	CANUM Sallocl	CANUM IC	Proportion Match (%)	2008 age	WECA salloc	WECA IC	Proportion Match (%)
0	798284	798284	100.000	0	0.008	0.008	99.496
1	235022	235145	99.948	1	0.054	0.054	99.944
2	331772	331750	100.007	2	0.129	0.129	99.984
3	184771	184621	100.081	3	0.180	0.180	99.994
4	199069	198789	100.141	4	0.181	0.181	100.000
5	137529	137494	100.026	5	0.183	0.183	99.978
6	118349	118314	100.030	6	0.216	0.216	100.005
7	215542	215285	100.120	7	0.216	0.216	99.986
8	74339	74334	100.006	8	0.256	0.256	99.980
9+	42919	42922	99.994	9+	0.273	0.273	99.996

West of Scotland (VIaN)

2008 age	CANUM Sallocl	CANUM IC	Proportion Match (%)	2008 age	WECA salloc	WECA IC	Proportion Match (%)
1	0	0		1	0.000	0.000	
2	7898	7899	99.994	2	0.171	0.171	99.877
3	13039	13040	99.995	3	0.206	0.206	100.136
4	5428	5427	100.007	4	0.231	0.231	99.853
5	3220	3220	99.973	5	0.231	0.231	99.896
6	5689	5689	100.001	6	0.249	0.249	100.084
7	14832	14832	99.999	7	0.253	0.253	99.937
8	8142	8143	99.994	8	0.284	0.284	100.011
9+	8969	8968	100.002	9+	0.288	0.288	100.049

Irish Sea (her-nirs)

2008 age	CANUM Excel	CANUM IC	Proportion Match (%)	2008 age	WECA Excel	WECA IC	Proportion Match (%)
1	8939	8939	100.000	1	0.071	0.071	99.995
2	18974	18974	100.000	2	0.110	0.110	99.998
3	7487	7487	100.000	3	0.135	0.135	99.999
4	2696	2696	100.000	4	0.153	0.153	99.998
5	2082	2082	100.000	5	0.156	0.156	100.003
6	1761	1761	100.000	6	0.182	0.182	99.998
7	328	328	100.000	7	0.196	0.196	100.003
8	190	190	99.999	8	0.204	0.204	100.002
9+	27	27	99.998	9+	0.225	0.225	100.000

Her IRLW

2008 age	CANUM Excel	CANUM IC	Proportion Match (%)	2008 age	WECA Excel	WECA IC	Proportion Match (%)
1	483	483	100.00%	1	0.111	0.111	100.00%
2	12265	12265	100.00%	2	0.148	0.148	100.00%
3	19661	19659	99.99%	3	0.150	0.150	100.00%
4	28483	28479	99.98%	4	0.166	0.166	100.00%
5	11110	11109	99.98%	5	0.175	0.175	100.00%
6	5989	5984	99.93%	6	0.185	0.185	100.00%
7	2738	2744	100.23%	7	0.194	0.194	99.98%
8	745	744	99.84%	8	0.199	0.199	100.00%
9+	267	267	99.85%	9+	0.241	0.241	100.07%

Her IRLS (Celtic Sea)

2008 age	CANUM Excel	CANUM IC	Proportion Match (%)	2008 age	WECA Excel	WECA IC	Proportion Match (%)
1	1288	1288	99.99%	1	0.091	0.091	100.00%
2	12468	12468	100.00%	2	0.120	0.120	100.00%
3	8144	8144	100.00%	3	0.144	0.144	100.00%
4	15565	15565	100.00%	4	0.156	0.156	100.00%
5	2328	2328	100.00%	5	0.172	0.172	100.00%
6+	909	908	99.93%	6+	0.193	0.194	100.17%

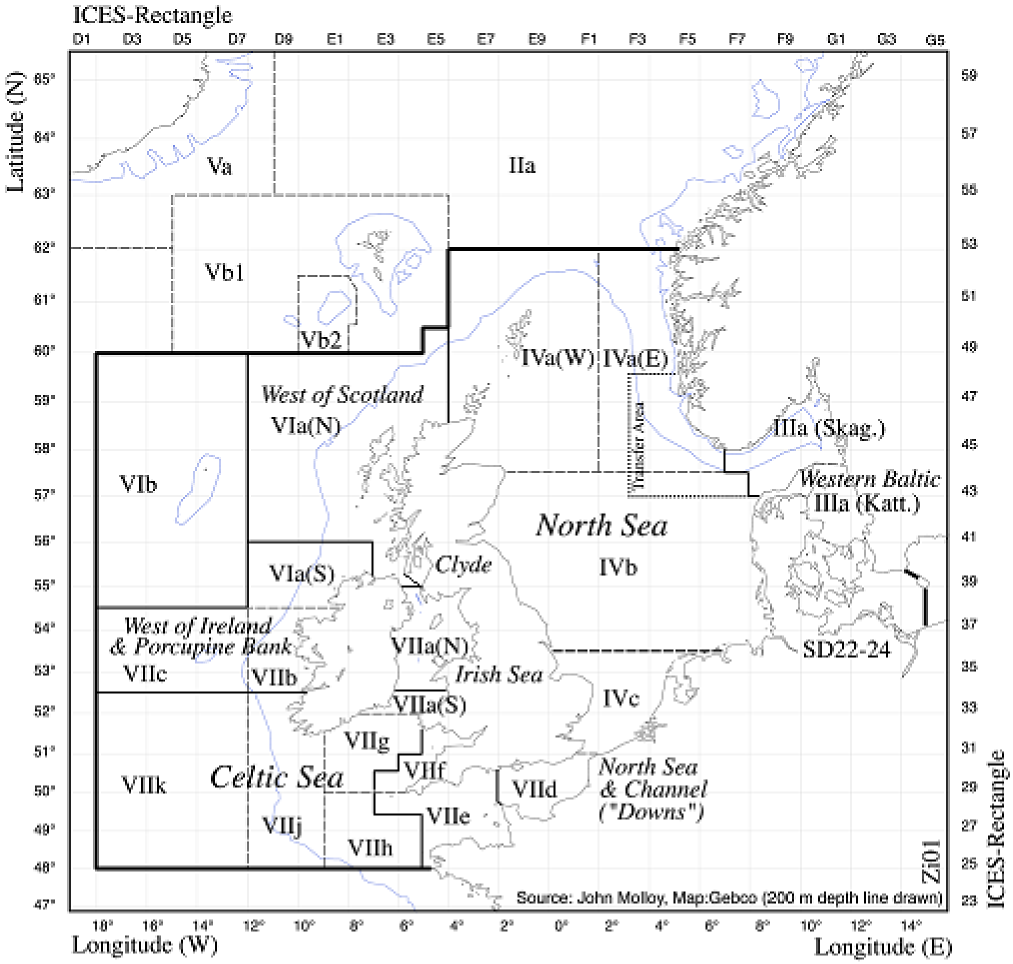


Figure 1.5.1 ICES areas as used for the assessment of herring stocks south of 62°N. Area names in italics indicate the area separation applied to the commercial catch and sampling data kept in long term storage. "Transfer area" refers to the transfer of Western Baltic Spring Spawners caught in the North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

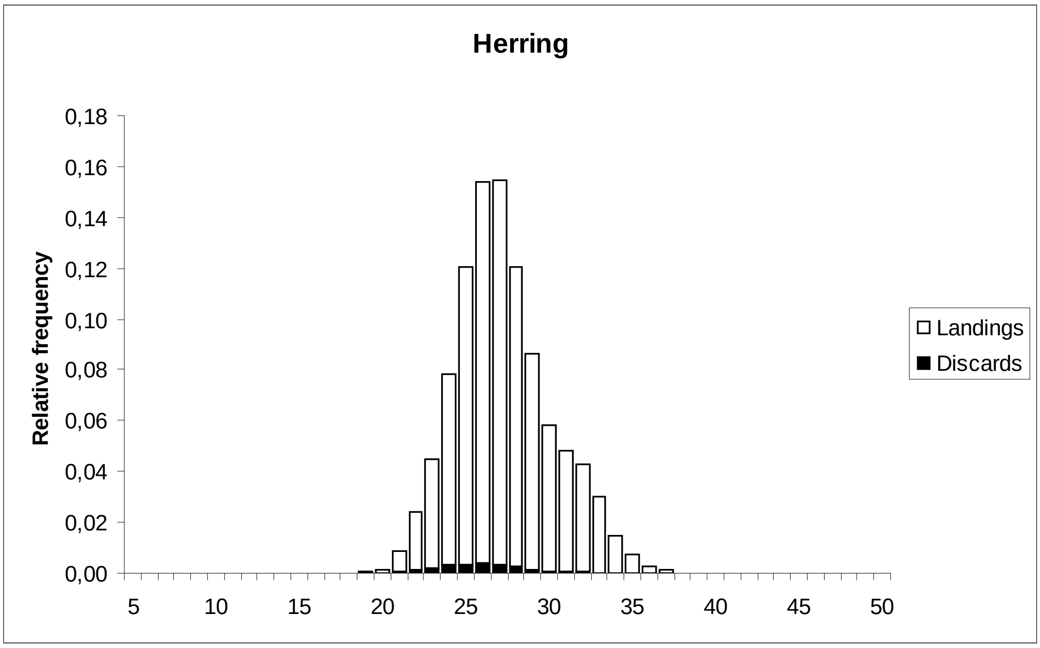


Figure 1.7.1 Relative length frequency of discarded and landed herring by the sampled Dutch pelagic freezer trawler fleet between 2003 and 2008 in the ICES area.

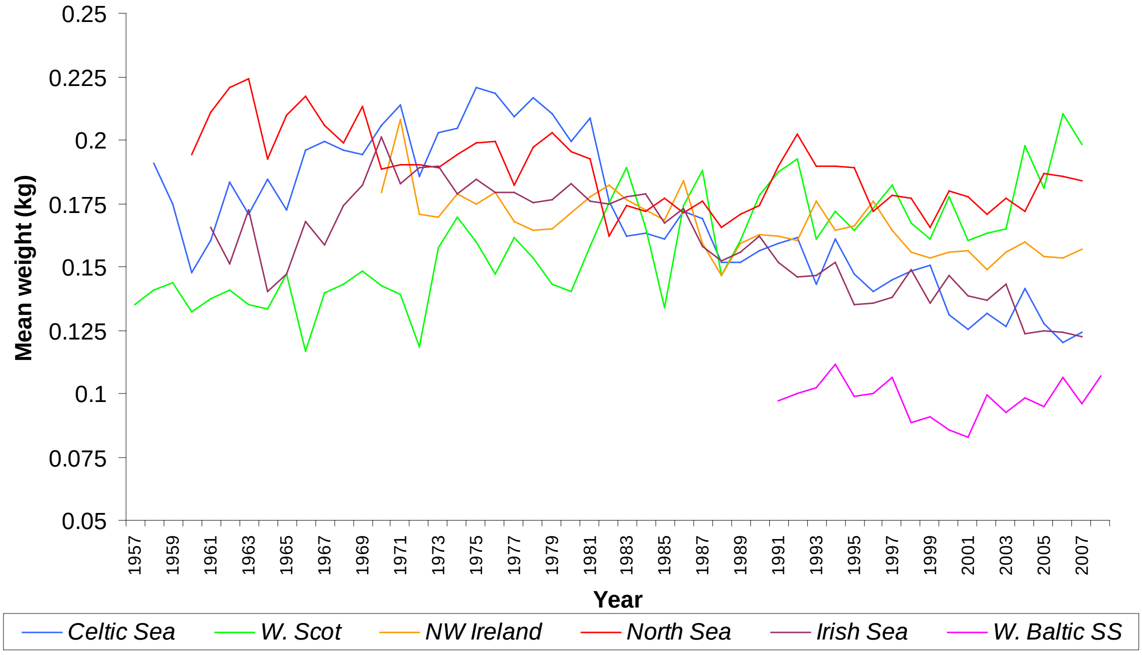


Figure 1.8.1 Long-term trend of annual mean-weight-at-age average over the time, for the different herring stocks (1. Celtic Sea: Celtic sea + Division VIIj; 2. W. Scot: VIa (North); 3. NW. Ireland: VIaS + VIIb,c; 4. North sea: 47d3; 5. Irish sea: VIIa (North); 6. W.Baltic SS: IIIa22).

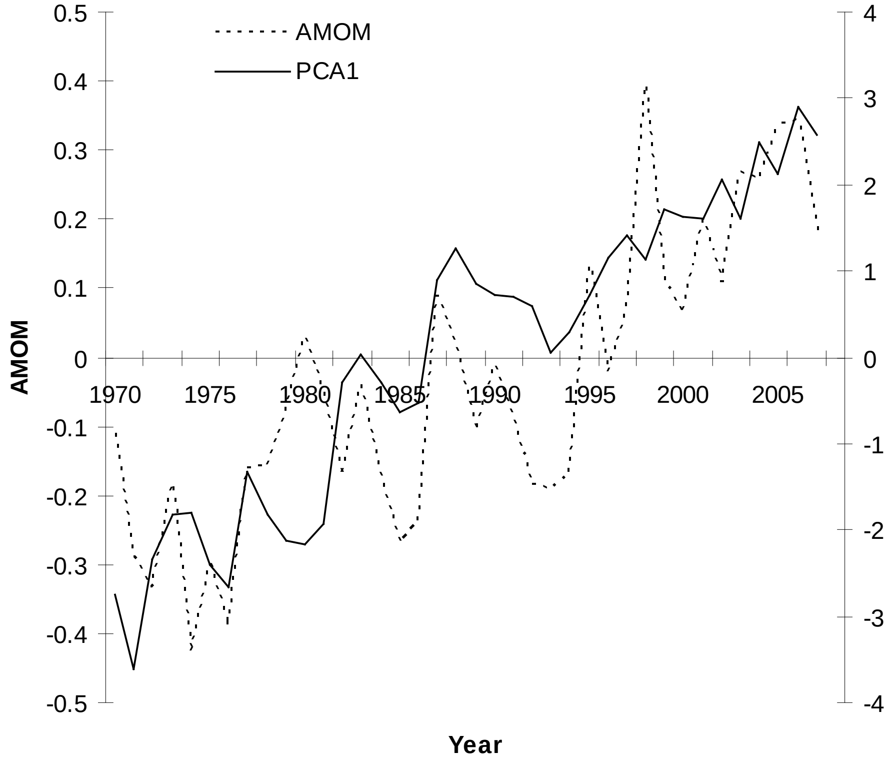


Figure 1.8.2 First component (PCA1) of a Principal Component Analysis (PCA) of the weight at age time series and median of the monthly average of AMO (Atlantic Multidecadal Oscillation).

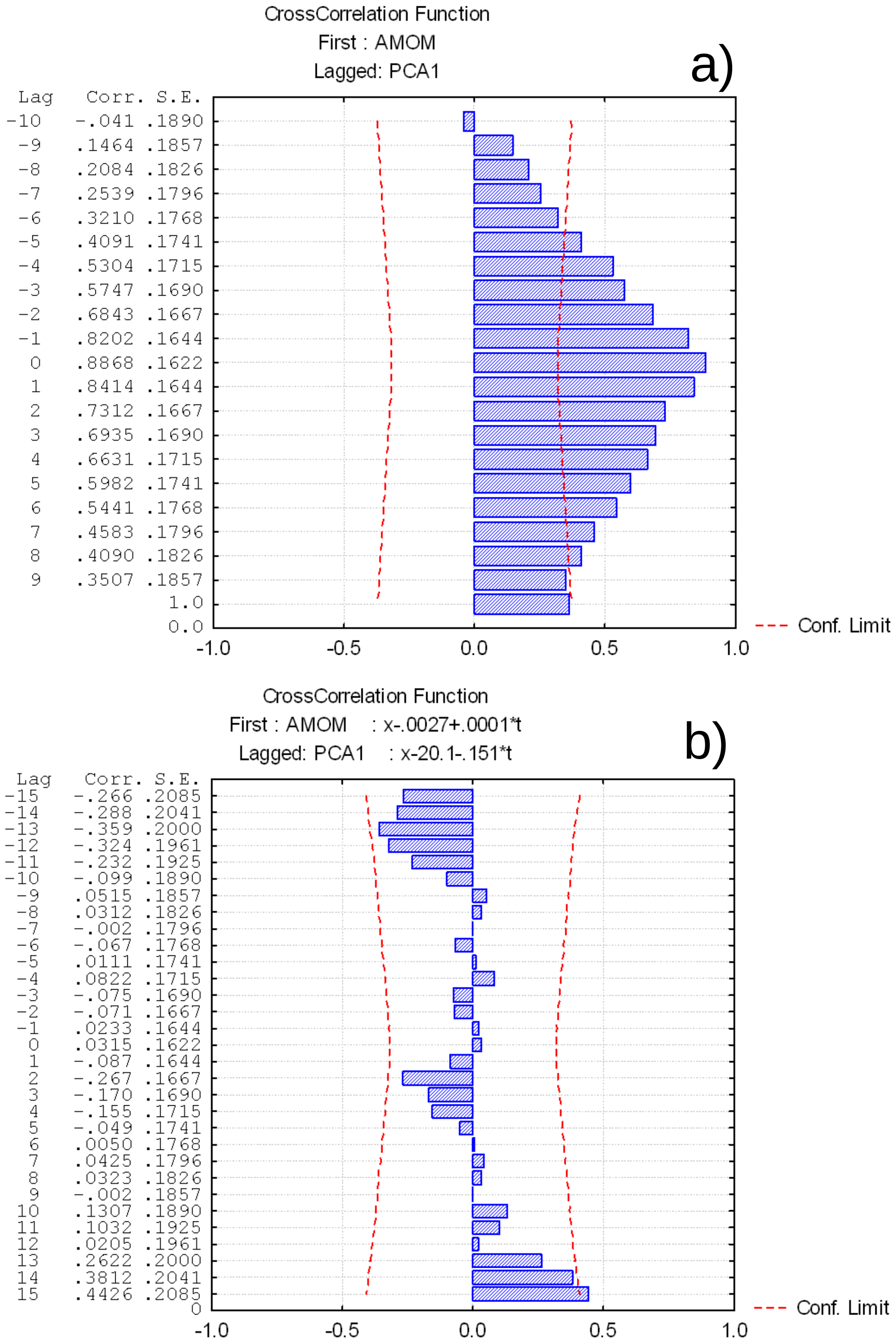


Figure 1.8.3 Cross correlation function between Principal Component Analysis (PCA) of the weight at age time series and median of the monthly average of AMO (Atlantic Multidecadal Oscillation). a) before detrending and b) after detrending.

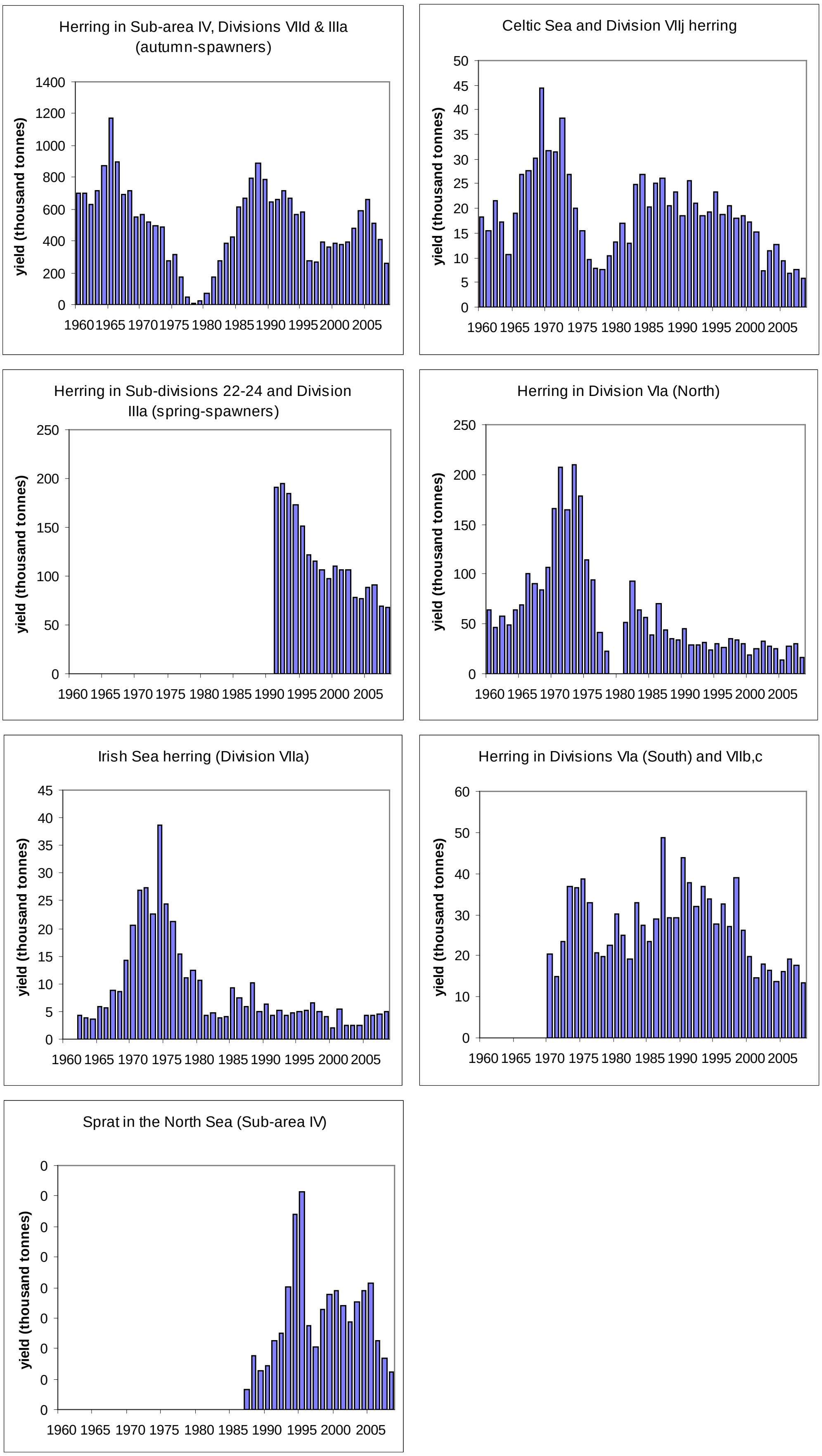


Figure 1.11.1 WG estimates of catch (yield) of the stocks presented in HAWG 2009.

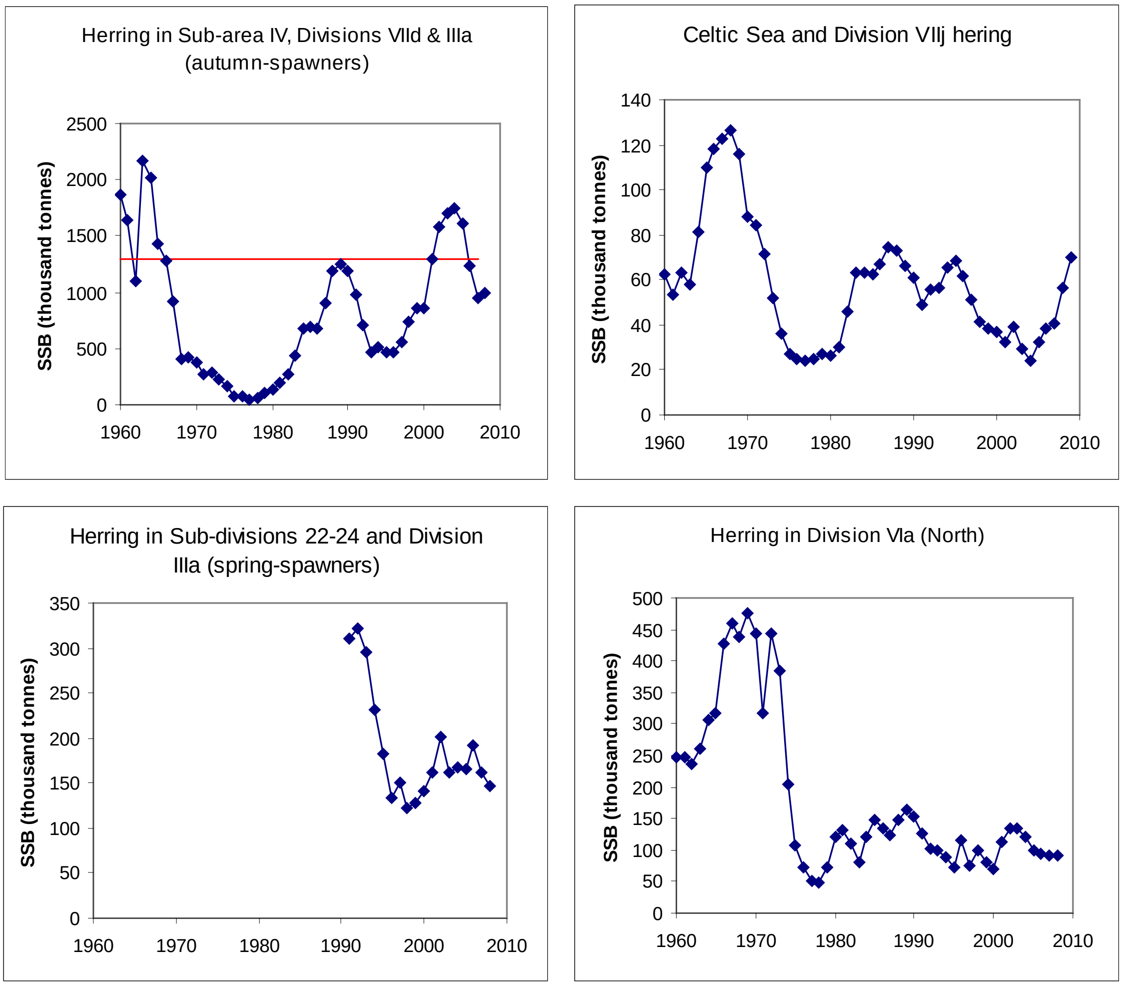


Figure 1.11.2 Spawning stock biomass estimates of the 4 herring stocks for which analytical assessments were presented in HAWG 2009. The B_{pa} level (if defined) is indicated in the graphs.

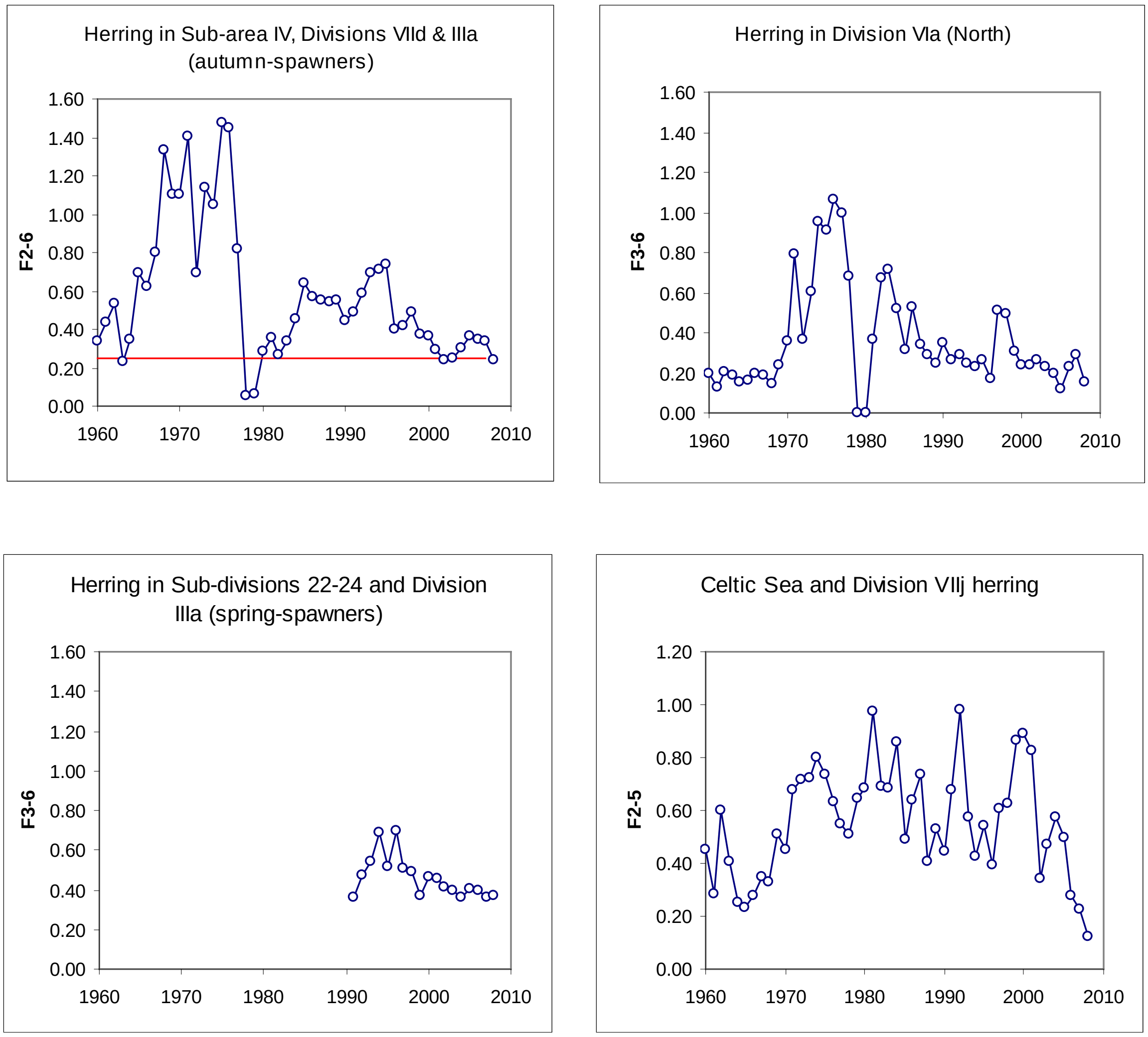


Figure 1.11.3 Estimates of mean F of the 4 herring stocks for which analytical assessments were presented in HAWG 2009. The F_{pa} level (if defined) is indicated in the graphs.

2 North Sea Herring

2.1 The Fishery

2.1.1 ICES advice and management applicable to 2008 and 2009

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

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

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

When the harvest rule leads to SSB below the trigger biomass (1.5 million tonnes), an iterative procedure is needed to find a fishing mortality and a corresponding SSB in the TAC year (see Stock Annex 3).

The final TAC adopted by the management bodies for 2008 was 201 227 t for Area IV and Division VIId, whereof not more than 26 661 t should be caught in Division IVc and VIId. For 2009, the total TAC was reduced by 15% to 186 985 t (171 000 t for the A-Fleet), including a TAC of 23 567 t for Division IVc and VIId.

The by-catch ceiling set for fleet B in the North Sea was 18 806 t for 2008 and was decreased by 15% to 15 985 t for 2009. As North Sea autumn spawners are also caught in Division IIIa, regulations for the fleets operating in this area have to be taken into account for the management of the WBSS stock (see Section 3). Catches of herring in the Thames estuary are 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 2008

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 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. Denmark and Norway provided information on by-catches of herring in the industrial fishery. These are taken in the small-meshed fishery (B-fleet) under an EU quota by Denmark and are included in the A-fleet figures for Norway. Catch estimates of herring taken as by-catch by other small-mesh fisheries in the North Sea may be an underestimate. The total Working Group catch of all herring caught in the North Sea in 2008 amounted to 245 000 t.

Landings of herring taken as by-catch in the Danish small-meshed fishery in the North Sea have increased by more than 20 % to 8 606 t as compared to last year (Table 2.1.6). These industrial herring catches were much lower than the by-catch ceiling set by the EU (18 800 t).

In the Norwegian industrial fishery, herring by-catch has decreased substantially in 2008 to 50 t (compared to 345 t last year).

Official catches by the human consumption fishery were 219 100 t in 2008 (9 % above the TAC). Working group catches in the human consumption fishery were 236 400 t in 2008 (decreased by 38 % from last year). The excess over the TAC for the human consumption fishery amounted to 35 200 t (17 %) in the actual year.

In the southern North Sea and the Eastern Channel, the total catch of 39 000 t in 2007 was slightly higher than the TAC of 37 500 t. The over catch ratio increased again in 2008, when the catch exceed the TAC by 2 900 tonnes.

The total North Sea TAC and catch estimates for the years 2000 to 2008 are shown in the table below (adapted from Table 2.1.6). Since the introduction of yearly by-catch ceilings in 1996, these ceilings have never been exceeded.

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008
TAC HC ('000 t)	265	265	265	400	460	535	455	341	201
"Official" landings HC ('000 t)[1]	267	275	282	414	484	547	478	354	219
Working Group catch HC ('000 t)	328	303	331	438	537	617	498	381	236
Excess of landings over TAC HC ('000 t)	63	38	66	38	77	83	43	40	35
By-catch ceiling ('000 t) [2]	36	36	36	52	38	50	42	32	19
Reported by-catches ('000 t) [3]	18	20	22	12	14	22	12	7	9
Working Group catch North Sea ('000 t)	346	323	353	450	550	639	511	388	245

HC = human consumption fishery

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

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

3 provided by Denmark only.

2.1.3 Regulations and their effects

Landings taken in the North Sea but reported from other areas such as Divisions IIa and IIIa and from Division VIaN have decreased in 2008 compared to 2007 (from 26 000 t to 17 000 t). The estimates of the total amount of catch in excess of the TAC in the human consumption fishery (excluding within-area misreporting) was about 35 000 t, which is similar to last year. Along with the reduction of TACs, which have been put into place since 2006, the proportion of catch exceeding the TAC for the human consumption has increased from 9% in 2006 up to 17% in 2008.

Following the apparent recovery of the autumn spawning North Sea herring, some regulatory measures were amended: In 2004, the total Norwegian quota and half of the EU quota for Division IIIa could be taken in the North Sea. A licence scheme introduced in 1997 by UK/Scotland to reduce misreporting between the North Sea and VIaN was relaxed. The minimal amount of target species in the EU industrial fisheries in IIIa has been reduced to 50 % (for sprat, blue whiting and Norway pout). In 2009, Norway can take up to 20 % of it's quota for Division IIIa in the North Sea.

2.1.4 Changes in fishing technology and fishing patterns.

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

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, Western Baltic spring spawners (only in IVaE), and the total NSAS stock, including catches in Division IIIa.

Biological information on the NSAS caught in Division IIIa was obtained using splitting procedures described in Sec. 3.2 and in the stock annex 2. Note that splitting was only applied to the working group catch, following the correction of area misreporting.

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 1993-2008 (herring caught in the North Sea)
- Table 2.2.8: WBSS taken in the North Sea (see below)
- Table 2.2.9: NSAS caught in Division IIIa
- Table 2.2.10: Total numbers of NSAS
- Table 2.2.11: Mean weights-at-age, separately for the different Divisions where NSAS are caught, for the period 1998 – 2008.

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

2.2.1 Catch in numbers-at-age

The total number of herring taken in the North Sea (2.1 billion fish) and the total number of NSAS (2.3 billion fish) have decreased in both cases by 22 %, as compared to last year. 0- and 1-ringers contributed 41 % of the total catch in numbers of NSAS in 2008 (Table 2.2.7). 0- and 1-ringer catch has increased by 41 % as compared to 2007. Most of these herring are still taken in the B-Fleet, but the amount has somewhat increased in the A-Fleet. The majority of 0- and 1-ringers is taken in Divisions IVb and IVc, where they account up to 70% of the total catch. Roughly 40 % of the total catch in the North Sea consist of the age group 4+ winter ringers.

Western Baltic and local Division IIIa Spring-spawners (WBSS) are taken in the eastern North Sea during the summer feeding migration (see stock annex 3 and section 3.2.2). These catches are included in Table 2.1.1 and listed as IIIa type. Table 2.2.8 specifies the estimated catch numbers of WBSS caught in the North Sea, which are transferred from the North Sea assessment to the assessment of Division IIIa/Western Baltic in 1993-2008. After splitting the herring caught in the North Sea and IIIa between stocks, the total catch of North Sea Autumn spawners was 257 900 tonnes.

AREA	ALLOCATED	UNALLOCATED	DISCARDS	TOTAL
IVa West	124 370	14 952	194	139 516
IVa East	19 461	-	-	19 461
IVb	57 332	-904	30	56 458
IVc/VIId	26 509	3 103	-	29 612
	Total catch in the North Sea			245 047
	Autumn Spawners caught in Division IIIa (SOP)			12 949
	Baltic Spring Spawners caught in the North Sea (SOP)			-124
	Blackwater Spring Spawning herring			-7
	Other Spring Spawners			0
	Total Catch NSAS used for the assessment			**257 870**

2.2.2 Other Spring-spawning herring in the North Sea

Norwegian Spring-spawners and local fjord-type spring spawning herring are taken in Division IVa (East) close to the Norwegian coast under a separate TAC. These catches are not included in the Norwegian North Sea catch figures given in Tables 2.1.1 to 2.1.6, but are listed separately in the respective catch tables. Catches were 2 721 t in 2008.

Blackwater herring are caught in the Thames estuary under a separate quota and included in the catch figure for England & Wales. Catches were only 7 t in 2008.

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

2.2.3 Data revisions

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

2.2.4 Quality of catch and biological data, discards

As in previous years, some nations provided information on misreported and unallocated catches of herring in the North Sea and adjacent areas. The **Working Group catch**, which include estimates of all fleets (and discards and misreported or unallocated catches; see Section 1.5), was estimated to exceed the official catch by 8 %.

Information on discards has improved compared to 2007, but is still on a low level. The final figure for discards as used in the assessment was only 224 t, based on the raised discards for three fleets. As discards are likely to occur in all national fisheries, this figure may be an underestimate. Discard data has not been consistently available for the whole time series and was only included in the assessment when reported. Estimates of discards in the Dutch fleet are approximately 970 t (CV=35 %) in 2008, but can't be sampled at a high enough resolution to be split between area IV, VIId, VIaN and IIa (Helmond & van Overzee WD03; Borges et al. 2008). These are not included in the assessment (see section 1.7).

In 2008, the sampling of commercial landings covers 76 % of the total catch (2007: 86 %). However, the number of herring length and weight measured has decreased by 17 % when compared to 2007, and the number of age readings has decreased by 34 % (Table 2.2.12). It should be observed that "sampled catch" in Table 2.2.12 refers to the proportion of the reported catch to which sampling was applied. This figure is limited to 100 % but might in fact exceed the official landings due to sampling of discards, unallocated and misreported catches.

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. The definition of metiers may change in 2009, when new DCF rules may be put into place). Of 93 different *reported* metiers, only 29 were sampled in 2008. The recommended sampling level of more than 1 sample per 1 000 t catch has been met only for 21 metiers, (17 in 2007). For age readings (recommended level >25 fish aged per 1 000 t catch) also 21 metiers appear to be sampled sufficiently (2007: 16).

On the other hand, some of the metiers yielded very little catch. In 58 metiers the catch is below 1000 t. The total catch in these metiers sums to 14 419 t, so the remaining 35 metiers represents 213 476 t of the official catch (94 %). Of these 35 metiers, 20 were sampled and 11 of them fulfil the recommended level of more than 1 sample per 1 000 t catch. Also 12 metiers have more than 25 age readings per 1 000 t catch and 11 metiers fulfil both criteria.

However, the catch of France, Sweden, UK/Northern Ireland and the Faroe Islands from the North Sea has not been sampled.

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).

Table 2.1.1: Herring caught in the North Sea (Sub-area IV and Division VIId). Catch in tonnes by country, 1999 – 2008. These figures do not in all cases correspond to the official statistics and cannot be used for legal purposes.

Country	1999	2000	2001	2002	2003
Belgium	2	-	-	23	5
Denmark [6]	61268	64123	67096	70825	78606
Faroe Islands	1977	915	1082	1413	627
France	26962	20952	24880	25422	31544
Germany	26764	26687	29779	27213	43953
Netherlands	54467	54341	51293	55257	81108
Norway [1]	74071	72072	75886	74974	112481
Poland			-	-	-
Sweden	3241	3046	3695	3418	4781
USSR/Russia	-	-	-	-	-
UK (England)	11434	11179	14582	13757	18639
UK (Scotland)	29911	30033	26719	30926	40292
UK (N.Ireland)	-	996	1018	944	2010
Unallocated landings	43327 [5]	61673 [5]	27362 [5]	31552 [5]	31875 [5]
Total landings	333424	346017	323392	335724	445921
Discards	-	-	-	17093	4125
Total catch	**333424**	**346017**	**323392**	**352817**	**450046**
Estimates of the parts of the catches which have been allocated to spring spawning stocks					
IIIa type (WBSS)	4732	6649	6449	6652	2821
Thames estuary [2]	88	76	107	60	84
Others [3]	-	378	1097	0	308
Norw. Spring Spawners [4]	32106	25678	7108	4069	979

Country	2004	2005	2006	2007	2008
Belgium	8	6	3	1	-
Denmark [6]	99037	128380	102322	84697	62864
Faroe Islands	402	738	1785	2891	2014
France	34521	38829	49475	24909	30347
Germany	41858	46555	40414	14893	8095
Netherlands	96162	81531	76315	66393	23122
Norway [1]	137638	156802	135361	100050	59321
Poland	-	458	-	-	-
Sweden	5692	13464	10529	15448	13840
Russia	-	99	-	-	-
UK (England)	20855	25311	22198	15993	11717
UK (Scotland)	45331	73227	48428	35115	16021
UK (N.Ireland)	2656	2912	3531	638	331
Unallocated landings	48898 [5]	57788	18764	26641	17151
Total landings	533058	626101	509125	387669	244823
Discards	17059	12824	1492	93	224
Total catch	**550117**	**638925**	**510617**	**387762**	**245047**
Estimates of the parts of the catches which have been allocated to spring spawning stocks					
IIIa type (WBSS)	7079	7039	10954	1070	124
Thames estuary [2]	62	74	65	2	7
Others [3]	0	0	0	0	0
Norw. Spring Spawners [4]	452	417	626	685	2721

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

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

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

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

[5] may include misreported catch from VIaN and discards

[6] Including any bycatches in the industrial fishery

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

Country	1999	2000	2001	2002	2003
Denmark [1]	15359	25530	17770	26422	48358
Faroe Islands	1977	205	192	-	95
France	6369	3210	8164	10522	11237
Germany	11206	5811	17753	15189	25796
Netherlands	21552	15117	17503 [3]	18289	25045
Norway	31395	33164	11653	10836	34443
Sweden	859	1479	-	-	-
Poland			1418	2397	2647
Russia	-	-	-	-	-
UK (England)	7999	8859	12283	10142	12030
UK (Scotland)	28537	29055	25105	30014	39970
UK (N. Ireland)	-	996	1018	944	2010
Unallocated landings	25469 [2]	44334 [2]	24725 [2]	14201 [2]	14115 [2]
Misreporting from VIa North					
Total Landings	150722	167760	137584	138956	215746
Discards				17093	4125
Total catch	**150722**	**167760**	**137584**	**156049**	**219871**

Country	2004	2005	2006	2007	2008
	48128	80990	60462	45948	28426
Faroe Islands	-		580	1118	2
France	10941	13474	18453	8570	13068
Germany	17559	22278	18605	4985	498
Netherlands	43876	36619	39209	42622	11634
Norway	36119	66232	38363	40279	40304
Poland	-	458	-	-	-
Sweden	2178	8261	4957	7658	7025
Russia	-	99	-	-	-
UK (England)	13480	15523	12031	11833	8355
UK (Scotland)	43490	71941	47368	35115	14727
UK (N. Ireland)	2656	2912	3531	638	331
Unallocated landings	28631 [2]	39324 [2]	10981 [2]	22215	14952
Misreporting from VIa North					
Total Landings	247058	358111	253048	220981	139322
Discards	15794	10861	1492	93	194
Total catch	**262852**	**368972**	**254540**	**221074**	**139516**

[1] Including any by-catches in the industrial fishery
[2] May include misreported catch from VIaN and discards
[3] Including 1057 t of local spring spawners

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

Country	1999	2000	2001	2002	2003
Denmark [1]	18259	11300	18466	17846	7401
Faroe Islands	-	710	890	1365	359
France	115	-	-	-	-
Germany	-	29	-	81	54
Netherlands	-	38	-	-	-
Norway [2]	39977	38655	56904	63482	62306
Sweden	772	1177	517	568	1529
Unallocated landings	-	338	0	3959	9988
Total landings	59123	52247	76777	89303	83640
Discards	-	-	-	-	-
Total catch	**59123**	**52247**	**76777**	**89303**	**83640**
Norw. Spring Spawners [4]	32106	25678	7108	4069	979

Country	2004	2005	2006	2007	2008
Denmark [1]	16278	5761	8614	2646	1587
Faroe Islands	-	738	975	577	400
France	-		-	-	-
Germany	888		34	-	-
Netherlands	-		-	263	-
Norway [2]	100443	89925	90065	54424	17474
UK (Scotland)	-	-	83	-	-
Sweden	1720	3510	2857	640	-
Unallocated landings	0	0	0	-96 [3]	0
Total landings	119329	99934	102628	58454	19461
Discards	-	-	-	-	-
Total catch	**119329**	**99934**	**102628**	**58454**	**19461**
Norw. Spring Spawners [4]	452	417	626	685	2721

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

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

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

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

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

Country	1999	2000	2001	2002	2003
Belgium	1	-	-	-	-
Denmark 1	26211	26825	30277	26387	22574
Faroe Islands	-	-	-	48	173
France	7634	10863	7796	4214	7918
Germany	13529	18818	8340	7577	12116
Netherlands	22343	26839	24160	13154	19115
Norway	2699	253	7329	656	15732
Sweden	1610	390	1760	453	605
UK (England)	1641	669	814	317	2632
UK (Scotland)	1374	978	1614	289	322
Unallocated landings [3]	-3794 [4]	-9820 [4]	-22885 [4]	4052	-2401
Total landings	73248	75815	59205	57147	78786
Discards 2					
Total catch	**73248**	**75815**	**59205**	**57147**	**78786**

Country	2004	2005	2006	2007	2008
Belgium	-	-	-	-	-
Denmark 1	33857	41423	32277	35990	32230
Faroe Islands	402	-	200	1196	1612
France	10592	10205	17385	8421	9687
Germany	13823	14381	14222	2205	2415
Netherlands	23649	10038	13363	8550	904
Norway	1076	645	6933	5347	1543
Sweden	1794	1694	2715	7150	6815
UK (England)	2864	3869	4924	577	833
UK (Scotland)	1841	1286	977	-	1293
Unallocated landings [3]	8300	10233	2364	-203	-904
Total landings	98198	93774	95360	69233	56428
Discards 2	1265	1963			30
Total catch	**99463**	**95737**	**95360**	**69233**	**56458**

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

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

Country	1999	2000	2001	2002	2003
Belgium	1	1	-	23	5
Denmark	1439	468	583	170	273
France	12844	6879	8750	10686	12389
Germany	2029	2029	3686	4366	5987
Netherlands	10572	12348	9630	23814	36948
UK (England)	1794	1651	1485	3298	3977
UK (Scotland)	-	-	-	623	-
Unallocated landings	21652 [3]	26822 [3]	25522 [3]	5336	8170
Total landings	50331	50198	49656	50318	67749
Discards [2]				-	-
Total catch	**50331**	**50198**	**49656**	**50318**	**67749**
Coastal spring spawners included above [1]	88	76	147 [4]	60	84

Country	2004	2005	2006	2007	2008
Belgium	8	6	3	1	-
Denmark	774	206	969	113	621
Faroe Islands	-	-	30	-	-
France	12988	15150	13637	7918	7592
Germany	9588	9896	7553	7703	5182
Netherlands	28637	34874	23743	14958	10584
UK (England)	4511	5919	5243	3583	2529
UK (Scotland)	-	-	-	-	1
Unallocated landings	11967	8231	5419	4725	3103
Total landings	68473	74282	56597	39001	29612
Discards [2]	-	-	-	-	-
Total catch	**68473**	**74282**	**56597**	**39001**	**29612**
Coastal spring spawners included above [1]	62	74	65	2	7

[1] Landings from the Thames estuary area are included in the North Sea catch figure for UK (England)
[2] Discards partly included in unallocated landings
[3] May include misreported catch and discards
[4] Thames/Blackwater herring landings: 107 t, others included in the catch figure for The Netherlands

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

Year	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Sub-Area IV and Division VIId: TAC (IV and VIId)																		
Recommended Divisions IVa, b	352	290 [5]	296 [5]	389 [8]	156	159	254	265	265	- [15]	- [15]	- [15]	- [15]	- [15]	- [15]	- [15]	- [15]	
Recommended Divisions IVc, VIId	54	50	50	50	- [11]	- [11]	- [11]	- [11]	- [11]	- [11]	- [11]	- [11]	- [11]	- [11]	- [11]	- [11]	- [11]	
Expected catch of spring spawners	10	8																
Agreed Divisions IVa,b [1]	380	380	390	390	263;131 [10]	134	229	240	240	240	223	340.5	393.9	460.7	404.7	303.5	174.6	147.4
Agreed Div. IVc, VIId	50	50	50	50	50; 25 [10]	25	25	25	25	25	42.7	59.5	66.1	74.3	50.0	37.5	26.7	23.6
Bycatch ceiling in the small mesh fishery						24	22	30	36	36	36	52.0	38.0	50.0	42.5	31.9	18.8	16.0
CATCH (IV and VIId)																		
National landings Divisions IVa,b [2]	481	463	421	465	183	149	245	261	261	272	261	354.5	427.7	502.3	439.2	326.8	201.2	
Unallocated landings Divisions IVa,b	14	-1	6	-15	-5	36	44	22	35	2	24	23.7	36.9	49.6	13.3	21.9	14.0	
Discard/slipping Divisions IVa,b [3]	3	1	1	-	-	-	-	-	-	-	17	4.1	17.1	12.8	1.5	0.1	0.2	
Total catch Divisions IVa,b [4]	498	463	428	450	178	185	289	283	296	273	303	382.3	481.6	564.6	454.0	348.8	215.4	
National landings Divisions IVc, VIId [3]	37	32	42	45	24	26	23	29	23	24	43	59.5	56.5	66.1	51.2	34.3	26.5	
Unallocated landings Divisions IVc,VIId	35	43	30	22	31	27	27	22	27	26	7	8.2	12.0	8.2	5.4	4.7	3.1	
Discard/slipping Divisions IVc, VIId [3]	2	2	2	-	-	-	-	-	-	-	0	-	-	-	-	-	-	
Total catch Divisions IVc, VIId	74	77	74	67	55	53	49	50	50	50	50	67.7	68.5	74.3	56.6	39.0	29.6	
Total catch IV and VIId as used by ICES [4]	**572**	**540**	**498**	**516**	**233**	**238**	**338**	**333**	**346**	**323**	**353**	**450.0**	**550.1**	**638.9**	**510.6**	**387.8**	**245.0**	
CATCH BY FLEET/STOCK (IV and VIId) [7]																		
North Sea autumn spawners directed fisheries (Fleet A)	441	438	447	439	195	225	316	313	322	296	323	434.9	529.5	610.0	487.1	379.6	236.3	
North Sea autumn spawners industrial (Fleet B)	124	101	38	67	38	13	14	15	18	20	22	12.3	13.6	21.8	11.9	7.1	8.6	
North Sea autumn spawners in IV and VIId total	**564**	**539**	**485**	**506**	**233**	**237**	**330**	**329**	**339**	**317**	**346**	**447.2**	**543.0**	**631.9**	**499.0**	**386.7**	**244.9**	
Baltic-IIIa-type spring spawners in IV	8	9	13	10	1	1	8	5	7	6	7	2.8	7.1	7.0	11.0	1.1	0.1	
Coastal-type spring spawners	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	1.2	0.1	0.1	0.1	0.1	0.1	0.0	0.0	
Norw. Spring Spawners caught under a separate quota in IV [14]	5	9	6	10	30	55	29	32	26	7	4	1.0	0.5	0.4	0.6	0.7	2.7	
Division IIIa: TAC (IIIa)																		
Predicted catch of autumn spawners	153	102	77	98	48	35	58	43	53	- [15]	- [15]	- [15]	- [15]	- [15]	- [15]	- [15]	- [15]	
Recommended spring spawners	90	93–113	- [6]	- [9]	- [9]	- [12]	- [12]	- [12]	- [12]	- [12]	- [12]	- [12]	- [15]	- [15]	- [15]	- [15]	- [15]	
Recommended mixed clupeoids	0	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Agreed herring TAC	124	165	148	140	120	80	80	80	80	80	80	80.0	70.0	96.0	81.6	69.4	51.7	37.7
Agreed mixed clupeoid TAC	50	45	43	43	43													
Bycatch ceiling in the small mesh fishery						20	17	19	21	21	21	21.0	21.0	24.2	20.5	15.4	11.5	8.4
CATCH (IIIa)																		
National landings	227	214	168	157	115	83	120	86	108	90	79	76.0	61.1	90.8	88.9	47.3	38.2	
Catch as used by ICES	227	214	168	140	105	74	108	79	99	82	73	68.1	52.7	69.6	51.2	47.4	38.2	
CATCH BY FLEET/STOCK (IIIa) [7]																		
Autumn spawners human consumption (Fleet C)	47	44	42	38	24	21	59	28	36	34	17	24.1	13.4	22.9	11.6	16.4	9.2	
Autumn spawners mixed clupeoid (Fleet D) [13]	23	25	12	6	9	4	6	8	13	12	9	8.4	10.8	9.0	3.4	3.4	3.7	
Autumn spawners other industrial landings (Fleet E)	82	63	32	29	8	2												
Autumn spawners in IIIa total	**152**	**132**	**86**	**73**	**43**	**27**	**61**	**34**	**49**	**46**	**26**	**32.5**	**24.2**	**31.9**	**15.0**	**19.8**	**12.9**	
Spring spawners human consumption (Fleet C)	53	68	59	44	58	43	40	40	45	33	38	31.6	16.8	32.5	30.2	25.3	23.0	
Spring spawners mixed clupeoid (Fleet D) [13]	2	1	1	2	4	3	3	3	5	3	9	4.0	11.2	5.1	5.9	2.3	2.2	
Spring spawners other industrial landings (Fleet E)	20	12	24	21	2	1												
Spring spawners in IIIa total	**75**	**81**	**84**	**67**	**64**	**47**	**43**	**43**	**50**	**36**	**47**	**35.6**	**28.0**	**37.6**	**36.1**	**27.6**	**25.2**	
North Sea autumn spawners Total as used by ICES	**716**	**671**	**571**	**579**	**275**	**264**	**392**	**363**	**388**	**363**	**372**	**479.7**	**567.2**	**663.8**	**514.6**	**406.5**	**257.9**	

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

Table 2.2.1: North Sea autumn spawning herring (NSAS), and western Baltic spring spawners (WBSS) caught in the North Sea and Div IIIa in 2008. 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	85.7	0.0	0.0	0.0	51.5	646.3	14.9	0.0	697.8	14.9	798.3	712.6
1	86.6	1.4	0.0	1.4	37.5	98.0	8.5	3.0	136.8	11.6	235.0	148.4
2	72.0	11.2	0.1	11.2	158.4	77.4	0.5	12.1	247.0	12.7	331.6	259.7
3	1.9	10.7	0.1	10.6	115.5	46.3	0.7	9.6	172.4	10.3	184.6	182.8
4	0.3	17.6	0.2	17.5	116.4	38.1	1.6	24.9	172.0	26.5	198.7	198.7
5	0.1	9.0	0.1	9.0	65.5	23.3	1.6	37.9	97.8	39.4	137.4	137.3
6	0.1	11.3	0.1	11.2	54.4	20.4	0.9	31.2	86.1	32.1	118.2	118.2
7	0.3	21.9	0.2	21.7	122.7	41.1	1.2	28.0	185.6	29.3	215.2	215.0
8	0.1	9.6	0.0	9.5	40.2	15.6	0.2	8.7	65.4	8.9	74.3	74.3
9+	0.0	7.4	0.0	7.3	29.8	2.0	0.1	3.7	39.1	3.8	42.9	42.9
Sum	247.0	100.0	0.7	99.3	792.0	1008.6	30.1	159.1	1899.9	189.3	2336.2	2089.9
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	21.9	1.3	0.0	1.3	10.6	1.1	0.0	0.0	12.9	0.0	34.8	12.9
2	52.0	4.0	0.0	4.0	33.2	0.9	0.1	0.0	38.1	0.1	90.2	38.2
3	1.1	1.6	0.0	1.6	9.7	0.6	0.4	1.4	11.9	1.8	14.8	13.7
4	0.2	1.6	0.0	1.6	4.3	1.0	1.1	7.1	6.9	8.2	15.3	15.2
5	0.0	1.5	0.0	1.5	8.3	1.0	1.0	5.6	10.8	6.5	17.3	17.3
6	0.0	0.6	0.0	0.6	0.2	0.4	0.4	3.0	1.2	3.5	4.6	4.6
7	0.3	1.5	0.0	1.5	2.6	0.7	0.8	7.0	4.8	7.7	12.8	12.5
8	0.0	0.1	0.0	0.1	0.0	0.0	0.1	0.9	0.2	0.9	1.2	1.1
9+	0.0	0.1	0.0	0.1	0.0	0.0	0.0	0.4	0.1	0.4	0.5	0.5
Sum	75.4	12.2	0.0	12.2	68.9	5.7	3.8	25.4	86.9	29.2	191.5	116.0
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	14.9	0.1	0.0	0.1	6.3	16.4	0.0	0.0	22.8	0.0	37.7	22.8
2	14.4	7.0	0.1	6.9	79.6	3.1	0.0	0.0	89.6	0.0	104.0	89.7
3	0.3	7.2	0.1	7.2	34.2	1.3	0.0	0.0	42.7	0.0	43.0	42.8
4	0.0	14.6	0.1	14.5	53.9	1.5	0.0	0.1	69.9	0.1	70.0	70.1
5	0.0	6.5	0.1	6.4	32.4	1.1	0.0	0.0	39.9	0.1	40.0	40.0
6	0.0	6.4	0.1	6.4	12.2	0.6	0.0	0.0	19.1	0.0	19.1	19.2
7	0.0	14.3	0.1	14.2	46.7	1.4	0.0	0.1	62.3	0.1	62.4	62.5
8	0.0	1.6	0.0	1.6	4.5	0.3	0.0	0.0	6.3	0.0	6.3	6.3
9+	0.0	1.2	0.0	1.2	3.1	0.1	0.0	0.0	4.4	0.0	4.4	4.4
Sum	29.7	58.9	0.5	58.4	272.9	25.7	0.1	0.2	357.0	0.3	387.0	357.8
Quarter: 3												
0	39.3	0.0	0.0	0.0	39.5	559.6	0.0	0.0	599.2	0.0	638.5	599.2
1	40.2	0.0	0.0	0.0	13.8	21.9	0.0	0.0	35.7	0.0	75.9	35.7
2	5.5	0.2	0.0	0.2	42.4	54.5	0.0	0.0	97.2	0.0	102.7	97.2
3	0.2	0.7	0.0	0.6	60.5	39.8	0.0	0.0	101.0	0.0	101.2	101.0
4	0.0	0.6	0.0	0.6	53.1	23.4	0.0	0.0	77.1	0.0	77.1	77.1
5	0.0	0.7	0.0	0.7	21.6	16.5	0.0	0.0	38.8	0.0	38.8	38.8
6	0.0	1.2	0.0	1.2	31.4	15.4	0.0	0.0	48.0	0.0	48.0	48.0
7	0.1	1.5	0.1	1.4	53.7	28.1	0.0	0.0	83.2	0.0	83.3	83.3
8	0.0	0.5	0.0	0.5	19.3	13.0	0.0	0.0	32.7	0.0	32.8	32.7
9+	0.0	0.4	0.0	0.3	15.9	0.0	0.0	0.0	16.3	0.0	16.3	16.3
Sum	85.3	5.7	0.2	5.5	351.2	772.3	0.1	0.0	1129.0	0.2	1214.5	1129.4
Quarter: 4												
0	46.3	0.0	0.0	0.0	12.0	86.6	14.9	0.0	98.6	14.9	159.8	113.5
1	9.7	0.0	0.0	0.0	6.8	58.7	8.5	3.0	65.4	11.6	86.7	77.0
2	0.2	0.0	0.0	0.0	3.2	18.9	0.4	12.1	22.1	12.5	34.8	34.6
3	0.2	1.2	0.0	1.2	11.1	4.6	0.2	8.3	16.9	8.5	25.6	25.4
4	0.1	0.8	0.0	0.8	5.2	12.1	0.4	17.7	18.1	18.1	36.3	36.2
5	0.1	0.4	0.0	0.4	3.3	4.7	0.6	32.2	8.4	32.8	41.2	41.1
6	0.0	3.1	0.0	3.1	10.6	4.1	0.5	28.1	17.8	28.6	46.5	46.4
7	0.0	4.7	0.0	4.7	19.6	10.9	0.4	21.0	35.2	21.5	56.7	56.7
8	0.0	7.4	0.0	7.4	16.5	2.3	0.2	7.8	26.1	7.9	34.1	34.1
9+	0.0	5.7	0.0	5.7	10.8	1.9	0.1	3.3	18.4	3.3	21.7	21.7
Sum	56.6	23.2	0.0	23.2	98.9	204.9	26.1	133.5	327.1	159.6	543.3	486.7

Table 2.2.2: North Sea autumn spawning herring (NSAS), and western Baltic spring spawners (WBSS) caught in the North Sea and Div IIIa in 2008. Mean weight-at-age (kg) in the catch (WECA), by quarter and division.

WR	IIIa NSAS	IVa(E) all	IVa(E) WBSS	IVa(W)	IVb	IVc	VIId	IVa & IVb all	IVc & VIId	Total NSAS	Herring caught in the North Sea
Quarters: 1-4											
0	0.016	0.000	0.000	0.007	0.007	0.012	0.000	0.007	0.012	0.008	0.007
1	0.058	0.072	0.000	0.072	0.042	0.044	0.107	0.050	0.060	0.054	0.051
2	0.087	0.138	0.142	0.142	0.142	0.118	0.120	0.142	0.120	0.129	0.141
3	0.109	0.173	0.165	0.187	0.172	0.128	0.159	0.182	0.157	0.180	0.180
4	0.139	0.172	0.166	0.187	0.185	0.133	0.157	0.185	0.156	0.181	0.181
5	0.168	0.174	0.168	0.188	0.191	0.142	0.174	0.188	0.173	0.183	0.183
6	0.176	0.216	0.192	0.230	0.222	0.167	0.188	0.226	0.188	0.216	0.216
7	0.204	0.210	0.199	0.219	0.228	0.162	0.193	0.220	0.192	0.216	0.216
8	0.198	0.253	0.203	0.262	0.265	0.210	0.215	0.262	0.215	0.256	0.256
9+	0.000	0.266	0.233	0.281	0.223	0.241	0.247	0.275	0.247	0.273	0.273
Quarter: 1											
0	0.000	0.000	0.020	0.000	0.000	0.000	0.000	na	na	0.000	0.000
1	0.034	0.072	0.024	0.074	0.029	0.000	0.000	0.070	na	0.047	0.070
2	0.083	0.129	0.056	0.127	0.104	0.085	0.000	0.127	0.085	0.102	0.127
3	0.103	0.150	0.110	0.143	0.115	0.101	0.101	0.143	0.101	0.135	0.137
4	0.129	0.161	0.244	0.146	0.122	0.117	0.125	0.145	0.124	0.134	0.134
5	0.000	0.156	0.262	0.153	0.128	0.118	0.136	0.151	0.133	0.144	0.144
6	0.000	0.189	0.325	0.177	0.133	0.133	0.152	0.169	0.150	0.155	0.155
7	0.208	0.187	0.267	0.167	0.141	0.133	0.158	0.169	0.156	0.162	0.161
8	0.199	0.192	0.268	0.215	0.160	0.160	0.171	0.186	0.170	0.174	0.173
9+	0.000	0.235	0.269	0.215	0.000	0.000	0.198	0.234	0.198	0.205	0.205
Quarter: 2											
0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	na	na	na	na
1	0.031	0.076	0.067	0.076	0.016	0.101	0.000	0.033	0.101	0.032	0.033
2	0.091	0.143	0.144	0.134	0.143	0.109	0.000	0.135	0.109	0.129	0.135
3	0.109	0.163	0.163	0.164	0.163	0.134	0.101	0.164	0.122	0.164	0.164
4	0.121	0.166	0.166	0.163	0.165	0.154	0.125	0.163	0.135	0.163	0.163
5	0.132	0.164	0.163	0.169	0.171	0.157	0.136	0.168	0.143	0.168	0.168
6	0.141	0.190	0.189	0.190	0.205	0.180	0.152	0.190	0.161	0.190	0.190
7	0.154	0.191	0.191	0.187	0.194	0.180	0.158	0.188	0.164	0.188	0.188
8	0.164	0.192	0.192	0.210	0.227	0.212	0.171	0.206	0.186	0.206	0.206
9+	0.000	0.235	0.235	0.195	0.227	0.000	0.198	0.207	0.198	0.207	0.207
Quarter: 3											
0	0.015	0.000	0.000	0.006	0.006	0.000	0.000	0.006	na	0.007	0.006
1	0.076	0.000	0.072	0.083	0.039	0.104	0.107	0.056	0.105	0.067	0.056
2	0.108	0.144	0.128	0.166	0.143	0.137	0.115	0.153	0.134	0.151	0.153
3	0.123	0.211	0.143	0.205	0.172	0.167	0.169	0.192	0.167	0.192	0.192
4	0.000	0.210	0.160	0.214	0.192	0.186	0.169	0.207	0.182	0.207	0.207
5	0.000	0.230	0.180	0.221	0.197	0.190	0.180	0.211	0.186	0.211	0.211
6	0.000	0.236	0.200	0.246	0.228	0.209	0.190	0.240	0.202	0.240	0.240
7	0.191	0.228	0.220	0.244	0.240	0.215	0.201	0.243	0.211	0.243	0.243
8	0.198	0.231	0.229	0.282	0.268	0.232	0.212	0.276	0.226	0.276	0.276
9+	0.000	0.255	0.229	0.313	0.238	0.218	0.241	0.312	0.235	0.312	0.312
Quarter: 4											
0	0.017	0.000	0.015	0.012	0.012	0.012	0.000	0.012	0.012	0.013	0.012
1	0.076	0.000	0.056	0.043	0.050	0.044	0.107	0.049	0.060	0.054	0.051
2	0.110	0.183	0.110	0.150	0.140	0.126	0.120	0.142	0.120	0.134	0.134
3	0.125	0.244	0.244	0.193	0.180	0.175	0.169	0.193	0.169	0.185	0.185
4	0.164	0.262	0.262	0.204	0.180	0.172	0.170	0.191	0.170	0.181	0.181
5	0.185	0.325	0.325	0.248	0.190	0.181	0.180	0.218	0.180	0.188	0.188
6	0.183	0.267	0.267	0.229	0.207	0.193	0.192	0.230	0.192	0.207	0.207
7	0.182	0.268	0.268	0.234	0.208	0.207	0.205	0.230	0.205	0.221	0.221
8	0.213	0.269	0.269	0.254	0.254	0.225	0.221	0.258	0.221	0.249	0.249
9+	0.000	0.274	0.274	0.258	0.222	0.241	0.254	0.259	0.254	0.258	0.258

Table 2.2.3: North Sea autumn spawning herring (NSAS), and western Baltic spring spawners (WBSS) caught in the North Sea in 2008. Mean length-at-age (cm) in the catch, by quarter and division.

WR	IIIa NSAS	IVa(E) all	IVa(E) WBSS	IVa(W)	IVb	IVc	VIId	IVa & IVb all	IVc & VIId
Quarters: 1-4									
0	n.d.	0.0	n.d.	11.1	10.9	12.5	0.0	11.0	12.5
1	n.d.	20.2	n.d.	20.5	17.9	18.9	22.8	18.7	19.9
2	n.d.	24.9	n.d.	25.1	25.1	24.3	23.9	25.1	24.0
3	n.d.	26.8	n.d.	27.3	26.7	25.9	26.1	27.1	26.0
4	n.d.	26.8	n.d.	27.1	27.3	26.5	26.3	27.1	26.3
5	n.d.	27.2	n.d.	27.3	27.9	26.6	27.0	27.4	27.0
6	n.d.	28.9	n.d.	29.1	29.1	27.5	27.8	29.1	27.8
7	n.d.	28.8	n.d.	28.6	29.4	27.7	28.0	28.8	28.0
8	n.d.	31.4	n.d.	30.6	31.0	29.1	28.9	30.8	28.9
9+	n.d.	31.9	n.d.	31.3	29.0	29.3	29.8	31.3	29.8
Quarter: 1									
0	n.d.	0.0	n.d.	0.0	0.0	0.0	0.0	-	-
1	n.d.	20.1	n.d.	20.3	15.1	0.0	0.0	19.9	-
2	n.d.	24.7	n.d.	24.7	24.0	23.3	0.0	24.7	23.3
3	n.d.	26.1	n.d.	25.9	25.6	25.4	24.0	25.9	24.3
4	n.d.	26.4	n.d.	25.7	26.2	26.4	25.7	25.9	25.8
5	n.d.	26.7	n.d.	26.6	26.4	26.3	26.3	26.6	26.3
6	n.d.	27.6	n.d.	26.9	27.2	27.2	27.2	27.3	27.2
7	n.d.	27.8	n.d.	27.4	27.4	27.3	27.3	27.5	27.3
8	n.d.	28.4	n.d.	28.7	29.3	29.3	28.1	28.6	28.2
9+	n.d.	29.7	n.d.	28.7	0.0	0.0	28.7	29.7	28.7
Quarter: 2									
0	n.d.	0.0	n.d.	0.0	0.0	0.0	0.0	-	-
1	n.d.	20.6	n.d.	20.6	13.6	22.8	0.0	15.6	22.8
2	n.d.	25.0	n.d.	24.6	25.3	23.8	0.0	24.6	23.8
3	n.d.	26.2	n.d.	25.9	26.4	25.9	24.0	26.0	25.2
4	n.d.	26.6	n.d.	26.1	26.5	27.1	25.7	26.2	26.2
5	n.d.	26.8	n.d.	26.5	27.1	27.2	26.3	26.6	26.6
6	n.d.	27.6	n.d.	27.3	28.3	28.3	27.2	27.4	27.5
7	n.d.	27.8	n.d.	27.1	28.1	28.4	27.3	27.3	27.6
8	n.d.	28.4	n.d.	28.1	29.6	30.2	28.1	28.2	28.9
9+	n.d.	29.7	n.d.	27.8	29.4	0.0	28.7	28.4	28.7
Quarter: 3									
0	n.d.	0.0	n.d.	10.7	10.7	0.0	0.0	10.7	-
1	n.d.	0.0	n.d.	21.4	17.6	22.8	22.8	19.1	22.8
2	n.d.	25.0	n.d.	26.2	25.1	24.6	23.9	25.6	24.5
3	n.d.	28.7	n.d.	27.8	26.7	26.3	26.5	27.4	26.3
4	n.d.	28.5	n.d.	28.1	27.7	27.3	26.6	28.0	27.1
5	n.d.	29.3	n.d.	28.4	28.1	27.4	27.0	28.3	27.2
6	n.d.	29.7	n.d.	29.4	29.4	28.3	27.6	29.4	28.0
7	n.d.	29.6	n.d.	29.3	29.9	28.5	28.0	29.5	28.4
8	n.d.	30.3	n.d.	30.4	31.1	29.3	28.4	30.7	29.0
9+	n.d.	31.1	n.d.	31.5	28.8	28.3	29.3	31.5	29.0
Quarter: 4									
0	n.d.	0.0	n.d.	12.5	12.5	12.5	0.0	12.5	12.5
1	n.d.	0.0	n.d.	18.8	19.3	18.9	22.8	19.3	19.9
2	n.d.	28.6	n.d.	27.4	25.2	24.6	23.9	25.5	24.0
3	n.d.	30.6	n.d.	29.4	27.3	26.8	26.4	28.9	26.4
4	n.d.	30.8	n.d.	29.1	26.7	26.8	26.5	27.6	26.5
5	n.d.	31.8	n.d.	30.0	27.6	27.0	27.1	28.7	27.1
6	n.d.	31.6	n.d.	30.5	28.4	27.8	27.9	30.2	27.9
7	n.d.	32.0	n.d.	30.6	28.3	28.3	28.2	30.1	28.2
8	n.d.	32.2	n.d.	31.6	30.5	29.0	28.9	31.6	28.9
9+	n.d.	32.5	n.d.	32.0	29.0	29.3	29.9	31.8	29.9

Table 2.2.4: North Sea autumn spawning herring (NSAS), and western Baltic spring spawners (WBSS) caught in the North Sea and Div IIIa in 2008. 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	1.4	0.0	0.0	0.0	0.4	4.4	0.2	0.0	4.8	0.2	6.3	5.0
1	5.0	0.1	0.0	0.1	2.7	4.1	0.4	0.3	6.9	0.7	12.6	7.6
2	6.2	1.6	0.0	1.5	22.4	11.0	0.1	1.5	35.0	1.5	42.7	36.5
3	0.2	1.9	0.0	1.8	21.5	7.9	0.1	1.5	31.3	1.6	33.2	33.0
4	0.0	3.0	0.0	3.0	21.8	7.1	0.2	3.9	31.9	4.1	36.0	36.0
5	0.0	1.6	0.0	1.6	12.3	4.5	0.2	6.6	18.3	6.8	25.2	25.2
6	0.0	2.4	0.0	2.4	12.5	4.5	0.2	5.9	19.5	6.0	25.5	25.5
7	0.1	4.6	0.0	4.6	26.9	9.4	0.2	5.4	40.8	5.6	46.5	46.5
8	0.0	2.4	0.0	2.4	10.6	4.1	0.0	1.9	17.1	1.9	19.0	19.0
9+	0.0	2.0	0.0	2.0	8.4	0.4	0.0	0.9	10.8	0.9	11.7	11.7
Sum	13.0	19.5	0.1	19.4	139.5	57.5	1.5	27.9	216.3	29.4	258.7	245.9
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	0.7	0.1	0.0	0.1	0.8	0.0	0.0	0.0	0.9	0.0	1.6	0.9
2	4.3	0.5	0.0	0.5	4.2	0.1	0.0	0.0	4.8	0.0	9.2	4.8
3	0.1	0.2	0.0	0.2	1.4	0.1	0.0	0.1	1.7	0.2	2.0	1.9
4	0.0	0.3	0.0	0.3	0.6	0.1	0.1	0.9	1.0	1.0	2.0	2.0
5	0.0	0.2	0.0	0.2	1.3	0.1	0.1	0.8	1.6	0.9	2.5	2.5
6	0.0	0.1	0.0	0.1	0.0	0.0	0.1	0.5	0.2	0.5	0.7	0.7
7	0.1	0.3	0.0	0.3	0.4	0.1	0.1	1.1	0.8	1.2	2.1	2.0
8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.2	0.2	0.2
9+	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.1	0.1	0.1
Sum	5.3	1.8	0.0	1.8	8.8	0.6	0.5	3.6	11.1	4.0	20.4	15.2
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	0.5	0.0	0.0	0.0	0.5	0.3	0.0	0.0	0.7	0.0	1.2	0.7
2	1.3	1.0	0.0	1.0	10.7	0.4	0.0	0.0	12.1	0.0	13.4	12.1
3	0.0	1.2	0.0	1.2	5.6	0.2	0.0	0.0	7.0	0.0	7.0	7.0
4	0.0	2.4	0.0	2.4	8.8	0.2	0.0	0.0	11.4	0.0	11.4	11.4
5	0.0	1.1	0.0	1.0	5.5	0.2	0.0	0.0	6.7	0.0	6.7	6.7
6	0.0	1.2	0.0	1.2	2.3	0.1	0.0	0.0	3.6	0.0	3.6	3.6
7	0.0	2.7	0.0	2.7	8.7	0.3	0.0	0.0	11.7	0.0	11.7	11.7
8	0.0	0.3	0.0	0.3	0.9	0.1	0.0	0.0	1.3	0.0	1.3	1.3
9+	0.0	0.3	0.0	0.3	0.6	0.0	0.0	0.0	0.9	0.0	0.9	0.9
Sum	1.8	10.2	0.1	10.1	43.6	1.8	0.0	0.0	55.5	0.0	57.4	55.6
Quarter: 3												
0	0.6	0.0	0.0	0.0	0.2	3.4	0.0	0.0	3.6	0.0	4.2	3.6
1	3.1	0.0	0.0	0.0	1.1	0.9	0.0	0.0	2.0	0.0	5.1	2.0
2	0.6	0.0	0.0	0.0	7.1	7.8	0.0	0.0	14.9	0.0	15.5	14.9
3	0.0	0.1	0.0	0.1	12.4	6.8	0.0	0.0	19.4	0.0	19.4	19.4
4	0.0	0.1	0.0	0.1	11.3	4.5	0.0	0.0	16.0	0.0	16.0	16.0
5	0.0	0.2	0.0	0.2	4.8	3.2	0.0	0.0	8.2	0.0	8.2	8.2
6	0.0	0.3	0.0	0.3	7.7	3.5	0.0	0.0	11.5	0.0	11.5	11.5
7	0.0	0.3	0.0	0.3	13.1	6.7	0.0	0.0	20.2	0.0	20.2	20.2
8	0.0	0.1	0.0	0.1	5.4	3.5	0.0	0.0	9.0	0.0	9.0	9.0
9+	0.0	0.1	0.0	0.1	5.0	0.0	0.0	0.0	5.1	0.0	5.1	5.1
Sum	4.3	1.3	0.0	1.2	68.3	40.4	0.0	0.0	109.9	0.0	114.2	109.9
Quarter: 4												
0	0.8	0.0	0.0	0.0	0.1	1.0	0.2	0.0	1.2	0.2	2.1	1.4
1	0.7	0.0	0.0	0.0	0.3	2.9	0.4	0.3	3.2	0.7	4.7	3.9
2	0.0	0.0	0.0	0.0	0.5	2.7	0.1	1.5	3.1	1.5	4.7	4.6
3	0.0	0.3	0.0	0.3	2.1	0.8	0.0	1.4	3.3	1.4	4.7	4.7
4	0.0	0.2	0.0	0.2	1.1	2.2	0.1	3.0	3.5	3.1	6.6	6.5
5	0.0	0.1	0.0	0.1	0.8	0.9	0.1	5.8	1.8	5.9	7.8	7.7
6	0.0	0.8	0.0	0.8	2.4	0.9	0.1	5.4	4.1	5.5	9.6	9.6
7	0.0	1.2	0.0	1.2	4.6	2.3	0.1	4.3	8.1	4.4	12.5	12.5
8	0.0	2.0	0.0	2.0	4.2	0.6	0.0	1.7	6.7	1.7	8.5	8.5
9+	0.0	1.6	0.0	1.6	2.8	0.4	0.0	0.8	4.8	0.8	5.6	5.6
Sum	1.6	6.3	0.0	6.2	18.9	14.7	1.0	24.3	39.8	25.3	66.7	65.1

Table 2.2.5: North Sea autumn spawning herring (NSAS), and western Baltic spring spawners (WBSS) caught in the North Sea in 2008. 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	34.7%	0.0%	0.0%	0.0%	6.5%	64.1%	49.3%	0.0%	36.7%	7.8%	34.2%	34.1%
1	35.1%	1.4%	0.0%	1.4%	4.7%	9.7%	28.3%	1.9%	7.2%	6.1%	10.1%	7.1%
2	29.2%	11.2%	10.1%	11.2%	20.0%	7.7%	1.8%	7.6%	13.0%	6.7%	14.2%	12.4%
3	0.8%	10.7%	12.4%	10.7%	14.6%	4.6%	2.2%	6.1%	9.1%	5.4%	7.9%	8.7%
4	0.1%	17.6%	23.9%	17.6%	14.7%	3.8%	5.2%	15.6%	9.1%	14.0%	8.5%	9.5%
5	0.1%	9.0%	11.0%	9.0%	8.3%	2.3%	5.1%	23.8%	5.1%	20.8%	5.9%	6.6%
6	0.0%	11.3%	11.6%	11.2%	6.9%	2.0%	3.1%	19.6%	4.5%	16.9%	5.1%	5.7%
7	0.1%	21.9%	26.0%	21.9%	15.5%	4.1%	4.1%	17.6%	9.8%	15.5%	9.2%	10.3%
8	0.0%	9.6%	2.9%	9.6%	5.1%	1.5%	0.7%	5.4%	3.4%	4.7%	3.2%	3.6%
9+	0.0%	7.4%	2.2%	7.4%	3.8%	0.2%	0.2%	2.3%	2.1%	2.0%	1.8%	2.1%
Sum 3+	1.1%	87.4%	89.9%	87.4%	68.8%	18.5%	20.6%	90.5%	43.1%	79.3%	41.6%	46.4%
Quarter: 1												
0	0.0%	0.0%	-	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
1	29.0%	10.3%	-	10.3%	15.4%	18.8%	0.0%	0.0%	14.9%	0.0%	18.2%	11.1%
2	68.9%	32.8%	-	32.8%	48.2%	15.0%	2.7%	0.0%	43.9%	0.3%	47.1%	32.9%
3	1.5%	13.3%	-	13.3%	14.0%	10.2%	10.7%	5.4%	13.7%	6.1%	7.7%	11.8%
4	0.2%	12.9%	-	12.9%	6.3%	18.2%	29.3%	28.0%	8.0%	28.2%	8.0%	13.1%
5	0.0%	12.1%	-	12.1%	12.0%	18.3%	25.3%	22.0%	12.4%	22.4%	9.0%	14.9%
6	0.0%	4.6%	-	4.6%	0.4%	6.2%	10.7%	12.0%	1.3%	11.8%	2.4%	4.0%
7	0.3%	12.1%	-	12.1%	3.8%	12.5%	20.0%	27.4%	5.5%	26.5%	6.7%	10.8%
8	0.0%	1.1%	-	1.1%	0.0%	0.8%	1.4%	3.4%	0.2%	3.2%	0.6%	1.0%
9+	0.0%	0.9%	-	0.9%	0.0%	0.0%	0.0%	1.7%	0.1%	1.5%	0.3%	0.5%
Sum 3+	2.1%	56.9%	-	56.9%	36.4%	66.1%	97.3%	100.0%	41.3%	99.7%	34.7%	55.9%
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	50.1%	0.2%	0.0%	0.2%	2.3%	63.7%	0.3%	0.0%	6.4%	0.1%	9.7%	6.4%
2	48.6%	11.9%	12.2%	11.9%	29.2%	12.1%	13.2%	0.0%	25.1%	5.0%	26.9%	25.1%
3	1.0%	12.3%	11.3%	12.3%	12.5%	5.2%	15.0%	0.0%	12.0%	9.1%	11.1%	12.0%
4	0.0%	24.8%	23.3%	24.8%	19.8%	5.9%	22.4%	28.0%	19.6%	25.9%	18.1%	19.6%
5	0.2%	11.0%	10.9%	11.0%	11.9%	4.2%	18.5%	22.0%	11.2%	20.7%	10.3%	11.2%
6	0.0%	10.9%	11.5%	10.9%	4.5%	2.2%	9.5%	12.0%	5.3%	11.1%	4.9%	5.4%
7	0.0%	24.3%	25.8%	24.3%	17.1%	5.5%	17.5%	27.4%	17.5%	23.7%	16.1%	17.5%
8	0.0%	2.7%	2.9%	2.7%	1.6%	1.0%	3.4%	3.4%	1.8%	3.4%	1.6%	1.8%
9+	0.0%	2.0%	2.2%	2.0%	1.1%	0.3%	0.0%	1.7%	1.2%	1.1%	1.1%	1.2%
Sum 3+	1.3%	87.9%	87.8%	87.9%	68.5%	24.2%	86.5%	100.0%	68.5%	94.8%	63.4%	68.6%
Quarter: 3												
0	46.1%	0.0%	0.0%	0.0%	11.2%	72.5%	0.0%	0.0%	53.1%	0.0%	52.6%	53.1%
1	47.1%	0.0%	0.0%	0.0%	3.9%	2.8%	3.1%	2.9%	3.2%	3.1%	6.2%	3.2%
2	6.4%	4.0%	5.1%	4.0%	12.1%	7.1%	23.0%	11.1%	8.6%	20.0%	8.5%	8.6%
3	0.3%	11.4%	12.2%	11.4%	17.2%	5.2%	13.9%	6.7%	8.9%	12.1%	8.3%	8.9%
4	0.0%	10.8%	25.2%	10.3%	15.1%	3.0%	18.9%	15.6%	6.8%	18.1%	6.3%	6.8%
5	0.0%	13.0%	11.8%	13.0%	6.1%	2.1%	11.6%	22.2%	3.4%	14.2%	3.2%	3.4%
6	0.0%	20.7%	12.4%	21.0%	8.9%	2.0%	10.9%	19.5%	4.2%	13.1%	4.0%	4.3%
7	0.1%	25.7%	27.9%	25.6%	15.3%	3.6%	13.8%	14.9%	7.4%	14.1%	6.9%	7.4%
8	0.0%	8.1%	3.1%	8.3%	5.5%	1.7%	4.5%	5.0%	2.9%	4.7%	2.7%	2.9%
9+	0.0%	6.2%	2.3%	6.4%	4.5%	0.0%	0.2%	2.1%	1.4%	0.7%	1.3%	1.4%
Sum 3+	0.4%	96.0%	94.9%	96.0%	72.7%	17.6%	73.9%	86.1%	35.2%	76.9%	32.7%	35.2%
Quarter: 4												
0	81.8%	0.0%	0.0%	0.0%	12.1%	42.3%	56.9%	0.0%	30.2%	9.3%	29.4%	23.3%
1	17.1%	0.0%	0.0%	0.0%	6.8%	28.6%	32.7%	2.3%	20.0%	7.3%	16.0%	15.8%
2	0.3%	0.0%	0.0%	0.0%	3.2%	9.2%	1.5%	9.1%	6.7%	7.8%	6.4%	7.1%
3	0.3%	5.2%	4.0%	5.1%	11.2%	2.2%	0.8%	6.2%	5.2%	5.3%	4.7%	5.2%
4	0.1%	3.6%	1.4%	3.6%	5.2%	5.9%	1.6%	13.3%	5.5%	11.4%	6.7%	7.4%
5	0.2%	1.5%	0.0%	1.5%	3.3%	2.3%	2.1%	24.1%	2.6%	20.5%	7.6%	8.5%
6	0.1%	13.3%	0.0%	13.4%	10.7%	2.0%	1.9%	21.0%	5.5%	17.9%	8.6%	9.5%
7	0.0%	20.0%	0.0%	20.0%	19.9%	5.3%	1.7%	15.7%	10.8%	13.4%	10.4%	11.6%
8	0.0%	31.8%	0.0%	31.8%	16.6%	1.1%	0.6%	5.8%	8.0%	5.0%	6.3%	7.0%
9+	0.0%	24.6%	0.0%	24.6%	10.9%	0.9%	0.2%	2.5%	5.6%	2.1%	4.0%	4.5%
Sum 3+	0.8%	100.0%	5.4%	100.0%	77.9%	19.9%	8.9%	88.6%	43.1%	75.6%	48.2%	53.8%

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

2005	Fleet A		Fleet B		Fleet C		Fleet D		TOTAL	
Total		Mean		Mean		Mean		Mean		**Mean**
Winter rings	Numbers	Weight	Numbers	Weight	Numbers	Weight	Numbers	Weight	**Numbers**	**Weight**
0	0.4	0.119	918.7	0.011	11.3	0.027	85.1	0.015	**1,015.6**	**0.011**
1	42.3	0.088	365.8	0.033	174.6	0.065	132.9	0.032	**715.5**	**0.044**
2	196.3	0.122	0.0	0.000	115.9	0.072	43.3	0.068	**355.4**	**0.099**
3	469.5	0.155	0.0	0.000	12.4	0.106	3.7	0.105	**485.7**	**0.153**
4	1313.0	0.166	0.0	0.000	4.7	0.154	0.6	0.158	**1,318.4**	**0.166**
5	477.6	0.208	0.0	0.000	2.1	0.175	0.2	0.157	**479.9**	**0.208**
6	573.6	0.223	0.0	0.000	1.9	0.189	0.3	0.160	**575.9**	**0.223**
7	114.7	0.240	0.0	0.000	0.3	0.216	0.2	0.178	**115.2**	**0.240**
8	107.8	0.266	0.0	0.000	0.2	0.209	0.0	0.000	**108.0**	**0.266**
9+	39.1	0.265	0.0	0.000					**39.1**	**0.265**
TOTAL	3,334.2		1,284.5		323.5		266.4		**5,208.7**	
SOP catch		**611.7**		**21.8**		**22.9**		**9.0**		**665.4**

Figures for A fleet include 998 t unsampled bycatch in the industrial fishery

2006	Fleet A		Fleet B		Fleet C		Fleet D		TOTAL	
Total		Mean		Mean		Mean		Mean		**Mean**
Winter rings	Numbers	Weight	Numbers	Weight	Numbers	Weight	Numbers	Weight	**Numbers**	**Weight**
0	7.6	0.065	835.9	0.010	6.0	0.020	29.1	0.013	**878.6**	**0.010**
1	14.3	0.111	57.8	0.023	93.3	0.068	56.8	0.030	**222.2**	**0.049**
2	334.1	0.127	20.3	0.044	42.1	0.081	8.1	0.069	**404.5**	**0.117**
3	308.2	0.145	1.0	0.119	7.3	0.119	2.9	0.113	**319.4**	**0.144**
4	471.8	0.172	3.8	0.153	2.4	0.141	0.8	0.137	**478.8**	**0.172**
5	1012.6	0.181	4.7	0.160	2.1	0.184	1.2	0.188	**1,020.6**	**0.181**
6	257.5	0.220	0.0	0.000	0.4	0.188	0.1	0.197	**258.1**	**0.219**
7	253.3	0.237	0.0	0.000	0.3	0.213	0.1	0.225	**253.7**	**0.237**
8	64.6	0.235	0.5	0.214	0.1	0.206	0.0	0.209	**65.3**	**0.235**
9+	44.7	0.262	0.0	0.000					**44.7**	**0.262**
TOTAL	2,768.8		924.0		154.1		99.2		3,946.0	
SOP catch		**497.5**		**11.8**		**11.6**		**3.4**		**524.3**

Figures for A fleet include 961 t unsampled bycatch in the industrial fishery

2007	Fleet A		Fleet B		Fleet C		Fleet D		TOTAL	
Total		Mean		Mean		Mean		Mean		**Mean**
Winter rings	Numbers	Weight	Numbers	Weight	Numbers	Weight	Numbers	Weight	**Numbers**	**Weight**
0	20.5	0.008	532.8	0.011	14.2	0.048	53.5	0.021	**621.0**	**0.012**
1	21.0	0.099	25.2	0.045	150.3	0.071	39.0	0.031	**235.6**	**0.064**
2	142.1	0.149	0.0	0.000	59.5	0.075	17.4	0.059	**219.0**	**0.121**
3	412.8	0.152	0.0	0.000	1.9	0.111	0.2	0.085	**414.8**	**0.151**
4	284.0	0.164	0.0	0.000	0.3	0.123	0.1	0.130	**284.5**	**0.163**
5	307.4	0.194	0.0	0.000	1.4	0.152	0.1	0.145	**308.9**	**0.193**
6	628.1	0.190	0.0	0.000	0.2	0.179	0.1	0.191	**628.4**	**0.190**
7	146.8	0.224	0.0	0.000	0.6	0.175	0.0	0.165	**147.5**	**0.223**
8	132.9	0.235	0.0	0.000	0.0	0.144	0.0	0.216	**132.9**	**0.235**
9+	23.2	0.252	0.0	0.000	0.0	0.000	0.0	0.000	**23.2**	**0.252**
TOTAL	2,118.9		558.1		228.4		110.4		3,015.8	
SOP catch		**381.1**		**6.9**		**16.4**		**3.4**		**407.8**

Figures for A fleet include 345 t unsampled bycatch in the industrial fishery

2008	Fleet A		Fleet B		Fleet C		Fleet D		TOTAL	
Total		Mean		Mean		Mean		Mean		**Mean**
Winter rings	Numbers	Weight	Numbers	Weight	Numbers	Weight	Numbers	Weight	**Numbers**	**Weight**
0	66.3	0.010	646.3	0.007	4.3	0.036	81.3	0.015	**798.3**	**0.008**
1	78.4	0.061	70.1	0.040	59.2	0.071	27.4	0.029	**235.0**	**0.053**
2	259.7	0.141	0.0	0.000	52.6	0.087	19.4	0.085	**331.7**	**0.129**
3	182.8	0.180	0.0	0.000	1.7	0.109	0.2	0.110	**184.7**	**0.180**
4	198.7	0.181	0.0	0.000	0.2	0.139	0.0	0.133	**198.9**	**0.181**
5	137.3	0.183	0.0	0.000	0.1	0.168	0.0	0.187	**137.5**	**0.183**
6	118.2	0.216	0.0	0.000	0.1	0.175	0.0	0.161	**118.3**	**0.216**
7	215.0	0.216	0.0	0.000	0.3	0.203	0.0	0.184	**215.4**	**0.216**
8	74.3	0.256	0.0	0.000	0.1	0.199	0.0	0.159	**74.3**	**0.256**
9+	42.9	0.273	0.0	0.000	0.0	0.000	0.0	0.000	**42.9**	**0.273**
TOTAL	1,373.6		716.4		118.6		128.3		2,336.9	
SOP catch		**238.7**		**7.1**		**9.2**		**3.7**		**258.8**

Figures for A fleet include 50 t unsampled bycatch in the industrial fishery

Table 2.2.7: Catch at age (numbers in millions) of herring caught in the North Sea, 1993-2008.
SG Rednose's revisions for 1995-2001 are included.

Year/rings	0	1	2	3	4	5	6	7	8	9+	Total
1993	7254	1385	792	614	315	222	230	191	88	42	11133
1994	3834	497	1438	504	355	117	98	78	71	46	7038
1995	6294	484	1319	818	244	122	57	43	69	29	9480
1996	1795	645	488	516	170	57	22	9	17	4	3723
1997	364	174	565	428	285	109	31	12	19	6	1993
1998	208	254	1084	525	267	179	89	14	17	4	2642
1999	968	73	487	1034	289	134	70	28	10	2	3096
2000	873	194	516	453	636	212	82	36	15	3	3019
2001	1025	58	678	473	279	319	92	39	18	2	2982
2002	319	490	513	913	294	136	164	47	34	7	2917
2003	347	172	1022	507	809	244	106	121	37	8	3375
2004	627	136	274	1333	517	721	170	100	70	22	3970
2005	919	408	203	487	1326	480	577	116	108	39	4664
2006	844	72	354	309	475	1017	257	252	65	44	3689
2007	553	46	142	413	284	307	628	147	133	23	2677
2008	713	148	260	183	199	137	118	215	74	43	2090

Table 2.2.8: Catch at age (numbers in millions) of Baltic Spring spawning Herring taken in the North Sea, and transfered to the assessment of the spring spawning stock in IIIa, 1993-2008.

Year/rings	0	1	2	3	4	5	6	7	8	9+	Total
1993	0.0	0.0	4.2	10.8	12.3	8.4	5.9	4.7	1.7	1.0	49.0
1994	0.0	0.0	8.8	28.2	16.3	11.0	8.6	3.4	3.2	0.7	80.2
1995	0.0	0.0	22.4	11.0	14.9	4.0	2.9	1.9	0.7	0.0	57.8
1996	0.0	0.0	0.0	2.8	0.8	0.4	0.1	0.1	0.3	0.0	4.5
1997	0.0	0.0	2.2	1.3	1.5	0.4	0.2	0.1	0.2	0.0	5.9
1998	0.0	5.1	9.5	12.0	10.1	6.0	3.0	0.4	0.9	0.0	47.0
1999	0.0	0.0	3.3	14.3	5.6	3.6	1.4	0.6	0.4	0.0	29.3
2000	0.0	0.0	8.2	9.8	10.2	5.7	2.5	0.6	0.7	0.1	37.6
2001	0.0	0.0	11.3	10.2	6.1	7.2	2.7	1.6	0.4	0.0	39.9
2002	0.0	0.0	7.6	14.8	10.6	3.3	2.9	1.0	0.5	0.1	40.8
2003	0.0	0.0	0.0	3.1	6.0	3.5	1.2	1.3	0.5	0.1	15.7
2004	0.0	0.0	15.1	27.9	3.5	4.1	1.0	0.5	0.1	0.0	52.3
2005	0.0	0.0	6.6	17.4	12.7	2.6	3.8	1.1	0.4	0.3	44.8
2006	0.0	0.1	3.5	8.8	14.0	22.4	5.1	5.3	2.1	1.0	62.2
2007	0.0	0.0	0.1	2.6	1.3	0.6	0.8	0.4	0.5	0.2	6.3
2008	0.0	0.0	0.1	0.1	0.2	0.1	0.1	0.2	0.0	0.0	0.7

Table 2.2.9: Catch at age (numbers in millions) of North Sea Autumn Spawners taken in IIIa, and transfered to the assessment of NSAS, 1993 - 2008. SG Rednose's revisions and revision of 2002 splitting are included.

Year/rings	0	1	2	3	4	5	6	7	8+	Total
1993	2795	2033	238	27	8	4	3	2	1	5109
1994	482	1087	201	27	6	3	2	0	0	1807
1995	1145	1181	147	10	3	1	1	0	0	2487
1996	516	961	154	13	3	1	1	0	0	1649
1997	68	305	125	20	1	1	0	0	0	521
1998	51	729	145	25	19	3	3	1	0	977
1999	598	231	133	39	10	5	1	1	0	1017
2000	232	978	115	20	21	7	3	1	0	1377
2001	808	557	140	15	1	0	0	0	0	1521
2002	411	345	48	5	1	0	0	0	0	811
2003	22	445	182	13	16	2	1	1	0	682
2004	88	71	180	21	6	10	2	2	1	380
2005	96	307	159	16	5	2	2	0	0	590
2006	35	150	50	10	3	3	1	0	0	253
2007	68	189	77	2	0	1	0	1	0	339
2008	86	87	72	2	0	0	0	0	0	247

Table 2.2.10: Catch at age (numbers in millions) of the total North Sea Autumn Spawning stock 1993 - 2008.
SG Rednose's revisions and the revision of 2002 splitting are included.

Year/rings	0	1	2	3	4	5	6	7	8	9+	Total
1993	10280	4160	1305	577	295	210	221	184	86	41	17358
1994	4437	1890	1839	449	332	103	88	74	68	45	9325
1995	7438	1665	1444	817	232	119	55	41	69	29	11909
1996	2311	1606	642	526	172	58	23	9	17	4	5368
1997	431	480	688	447	285	109	31	12	19	6	2507
1998	260	978	1220	538	276	176	89	15	17	4	3572
1999	1566	304	616	1059	294	136	69	28	10	2	4084
2000	1105	1172	623	463	647	213	82	36	15	2	4358
2001	1833	614	806	477	274	312	89	37	17	2	4463
2002	730	835	553	903	284	133	161	46	33	7	3687
2003	369	617	1204	517	820	243	106	120	37	8	4042
2004	716	207	439	1326	520	726	171	101	71	22	4298
2005	1016	716	355	486	1318	480	576	115	108	39	5209
2006	879	222	401	311	465	999	253	249	63	44	3885
2007	621	236	219	412	283	308	628	147	132	23	3009
2008	798	235	332	185	199	137	118	215	74	43	2336

Table 2.2.11: Comparison of mean weights (kg) at age (rings) in the catch of adult herring in the North Sea (by Div.) and North Sea autumn spawners caught in Div. IIIa in 1998 – 2008. SG Red-nose's revisions are included.

		Age (Rings)							
Div.	Year	2	3	4	5	6	7	8	9+
IIIa	1998	0.078	0.118	0.163	0.180	0.197	0.179	0.226	-
	1999	0.084	0.113	0.141	0.161	0.181	0.206	0.199	-
	2000	0.076	0.103	0.162	0.190	0.184	0.186	0.177	-
	2001	0.073	0.105	0.128	0.133	0.224	0.170	0.192	-
	2002	0.104	0.126	0.144	0.164	0.180	0.180	0.218	-
	2003	0.067	0.123	0.150	0.163	0.191	0.214	0.187	-
	2004	0.070	0.121	0.141	0.152	0.170	0.187	0.178	-
	2005	0.071	0.106	0.155	0.173	0.185	0.200	0.209	-
	2006	0.079	0.117	0.140	0.186	0.191	0.216	0.207	-
	2007	0.071	0.108	0.125	0.152	0.184	0.175	0.154	-
	2008	0.087	0.109	0.139	0.168	0.176	0.204	0.198	-
IVa(E)	1998	0.114	0.148	0.171	0.199	0.219	0.237	0.269	0.233
	1999	0.125	0.143	0.162	0.191	0.207	0.226	0.232	0.272
	2000	0.130	0.154	0.172	0.195	0.202	0.218	0.261	0.256
	2001	0.121	0.148	0.165	0.177	0.197	0.220	0.262	0.238
	2002	0.130	0.154	0.167	0.189	0.198	0.212	0.229	0.238
	2003	0.122	0.154	0.162	0.177	0.189	0.203	0.213	0.218
	2004	0.119	0.133	0.171	0.185	0.212	0.192	0.218	0.252
	2005	0.117	0.146	0.153	0.202	0.209	0.233	0.262	0.265
	2006	0.125	0.149	0.164	0.175	0.214	0.224	0.229	0.254
	2007	0.156	0.148	0.156	0.186	0.184	0.204	0.226	0.239
	2008	0.138	0.173	0.172	0.174	0.216	0.210	0.253	0.266
IVa(W)	1998	0.130	0.170	0.205	0.244	0.263	0.270	0.308	0.314
	1999	0.129	0.162	0.192	0.227	0.250	0.261	0.272	0.309
	2000	0.127	0.159	0.187	0.214	0.237	0.271	0.293	0.265
	2001	0.138	0.168	0.193	0.222	0.235	0.266	0.285	0.296
	2002	0.144	0.161	0.191	0.211	0.230	0.242	0.261	0.263
	2003	0.130	0.167	0.184	0.202	0.224	0.237	0.259	0.276
	2004	0.131	0.155	0.193	0.220	0.242	0.251	0.246	0.299
	2005	0.122	0.158	0.174	0.213	0.229	0.245	0.275	0.267
	2006	0.145	0.156	0.180	0.193	0.230	0.251	0.247	0.286
	2007	0.150	0.156	0.166	0.196	0.191	0.227	0.241	0.264
	2008	0.142	0.187	0.187	0.188	0.230	0.219	0.262	0.281
IVb	1998	0.117	0.162	0.203	0.216	0.243	0.218	0.311	0.307
	1999	0.118	0.148	0.154	0.207	0.226	0.209	0.287	0.345
	2000	0.118	0.173	0.194	0.224	0.229	0.251	0.240	0.268
	2001	0.105	0.150	0.176	0.188	0.199	0.206	0.244	0.275
	2002	0.086	0.149	0.161	0.206	0.214	0.189	0.270	0.241
	2003	0.098	0.161	0.178	0.195	0.214	0.214	0.222	0.281
	2004	0.118	0.143	0.186	0.214	0.234	0.239	0.297	0.308
	2005	0.132	0.172	0.187	0.217	0.220	0.245	0.253	0.252
	2006	0.097	0.141	0.172	0.183	0.202	0.220	0.232	0.239
	2007	0.145	0.160	0.180	0.201	0.210	0.246	0.234	0.252
	2008	0.142	0.172	0.185	0.191	0.222	0.228	0.265	0.223
IVa & IVb	1998	0.123	0.162	0.194	0.224	0.243	0.253	0.293	0.283
	1999	0.124	0.155	0.179	0.213	0.236	0.250	0.264	0.301
	2000	0.125	0.162	0.185	0.210	0.227	0.258	0.275	0.263
	2001	0.129	0.156	0.180	0.202	0.217	0.242	0.275	0.285
	2002	0.119	0.157	0.177	0.203	0.219	0.228	0.253	0.253
	2003	0.113	0.163	0.178	0.190	0.210	0.225	0.239	0.255
	2004	0.122	0.147	0.187	0.210	0.227	0.233	0.247	0.266
	2005	0.121	0.157	0.172	0.212	0.225	0.242	0.269	0.265
	2006	0.123	0.150	0.174	0.187	0.222	0.239	0.238	0.269
	2007	0.149	0.155	0.165	0.196	0.192	0.227	0.238	0.257
	2008	0.142	0.182	0.185	0.188	0.226	0.220	0.262	0.275
IVc & VIId	1998	0.096	0.114	0.146	0.149	0.184	0.000	0.176	-
	1999	0.116	0.139	0.159	0.189	0.198	0.217	-	-
	2000	0.106	0.133	0.150	0.180	0.194	0.203	-	-
	2001	0.113	0.138	0.171	0.167	0.171	0.168	0.180	-
	2002	0.108	0.123	0.153	0.170	0.187	0.219	0.208	-
	2003	0.103	0.127	0.144	0.168	0.176	0.188	0.200	0.227
	2004	0.099	0.113	0.135	0.162	0.184	0.191	0.186	0.224
	2005	0.122	0.132	0.139	0.170	0.207	0.228	0.237	0.245
	2006	0.119	0.125	0.153	0.152	0.178	0.205	0.209	0.219
	2007	0.129	0.131	0.154	0.158	0.173	0.196	0.209	0.218
	2008	0.120	0.157	0.156	0.173	0.188	0.192	0.215	0.247
Total North Sea Catch	1998	0.119	0.146	0.185	0.219	0.239	0.253	0.288	0.283
	1999	0.123	0.152	0.172	0.208	0.233	0.246	0.264	0.301
	2000	0.122	0.159	0.180	0.202	0.217	0.247	0.275	0.263
	2001	0.118	0.149	0.177	0.198	0.213	0.238	0.267	0.288
	2002	0.118	0.153	0.170	0.199	0.214	0.228	0.250	0.252
	2003	0.104	0.158	0.174	0.184	0.205	0.222	0.232	0.256
	2004	0.100	0.138	0.183	0.201	0.216	0.228	0.246	0.272
	2005	0.099	0.153	0.166	0.208	0.223	0.240	0.257	0.278
	2006	0.122	0.145	0.172	0.181	0.220	0.237	0.235	0.262
	2007	0.149	0.152	0.164	0.194	0.190	0.224	0.235	0.252
	2008	0.141	0.180	0.181	0.183	0.216	0.216	0.256	0.273

Figures for total NS catch updatad in 2006 for the years 2001-2005 due to an incorrect allocation of fish in the plus group in the danish catches and new information of misreportings from the UK.

Table 2.2.12: Sampling of commercial landings of herring in the North Sea (Div. IV and VIId) in 2008 by quarter. Sampled catch means the proportion of the reported catch to which sampling was applied. It is limited by 100 % but might exceed the official landings due to sampling of discards, unallocated and misreported catches. It is not possible to judge the quality of the sampling by this figure alone. Note that only one nation sampled their by-catches in the industrial fishery (Denmark, fleet B). Metiers are each *reported* combination of nation/fleet/area/quarter.

Country (fleet)	Quarter	No of metiers	Metiers sampled	Sampled Catch %	Official Catch	No. of samples	No. fish aged	No. fish measured	>1 sample per 1 kt catch
Denmark (A)	1	3	0	0%	8776	0	0	0	n
	2	3	1	92%	2109	2	55	292	n
	3	3	3	100%	34864	19	504	2730	n
	4	4	1	52%	8509	1	25	141	n
total		**13**	**5**	**76%**	**54258**	**22**	**584**	**3163**	**n**
Denmark (B)	1	3	1	61%	17	3	16	16	y
	2	1	0	0%	195	9	0	11	y
	3	2	1	93%	4262	9	395	405	y
	4	3	1	76%	4133	4	71	72	y
total		**9**	**3**	**83%**	**8606**	**25**	**482**	**504**	**y**
England	1	2	0	0%	179	0	0	0	n
and Wales*	2	2	1	100%	872	5	125	629	y
	3	3	2	100%	7893	11	275	1274	y
	4	4	0	0%	2772	0	0	0	n
total		**11**	**3**	**75%**	**11717**	**16**	**400**	**1903**	**y**
Faroe	1	2	0	0%	600	0	0	0	n
Island	4	2	0	0%	1414	0	0	0	n
total		**4**	**0**	**0%**	**2014**	**0**	**0**	**0**	**n**
France	1	3	0	0%	619	0	0	0	n
	2	4	0	0%	1156	0	0	0	n
	3	4	0	0%	20925	0	0	0	n
	4	3	0	0%	7647	0	0	0	n
total		**14**	**0**	**0%**	**30346**	**0**	**0**	**0**	**n**
Germany	3	2	0	0%	2145	0	0	0	n
	4	4	4	100%	5965	27	2284	11878	y
total		**6**	**4**	**74%**	**8109**	**27**	**2284**	**11878**	**y**
Netherlands	1	2	2	100%	1391	17	425	3014	y
	2	1	1	100%	4470	17	425	2626	y
	3	3	1	100%	8325	29	725	2891	y
	4	4	1	100%	8936	4	100	509	n
total		**10**	**5**	**100%**	**23122**	**67**	**1675**	**9040**	**y**
Northern Irelan	1	1	0	0%	331	0	0	0	n
total		**1**	**0**	**0%**	**331**	**0**	**0**	**0**	**n**
Norway	1	1	0	0%	489	0	0	0	n
	2	3	2	99%	34231	17	584	1700	n
	3	3	0	0%	3695	0	0	0	n
	4	3	3	100%	20906	8	313	572	n
total		**10**	**5**	**93%**	**59321**	**25**	**897**	**2272**	**n**
Scotland	1	1	0	0%	895	0	0	0	n
	2	2	1	86%	1243	7	355	1270	y
	3	2	2	100%	12735	26	1875	5823	y
	4	3	1	94%	1183	2	111	379	y
total		**8**	**4**	**100%**	**16056**	**35**	**2341**	**7472**	**y**
Sweden	2	2	0	0%	6625	0	0	0	n
	3	3	0	0%	5085	0	0	0	n
	4	2	0	0%	2305	0	0	0	n
total		**5**	**0**	**0%**	**7390**	**0**	**0**	**0**	**n**
grand total		**93**	**29**	**76%**	**227895**	**217**	**8663**	**36232**	**y**
Period total	**1**	18	3	24%	13297	20	441	3030	n
Period total	**2**	18	6	93%	50900	57	1544	6528	y
Period total	**3**	25	9	77%	99928	94	3774	13123	y
Period total	**4**	32	11	72%	63770	46	2904	13551	n
Total for stock 2008		**93**	**29**	**76%**	**227895**	**217**	**8663**	**36232**	**n**
Human Cons. only		84	26	76%	219290	192	8181	35728	n
Total for stock 2006		107	39	79%	490362	404	23581	65536	n
Total for stock 2007		100	30	86%	361114	335	10342	54639	n
Human Cons. only 2007		91	27	85%	354017	318	10194	54310	n

* majority of catches landed to Ijmuiden, the Netherlands

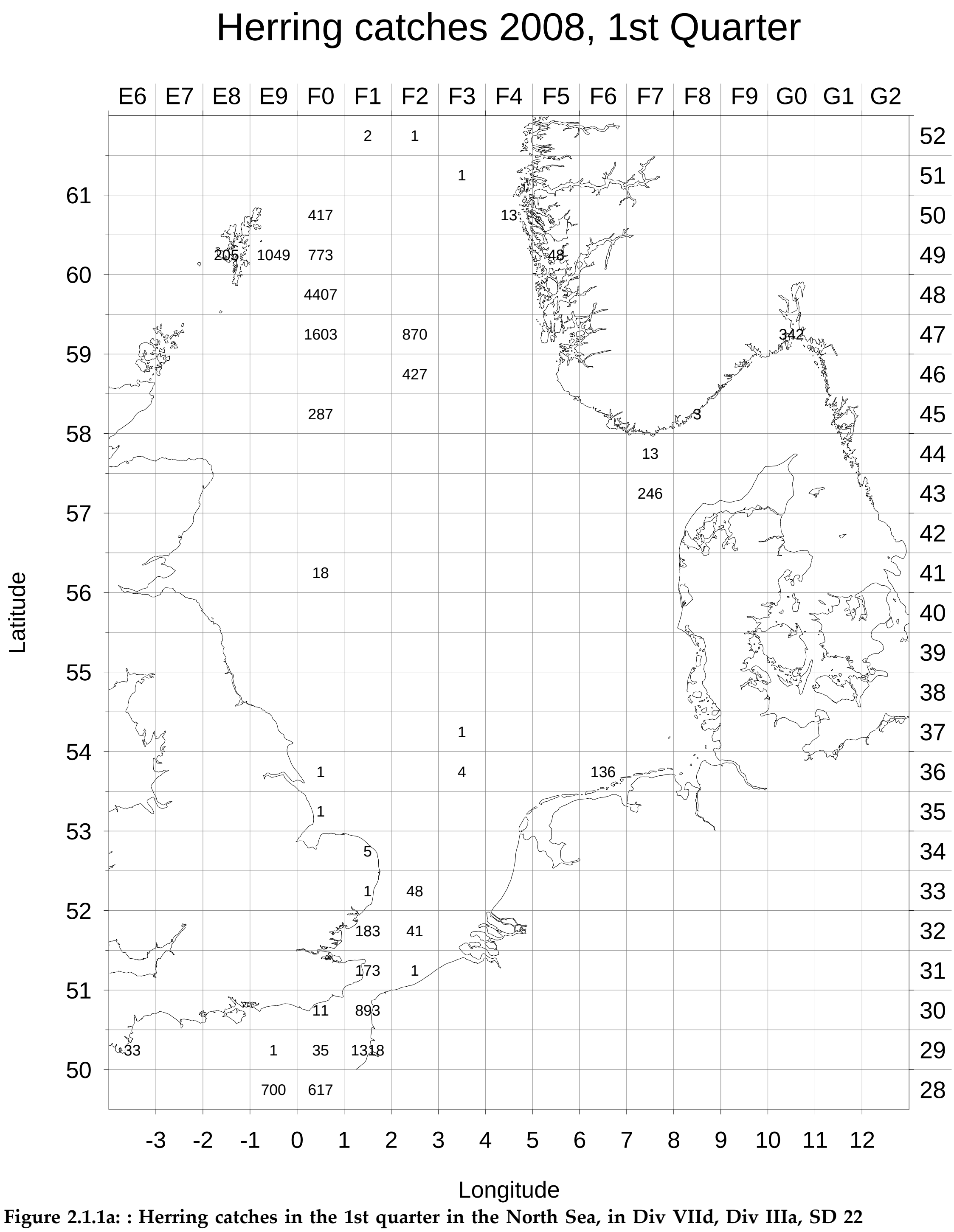


Figure 2.1.1a: : Herring catches in the 1st quarter in the North Sea, in Div VIId, Div IIIa, SD 22 and SD 24 (in tonnes) in 2008 by statistical rectangle. Working group estimates (if available).

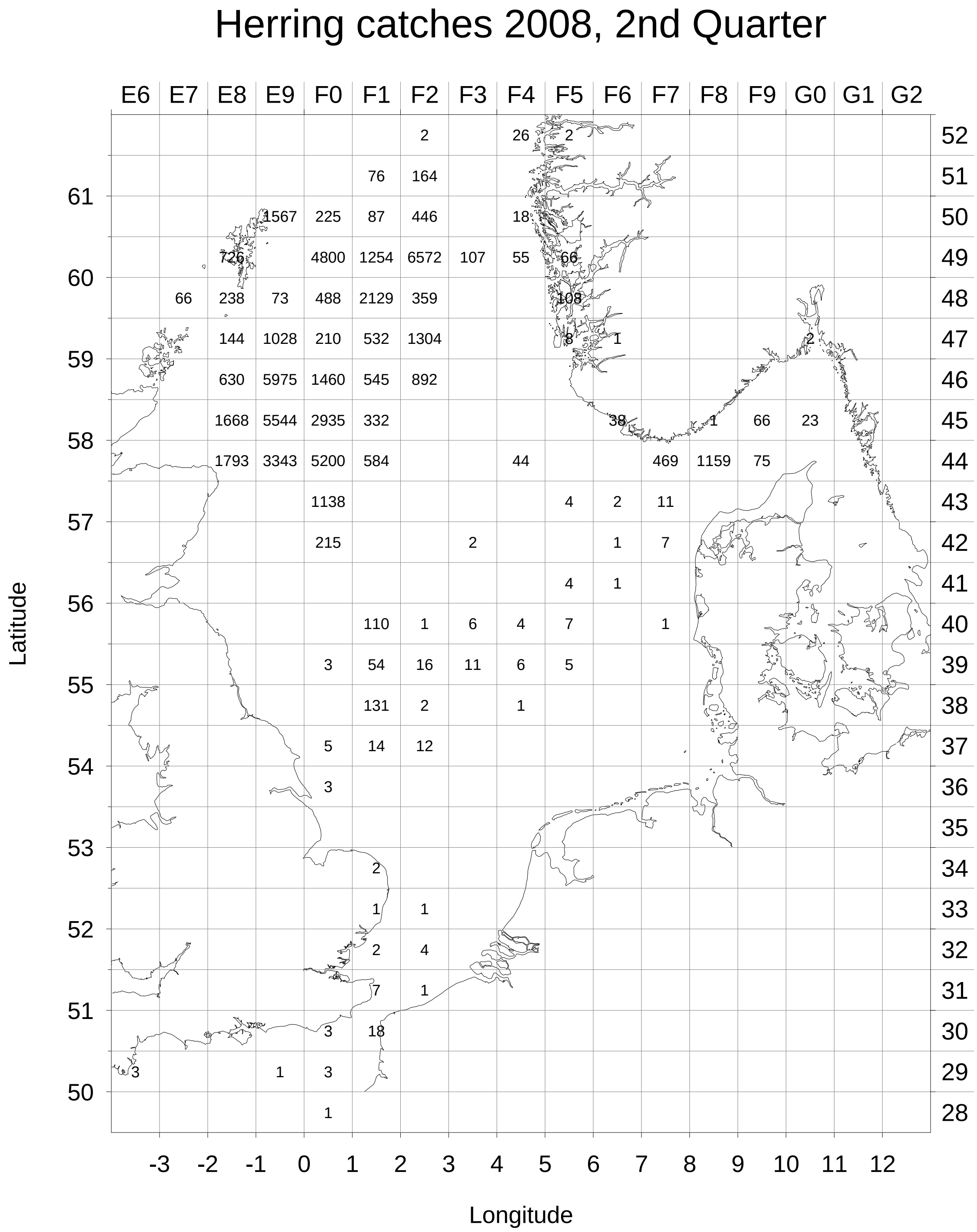


Figure 2.1.1b: Herring catches in the 2nd quarter in the North Sea, in Div VIId, Div IIIa, SD 22 and SD 24 (in tonnes) in 2008 by statistical rectangle. Working group estimates (if available).

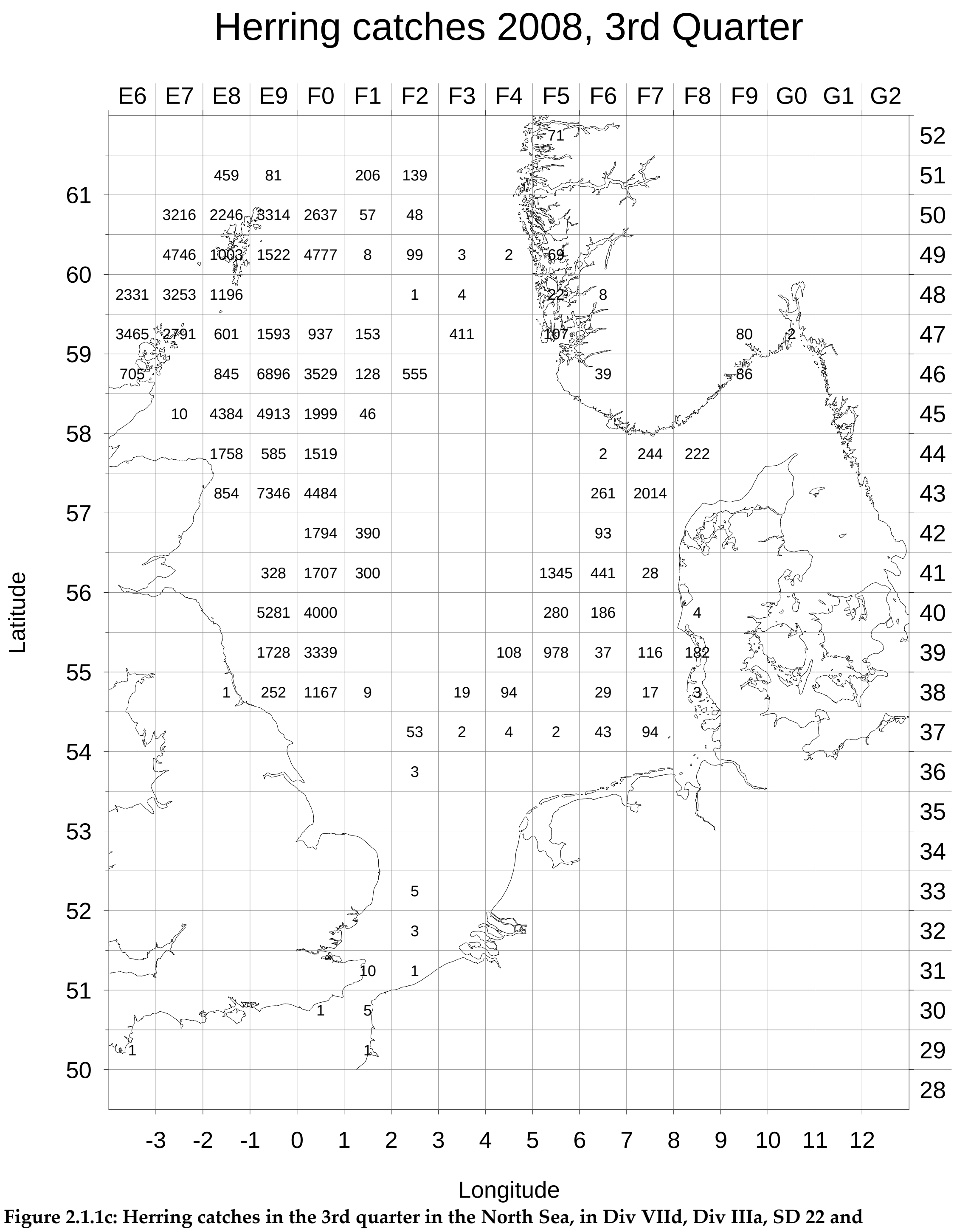


Figure 2.1.1c: Herring catches in the 3rd quarter in the North Sea, in Div VIId, Div IIIa, SD 22 and SD 24 (in tonnes) in 2008 by statistical rectangle. Working group estimates (if available).

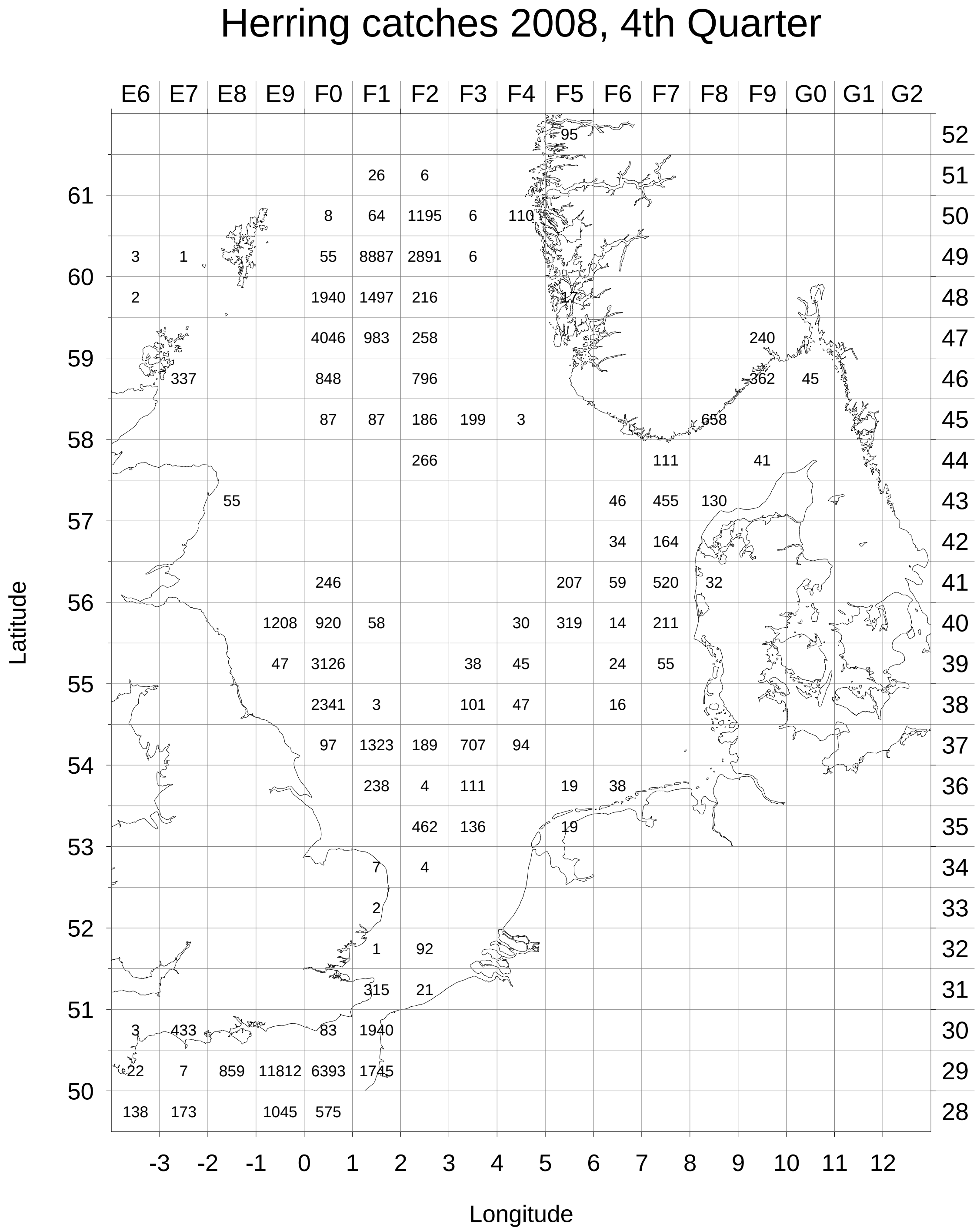


Figure 2.1.1d: Herring catches in the 4th quarter in the North Sea, in Div VIId, Div IIIa, SD 22 and SD 24 (in tonnes) in 2008 by statistical rectangle. Working group estimates (if available).

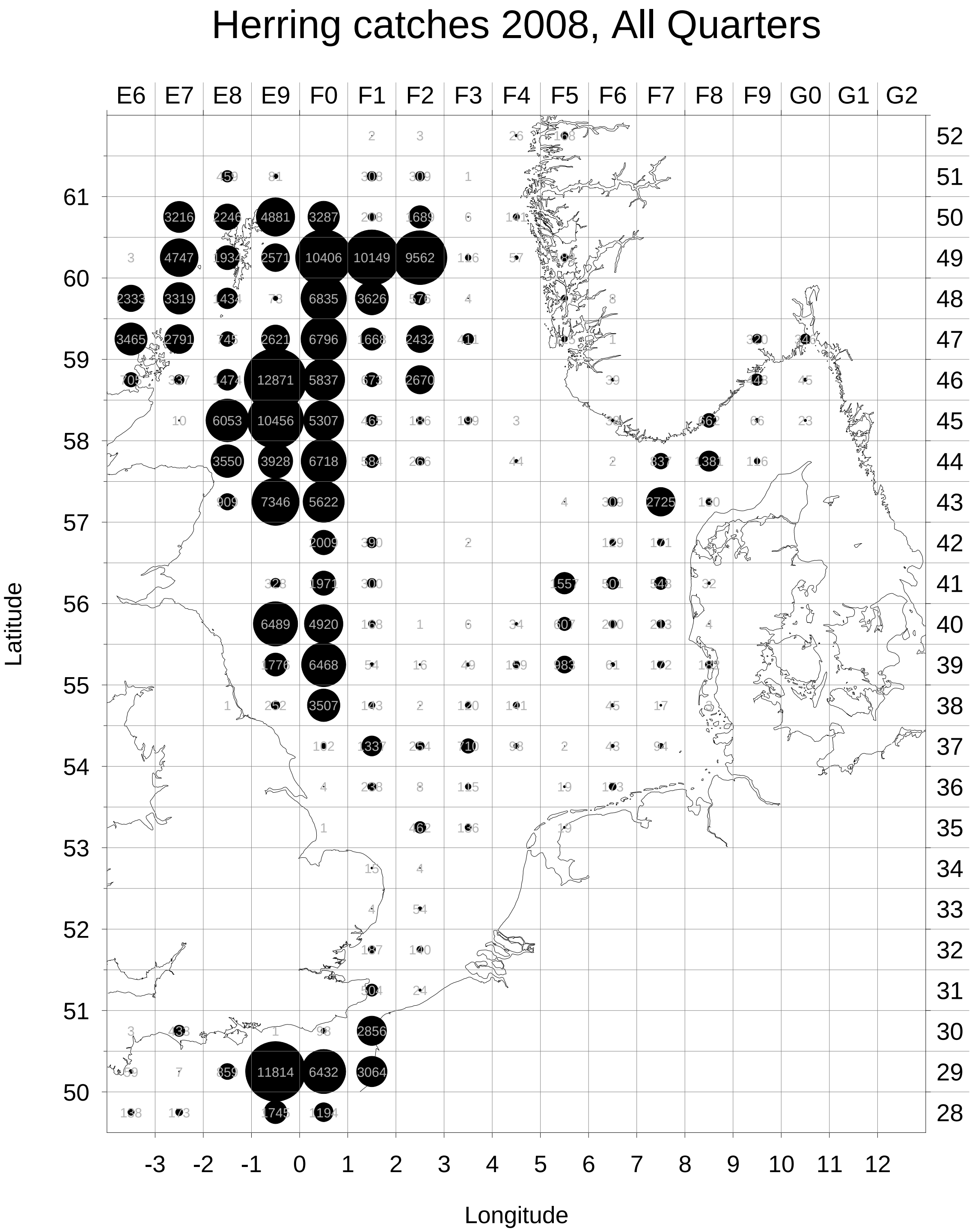
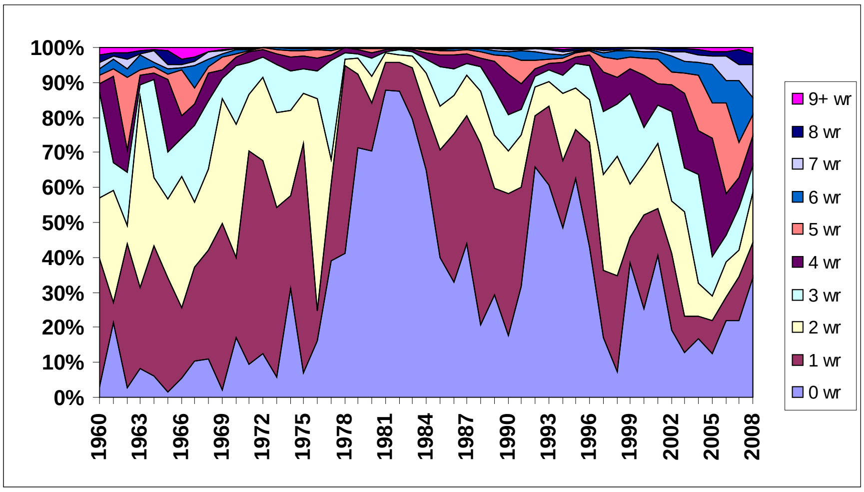
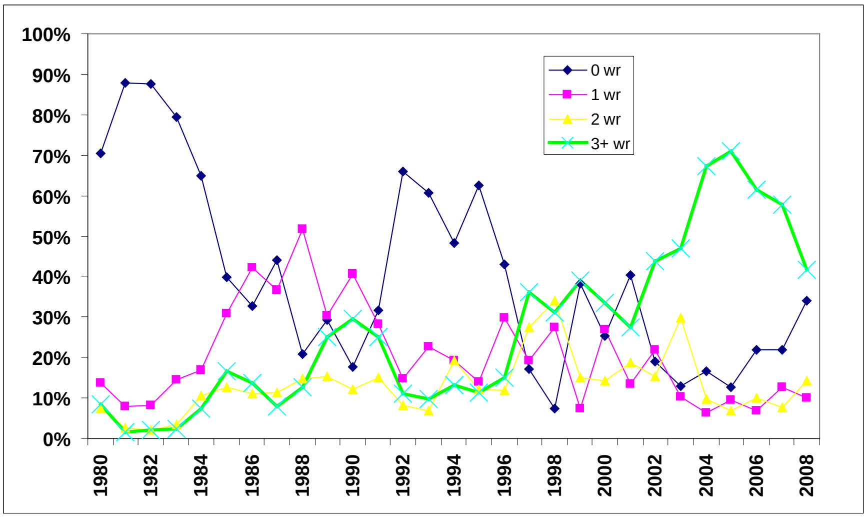


Figure 2.1.1e: Herring catches in all quarters in the North Sea, in Div VIId, Div IIIa, SD 22 and SD 24 (in tonnes) in 2008 by statistical rectangle. Working group estimates (if available).





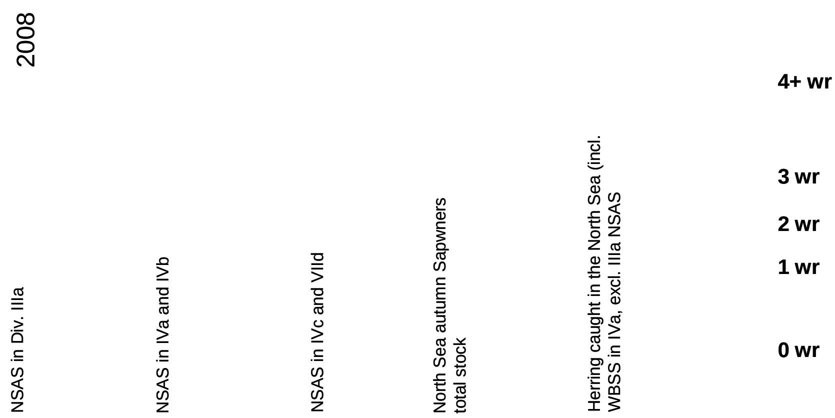


Figure 2.2.1: Proportions of age groups (numbers) in the total catch of herring in the North Sea (upper, 1960-2008, and middle panel, 1980-2008), and in the total catch of North Sea autumn spawners in 2008 (lower panel).

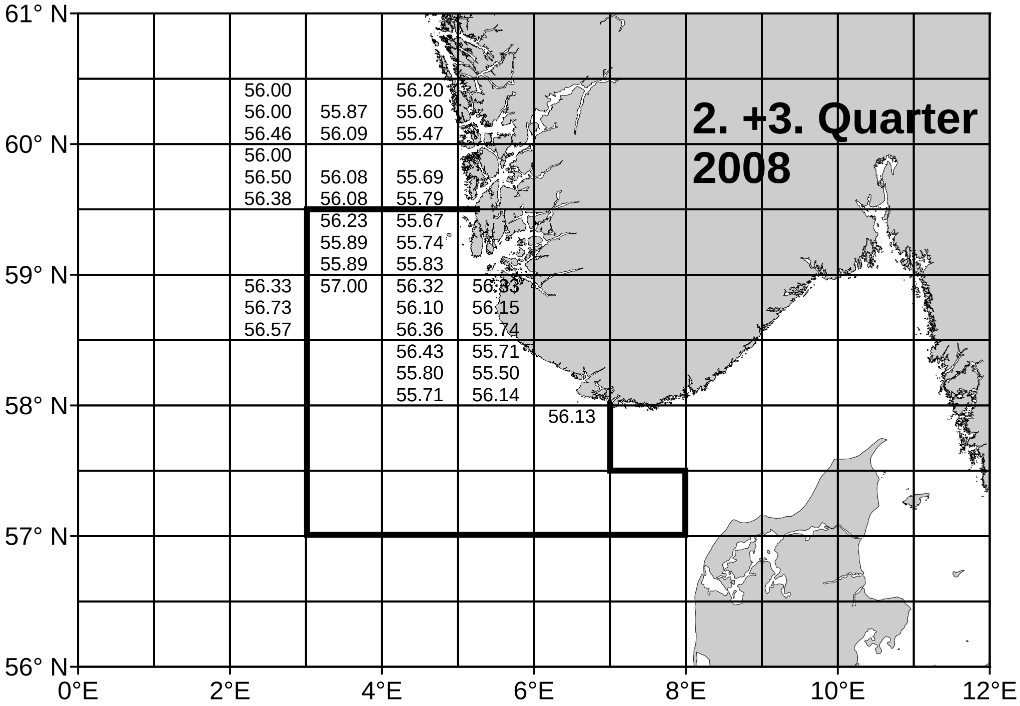


Figure 2.2.2: Mean vertebrae counts of 2 (upper number), 3 (middle) and 4+ herring (lower) in the North Sea and Div. IIIa as obtained by Norwegian sampling in the 2nd and 3rd quarter 2008. The transfer area (Western Baltic spring spawners transferred to the assessment of IIIa herring) is indicated.

2.3 Fishery Independent Information

2.3.1 Acoustic Surveys in the North Sea, West of Scotland VIa(N) and the Malin Shelf area in July 2008

Eight surveys were carried out during late June and July 2008 covering most of the continental shelf in the North Sea, West of Scotland and the Malin Shelf. The individual surveys and the survey methods are given in the report of the Planning Group of International Pelagic Surveys (PGIPS; ICES, 2009/LRC:02). The vessels, areas and dates of cruises are given in Table 2.3.1.1 and in Figure 2.3.1.1.

The data has been combined to provide an overall estimate of numbers-at-age, maturity ogive and mean weights-at-age. These have been calculated as weighted means of individual survey estimates by ICES statistical rectangle. The weighting applied is proportional to the survey track for each vessel that has been covered in each statistical rectangle.

The estimate of North Sea autumn spawning herring spawning stock is higher than the previous year, at 1.8 million tonnes and 9.5 million herring (Table 2.3.1.2). The survey indicates that the strong 2000 year class of herring still persists in the population. Growth of the 2000 year class seems still to be slower than average, with individuals of this year class having a lower mean size and mean weight of those fish which are one year younger (the 2001 year class).

The spatial distribution of mature and immature autumn spawning herring is shown in Figures 2.3.1.2 and 2.3.1.3 respectively. Adult herring in the North Sea are concentrated in northern areas close to the Fladen grounds.

The time series of abundance for North Sea autumn spawners are given in Table 2.3.1.3.

Table 2.3.1.1: Pelagic Acoustic Surveys. Vessels, areas and cruise dates in 2008.

Vessel	Period	Area	Rectangles
Corystes (NIR)	05 July – 11 July	Clyde/ North Channel	40E3-E5, 39E4-E5,38E4
Celtic Explorer (IR)	28 June – 14 July	52°30′-56°N ,12°-6°W	34D9-E0, 35D9-E0, 36D9-E0, 37D9-E1, 38D9-E1, 39E0-E3, 40E1-E3
Charter west Sco (SCO)	30 June – 19 July	55°30′-60°30′N, 4°-10°W	41E0-E3, 42E0-E3, 43E0-E3, 44E0-E3, 45E0-E4, 46E2-E5, 47E2-E5, 48E4-E5, 49E5
Johan Hjort (NOR)	01 July – 31 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
Scotia (SCO)	28 June – 18 July	58°30′-62°N, 4°W-2°E	46E6-F1, 47E6-F1, 48E6-F1, 49E6-F1, 50E7-F1, 51E8-F1, 52E9-F1
Tridens (NED)	23 June – 18 July	54°– 58°30′N, 4° W–2°/ 6°E	37E9-F1, 38E8-F1, 39E8-F1, 40E8-F5, 41E7-F5, 42E7-F1, 43E7-F1, 44E6-F1, 45E6-F1
Solea (GER) DBFH	26 June – 16 July	52°-56°N, Eng to Den/Ger coasts	33F1-F4, 34F2-F4, 35F2-F4, 36F0-F7, 37F2-F8, 38F2-F7, 39F2-F7, 40F6-F7
Dana (DEN) OXBH	26 June –07 July	Kattegat and North of 56°N, east of 6°E	41 F6-F7, 41G1-G2, 42F6-F7, 42G0-G2, 43F6-G1, 44F6-G1, 45F8-G1, 46F9-G0

Table 2.3.1.2: 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 July 2008, with mean weights and mean lengths by age ring.

Age (ring)	Numbers	Biomass	Maturity	weight(g)	Length (cm)
0	**6,870**	**60**	**0.00**	**8.7**	**10.5**
1	**3,714**	**232**	**0.05**	**62.4**	**19.2**
2	**2,853**	**403**	**0.86**	**141.4**	**25.0**
3	**1,709**	**307**	**0.98**	**179.7**	**26.8**
4	**1,485**	**272**	**0.99**	**183.3**	**27.0**
5	**809**	**157**	**1.00**	**194.4**	**27.5**
6	**712**	**164**	**1.00**	**229.9**	**28.7**
7	**1,749**	**380**	**1.00**	**217.4**	**28.4**
8	**185**	**50**	**1.00**	**267.9**	**29.7**
9+	**270**	**76**	**1.00**	**282.3**	**30.2**
IMMATURE	**10,841**	**317**		**29.2**	**13.8**
MATURE	**9,514**	**1,784**		**187.5**	**27.0**
TOTAL	**20,355**	**2,100**	**0.47**	**103.2**	**20.0**

Table 2.3.1.3: Estimates of North Sea autumn spawners (millions) at age from acoustic surveys, 1985-2008. For 1985-1986 the estimates are the sum of those from the Division IVa summer survey, the Division IVb autumn survey, and the Divisions IVc, VIId winter survey. The 1987 to 2008 estimates are from the summer survey in Divisions IVa,b and IIIa excluding estimates of Division IIIa/Baltic spring spawners. For 1999 and 2000 the Kattegat was excluded from the results because it was not surveyed.

Years / Age (rings)	1	2	3	4	5	6	7	8	9+	Total	SSB ('000t)
1985	726	2,789	1,433	323	113	41	17	23	19	5,484	697
1986	1,639	3,206	1,637	833	135	36	24	6	8	7,542	942
1987	13,736	4,303	955	657	368	77	38	11	20	20,165	817
1988	6,431	4,202	1,732	528	349	174	43	23	14	13,496	897
1989	6,333	3,726	3,751	1,612	488	281	120	44	22	16,377	1,637
1990	6,249	2,971	3,530	3,370	1,349	395	211	134	43	18,262	2,174
1991	3,182	2,834	1,501	2,102	1,984	748	262	112	56	12,781	1,874
1992	6,351	4,179	1,633	1,397	1,510	1,311	474	155	163	17,173	1,545
1993	10,399	3,710	1,855	909	795	788	546	178	116	19,326	1,216
1994	3,646	3,280	957	429	363	321	238	220	132	13,003	1,035
1995	4,202	3,799	2,056	656	272	175	135	110	84	11,220	1,082
1996	6,198	4,557	2,824	1,087	311	99	83	133	206	18,786	1,446
1997	9,416	6,363	3,287	1,696	692	259	79	78	158	22,028	1,780
1998	4,449	5,747	2,520	1,625	982	445	170	45	121	16,104	1,792
1999	5,087	3,078	4,725	1,116	506	314	139	54	87	15,107	1,534
2000	24,735	2,922	2,156	3,139	1,006	483	266	120	97	34,928	1,833
2001	6,837	12,290	3,083	1,462	1,676	450	170	98	59	26,124	2,622
2002	23,055	4,875	8,220	1,390	795	1,031	244	121	150	39,881	2,948
2003	9,829	18,949	3,081	4,189	675	495	568	146	178	38,110	2,999
2004	5,183	3,415	9,191	2,167	2,590	317	328	342	186	23,722	2,584
2005	3,113	1,890	3,436	5,609	1,211	1,172	140	127	107	16,805	1,868
2006	6,823	3,772	1,997	2,098	4,175	618	562	84	70	20,199	2,130
2007	6,261	2,750	1,848	898	806	1,323	243	152	65	14,346	1,203
2008	3,714	2,853	1,709	1,485	809	712	1,749	185	270	20,355	1,784

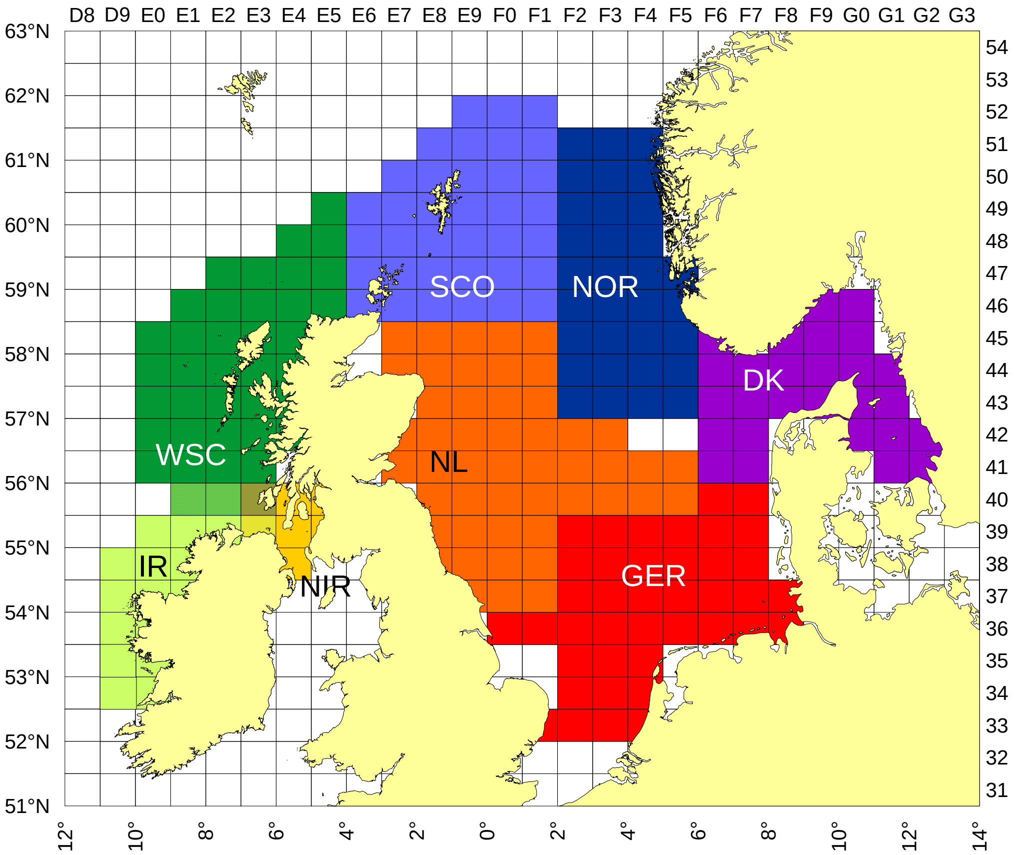


Figure 2.3.1.1: Survey area coverage in the pelagic acoustic surveys in 2008, by rectangle and nation (IR = Celtic Explorer; NIR = Corystes; WSC = West of Scotland charter vessel; SCO = Scotia; NOR = Johan Hjort; DK = Dana; NL = Tridens; GER = Solea). Multi-coloured rectangles indicate overlapping coverage by two or more nations (e.g. 40E1-40E3).

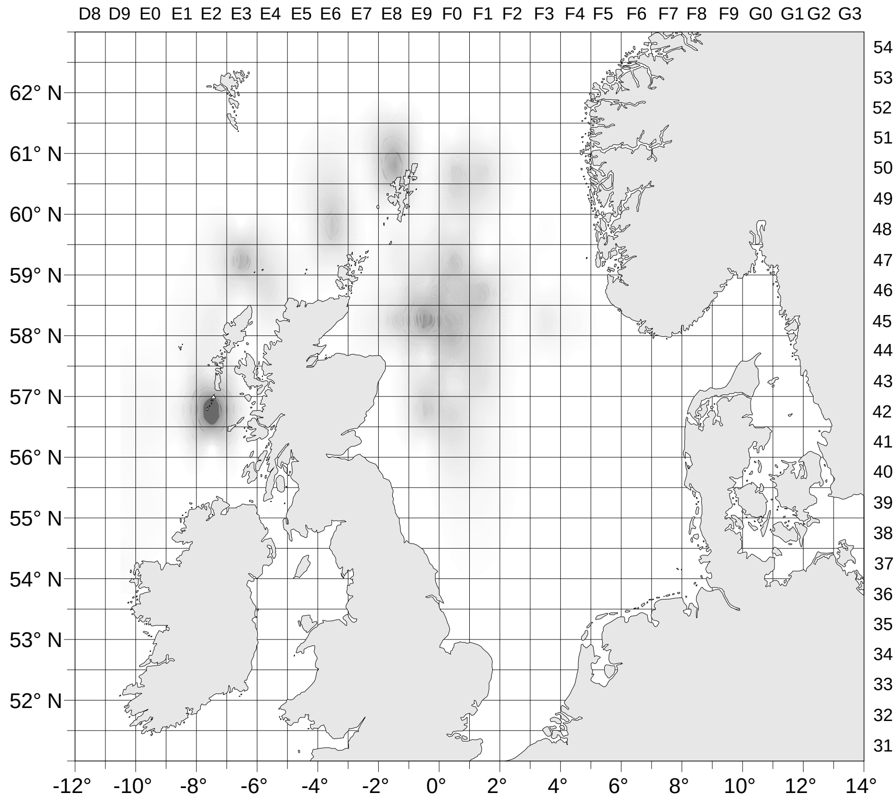


Figure 2.3.1.2: Biomass of mature autumn spawning herring from the combined acoustic survey in June – July 2008 (maximum grid density = 200 000 t).

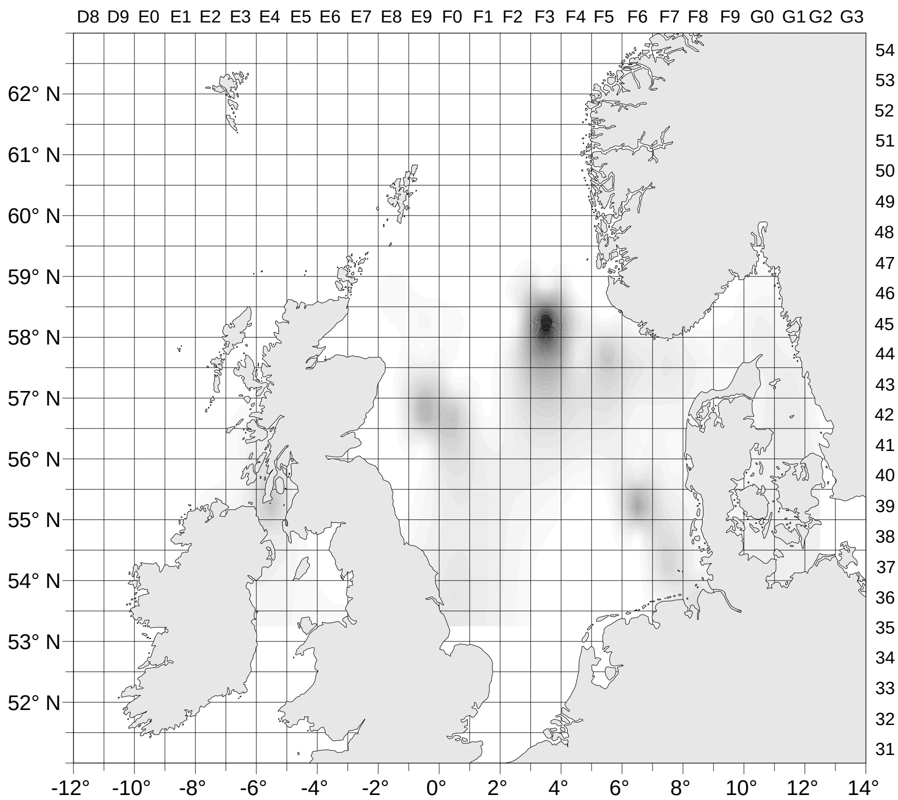


Figure 2.3.1.3: Biomass of immature autumn spawning herring from the combined acoustic survey in June – July 2008 (maximum grid density = 56 000 t).

2.3.2 Larvae Surveys in the North Sea 2008

Seven larvae surveys were conducted between September 2008 and January 2009 (Table 2.3.2.1). The survey effort in numbers of samples taken and vessel days in the surveys was comparable to previous years (Table 2.3.2.2).

Large numbers of newly hatched herring larvae were obtained from all areas observed, with the only exception of the Buchan area. When compared to previous years, herring larvae abundance has decreased in the Buchan area, while the Larvae Abundance Indices (LAI) estimated for the Orkney/Shetland area, the central North Sea area and the southern North Sea have increased (Tab. 2.3.2.3, Figure 2.3.2.1). The LAI in the Central North Sea revealed the highest level observed since 2003. However, this area is well known for large annual variabilities both in larvae abundance and survey effort.

The MLAI for the whole North Sea derived from the larvae surveys in period 2008/2009 indicate that the SSB has increased when compared to last year's WG estimate (Figure 2.3.2.2). The updated MLAI time-series is shown in Table 2.3.2.3.

Detailed information on survey coverage and effort in the North Sea are given in the Report of the herring larvae surveys in the North Sea (Rohlf & Gröger, WD 12).

Table 2.3.2.1: North Sea autumn spawners, Herring Larvae Surveys. Fortnightly time periods sampled and survey effort in 2008/2009.

NL – Netherlands, FRG – Federal Republic of Germany

Area	Time period	Samples available	Vessel days	Nation	Coverage
Orkney/Shetland	01-15 Sep.	78	7	GER	Total
	16-30 Sep.	78	5	GER	Total
Buchan	01-15 Sep.	None			
	16-30 Sep.	80	5	NL	Total
Central North Sea	01-15 Sep.	None			
	16-30 Sep.	63	4	NL	Partly
	01-15 Oct.	None			
Southern North Sea	16-31 Dec.	78	4	NL	Total
	01-15 Jan.	21	2	GER	Partly
	16-31 Jan.	83	4	NL	Total

Table 2.3.2.2: North Sea autumn spawners, Herring Larvae Surveys. Number of samples taken and sampling effort in Orkney/Shetland, Buchan, Central North Sea and Southern North Sea by year

Year	Samples	Vessel–days (sampling)
1988/89	1355	98
1989/90	1300	96
1990/91	634	49
1991/92	738	51
1992/93	498	31
1993/94	491	34
1994/95	450	33
1995/96	421	26
1996/97	469	32
1997/98	456	29
1998/99	531	37
1999/00	645	38
2000/01	696	53
2001/02	534	32
2002/03	533	35
2003/04	568	35
2004/05	483	33
2005/06	543	36
2006/07	568	35
2007/08	495	34
2008/09	481	31

Table 2.3.2.3: North Sea autumn spawners. Estimated abundances of herring larvae <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 Assess
Period	1-15 Sep.	16-30 Sep.	1-15 Sep.	16-30 Sep.	1-15 Sep.	16-30 Sep.	1-15 Oct.	16-31 Dec.	1-15 Jan.	16-31 Jan.	
1972	1133	4583	30		165	88	134	2	46		
1973	2029	822	3	4	492	830	1213			1	13.182
1974	758	421	101	284	81		1184		10		7.943
1975	371	50	312			90	77	1	2		2.819
1976	545	81		1	64	108			3		2.494
1977	1133	221	124	32	520	262	89	1			6.151
1978	3047	50		162	1406	81	269	33	3		7.427
1979	2882	2362	197	10	662	131	507		111	89	14.363
1980	3534	720	21	1	317	188	9	247	129	40	9.771
1981	3667	277	3	12	903	235	119	1456		70	14.337
1982	2353	1116	340	257	86	64	1077	710	275	54	20.891
1983	2579	812	3647	768	1459	281	63	71	243	58	26.804
1984	1795	1912	2327	1853	688	2404	824	523	185	39	48.366
1985	5632	3432	2521	1812	130	13039	1794	1851	407	38	73.818
1986	3529	1842	3278	341	1611	6112	188	780	123	18	38.444
1987	7409	1848	2551	670	799	4927	1992	934	297	146	67.690
1988	7538	8832	6812	5248	5533	3808	1960	1679	162	112	134.382
1989	11477	5725	5879	692	1442	5010	2364	1514	2120	512	131.732
1990		10144	4590	2045	19955	1239	975	2552	1204		171.592
1991	1021	2397		2032	4823	2110	1249	4400	873		90.332
1992	189	4917		822	10	165	163	176	1616		42.147
1993		66		174		685	85	1358	1103		30.069
1994	26	1179				1464	44	537	595		20.798
1995		8688					43	74	230	164	22.353
1996		809		184		564		337	675	691	43.983
1997		3611		23				9374	918	355	56.462
1998		8528		1490	205	66		1522	953	170	72.912
1999		4064		185		134	181	804	1260	344	60.531
2000		3352	28	83		376		7346	338	106	40.441
2001		11918		164		1604		971	5531	909	129.562
2002		6669		1038			3291	2008	260	925	109.899
2003		3199		2263		12018	3277	12048	3109	1116	267.813
2004		7055		3884		5545		7055	2052	4175	321.660
2005		3380		1364		5614		498	3999	4822	192.265
2006	6311	2312		280		2259		10858	2700	2106	117.856
2007		1753		1304		291		4443	2439	3854	173.003
2008	4978	6875		533		11201		8426	2317	4008	181.746

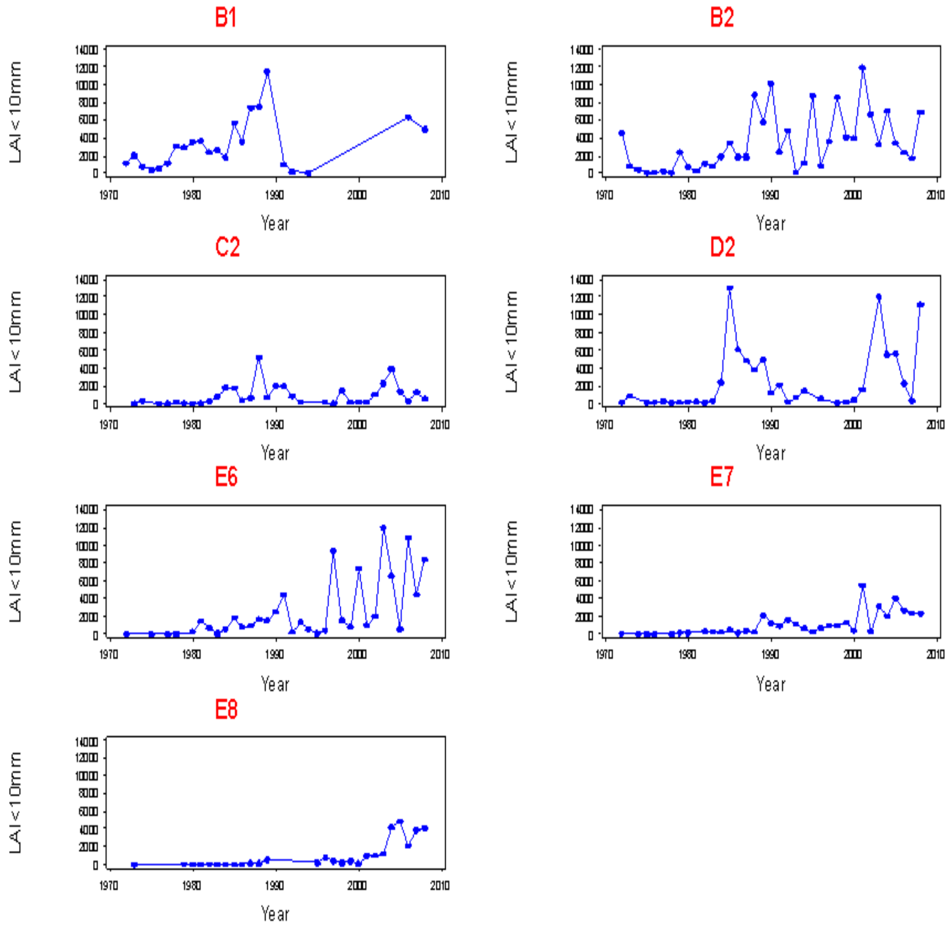


Figure 2.3.2.1: North Sea autumn spawners. Larval Abundance Index time-series for a collection of areas and sampling periods (B = Orkney/Shetland 1st and 2nd fortnight, C = Buchan 2nd fortnight, D = Central North Sea 2nd fortnight, E = Southern North Sea all 3 fortnights).

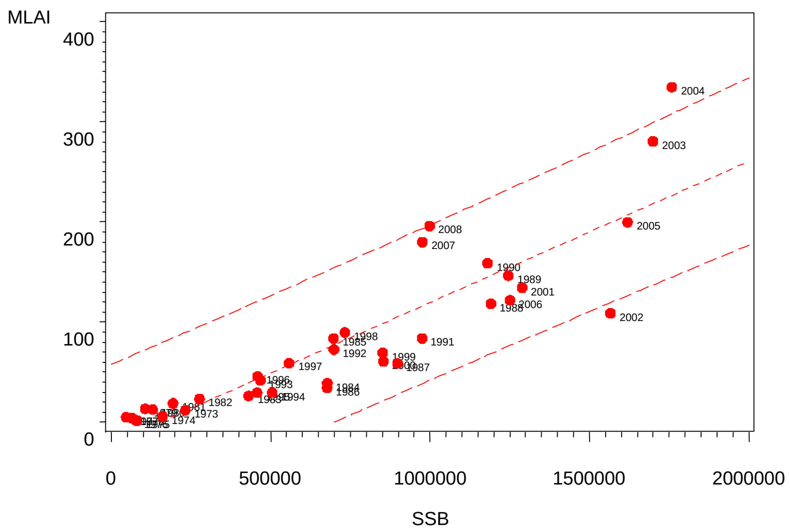


Figure 2.3.2.2: North Sea autumn spawners. Comparison of spawning stock size estimates (x axis) and year effects (y axis) when fitting small larvae abundances to SSB using the multiplicative model (with regression line and 95% confidence limits). The SSB estimate is derived from the ICA-output.

2.3.3 International Bottom Trawl Survey (IBTS)

The International Bottom Trawl Survey (IBTS) started out as a young herring fish survey in 1966 with the objective of obtaining annual recruitment indices (abundance of 1-ringers in 1st quarter) for the combined North Sea herring stock. The survey has been carried out every year since, and presently it provides recruitment indices not only for herring, but for demersal species as well. Examinations of the catch of adult herring during the 1st quarter IBTS have shown that this catch also indicates abundances of 2-5+ herring. Further, sampling for large herring larvae (0-ringers) is carried out at night-time during the IBTS 1st quarter using a fine-meshed 2 metre ring net (MIK). Hence, the sampling during IBTS affords an extended series of herring abundance indices (0 to 5+ ringers).

2.3.3.1 The index of 0-ringer abundance

The total abundance of 0-ringers in the survey area is used as recruitment index for the stock. This year's 0-ringer index is based on 641 depth-integrated hauls with a 2 metre ring-net (MIK). Index values are calculated as described in the WG report of 1996 (ICES 1996/ACFM:10). The series of estimates is shown in Table 2.3.3.1, the new index value of 0-ringer abundance of the 2008 year class is estimated at 95.8.

The index indicates a significant increase in recruitment from last year's estimate, which was outstandingly low, but was one in a series of poor recruitments starting from the 2002 year class. The 0-ringers which are included in the index were predominantly distributed off the Scottish coast, and in the northern areas (Figure 2.3.3.1). Compared to the preceding two year classes, the 0-ringers from this year class is distributed further from the Scottish coast and further to the north. A large concentration was found centrally in the North Sea, and concentrations were also seen in the Skagerrak/Kattegat. Downs herring larvae were apparent from MIK catches in the area of the English Channel, however, due to their small size (many below 12 mm mean length) most of these will not contribute to the recruitment index at a scale comparable to estimates based on larger larvae (> 20 mm). Hence, these small larvae are not included in the standard procedure of index estimation (see ICES 1996 /ACFM:10). As for last year's index estimation the WG investigated changes in 0-ringer estimates, when including the catches of small Downs larvae, but accounting for a daily mortality rate of 0.1 until these reached the 20 mm length. This procedure led to only slight increase in this year's index estimate, which indicates a relatively minor bias from the exclusion of this group from the present index estimation. To further investigate the influence of such changes in estimation procedures, a test-series of indices, which included the small Downs larvae, was calculated for the period 1992-09 (Table 2.3.3.2) and exploratory assessment runs were carried out. The outcome of this investigation is described in section 2.10.

The long term trend in the distributional patterns of 0-ringers is apparent from the changes in absolute and relative abundance of 0-ringers in the western part of the North Sea, as illustrated in Figure 2.3.3.2. In this figure the relative abundance is given as the number of 0-ringers in the area west of 2°E relative to the total number of 0-ringers in the given year class. Since the year class 1982, when the relative abundance was 25%, a general increase in abundance has been seen for the western part. In the last decade, the majority of 0-ringers has been distributed in this area, and the calculated relative abundance of 55% for the present year class is in accordance with the long term trend.

2.3.3.2 The indices of 1-5+ ringer herring abundances

1-ringer abundance

The 1-ringer index of recruitment is based on trawl catches in the entire survey area. The time series for year classes 1977 to 2007 are shown in Table 2.3.3.3. This year's estimate of the 2007 year class strength indicates a recruitment in the order of the long term mean (84%) which is a significant increase from the low recruitments estimated for the year classes 2002-2005. However, it should be noted that the index is strongly influenced by outstandingly high trawl catches in the Kattegat. The 1-ringers caught in Kattegat in 2009 are very small in size, and otolith examination of spawning origin indicates that a large fraction of these 1-ringers is from the Western Baltic Spring Spawner stock. If the fraction of potential WBSS 1-ringers is excluded in the index calculation, the index will be reduced to approx 70% of the present value. . To further investigate the influence of such changes in estimation procedures, a test-series of 1-ringer indices, which excluded the WBSS 1-ringers in the Kattegat, was calculated for the period 1992-09 (Table 2.3.3.2) and exploratory assessment runs were carried out. The outcome of this investigation is described in section 2.10.

Figure 2.3.3.3 illustrates the spatial distribution of 1-ringers as estimated by trawling in February 2007, 2008 and 2009. Across years, the main areas of 1-ringer distribution is in the German Bight and south of Dogger Bank, however, large catches might be seen at other sites, in 2009 such outstanding large catches were made in the Kattegat area.

The Downs herring hatch later than the autumn spawned herring and generally appears as a smaller sized group during the 1st quarter IBTS. A recruitment index of smaller sized 1-ringers is calculated based on abundance estimates of herring <13 cm (ICES CM 2000/ ACFM:12, and ICES CM 2001/ ACFM:12). Table 2.3.3.3 includes abundance estimates of 1-ringer herring smaller than 13 cm, calculated as the standard index but is in this case for herring <13 cm only. Indices for these small 1-ringers are given either for the total area or the area excluding division IIIa, and their relative proportions are also shown. In the time-series, the proportion of 1-ringers smaller than 13 cm (of total catches) is in the order of 20%, and the contribution from division IIIa to the overall abundance of <13 cm herring varies markedly during the period (Table 2.3.3.3). About 31% of this year's group of 1-ringers is smaller than 13 cm. A large part of these are found in the IIIa (incl. Kattegat), but as mentioned above, the small 1-ringers in this area more likely stem from Western Baltic Spring Spawners.

2-5+ ringer abundances

Table 2.3.3.4 shows the time-series of abundance estimates of 2-5+ ringers from the 1st quarter IBTS for the period 1983-2009. The present 2009 indices for 2 -4 ringers are very low (8-18% of long term means), only the index of 5+ ringers – which includes the large 2000 year class - is of significant magnitude (84% of long term mean)

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

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

Table 2.3.3.2. Test indices of 0-ringers and 1-ringers. Used in exploration of the influence from exclusion of small larvae from Downs herring in standard 0-ringer index estimation, and of the influence from inclusion of Kattegat WBSS 1-ringers in standard 1-ringer index estimation.

Year of sampling	Test indices of 0-ringers	Test indices of 1-ringers
1984		1216
1985		1868
1986		1668
1987		3514
1988		2043
1989		1730
1990		912
1991		1245
1992	165	1194
1993	195	2909
1994	158	1404
1995	172	1040
1996	102	1243
1997	133	3266
1998	47	2078
1999	240	670
2000	109	2903
2001	371	1975
2002	147	3288
2003	62	1216
2004	42	1039
2005	62	1052
2006	83	857
2007	49	1176
2008	40	1638
2009	93	1692

Table 2.3.3.3. North Sea herring. Indices of 1-ringers from the IBTS 1st Quarter. Estimation of the small sized component (possibly Downs herring) in different areas. " North Sea" = total area of sampling minus IIIa.

Year class	Year of sampling	All 1-ringers in total area (no/hour)	Small<13cm 1-ringers in total area (no/hour)	Proportion of small in total area vs. all sizes	Small<13cm 1-ringers in North Sea (no/hour)	Proportion of small in North Sea vs. all sizes	Proportion of small in IIIa vs small in total area
1977	1979	168	11	0.07	12	0.07	0
1978	1980	316	108	0.34	106	0.34	0.09
1979	1981	495	51	0.1	41	0.08	0.25
1980	1982	798	177	0.22	185	0.23	0.03
1981	1983	1270	192	0.15	185	0.15	0.10
1982	1984	1516	346	0.23	297	0.20	0.20
1983	1985	2097	315	0.15	298	0.14	0.12
1984	1986	2663	596	0.22	390	0.15	0.39
1985	1987	3693	628	0.17	529	0.14	0.22
1986	1988	4394	2371	0.54	720	0.16	0.72
1987	1989	2332	596	0.26	531	0.23	0.17
1988	1990	1062	70	0.07	62	0.06	0.18
1989	1991	1287	330	0.26	337	0.26	0.05
1990	1992	1268	125	0.1	130	0.10	0.03
1991	1993	2794	676	0.24	176	0.06	0.76
1992	1994	1752	283	0.16	240	0.14	0.21
1993	1995	1346	449	0.33	445	0.33	0.08
1994	1996	1891	604	0.32	467	0.25	0.28
1995	1997	4405	1356	0.31	1089	0.25	0.25
1996	1998	2276	1322	0.58	1399	0.61	0.02
1997	1999	753	152	0.2	149	0.20	0.09
1998	2000	3725	1117	0.3	991	0.27	0.18
1999	2001	2499	328	0.13	307	0.12	0.13
2000	2002	4065	1553	0.38	1471	0.36	0.12
2001	2003	2765	717	0.26	237	0.09	0.69
2002	2004	979	665	0.68	710	0.73	0.01
2003	2005	1002	340	0.34	356	0.36	0.03
2004	2006	922	122	0.13	128	0.14	0.02
2005	2007	1336	304	0.23	305	0.23	0.07
2006	2008	1901	440	0.23	471	0.25	0.01
2007	2009	**2347**	739	0.31	629	0.27	0.21

Table 2.3.3.4. North Sea herring. Indices of 2-5+ ringers from the 1st quarter IBTS

YEAR OF SAMPLING	2-RINGER NO/H	3-RINGER NO/H	4-RINGER NO/H	5+ RINGER NO/H
1983	139	45	14	24
1984	161	61	27	10
1985	722	282	42	28
1986	782	276	79	28
1987	918	116	59	49
1988	4163	792	58	25
1989	875	339	89	9
1990	462	280	269	71
1991	693	259	222	146
1992	437	193	55	92
1993	787	223	45	66
1994	1167	213	69	43
1995	1393	279	37	7
1996	198	33	10	8
1997	507	163	31	20
1998	792	96	21	18
1999	451	501	98	36
2000	199	155	59	9
2001	1129	317	94	68
2002	658	338	25	20
2003	1556	612	360	53
2004	451	777	112	171
2005	214	356	389	131
2006	1464	330	252	339
2007	41	18	8	41
2008	253	155	255	200
2009	136	22	14	55

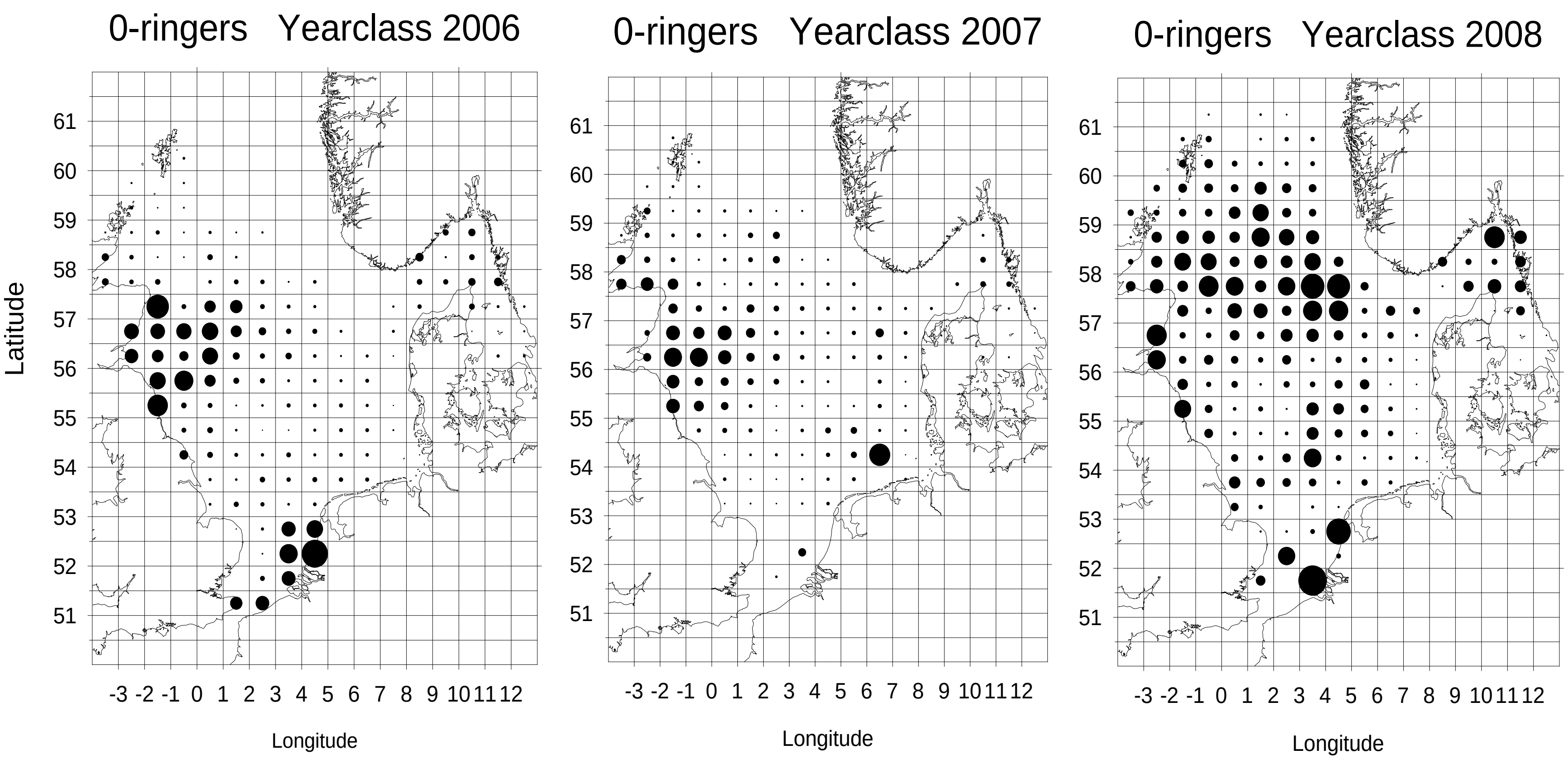


Figure 2.3.3.1. North Sea herring. Distribution of 0-ringer herring, year classes 2006-2008. Density estimates of 0-ringers within each statistical rectangle are based on MIK catches during IBTS in February 2007-2009. Areas of filled circles illustrate densities in no m^{-2}, the area of a circle extending to the border of a rectangle represents 1 m^{-2}

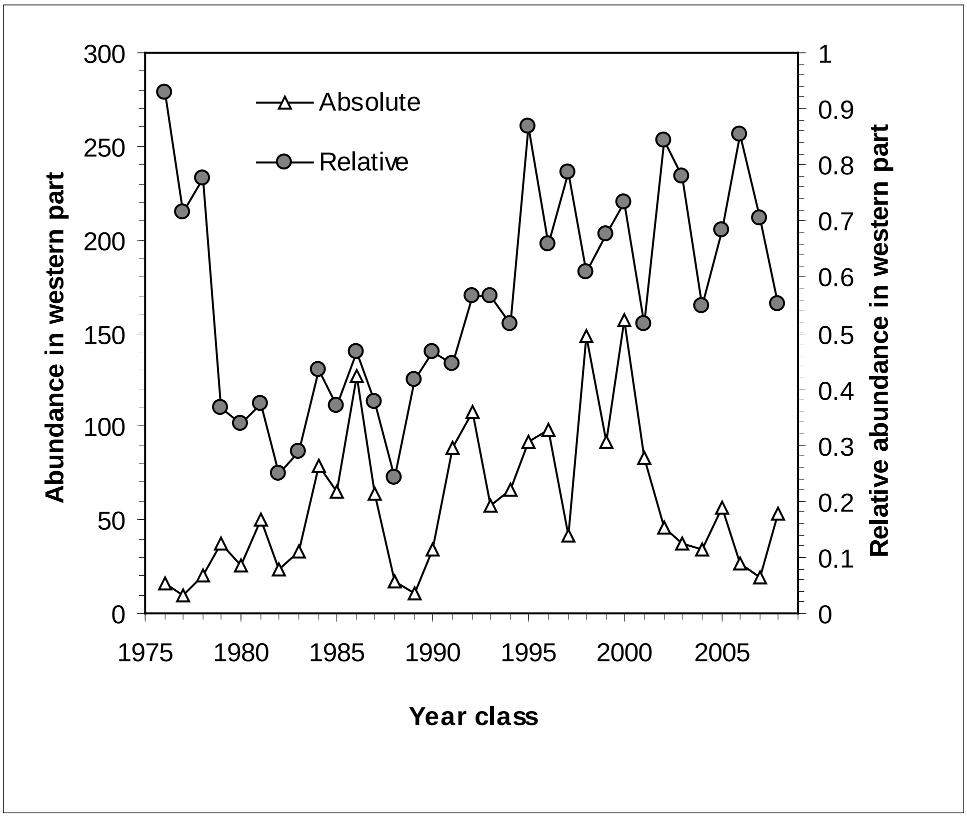


Figure 2.3.3.2 North Sea herring. Absolute (no * 10^9) and relative abundance of 0-ringers in the area west of 2°E in the North Sea. Abundances are based on MIK sampling during IBTS, the relative abundance in the western part is estimated as the number of 0-ringers west of 2°E relative to total number of 0-ringers.

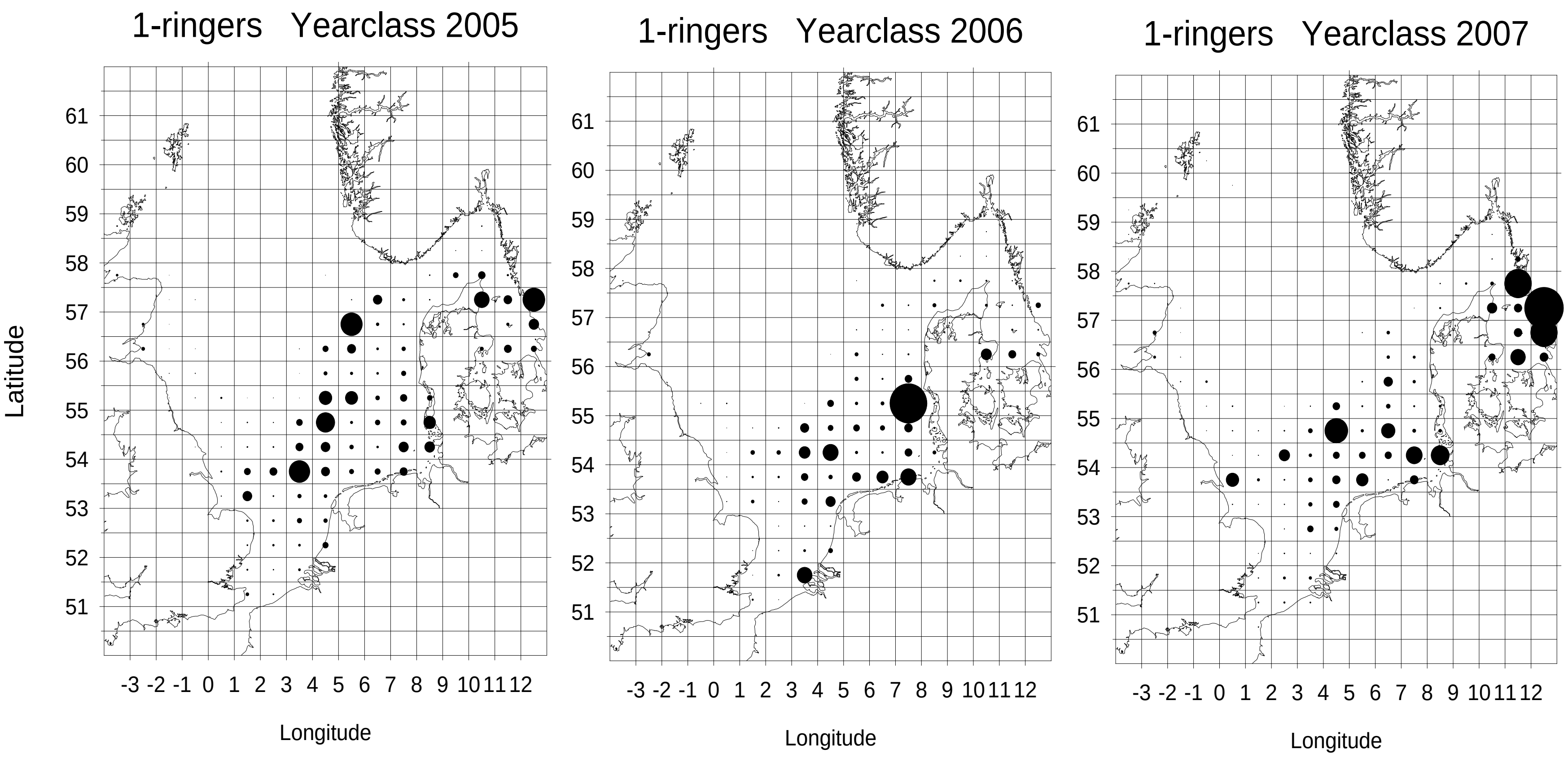


Figure 2.3.3.3. North Sea herring. Distribution of 1-ringer herring, year classes 2005-2007. Density estimates of 1-ringers within each statistical rectangle are based on GOV catches during IBTS in February 2007-2009. Areas of filled circles illustrate numbers per hour, the area of a circle extending to the border of a rectangle represents 45000 h^{-1}.

2.4 Mean weights-at-age and maturity-at-age

2.4.1 Mean weights-at-age

Table 2.4.1.1 shows the historic mean weights-at-age (winter ringers, wr) in the North Sea stock during the 3rd quarter in Divisions IV and IIIa (acoustic survey) as well as the mean weights-in-the-catch from 1996 to 2008, for comparison. The data for 2008 are taken from Table 2.3.1.2. In the third quarter most fish are approaching their peak weights just prior to spawning. The catch and acoustic survey mean weights of 1-ringers in 2008 are high, but slightly lower than in 2007. The mean weights for 2008 for 2-ringers and olders are higher than in 2007 except for the 5-ringers and 7-ringers. This last class corresponds to the 2000 year class which is possibly the largest in recent years and the first large one competing with an already large herring stock biomass, grew more slowly than the other year classes. As a general rule, a decline in mean weights in the older fish (4+wr), has been observed since 1996 although the rate of decline has reduced to almost zero in recent years (Figure 2.4.1.1).

2.4.2 Maturity ogive

The percentages of North Sea autumn-spawning herring (at age) that are considered mature in 2008 were estimated from the 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). For 2-ringers, 3-ringers and 4-ringers, the proportions mature are 86 %, 98% and 99%, respectively (Table2.4.2.1). The percentage mature of 2- ring fish is high but similar to 2002. For the 3 and 4-ringers, the proportions mature are high.

Mean weight for the 3-ringers in the 2007 acoustic survey (Table 2.4.1.1) is below the historical average but this has not led to a decrease in the maturity ogive. The 2000 year class, which matured more slowly, became fully mature in 2006.

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

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

Table 2.4.2.1: North Sea herring. Percentage maturity at 2, 3, 4 and 5+ ring for Autumn Spawning herring in the North Sea. The values are derived from the acoustic survey for 1988 to 2007.

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

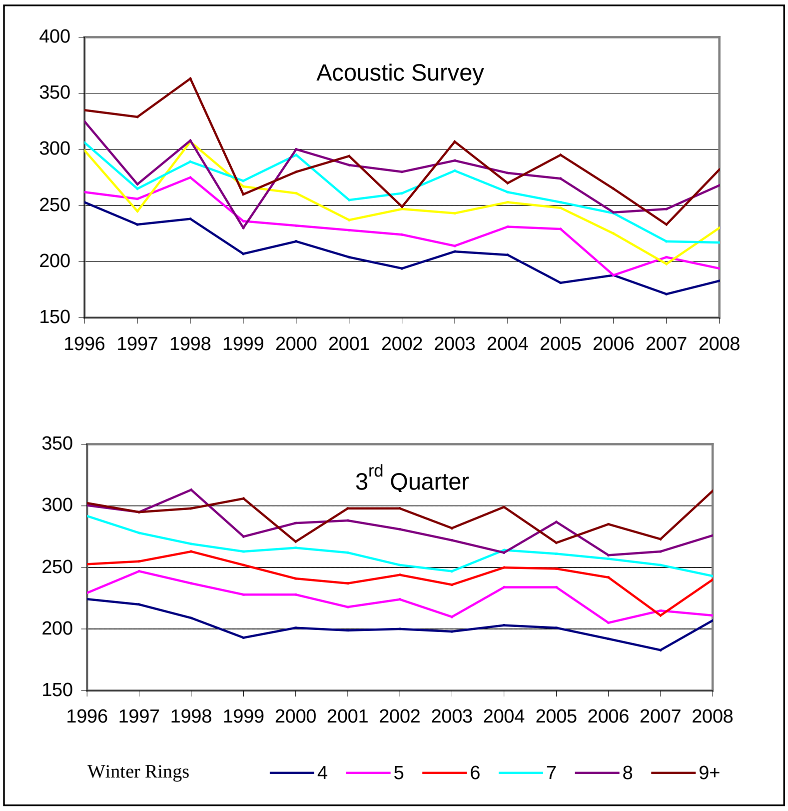


Figure 2.4.1.1: Figure 2.4.1.1 North Sea Herring. Mean weights for 4-ringers and older for the 3rd quarter in Divisions IV and IIIa (acoustic survey) and mean weights-in-the-catch for comparison

2.5 Recruitment

Information on the development in North Sea herring recruitment is available from the two IBTS indices, the 1-ringer and the 0-ringer index. Further, the ICA assessment provides estimates of the recruitment of herring in which information from the catch and from all fishery independent indices is incorporated.

2.5.1 Relationship between the MIK 0-ringer and the IBTS 1-ringer indices

The 0-ringer MIK index predicts the year class strength one year before the information is available from the IBTS 1-ringer estimates. The relationship between year class estimates from the two indices is illustrated in Figure 2.5.1 and described by the fitted linear regression. Last year's prediction of the 2007 year class was much lower than indicated from this year's IBTS 1-ringer index of the year class (circled in the figure). Generally, there is a good agreement between the indices in their description of temporal trends in recruitment (Figure 2.5.2), but for the last two year classes the predicted levels of recruitment deviate. Possible explanations for this discrepancy are discussed in sections 2.3.3.1 and 2.3.3.2.

2.5.2 Trends in recruitment from the assessment

Abundances of recruiting North Sea herring are estimated from the assessment (see the temporal trend of recruitment in Figure 2.6.2.1). The recruitment declined during the sixties and the seventies, followed by a marked increase in the early eighties. After the strong 1985 year class recruitment declined again until the appearance of the strong year classes 1998-2001. During the following years the recruitment has generally been low. The trends in recruitment are described in detail by Payne et al. (2009). The MIK index of 0-ringer recruitment for the present year indicates a marked increase for the 2008 year class (section 2.3.3.1).

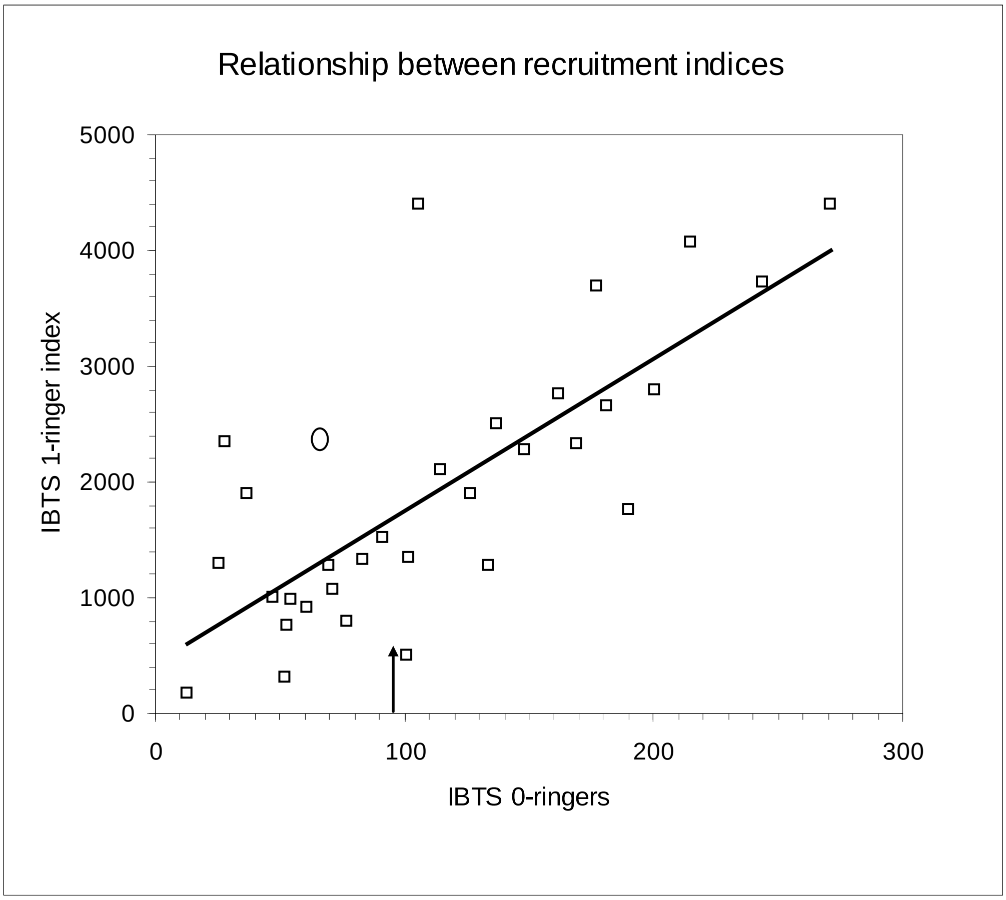


Figure 2.5.1 North Sea herring. Relationship between indices of 0-ringers and 1-ringers for year classes 1977 to 2007. The 2007 relation is circled, the present 0-ringer index for year class 2008 is indicated by an arrow.

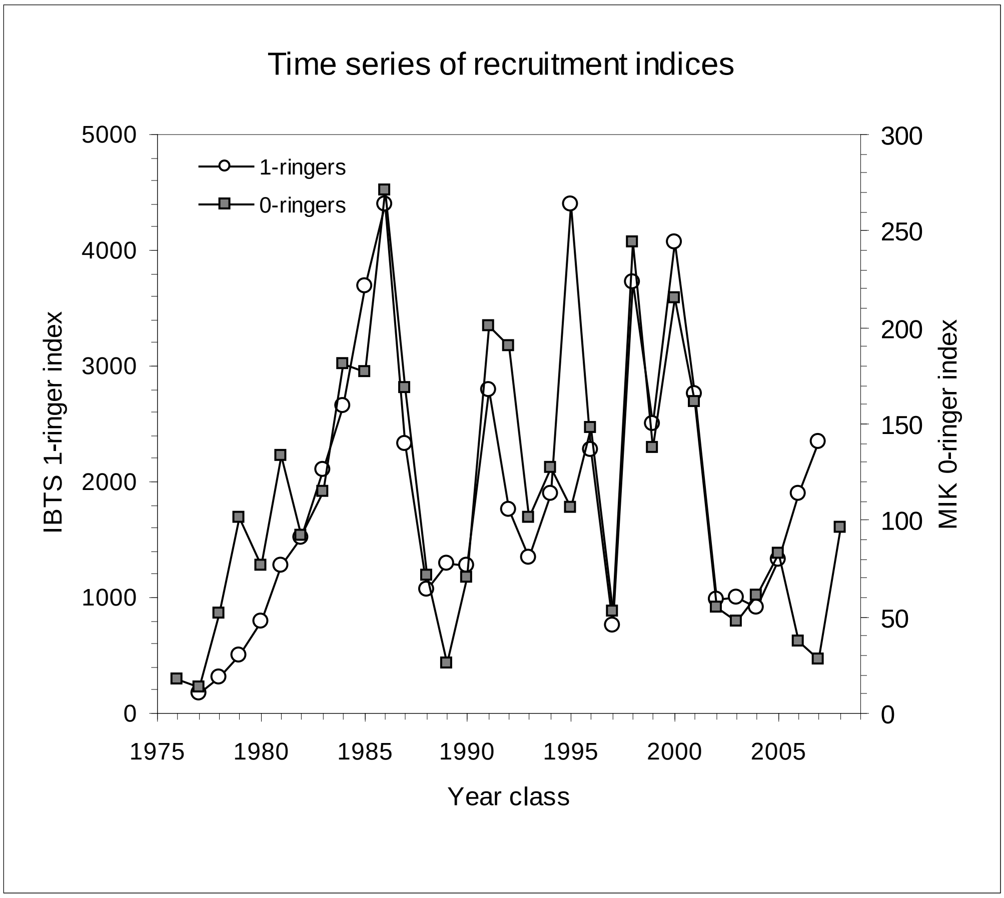


Figure 2.5.2 North Sea herring. Time series of 0-ringer and 1-ringer indices. Year classes 1976 to 2008 for 0-ringers, year classes 1977-2007 for 1-ringers.

2.6 Assessment of North Sea herring

2.6.1 Data exploration and preliminary results

North Sea was classed as an update assessment in 2009 by ACOM, as a benchmark assessment took place in 2006. The choice of assessment model, catch and survey weightings and the length of separable period were not explored in 2009, and for justification of the approach refer to the benchmark assessment (HAWG 2006) and Simmonds (2003; 2009). Following the benchmark investigation in 2006, the tool for the assessment of North Sea herring is FLICA, similar to 2008.

Acoustic, bottom trawl (IBTS), MIK and larvae (MLAI) surveys 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 WG still shares the opinion that the assessment is best executed including all surveys (Simmonds 2009).

This year's assessment is an update assessment, therefore the input data and the performance of the assessment has been carefully scrutinised to check for potential problems, but no changes to the methods or development of the model took place in 2009. The diagnostics do not indicate any significant pattern or unreliable data points (Figure 2.6.1.1 to Figure 2.6.1.16). There is no evidence of cohort effects during the full selection pattern of the separable period. Overall the catch residuals are small. There has been no major change in the patterns in the residuals for the surveys by adding the extra year of data and the contribution of each indices to the objective function is in range with the expected. (Figures 2.6.1.17 and 2.6.1.18).

It has been noted that in recent years the MLAI has positive residuals (Figure 2.6.1.17) and the acoustic survey has a block of negative residuals at older ages. The current assessment shows that this pattern for the MLAI and acoustics has been maintained (Figure 2.6.1.17). However, in 2006 the residual from the MLAI is small. In the 2006 benchmark assessment it was concluded that one of the reasons for the relatively stable assessment was the balance of the major sources of information, with each potentially delivering short periods with bias but in combination providing a balance of errors.

Figures 2.6.1.29 to 2.6.1.21 shows retrospective estimates of SSB, recruitment, mean F_{2-6}, selectivity pattern and year class cohorts, by removing one year of data at a time, up to 8 years in total. The estimation of F shows considerable consistency over the last 10 years. SSB is reasonable consistent over the last 6 years. The retrospective estimates for recruitment in the years 2003 to 2007 deviate from each other in a larger extend than observed within the SSB and F_{2-6} retrospectives, for the first year of estimation. However, for all three historical retrospective estimates it can be concluded that the patterns are consistent. Figure 2.6.1.21 shows the retrospective pattern of the number per cohort. This pattern is consistent over the years as well. The selectivity pattern has not changed greatly over the recent period, however selectivity increased for the 5 to 7 year olds for 4 years in a row (Figure 2.6.1.19). Figure 2.6.1.22 shows the 'otolith' plot, representing the uncertainty of the fit of the assessment model. The 90% confidence interval of SSB indicates that the stock is above B_{lim}.

Further data screening of the input data on mature – immature biomass ratio's, survey CPUE's, 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 (see Figures 2.6.1.23 to 2.6.1.30). No issues were raised by this exercise.

2.6.2 Final Assessment for NS herring

In according with the settings described in the stock annex, the final assessment of North Sea herring was carried out by fitting the integrated catch-at-age model (ICA, in the FLR environment - version 1.4-9 - Sat Mar 21 13:07:02 2009)). The input data and model settings are shown in Table 2.6.2.1 – Table 2.6.2.11, the ICA output is presented in Table 2.6.2.12 – Table 2.6.2.21, the stock summary in Table 2.6.2.12 and Figure 2.6.2.1 and model fit and parameter estimates in Table 2.6.2.21. Diagnostics of the catch for the separable period are shown in Figure 2.6.2.2. In Figure 2.6.2.3 Yield to F and Yield to SSB curves are shown, also indicating reference points B_{MSY} and F_{MSY}. Figure 2.6.2.4 shows the agreed management plan including the biomass trigger points and contains the F_{2-6} estimates of the past 7 years.

The spawning stock at spawning time in 2008 is estimated at approximately 1.0 million tonnes, increasing from 0.95 million tonnes in 2007. The estimate of 0-wr fish in 2009 (2008 year class) is 1.6 times bigger than in 2008 and 81% of the geometric mean of recruitment since 1981 (see Table 2.6.2.15). This new recruitment is higher than the previous 6 years but similar to the 2001 year class (Figure 2.6.2.5). It does not suggest that recruitment has recovered. The strong 2000 year class is still evident in the population, at 7-wr in 2008. Mean F_{2-6} in 2008 is estimated at approximately 0.24, which is above the management agreement target F, while mean F_{0-1} is 0.05, approximately at the agreed target, and lower than 2007.

2.6.3 State of the Stock

Spawning biomass in relation to precautionary limits	Fishing mortality in relation to precautionary limits	Fishing mortality in relation to highest yield	Fishing mortality in relation to agreed target	Comment
Increased risk	Harvested sustainably	Appropriate	Above target	

Based on the most recent estimates of SSB and fishing mortality, ICES classifies the stock as being at risk of having reduced reproductive capacity and harvested sustainably. The SSB in autumn 2008 was estimated at 1.0 million t, and is expected to remain below Bpa (1.3 million t) in 2009. F_{2-6} in 2008 was estimated at 0.24, above the target F_{2-6} of 0.14. The year classes since 2002 are estimated to be among the weakest since the late 1970s.

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
MLAI (Larvae survey)	*SSB*	*1972-2008*	*1973-2008*
IBTS 1st Quarter (Trawl survey)	*1-5wr*	*1971-2009*	*1984-2009*
Acoustic (+trawl)	*1wr*	*1995-2008*	*1997-2008*
	2-9+wr	*1984-2008*	*1989-2008*
MIK net	*0wr*	*1977-2009*	*1992-2009*

TABLE 2.6.2.1 North Sea Autumn Spawning Herring. Catch in Number

year Units : thousands

age	1960	1961	1962	1963	1964	1965	1966	1967	1968
0	194600	1269200	141800	442800	496900	157100	374500	645400	839300
1	2392700	336000	2146900	1262200	2971700	3209300	1383100	1674300	2425000
2	1142300	1889400	269600	2961200	1547500	2217600	2569700	1171500	1795200
3	1966700	479900	797400	177200	2243100	1324600	741200	1364700	1494300
4	165900	1455900	335100	158300	148400	2039400	450100	371500	621400
5	167700	124000	1081800	80600	149000	145100	889800	297800	157100
6	112900	157900	126900	229700	95000	151900	45300	393100	145000
7	125800	61400	145100	22400	256300	117600	64800	67900	163400
8	128600	56000	86300	42000	26300	413000	95500	81600	13700
9	142000	87500	86800	51000	57700	78400	236300	172800	91800

year

age	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978
0	112000	898100	684000	750400	289400	996100	263800	238200	256800	130000
1	2503300	1196200	4378500	3340600	2368000	846100	2460500	126600	144300	168600
2	1883000	2002800	1146800	1440500	1344200	772600	541700	901500	44700	4900
3	296300	883600	662500	343800	659200	362000	259600	117300	186400	5700
4	133100	125200	208300	130600	150200	126000	140500	52000	10800	5000
5	190800	50300	26900	32900	59300	56100	57200	34500	7000	300
6	49900	61000	30500	5000	30600	22300	16100	6100	4100	200
7	42700	7900	26800	200	3700	5000	9100	4400	1500	200
8	27400	12000	100	1100	1400	2000	3400	1000	700	200
9	25100	12200	12400	400	600	1100	1400	400	0	300

year

age	1979	1980	1981	1982	1983	1984	1985	1986	1987
0	542000	1262700	9519700	11956700	13296900	6973300	4211000	3724700	8229200
1	159200	245100	872000	1116400	2448600	1818400	3253000	4801400	6836300
2	34100	134000	284300	299400	573800	1146200	1326300	1266700	2137200
3	10000	91800	56900	230100	216400	441400	1182400	840800	667900
4	10100	32200	39500	33700	105100	201500	368500	465900	467100
5	2100	21700	28500	14400	26200	81100	124500	129800	245800
6	200	2300	22700	6800	22800	22600	43600	62100	74700
7	800	1400	18700	7800	12800	25200	20200	20500	23800
8	600	400	5500	3600	11000	11100	13100	13600	8000
9	100	100	1100	1100	12100	18600	16100	14800	8200

year

age	1988	1989	1990	1991	1992	1993	1994	1995	1996
0	3164800	3057800	1302800	2386600	10331300	10265400	4498900	7438469	2311226
1	7867000	3145900	3020000	2138900	2303100	3826800	1785200	1664874	1606393
2	2232500	1593700	899300	1132800	1284900	1176300	1783200	1444061	642084
3	1090700	1363800	779100	556700	442700	609000	489100	816703	525601
4	383700	809300	861000	548900	361500	305500	347600	231794	172099
5	255800	211800	387500	501200	360500	215600	109000	118536	57586
6	128100	123700	80200	205300	375600	226000	91800	55128	22534
7	38000	61000	54400	39300	152400	188000	76400	41409	9264
8	15300	19500	28800	25600	39200	87300	70000	68955	17195
9	8500	8700	11900	13000	23300	41700	46600	29245	3948

age	1997	1998	1999	2000	2001	2002	2003	2004	2005
0	431175	259526	1566349	1105085	1832691	730279	369074	715597	1015554
1	479702	977680	303520	1171677	614469	837557	617021	206648	715547
2	687920	1220105	616354	622853	842635	579592	1221992	447918	355453
3	446909	537932	1058716	463170	485628	970577	529386	1366155	485746
4	284920	276333	294066	646814	278884	292205	835552	543376	1318647
5	109178	175817	135648	213466	321743	140701	244780	753231	479961
6	31389	88927	69299	82481	90918	174570	107751	169324	576154
7	11832	15232	27998	35706	38252	48908	123291	104945	115212
8	18770	16766	10174	14624	17910	34620	37671	65341	88311
9	5697	3784	2054	2463	2692	8702	9044	31801	58497

year

age	2006	2007	2008
0	878637	621005	798284
1	222111	235553	235022
2	401087	219115	331772
3	310602	417452	184771
4	464620	285746	199069
5	997782	309454	137529
6	252150	629187	118349
7	247042	147830	215542
8	63035	133388	74339
9	43377	23362	42919

Table 2.6.2.2 North Sea Autumn Spawning Herring. Weights at age in the Catch

Units : kg

year

age	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971
0	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015
1	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
2	0.126	0.126	0.126	0.126	0.126	0.126	0.126	0.126	0.126	0.126	0.126	0.126
3	0.176	0.176	0.176	0.176	0.176	0.176	0.176	0.176	0.176	0.176	0.176	0.176
4	0.211	0.211	0.211	0.211	0.211	0.211	0.211	0.211	0.211	0.211	0.211	0.211
5	0.243	0.243	0.243	0.243	0.243	0.243	0.243	0.243	0.243	0.243	0.243	0.243
6	0.251	0.251	0.251	0.251	0.251	0.251	0.251	0.251	0.251	0.251	0.251	0.251
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
9	0.271	0.271	0.271	0.271	0.271	0.271	0.271	0.271	0.271	0.271	0.271	0.271

year

age	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
0	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.007	0.010	0.010
1	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.049	0.059	0.059
2	0.126	0.126	0.126	0.126	0.126	0.126	0.126	0.126	0.126	0.118	0.118	0.118
3	0.176	0.176	0.176	0.176	0.176	0.176	0.176	0.176	0.176	0.142	0.149	0.149
4	0.211	0.211	0.211	0.211	0.211	0.211	0.211	0.211	0.211	0.189	0.179	0.179
5	0.243	0.243	0.243	0.243	0.243	0.243	0.243	0.243	0.243	0.211	0.217	0.217
6	0.251	0.251	0.251	0.251	0.251	0.251	0.251	0.251	0.251	0.222	0.238	0.238
7	0.267	0.267	0.267	0.267	0.267	0.267	0.267	0.267	0.267	0.267	0.265	0.265
8	0.271	0.271	0.271	0.271	0.271	0.271	0.271	0.271	0.271	0.271	0.274	0.274
9	0.271	0.271	0.271	0.271	0.271	0.000	0.271	0.271	0.271	0.271	0.275	0.275

year

age	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
0	0.010	0.009	0.006	0.011	0.011	0.017	0.019	0.017	0.010	0.010	0.006	0.009
1	0.059	0.036	0.067	0.035	0.055	0.043	0.055	0.058	0.053	0.033	0.056	0.042
2	0.118	0.128	0.121	0.099	0.111	0.115	0.114	0.130	0.102	0.115	0.130	0.130
3	0.149	0.164	0.153	0.150	0.145	0.153	0.149	0.166	0.175	0.145	0.159	0.169
4	0.179	0.194	0.182	0.180	0.174	0.173	0.177	0.184	0.189	0.189	0.181	0.198
5	0.217	0.211	0.208	0.211	0.197	0.208	0.193	0.203	0.207	0.204	0.214	0.207
6	0.238	0.220	0.221	0.234	0.216	0.231	0.229	0.217	0.223	0.228	0.240	0.243
7	0.265	0.258	0.238	0.258	0.237	0.247	0.236	0.235	0.237	0.244	0.255	0.247
8	0.274	0.270	0.252	0.277	0.253	0.265	0.250	0.259	0.249	0.256	0.273	0.283
9	0.275	0.292	0.262	0.299	0.263	0.259	0.287	0.271	0.287	0.310	0.281	0.276

year

age	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
0	0.015	0.015	0.021	0.009	0.015	0.012	0.012	0.014	0.014	0.011	0.010	0.0124
1	0.018	0.044	0.051	0.045	0.033	0.048	0.037	0.037	0.036	0.044	0.049	0.0638
2	0.112	0.108	0.114	0.115	0.113	0.118	0.118	0.104	0.100	0.099	0.117	0.1214
3	0.156	0.148	0.145	0.151	0.157	0.149	0.153	0.158	0.138	0.153	0.144	0.1513
4	0.188	0.195	0.183	0.171	0.179	0.177	0.170	0.174	0.183	0.166	0.172	0.1634
5	0.204	0.227	0.219	0.207	0.201	0.198	0.199	0.184	0.201	0.208	0.181	0.1933
6	0.212	0.226	0.238	0.233	0.216	0.213	0.214	0.205	0.216	0.223	0.220	0.1900
7	0.261	0.235	0.247	0.245	0.246	0.238	0.228	0.222	0.228	0.240	0.237	0.2232
8	0.280	0.244	0.289	0.261	0.275	0.267	0.250	0.232	0.246	0.257	0.235	0.2349
9	0.288	0.291	0.283	0.301	0.262	0.288	0.252	0.256	0.272	0.278	0.262	0.2523

year

age	2008
0	0.0079
1	0.0535
2	0.1288
3	0.1796
4	0.1812
5	0.1832
6	0.2157
7	0.2161
8	0.2560
9	0.2726

Table 2.6.2.3 North Sea Autumn Spawning Herring. Weights at age in the Stock.

Units : kg

age \ year	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971
0	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015
1	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
2	0.155	0.155	0.155	0.155	0.155	0.155	0.155	0.155	0.155	0.155	0.155	0.155
3	0.187	0.187	0.187	0.187	0.187	0.187	0.187	0.187	0.187	0.187	0.187	0.187
4	0.223	0.223	0.223	0.223	0.223	0.223	0.223	0.223	0.223	0.223	0.223	0.223
5	0.239	0.239	0.239	0.239	0.239	0.239	0.239	0.239	0.239	0.239	0.239	0.239
6	0.276	0.276	0.276	0.276	0.276	0.276	0.276	0.276	0.276	0.276	0.276	0.276
7	0.299	0.299	0.299	0.299	0.299	0.299	0.299	0.299	0.299	0.299	0.299	0.299
8	0.306	0.306	0.306	0.306	0.306	0.306	0.306	0.306	0.306	0.306	0.306	0.306
9	0.312	0.312	0.312	0.312	0.312	0.312	0.312	0.312	0.312	0.312	0.312	0.312

age \ year	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
0	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.017
1	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.057
2	0.155	0.155	0.155	0.155	0.155	0.155	0.155	0.155	0.155	0.155	0.155	0.150
3	0.187	0.187	0.187	0.187	0.187	0.187	0.187	0.187	0.187	0.187	0.187	0.190
4	0.223	0.223	0.223	0.223	0.223	0.223	0.223	0.223	0.223	0.223	0.223	0.230
5	0.239	0.239	0.239	0.239	0.239	0.239	0.239	0.239	0.239	0.239	0.239	0.243
6	0.276	0.276	0.276	0.276	0.276	0.276	0.276	0.276	0.276	0.276	0.276	0.282
7	0.299	0.299	0.299	0.299	0.299	0.299	0.299	0.299	0.299	0.299	0.299	0.311
8	0.306	0.306	0.306	0.306	0.306	0.306	0.306	0.306	0.306	0.306	0.306	0.338
9	0.312	0.312	0.312	0.312	0.312	0.312	0.312	0.312	0.312	0.312	0.312	0.347

age \ year	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
0	0.016	0.014	0.009	0.008	0.009	0.012	0.011	0.010	0.006	0.007	0.006	0.006
1	0.056	0.061	0.050	0.048	0.044	0.052	0.059	0.064	0.061	0.060	0.057	0.054
2	0.138	0.130	0.122	0.123	0.122	0.126	0.139	0.137	0.134	0.126	0.129	0.130
3	0.187	0.183	0.170	0.166	0.165	0.174	0.184	0.194	0.184	0.192	0.186	0.199
4	0.232	0.232	0.212	0.208	0.205	0.212	0.212	0.214	0.213	0.214	0.211	0.227
5	0.247	0.252	0.230	0.229	0.228	0.244	0.239	0.234	0.234	0.240	0.224	0.234
6	0.275	0.273	0.242	0.248	0.252	0.271	0.265	0.253	0.262	0.275	0.268	0.274
7	0.321	0.315	0.275	0.259	0.261	0.284	0.280	0.272	0.273	0.291	0.293	0.301
8	0.341	0.331	0.268	0.263	0.277	0.298	0.300	0.291	0.302	0.309	0.318	0.323
9	0.365	0.392	0.343	0.325	0.315	0.331	0.328	0.312	0.320	0.337	0.345	0.343

age \ year	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
0	0.005	0.006	0.006	0.006	0.006	0.006	0.007	0.007	0.006	0.007	0.006	0.008
1	0.049	0.047	0.051	0.051	0.051	0.047	0.047	0.042	0.041	0.041	0.051	0.055
2	0.123	0.116	0.116	0.116	0.122	0.128	0.123	0.119	0.118	0.126	0.128	0.125
3	0.183	0.187	0.179	0.184	0.172	0.172	0.173	0.165	0.164	0.155	0.161	0.156
4	0.230	0.241	0.226	0.221	0.210	0.205	0.202	0.203	0.198	0.191	0.180	0.180
5	0.237	0.264	0.256	0.248	0.233	0.228	0.222	0.223	0.225	0.216	0.207	0.196
6	0.257	0.284	0.273	0.279	0.255	0.248	0.242	0.248	0.248	0.242	0.224	0.212
7	0.280	0.287	0.276	0.286	0.275	0.270	0.266	0.268	0.265	0.252	0.238	0.230
8	0.303	0.301	0.270	0.281	0.274	0.289	0.285	0.283	0.281	0.266	0.255	0.245
9	0.334	0.342	0.318	0.303	0.280	0.275	0.283	0.275	0.291	0.277	0.264	0.249

age \ year	2008
0	0.008
1	0.058
2	0.130
3	0.164
4	0.181
5	0.195
6	0.218
7	0.226
8	0.253
9	0.260

Table 2.6.2.4 North Sea Autumn Spawning Herring. Natural Mortality.

Units : NA

age \ year	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
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	1.0
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
2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
4	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
5	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
6	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
7	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
8	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
9	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1

age \ year	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
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	1.0
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
2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
4	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
5	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
6	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
7	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
8	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
9	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1

age \ year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
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	1.0
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
2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
4	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
5	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
6	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
7	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
8	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
9	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1

age \ year	2005	2006	2007	2008
0	1.0	1.0	1.0	1.0
1	1.0	1.0	1.0	1.0
2	0.3	0.3	0.3	0.3
3	0.2	0.2	0.2	0.2
4	0.1	0.1	0.1	0.1
5	0.1	0.1	0.1	0.1
6	0.1	0.1	0.1	0.1
7	0.1	0.1	0.1	0.1
8	0.1	0.1	0.1	0.1
9	0.1	0.1	0.1	0.1

Table 2.6.2.5 North Sea Autumn Spawning Herring. Proportion Mature

Units : NA

year

age	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
1	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
2	1	1	1	1	1	1	1	1	1	1	1	1	0.82	0.82	0.82
3	1	1	1	1	1	1	1	1	1	1	1	1	1.00	1.00	1.00
4	1	1	1	1	1	1	1	1	1	1	1	1	1.00	1.00	1.00
5	1	1	1	1	1	1	1	1	1	1	1	1	1.00	1.00	1.00
6	1	1	1	1	1	1	1	1	1	1	1	1	1.00	1.00	1.00
7	1	1	1	1	1	1	1	1	1	1	1	1	1.00	1.00	1.00
8	1	1	1	1	1	1	1	1	1	1	1	1	1.00	1.00	1.00
9	1	1	1	1	1	1	1	1	1	1	1	1	1.00	1.00	1.00

year

age	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
0	0.00	0.00	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
1	0.00	0.00	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
2	0.82	0.82	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
3	1.00	1.00	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
4	1.00	1.00	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
5	1.00	1.00	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
6	1.00	1.00	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
7	1.00	1.00	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
8	1.00	1.00	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
9	1.00	1.00	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

year

age	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
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	0.91	0.86	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
3	0.97	0.99	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
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	2005	2006	2007	2008
0	0.00	0.00	0.00	0.00
1	0.00	0.00	0.00	0.00
2	0.76	0.66	0.71	0.86
3	0.96	0.88	0.92	0.98
4	0.96	0.98	0.93	0.99
5	1.00	1.00	1.00	1.00
6	1.00	1.00	1.00	1.00
7	1.00	1.00	1.00	1.00
8	1.00	1.00	1.00	1.00
9	1.00	1.00	1.00	1.00

Table 2.6.2.6 North Sea Autumn Spawning Herring. Fraction of Harvest before Spawning

Units : NA

age \ year	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
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
9	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67

age \ year	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
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
9	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67

age \ year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
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
9	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67

age \ year	2005	2006	2007	2008
0	0.67	0.67	0.67	0.67
1	0.67	0.67	0.67	0.67
2	0.67	0.67	0.67	0.67
3	0.67	0.67	0.67	0.67
4	0.67	0.67	0.67	0.67
5	0.67	0.67	0.67	0.67
6	0.67	0.67	0.67	0.67
7	0.67	0.67	0.67	0.67
8	0.67	0.67	0.67	0.67
9	0.67	0.67	0.67	0.67

Table 2.6.2.7 North Sea Autumn Spawning Herring. Fraction of Natural Mortality before Spawning

Units : NA

year

age	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
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
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

year

age	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
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
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

year

age	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
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
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

year

age	2005	2006	2007	2008
0	0.67	0.67	0.67	0.67
1	0.67	0.67	0.67	0.67
2	0.67	0.67	0.67	0.67
3	0.67	0.67	0.67	0.67
4	0.67	0.67	0.67	0.67
5	0.67	0.67	0.67	0.67
6	0.67	0.67	0.67	0.67
7	0.67	0.67	0.67	0.67
8	0.67	0.67	0.67	0.67
9	0.67	0.67	0.67	0.67

Table 2.6.2.8 North Sea Autumn Spawning Herring. Survey Indicies

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MLAI - Configuration

"Herring" "in" "Sub-area" "IV," "Divisions" "VIId" "&" "IIIa" "(autumn-
spawners)"
      min       max plusgroup   minyear   maxyear    startf      endf
       NA        NA        NA      1973      2008        NA        NA
Index type : biomass

MLAI - Index Values

Units  :  NA
     year
age     1973  1974  1975  1976  1977  1978   1979  1980   1981   1982   1983
  all 13.182 7.943 2.819 2.494 6.151 7.427 14.363 9.771 14.337 20.891 26.804
     year
age     1984   1985   1986  1987    1988    1989    1990   1991   1992   1993
  all 48.367 73.818 38.444 67.69 134.382 131.732 171.592 90.332 42.147 30.069
     year
age     1994   1995   1996   1997   1998   1999   2000    2001    2002    2003
  all 20.798 22.353 43.982 56.462 72.912 60.531 40.441 129.562 109.899 267.813
     year
age      2004    2005    2006    2007    2008
  all 321.658 192.266 117.856 173.003 181.746

MLAI - Index Variance (Inverse Weights)

Units  :  NA
     year
age       1973     1974     1975     1976     1977     1978     1979     1980
  all 1.666667 1.666667 1.666667 1.666667 1.666667 1.666667 1.666667 1.666667
     year
age       1981     1982     1983     1984     1985     1986     1987     1988
  all 1.666667 1.666667 1.666667 1.666667 1.666667 1.666667 1.666667 1.666667
     year
age       1989     1990     1991     1992     1993     1994     1995     1996
  all 1.666667 1.666667 1.666667 1.666667 1.666667 1.666667 1.666667 1.666667
     year
age       1997     1998     1999     2000     2001     2002     2003     2004
  all 1.666667 1.666667 1.666667 1.666667 1.666667 1.666667 1.666667 1.666667
     year
age       2005     2006     2007     2008
  all 1.666667 1.666667 1.666667 1.666667

MIK 0-wr - Configuration

"Herring in Sub-area IV, Divisions VIId & IIIa (autumn-spawners) . Imported from VPA
file."
      min       max plusgroup   minyear   maxyear    startf      endf
     0.00      0.00        NA   1992.00   2009.00      0.08      0.17
Index type : number

MIK 0-wr - Index Values

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

MIK 0-wr - Index Variance (Inverse Weights)

Units  :  NA
   year
age     1992     1993     1994     1995     1996     1997     1998     1999
  0 1.587302 1.587302 1.587302 1.587302 1.587302 1.587302 1.587302 1.587302
   year
age     2000     2001     2002     2003     2004     2005     2006     2007
  0 1.587302 1.587302 1.587302 1.587302 1.587302 1.587302 1.587302 1.587302
   year
age     2008     2009
  0 1.587302 1.587302

IBTS1: 1-5+ wr - Configuration

"Herring in Sub-area IV, Divisions VIId & IIIa (autumn-spawners) . Imported from VPA
file."
      min       max plusgroup   minyear   maxyear    startf      endf
     1.00      5.00      5.00   1984.00   2009.00      0.08      0.17
Index type : number
```

IBTS1: 1-5+ wr - Index Values

Units : NA

age	1984	1985	1986	1987	1988	1989	1990	1991
1	1515.627	2097.280	2662.812	3692.965	4394.168	2331.566	1061.572	1286.747
2	161.480	721.646	782.122	917.550	4163.384	875.336	462.097	693.020
3	61.428	281.990	276.031	116.315	791.528	338.514	279.780	258.604
4	26.888	42.088	79.007	59.351	57.957	89.381	269.108	221.523
5	10.238	27.941	28.076	48.763	25.054	8.519	71.303	146.096

age	1992	1993	1994	1995	1996	1997	1998	1999
1	1268.145	2794.007	1752.053	1345.754	1890.872	4404.647	2275.845	752.862
2	436.563	787.421	1167.221	1392.857	197.522	506.536	791.593	450.623
3	193.085	222.585	213.059	278.544	32.875	162.660	95.660	501.325
4	54.810	45.042	69.004	36.670	10.193	30.532	20.810	98.179
5	92.268	65.534	42.503	6.551	8.079	19.935	17.841	35.566

age	2000	2001	2002	2003	2004	2005	2006	2007
1	3725.131	2499.391	4064.829	2765.059	979.101	1001.585	911.241	1321.005
2	199.374	1129.308	658.154	1556.082	436.519	214.191	1481.330	50.003
3	154.691	317.069	338.153	611.890	766.031	356.007	334.732	18.250
4	58.838	93.886	25.048	359.989	112.374	388.922	241.137	7.937
5	8.952	68.284	19.936	53.166	170.998	131.481	328.414	41.284

age	2008	2009
1	1901.333	2346.830
2	252.644	135.824
3	155.190	22.304
4	254.853	13.528
5	200.270	55.003

IBTS1: 1-5+ wr - Index Variance (Inverse Weights)

Units : NA

age	1984	1985	1986	1987	1988	1989
1	2.127660	2.127660	2.127660	2.127660	2.127660	2.127660
2	3.571429	3.571429	3.571429	3.571429	3.571429	3.571429
3	100.000000	100.000000	100.000000	100.000000	100.000000	100.000000
4	100.000000	100.000000	100.000000	100.000000	100.000000	100.000000
5	100.000000	100.000000	100.000000	100.000000	100.000000	100.000000

age	1990	1991	1992	1993	1994	1995
1	2.127660	2.127660	2.127660	2.127660	2.127660	2.127660
2	3.571429	3.571429	3.571429	3.571429	3.571429	3.571429
3	100.000000	100.000000	100.000000	100.000000	100.000000	100.000000
4	100.000000	100.000000	100.000000	100.000000	100.000000	100.000000
5	100.000000	100.000000	100.000000	100.000000	100.000000	100.000000

age	1996	1997	1998	1999	2000	2001
1	2.127660	2.127660	2.127660	2.127660	2.127660	2.127660
2	3.571429	3.571429	3.571429	3.571429	3.571429	3.571429
3	100.000000	100.000000	100.000000	100.000000	100.000000	100.000000
4	100.000000	100.000000	100.000000	100.000000	100.000000	100.000000
5	100.000000	100.000000	100.000000	100.000000	100.000000	100.000000

age	2002	2003	2004	2005	2006	2007
1	2.127660	2.127660	2.127660	2.127660	2.127660	2.127660
2	3.571429	3.571429	3.571429	3.571429	3.571429	3.571429
3	100.000000	100.000000	100.000000	100.000000	100.000000	100.000000
4	100.000000	100.000000	100.000000	100.000000	100.000000	100.000000
5	100.000000	100.000000	100.000000	100.000000	100.000000	100.000000

age	2008	2009
1	2.127660	2.127660
2	3.571429	3.571429
3	100.000000	100.000000
4	100.000000	100.000000
5	100.000000	100.000000

Acoustic survey 1-9+ wr - Configuration

"Herring in Sub-area IV, Divisions VIId & IIIa (autumn-spawners) . Imported from VPA file."

min	max	plusgroup	minyear	maxyear	startf	endf
1.00	9.00	9.00	1989.00	2008.00	0.54	0.56

Index type : number

Acoustic survey 1-9+ wr - 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	44000	133000	94000	114000	180000	219000	119000	133000	78000
9	22000	43000	51000	104000	116000	131000	93000	206000	159000

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	45000	54000	120000	98000	121000	145500	342050	126500	84300
9	121000	87000	97000	59000	149500	177700	185600	106700	70400

age \ year	2007	2008
1	6261000	3714000
2	2750000	2853000
3	1848000	1709000
4	898000	1485000
5	806000	809000
6	1323000	712000
7	243000	1749000
8	152000	185000
9	65000	270000

Acoustic survey 1-9+ wr - Index Variance (Inverse Weights)

Units : NA

age \ year	1989	1990	1991	1992	1993	1994	1995
1	1.587302	1.587302	1.587302	1.587302	1.587302	1.587302	1.587302
2	1.612903	1.612903	1.612903	1.612903	1.612903	1.612903	1.612903
3	5.882353	5.882353	5.882353	5.882353	5.882353	5.882353	5.882353
4	10.000000	10.000000	10.000000	10.000000	10.000000	10.000000	10.000000
5	11.111111	11.111111	11.111111	11.111111	11.111111	11.111111	11.111111
6	12.500000	12.500000	12.500000	12.500000	12.500000	12.500000	12.500000
7	14.285714	14.285714	14.285714	14.285714	14.285714	14.285714	14.285714
8	14.285714	14.285714	14.285714	14.285714	14.285714	14.285714	14.285714
9	20.000000	20.000000	20.000000	20.000000	20.000000	20.000000	20.000000

age \ year	1996	1997	1998	1999	2000	2001	2002
1	1.587302	1.587302	1.587302	1.587302	1.587302	1.587302	1.587302
2	1.612903	1.612903	1.612903	1.612903	1.612903	1.612903	1.612903
3	5.882353	5.882353	5.882353	5.882353	5.882353	5.882353	5.882353
4	10.000000	10.000000	10.000000	10.000000	10.000000	10.000000	10.000000
5	11.111111	11.111111	11.111111	11.111111	11.111111	11.111111	11.111111
6	12.500000	12.500000	12.500000	12.500000	12.500000	12.500000	12.500000
7	14.285714	14.285714	14.285714	14.285714	14.285714	14.285714	14.285714
8	14.285714	14.285714	14.285714	14.285714	14.285714	14.285714	14.285714
9	20.000000	20.000000	20.000000	20.000000	20.000000	20.000000	20.000000

age \ year	2003	2004	2005	2006	2007	2008
1	1.587302	1.587302	1.587302	1.587302	1.587302	1.587302
2	1.612903	1.612903	1.612903	1.612903	1.612903	1.612903
3	5.882353	5.882353	5.882353	5.882353	5.882353	5.882353
4	10.000000	10.000000	10.000000	10.000000	10.000000	10.000000
5	11.111111	11.111111	11.111111	11.111111	11.111111	11.111111
6	12.500000	12.500000	12.500000	12.500000	12.500000	12.500000
7	14.285714	14.285714	14.285714	14.285714	14.285714	14.285714
8	14.285714	14.285714	14.285714	14.285714	14.285714	14.285714
9	20.000000	20.000000	20.000000	20.000000	20.000000	20.000000

Table 2.6.2.9 North Sea Autumn Spawning Herring. Stock object configuration

min	max	plusgroup	minyear	maxyear	minfbar	maxfbar
0	9	9	1960	2008	2	6

Table 2.6.2.10 North Sea Autumn Spawning Herring. FLICA configuration settings

```
sep.2       : NA
sep.gradual : TRUE
sr          : TRUE
sr.age      : 1
lambda.age  : 0.1 0.1 3.67 2.87 2.23 1.74 1.37 1.04 0.94 0
lambda.yr   : 1 1 1 1 1
lambda.sr   : 0.1
index.model : power linear linear linear
index.cor   : F
sep.nyr     : 5
sep.age     : 4
sep.sel     : 1
```

Table 2.6.2.11 North Sea Autumn Spawning Herring. FLR R software versions

```
R version 2.8.1 (2008-12-22)

Package  : FLICA
Version  : 1.4-9
Packaged : Sat Mar 21 13:07:02 2009; mpa
Built    : R 2.8.0; ; 2009-03-21 13:07:03; windows

Package  : FLAssess
Version  : 1.99-102
Packaged : Wed Sep 24 16:58:05 2008; mpa
Built    : R 2.7.0; i386-pc-mingw32; 2008-09-24 16:58:07; windows

Package  : FLCore
Version  : 3.0
Packaged : Tue Mar 10 04:42:26 2009; theussl
Built    : R 2.8.1; i386-pc-mingw32; 2009-03-10 04:42:28; windows
```

Table 2.6.2.12 North Sea Autumn Spawning Herring. Stock Summary

Year	Recruitment thousands Age 0	TSB tonnes	SSB tonnes	Fbar (2-6)	Fbar (0-1)	Landings tonnes	SOP
1960	12087837	3723796.2	1861453	0.339	0.141	696200	1.18
1961	108858073	4343827.3	1643371	0.436	0.074	696700	1.13
1962	46275907	4385354.8	1103051	0.536	0.047	627800	1.17
1963	47657598	4611328.5	2172543	0.227	0.069	716000	0.86
1964	62784953	4783460.8	2018320	0.344	0.161	871200	1.07
1965	34894783	4332830.9	1438153	0.694	0.127	1168800	1.15
1966	27858148	3310425.9	1274731	0.620	0.103	895500	1.07
1967	40255855	2816512	921824	0.798	0.162	695500	1.18
1968	38698462	2520862.8	412347	1.336	0.168	717800	1.26
1969	21581503	1905375.6	424149	1.105	0.169	546700	0.97
1970	41072449	1921915.3	374690	1.106	0.152	563100	0.97
1971	32306362	1849387.7	266027	1.408	0.318	520100	1.07
1972	20858534	1549402.7	288267	0.697	0.318	497500	0.92
1973	10102036	1155879.9	233324	1.135	0.360	484000	0.96
1974	21688511	911745	161930	1.053	0.263	275100	0.97
1975	2814491	679921.7	81542	1.473	0.423	312800	0.93
1976	2720374	358115	77673	1.451	0.199	174800	0.95
1977	4326038	209911.7	47180	0.815	0.198	46000	1.20
1978	4594665	224320.4	64421	0.054	0.123	11000	1.22
1979	10600186	381521.6	106648	0.065	0.125	25100	1.01
1980	16716729	629858.8	130506	0.285	0.120	70764	1.09
1981	37860685	1158012.2	195088	0.353	0.384	174879	1.01
1982	64740217	1842378	277945	0.264	0.280	275079	0.98
1983	61794951	2717821.1	431973	0.338	0.326	387202	1.08
1984	53439842	2863511.4	678583	0.456	0.216	428631	1.05
1985	80893853	3460695.6	698559	0.644	0.234	613780	1.04
1986	97583821	3470896.9	678431	0.573	0.189	671488	1.14
1987	86180225	3934291.6	899264	0.553	0.267	792058	1.02
1988	42262187	3618637.4	1192606	0.539	0.353	887686	1.16
1989	39173461	3307320.2	1247533	0.547	0.281	787899	1.03
1990	35871987	2973565.7	1182522	0.443	0.256	645229	1.05
1991	33634923	2712272.5	978026	0.491	0.213	658008	1.02
1992	62138096	2433999	701221	0.584	0.342	716799	1.00
1993	50250988	2515705.5	470816	0.692	0.399	671397	1.02
1994	34500565	2022343.8	508453	0.709	0.236	568234	1.05
1995	41602863	1841589.4	460948	0.739	0.308	579371	1.01
1996	49747245	1623067.6	462153	0.402	0.165	275098	1.00
1997	28730419	1946578.6	560344	0.421	0.035	264313	1.00
1998	27373602	2066498.6	733708	0.486	0.088	391628	1.00
1999	67697220	2331905.9	857946	0.370	0.043	363163	1.00
2000	40678164	2858800.5	865448	0.362	0.062	388157	1.00
2001	90678376	3236723.2	1301315	0.294	0.051	374065	0.99
2002	30444152	3933139.9	1587054	0.244	0.040	394709	1.00
2003	19069558	3647277.7	1708980	0.245	0.063	482281	1.02
2004	23729100	3343287.6	1752878	0.298	0.062	587698	1.00
2005	16141706	2862232.2	1615686	0.366	0.075	663813	1.00
2006	27136239	2340941	1233800	0.349	0.072	514597	1.00
2007	17358063	2085121.8	952774	0.339	0.070	406482	1.01
2008	20044858	1868926.6	999336	0.236	0.049	257870	1.00

Table 2.6.2.13 North Sea Autumn Spawning Herring. Estimated Fishing Mortality

Units : f

age \ year	1960	1961	1962	1963	1964	1965
0	0.02574284	0.01858824	0.004857388	0.01478961	0.01258623	0.007143512
1	0.25593593	0.12937978	0.089672658	0.12406122	0.30843530	0.246129893
2	0.43747076	0.61737576	0.250233880	0.29752416	0.38895838	0.775347360
3	0.32978964	0.35401289	0.627471177	0.27556155	0.41239120	0.738840142
4	0.34021201	0.41116964	0.424420432	0.22726359	0.37041932	0.776718126
5	0.26989927	0.40731634	0.539913509	0.15182178	0.30822633	0.660342541
6	0.31510911	0.38874213	0.836255146	0.18449853	0.24005044	0.520925638
7	0.62025784	0.25198971	0.656754412	0.29603392	0.28720584	0.462824553
8	0.59556157	0.54998866	0.586878207	0.35349764	0.59051441	0.890581695
9	0.59556157	0.54998866	0.586878207	0.35349764	0.59051441	0.890581695

age \ year	1966	1967	1968	1969	1970	1971
0	0.02145791	0.02563555	0.03481149	0.008238172	0.03510148	0.03397157
1	0.18523876	0.29805042	0.30024977	0.329105590	0.26806072	0.60218038
2	0.59208152	0.42223503	1.32730552	0.784407945	0.97284421	0.88261747
3	0.70824008	0.80462916	1.87222392	0.912609784	1.26704927	1.21478490
4	0.57175522	0.92443845	1.07164717	0.874419941	1.33130509	1.22679764
5	0.83467742	0.82752982	1.23399149	1.054647759	0.87625303	1.08703849
6	0.39078786	1.01011159	1.17445298	1.900945102	1.08154540	2.62891764
7	0.38954212	1.53682847	1.60168399	1.298798275	4.12205870	2.74329509
8	0.74863294	1.07648090	1.67681829	1.330363979	1.74277839	1.95979538
9	0.74863294	1.07648090	1.67681829	1.330363979	1.74277839	1.95979538

age \ year	1972	1973	1974	1975	1976	1977	1978
0	0.05830911	0.04619983	0.07495212	0.1582624	0.1471847	0.09778987	0.04561793
1	0.57826354	0.67397022	0.45203603	0.6884375	0.2510508	0.29832993	0.20066532
2	0.81222816	1.02237645	1.02881936	1.3142612	1.3415528	0.22738272	0.02433139
3	0.80144813	1.33418233	0.97367493	1.5053639	1.4475333	1.42176700	0.04300972
4	0.79969518	0.98794653	0.99487298	1.3763271	1.7446250	0.43887061	0.10568299
5	0.54992457	0.95167186	1.18663933	1.8930981	1.6190729	1.22247577	0.01711883
6	0.52019346	1.38091457	1.07928351	1.2779410	1.1044608	0.76619614	0.07941844
7	0.09977124	0.81355052	0.77743935	2.0396417	1.5170133	0.79771717	0.06447590
8	1.09959652	1.61918785	1.37431188	2.0806522	1.6833630	0.98944131	0.19933854
9	1.09959652	1.61918785	1.37431188	2.0806522	1.6833630	0.98944131	0.19933854

age \ year	1979	1980	1981	1982	1983	1984	1985
0	0.08374700	0.12587185	0.4822165	0.3345558	0.3998236	0.2264703	0.08531661
1	0.16704921	0.11330386	0.2857669	0.2251992	0.2518700	0.2053172	0.38311217
2	0.09502297	0.36493691	0.3244910	0.2609733	0.3024553	0.3148049	0.40473190
3	0.06682723	0.42114976	0.2766902	0.5092484	0.3252089	0.4303415	0.67238411
4	0.09495012	0.29910506	0.3055837	0.2486825	0.4377708	0.5390206	0.73984869
5	0.05315146	0.26940314	0.4165956	0.1556973	0.2777677	0.6304763	0.66799319
6	0.01280347	0.06835163	0.4415147	0.1468505	0.3486088	0.3638644	0.73712230
7	0.45298473	0.10492787	0.9965562	0.2371677	0.3980662	0.7092367	0.56705127
8	0.24906938	0.38099618	0.6504193	0.4544292	0.5380664	0.6305582	0.89711388
9	0.24906938	0.38099618	0.6504193	0.4544292	0.5380664	0.6305582	0.89711388

age \ year	1986	1987	1988	1989	1990	1991	1992
0	0.06195776	0.1614404	0.1247302	0.1303117	0.05887783	0.1178547	0.2967334
1	0.31598283	0.3724859	0.5803473	0.4310887	0.45270573	0.3082005	0.3872125
2	0.46001028	0.4066822	0.3559203	0.3987206	0.37735022	0.5741585	0.5727086
3	0.52343315	0.5066230	0.4014664	0.4105377	0.37009024	0.4553957	0.4981599
4	0.58390829	0.5909160	0.5841581	0.5573658	0.46824329	0.4587321	0.5743451
5	0.55711585	0.6203684	0.6680487	0.6611778	0.50247822	0.4847335	0.5484874
6	0.74140486	0.6422858	0.6829116	0.7088260	0.49868268	0.4817589	0.7248097
7	0.83450559	0.6271237	0.7055905	0.7243905	0.69602677	0.4313076	0.7068996
8	0.83595398	0.8262087	0.9623706	0.8688489	0.80862150	0.7400162	0.8970386
9	0.83595398	0.8262087	0.9623706	0.8688489	0.80862150	0.7400162	0.8970386

age \ year	1993	1994	1995	1996	1997	1998	1999
0	0.3761026	0.2263023	0.3223363	0.07584806	0.02398034	0.01509334	0.03717430
1	0.4221388	0.2460424	0.2931471	0.25425330	0.04559094	0.16009951	0.04941211
2	0.6685587	0.6837089	0.5998989	0.30862192	0.28759250	0.26823878	0.24745134
3	0.6408413	0.7162350	0.8669505	0.49024493	0.39182316	0.40856139	0.42068092
4	0.7328861	0.9116612	0.8669226	0.41831295	0.51172400	0.42472495	0.38869502
5	0.7151399	0.5566919	0.8240693	0.47800354	0.45263680	0.60754473	0.33867430
6	0.7043484	0.6765854	0.5385746	0.31470076	0.46082666	0.72191178	0.45348849
7	0.8867284	0.4824257	0.6581933	0.14266590	0.24175538	0.37710936	0.46052795
8	1.0465457	0.8850118	0.9572787	0.55816335	0.41943847	0.55716662	0.41254439
9	1.0465457	0.8850118	0.9572787	0.55816335	0.41943847	0.55716662	0.41254439

```
   year
age       2000       2001       2002      2003       2004       2005       2006
  0 0.04376704 0.03240791 0.03856206 0.0310161 0.05907963 0.07243465 0.06920000
  1 0.07984775 0.06986187 0.04174734 0.0941856 0.06407668 0.07856128 0.07505304
  2 0.23115453 0.12703215 0.14621638 0.1320715 0.14985609 0.18373123 0.17552652
  3 0.31705738 0.30256794 0.22394358 0.2046686 0.23445697 0.28745623 0.27461957
  4 0.46656992 0.30386150 0.28498251 0.2899446 0.32991277 0.40448992 0.38642701
  5 0.47937736 0.39604002 0.22079729 0.3639487 0.38348993 0.47017826 0.44918196
  6 0.31597906 0.34227126 0.34461327 0.2345661 0.39294747 0.48177369 0.46025959
  7 0.39585030 0.21149488 0.27809321 0.3871822 0.34856900 0.42736342 0.40827906
  8 0.41215408 0.31389006 0.26849109 0.3185907 0.32991277 0.40448992 0.38642701
  9 0.41215408 0.31389006 0.26849109 0.3185907 0.32991277 0.40448992 0.38642701
   year
age       2007       2008
  0 0.06712092 0.04679468
  1 0.07279811 0.05075265
  2 0.17025290 0.11869519
  3 0.26636875 0.18570426
  4 0.37481698 0.26131109
  5 0.43568649 0.30374747
  6 0.44643129 0.31123843
  7 0.39601250 0.27608797
  8 0.37481698 0.26131109
  9 0.37481698 0.26131109
```

Table 2.6.2.14 North Sea Autumn Spawning Herring. Estimated Population Abundance

Units : NA

year

age	1960	1961	1962	1963	1964	1965
0	12087836.8	108858073.4	46275906.8	47657597.58	62784952.77	34894782.6
1	16417330.1	4333852.6	39309126.5	16941463.29	17274863.21	22808407.2
2	3691251.0	4675806.0	1400847.1	13220703.68	5505253.68	4668403.5
3	7682034.9	1765607.2	1868294.2	808029.45	7273662.15	2764181.2
4	602818.4	4522635.2	1014587.1	816731.10	502219.34	3942711.6
5	743328.6	388154.7	2712647.8	600532.42	588776.30	313756.6
6	437783.2	513494.3	233711.6	1430482.33	466843.85	391435.2
7	284553.0	289054.3	314976.1	91636.77	1076282.69	332268.8
8	299663.5	138471.1	203288.3	147782.62	61670.06	730743.6
9	330888.2	216361.1	204466.1	179450.32	135298.96	138717.4

year

age	1966	1967	1968	1969	1970	1971
0	27858147.7	40255855.05	38698461.52	21581503.18	41072449.18	32306362.3071
1	12745698.1	10030872.38	14434481.71	13749306.07	7874253.93	14588536.8900
2	6560057.1	3896018.18	2739066.46	3932872.74	3639632.68	2215632.0773
3	1592762.3	2688323.59	1892161.86	538112.10	1329711.75	1019220.9459
4	1081019.2	642254.72	984411.42	238233.52	176877.45	306638.0915
5	1640745.3	552196.74	230568.16	305025.92	89912.00	42273.1458
6	146683.2	644341.22	218410.12	60737.12	96134.57	33871.6506
7	210375.6	89791.22	212324.73	61063.94	8212.11	29494.4939
8	189259.6	128940.65	17473.03	38722.97	15076.29	120.4586
9	468293.8	273050.79	117082.08	35472.50	15327.56	14936.8724

year

age	1972	1973	1974	1975	1976
0	20858533.7521	10102036.0643	21688511.493	2814490.720	2720373.7000
1	11487880.5463	7238789.8619	3548543.252	7402594.685	883838.3969
2	2938959.7569	2370329.7437	1357281.527	830689.784	1368059.1934
3	679036.9397	966404.8213	631695.775	359394.165	165338.5610
4	247648.1377	249442.2425	208387.742	195338.310	65304.1659
5	81358.9262	100716.9151	84038.991	69722.809	44629.9807
6	12898.5324	42476.2875	35185.776	23211.354	9501.3070
7	2211.4773	6937.3515	9660.365	10819.590	5851.5145
8	1717.5666	1811.0187	2782.555	4017.228	1273.4333
9	624.5697	776.1509	1530.405	1654.153	509.3733

year

age	1977	1978	1979	1980	1981
0	4326037.8978	4594664.591	10600185.9513	16716728.9328	37860684.706
1	863798.7865	1443199.057	1614907.7459	3586312.5875	5422397.705
2	252957.9919	235806.116	434394.0941	502695.1404	1178003.052
3	264964.4370	149282.534	170490.3233	292635.9096	258539.114
4	31831.6794	52343.544	117076.9007	130562.4044	157240.966
5	10323.5826	18570.817	42612.4141	96339.7368	87596.956
6	7999.1315	2750.974	16518.3612	36561.4409	66584.894
7	2849.0013	3364.021	2299.1435	14756.2850	30896.488
8	1161.4709	1160.965	2853.8271	1322.5371	12022.035
9	299.6398	1741.447	475.6379	330.6343	2404.407

year

age	1982	1983	1984	1985	1986	1987
0	64740217.240	61794951.30	53439842.19	80893853.33	97583820.80	86180225.01
1	8599436.977	17044486.88	15241135.57	15675301.57	27325524.59	33742357.56
2	1498959.513	2525647.72	4874204.08	4566197.55	3931315.71	7328995.04
3	630860.626	855386.33	1382705.74	2635708.35	2256802.33	1838525.48
4	160510.085	310392.16	505902.66	736166.32	1101604.62	1094738.76
5	104814.883	113258.67	181284.16	267020.04	317858.84	555914.69
6	52255.789	81166.17	77626.33	87320.87	123882.13	164760.28
7	38743.502	40825.23	51825.88	48815.22	37805.98	53406.14
8	10320.026	27654.69	24809.68	23072.77	25052.93	14849.43
9	3153.341	30420.16	41572.98	28356.61	27263.49	15220.67

year

age	1988	1989	1990	1991	1992	1993
0	42262187.24	39173461.34	35871987.16	33634923.08	62138096.24	50250987.78
1	26977422.67	13724225.42	12650386.93	12442012.61	10997964.41	16990016.52
2	8552879.80	5554747.56	3280755.80	2959386.76	3363150.93	2746967.81
3	3615232.47	4438638.55	2761937.29	1666496.63	1234694.48	1405186.09
4	906958.01	1981174.38	2410441.63	1561804.85	865305.97	614260.38
5	548592.00	457573.74	1026673.52	1365562.86	893248.94	440864.72
6	270493.07	254501.38	213740.00	562055.75	760965.84	467022.73
7	78429.94	123635.15	113349.99	117457.62	314141.07	333545.33
8	25811.03	35044.38	54214.28	51134.20	69045.80	140182.14
9	14339.46	15635.18	22401.04	25966.58	41039.98	66959.85

age	1994	1995	1996	1997	1998	1999
0	34500564.63	41602862.72	49747244.618	28730419.08	27373601.838	67697219.697
1	12691438.40	10121616.83	11087659.044	16964230.16	10318889.224	9919333.955
2	4097951.17	3650577.11	2777430.711	3163184.87	5962656.369	3234507.286
3	1042830.84	1532312.87	1484363.940	1511200.51	1757666.177	3377977.985
4	606123.45	417155.56	527201.639	744339.10	836173.805	956404.349
5	267075.87	220395.25	158623.998	313961.43	403740.648	494779.169
6	195116.77	138495.92	87475.019	88990.81	180662.988	198984.709
7	208936.33	89748.64	73132.015	57780.57	50790.352	79417.724
8	124343.80	116699.69	42048.324	57374.52	41054.363	31519.206
9	82777.45	49494.35	9654.364	17414.10	9265.759	6363.323

age	2000	2001	2002	2003	2004	2005
0	40678163.506	90678376.18	30444151.68	19069557.74	23729099.5	16141705.8
1	23995607.883	14323827.15	32294954.42	10776112.25	6801050.8	8228654.3
2	3473190.639	8150041.84	4913873.43	11394874.69	3607973.5	2346677.4
3	1870910.611	2041978.39	5317434.27	3145101.41	7397130.9	2300876.6
4	1815927.538	1115572.68	1235346.13	3480052.33	2098405.0	4790502.1
5	586683.662	1030481.80	744908.71	840606.76	2356323.9	1365150.6
6	319078.529	328687.82	627498.77	540483.65	528570.0	1452974.5
7	114404.395	210494.22	211206.67	402271.99	386796.3	322862.9
8	45340.180	69678.32	154155.73	144711.76	247137.8	246985.4
9	7636.273	10473.15	38748.21	34742.19	118592.3	184153.0

age	2006	2007	2008
0	27136239.0	17358062.70	20044857.8
1	5523278.9	9315410.43	5971130.0
2	2798437.5	1884982.72	3186336.9
3	1446677.0	1739390.38	1177820.6
4	1413167.9	900009.15	1091077.7
5	2892569.8	868842.79	559804.7
6	771889.8	1670233.35	508505.3
7	812076.4	440796.00	967085.9
8	190540.4	488488.21	268424.5
9	141757.2	78293.18	195699.5

Table 2.6.2.15 North Sea Autumn Spawning Herring. Survivors after terminal year.

Units : NA

age	2009
0	32832169.0
1	7036972.0
2	2087951.7
3	2096306.0
4	800884.5
5	760221.7
6	373844.7
7	337052.0
8	663945.0
9	323384.1

Table 2.6.2.16 North Sea Autumn Spawning Herring. Fitted Selection Pattern

Units : NA

age \ year	2004	2005	2006	2007	2008
0	0.1790765	0.1790765	0.1790765	0.1790765	0.1790765
1	0.1942231	0.1942231	0.1942231	0.1942231	0.1942231
2	0.4542294	0.4542294	0.4542294	0.4542294	0.4542294
3	0.7106635	0.7106635	0.7106635	0.7106635	0.7106635
4	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000
5	1.1623980	1.1623980	1.1623980	1.1623980	1.1623980
6	1.1910647	1.1910647	1.1910647	1.1910647	1.1910647
7	1.0565490	1.0565490	1.0565490	1.0565490	1.0565490
8	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000
9	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000

Table 2.6.2.17 North Sea Autumn Spawning Herring. Predicted catch in numbers

Units : NA

age \ year	1960	1961	1962	1963	1964	1965	1966	1967	1968
0	194600	1269200	141800	442800	496900	157100	374500	645400	839300
1	2392700	336000	2146900	1262200	2971700	3209300	1383100	1674300	2425000
2	1142300	1889400	269600	2961200	1547500	2217600	2569700	1171500	1795200
3	1966700	479900	797400	177200	2243100	1324600	741200	1364700	1494300
4	165900	1455900	335100	158300	148400	2039400	450100	371500	621400
5	167700	124000	1081800	80600	149000	145100	889800	297800	157100
6	112900	157900	126900	229700	95000	151900	45300	393100	145000
7	125800	61400	145100	22400	256300	117600	64800	67900	163400
8	128600	56000	86300	42000	26300	413000	95500	81600	13700
9	142000	87500	86800	51000	57700	78400	236300	172800	91800

age \ year	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978
0	112000	898100	684000	750400	289400	996100	263800	238200	256800	130000
1	2503300	1196200	4378500	3340600	2368000	846100	2460500	126600	144300	168600
2	1883000	2002800	1146800	1440500	1344200	772600	541700	901500	44700	4900
3	296300	883600	662500	343800	659200	362000	259600	117300	186400	5700
4	133100	125200	208300	130600	150200	126000	140500	52000	10800	5000
5	190800	50300	26900	32900	59300	56100	57200	34500	7000	300
6	49900	61000	30500	5000	30600	22300	16100	6100	4100	200
7	42700	7900	26800	200	3700	5000	9100	4400	1500	200
8	27400	12000	100	1100	1400	2000	3400	1000	700	200
9	25100	12200	12400	400	600	1100	1400	400	0	300

age \ year	1979	1980	1981	1982	1983	1984	1985	1986	1987
0	542000	1262700	9519700	11956700	13296900	6973300	4211000	3724700	8229200
1	159200	245100	872000	1116400	2448600	1818400	3253000	4801400	6836300
2	34100	134000	284300	299400	573800	1146200	1326300	1266700	2137200
3	10000	91800	56900	230100	216400	441400	1182400	840800	667900
4	10100	32200	39500	33700	105100	201500	368500	465900	467100
5	2100	21700	28500	14400	26200	81100	124500	129800	245800
6	200	2300	22700	6800	22800	22600	43600	62100	74700
7	800	1400	18700	7800	12800	25200	20200	20500	23800
8	600	400	5500	3600	11000	11100	13100	13600	8000
9	100	100	1100	1100	12100	18600	16100	14800	8200

age \ year	1988	1989	1990	1991	1992	1993	1994	1995	1996
0	3164800	3057800	1302800	2386600	10331300	10265400	4498900	7438469	2311226
1	7867000	3145900	3020000	2138900	2303100	3826800	1785200	1664874	1606393
2	2232500	1593700	899300	1132800	1284900	1176300	1783200	1444061	642084
3	1090700	1363800	779100	556700	442700	609000	489100	816703	525601
4	383700	809300	861000	548900	361500	305500	347600	231794	172099
5	255800	211800	387500	501200	360500	215600	109000	118536	57586
6	128100	123700	80200	205300	375600	226000	91800	55128	22534
7	38000	61000	54400	39300	152400	188000	76400	41409	9264
8	15300	19500	28800	25600	39200	87300	70000	68955	17195
9	8500	8700	11900	13000	23300	41700	46600	29245	3948

age	1997	1998	1999	2000	2001	2002	2003	2004	2005
0	431175	259526	1566349	1105085	1832691	730279	369074	864675.83	717192.41
1	479702	977680	303520	1171677	614469	837557	617021	268233.90	395531.34
2	687920	1220105	616354	622853	842635	579592	1221992	435420.21	341838.94
3	446909	537932	1058716	463170	485628	970577	529386	1406680.78	523487.78
4	284920	276333	294066	646814	278884	292205	835552	562695.51	1521724.16
5	109178	175817	135648	213466	321743	140701	244780	716510.09	489212.51
6	31389	88927	69299	82481	90918	174570	107751	163977.08	530735.30
7	11832	15232	27998	35706	38252	48908	123291	108642.71	107231.16
8	18770	16766	10174	14624	17910	34620	37671	66270.98	78456.01
9	5697	3784	2054	2463	2692	8702	9044	31801.00	58497.00

age	2006	2007	2008
0	1153386.99	716227.5	581489.23
1	254001.62	415907.7	187562.29
2	390915.84	256024.8	309011.00
3	316307.44	370286.9	181482.64
4	432422.39	268554.9	239285.05
5	999762.42	293071.0	139901.50
6	271997.29	574467.5	129761.37
7	259924.68	137620.1	222537.16
8	58304.43	145760.6	58868.37
9	43377.00	23362.0	42919.00

Table 2.6.2.18 North Sea Autumn Spawning Herring. Catch Residuals

Units : thousands NA

age	2004	2005	2006	2007	2008
0	-0.18923751	0.34784540	-0.272086254	-0.1426587551748559057341	0.31687197
1	-0.26084251	0.59281726	-0.134163373	-0.5685273456876875908250	0.22556813
2	0.02829862	0.03905334	0.025686068	-0.1556776339151793864257	0.07107111
3	-0.02923265	-0.07482783	-0.018202293	0.1198915057863032262997	0.01795722
4	-0.03493712	-0.14323780	0.071817008	0.0620480828058247377288	-0.18400401
5	0.04997962	-0.01909213	-0.001982850	0.0543946545494838409884	-0.01710378
6	0.03208736	0.08211159	-0.075767948	0.0909849863773814493406	-0.09205924
7	-0.03462823	0.07178706	-0.050833542	0.0715662848336484219702	-0.03193832
8	-0.01413238	0.11832661	0.078012075	-0.0887034451925809569461	0.23333173
9	0.00000000	0.00000000	0.000000000	-0.0000000000000001110223	0.00000000

Table 2.6.2.19 North Sea Autumn Spawning Herring. Predicted Index Values

MLAI

Units : NA NA

age \ year	1973	1974	1975	1976	1977	1978	1979	1980
all	17.18295	11.23541	5.058694	4.780577	2.677022	3.845841	6.912359	8.741913

age \ year	1981	1982	1983	1984	1985	1986	1987	1988
all	13.95368	21.06175	35.17468	59.48045	61.52186	59.46491	82.529	114.6086

age \ year	1989	1990	1991	1992	1993	1994	1995	1996
all	120.7709	113.4823	90.99509	61.79464	38.87996	42.51809	37.93372	38.04904

age \ year	1997	1998	1999	2000	2001	2002	2003	2004
all	47.606	65.13704	78.13517	78.93044	126.8478	159.7921	174.1584	179.3726

age \ year	2005	2006	2007	2008
all	163.1501	119.2259	88.2682	93.30518

MIK 0-wr

Units : NA NA

age \ year	1992	1993	1994	1995	1996	1997	1998	1999
0	175.7339	140.7128	98.43448	117.2819	144.6298	84.07104	80.18975	197.7694

age \ year	2000	2001	2002	2003	2004	2005	2006	2007
0	118.7385	265.0640	88.92354	55.75234	69.13218	46.94869	78.95857	50.52005

age \ year	2008	2009
0	58.48829	95.8

IBTS1: 1-5+ wr

Units : NA NA

age \ year	1984	1985	1986	1987	1988	1989
1	2278.05588	2291.45342	4028.17077	4939.09543	3847.58582	1994.24484
2	666.34730	617.26233	527.77901	990.49806	1163.26128	751.45978
3	128.16866	237.03349	206.77210	168.80319	336.32244	412.45535
4	29.22657	41.47482	63.28486	62.83536	52.10119	114.19252
5	11.88516	14.13035	16.63513	25.19389	29.17576	27.55435

age \ year	1990	1991	1992	1993	1994	1995
1	1833.24675	1835.91461	1606.88517	2471.55511	1887.32658	1496.33535
2	445.01582	391.66898	445.18705	359.29100	534.97944	481.59460
3	257.95072	153.99138	113.48277	126.86989	93.27080	134.49230
4	140.49141	91.13732	49.76946	34.63690	33.42277	23.13173
5	45.37544	67.68483	64.93911	44.45886	27.48521	18.93528

age \ year	1996	1997	1998	1999	2000	2001
1	1647.13929	2586.73676	1551.08188	1511.79586	3643.25981	2177.50700
2	379.99319	433.90912	819.90708	445.92464	479.80709	1140.64460
3	136.56534	140.75545	163.36945	313.49696	175.89559	192.32672
4	30.92007	43.14829	49.00182	56.30061	105.86259	66.37045
5	11.98965	17.21664	21.52126	26.21995	34.53573	53.49843

age \ year	2002	2003	2004	2005	2006	2007	2008
1	4926.76005	1633.21040	1034.6431	1249.5598	839.10373	1415.60824	909.90153
2	686.07726	1593.77312	503.5178	326.1113	389.29024	262.39259	446.41091
3	505.77678	299.87329	702.6666	217.1212	136.73425	164.57001	112.56718
4	73.66996	207.40450	124.4377	281.4460	83.21248	53.07279	65.25932
5	58.19482	63.87802	117.6825	114.3155	154.34294	114.02669	81.77310

age \ year	2009
1	1072.31824
2	292.52538
3	200.34907
4	47.90234
5	80.58949

```
Acoustic survey 1-9+ wr

Units  :  NA NA
   year
age       1989       1990       1991       1992      1993      1994      1995
  1         NA         NA         NA         NA        NA        NA        NA
  2 5800435.14 3466368.51 2806031.46 3191416.64 2472838.6 3658391.5 3412745.8
  3 5624744.54 3578723.94 2060357.55 1491018.10 1568830.7 1116985.2 1510709.0
  4 2468798.89 3154624.05 2054705.70 1068260.09  695008.9  621579.1  438449.6
  5  555220.24 1359389.26 1825835.76 1153172.15  519302.1  343238.9  244510.7
  6  293928.57  277097.56  735476.41  871162.01  540703.5  229375.7  175652.9
  7  131397.63  122360.73  146667.25  337091.80  324208.3  253662.2   98920.3
  8   35311.91   56468.02   55307.95   68502.54  128100.4  124184.2  112008.3
  9   38263.82   56668.22   68213.98   98891.51  148612.3  200787.5  115376.8
   year
age       1996        1997       1998       1999        2000       2001
  1         NA 11219244.20 6407825.14 6546350.03 15573224.79 9347406.17
  2 3047618.74  3511277.12 6689646.67 3670598.32  3976949.15 9882165.64
  3 1800339.44  1934841.12 2229777.29 4256836.90  2495944.69 2745958.92
  4  709176.28   951121.36 1120836.91 1307656.24  2378752.24 1598134.84
  5  212875.87   427260.75  504565.51  716884.86   786743.91 1446691.20
  6  125480.79   117797.05  207154.87  264461.09   457388.70  464398.97
  7  107029.87    80077.50   65339.99   97586.50   145667.96  296617.65
  8   50264.63    74023.39   49103.36   40819.90    58731.77   95270.64
  9   28029.80    54567.42   26916.30   20015.35    24024.47   34779.32
   year
age       2002       2003       2004      2005      2006      2007      2008
  1 21403372.5  6938796.2  4452356.4 5344202.5 3594090.8 6069217.2 3937794.4
  2  5895679.6 13778379.6  4320200.0 2758051.9 3303881.3 2231905.9 3881283.5
  3  7466643.1  4463360.6 10327027.1 3119937.0 1975560.3 2386088.6 1689025.9
  4  1788190.1  5023721.3  2963344.9 6493222.5 1934583.8 1239977.8 1600055.0
  5  1151588.7  1201140.5  3330951.0 1839955.3 3943898.9 1193456.7  826831.9
  6   885444.0   810246.0   726282.5 1901270.0 1022068.5 2228460.4  730828.9
  7   286917.2   514649.6   505472.3  404028.7 1026950.3  561203.3 1315203.8
  8   216105.2   197352.4   334945.0  321286.0  250335.4  645895.7  377783.2
  9   131928.8   115074.3   390367.2  581810.7  452337.6  251428.6  668948.6
```

Table 2.6.2.20 North Sea Autumn Spawning Herring. Index Residuals

```
MLAI

Units  :  NA
     year
age         1973       1974      1975       1976      1977      1978      1979
  all -0.2650651 -0.3467792 -0.584726 -0.6506734 0.8319098 0.6581298 0.7313446
     year
age        1980       1981         1982       1983     1984      1985
  all 0.1112897 0.02710064 -0.008140212 -0.2717754 -0.20683 0.1822101
     year
age         1986       1987      1988       1989      1990         1991
  all -0.4361838 -0.1982113 0.1591638 0.08687406 0.4134727 -0.007313785
     year
age         1992       1993       1994       1995      1996     1997      1998
  all -0.3826531 -0.2569843 -0.7150729 -0.5288799 0.1449045 0.170609 0.1127599
     year
age         1999       2000       2001       2002      2003      2004      2005
  all -0.2552847 -0.6687228 0.02117124 -0.3743119 0.4303238 0.5840236 0.1642094
     year
age          2006      2007      2008
  all -0.01155663 0.6729291 0.6667344

MIK 0-wr

Units  :  NA
   year
age      1992      1993       1994       1995       1996      1997       1998
  0 0.1328404 0.3008296 0.03263617 0.07960692 -0.3060323 0.5662256 -0.4122187
   year
age      1999      2000       2001      2002        2003       2004      2005
  0 0.2100667 0.1437868 -0.2102638 0.5985841 -0.02455528 -0.3795101 0.2667246
   year
age       2006       2007       2008                  2009
  0 0.05112141 -0.3060615 -0.7437905 0.00000000000001154632
```

IBTS1: 1-5+ wr

Units : NA

age	1984	1985	1986	1987	1988	1989
1	-0.4074932	-0.08854503	-0.4139297	-0.29075254	0.1328323	0.1562747
2	-1.4174297	0.15624061	0.3933331	-0.07650083	1.2751007	0.1525901
3	-0.7354813	0.17367018	0.2888959	-0.37243145	0.8558949	-0.1975625
4	-0.0833981	0.01467620	0.2218904	-0.05704904	0.1065135	-0.2449777
5	-0.1491846	0.68176983	0.5233982	0.66037034	-0.1523048	-1.1738615

age	1990	1991	1992	1993	1994	1995
1	-0.54633775	-0.3554255	-0.23674243	0.1226292	-0.07437308	-0.1060646
2	0.03766500	0.5706418	-0.01956183	0.7846304	0.78015268	1.0620096
3	0.08123504	0.5184013	0.53147947	0.5621470	0.82606205	0.7280691
4	0.64996647	0.8881591	0.09647116	0.2626758	0.72492697	0.4607536
5	0.45196734	0.7694019	0.35124735	0.3880048	0.43592655	-1.0614092

age	1996	1997	1998	1999	2000	2001
1	0.1379981	0.5322630	0.38339874	-0.69717159	0.02222319	0.13786646
2	-0.6543034	0.1547603	-0.03514365	0.01048110	-0.87820167	-0.00998849
3	-1.4240907	0.1446382	-0.53521396	0.46946493	-0.12846099	0.49992380
4	-1.1097042	-0.3458674	-0.85642371	0.55608696	-0.58735398	0.34682933
5	-0.3947759	0.1466005	-0.18754221	0.30486937	-1.35011738	0.24402316

age	2002	2003	2004	2005	2006	2007
1	-0.19230991	0.52651433	-0.05517701	-0.2212076	0.08247307	-0.06916648
2	-0.04155130	-0.02393311	-0.14278712	-0.4203707	1.33637043	-1.65775882
3	-0.40259698	0.71319249	0.08634008	0.4944948	0.89529096	-2.19917099
4	-1.07880115	0.55140247	-0.10197259	0.3234381	1.06396793	-1.90012891
5	-1.07126914	-0.18355624	0.37366147	0.1398998	0.75509799	-1.01595751

age	2008	2009
1	0.7369741	0.7832426
2	-0.5692585	-0.7671915
3	0.3211000	-2.1952952
4	1.3623181	-1.2644027
5	0.8957181	-0.3819805

Acoustic survey 1-9+ wr

Units : NA

age	1989	1990	1991	1992	1993	1994
1	NA	NA	NA	NA	NA	NA
2	-0.34938797	-0.047368507	-0.06326759	0.15701514	0.18789798	-0.1385713
3	-0.36543004	-0.016261254	-0.19225129	-0.07882601	0.04253472	-0.2861779
4	-0.41331294	0.079015294	-0.04769849	0.07111860	0.26068982	-0.4433018
5	-0.12088614	0.004851235	0.01260712	-0.01676533	0.35551492	0.1043726
6	-0.03788990	0.346892189	-0.13281974	0.35786574	0.36256920	0.3360801
7	-0.09073632	0.540134030	0.44117924	0.15853045	0.53034872	0.2508940
8	0.21996933	0.856674606	0.53037820	0.50932766	0.34014248	0.5673059
9	-0.55346243	-0.276013431	-0.29082396	0.05036748	-0.24775086	-0.4270498

age	1995	1996	1997	1998	1999	2000
1	NA	NA	-0.18107841	-0.36484057	-0.2522194	0.46270659
2	0.12029620	0.3890500	0.52909066	-0.15188308	-0.1760746	-0.30790449
3	0.30086078	0.4501791	0.41668224	0.12235719	0.1043412	-0.14641264
4	0.42701340	0.4270728	0.41545093	0.37143217	-0.1584855	0.27764672
5	0.20118459	0.3790837	0.34120046	0.66589363	-0.3483786	0.24682810
6	0.14469633	-0.2370328	0.60167480	0.76460759	0.1716989	0.05448308
7	0.33293923	-0.2542673	-0.55435358	0.95619422	0.3537348	0.60216654
8	0.06055088	0.9730475	0.05232767	-0.08726495	0.2798144	0.71451090
9	-0.21560363	1.9946080	1.06946717	1.50305847	1.4694088	1.39563802

age	2001	2002	2003	2004	2005	2006
1	-0.31274985	0.07433416	0.34824959	0.15208560	-0.5400721	0.64097889
2	0.21805424	-0.19009971	0.31867160	-0.23486070	-0.2942001	0.13258696
3	0.11577280	0.09612469	-0.37064776	-0.11645267	0.1565033	0.01089416
4	-0.08903186	-0.25190023	-0.18173279	-0.31283651	-0.1146957	0.08085392
5	0.14713099	-0.37105888	-0.57616594	-0.25132973	-0.4167271	0.05696851
6	-0.03149645	0.15219524	-0.49318421	-0.82872182	-0.4813391	-0.50277180
7	-0.55664551	-0.16038760	0.09916326	-0.43369993	-1.0605580	-0.60266908
8	0.02824584	-0.57997463	-0.30481495	0.02099073	-0.9320895	-1.08841965
9	0.52851460	0.12503387	0.43451870	-0.74349403	-1.6961241	-1.86023556

age	2007	2008
(year)		
1	0.03111028	-0.05851130
2	0.20874505	-0.30779484
3	-0.25555149	0.01175641
4	-0.32267868	-0.07462323
5	-0.39252546	-0.02180249
6	-0.52140908	-0.02610149
7	-0.83702182	0.28505257
8	-1.44675744	-0.71396474
9	-1.35277186	-0.90728526

Table 2.6.2.21 North Sea Autumn Spawning Herring. Fit Parameters

	Value	CV.pct	Lower.95.pct.CL
F, 2004	0.33	8	0.28
F, 2005	0.40	9.8	0.34
F, 2006	0.39	9.9	0.32
F, 2007	0.37	10.4	0.31
F, 2008	0.26	8.4	0.21
Selectivity at age 0	0.18	17.6	0.10
Selectivity at age 1	0.19	18.2	0.11
Selectivity at age 2	0.45	11.3	0.38
Selectivity at age 3	0.71	25.8	0.60
Selectivity at age 5	1.16	61.4	0.97
Selectivity at age 6	1.19	56.1	0.98
Selectivity at age 7	1.06	205.6	0.85
Terminal year pop, age 0	20044856.76	1.1	13783885.26
Terminal year pop, age 1	5971129.00	0.9	4488422.98
Terminal year pop, age 2	3186335.92	0.7	2590466.26
Terminal year pop, age 3	1177819.56	0.7	973686.34
Terminal year pop, age 4	1091076.72	0.7	907996.60
Terminal year pop, age 5	559803.69	0.8	460826.11
Terminal year pop, age 6	508504.34	0.8	410586.30
Terminal year pop, age 7	967084.92	0.9	751532.58
Terminal year pop, age 8	268423.50	1.2	199834.70
Last true age pop, 2004	247136.84	1.8	160013.05
Last true age pop, 2005	246984.42	1.4	176285.01
Last true age pop, 2006	190539.43	1.3	140911.69
Last true age pop, 2007	488487.21	1.1	367695.30
Recruitment prediction	32832169.01	1.6	19169423.75
Index 1, biomass, K	1.16	3.9	1.07
Index 1, biomass, Q	0.00	5.2	0.00
Index 2, age 0 numbers, Q	0.00	0.5	0.00
Index 3, age 1 numbers, Q	0.00	0.7	0.00
Index 3, age 2 numbers, Q	0.00	0.9	0.00
Index 3, age 3 numbers, Q	0.00	4.5	0.00
Index 3, age 4 numbers, Q	0.00	4.3	0.00
Index 3, age 5 numbers, Q	0.00	4	0.00
Index 4, age 1 numbers, Q	1.18	49.7	1.00
Index 4, age 2 numbers, Q	1.53	14.4	1.36
Index 4, age 3 numbers, Q	1.77	20.1	1.41
Index 4, age 4 numbers, Q	1.79	25.8	1.33
Index 4, age 5 numbers, Q	1.84	25.9	1.35
Index 4, age 6 numbers, Q	1.80	28.6	1.30
Index 4, age 7 numbers, Q	1.67	35.1	1.17
Index 4, age 8 numbers, Q	1.72	33.5	1.20
Index 4, age 9 numbers, Q	4.17	14.9	2.75
SRR, a	55594838.22	1.2	36805245.93
SRR, b	375622.06	3.6	152326.55

	Upper.95.pct.CL
F, 2004	0.39
F, 2005	0.48
F, 2006	0.46
F, 2007	0.46
F, 2008	0.33
Selectivity at age 0	0.32
Selectivity at age 1	0.35
Selectivity at age 2	0.54
Selectivity at age 3	0.84
Selectivity at age 5	1.39
Selectivity at age 6	1.44
Selectivity at age 7	1.32

Terminal year pop, age 0	29149711.77
Terminal year pop, age 1	7943632.26
Terminal year pop, age 2	3919269.96
Terminal year pop, age 3	1424749.29
Terminal year pop, age 4	1311071.44
Terminal year pop, age 5	680039.97
Terminal year pop, age 6	629774.21
Terminal year pop, age 7	1244461.34
Terminal year pop, age 8	360553.88
Last true age pop, 2004	381697.75
Last true age pop, 2005	346037.93
Last true age pop, 2006	257645.58
Last true age pop, 2007	648960.56
Recruitment prediction	56232849.54
Index 1, biomass, K	1.25
Index 1, biomass, Q	0.00
Index 2, age 0 numbers, Q	0.00
Index 3, age 1 numbers, Q	0.00
Index 3, age 2 numbers, Q	0.00
Index 3, age 3 numbers, Q	0.00
Index 3, age 4 numbers, Q	0.00
Index 3, age 5 numbers, Q	0.00
Index 4, age 1 numbers, Q	1.38
Index 4, age 2 numbers, Q	1.73
Index 4, age 3 numbers, Q	2.22
Index 4, age 4 numbers, Q	2.40
Index 4, age 5 numbers, Q	2.52
Index 4, age 6 numbers, Q	2.51
Index 4, age 7 numbers, Q	2.38
Index 4, age 8 numbers, Q	2.45
Index 4, age 9 numbers, Q	6.32
SRR, a	83976779.91
SRR, b	926246.51

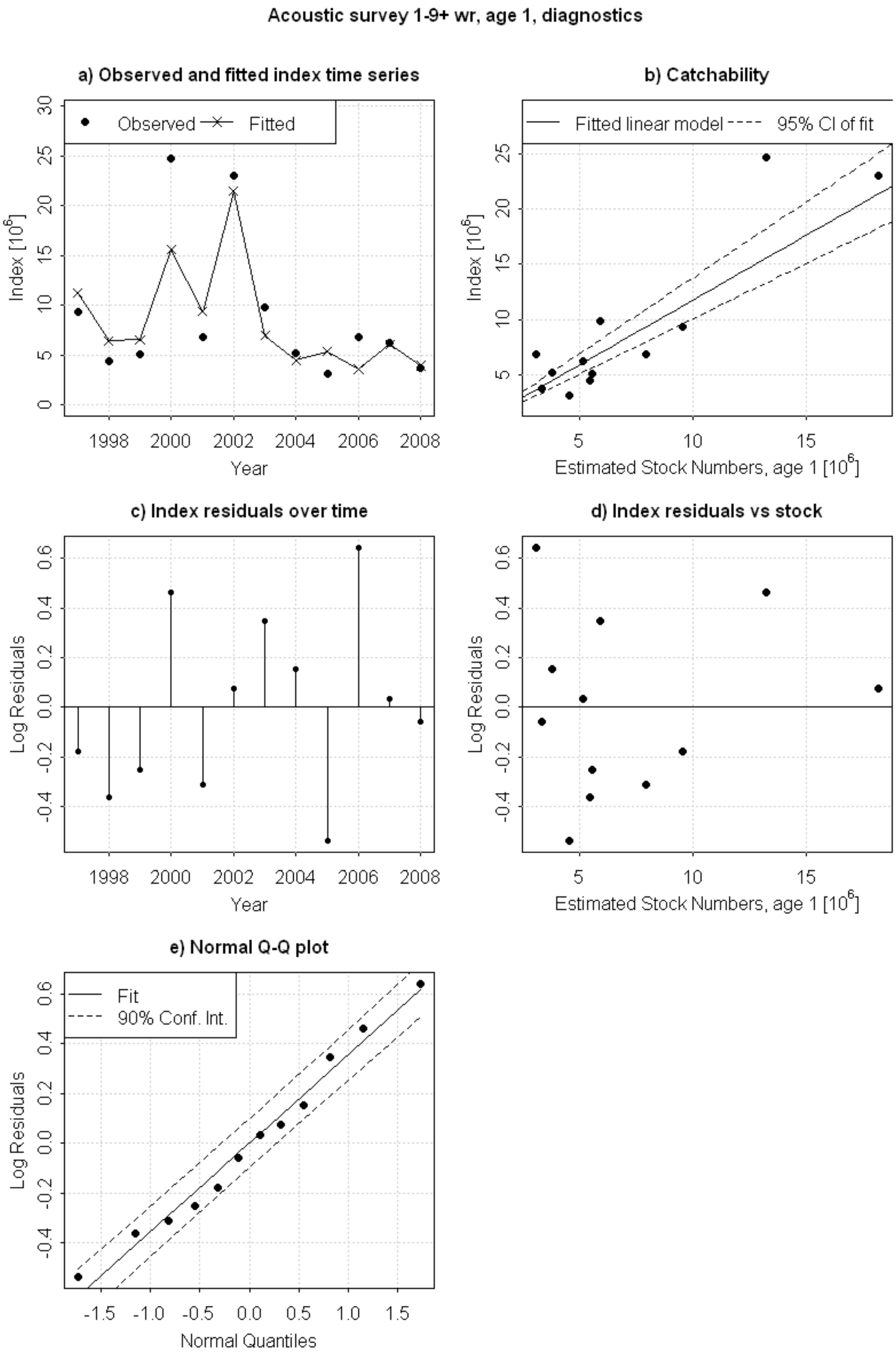


Figure 2.6.1.1 North Sea herring. Diagnostics of Acoustic survey catchability at 1 wr from the final ICA assessment. Top left: VPA estimates of numbers at 1 wr (line) and numbers predicted from index abundance at 1 wr. Top right: scatterplot of index observations versus VPA estimates of numbers at 1 wr with the best-fit catchability model (linear function). Middle right: log residuals of catchability model by VPA estimate of numbers at 1 wr. Middle left: log residuals of catchability model by year. Bottom left: normal Q-Q plot of log residuals.

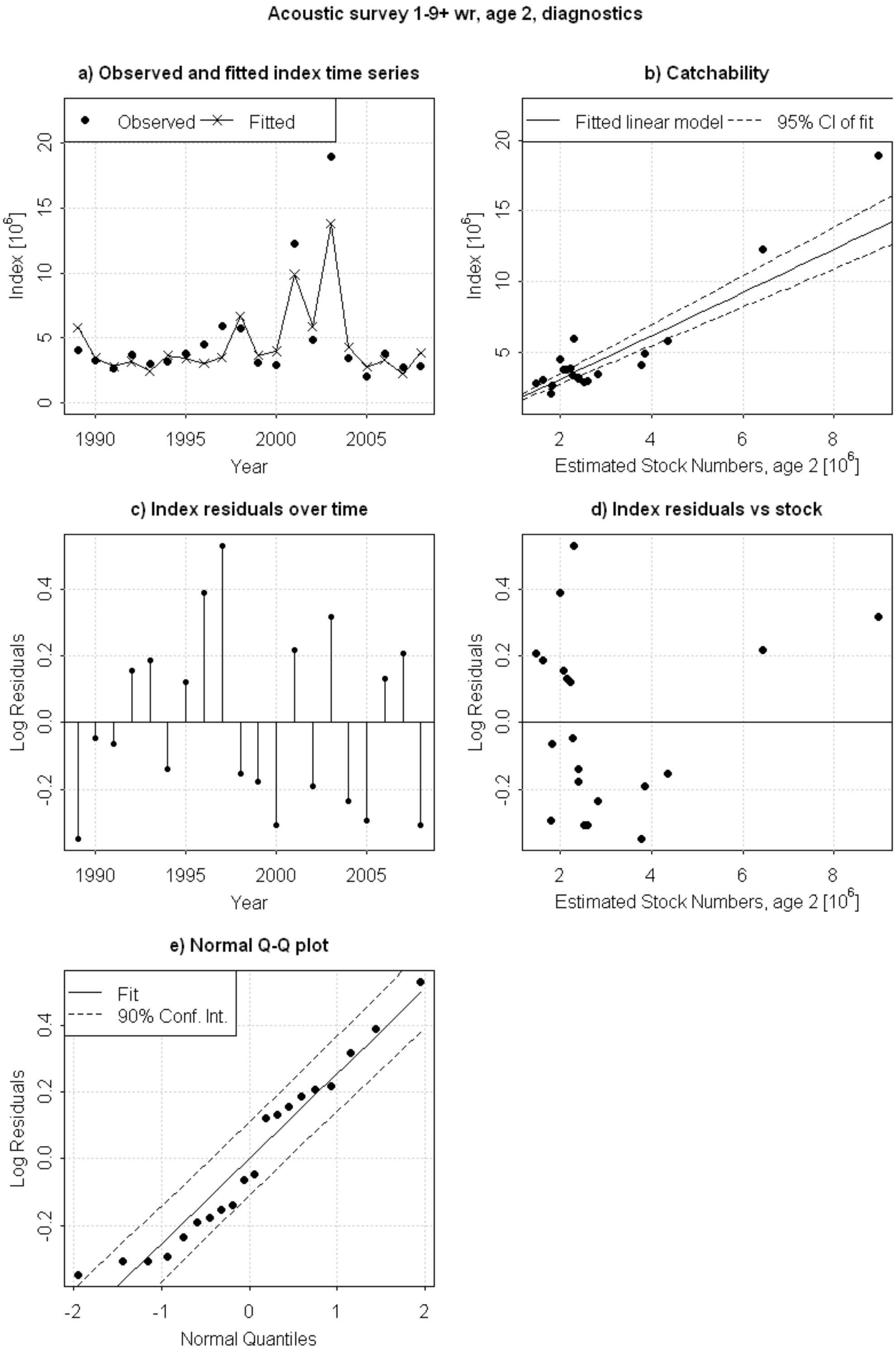


Figure 2.6.1.2. North Sea herring. Diagnostics of Acoustic survey catchability at 2 wr from the final ICA assessment. Top left: VPA estimates of numbers at 2 wr (line) and numbers predicted from index abundance at 2 wr. Top right: scatterplot of index observations versus VPA estimates of numbers at 2 wr with the best-fit catchability model (linear function). Middle right: log residuals of catchability model by VPA estimate of numbers at 2 wr. Middle left: log residuals of catchability model by year. Bottom left: normal Q-Q plot of log residuals.

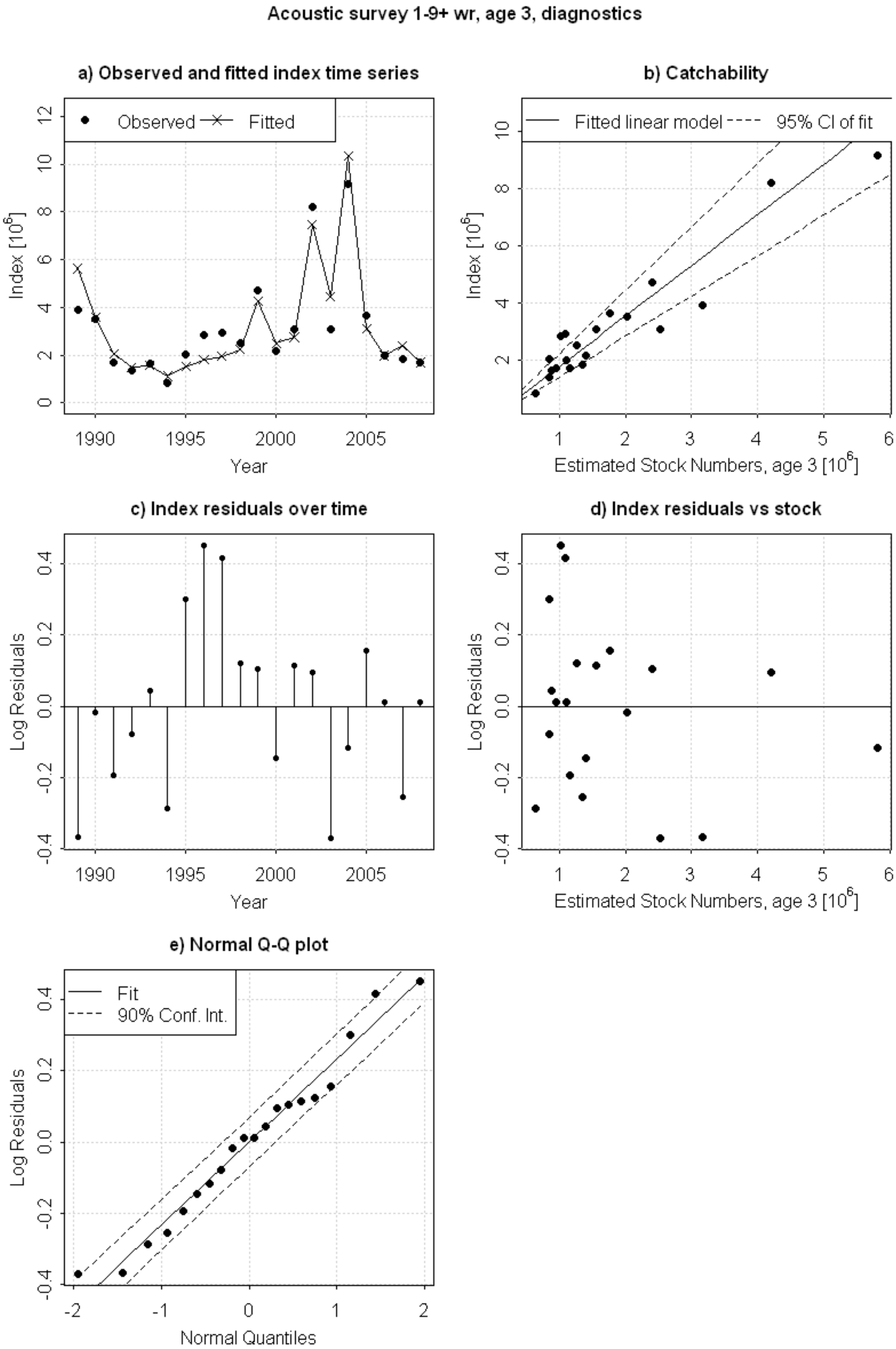


Figure 2.6.1.3. North Sea herring. Diagnostics of Acoustic survey catchability at 3 wr from the final ICA assessment. Top left: VPA estimates of numbers at 3 wr (line) and numbers predicted from index abundance at 3 wr . Top right: scatterplot of index observations versus VPA estimates of numbers at 3 wr with the best-fit catchability model (linear function). Middle right: log residuals of catchability model by VPA estimate of numbers at 3 wr. Middle left: log residuals of catchability model by year. Bottom left: normal Q-Q plot of log residuals.

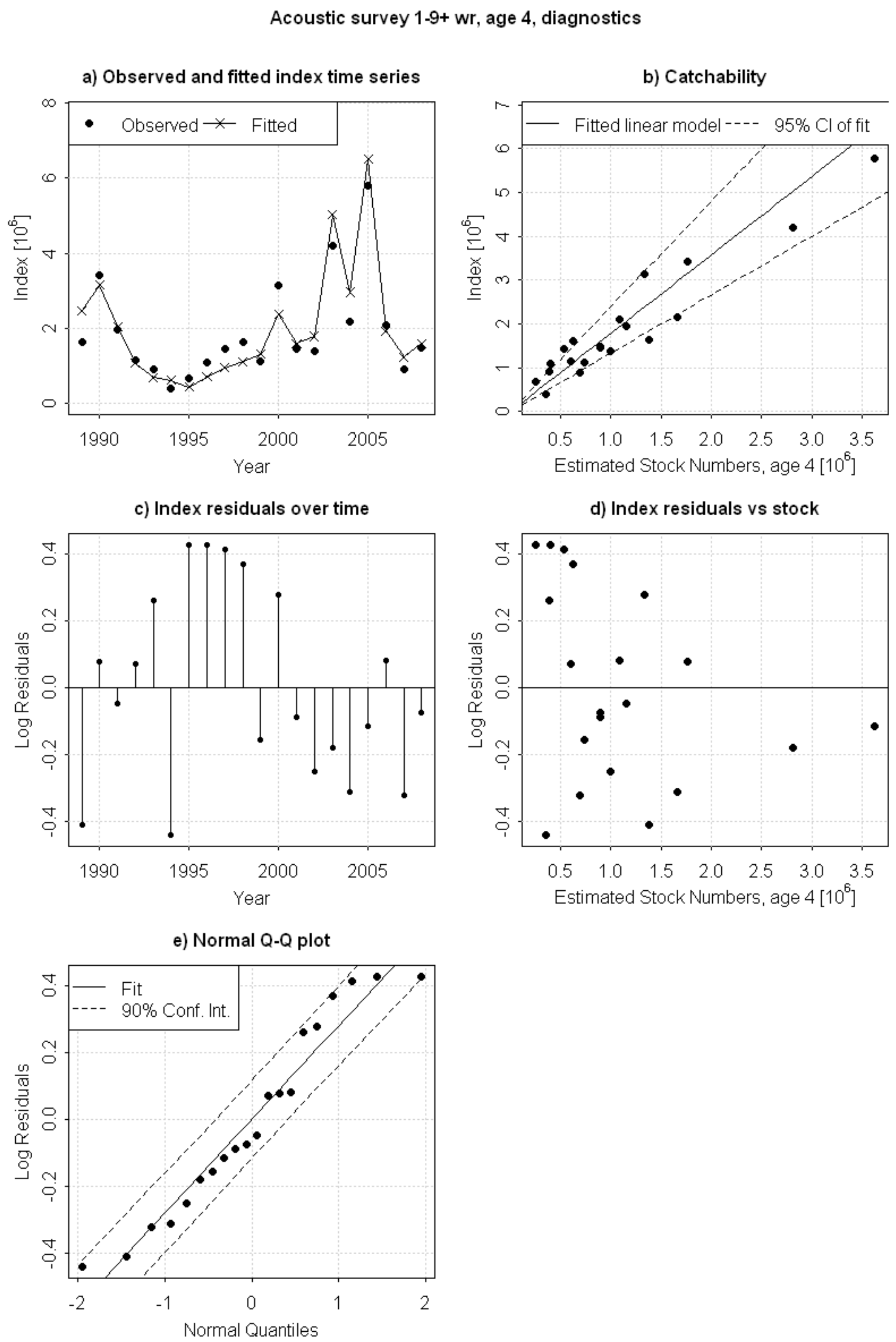


Figure 2.6.1.4. North Sea herring. Diagnostics of Acoustic survey catchability at 4 wr from the final ICA assessment. Top left: VPA estimates of numbers at 4 wr (line) and numbers predicted from index abundance at 4 wr. Top right: scatterplot of index observations versus VPA estimates of numbers at 4 wr with the best-fit catchability model (linear function). Middle right: log residuals of catchability model by VPA estimate of numbers at 4 wr. Middle left: log residuals of catchability model by year. Bottom left: normal Q-Q plot of log residuals.

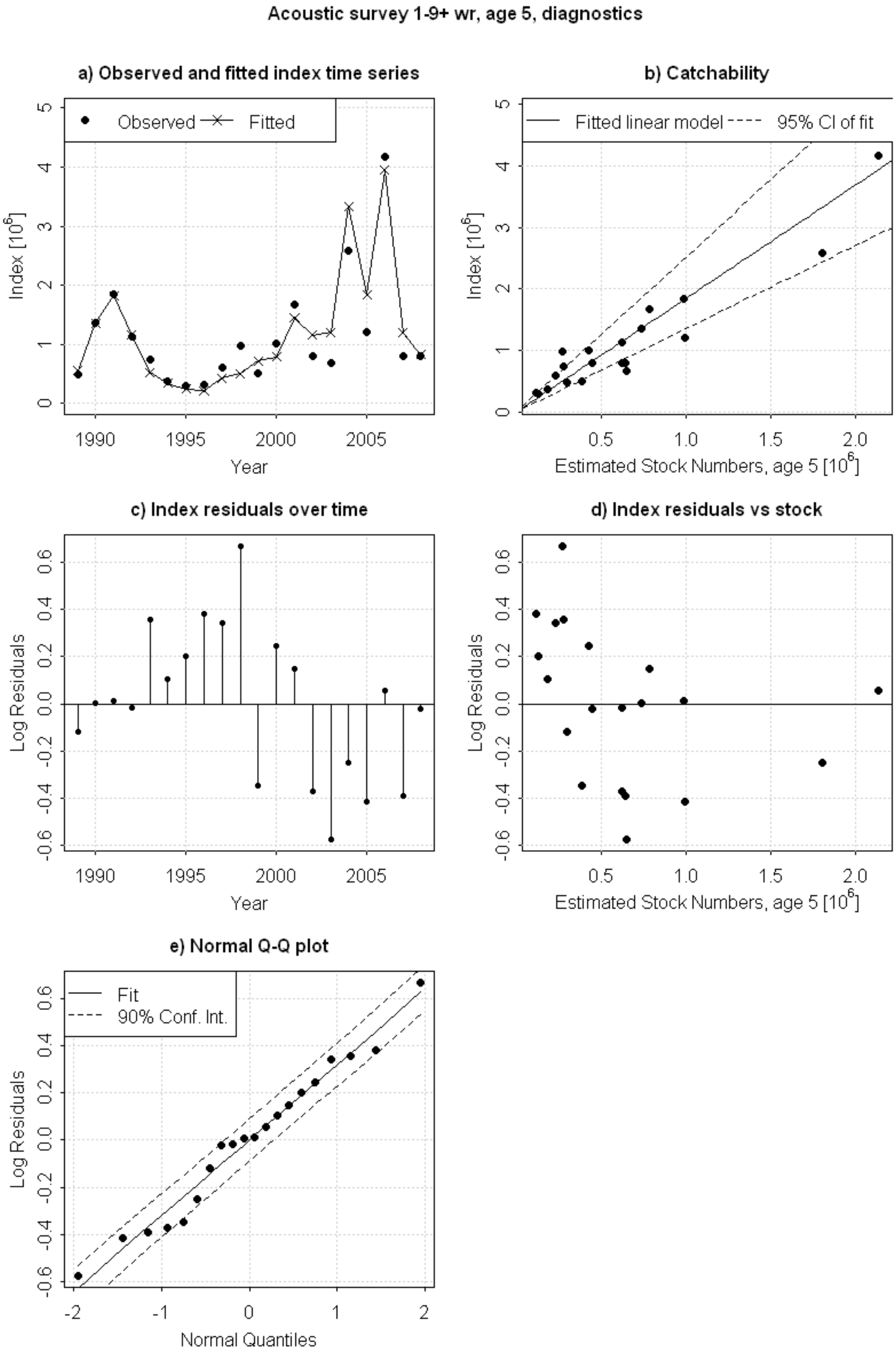


Figure 2.6.1.5. North Sea herring. Diagnostics of Acoustic survey catchability at 5 wr from the final ICA assessment. Top left: VPA estimates of numbers at 5 wr (line) and numbers predicted from index abundance at 5 wr. Top right: scatterplot of index observations versus VPA estimates of numbers at 5 wr with the best-fit catchability model (linear function). Middle right: log residuals of catchability model by VPA estimate of numbers at 5 wr. Middle left: log residuals of catchability model by year. Bottom left: normal Q-Q plot of log residuals.

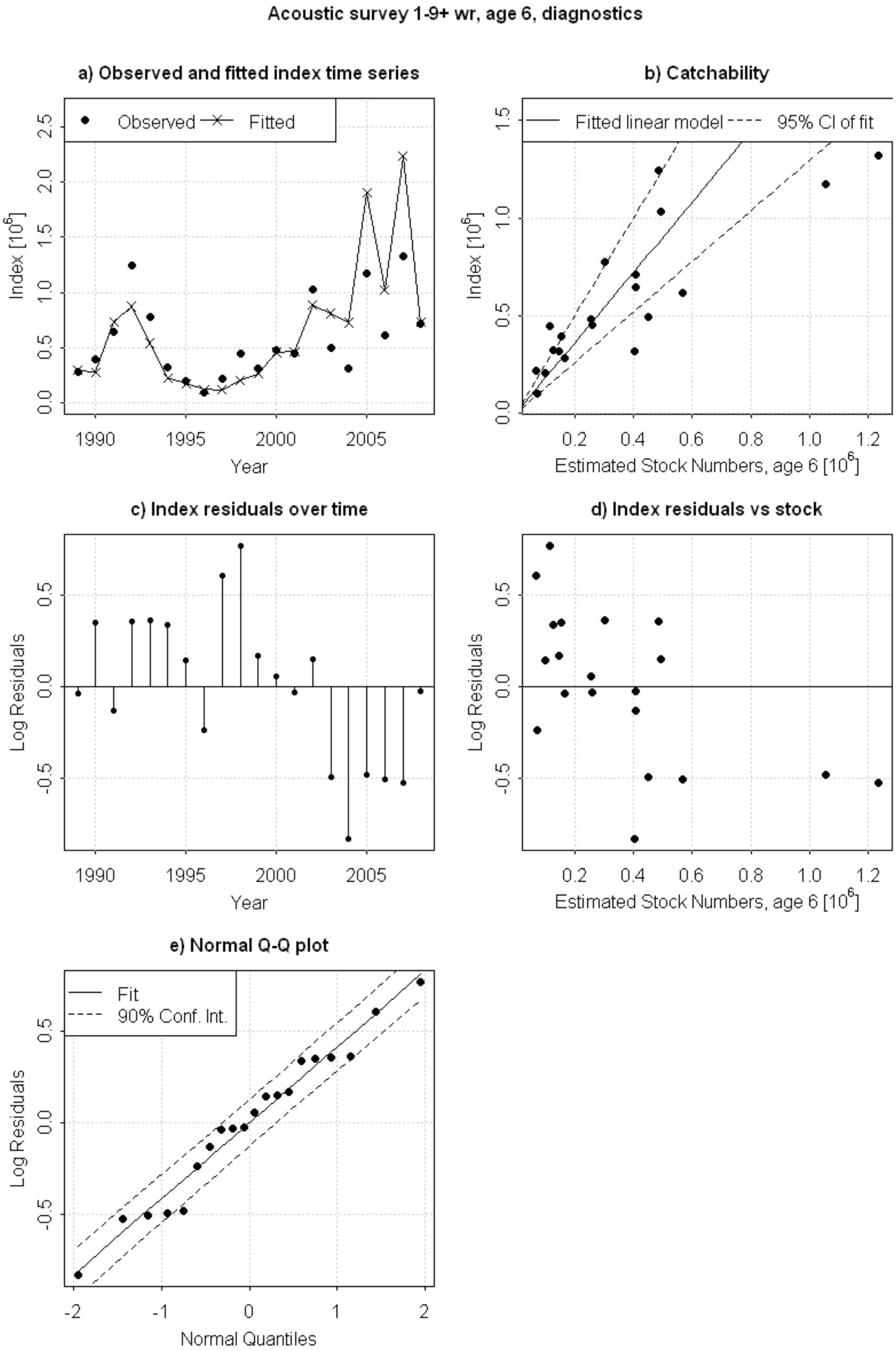


Figure 2.6.1.6. North Sea herring. Diagnostics of Acoustic survey catchability at 6 wr from the final ICA assessment. Top left: VPA estimates of numbers at 6 wr (line) and numbers predicted from index abundance at 6 wr. Top right: scatterplot of index observations versus VPA estimates of numbers at 6 wr with the best-fit catchability model (linear function). Middle right: log residuals of catchability model by VPA estimate of numbers at 6 wr. Middle left: log residuals of catchability model by year. Bottom left: normal Q-Q plot of log residuals.

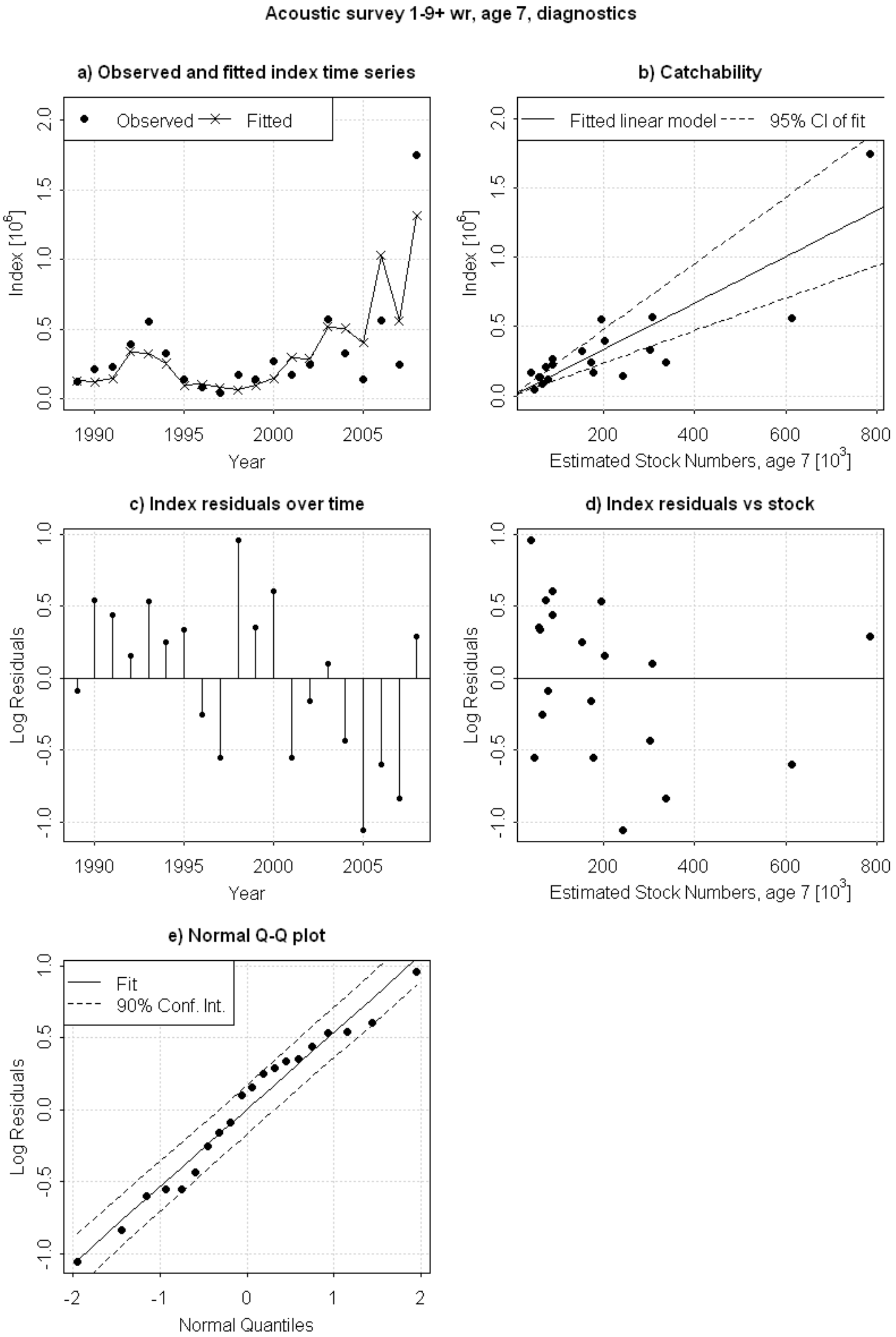


Figure 2.6.1.7. North Sea herring. Diagnostics of Acoustic survey catchability at 7 wr from the final ICA assessment. Top left: VPA estimates of numbers at 7 wr (line) and numbers predicted from index abundance at 7 wr. Top right: scatterplot of index observations versus VPA estimates of numbers at 7 wr with the best-fit catchability model (linear function). Middle right: log residuals of catchability model by VPA estimate of numbers at 7 wr. Middle left: log residuals of catchability model by year. Bottom left: normal Q-Q plot of log residuals.

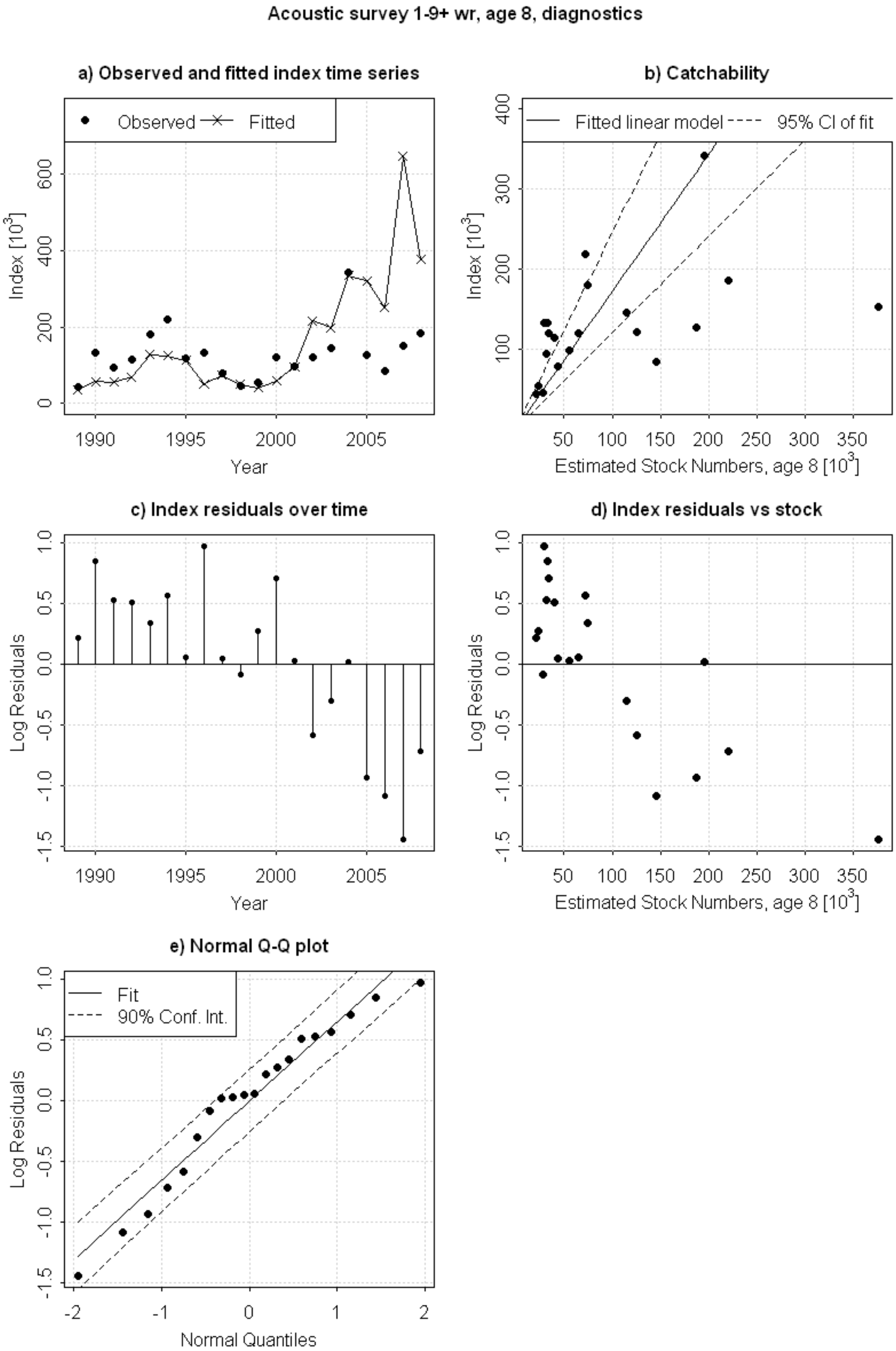


Figure 2.6.1.8. North Sea herring. Diagnostics of Acoustic survey catchability at 8 wr from the final ICA assessment. Top left: VPA estimates of numbers at 8 wr (line) and numbers predicted from index abundance at 8 wr. Top right: scatterplot of index observations versus VPA estimates of numbers at 8 wr with the best-fit catchability model (linear function). Middle right: log residuals of catchability model by VPA estimate of numbers at 8 wr. Middle left: log residuals of catchability model by year. Bottom left: normal Q-Q plot of log residuals.

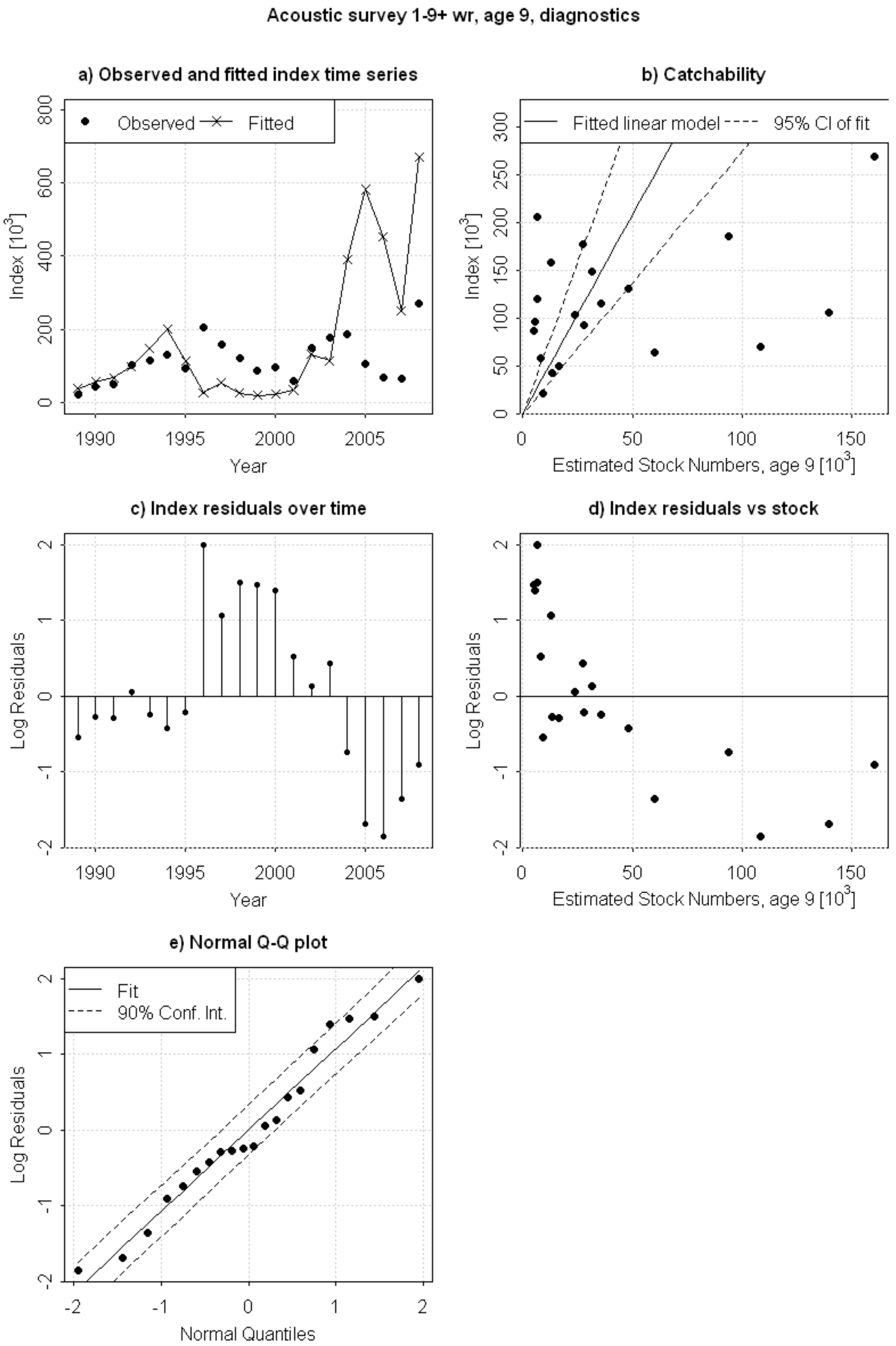


Figure 2.6.1.9. North Sea herring. Diagnostics of Acoustic survey catchability at 9+ wr from the final ICA assessment. Top left: VPA estimates of numbers at 9+ wr (line) and numbers predicted from index abundance at 9+ wr. Top right: scatterplot of index observations versus VPA estimates of numbers at 9+ wr with the best-fit catchability model (linear function). Middle right: log residuals of catchability model by VPA estimate of numbers at 9+ wr. Middle left: log residuals of catchability model by year. Bottom left: normal Q-Q plot of log residuals.

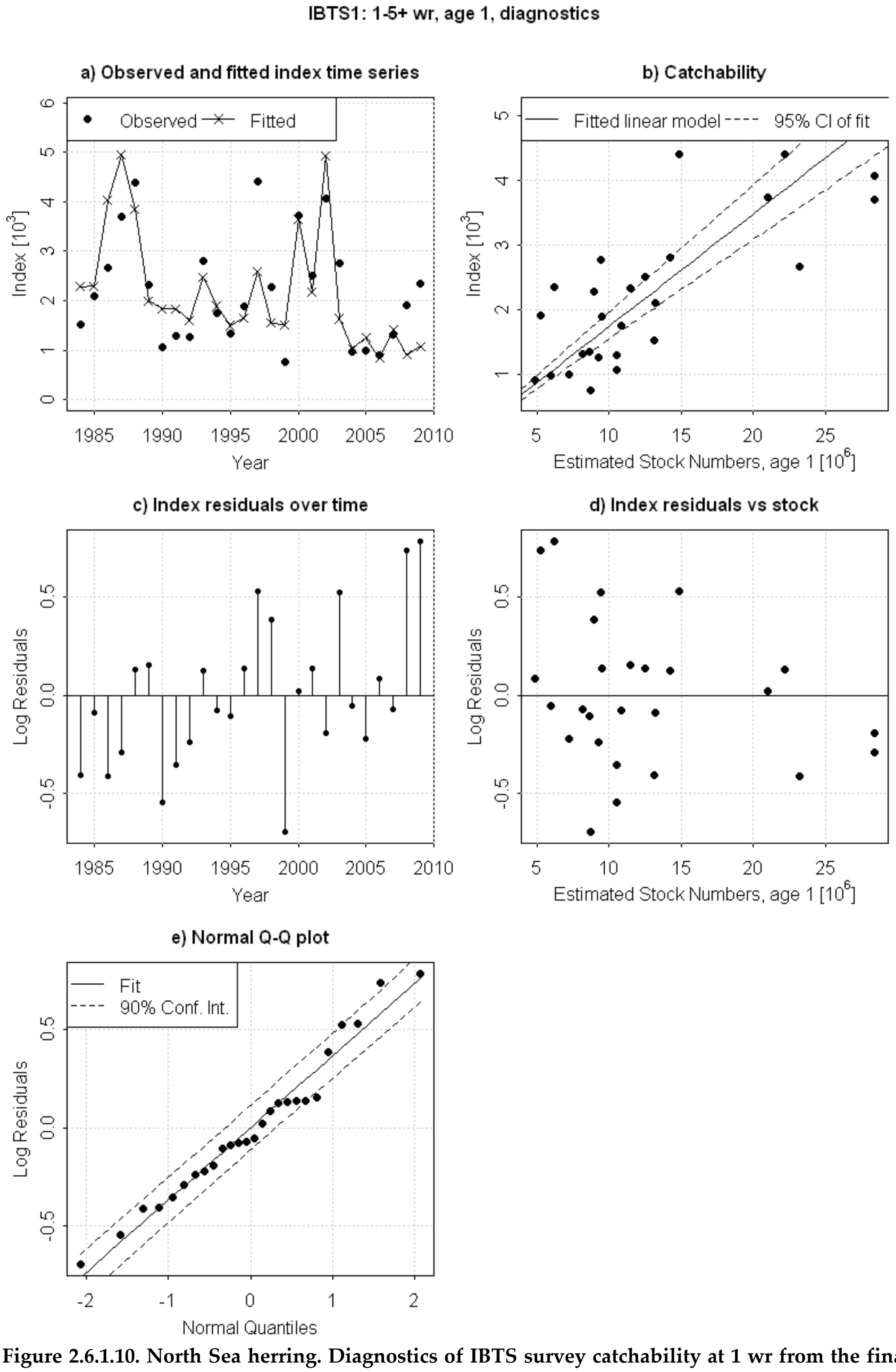


Figure 2.6.1.10. North Sea herring. Diagnostics of IBTS survey catchability at 1 wr from the final ICA assessment. Top left: VPA estimates of numbers at 1 wr (line) and numbers predicted from index abundance at 1 wr. Top right: scatterplot of index observations versus VPA estimates of numbers at 1 wr with the best-fit catchability model (linear function). Middle right: log residuals of catchability model by VPA estimate of numbers at 1 wr. Middle left: log residuals of catchability model by year. Bottom left: normal Q-Q plot of log residuals.

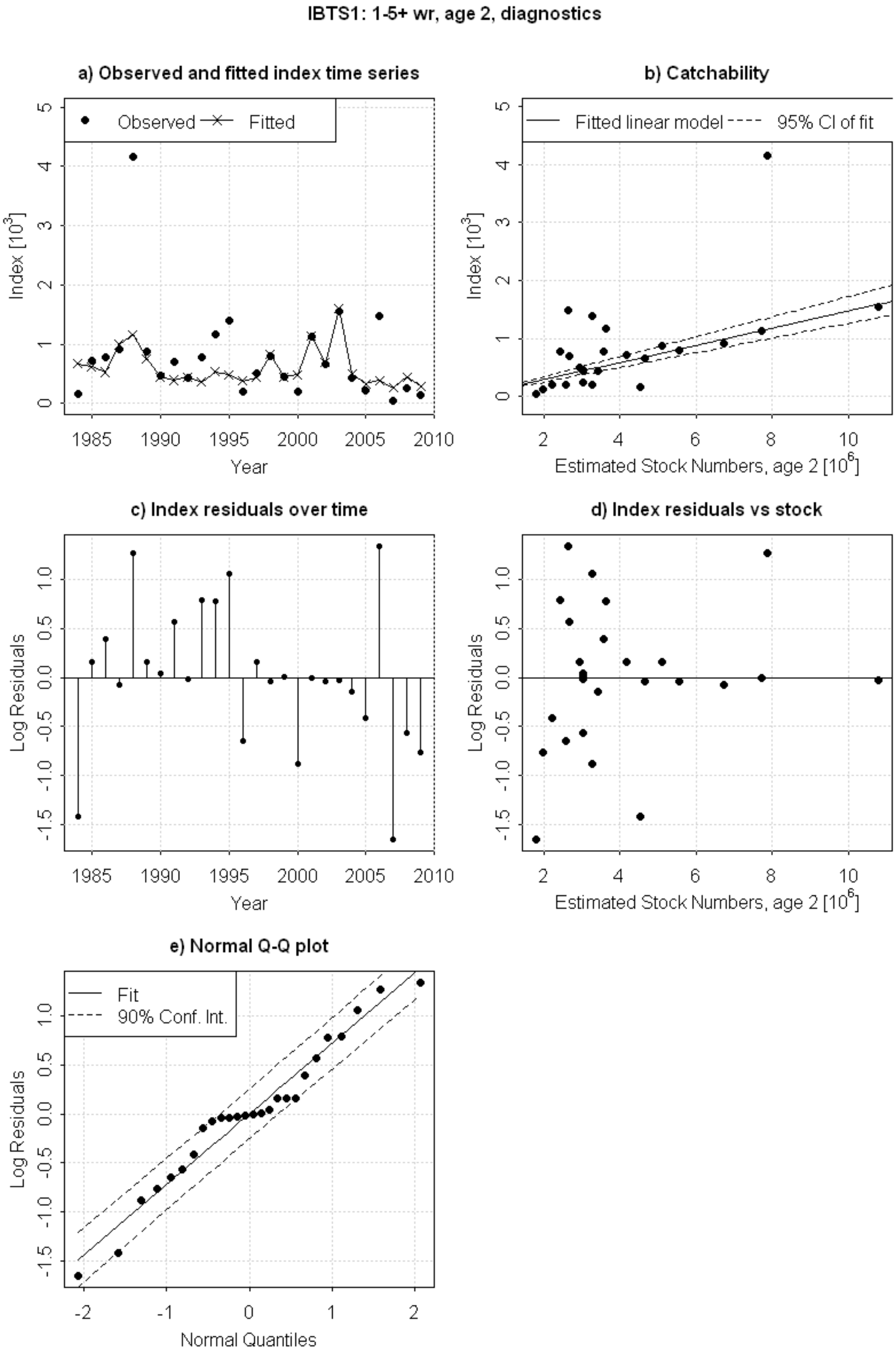


Figure 2.6.1.11. North Sea herring. Diagnostics of IBTS survey catchability at 2 wr from the final ICA assessment. Top left: VPA estimates of numbers at 2 wr (line) and numbers predicted from index abundance at 2 wr. Top right: scatterplot of index observations versus VPA estimates of numbers at 2 wr with the best-fit catchability model (linear function). Middle right: log residuals of catchability model by VPA estimate of numbers at 2 wr. Middle left: log residuals of catchability model by year. Bottom left: normal Q-Q plot of log residuals.

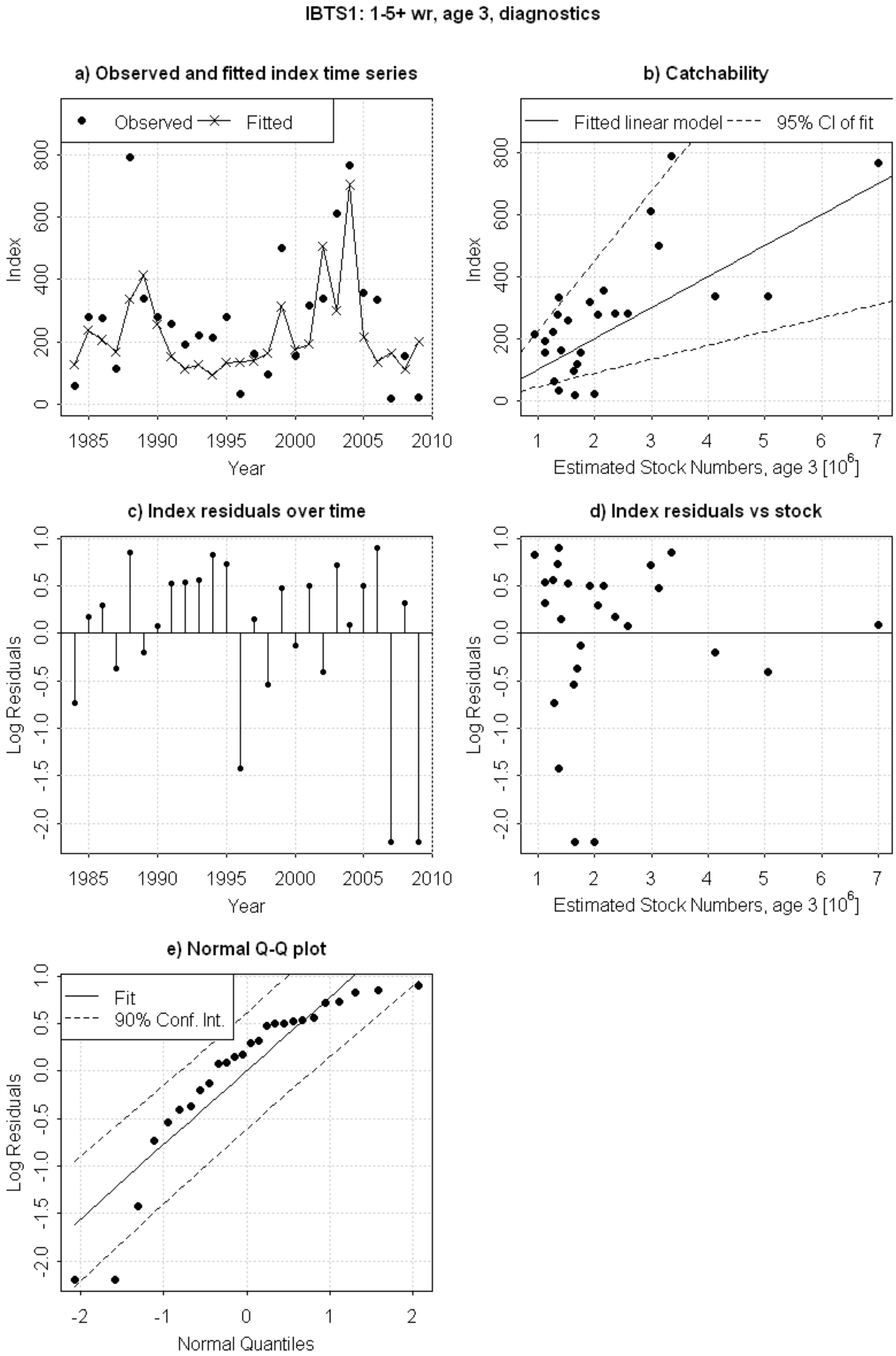


Figure 2.6.1.12. North Sea herring. Diagnostics of IBTS survey catchability at 3 wr from the final ICA assessment. Top left: VPA estimates of numbers at 3 wr (line) and numbers predicted from index abundance at 3 wr. Top right: scatterplot of index observations versus VPA estimates of numbers at 3 wr with the best-fit catchability model (linear function). Middle right: log residuals of catchability model by VPA estimate of numbers at 3 wr. Middle left: log residuals of catchability model by year. Bottom left: normal Q-Q plot of log residuals.

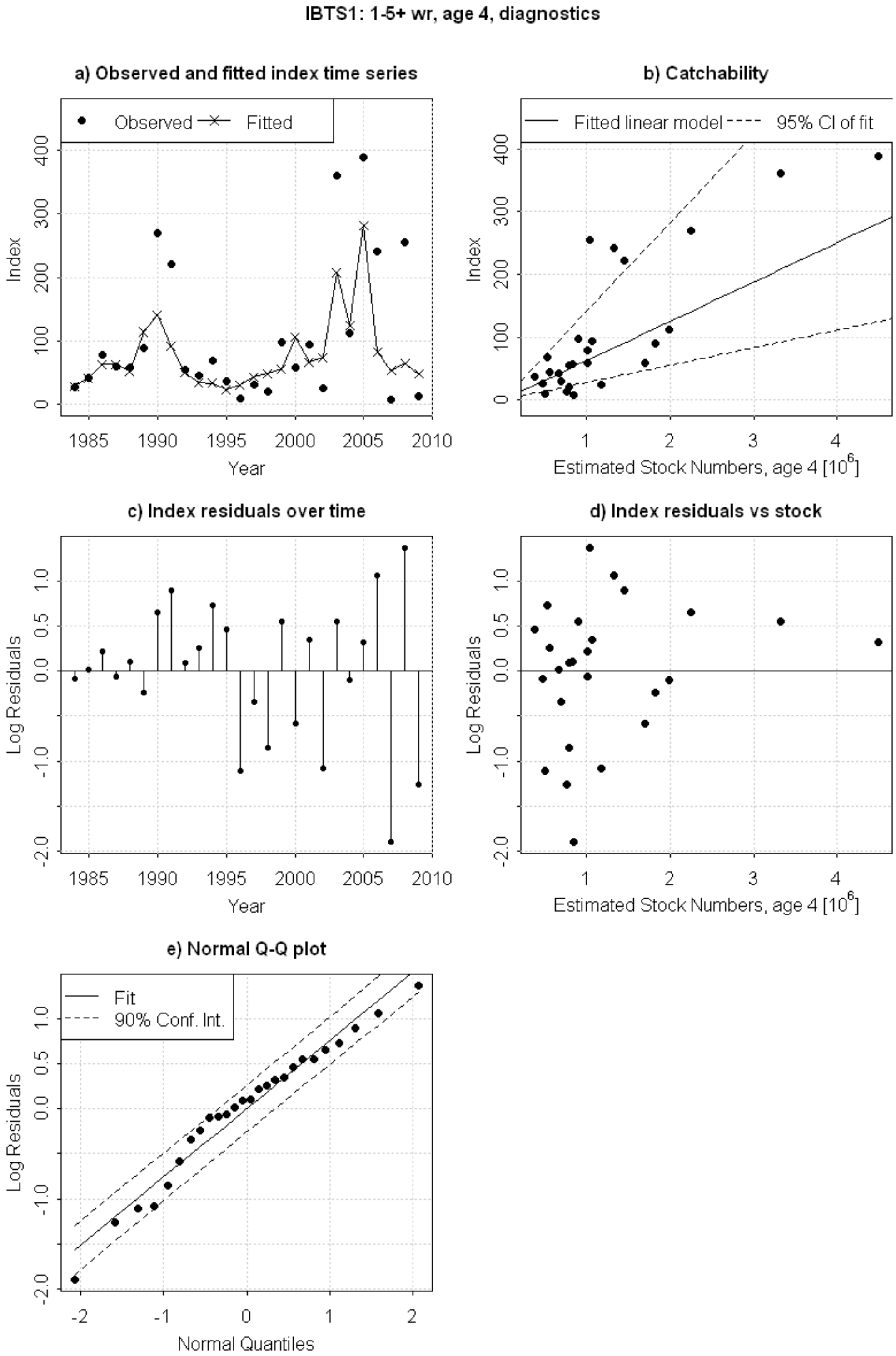


Figure 2.6.1.13. North Sea herring. Diagnostics of IBTS survey catchability at 4 wr from the final ICA assessment. Top left: VPA estimates of numbers at 4 wr (line) and numbers predicted from index abundance at 4 wr. Top right: scatterplot of index observations versus VPA estimates of numbers at 4 wr with the best-fit catchability model (linear function). Middle right: log residuals of catchability model by VPA estimate of numbers at 4 wr. Middle left: log residuals of catchability model by year. Bottom left: normal Q-Q plot of log residuals.

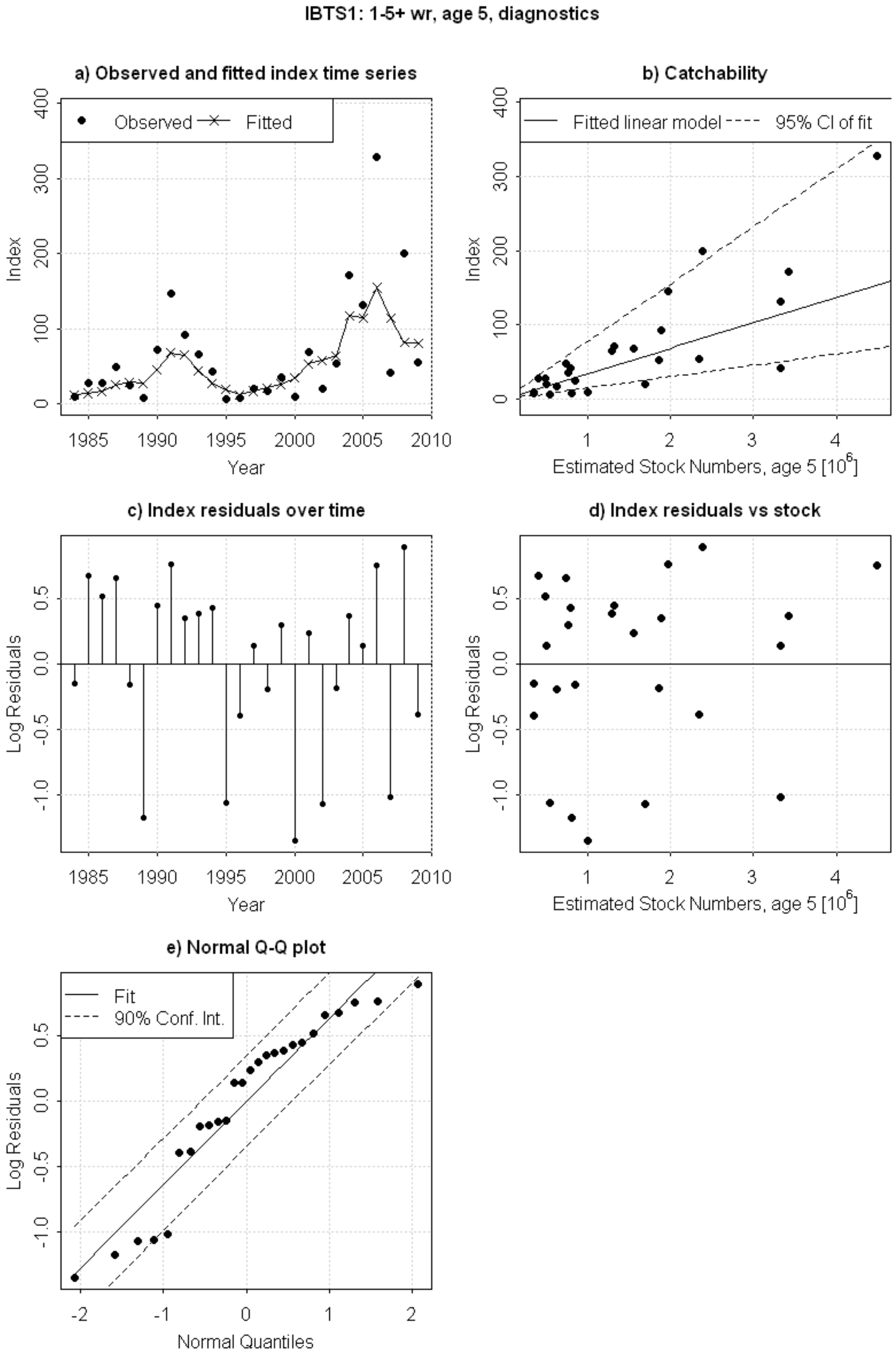


Figure 2.6.1.14. North Sea herring. Diagnostics of IBTS survey catchability at 5+ wr from the final ICA assessment. Top left: VPA estimates of numbers at 5+ wr (line) and numbers predicted from index abundance at 5+ wr. Top right: scatterplot of index observations versus VPA estimates of numbers at 5+ wr with the best-fit catchability model (linear function). Middle right: log residuals of catchability model by VPA estimate of numbers at 5+ wr. Middle left: log residuals of catchability model by year. Bottom left: normal Q-Q plot of log residuals.

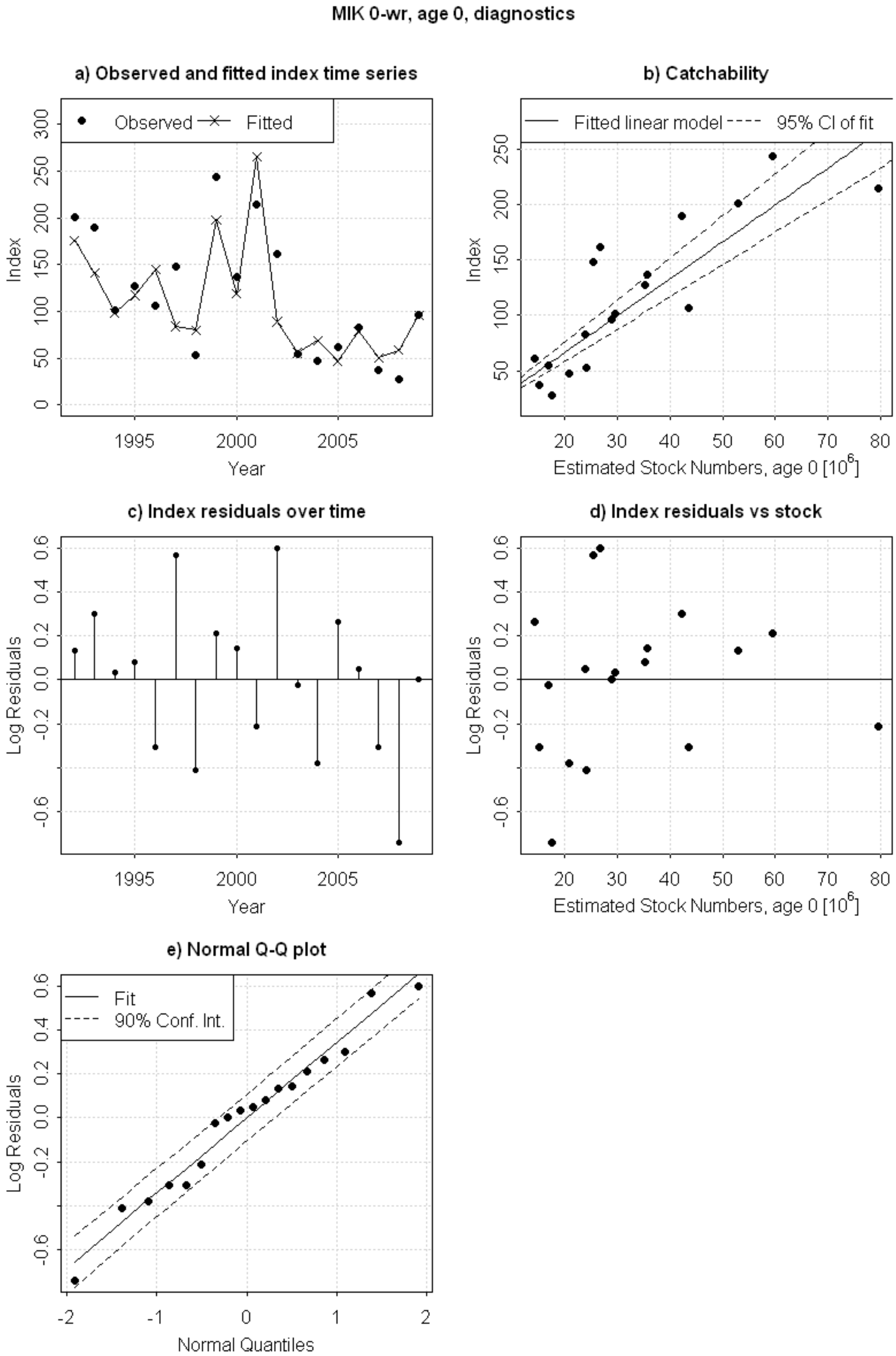


Figure 2.6.1.15. North Sea herring. Diagnostics of MIK survey catchability at 0 wr from the final ICA assessment. Top left: VPA estimates of numbers at 0 wr (line) and numbers predicted from index abundance at 0 wr. Top right: scatterplot of index observations versus VPA estimates of numbers at 0 wr with the best-fit catchability model (linear function). Middle right: log residuals of catchability model by VPA estimate of numbers at 0 wr. Middle left: log residuals of catchability model by year. Bottom left: normal Q-Q plot of log residuals.

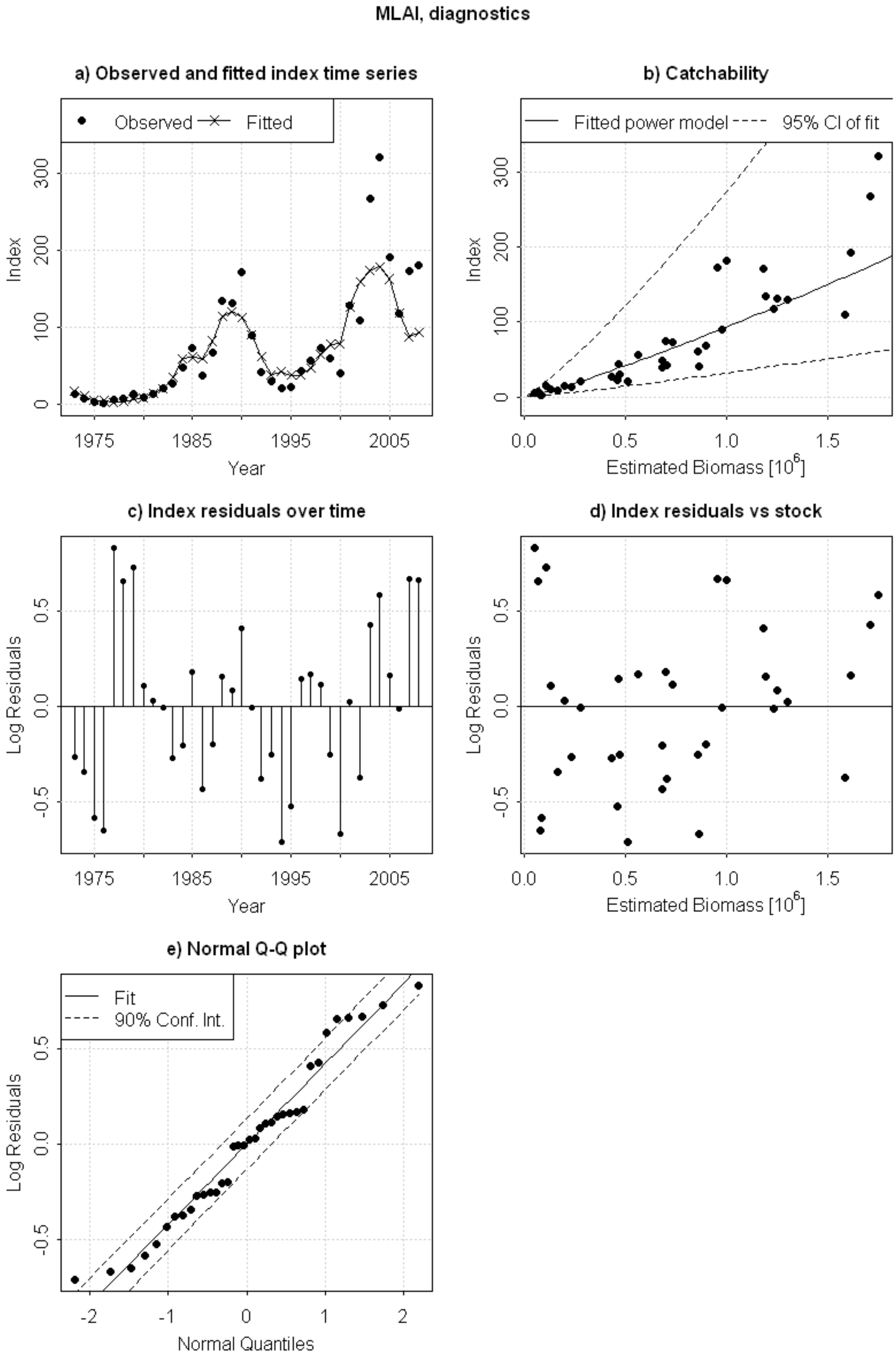


Figure 2.6.1.16. North Sea herring. Diagnostics of MLAI survey catchability at all ages from the final ICA assessment. Top left: VPA estimates of biomass of all ages and biomass predicted from index abundance for all ages. Top right: scatterplot of index observations versus VPA estimates of all ages with the best-fit catchability model (power function). Middle left: log residuals of catchability model by VPA estimate of numbers at 0 wr. Middle right: log residuals of catchability model by year. Bottom left: normal Q-Q plot of log residuals.

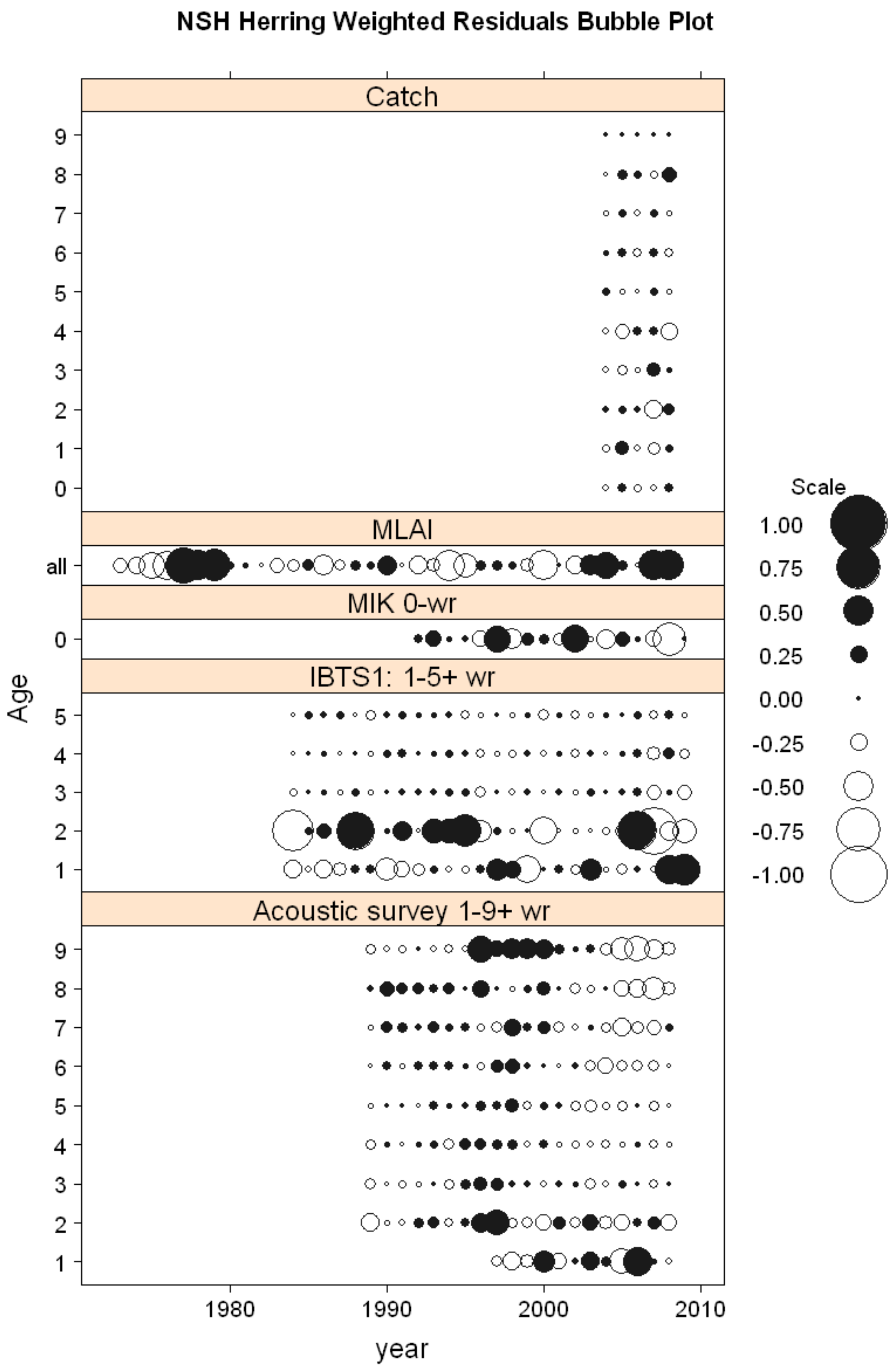


Figure 2.6.1.17. North Sea herring. Weighted Residuals of surveys and catch for the assessment up to 2009.

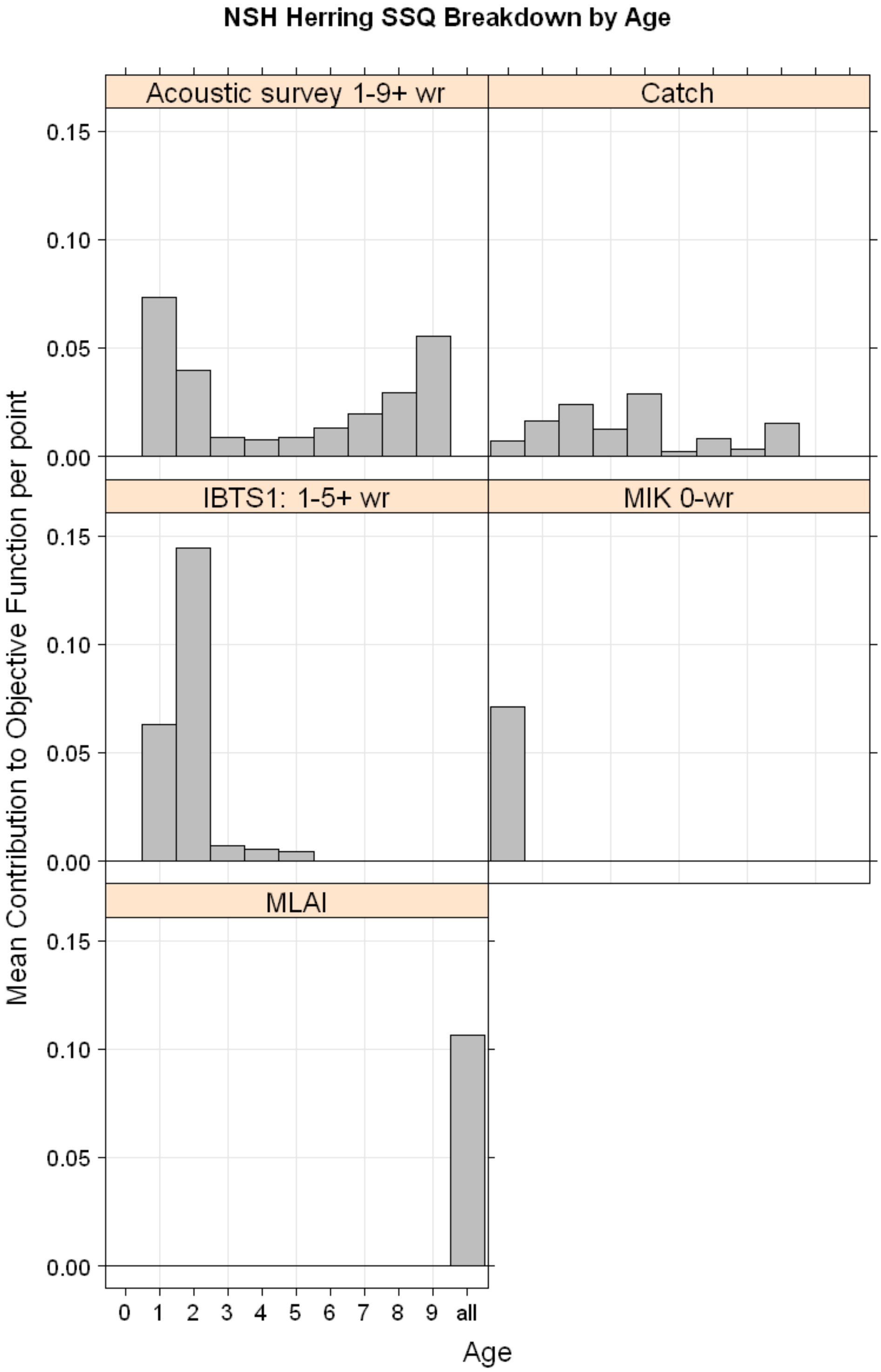


Figure 2.6.1.18. North Sea herring. Mean contribution of each indices or catch to the objective function by age.

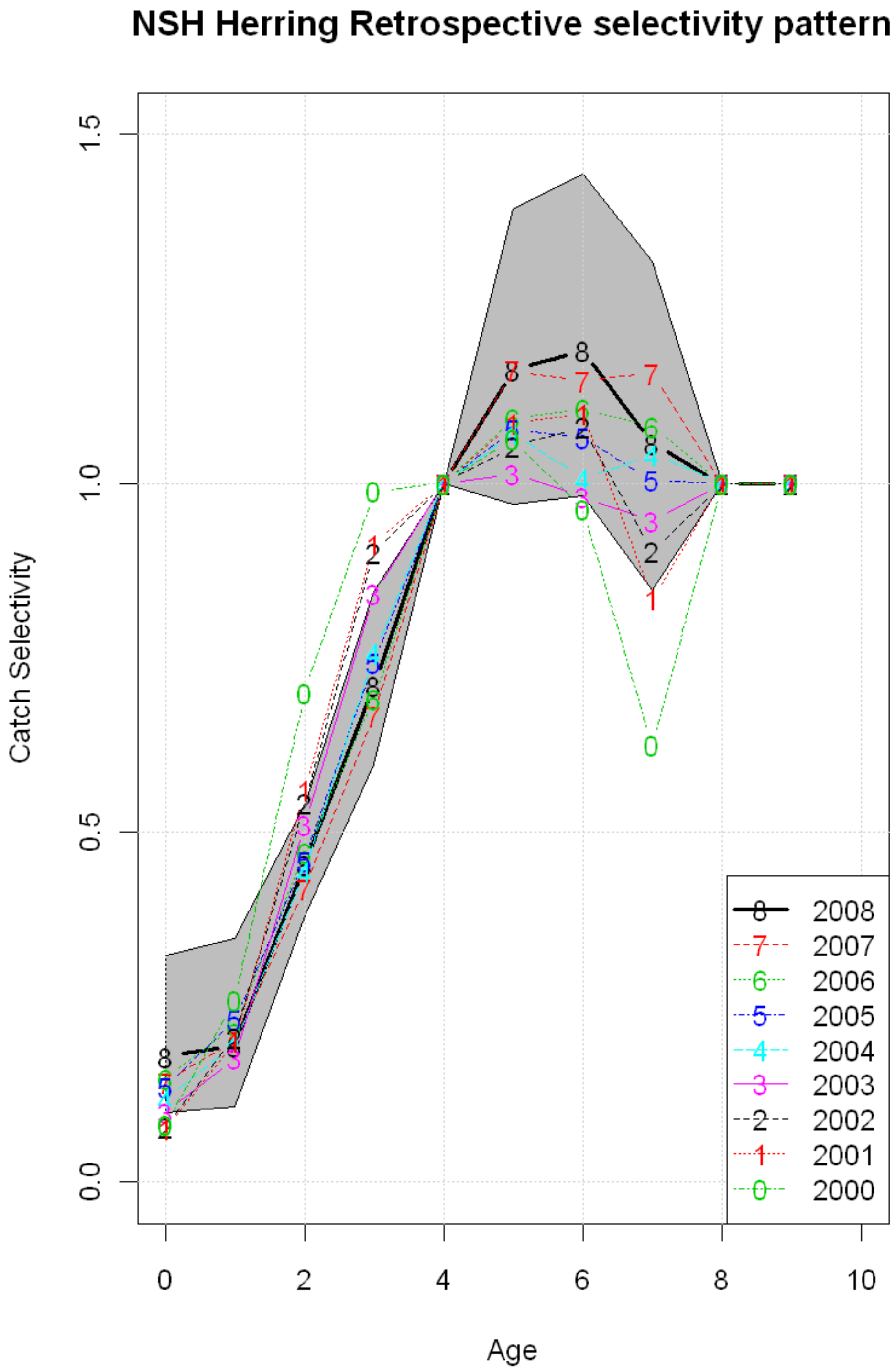


Figure 2.6.1.19. North Sea herring. Retrospective selectivity pattern for the year 2000 till 2008.

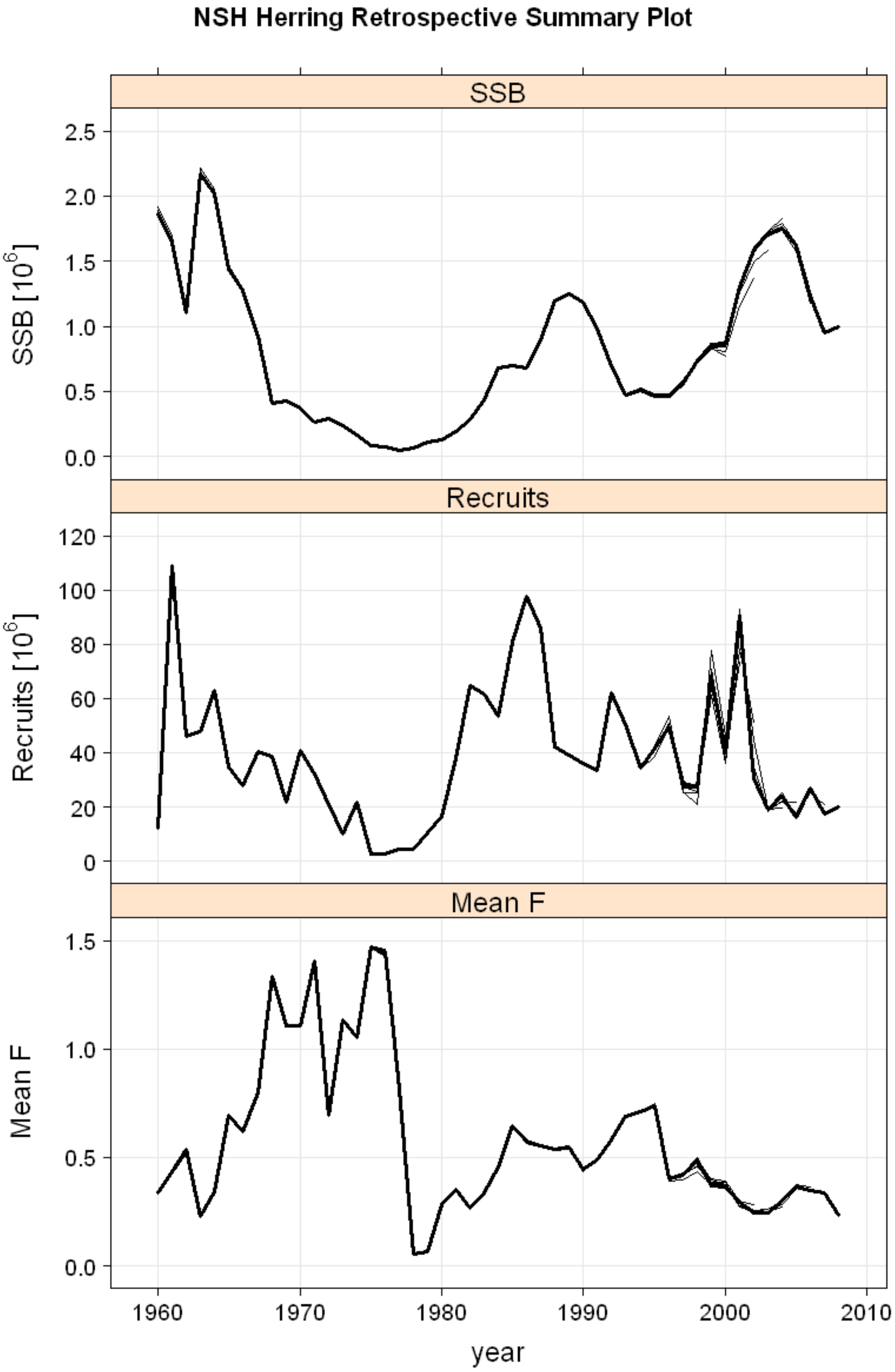


Figure 2.6.1.20. North Sea herring. Retrospective pattern plots for SSB, Recruits and $F_{2\text{-}6}$

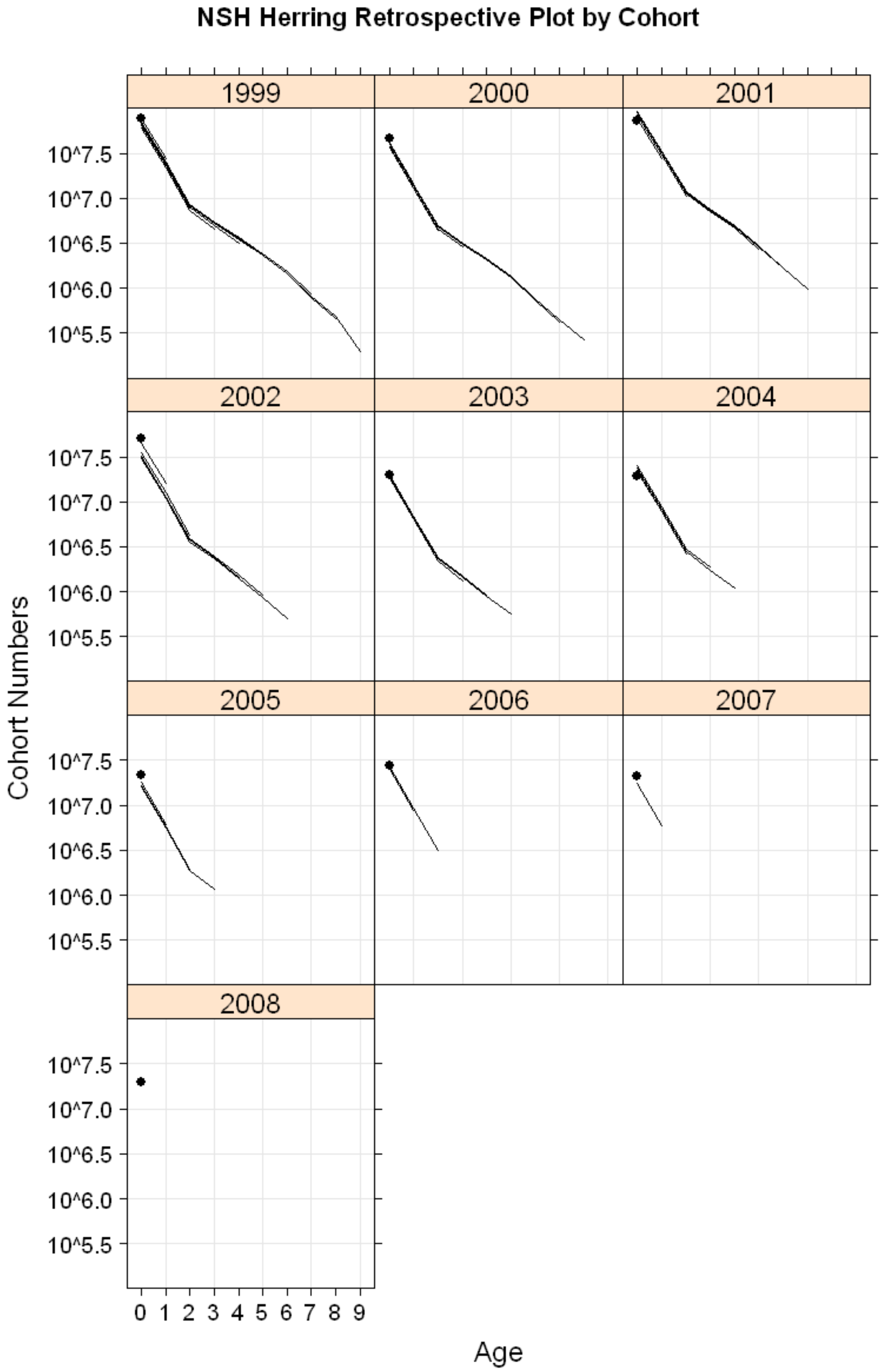


Figure 2.6.1.21. North Sea Herring. Yearclass cohort retrospectives for cohorts that contribute the current stock of North Sea herring.

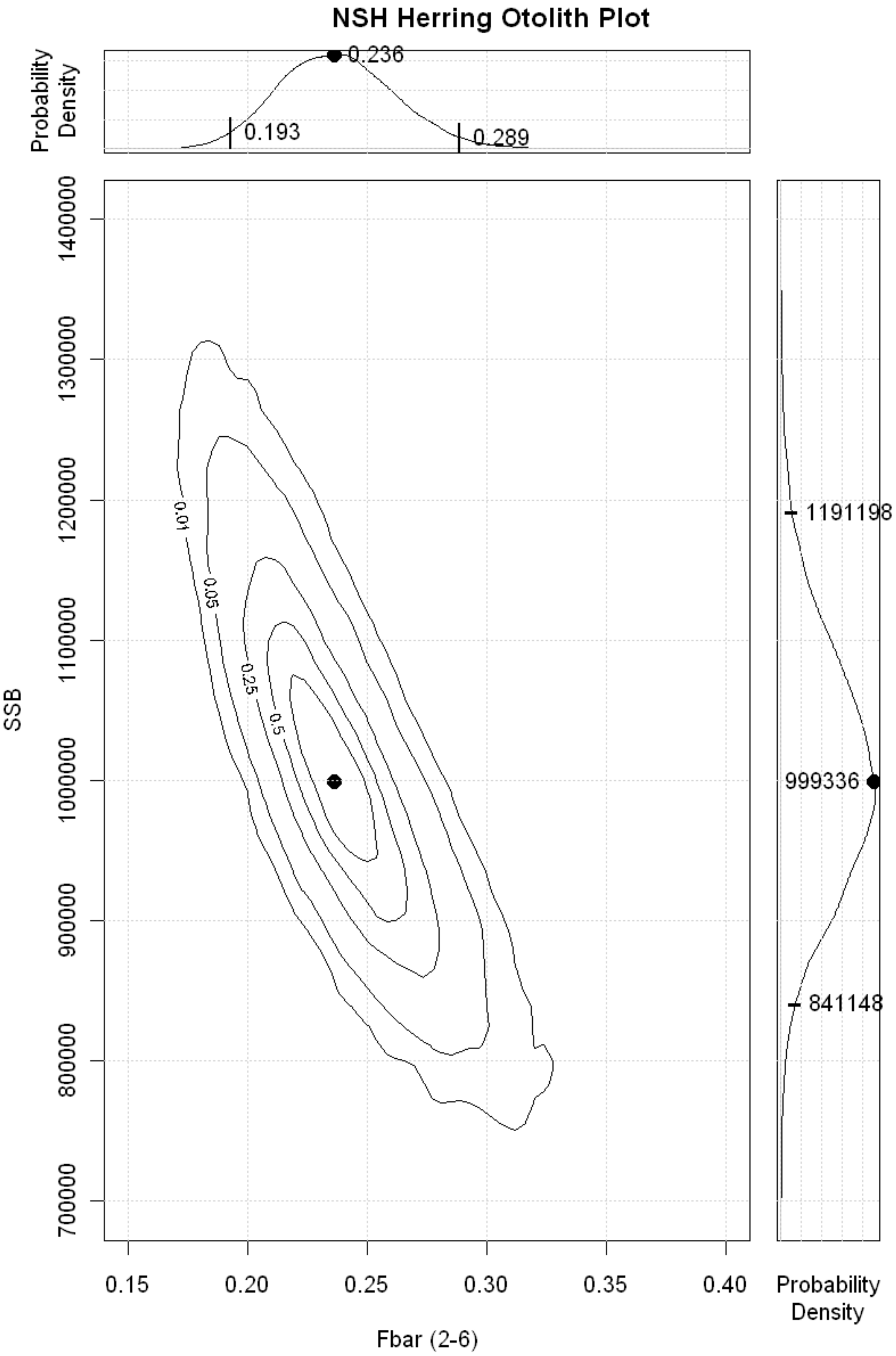


Figure 2.6.1.22 Model uncertainty; distribution and quantiles of estimated SSB and F2-6 in the terminal year of the assessment. Estimates of precision are based on a parametric bootstrap from the FLICA estimated variance/covariance estimates from the model.

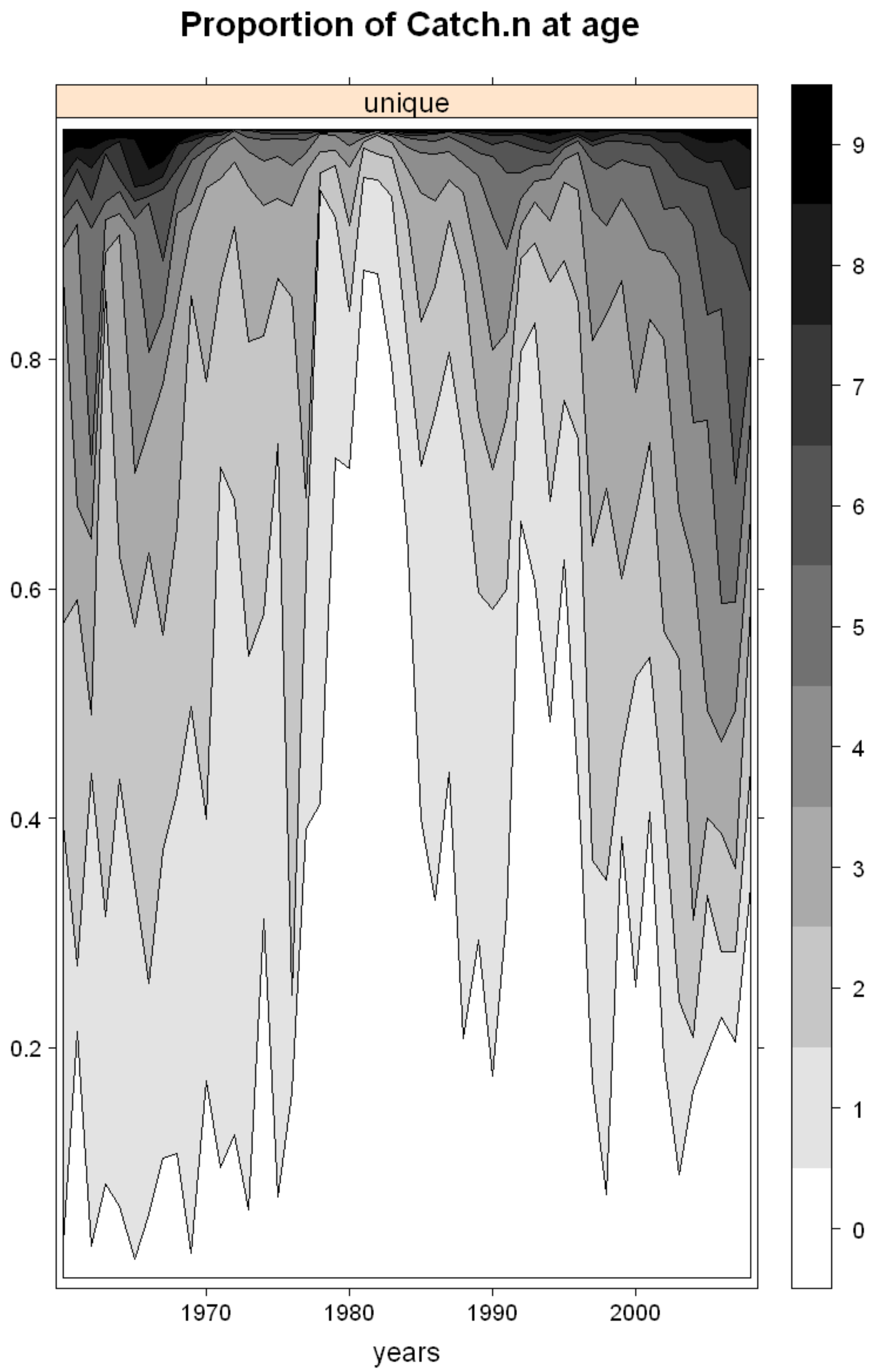


Figure 2.6.1.23 North Sea Herring. Proportion of catch numbers at age.

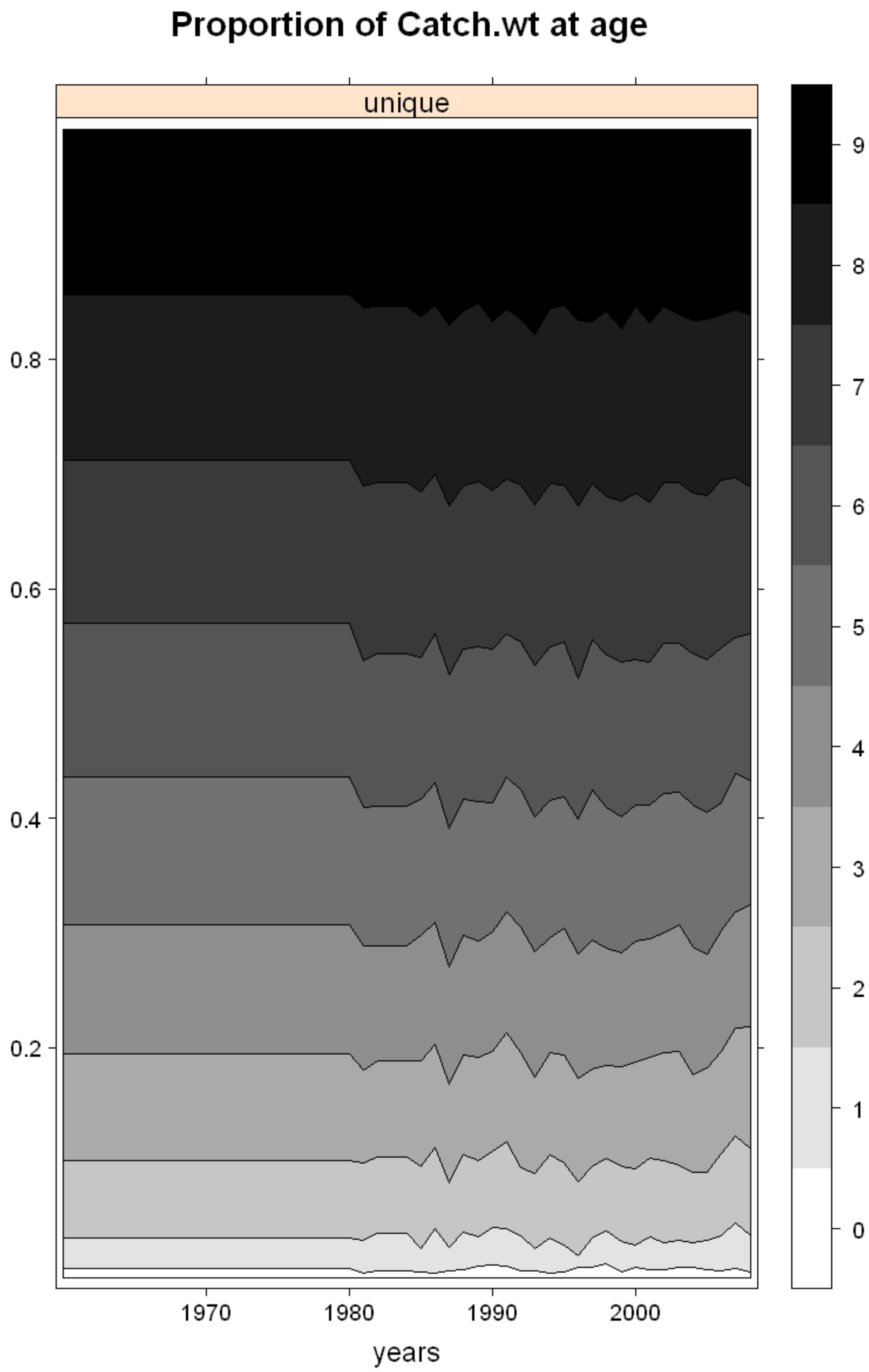


Figure 2.6.1.24 North Sea Herring. Proportion of catch weight at age.

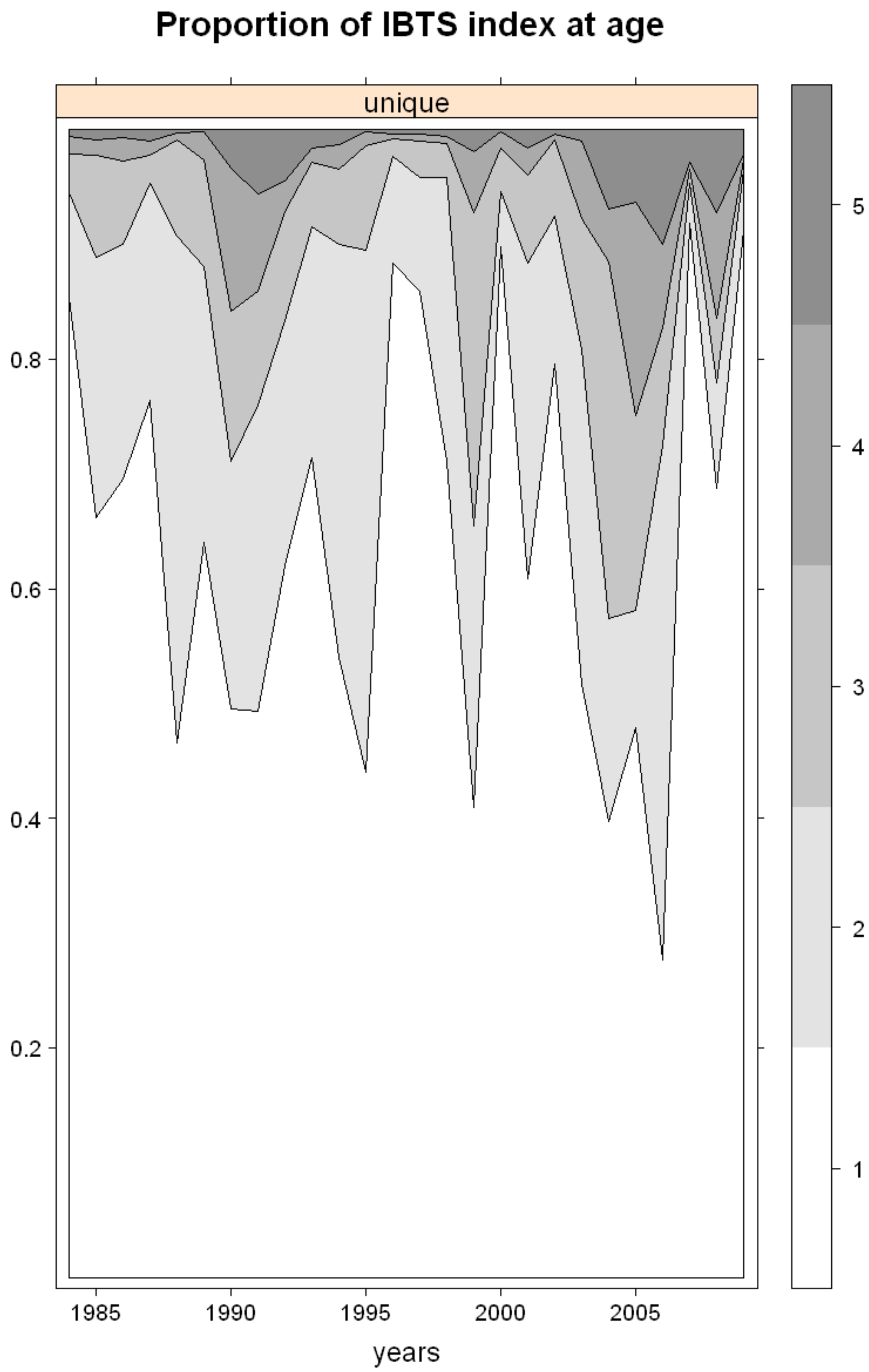


Figure 2.6.1.25 North Sea Herring. Proportion of IBTS index at age.

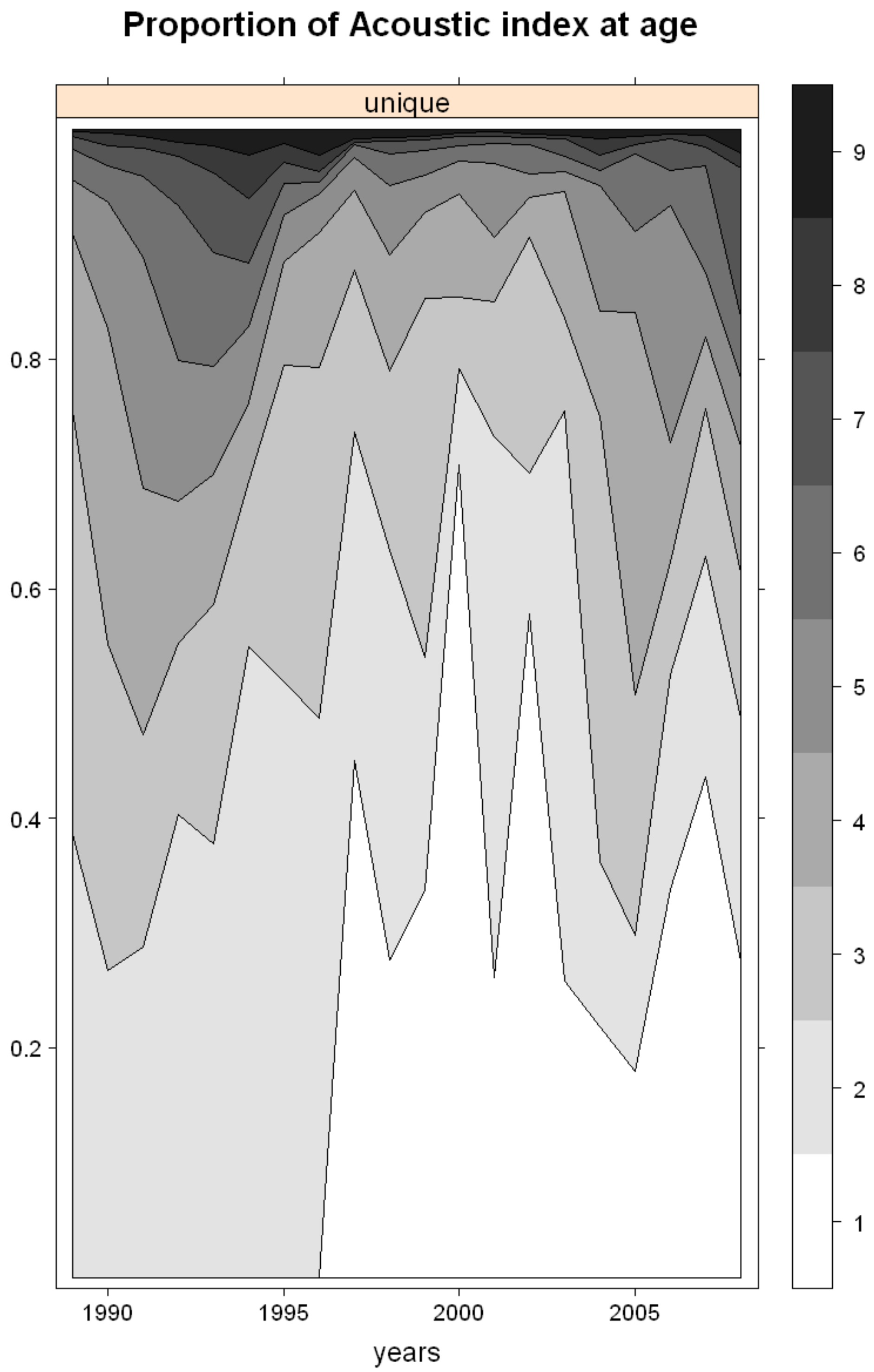


Figure 2.6.1.26 North Sea Herring. Proportion of Acoustic index at age.

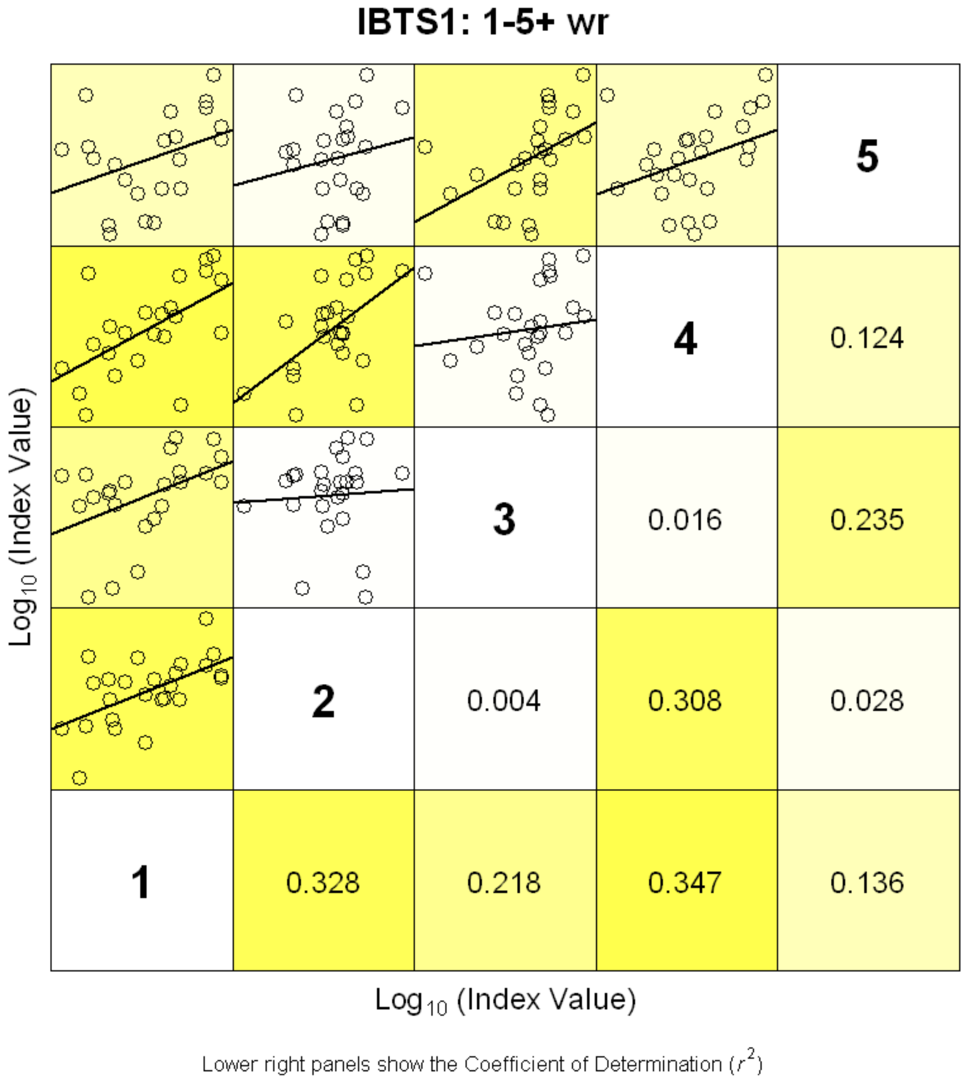


Figure 2.6.1.27 North Sea Herring. Correlation coefficient diagram for IBTS survey.

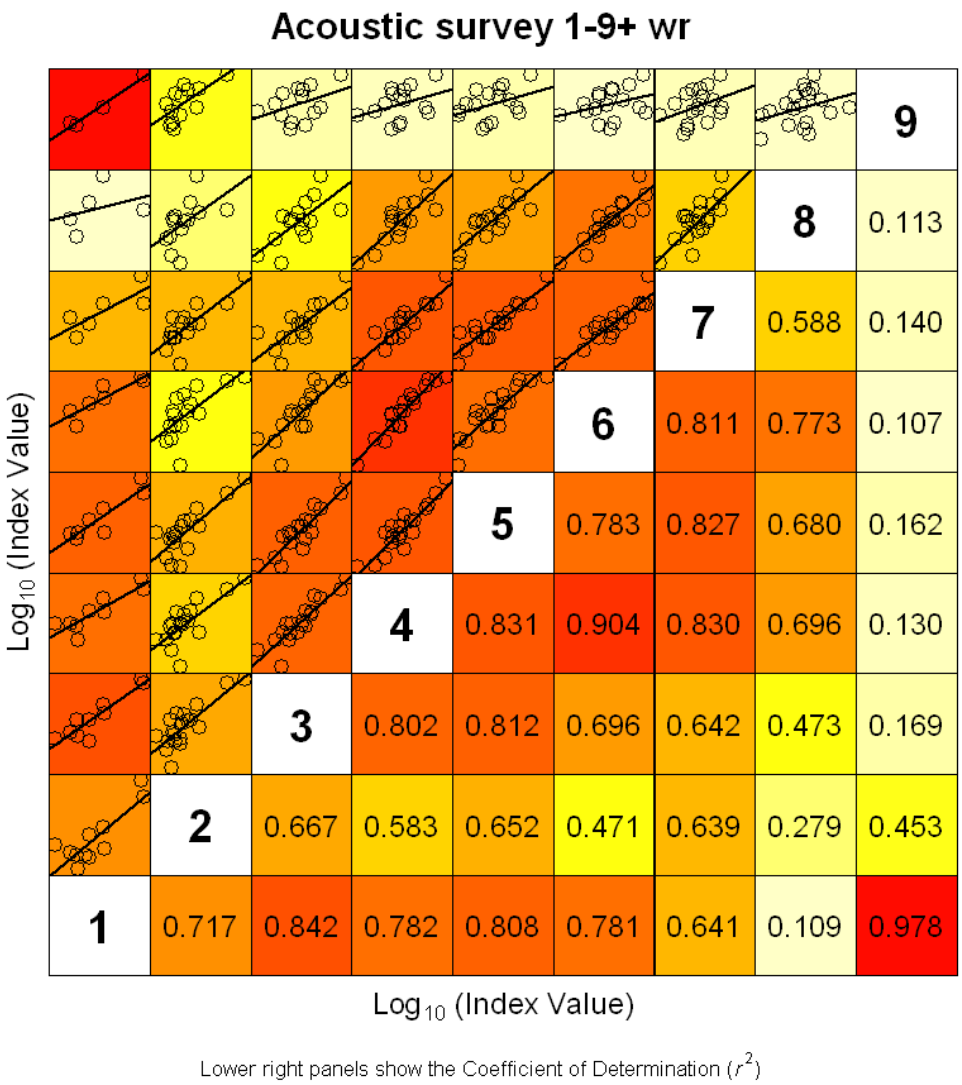


Figure 2.6.1.28 North Sea Herring. Correlation coefficient diagram for Acoustic survey.

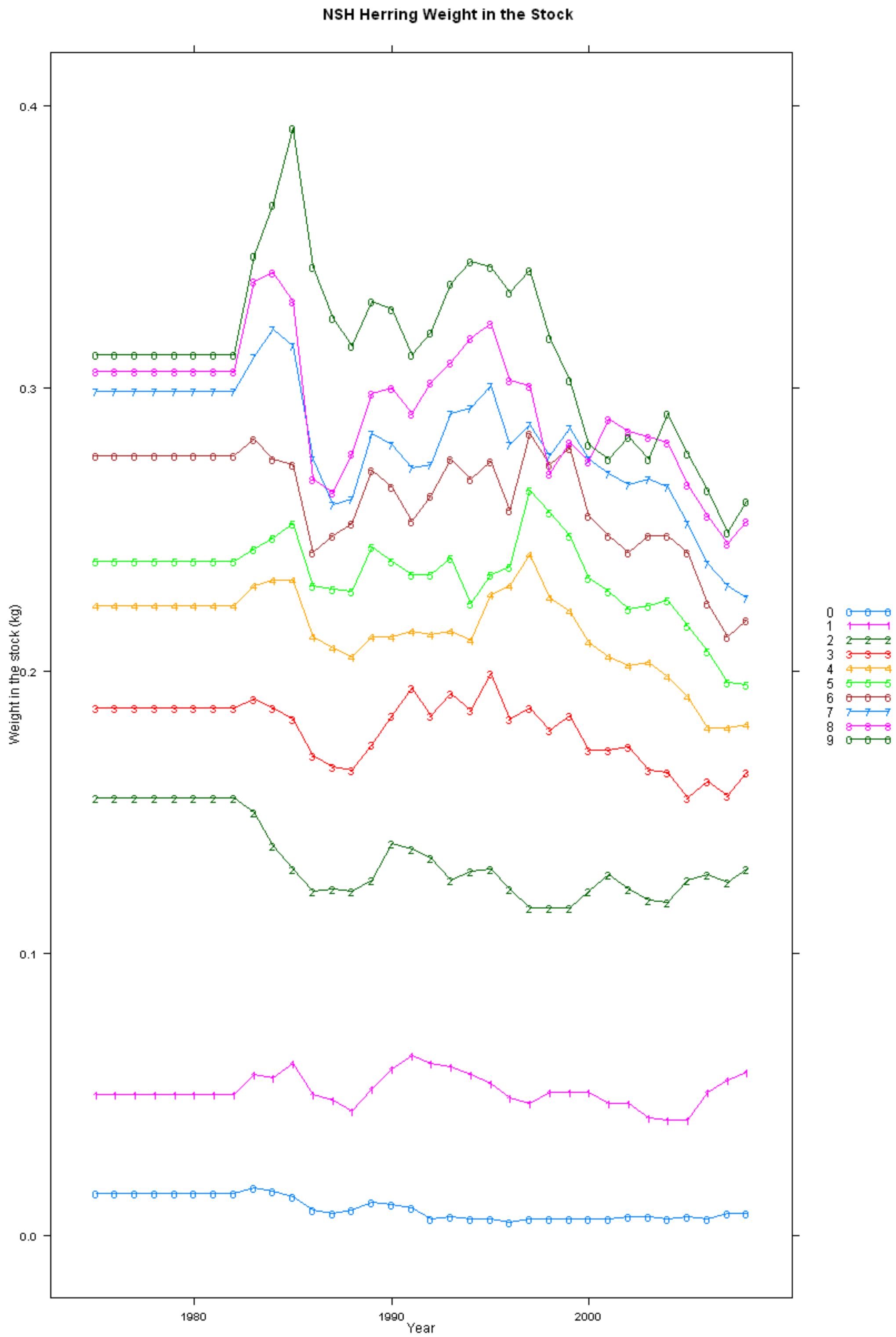


Figure 2.6.1.29 North Sea Herring. Weight at age in the stock over time.

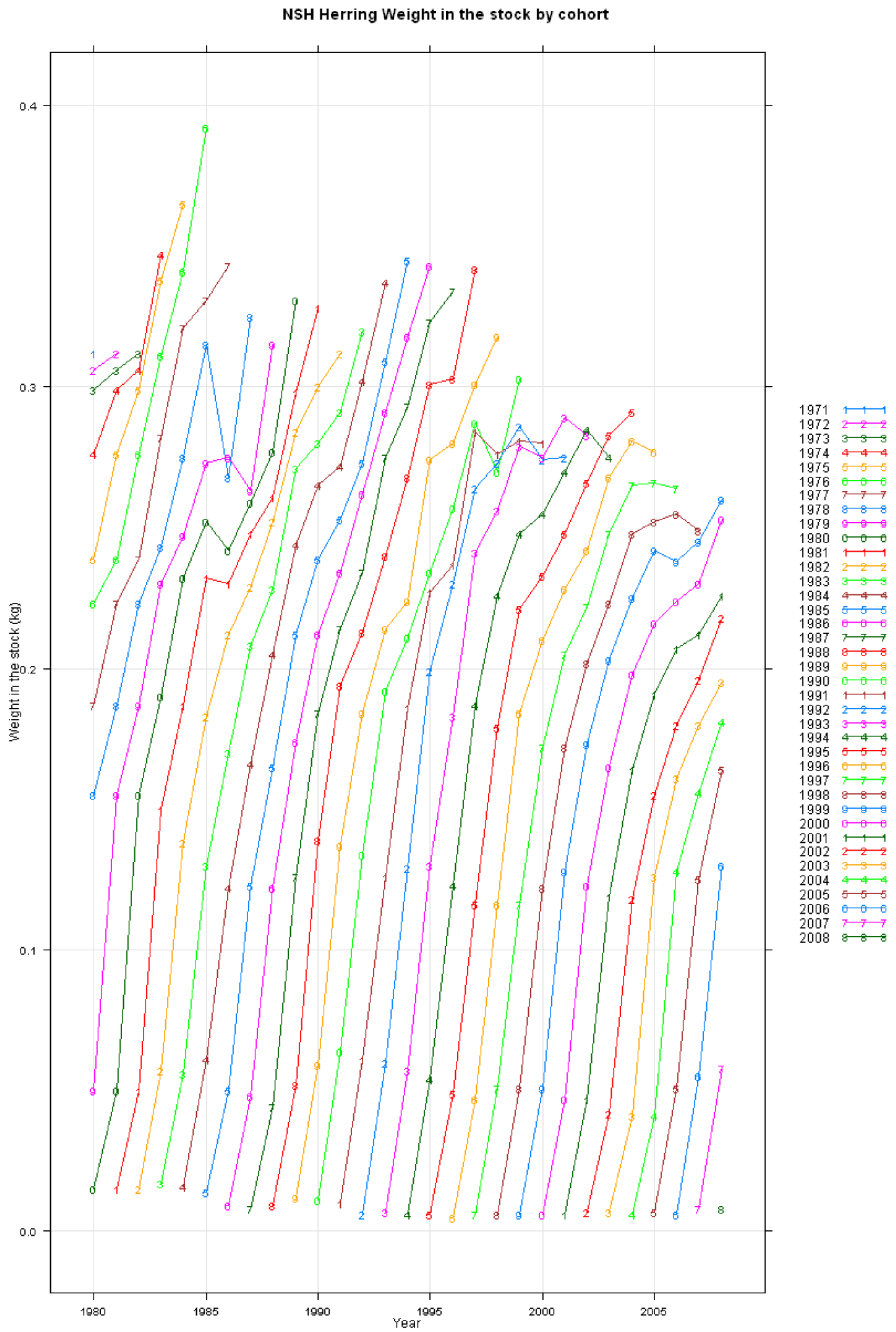


Figure 2.6.1.30 North Sea Herring. Weight at age in the cohort over time.

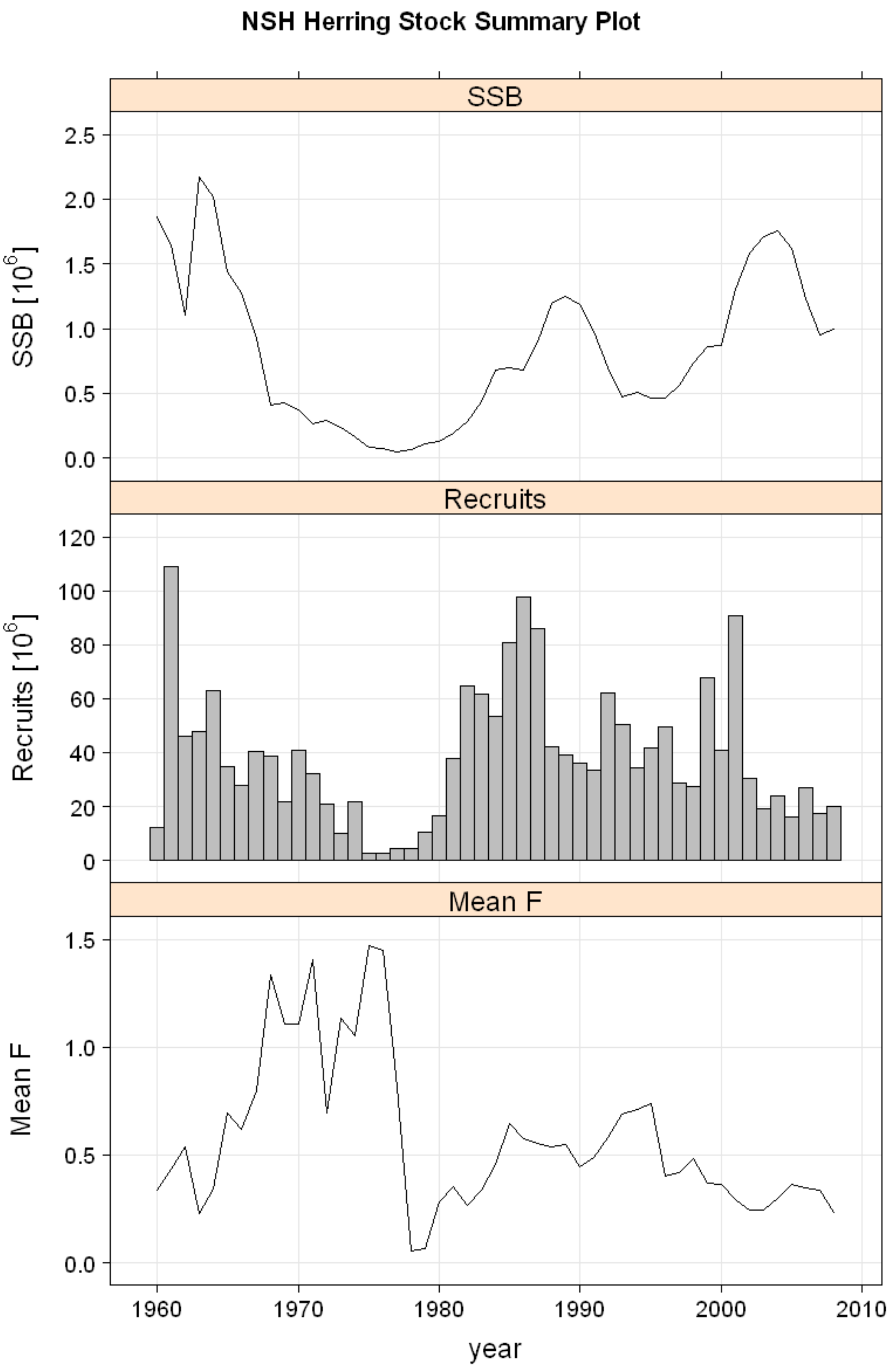


Figure 2.6.2.1. North Sea herring. Stock summary plot for SSB, recruitment and mean F on ages 2-6.

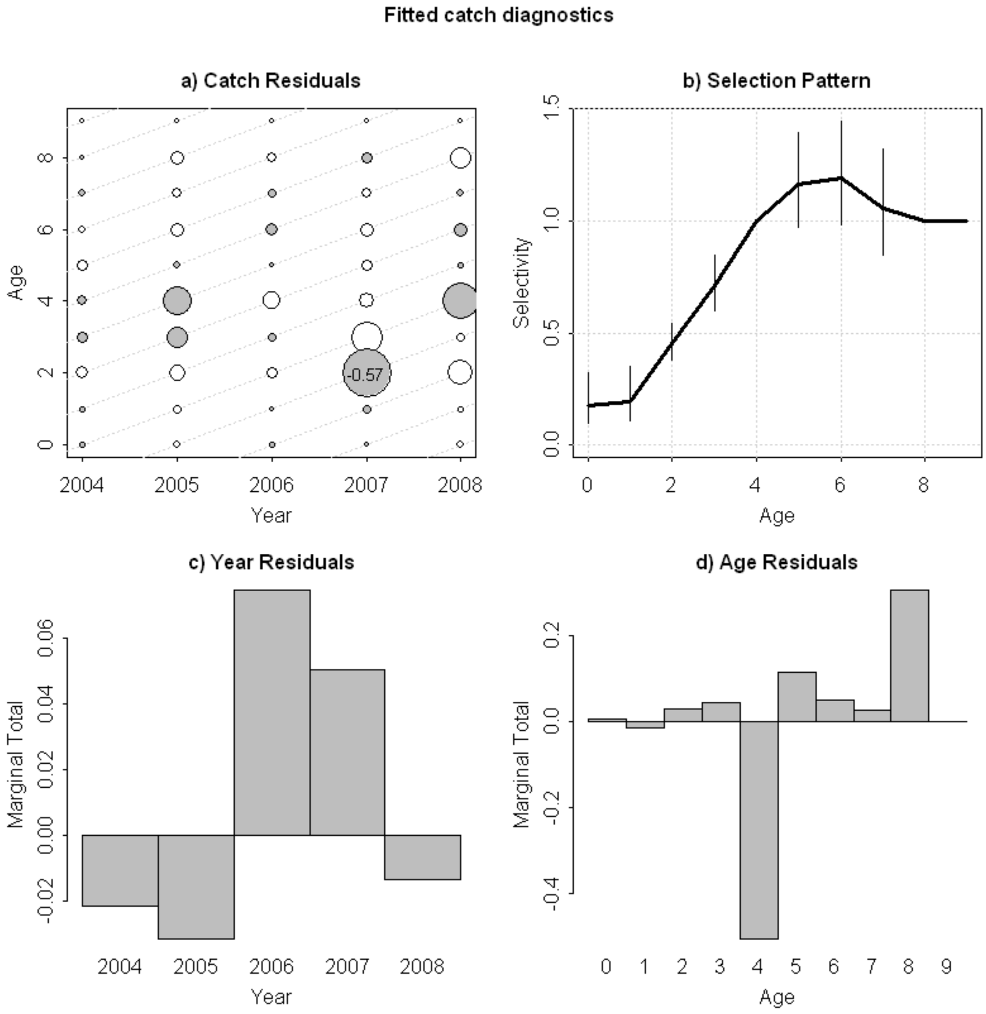


Figure 2.6.2.2. North Sea herring. Diagnostics of selection pattern from the final ICA assessment. Top left: bubbles plot of log catch residuals by age (weighting applied) and year (5 yr separable period). Top right: estimated selection parameters (relative to 4 wr) with 95% confidence intervals. Bottom left: marginal totals of log residuals by year. Bottom right: marginal totals of log residuals by age (wr).

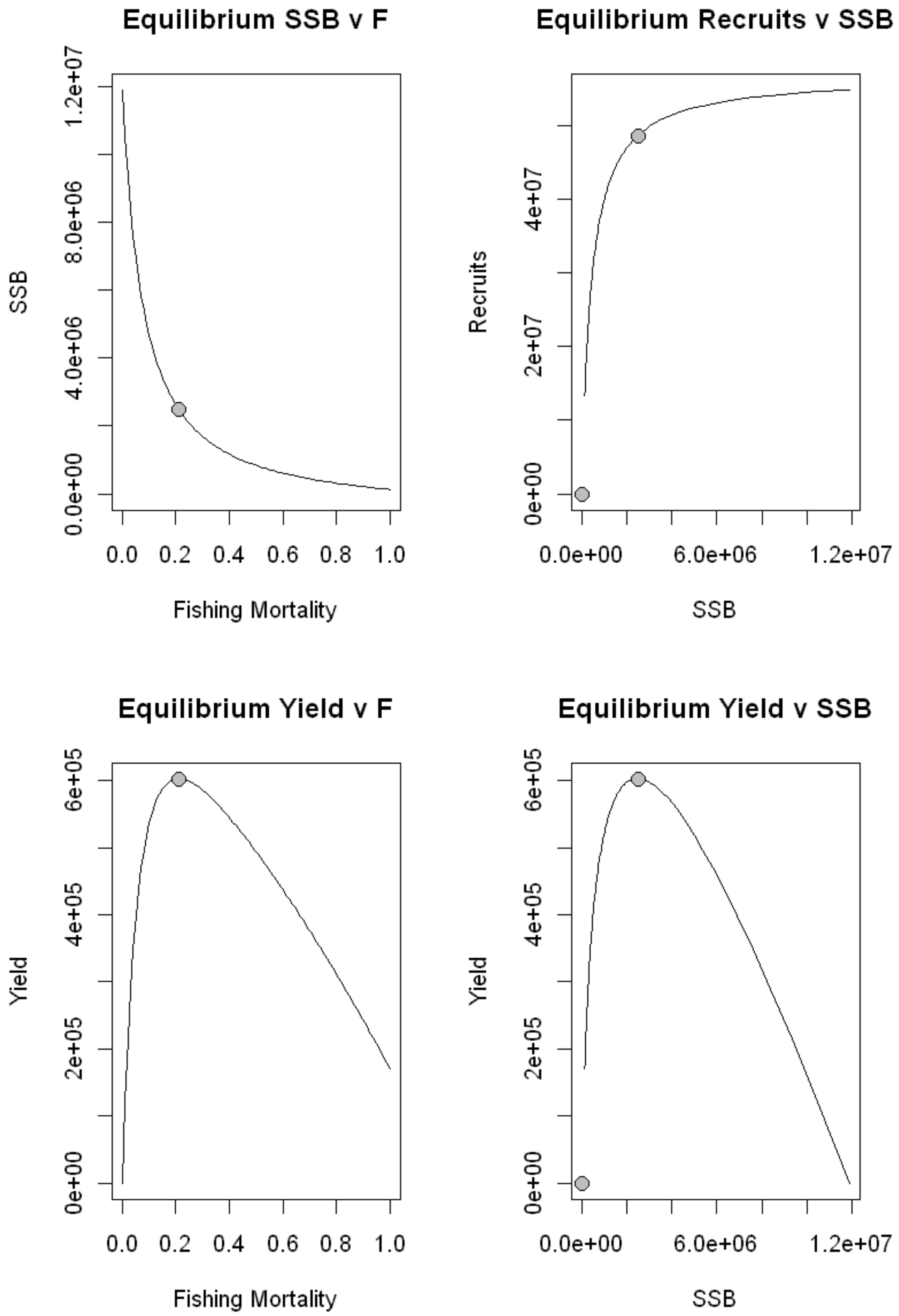


Figure 2.6.2.3 North Sea Herring. Reference diagrams including indication of reference points assuming a Beverton and Holt stock to recruit relationship. Upper left panel: Equilibrium SSB versus Fishing mortality (ages 2-6). Upper right panel: Recruit versus SSB relationship. Bottom right panel: Yield versus Fishing mortality (ages 2-6). Bottom right: Yield versus SSB. Grey points indicate B_{MSY} and F_{MSY}

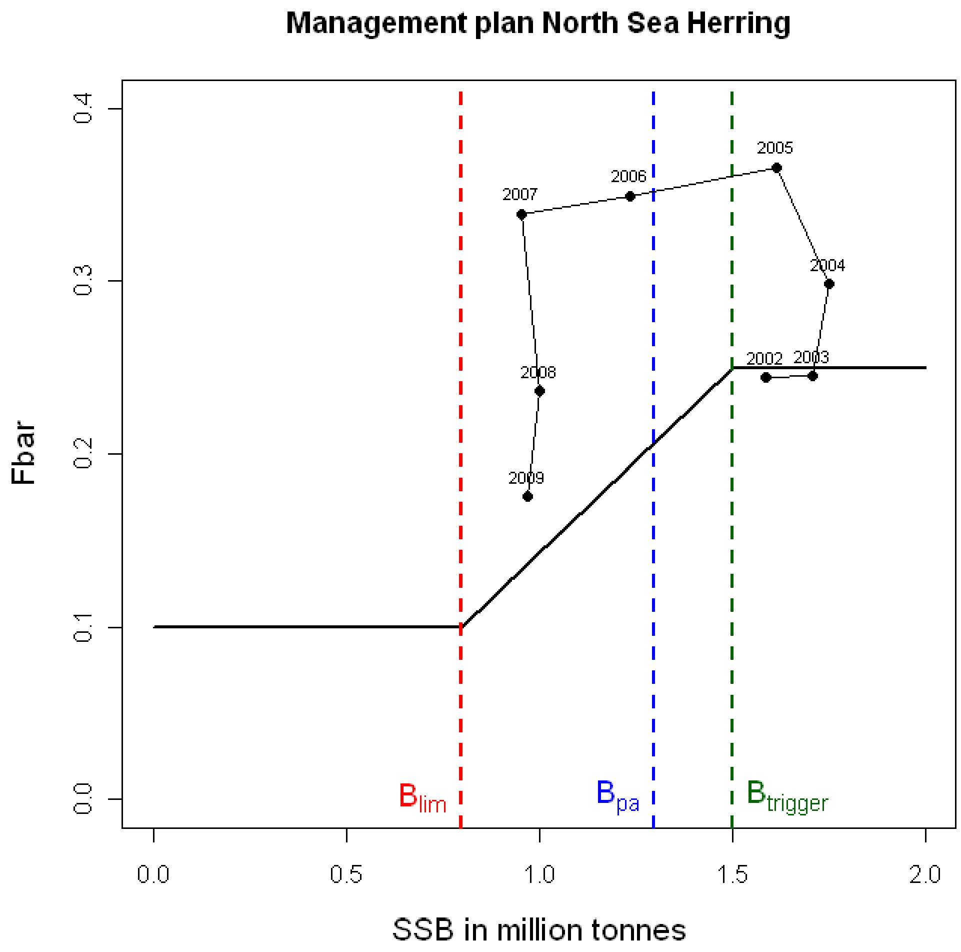


Figure 2.6.2.4. North Sea herring. Agreed management plan for adult fishery (A-fleet, ages 2-6) including trigger biomass points (B_{lim} and $B_{trigger}$) and B_{pa}. Black dots represent realised estimated fishing mortalities from 2002 untill 2008. Fishing mortality in 2009 is estimated based on the agreed TACS for the A-fleet from the short term prediction (see section 2.7).

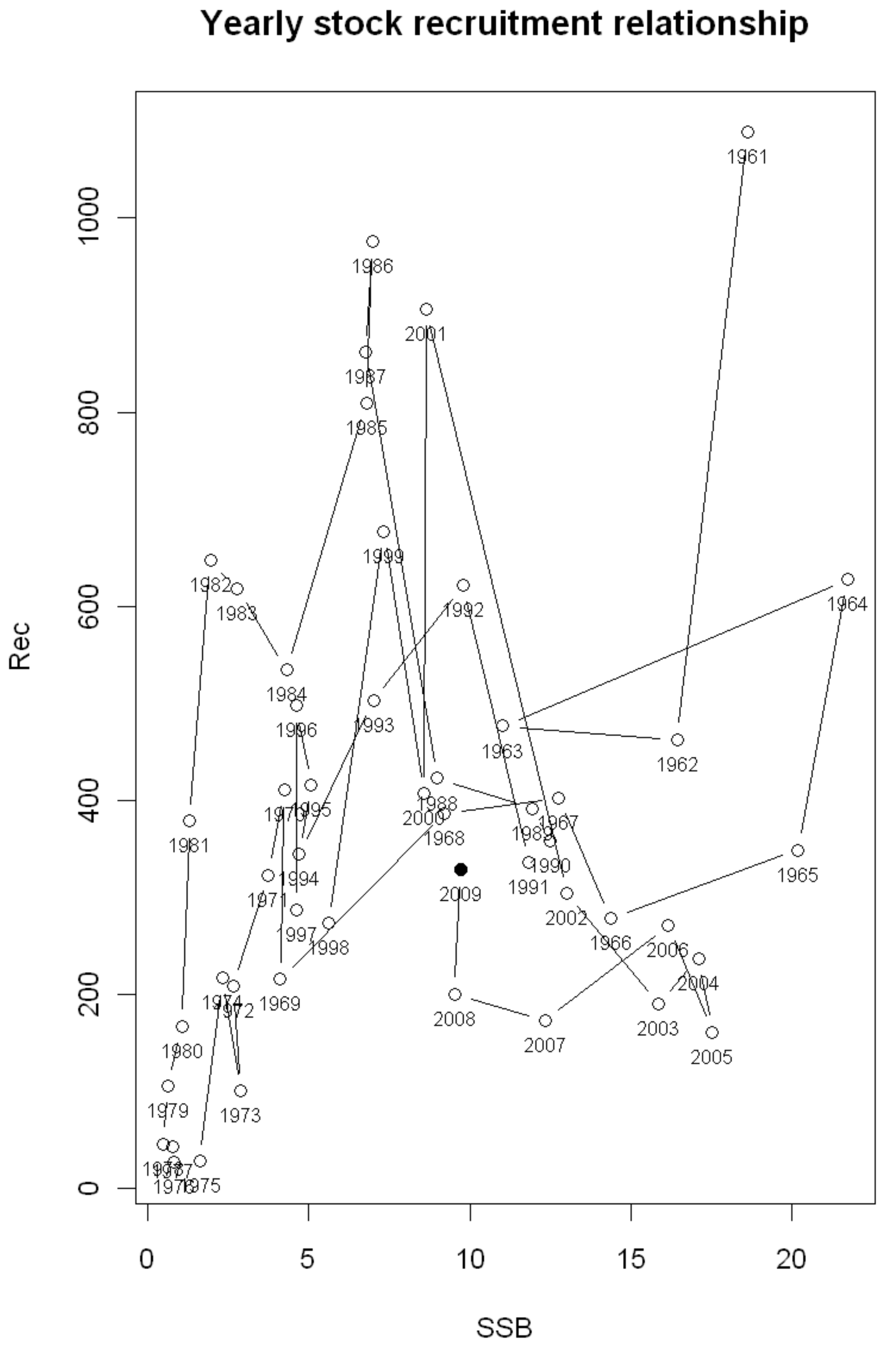


Figure 2.6.2.5. North Sea herring. Stock and recruit plot. Each point labelled by year class.

2.7 Short term predictions

Short term predictions for 2010 were done with the MFSP software, following the procedures in the stock annex 3. This assumes that recruitment will continue to be at the low level since 2002 (geometric mean of 2001 to 2007 year classes)

For the intermediate year, an overshoot of 13%, which is the average overshoot in 2006 – 2008 for the A fleet was assumed. For the B, C and D fleets the same fraction of the TAC as last year was assumed. See table 2.7.1 for other inputs.

The seven scenarios presented below are based on an interpretation of the harvest control rule or other options and are only illustrative:

a) No fishing;
b) The EU–Norway management plan;
c) A roll over TAC from 2009 to 2010 of 171 kt for the A fleet;
d) Catches that are estimated lead to SSB>Bpa in 2011;
e) A 15% decrease in A fleet in TAC between 2009 and 2010;
f) A 15% increase in A fleet in TAC between 2009 and 2010;
g) Option b but with larger catches of approximately 40% for the C and D fleet

Since the current management plan only stipulates overall fishing mortalities for juveniles and adults, making fleet-wise predictions for four fleets that are more or less independent provides different options for 2010. The consequence of other combinations of catch options can be explored on request.

For options b, c, e and f, the C and D fleets are assumed to have a catch for 2010 of 39800 tonnes, giving expected catches of 7.4 and 3.7 thousand tonnes respectively of North Sea autumn spawners. For option g the catches of the C and D fleet are assumed to be 56600 tonnes.

All predictions are for North Sea autumn spawning herring only. The results are presented in Table 2.7.2.

2.7.1 Comments on the short-term projections

HAWG assumed that recruitment was likely to remain poor in 2010. A slight decrease in SSB is expected from 2008 to 2009. The SSB is expected to increase slightly both in 2010 and further in 2011, indicating that the current management has the potential to reverse the decline in the stock and stabilize it above the present level. The SSB is not expected to reach Bpa in 2010 even without fishery, but it may reach Bpa in 2011 with a substantial reduction (well over 30%) in catches.

The estimated impact of the juvenile fishery depends on the assumed value for natural mortality. It has not been investigated to what extent changes in natural mortality would affect the current advice, or if indeed such changes are taking place. Some of the important predator stocks are currently in a poor condition.

The predictions this year are in line with those obtained last year. The predicted catch according to the harvest rule implies less reduction than 15%.

Table 2.7.1. North Sea autumn spawning herring. The input file used for the short term prediction of North Sea herring.

```
North sea herring 2009
2009
0 9
4
F ref. age for each fleet
1 2 6
2 0 1
3 0 1
4 0 1
Two age ranges for overall F
0 1
2 6
Init numbers by start of 2009
       0      32832.169
       1       7036.972
       2       2087.952
       3       2096.306
       4        800.885
       5        760.222
       6        373.845
       7        337.052
       8        663.945
       9        323.384
recruitments
21465
21465
Selection by age and fleet
                0            0.0039      0.0379      0.0003      0.0048
                1            0.0169      0.0151      0.0128      0.0059
                2            0.0929      0.0000      0.0180      0.0070
                3            0.1838      0.0000      0.0017      0.0002
                4            0.2610      0.0000      0.0003      0.0000
                5            0.3034      0.0000      0.0003      0.0000
                6            0.3111      0.0000      0.0001      0.0000
                7            0.2757      0.0000      0.0004      0.0000
                8            0.2611      0.0000      0.0002      0.0000
                9            0.2613      0.0000      0.0000      0.0000
Natmor at age
0 1.0
1 1.0
2 0.3
3 0.2
4 0.1
5 0.1
6 0.1
7 0.1
8 0.1
9 0.1
weca 2009
               0            0.0274      0.0090      0.0349      0.0164
               1            0.0904      0.0359      0.0698      0.0301
               2            0.1387      0.0000      0.0810      0.0709
               3            0.1589      0.0000      0.1131      0.1028
               4            0.1723      0.0000      0.1334      0.1336
               5            0.1861      0.0000      0.1680      0.1730
               6            0.2084      0.0000      0.1808      0.1831
               7            0.2255      0.0000      0.1969      0.1914
               8            0.2421      0.0000      0.1830      0.1943
               9            0.2624      0.0000      0.0000      0.0000
weca 2010
               0            0.0274      0.0090      0.0349      0.0164
               1            0.0904      0.0359      0.0698      0.0301
               2            0.1387      0.0000      0.0810      0.0709
               3            0.1589      0.0000      0.1131      0.1028
               4            0.1723      0.0000      0.1334      0.1336
               5            0.1861      0.0000      0.1680      0.1730
               6            0.2084      0.0000      0.1808      0.1831
               7            0.2255      0.0000      0.1969      0.1914
               8            0.2421      0.0000      0.1830      0.1943
               9            0.2624      0.0000      0.0000      0.0000
```

```
west  2009
              0            0.008
              1            0.058
              2            0.130
              3            0.164
              4            0.181
              5            0.195
              6            0.218
              7            0.226
              8            0.253
              9            0.260
west  2010
              0            0.008
              1            0.058
              2            0.130
              3            0.164
              4            0.181
              5            0.195
              6            0.218
              7            0.226
              8            0.253
              9            0.260
west  2011
              0            0.008
              1            0.058
              2            0.130
              3            0.164
              4            0.181
              5            0.195
              6            0.218
              7            0.226
              8            0.253
              9            0.260
maturity 2009
             0              0.00
             1              0.00
             2              0.74
             3              0.93
             4              0.97
             5              1.00
             6              1.00
             7              1.00
             8              1.00
             9              1.00
maturity 2010
             0              0.00
             1              0.00
             2              0.74
             3              0.93
             4              0.97
             5              1.00
             6              1.00
             7              1.00
             8              1.00
             9              1.00
maturity 2011
             0              0.00
             1              0.00
             2              0.74
             3              0.93
             4              0.97
             5              1.00
             6              1.00
             7              1.00
             8              1.00
             9              1.00
Proportion of F and M before spawning
0.67 0.67
```

Table 2.7.2. North Sea autumn spawning herring. Management options for North Sea herring.

Outlook assuming a TAC constraint for fleet A in 2009

Basis: Intermediate year (2009) with catch constraint

F fleet A	F fleet B	F fleet C	F fleet D	F_{0-1}	F_{2-6}	Catch fleet A	Catch fleet B	Catch Fleet C	Catch fleet D	SSB 2009
0.184	0.021	0.006	0.004	0.04	0.189	194.2	7.4	6.5	2.7	971

Scenarios for prediction year (2010)

	F-values by fleet and total						Catches by fleet				results			
	F FLEET A	F FLEET B	F FLEET C	F FLEET D	F_{0-1}	F_{2-6}	CATCH FLEET A	CATCH FLEET B	CATCH FLEET C	CATCH FLEET D	**SSB 2010[1)]**	**SSB 2011**	**%SSB change [2)]**	**%TAC change fleet A [3)]**
a	0	0	0	0	0	0	0	0	0	0	1133	1497	17%	-100%
b	0.144	0.033	0.005	0.006	0.050	0.148	164.3	10.4	7.4	3.7	1027	1209	6%	-4%
c	0.150	0.033	0.005	0.006	0.050	0.155	171.0	10.4	7.4	3.7	1023	1198	6%	0%
d	0.094	0.022	0.003	0.004	0.033	0.097	110.2	7.0	5.0	2.5	1063	1300	9%	-36%
e	0.126	0.033	0.005	0.006	0.049	0.131	145.4	10.4	7.4	3.7	1040	1238	7%	-15%
f	0.174	0.033	0.005	0.006	0.051	0.179	196.7	10.4	7.4	3.7	1007	1160	4%	15%
g	0.144	0.028	0.007	0.008	0.050	0.149	162.6	9.0	10.5	5.3	1027	1206	6%	-5%

Weights in ‘000 t.

Shaded areas are considered not in accordance with the precautionary approach.

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 (2010) relative to SSB (2009).

3) Calculated landings (2009) relative to TAC 2008.

2.8 Medium term predictions and HCR simulations

The ICES workshop on herring management plans (WKHMP, ICES CM 2008 (ACOM:27)) met in February 2008 and carried out extensive investigation of the medium term scenarios for North Sea herring (see section 1.3), this lead to an adjustment of the management plan in November 2008. Further analysis was thus not carried out by HAWG.

2.9 Precautionary and Limit Reference Points

The precautionary reference points for this stock were adopted in 1998. The situation has now arisen that North Sea herring is nominally being managed by a precautionary management plan, although the SSB is now below the precautionary biomass reference point. We consider that the critical issue is identifying the risk of SSB falling below Blim. The following section is adapted from ICES WKHMP (ICES CM 2008 (ACOM:27)) and explores and discusses the issues about precautionary status of the management of North Sea herring.

The Blim

The 1998 Study Group on Precautionary Approach to Fisheries Management (ICES CM 1998/ACFM:10.) determined reference points for North Sea herring that were adopted by ICES (ICES CM 1998/ACFM:10.). The Blim (800 000 tonnes) was set at a level below which the recruitment may become impaired and was also the formally used MBAL. In 2007, WKREF (ICES CM 2007/ACFM:05) explored limit reference points for North Sea herring and concluded that there is no basis for changing Blim. A low risk of SSB falling below Blim is therefore the basis of ICES precautionary advice.

Fpa and Bpa

The target and trigger points used in the management plan (which began in 1997) were recommended by the Study Group on Precautionary Approach to Fisheries Management and adopted by ICES as the precautionary reference points. This means that the precautionary reference points were taken from the already existing management plan. In the management plan, the target fishing mortalities were intended as targets and not as bounds. The higher inflection point (B trigger) in the earlier rule (1.3 million tonnes) was derived largely as a compromise, allowing higher exploitation at higher biomass but reflecting an ambition to maintain the stock at a high level, by reducing the fishing mortality at an early stage of decline. This trigger was changed in November 2008 to 1.5 million tonnes after WKHMP and consultation with the stakeholders. Thus currently the trigger and Bpa are different at 1.5 million tonnes and 1.3 million tonnes respectively.

Concept of a management plan (harvest control rule)

In a harvest control rule, parameters (trigger and targets) serve as guidance to actions according to the state of the stock (ICES Study Group on the Precautionary Approach, ICES CM 2002/ACFM:10). These should be chosen according to management objectives, one of which should be to have a low risk of bringing the SSB to unacceptably low levels. In the evaluation of a harvest rule, one will use simulations with a 'virtual stock' which as far as possible resembles the stock in question, and the risk is evaluated as the probability of the virtual SSB being below the Blim value. Within the constraints needed to keep the risk to Blim low, parameters of the rule will be chosen to serve other management objectives, e.g. to ensure a high long term yield and stable catches over time. Such a management plan would be classed by ICES as precautionary provided the risk of SSB being below Blim is sufficiently low. This conforms to the recommendations of WKOMSE (ICES 2009).

Concept of precautionary reference points

Conceptually, precautionary reference points (Bpa) are different from parameters in a harvest control rule. In the precautionary approach, as interpreted by ICES, the function of the reference points is to ensure that the SSB is above the range where recruitment may be impaired or the stock dynamics is unknown. The real limit is represented by Blim, while the Bpa takes assessment uncertainty into account, so that if SSB is estimated at Bpa, the probability that it is below Blim shall be small. The Flim is the fishing mortality that corresponds to Blim in a deterministic equilibrium. The Fpa is related to Flim the same way as Bpa is related to Blim (ICES Study Group on the Precautionary Approach 2002b). In the advisory practice, Fpa has been the basis for the advice unless the SSB has been below Bpa, where a reduction in F has been advised. Furthermore, Fpa and Bpa are currently used to classify the state of stock and rate of exploitation relative to precautionary limits. Precautionary reference points are used by ICES to provide advice and classify the state of the stock in the absence of other information, such as extensive evaluations of management plans.

Conclusion

ICES will accept that a harvest control rule is in accordance with the precautionary approach as long as it implies a low risk to being below Blim, even if other reference points may be exceeded occasionally. When a rule is regarded as precautionary, ICES gives its advice according to the rule. If the rule is followed, then ICES classifies exploitation as precautionary. Within this framework, other precautionary reference points generally will be redundant. However, the precautionary reference points may also be used to classify the stock with respect to precautionary limits, which may lead to a conflicting classification. This discrepancy is still unresolved. For North Sea herring in the present situation, with a reduced recruitment, the SSB may be expected to be below 1.3 million tonnes most of the time. The management plan will reduce fishing mortality accordingly. Following the acceptance by ICES that the management plan is precautionary (and the findings of WKHMP), **HAWG considers that the parameters of the management plan should take primacy over the management against precautionary reference points Fpa or Bpa**.

2.10 Quality of the Assessment

2.10.1 Precision of the estimates

The precision of the assessment derived from the FLICA model is based on a parametric variance covariance bootstrap of the parameters that influence the estimates of terminal F and SSB. The estimated precision expressed as a percentile contour plot is shown in Figure 2.6.1.22. The 95% intervals are given for F and SSB in combination and separately.

2.10.2 Comparison with earlier assessments

The historical evaluation of the NS herring assessment from 1990 to 2008 Simmonds (2009) supports the contention of a precise assessment, particularly in its current configuration since 2002. This years diagnostics continue to support that view. An eight year analytic retrospective (Figure 2.6.1.20) shows the current consistency of the assessment. The data from the stock summary table is compared with the stock summary from the 2008 assessment and the first year (intermediate year) of the 2008 short term prediction. With the exception of the estimate of recruitment age 0 in 2008 the 2009 assessment is in good agreement with the assessment carried out last year, see text table below.

	2008 ASSESSMENT				2009 ASSESSMENT				PERCENTAGE CHANGE IN ESTIMATE 2008-2009			
Year	Rec	SSB	Catch	$F_{2\text{-}6}$	Rec	SSB	Catch	$F_{2\text{-}6}$	Rec	SSB	Catch	$F_{2\text{-}6}$
2006	25024	1252	NA	0.35	27695	1234	NA	0.35	11%	-1%	NA	0%
2007	20853	977	NA	0.33	19044	953	NA	0.34	-9%	-2%	NA	3%
2008	9223	978	240	0.21	22909	1000	258	0.24	148%	2%	8%	14%

*** projected values from the intermediate year in the deterministic short term projection, assuming catch constraint with small overshoot. (Recruits are defined as age 0)**

The revision on F and SSB are all small. The revision of recruitment at +148% is more important. In 2008 the recruitment (age 0) was only estimated by one survey (MIK), this year (in 2009) that cohort has additional estimates from 1 year of catch and the IBTS survey. To try to address this issue adapted time-series of MIK 0wr and IBTS 1wr have been calculated to take into account more biological realism (Table 2.3.3.2). These account for the presence of the Downs herring in the MIK survey and the presence of some 1wr WBSS herring in the IBTS in the Kattegat. Fitting these adapted indices in ICA assessment very slightly improves the fit in the model. The changes are mostly coming from the fit to the IBTS 1wr, where 19 of the 26 residuals are reduced in magnitude. In contrast although the MIK fits better overall, there are increases and decreases in the magnitude of residuals in almost equal numbers of years. The initial indications are that SSB would be estimated as 3% lower and F 3% higher in 2008. These adapted series need more exploration before they can be used in an assessment, but they do not indicate substantive revision to terminal values.

The cohort retrospective evaluations suggest the WG is providing a very consistent evaluation of most year classes (Figure 2.6.1.21). The exceptions are the 2001, 2004 and 2006 year classes which are more variable in the first two years of observations. In particular the large 2000 year class has been estimated consistently since it was first seen in 2001.

The both assessment and projections currently appear to be a good basis for management advice.

2.11 Herring in Division IVc and VIId (Downs Herring).

Over many years the working group has attempted to assess the contribution of winter spawning Downs herring to the overall population of North Sea herring. Since 1985, there is a separate TAC for herring in Divisions IVc and VIId as part of the total North Sea TAC.

Historically, the TAC for herring in IVc and VIId has been set as a proportion of the total North Sea TAC and this has varied between 6 and 16% since 1986. The proportion has been relatively high, particularly between 2002 and 2005. However, ICES in 2005 expressed concerns regarding Downs herring and recommended that the proportion used to determine the TAC should be set to the long term average of the proportions used since 1986 (11%). In accordance with ICES advice the sub-TAC was cut by 33% in 2006 and the proportion was kept to 11% of the human consumption TAC in 2007. For 2008, it was set at 26 771 tonnes and at 23 567 tonnes for 2009, which represents respectively 13% and 14% of the total human consumption TAC for Divisions IV and VIId (Figure 2.11.1).

ICES has in the past expressed concern that there is a persistent tendency to overfish the Downs TAC. However, this tendency has been markedly reduced in recent years, mainly for the two last years (Figure 2.11.2). Landings in 2008 amounted to 29 600 tonnes (39 000 tonnes in 2007).

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

Downs herring is also taken in other herring fisheries in the North Sea. Downs herring mixes with other components of North Sea herring in the summer whilst feeding. Analysis of Dutch catches from this summer fishery, suggests that in recent years equal proportions of autumn and winter (Downs) herring were caught (Figure 2.11.3, see WD 10 for methods). There is also a summer industrial fishery in the eastern North Sea exploiting Downs and North Sea autumn spawning herring juveniles. Tagging experiments in the Eastern North Sea (Aasen *et al*, 1962) estimated that around 15% of those catches comprised Downs recruits. Otolith microstructure studies of catches from the northern North Sea suggested that the proportion of Downs herring may vary considerably from year to year (26 to 60 %) and may also vary between fleets.

The proportion of the autumn and winter spawning components in recruiting year classes of North Sea herring has been traditionally monitored through the abundance of different sized fish in the IBTS. The 1-ring fish from Downs spawning sites (winter) are thought to be smaller (<13 cm) than those from the more northern, autumn spawning sites (>13 cm). Both the total abundance and the proportion of Downs herring have, on average, been comparatively higher since the early 1990s, although there is considerable variation between year classes (Table 2.3.3.3 and Figure 2.11.4). These size data suggest that around 35% of the strong 2000 year class came from Downs production and approximately 70% of the 2002 year class (Figure 2.11.4). This is support by the analysis of the summer catches (WD10). For the 2007 year class, the percentage of 27% corresponds to the mean value of the time serie. However the number of small herrings shows signs of increasing since 2004 (Figure 2.11.5).

Using a ten layered finite-volume advection-dispersion model with real time meteorological and freshwater runoff drivers, the interannual variability in transport of Downs herring larvae transport, appears to be linked to recruitment variability (Dickey-Collas et al., WD4.) as shown. Almost all Downs herring larvae move east after hatching and simulations suggest that meteorologically forced transport will deliver the Downs herring larvae to the nursery grounds in the south-eastern North Sea. However it is not the delivery of the larvae that appears to be positively related to year class strength but rather the retention.

As mentioned on section 2.3.3.1 the MIK hauls for 0-ringers in this area also include Downs herring larvae. However, at the time of the IBTS survey these larvae are relatively small compared to herring larvae from other stocks. Accordingly their accumulated mortality to recruitment will be relatively higher compared to the larvae from the other stocks. Therefore the small larvae (<20 mm) have until now been excluded from the standard estimation of 0-ringer recruitment. During the present meeting of the WG, trials have been made to investigate the possibilities and consequences of including these in recruitment estimation for the North Sea herring stock. This is further described in section 2.10.2.

In 2007, the extension of the IBTS 1st quarter survey area in the Eastern English Channel was implemented in the survey design: additional GOV hauls and MIK stations carried out in this area have provided more information on Downs herring. (ICES CM 2007/ACFM:11). This sampling continued in 2008 and 2009.

Acoustic data recorded at the same time (January 2009) and in the same way as previous years showed that important herring schools were still along the French coast at this time of the years. The catch composition of the pelagic hauls consisted of herring smaller than previous years of 23 cm mean length fish (27.5 cm in 2008) belonging to age-groups 2-3. (Figure 2.11.6). Large and continuous shoals of herring were found at the survey time in a localised area, which the mean density could be estimated around 1 500 tonnes per nautical mile square but it could not be raised to the whole area due to the spatial heterogeneity and the sampling protocol used.

In conclusion, the TAC is specific to the conservation of the spawning aggregation of Downs herring. In the absence of other information there are uncertainties in the recruitment to the component in the next few years and HAWG recommends that the IVc-VIId TAC should be maintained at 11% of the total North Sea TAC (as recommended by ICES). This recommendation should be seen as an interim measure prior to the development of a more robust harvest control rule for setting the TAC of Downs herring, supported by increased research effort into the dynamics of this component in fisheries in the central and northern North Sea. Any new approach should provide an appropriate balance of F across stock components and be similarly conservative until the uncertainty in the Downs contribution to the catch in all fisheries in the North Sea is reduced. Methods illustrated by Kell *et al*. (2009) may be appropriate.

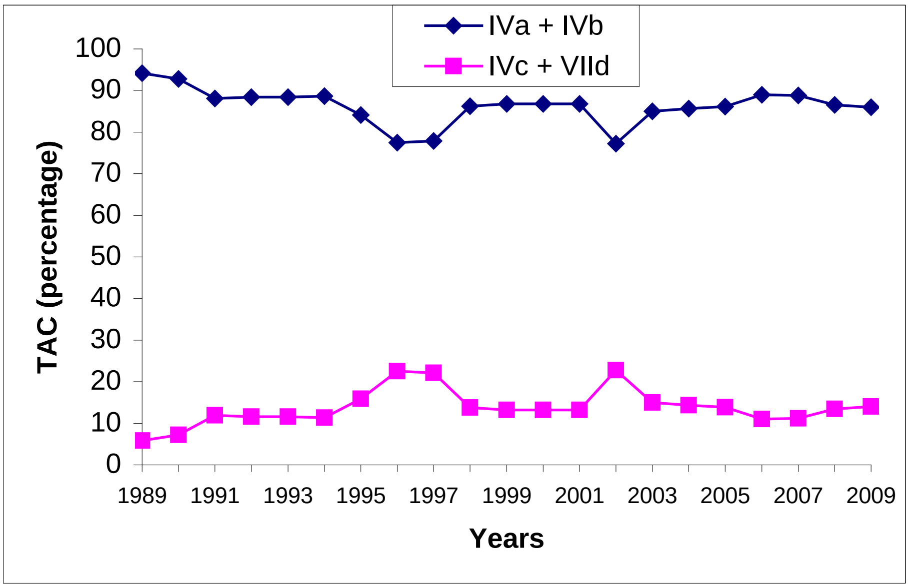


Figure 2.11.1. North Sea herring. Comparison of TACs for total North Sea and IVc and VIId

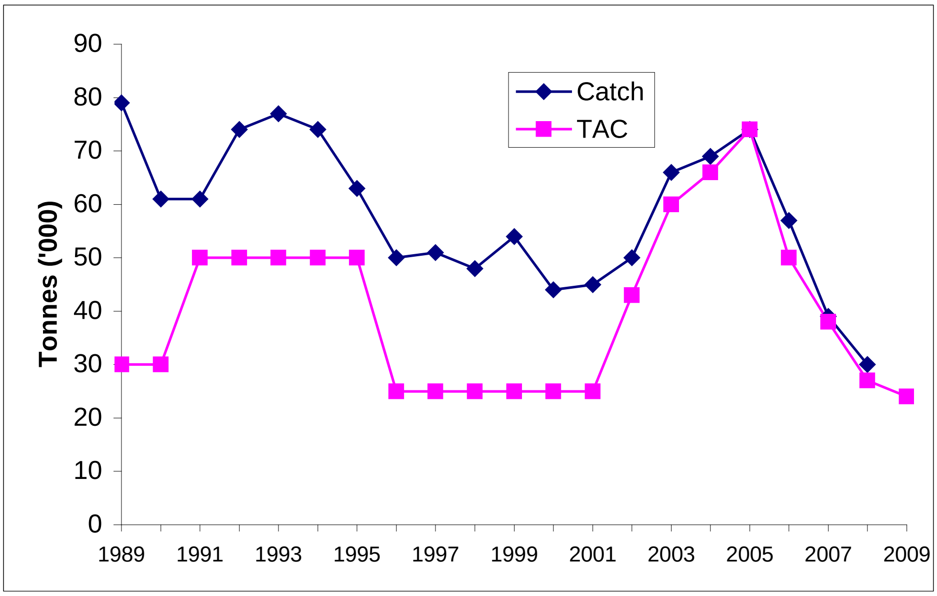


Figure 2.11.2. Downs herring in IVc and VIId. Comparison of historical catches and TACs

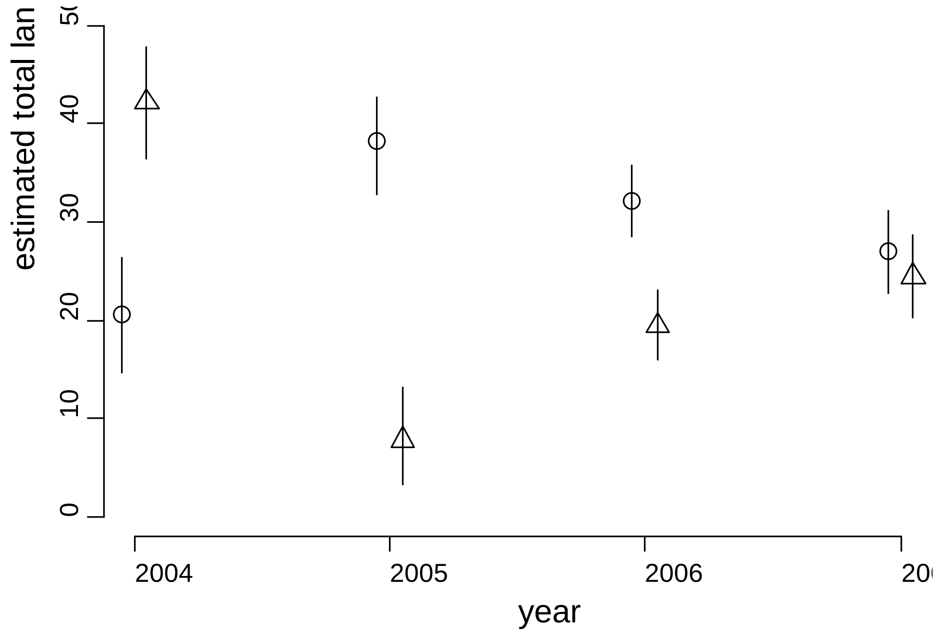


Figure 2.11.3 North Sea herring. Estimated totals landed catch by spawner types from the Dutch summer (May to July fishery). Open circles: autumn spawners; open triangles: winter spawners. Error bars denote standard errors.

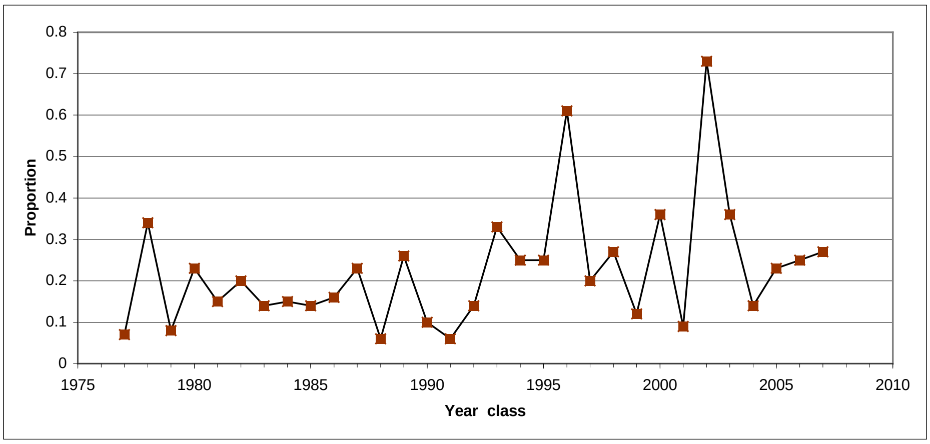


Figure 2.11.4. Downs herring. Proportion of small 1-ringers versus all sizes in the North sea (from table 2.3.3.3).

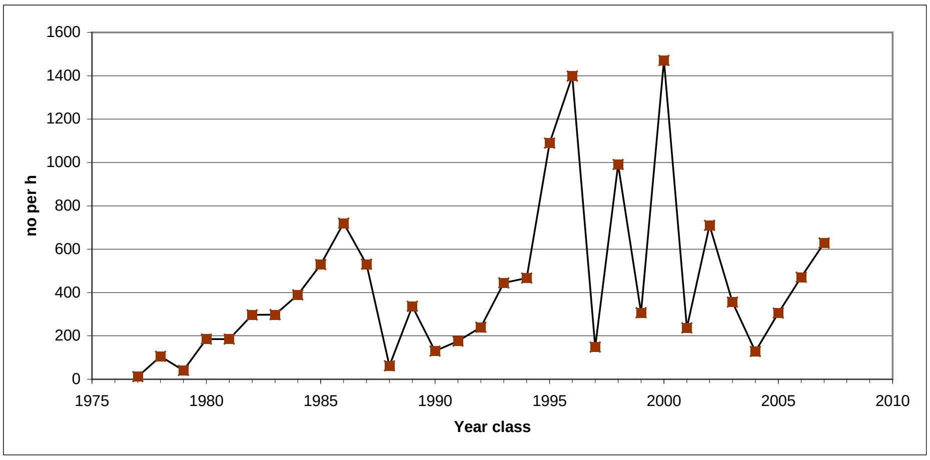


Figure 2.11.5. Downs herring. Index (Nos per hr) of small (<13cm) 1-ringers in the North from table 2.3.3.3).

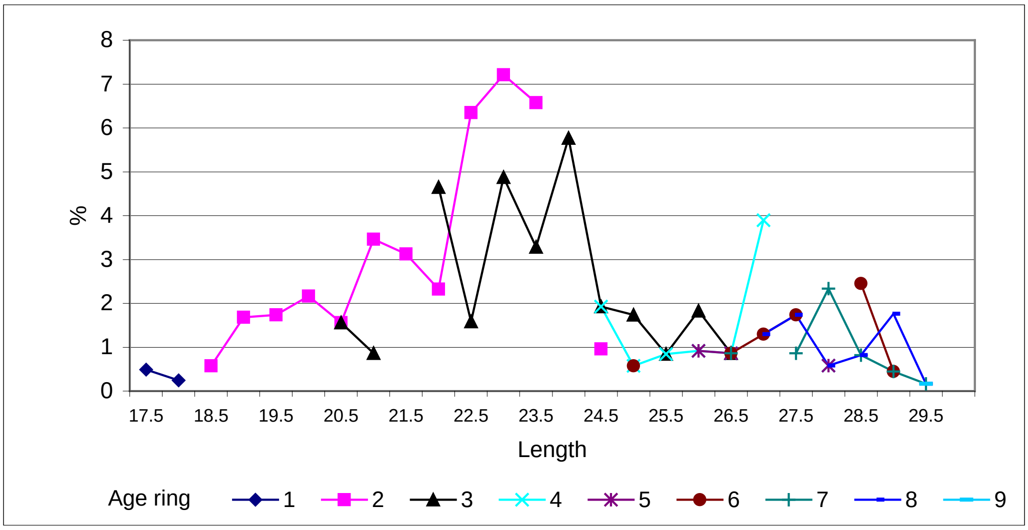


Figure 2.11.6. Downs herring. IBTS 09. Catch composition by age from pelagics hauls in the Eastern English Channel. The total percentage for the 2, 3 and 4 ringers represent respectively 38%, 30% and 10%.

2.12 Management Considerations

Based on the most recent estimates of SSB and fishing mortality, ICES classifies the stock as being at risk of having reduced reproductive capacity and is beingharvested sustainably. The SSB in autumn 2008 was estimated at 1.0 million t, and is expected to remain below Bpa (1.3 million t) in 2009. $F_{2\text{-}6}$ in 2008 was estimated at 0.24, above the target $F_{2\text{-}6}$ of 0.14. The year classes since 2002 are estimated to be among the weakest since the late 1970s.

The stock is managed according to the EU-Norway Management agreement which was updated on November 2008 (Table 2.12.1).

WKHMP examined the performance of this management plan and the plan is consistent with the precautionary approach because of the low risk of SSB<B_{lim}.

SSB and fishing mortality are reliably estimated. A reduction in fishing mortality to close to the target is expected to be achieved in 2009. The 2008 year class is estimated within the range of low recruitment. Therefore HAWG assumes that the recruitment will remain at the lower level. Delay in implementing substantial reductions in catch by not following the management plan has resulted in the SSB being at greater risk of being below Blim and in lower catches. The management plan should be followed.

North Sea herring and Western Baltic Spring Spawning herring are managed under mixed quotas in some areas of North Sea, Skagerrak and Kattegat. The management of these mixed components was discussed in detail in 2007 (ICES CM 2007 ACFM:11). With the decline of both the WBSS herring and the NS herring, conservation of both stock needs to be considered when setting TACs. With the mixing of stocks within a fishery, primacy of consideration should be given to protection of the stock most heavily exploited in the area of overlap.

The options selected for the C- and D-fleets are compatible with the advised exploitation of Western Baltic Spring Spawners assuming a TAC for 2010 of 39800 tonnes (see Section 6.4.7) and are 7.4 and 3.7 thousand tonnes of North Sea autumn spawning herring for C and D fleets respectively. A further option assuming higher catches of the C and D fleet (approximately 40% higher) results in lower catches for the A and B fleet.

The North Sea autumn spawning herring stock also includes the Downs herring component (herring in Divisions IVc and VIId), the management of this component was discussed in detail in 2007 (ICES CM 2007 ACFM:11). There is no update to this advice.

Table 2.12.1 North Sea herring. Agreed Management Plan for North Sea herring

According to the EU–Norway agreement (November 2008):

1. Every effort shall be made to maintain a minimum level of Spawning Stock Biomass (SSB) greater than 800,000 tonnes (Blim).
2. Where the SSB is estimated to be above 1.5 million tonnes the Parties agree to set quotas for the directed fishery and for bycatches in other fisheries, reflecting a fishing mortality rate of no more than 0.25 for 2 ringers and older and no more than 0.05 for 0 - 1 ringers.
3. Where the SSB is estimated to be below 1.5 million tonnes but above 800,000 tonnes, the Parties agree to set quotas for the direct fishery and for by-catches in other fisheries, reflecting a fishing mortality rate on 2 ringers and older equal to:

   0.25-(0.15*(1,500,000-SSB)/700,000) for 2 ringers and older,

   and no more than 0.05 for 0 - 1 ringers
4. Where the SSB is estimated to be below 800,000 tonnes the Parties agree to set quotas for the directed fishery and for bycatches in other fisheries, reflecting a fishing mortality rate of less than 0.1 for 2 ringers and older and of less than 0.04 for 0-1 ringers.
5. Where the rules in paragraphs 2 and 3 would lead to a TAC which deviates by more than 15 % from the TAC of the preceding year the parties shall fix a TAC that is no more than 15 % greater or 15 % less than the TAC of the preceding year.
6. Notwithstanding paragraph 5 the Parties may, where considered appropriate, reduce the TAC by more than 15 % compared to the TAC of the preceding year.
7. Bycatches of herring may only be landed in ports where adequate sampling schemes to effectively monitor the landings have been set up. All catches landed shall be deducted from the respective quotas set, and the fisheries shall be stopped immediately in the event that the quotas are exhausted.
8. The allocation of the TAC for the directed fishery for herring shall be 29 % to Norway and 71 % to the Community. The bycatch quota for herring shall be allocated to the Community.
9. A review of this arrangement shall take place no later than 31 December 2011.
10. This arrangement enters into force on 1 January 2009.

2.13 Ecosystem considerations

2.13.1 Ecosystem considerations

Herring is considered to have a major impact on most other fish stocks as prey and predator and is itself prey for seabirds and sea mammals in that area. Herring spawning and nursery areas, being near the coasts, are particularly sensitive and vulnerable to anthropogenic influences. The most serious of these is the extraction of marine sand and gravel and the development of coastal wind farms. Herring leave and then repopulate spawning grounds and the lack of spawning in recent years does not mean that the spawning ground is not required to maintain a resilient herring population.

The human consumption fisheries for herring are considered relatively clean, with little by-catch of other fish and almost no disturbance of the sea bed. The limited evidence from observer programmes suggest that discarding of herring is not widespread. Juvenile herring are caught as a by catch of industrial fisheries and these vessels catch a range of fish species. There is little information available on the catches of mega-fauna by the herring fleets.

2.13.2 Changes in the environment

This stock has recently produced six poor year classes in a row, which has never been observed before. Larval surveys show a large abundance of larvae in recent years. However, survival of these larvae seems to be very poor. The specific reasons for this are not known. An ICES study group has reviewed the hypotheses for the serial poor recruitment in North Sea herring (Payne et al., 2009) and commented that the reduction in herring recruitment is similar to the warming of the water on the spawning grounds and changes in the hydrography. These hydrographic changes may be linked to the AMO (Atlantic Multidecadal Oscillation) and are also associated with changes in the zooplankton community. Further investigation of the causes of the poor recruitment will require targeted research projects.

3 Herring in Division IIIa and Subdivisions 22–24 [update assessment]

3.1 The Fishery

3.1.1 Advice and management applicable to 2008 and 2009

A benchmark assessment was carried out in 2008. SSB appeared stable over a number of years. Fishing mortality estimates for 2007 were 0.47 for adults (Fbar) and 0.17 for the juveniles (1-ringers). The recruitment demonstrated a declining trend since 2003 and fishing mortality was estimated at a stable high level compared to other herring stocks. Because of the very low recruitment in recent years ACOM recommended in 2008 a substantial reduction in fishing mortality in 2009. In the absence of a management plan and agreed target and precautionary reference points ICES advised that fishing mortality should be less than the F related to high long-term yield (F = 0.25). This would correspond to landings of less than 32 800 t in 2009.

The EU and Norway agreement on a herring TAC for 2008 was 51 673 t in Division IIIa for the human consumption fleet and a by-catch ceiling of 11 470 t to be taken in the small mesh fishery. For 2009, the EU and Norway agreement on herring TACs in Division IIIa was 37 722 t for the human consumption fleet and a by-catch ceiling of 8 373 t to be taken in the small mesh fishery..

Previous to 2006 no special TAC for Subdivisions 22-24 was set. In 2008, a TAC (44 550 t) was set on the Western Baltic stock component. The TAC for 2009 was set at 27 176 t.

3.1.2 Catches in 2008

Herring caught in Division IIIa are a mixture of North Sea Autumn Spawners (NSAS) and Western Baltic Spring Spawners (WBSS). This Section gives the landings of both NSAS and WBSS, but the stock assessment applies only to the spring spawners.

Landings from 1987 to 2008 are given in Table 3.1.1 and Figure 3.1.1. In 2008 the total landings in Division IIIa and Subdivisions 22–24 have decreased to 81 300 t, which is the lowest value of the time series (1986-2008). The decrease in landings in 2008 is particularly evident in the Kattegat, where the Swedish landings were less than half of the landings in 2007 from that area. The German landings have increased slightly for the last three years in Subdivision 22-24, but are still small in Division IIIa. As in previous years the 2008 landing data are calculated by fleet according to the fleet definitions used when setting TACs.

The fleet definitions used since 1998 are:

Fleet C: directed fishery for herring in which trawlers (with 32 mm minimum mesh size) and purse seiners participate.

Fleet D: All fisheries in which trawlers (with mesh sizes less than 32 mm) and small purse seiners, fishing for sprat along the Swedish coast and in the Swedish fjords, participate. For most of the landings taken by this fleet, herring is landed as 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 2002 to 2008 in thousands of tonnes by fleet (as defined by HAWG) and quarter.

Selection by fleet is done disregarding the nationality of the fleets assuming that the fleets target the same part of the population regardless of national flag. However, analysing of the age distribution in the catches of the Danish and Swedish Fleet D in Subdivisions 20 and 21 it became apparent that the Swedish Fleet D targets a larger part of the population as the landings of fish older than 3 years are higher than what is observed in the Danish catches of the same fleet. Thus the selection by fleet is not identical between the two countries. The Danish fleet definition follows the definition set by HAWG, where Fleet D (or 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 and blue whiting fisheries. 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. Thus Swedish age-length keys cannot be used to raise Danish catches and vice versa.

The text table below give the TACs and Quotas (t) for the fishery by the C- and D-fleets in Division IIIa and for the F-fleet in Subdivisions 22-24.

	TAC	DK	GER	SF	PL	SWE	EC	NOR	FAROE
	2008								
Div. IIIa fleet-C	51,673	21,474	344			22,463	44,281	6,892	500
Div. IIIa fleet-D	11,470	9,805	87			1,578	11,470		
SD 22-24 fleet-F	44,550	6,245	24,579	3	5,797	7,926	44,550		
% of IIIa taken in IV								-30%	
	2009								
Div. IIIa fleet-C	37,722	15,611	250			16,329	32,190	5,032	500
Div. IIIa fleet-D	8,373	7,157	64			1,152	8,373		
SD 22-24 fleet-F	27,176	3,809	14,994	2	3,536	4,835	27,176		
% of IIIa taken in IV								-20%	

3.1.3 Regulations and their effects

In recent years, HAWG has calculated a substantial part of the catch reported as taken in Division IIIa in fleet C actually has been taken in Subarea IV. These catches have been allocated to the North Sea stock and accounted under the A-fleet. Estimates based on VMS and Industry information suggest that 36%, 28% and 30% of the official landings for human consumption in Division IIIa have been misreported in the last three years, respectively. These figures are probably underestimating the problem since only a subset of countries supply this information to the HAWG. Misreported catches have been moved to the appropriate stock for the assessment.

Regulations allowing quota transfers from Division IIIa to the North Sea were introduced as an incentive to decrease misreporting for the Norwegian part of the fishery, the percentage has gradually been decreased in recent years being 20% in 2009.

The quota for the C fleet and the by-catch quota 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.

3.1.3.1 Changes in fishing technology and fishing patterns

There have been no significant changes in fishery technology in the last few years.

3.2 Biological composition of the catch

Table 3.2.1 and Table 3.2.2 show the total catch (autumn- and spring-spawners combined) 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 acceptable (Table 3.2.4). In the cases of missing samples the corresponding landings were minor. 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 see Section 3.2.2 for more details)

The total numbers and mean weight-at-age of the WBSS and NSAS landed from Kattegat, Skagerrak, and Division IIIa respectively was 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 + Div. IIIa in 2008 was estimated to be 25 200 t, and has thereby decreased to below the levels observed in 2003 (38 000 t) and 2004 (35 000 t) from the somewhat high level in 2006 (48 700 t) (Table 3.2.13).

Total catches of WBSS from the North Sea, Division IIIa, and Subdivisions 22-24 respectively, by quarter, was estimated for 2008 (Table 3.2.14). Additionally, the total catches of WBSS in numbers and tonnes, divided between the North Sea and Division IIIa and Subdivisions 22–24 respectively for 1992–2008, are presented in Tables 3.2.15 and 3.2.16.

Catches of WBSS from Subdivisions 22-24 have remained rather stable since 2003. In 2008 the catch was again around the same level at 43 000 t (Table 3.2.16).

The total catch of NSAS in Div. IIIa amounted to 12 949 t in 2008, which is the lowest value observed in the time series (Table 3.2.17).

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 2008 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 2008 more than meets the recommended level of one sample per 1 000 t landed per quarter and the coverage of areas, times of the year and gear (mesh size) was acceptable. One exception is the scarce sampling covering catches from Subdivision 23 comprising 5 660 t, where the amount of total samples match the recommended level, but the temporal coverage is not acceptable. However, for some of the sampling units (SD and quarter) sample size of ages was possibly lower (see HAWG WD Cardinale and Hansson 2006 for details) than the value necessary to reach ±5% precision level as established by the current European Data Regulation system.

3.3 Fishery Independent Information

3.3.1 German Acoustic Survey in Subdivisions 21-24 (Autumn)

A joint German-Danish acoustic survey was carried out with R/V "SOLEA" between 2 and 21 October 2008 in the Western Baltic covering Subdivisions 21, 22, 23 and 24. A full survey report is given in the Report of the Planning Group for Herring Surveys (ICES 2009/LRC:02). The results for 2008 are presented in Table 3.3.1. The time series has been revised in 2008 (ICES 2008/ACOM:62) to include the southern part SD 21. The years 1991-1993 were excluded due to different recording method at that time and 2001 was also excluded since SD 23 was not covered (ICES 2008/ACOM:62). The Western Baltic spring spawning herring stock in 2008 was estimated to be 3.4 x 10^9 fish or about 118 x 10^3 tonnes in Subdivisions 21–24. Those estimates are comparable to levels of abundance and biomass observed in 2007 (Table 3.3.1).

3.3.2 Herring Acoustic Survey (HERAS) in Division IIIa (Summer)

The Herring acoustic survey (HERAS) from 26 June to 10 July 2008 covered the area in the Skagerrak and the Kattegat. Details of the survey are given in the 'Report of the Planning Group for Herring Surveys' (ICES 2009/LRC:02). The 1999 was excluded due to different survey area coverage. The estimates of the Western Baltic spring spawning herring stock are 629 000 tonnes and 8 839 million individuals, which is similar to last year's estimate. The stock is dominated by 1 and 2 ringer fish. The results from this survey are summarised in Table 3.3.2.

3.3.3 Larvae Surveys

Herring larvae surveys in the western Baltic (Greifswalder Bodden and adjacent waters; SD 24) were conducted in weekly intervals during the 2008 spawning season (March to June). This was defined as the total number of larvae that reach the length of 20 mm (N20; Table 3.3.3) (Oeberst et al, 2007, WD 7 in HAWG 2008 (ICES 2008/ACOM:62)). The values estimated for 2008 is the lowest on record if we excluded the value observed in the first year of the time series (1992) and in line with the value observed in 2007 (Table 3.3.3).

3.4 Mean weights-at-age and maturity-at-age

Mean weights at age in the catch in the 1st quarter were used as stock weights (Table 3.2.14).

The maturity ogive of WBSS applied in HAWG has been assumed constant between years and thus 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). A Workshop on Sexual Maturity Staging of Herring and Sprat is taking place during 2009 in order to, amongst other things, establish correspondence between old and new scales to convert time series and propose optimal sampling strategy to estimate accurate maturity ogives.

The same maturity ogive was used as in the HAWG 2008:

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 western Baltic spring spawning herring (WBSS) in Subdivisions 22-24 for 2008 were available from the revised larval survey and are described in Section 3.3.3 and Oeberst et al., 2007 (WD 7 to the HAWG 2007(ICES 2007/ACFM:11)).

3.6 Assessment of Western Baltic spring spawners in Division IIIa and Subdivisions 22–24

3.6.1 Input data

3.6.1.1 Catch data

Catch in numbers at age from 1991 to 2008 were available for Subdivision IVa (East), Division IIIa and Subdivisions 22-24 (Table 3.6.1; Figure 3.6.1.1). 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:62).

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 3.6.1.3). Proportions at age (by weight) thus reflect the combined variation in numbers at age and weight at age (Figure 3.6.1.2).

3.6.1.2 Biological data

Estimates of the mean weight of individuals in the stock (Tables 3.2.14 and 3.6.3) 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).

The proportion of individuals that are mature is assumed constant over the period considered (Table 3.6.5): ages 0-1 are assumed to be all immature, ages 2-4 are 20%, 75% and 90% mature respectively, and all older ages are 100% mature.

The proportions of fishing mortality, F (0.1) and natural mortality M (0.25) before spawning are assumed constant between years (Table 3.6.6-7). The difference between these two values arises due to the fact that the fishery is prosecuted in the latter half of the year.

3.6.1.3 Surveys

All surveys covering this stock were previously explored in terms of time series trends, internal consistency, and mortality signals during the Benchmark Assessment of this stock. The choice of age groups included was made there on the basis of existing knowledge of migration patterns and the analysis of the internal consistency of the surveys by age. (ICES 2008/ACOM:62; Payne et. al 2009) The final combination of surveys chosen was to include the N20 index as a recruitment index and apply the HERAS and German acoustic surveys to each characterise a subset of the total age classes.

The numerical values of the index for each individual age in each survey are given in Table 3.6.8, and are depicted in Figure 3.6.1.4. Each age and year in each survey is given an equal weighting.

3.6.2 Assessment method

As a part of the benchmark assessment process in 2008, the choice of assessment model was examined and the HAWG concluded that the underlying assumptions in the FLICA appeared to be valid. Details of the exact software package versions employed are given in Table 3.6.11.

3.6.3 Assessment configuration

Following the procedure in the WBSS stock annex (Annex 4), the following settings were used in this update assessment (Tables 3.6.9-10):

- The period for the separable constraint: 5 years (2003-2007)
- The weighing factor to all indices: lambda = 1
- A linear catchability model for all indices
- The reference F set at age 4 and the selection=1 for the oldest age
- The catch data were down-weighted to 0.1 for 0-ringer herring
- No stock-recruitment model was fitted
- Errors in index values are assumed to be correlated.
- Plus group is set to age 8+.

3.6.4 Assessment Results

The results of the assessment are given in Tables 3.6.12-21. The estimated SSB for 2008 is 159 406 tonnes. The mean fishing mortality (ages 3-6) is estimated as 0.37. Parametric bootstrap estimates of these values give 95% confidence intervals of [112 000, 196 000] for SSB and [0.24, 0.55] for the mean fishing mortality (Figure 3.6.4.1).

After a marked decline from over 300 000 tonnes in the early 1990s to a low of 120 000 tonnes in the late 1990s, the SSB of this stock recovered somewhat, reaching a secondary peak of around 200 000 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 recently declined with about 17%.

Fishing mortality on this stock was high in the mid 1990s, reaching a maximum of over 0.7 yr^{-1}. In recent years, the $F_{3\text{-}6}$ value has stabilised around 0.4 (Figure 3.6.4.2).

Recruitment in 2008 is estimated at approximately 0.9 billion individuals. This is the lowest value observed in the 18 years covered by the assessment, and represents the continuation of a trend of decreasing recruitment from 2003 (Figure 3.6.4.2).

The catch residuals are generally free from patterns (Figure 3.6.4.3). The marginal totals of residuals between the catch and the separable model are small overall, although there does appear to be a trend in the age residuals on either side of the reference age.

The individual diagnostics for the three surveys generally show good quality fits (Figures 3.6.4.4 – 3.6.4.11). The residuals appear to be distributed randomly, and the assumption of their being distributed normally is generally held up. Systematic year effects appear to be present in the Herring acoustic survey (HERAS), especially in the later ages. Most survey-ages appear to have at least one significant outlier, often occurring in the earlier part of the time series. Generally, however, the agreement between the data and the fitted model appears good through all data sources.

The mean contribution of the survey data points to the objective function is generally greater than that of the catch data (Figure 3.6.4.12): this is not surprising, however, as there are significantly more parameters fitted to the catch data. The agreement between the model and the GerAS survey is generally better than that of the HERAS survey. The N20 larval index shows the worst fit, on average.

Some patterns are apparent in the residuals (Figures 3.6.4.13). The HERAS survey shows appreciable year effects, with some years showing either positive or negative residuals across all ages. The German acoustic survey appears to give a more random pattern. The N20 index shows an improving fit in latter years, with one large dominating residual in its first year. The residuals are generally small (e.g. less than 0.5), but are dominated by a few outlying points. No cohort or age effects are apparent.

Retrospective analysis suggests the assessment method gives a relatively consistent perception of the stock and its development (Figure 3.6.4.14). There is a suggestion of biases in both the SSB and fishing mortality. However, the changes from year-to-year are generally less than the uncertainty of the estimated values (ICES 2008/ACOM:62), and are not a cause for great concern. The retrospective pattern in recruitment shows some variability, but is generally free from bias.

Retrospective analysis of the selectivity pattern for this fishery shows a stable selection pattern (Figure 3.6.4.15), especially in the most recent years covered by the separable period. Such a result suggests that the assumption of a constant selectivity in the fishery, a key criteria for the application of the FLICA method, is valid.

The stock-recruitment plot for this stock (Figure 3.6.4.16) does not show any clear relationship between stock-size and recruitment. Recent recruitment has dropped appreciably and consistently, while stock size has remained constant. The clustering of points suggests two different recruitment regimes, independent of stock size, may exist: a higher recruitment regime was present during the 1990s, which has been replaced by a lower recruitment regime in the 2000s. The mechanisms underpinning such a change remain unclear.

3.6.5 State of the stock

In the absence of defined reference points, the state of the stock cannot be evaluated. An analytical assessment demonstrates that the SBB has been stable over the last decade (to within ± 20% of the decadal mean), although the most recent value is in the lower quartile of all observations. Fishing mortality has also been stable in the same period but is larger than any proxy of F_{msy}. Recruitment has declined consistently since 2003 and the estimated number of 0-ringers in 2008 is the lowest observed value. These poor year classes have not had a dramatic effect on the spawning stock biomass as yet, due to the comparatively large size and good growth of the 2003 year class. This year class has been the largest component of the SSB for the last three years (2006-2008) and has supported the stock during this period (Figures 3.6.5.1-2). However, this year class is now in decline, and will pass out of the stock in the next two years, whilst its place will be taken by the sequence of poor year classes: a continuation of the decline in SSB can therefore be expected in the short and medium term.

3.6.6 Comparison with previous years perception of the stock

This year's assessment is an update assessment, and employs the same methodology as that in last year's Benchmark Assessment – the only difference between the two is the addition of a further year of data. The addition of this extra year of data appears to have modified the perception of the stock appreciably, increasing the SSBs and decreasing the fishing pressures estimated for 2006 and 2007 by around 20%.

The text table below summarises the differences in the previous year's assessment configuration and perception of the stock.

Category	Parameter	Assessment in 2009	Assessment in 2008	Diff. 08-09 (+/-) %
ICA results	SSB 2006	192 109	162 978	+17.9
	F(3-6) 2006	0.396	0.491	-19.3
	SSB 2007	161 537	133 503	+21.0
	F(3-6) 2007	0.358	0.465	-23.0%

3.7 Short term predictions

Short term predictions were made with the fwd() method of "FLash" FLR package.

3.7.1 Input data

Stock numbers at age at the start of 2009 were taken from the ICA assessment, except for age 0. For age 0, the geometric mean recruitment (2002-2007) was assumed. The selection at age was taken from the ICA assessment. Arithmetic averages over the years 2006 - 2008 were used for mean weights at age in the catch and in the stock, as well as maturities at age. The input data are shown in Table 3.7.1.

3.7.2 Intermediate year 2009

A catch constraint was assumed for the intermediate year. The 2009 catch was estimated from the agreed TACs by fleet for Division IIIa and Subdivisions 22-24. The Division IIIa TAC includes both WBSS and NSAS herring, while the Subdivision 22-24 TAC is assumed to be only WBSS herring.

- 2068 tonnes were subtracted from the Division IIIa TAC in 2008 and 1006 t subtracted from the TAC in 2009, to account for transfer of the Norwegian quota from IIIa to the North Sea.

- The catch by each fleet proportional to each TAC was assumed to be constant from 2008 to 2009. This gives the expected catch by fleet in 2009. Misreporting from Division IIIa into the North Sea is not explicitly included in these calculations, but is included implicitly via the proportions of quota taken.

- The catch of herring in Division IIIa consists of both WBSS and NSAS components. The expected catch of WBSS in IIIa was calculated assuming the same WBSS proportions in the catch of each fleet in 2009 as that in 2008 neglecting the small amount of about 120 t WBSS taken in Division IVaE by the A-fleet.

The resulting expected catch of WBSS in 2009 following this scheme was 45 087 tonnes.

	2008					2009			
Calculation of Intermediate year (2009) catch constraint	Catch of WBSS	Catch of NSAS	TAC* (WBSS+ NSAS)	Catch of NSAS + WBSS	Catch/ TAC	TAC* in 2009	Total catch in 2009	Proportion of WBSS in catch	Catch of WBSS in 2009
A-fleet	0.12						0.12		0.12
C-fleet	23.04	9.24	49.61	32.20	0.65	36.72	23.89	0.71	17.05
D-fleet	2.21	3.70	11.47	5.90	0.52	8.37	4.31	0.37	1.61
F-fleet	43.12		44.55	43.10	0.97	27.18	26.30	1.00	26.30
Total (Div. IIIa, SD 22-24 and IVaE)	68.48						54.63		**45.087**

*After accounting for Norwegian transfer from IIIa to North Sea (2 068 tonnes in 2008, 1 006 tonnes in 2009).

3.7.3 Catch options for 2010

Detailed single option tables are presented for the following scenarios (Table 3.7.2).

1. Zero catch

After a decline in 2010 the SSB increases to 157 000 t in 2011.

2. A 15% reduction of all fleet-wise TACs for 2009, converted into a total herring catch by assuming that the TAC is completely taken. The catches of WBSS herring are then calculated by assuming that the proportion of WBSS in each fleet's catch is the same as that in 2008, to give a catch in 2010 of 48 100 t.

With this assumption the decline in SSB in 2010 continues in 2011 down to 114 500 t, close to the suggested breakpoint of 110 000 t.

3. As for option 2, but with no change in the TAC, to give a catch in 2010 of 56 600 t.

With this assumption the decline in SSB in 2010 continues in 2011 down to 107 400 t, below the suggested breakpoint of 110 000 t.

4. As for option 2, but with a 15% increase in the TAC, to give a catch in 2010 of 65 100 t.

With this assumption the decline in SSB in 2010 continues in 2011 down to 100 300 t, well below the suggested breakpoint of 110 000 t.

5. Catch in 2010 as assumed for 2009 (45 087 tonnes).

This option will lead to an SSB of 127 700 t in 2010 and 117 300 t 2011, a little above the breakpoint of 110 000 tonnes.

6. $\boldsymbol{F_{2010} = 0.25}$, which is thought to lie close to F_{MSY}.

This option will give a yield of 39 800 t in 2010, with an SSB of 128 200 t in 2010 and 121 700 t in 2011.

3.8 Precautionary and yield based reference points

No precautionary reference points are defined for this stock. No new information was available (ICES 2008 ACOM:27).

3.9 Quality of the Assessment

There is retrospective bias with an underestimate of SSB and overestimate of F in the order of 20% (see Section 3.6.6).

The reason for this bias is not clear. Two factors are suggested, the relatively strong positive residuals across all ages in the 2008 HERAS acoustic survey, and the fact that a sequence of positive catch residuals in 2003 has now moved out of the separable period into the VPA region of the model. These changes acting together can be shown to cause the changes in the most recent years by the observed amount.

After the assessment was completed, an error was found in the input data: specifically, the total landings from Germany in Sub division 22 and 24 in 2008 were entered as 21 800 tonnes, instead of 22 800 tonnes (Table 3.1.1). Exploratory runs suggest that this error changes the SSB in 2008 by 0.1%, and the mean fishing mortality in 2008 by 1.5%. Such an error has an even smaller and therefore negligible effect on the catch advice in 2010. This error was discovered at a late stage. Given its small impact on the quality, accuracy and precision of the assessment and on the results of the projections, HAWG decided not to redo the assessment.

3.10 Management Considerations

Quotas in Division IIIa

The quota for the C-fleet and the by-catch quota for the D-fleet are set for both stocks of North Sea autumn spawners (NSAS) and Western Baltic spring spawners (WBSS) together (see Section 2.7).

ICES catch predictions versus management TAC

ICES gives advice on catch options for the entire distribution of the two herring stocks separately, whereas herring is managed by areas (see the following text diagram).

	Subarea IV	Subarea IV	Division IIIa	Division IIIa	Subdiv. 22-24	
	By-catch quota	TAC	TAC	By-catch quota	TAC	
	Fleet B	**Fleet A**	**Fleet C**	**Fleet D**	**Fleet F**	
ICES advice	NSAS	NSAS	NSAS	NSAS		
		WBSS	WBSS	WBSS	WBSS	ICES Advice

Development of a management plan for WBSS herring

ICES has explored management options under different assumptions of fishing mortality and recruitment using stochastic simulation with and without TAC constraints, including changes in selection pattern and different levels of uncertainty in the assessment. A proxy for F_{MSY}=0.25, a SSB breakpoint of 110 000 t equal to the lowest observed SSB below which the state of the stock is uncertain, and a maximum TAC variation of +/- 15% was suggested by WKHMP in 2008 (ICES 2008 ACOM:27). ICES concluded that, if recruitment does not further decline below the recent years' average, a fishing mortality of 0.25 could be a target in the development of a management plan for the western Baltic spring spawning herring stock.

Data used for catch options in 2009 (intermediate year)

There is no firm basis for predicting the yearly fraction of NSAS in the catches of the C- and D-fleets. The proportions of the two stocks are influenced by the year class strength and their relative geographical distributions as well as fleet behaviour.

The procedure of deriving separate catches by stock and fleet is described in the stock annex for North Sea herring. The catch option for 2010 is based on the share by fleet and stock composition in catches for the most recent year 2008.

Exploring a range of total WBSS catches for 2010 (prediction year)

Fleet wise catch options for the prediction year have the following assumptions:

- The TAC distribution by fleet in 2010 will be equal to 2009.
- There will be allowed a subtraction of 20% of the Norwegian quota that is transferred to the A-fleet (as NSAS).
- Each fleet catches its total TAC.
- The 2008 proportions of WBSS by fleet hold for 2010. (The proportions of WBSS in catches were 0.71 in the C-fleet, 0.37 in the D-fleet and 1.00 in the F-fleet).
- A constant catch of about 120 t of WBSS caught in the A-fleet in Division IVa East.

The table below gives the 2010 fleet wise catch options for the Western Baltic spring spawners and North Sea autumn spawners in Division IIIa, in Subdivisions 22–24, and in Subarea IVaE for the catch options described in section 3.7:

1) F=0 not shown, **2)** $F_{-15\%TAC}$=0.31, **3)** F_{TAC}=0.37, **4)** $F_{+15\%TAC}$=0.44, **5)** $F_{catch09}$=0.29 and **6)** F_{MSY}=0.25.

Catch option for the WBSS and NSAS herring stock in 2010											
Catch option for the WBSS herring stock		WBSS herring				NSAS herring		Total catches of both stocks in Division IIIa and Sub-division 22-24			
Option	Total catches of WBSS herring*	IVaE	Div IIIa		SD22-24	Div IIIa		Div IIIa		SD 22-24	TAC development
		Fleet A*	Fleet C	Fleet D	Fleet F	Fleet C	Fleet D	Fleet C**	Fleet D	Fleet F	Total area
2	48 100	120	22 300	2 700	23 100	8 900	4 500	31 200	7 100	23 100	-15%
3	56 600	120	26 200	3 100	27 200	10 500	5 200	36 700	8 400	27 200	0%
4	65 100	120	30 100	3 600	31 300	12 100	6 000	42 200	9 600	31 300	15%
5	45 100	120	20 900	2 500	21 600	8 400	4 200	29 200	6 700	21 600	-20%
6	39 800	120	18 400	2 200	19 100	7 400	3 700	25 800	5 900	19 100	-30%

* total catches of WBSS herring include a small constant catch of 120 t WBSS taken by the A-fleet in Div. IVa East
** total C-fleet catches in Division IIIa, the % of the Norwegian quota that can be transferred to the North Sea is subtracted

[1] Catches in 2010 relative to the TACs for 2009 in Division IIIa and Subdivisions 22-24; Fleet C: 37 722 t, Fleet D: 8 373 t, Fleet F: 27 176 t.

Adopting a fishing mortality of 0.25 (proxy for F_{msy}) as suggested by WKHMP (ICES 2008/ACOM:27) will to some degree reduce but not stop the present decline in SSB (Table 3.7.2). Catches corresponding to an F below 0.31 in 2010 should keep the SSB above the breakpoint of 110 000 t in 2011.

The catches of WBSS in the C- and D-fleets comprise 37% of the total out-take of the WBSS stock, whereas the catches of NSAS in the same fleets only comprise 5% of the total out-take of the NSAS stock. Due to the state of the WBSS stock exhibiting a drastic decline in recruitment and negative development of the spawning stock biomass both stocks now need to be considered in the management. Thus the resulting catch options were also used as constraints for short term predictions for the NSAS herring (see Section 2.7).

3.11 Ecosystem considerations

Herring in Division IIIa and Subdivisions 22–24 are migratory. There are feeding migrations from the Western Baltic into more saline waters of Division IIIa and the eastern parts of Division IVa. There are indications from parasite infections that yet unknown proportions of sub-stocks spawning at the southern coast in the Baltic proper may perform similar migrations.

Similarly to the North Sea herring the Western Baltic herring has recently produced five poor year classes in a row. Indications suggest that the declining trend continues and that the 2008 year class is the lowest ever in the time series. In a recent recruitment analysis for different Baltic herring stocks, the Baltic Sea Index (BSI) reflecting Sea Surface Temperature (SST) was the main predictor for Western Baltic herring (Cardinale et al. 2009). There are no indications of systematic changes in growth or age at maturity, and a candidate key stage for reduced recruitment is probably the larval stage. Recruitment failure appears to have been initiated before the observed occurrence of the Ctenophore (*Mnemiopsis leidyi*) in the Western Baltic. The specific reasons for reduced larval survival are not known. Further investigation of the causes of the poor recruitment will require targeted research projects.

Table 3.1.1 WESTERN BALTIC HERRING.
Total landings (autumn & spring spawners) in 1987-2008 in thousands of tonnes.
(Data provided by Working Group members 2008).

Year	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
Skagerrak											
Denmark	105.0	144.4	47.4	62.3	58.7	64.7	87.8	44.9	43.7	28.7	14.3
Faroe Islands											
Germany											
Norway	1.2	5.7	1.6	5.6	8.1	13.9	24.2	17.7	16.7	9.4	8.8
Sweden	51.2	57.2	47.9	56.5	54.7	88.0	56.4	66.4	48.5	32.7	32.9
Total	157.4	207.3	96.9	124.4	121.5	166.6	168.4	129.0	108.9	70.8	56.0
Kattegat											
Denmark	46.6	76.2	57.1	32.2	29.7	33.5	28.7	23.6	16.9	17.2	8.8
Sweden	29.8	49.7	37.9	45.2	36.7	26.4	16.7	15.4	30.8	27.0	18.0
Total	76.4	125.9	95.0	77.4	66.4	59.9	45.4	39.0	47.7	44.2	26.8
Sub. Div. 22+24											
Denmark	32.5	33.1	21.7	13.6	25.2	26.9	38.0	39.5	36.8	34.4	30.5
Germany	53.1	54.7	56.4	45.5	15.8	15.6	11.1	11.4	13.4	7.3	12.8
Poland	8.0	6.6	8.5	9.7	5.6	15.5	11.8	6.3	7.3	6.0	6.9
Sweden	7.8	4.6	6.3	8.1	19.3	22.3	16.2	7.4	15.8	9.0	14.5
Total	101.4	99.0	92.9	76.9	65.9	80.3	77.1	64.6	73.3	56.7	64.7
Sub. Div. 23											
Denmark	0.8	0.1	1.5	1.1	1.7	2.9	3.3	1.5	0.9	0.7	2.2
Sweden	0.2	0.1	0.1	0.1	2.3	1.7	0.7	0.3	0.2	0.3	0.1
Total	1.0	0.2	1.6	1.2	4.0	4.6	4.0	1.8	1.1	1.0	2.3
Grand Total	336.2	432.4	286.4	279.9	257.8	311.4	294.9	234.4	231.0	172.7	149.8

Year	1998 [2]	1999 [2]	2000	2001 [5]	2002 [4]	2003	2004	2005	2006 [1,3]	2007	2008 [1]
Skagerrak											
Denmark	10.3	10.1	16.0	16.2	26.0	15.5	11.8	14.8	5.2	3.6	3.9
Faroe Islands								0.4			0.0
Germany						0.7	0.5	0.8	0.6	0.5	1.6
Norway	8.0	7.4	9.7							3.5	4.0
Sweden	46.9	36.4	45.8	30.8	26.4	25.8	21.8	32.5	26.0	19.4	16.5
Total	65.2	53.9	71.5	47.0	52.3	42.0	34.1	48.5	31.8	26.9	26.0
Kattegat											
Denmark	23.7	17.9	18.9	18.8	18.6	16.0	7.6	11.1	8.6	9.2	7.0
Sweden	29.9	14.6	17.3	16.2	7.2	10.2	9.6	10.0	10.8	11.2	5.2
Total	53.6	32.5	36.2	35.0	25.9	26.2	17.2	21.1	19.4	20.3	12.2
Sub. Div. 22+24											
Denmark	30.1	32.5	32.6	28.3	13.1	6.1	7.3	5.3	1.4	2.8	3.1
Germany	9.0	9.8	9.3	11.4	**22.4**	18.8	18.5	21.0	22.9	24.6	**21.8 [6]**
Poland	6.5	5.3	6.6	9.3	-	4.4	5.5	6.3	5.5	2.9	5.5
Sweden	4.3	2.6	4.8	13.9	10.7	9.4	9.9	9.2	9.6	7.2	7.0
Total	49.9	50.2	53.3	62.9	46.2	38.7	41.2	41.8	39.4	37.6	37.5
Sub. Div. 23											
Denmark	0.4	0.5	0.9	0.6	4.6	2.3	0.1	1.8	1.8	2.9	5.3
Sweden	0.3	0.1	0.1	0.2	-	0.2	0.3	0.4	0.7		0.3
Total	0.7	0.6	1.0	0.8	4.6	2.6	0.4	2.2	2.5	2.9	5.7
Grand Total	169.4	137.2	162.0	145.7	128.9	109.5	92.8	113.6	93.0	87.7	81.3

(1) Preliminary data.
(2) Revised data for 1998 and 1999
Bold= German revised data for 2001
(3) 2000 tonnes of Danish landings are missing, see text section 3.1.2
(4) The Danish national management regime for herring and sprat fishery in Subdivision 22 was changed in 2002
(5) The total landings in Skagerrak have been updated for 1995-2001 due to Norwegian misreportings into Skagerrak.
(6) This value is incorrect but could not be corrected in subsequent calculations before the completion of the meeting. The correct value is 22.8

Table 3.1.2

WESTERN BALTIC HERRING.

Landings (SOP) in 2002-2008 by fleet and quarter (1000 t).

Year	Quarter	Div. IIIa		SD 22-24	Div. IIIa + SD 22-24
		Fleet C	Fleet D	Fleet F	Total
2002	1	11.4	6.2	19.6	37.2
	2	6.3	2.1	18.3	26.7
	3	23.2	7	1.5	31.7
	4	14.2	2.5	13.3	30.0
	Total	55.1	17.8	52.7	125.6
2003	1	10.9	7	20.3	38.2
	2	7.9	1.3	12.9	22.1
	3	21.9	0.9	1.5	24.3
	4	15	3.3	5.6	23.9
	Total	55.7	12.5	40.3	108.5
2004	1	13.5	2.8	20.4	36.7
	2	2.8	3.3	10.4	16.5
	3	8.2	10.8	2.4	21.4
	4	5.9	5.0	8.6	19.4
	Total	30.3	22.0	41.7	93.9
2005	1	16.6	6.1	20.4	43.1
	2	3.4	1.9	15.6	20.9
	3	23.4	3.4	1.9	28.7
	4	12.0	2.6	5.8	20.5
	Total	55.4	14.1	43.7	113.3
2006	1	15.3	5.9	15.1	36.2
	2	2.6	0.1	17.2	19.9
	3	15.7	0.8	3.0	19.5
	4	8.3	2.4	6.5	17.3
	Total	41.9	9.3	41.9	93.0
2007	1	7.7	3.0	18.8	29.5
	2	3.8	0.1	10.5	14.4
	3	22.4	0.8	1.7	24.9
	4	7.7	1.8	9.5	18.9
	Total	41.6	5.7	40.5	87.7
2008	1	8.2	3.9	18.4	30.5
	2	2.7	0.3	10.3	13.3
	3	14.9	0.6	6.0	21.5
	4	6.5	1.0	8.4	16.0
	Total	32.3	5.9	43.1	81.3

Table 3.2.1 WESTERN BALTIC HERRING.
Landings in numbers (mill.), mean weight (g.) and SOP (t) by age, quarter and fleet.
Division: Skagerrak Year: 2008 Country: All

		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
1	1	1.96	42	4.92	37	6.89	39
	2	19.83	92	20.83	88	40.66	90
	3	1.18	114	2.74	110	3.93	111
	4	0.13	142	0.58	142	0.70	142
	5	0.41	147	0.44	181	0.85	164
	6	0.07	193	0.31	193	0.38	193
	7	0.03	205	0.13	205	0.16	205
	8+	0.03	193	0.13	193	0.16	193
	Total	23.63		30.09		53.72	
	SOP		2,150		2,591		4,742
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
2	1	1.67	49	3.57	42	5.24	44
	2	18.77	94	0.02	94	18.79	94
	3	0.93	114	0.00	102	0.94	114
	4	0.22	121	0.00	121	0.22	121
	5	0.81	132	0.01	130	0.82	132
	6	0.17	141	0.00	141	0.17	141
	7	0.05	154	0.00	154	0.05	154
	8+	0.07	164	0.00	164	0.07	164
	Total	22.70		3.61		26.31	
	SOP		2,125		152		2,277
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
3	0	0.62	35	0.03	20	0.66	34
	1	75.03	77	0.06	75	75.09	77
	2	22.01	109	0.01	108	22.03	109
	3	14.07	126	0.01	126	14.08	126
	4	6.33	151	0.00	149	6.34	151
	5	7.52	183	0.01	183	7.52	183
	6	3.61	181	0.00	180	3.62	181
	7	1.20	191	0.00	193	1.21	191
	8+	0.56	198	0.00	194	0.56	198
	Total	130.96		0.13		131.09	
	SOP		13,281		10		13,291
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
4	0	4.04	37	2.04	26	6.07	33
	1	33.99	81	3.56	77	37.55	81
	2	7.72	110	0.28	104	8.00	110
	3	4.26	125	0.10	122	4.36	125
	4	1.67	163	0.02	187	1.69	164
	5	2.27	185	0.01	221	2.28	185
	6	1.06	183	0.01	170	1.06	183
	7	0.34	182	0.01	187	0.34	182
	8+	0.15	213			0.15	213
	Total	55.49		6.02		61.51	
	SOP		5,271		378		5,649
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
Total	0	4.66	37	2.07	26	6.73	33
	1	112.66	77	12.12	50	124.77	75
	2	68.33	100	21.14	88	89.47	97
	3	20.45	124	2.86	110	23.31	123
	4	8.35	153	0.60	144	8.95	152
	5	11.00	178	0.47	181	11.46	178
	6	4.91	180	0.32	192	5.23	181
	7	1.62	188	0.14	204	1.76	189
	8+	0.81	198	0.13	193	0.94	197
	Total	232.78		39.85		272.63	
	SOP		22,827		3,132		25,958

Table 3.2.2 WESTERN BALTIC HERRING.
Landings in numbers (mill.), mean weight (g.) and SOP (t) by age, quarter and fleet.
Division: Kattegat Year: 2008 Country: ALL

		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
1	1	6.68	39	14.49	28	21.17	32
	2	35.82	73	8.71	74	44.53	73
	3	12.89	102	1.88	110	14.78	103
	4	2.90	129	0.29	131	3.19	129
	5	3.15	149	0.13	138	3.28	149
	6	2.00	193	0.04	164	2.05	192
	7	2.58	208			2.58	208
	8+	0.28	201	0.01	158	0.29	199
	Total	66.31		25.56		91.86	
	SOP		6,018		1,319		7,337
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
2	1	2.09	54	9.14	18	11.24	24
	2	3.07	78			3.07	78
	3	0.83	97			0.83	97
	4	0.36	111			0.36	111
	5	0.21	139			0.21	139
	6	0.15	165			0.15	165
	7	0.17	189			0.17	189
	8+	0.05	164			0.05	164
	Total	6.94		9.14		16.09	
	SOP		568		161		730
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
3	0	0.20	22	42.44	15	42.64	15
	1	16.94	63	0.00	65	16.94	63
	2	3.47	79	0.00	84	3.47	79
	3	1.08	105	0.00	115	1.08	105
	4	0.59	105	0.00	137	0.59	105
	5	0.20	180	0.00	180	0.20	180
	6	0.15	129	0.00	204	0.15	129
	7	0.07	211	0.00	140	0.07	211
	8+	0.04	206	0.00	206	0.04	206
	Total	22.74		42.44		65.18	
	SOP		1,599		631		2,230
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
4	0	0.30	36	40.90	15	41.20	15
	1	13.66	67	0.58	73	14.24	67
	2	2.36	82	0.09	92	2.45	82
	3	0.68	106	0.03	122	0.72	107
	4	0.46	106	0.01	145	0.48	107
	5	0.04	147	0.00	147	0.04	147
	6	0.12	108	0.00	120	0.12	108
	7	0.06	236	0.00	238	0.06	236
	8+	0.01	162	0.00	162	0.01	162
	Total	17.70		41.62		59.32	
	SOP		1,271		666		1,938
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
Total	0	0.50	31	83.33	15	83.83	15
	1	39.37	60	24.21	25	63.59	47
	2	44.73	74	8.80	74	53.52	74
	3	15.49	102	1.92	110	17.41	103
	4	4.31	122	0.30	131	4.61	122
	5	3.60	150	0.13	139	3.73	150
	6	2.43	183	0.05	162	2.47	182
	7	2.88	207	0.00	238	2.88	207
	8+	0.37	195	0.02	158	0.39	194
	Total	113.70		118.76		232.45	
	SOP		9,456		2,777		12,234

Table 3.2.3 WESTERN BALTIC HERRING.
Landings in numbers (mill.), mean weight (g.) and SOP (t) by age and quarter.
Division: 22-24 Year: 2008 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	1.01	20			1.89	19	2.89	20
	2	1.81	48	2.40	70	10.45	51	14.66	54
	3	2.69	64	4.34	101	27.02	84	34.04	84
	4	0.59	66	3.26	119	26.53	110	30.39	111
	5	0.38	127	4.67	128	32.93	151	37.98	148
	6	1.05	153	2.06	138	15.27	163	18.39	159
	7	0.77	195			4.93	172	5.70	175
	8+	1.97	205	0.90	164	6.73	185	9.59	187
	Total	10.26		17.64		125.75		153.65	
	SOP		1,081		2,027		15,308		18,417
		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	2.66	13	0.38	25	3.51	26	6.55	21
	2	0.14	48	1.05	75	19.38	48	20.57	49
	3	0.21	64	0.88	90	30.48	71	31.57	71
	4	0.05	66	0.62	120	24.13	87	24.80	88
	5	0.03	127	0.39	119	17.55	100	17.97	101
	6	0.08	153	0.31	152	12.45	117	12.84	119
	7	0.06	195	0.08	163	4.40	131	4.55	132
	8+	0.15	205	0.13	161	5.21	136	5.49	138
	Total	3.37		3.84		117.13		124.34	
	SOP		115		370		9,796		10,281
		Sub-division 22		Sub-division 23		Sub-division 24		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
3	0	0.12	12	0.09	19	1.01	23	1.22	22
	1	0.02	28	0.69	66	16.85	64	17.55	64
	2			1.57	102	11.68	85	13.25	87
	3			2.53	136	8.90	108	11.43	114
	4			3.09	155	4.40	128	7.48	139
	5			1.26	183	4.44	128	5.70	140
	6			0.41	176	1.63	110	2.03	123
	7			0.53	184	0.48	158	1.02	172
	8+			0.54	224	0.13	215	0.67	222
	Total	0.14		10.71		49.52		60.37	
	SOP		2		1,550		4,469		6,021
		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	2.31	12	0.09	19	1.09	20	3.49	14
	1	0.30	28	1.00	60	20.13	50	21.42	50
	2			1.70	102	16.93	74	18.64	77
	3			2.61	139	16.51	102	19.13	107
	4			3.41	157	9.14	130	12.55	137
	5			1.37	186	7.45	124	8.82	133
	6			0.41	198	3.12	121	3.53	130
	7			0.58	184	0.85	126	1.43	150
	8+			0.62	220	0.66	140	1.28	178
	Total	2.60		11.79		75.90		90.29	
	SOP		36		1,712		6,649		8,397
		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	2.43	12	0.17	19	2.11	21	4.71	16
	1	3.98	16	2.07	56	42.38	52	48.42	50
	2	1.95	48	6.72	86	58.44	63	67.12	65
	3	2.89	64	10.36	118	82.92	85	96.17	88
	4	0.64	66	10.38	142	64.20	106	75.22	111
	5	0.40	127	7.69	147	62.37	132	70.46	133
	6	1.13	153	3.19	152	32.48	139	36.80	140
	7	0.83	195	1.20	182	10.67	151	12.70	157
	8+	2.12	205	2.19	194	12.73	163	17.04	172
	Total	16.37		43.98		368.29		428.64	
	SOP		1,234		5,660		36,222		43,116

Table 3.2.4 HERRING IN DIVISION IIIa AND SUBDIVISIONS 22-24. Samples of commercial landings by quarter and area for 2008 available to the Working Group.

	Country	Quarter	Landings in '000 tons	Numbers of samples	Numbers of fish meas.	Numbers of fish aged
Skagerrak	**Denmark**	**1**	1.2	2	225	166
		2	0.1	5	38	-
		3	1.9	6	632	614
		4	0.6	1	53	53
	Total		3.9	14	948	833
	Germany	**1**	-			
		2	0.0		No data available	
		3	0.2			
		4	1.4			
	Total		1.6	0	0	0
	Norway	**1**	0.4			
		2	1.8		No data available	
		3	0.5			
		4	1.4			
	Total		4.0	0	0	0
	Sweden	**1**	3.1	7	668	668
		2	0.3	5	667	667
		3	10.8	20	1,218	1,218
		4	2.2	9	730	730
	Total		16.5	41	3,283	3,283
Kattegat	**Denmark**	**1**	4.2	7	801	570
		2	0.3	2	12	11
		3	1.3	2	246	103
		4	1.2		No data available	
	Total		7.0	11	1,059	684
	Sweden	**1**	3.1	13	659	659
		2	0.4	7	664	664
		3	0.9	5	662	662
		4	0.8	6	714	714
	Total		5.2	31	2,699	2,699
Subdivision 22	**Denmark**	**1**	0.0	4	169	169
		2	0.0	2	166	63
		3	0.0	2	175	77
		4	0.0		No data available	
	Total		0.0	8	510	309
	Germany	**1**	1.1		No data available	
		2	0.1	2	857	176
		3	0.0		No data available	
		4	0.0		No data available	
	Total		1.2	2	857	176
Subdivision 23	**Denmark**	**1**	2.0	1	156	54
		2	0.4	2	372	52
		3	1.4		No data available	
		4	1.5	2	128	51
	Total		5.3	5	656	157
	Sweden	**1**	0.0			
		2	0.0		No data available	
		3	0.2			
		4	0.2			
	Total		0.3	0	0	0
Subdivision 24	**Denmark**	**1**	1.8	6	827	394
		2	0.5		No data available	
		3	0.6		No data available	
		4	0.2	3	407	214
	Total		3.0	9	1,234	608
	Germany	**1**	11.3	29	10,765	2,303
		2	5.3	13	5,732	1,048
		3	2		No data available	
		4	2.4	13	4,871	1,226
	Total		20.6	55	21,368	4,577
	Poland	**1**	0.6	4	395	169
		2	2.9	7	3,141	408
		3	1.4		No data available	
		4	0.6		No data available	
	Total		5.5	11	3536	577
	Sweden	**1**	1.6	5	649	649
		2	1.1	2	491	491
		3	0.8	1	256	256
		4	3.5	6	707	707
	Total		7.0	14	2,103	2,103

Table 3.2.5 **HERRING IN DIVISION IIIa AND SUBDIVISIONS 22-24.** Samples of landings by quarter and area used to to estimate catch in numbers and mean weight by age for 2008.

	Country	Quarter	Fleet	Sampling
Skagerrak	Denmark	1	C	Danish sampling in Q1
		2	C	Danish sampling in Q1
		3	C	Danish sampling in Q3
		4	C	Danish sampling in Q3
	Germany	1	C	No landings
		2	C	Danish sampling in Q1
		3	C	Danish sampling in Q3
		4	C	Danish sampling in Q3
	Sweden	1	C	Swedish sampling in Q1
		2	C	Swedish sampling in Q2
		3	C	Swedish sampling in Q3
		4	C	Swedish sampling in Q4
	Denmark	1	D	Swedish sampling in Q1
		2	D	Danish sampling in Q2
		3	D	Danish sampling in Q4
		4	D	Danish sampling in Q4
	Sweden	1	D	Swedish sampling in Q1
		2	D	Swedish sampling in Q2
		3	D	Danish sampling in Q3
		4	D	Swedish sampling in Q4
	Norway	1	C	Danish sampling in Q1
		2	C	Danish sampling in Q1
		3	C	Danish sampling in Q3
		4	C	Danish sampling in Q3
Kattegat	Denmark	1	C	Danish sampling in Q1
		2	C	Danish sampling in Q1
		3	C	Danish sampling in Q3
		4	C	Danish sampling in Q3
	Sweden	1	C	Swedish sampling in Q1
		2	C	Swedish sampling in Q2
		3	C	Swedish sampling in Q3
		4	C	Swedish sampling in Q4
	Denmark	1	D	Danish sampling in Q1
		2	D	Danish sampling in Q2
		3	D	Danish sampling in Q3
		4	D	Danish sampling in Q3
	Sweden	1	D	Danish sampling in Q1
		2	D	No landings
		3	D	Danish sampling in Q3
		4	D	Danish sampling in Q4

Fleet C= Human consumption, Fleet D= Industrial landings.

Table 3.2.5 continued. HERRING IN DIVISION IIIa AND SUBDIVISIONS 22-24. Samples of landings by quarter and area used to to estimate catch in numbers and mean weight by age for 2008.

	Country	Quarter	Fleet	Sampling
Subdivision 22	Denmark	1	F	Danish sampling in Q1
		2	F	Danish sampling in Q2
		3	F	Danish sampling in Q3
		4	F	Danish sampling in Q3
	Germany	1	F	Danish sampling in Q2
		2	F	Danish sampling in Q2
		3	F	Danish sampling in Q3
		4	F	Danish sampling in Q4
Subdivision 23	Denmark	1	F	Danish sampling in Q1
		2	F	Danish sampling in Q2
		3	F	Danish sampling in Q4
		4	F	Danish sampling in Q4
	Sweden	1	F	
		2	F	Swedish sampling in Q2 in Sub-division 24
		3	F	Swedish sampling in Q3 in Sub-division 24
		4	F	Swedish sampling in Q4 in Sub-division 24
Subdivision 24	Denmark	1	F	Danish sampling in Q1
		2	F	Danish sampling in Q2
		3	F	Danish sampling in Q4
		4	F	Danish sampling in Q4
	Germany	1	F	German sampling in Q1
		2	F	German sampling in Q2
		3	F	German sampling in Q4
		4	F	German sampling in Q4
	Poland	1	F	Polish sampling in Q1
		2	F	Polish sampling in Q2
		3	F	Danish sampling in Q4
		4	F	Danish sampling in Q4
	Sweden	1	F	Swedish sampling in Q1
		2	F	Swedish sampling in Q2
		3	F	Swedish sampling in Q3
		4	F	Swedish sampling in Q4

Fleet C= Human consumption, Fleet D= Industrial landings, Fleet F= All landings from Subdiv.22-24.

Table 3.2.6 WESTERN BALTIC HERRING.
Proportion of North Sea autumn spawners and Baltic spring spawners given in % in Skagerrak and Kattegat by age and quarter.
Year: 2008

		Skagerrak		Kattegat	
Quarter	W-rings	North Sea autumn SP	Baltic Spring SP	North Sea autumn SP	Baltic Spring SP
1	1	85.29%	14.71%	75.65%	24.35%
	2	71.76%	28.24%	51.15%	48.85%
	3	2.00%	98.00%	7.14%	92.86%
	4	0.00%	100.00%	5.13%	94.87%
	5	0.00%	100.00%	0.00%	100.00%
	6	0.00%	100.00%	0.00%	100.00%
	7	0.00%	100.00%	10.00%	90.00%
	8	0.00%	100.00%	10.00%	90.00%
		Skagerrak		Kattegat	
Quarter	W-rings	North Sea autumn SP	Baltic Spring SP	North Sea autumn SP	Baltic Spring SP
2	1	93.88%	6.12%	88.46%	11.54%
	2	65.31%	34.69%	69.39%	30.61%
	3	24.00%	76.00%	10.00%	90.00%
	4	6.25%	93.75%	0.00%	100.00%
	5	5.88%	94.12%	0.00%	100.00%
	6	5.88%	94.12%	0.00%	100.00%
	7	5.88%	94.12%	0.00%	100.00%
	8	5.88%	94.12%	0.00%	100.00%
		Skagerrak		Kattegat	
Quarter	W-rings	North Sea autumn SP	Baltic Spring SP	North Sea autumn SP	Baltic Spring SP
3	0	71.88%	28.13%	91.16%	8.84%
	1	50.21%	49.79%	14.67%	85.33%
	2	23.96%	76.04%	5.26%	94.74%
	3	1.56%	98.44%	2.44%	97.56%
	4	0.00%	100.00%	0.00%	100.00%
	5	0.00%	100.00%	0.00%	100.00%
	6	0.00%	100.00%	0.00%	100.00%
	7	4.55%	95.45%	0.00%	100.00%
	8	4.55%	95.45%	0.00%	100.00%
		Skagerrak		Kattegat	
Quarter	W-rings	North Sea autumn SP	Baltic Spring SP	North Sea autumn SP	Baltic Spring SP
4	0	84.38%	15.63%	100.00%	0.00%
	1	17.65%	82.35%	21.28%	78.72%
	2	2.33%	97.67%	0.00%	100.00%
	3	4.35%	95.65%	0.00%	100.00%
	4	4.35%	95.65%	0.00%	100.00%
	5	4.35%	95.65%	0.00%	100.00%
	6	4.35%	95.65%	0.00%	100.00%
	7	4.35%	95.65%	0.00%	100.00%
	8	4.35%	95.65%	0.00%	100.00%

Table 3.2.7 WESTERN BALTIC HERRING.
Landings in numbers (mill.), mean weight (g.) and SOP (t) by age, quarter and fleet. ***North Sea Autumn spawners***
Division: Kattegat Year: 2008 Country: All

		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
1	1	5.05	39	10.96	28	16.01	32
	2	18.32	73	4.45	74	22.78	73
	3	0.92	102	0.13	110	1.06	103
	4	0.15	129	0.01	131	0.16	129
	5						
	6						
	7	0.26	208			0.26	208
	8+	0.03	201	0.00	158	0.03	199
	Total	24.73		15.57		40.30	
	SOP		1,711		652		2,364
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
2	1	1.85	54	8.09	18	9.94	24
	2	2.13	78			2.13	78
	3	0.08	97			0.08	97
	4						
	5						
	6						
	7						
	8+						
	Total	4.07		8.09		12.16	
	SOP		275		143		418
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
3	0	0.18	22	38.69	15	38.87	15
	1	2.48	63	0.00	65	2.48	63
	2	0.18	79	0.00	84	0.18	79
	3	0.03	105	0.00	115	0.03	105
	4						
	5						
	6						
	7						
	8+						
	Total	2.88		38.69		41.56	
	SOP		178		575		753
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
4	0	0.30	36	40.90	15	41.20	15
	1	2.91	67	0.12	73	3.03	67
	2						
	3						
	4						
	5						
	6						
	7						
	8+						
	Total	3.21		41.02		44.23	
	SOP		205		618		822
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
Total	0	0.48	31	79.58	15	80.06	15
	1	12.30	53	19.17	24	31.47	35
	2	20.64	74	4.45	74	25.09	74
	3	1.03	102	0.13	110	1.17	102
	4	0.15	129	0.01	131	0.16	129
	5						
	6						
	7	0.26	208			0.26	208
	8+	0.03	201	0.00	158	0.03	199
	Total	34.88		103.36		138.24	
	SOP		2,368		1,988		4,356

Table 3.2.8 WESTERN BALTIC HERRING.
Landings in numbers (mill.), mean weight (g.) and SOP (t) by age, quarter and fleet. ***North Sea Autumn spawners***
Division: Skagerrak Year: 2008 Country: All

Quarter	W-rings	Fleet C Numbers	Fleet C Mean W.	Fleet D Numbers	Fleet D Mean W.	Total Numbers	Total Mean W.
1	1	1.67	42	4.20	37	5.87	39
	2	14.23	92	14.95	88	29.18	90
	3	0.02	114	0.05	110	0.08	111
	4						
	5						
	6						
	7						
	8+						
	Total	15.93		19.20		35.13	
	SOP		1,387		1,477		2,864
2	1	1.57	49	3.35	42	4.92	44
	2	12.26	94	0.01	94	12.27	94
	3	0.22	114	0.00	102	0.22	114
	4	0.01	121	0.00	121	0.01	121
	5	0.05	132	0.00	130	0.05	132
	6	0.01	141	0.00	141	0.01	141
	7	0.00	154	0.00	154	0.00	154
	8+	0.00	164	0.00	164	0.00	164
	Total	14.13		3.37		17.50	
	SOP		1,261		141		1,402
3	0	0.45	35	0.02	20	0.47	34
	1	37.67	77	0.03	75	37.70	77
	2	5.27	109	0.00	108	5.28	109
	3	0.22	126	0.00	126	0.22	126
	4						
	5						
	6						
	7	0.05	191	0.00	193	0.05	191
	8+	0.03	198	0.00	194	0.03	198
	Total	43.70		0.05		43.75	
	SOP		3,530		3		3,533
4	0	3.41	37	1.72	26	5.13	33
	1	6.00	81	0.63	77	6.63	81
	2	0.18	110	0.01	104	0.19	110
	3	0.19	125	0.00	122	0.19	125
	4	0.07	163	0.00	187	0.07	164
	5	0.10	185	0.00	221	0.10	185
	6	0.05	183	0.00	170	0.05	183
	7	0.01	182	0.00	187	0.01	182
	8+	0.01	213			0.01	213
	Total	10.01		2.36		12.37	
	SOP		698		95		793
Total	0	3.85	37	1.74	26	5.60	33
	1	46.92	75	8.21	42	55.13	70
	2	31.94	96	14.97	88	46.91	93
	3	0.65	121	0.06	111	0.71	120
	4	0.09	157	0.00	176	0.09	157
	5	0.15	168	0.00	187	0.15	168
	6	0.06	175	0.00	161	0.06	175
	7	0.07	187	0.00	184	0.07	187
	8+	0.04	197	0.00	172	0.04	197
	Total	83.76		24.99		108.75	
	SOP		6,877		1,716		8,592

Table 3.2.9 WESTERN BALTIC HERRING.
Landings in numbers (mill.), mean weight (g.) and SOP (t) by age, quarter and fleet. ***Baltic Spring spawners***
Division: Kattegat Year: 2008 Country: All

Quarter	W-rings	Fleet C Numbers	Fleet C Mean W.	Fleet D Numbers	Fleet D Mean W.	Total Numbers	Total Mean W.
1	1	1.63	39	3.53	28	5.15	32
	2	17.50	73	4.25	74	21.76	73
	3	11.97	102	1.75	110	13.72	103
	4	2.75	129	0.27	131	3.02	129
	5	3.15	149	0.13	138	3.28	149
	6	2.00	193	0.04	164	2.05	192
	7	2.33	208			2.33	208
	8+	0.25	201	0.01	158	0.26	199
	Total	41.58		9.99		51.57	
	SOP		4,307		666		4,973
2	1	0.24	54	1.05	18	1.30	24
	2	0.94	78			0.94	78
	3	0.75	97			0.75	97
	4	0.36	111			0.36	111
	5	0.21	139			0.21	139
	6	0.15	165			0.15	165
	7	0.17	189			0.17	189
	8+	0.05	164			0.05	164
	Total	2.87		1.05		3.93	
	SOP		293		19		312
3	0	0.02	22	3.75	15	3.77	15
	1	14.45	63	0.00	65	14.45	63
	2	3.29	79	0.00	84	3.29	79
	3	1.05	105	0.00	115	1.05	105
	4	0.59	105	0.00	137	0.59	105
	5	0.20	180	0.00	180	0.20	180
	6	0.15	129	0.00	204	0.15	129
	7	0.07	211	0.00	140	0.07	211
	8+	0.04	206	0.00	206	0.04	206
	Total	19.86		3.75		23.62	
	SOP		1,421		56		1,477
4	0						
	1	10.76	67	0.46	73	11.21	67
	2	2.36	82	0.09	92	2.45	82
	3	0.68	106	0.03	122	0.72	107
	4	0.46	106	0.01	145	0.48	107
	5	0.04	147	0.00	147	0.04	147
	6	0.12	108	0.00	120	0.12	108
	7	0.06	236	0.00	238	0.06	236
	8+	0.01	162	0.00	162	0.01	162
	Total	14.50		0.60		15.10	
	SOP		1,067		49		1,115
Total	0	0.02	22	3.75	15	3.77	15
	1	27.08	63	5.04	30	32.12	58
	2	24.09	75	4.34	74	28.43	75
	3	14.46	102	1.78	110	16.25	103
	4	4.16	121	0.29	131	4.45	122
	5	3.60	150	0.13	139	3.73	150
	6	2.43	183	0.05	162	2.47	182
	7	2.63	207	0.00	238	2.63	207
	8+	0.35	195	0.01	158	0.36	193
	Total	78.81		15.40		94.21	
	SOP		7,088		789		7,877

Table 3.2.10 WESTERN BALTIC HERRING.
Landings in numbers (mill.), mean weight (g.) and SOP (t) by age, quarter and fleet. ***Baltic Spring spawners***
Division: Skagerrak Year: 2008 Country: All

Quarter	W-rings	Fleet C Numbers	Fleet C Mean W.	Fleet D Numbers	Fleet D Mean W.	Total Numbers	Total Mean W.
1	1	0.29	42	0.72	37	1.01	39
	2	5.60	92	5.88	88	11.48	90
	3	1.16	114	2.69	110	3.85	111
	4	0.13	142	0.58	142	0.70	142
	5	0.41	147	0.44	181	0.85	164
	6	0.07	193	0.31	193	0.38	193
	7	0.03	205	0.13	205	0.16	205
	8+	0.03	193	0.13	193	0.16	193
	Total	7.70		10.89		18.59	
	SOP		764		1,114		1,878
2	1	0.10	49	0.22	42	0.32	44
	2	6.51	94	0.01	94	6.52	94
	3	0.71	114	0.00	102	0.71	114
	4	0.21	121	0.00	121	0.21	121
	5	0.76	132	0.01	130	0.77	132
	6	0.16	141	0.00	141	0.16	141
	7	0.05	154	0.00	154	0.05	154
	8+	0.07	164	0.00	164	0.07	164
	Total	8.57		0.24		8.81	
	SOP		864		11		875
3	0	0.18	35	0.01	20	0.18	34
	1	37.36	77	0.03	75	37.39	77
	2	16.74	109	0.01	108	16.75	109
	3	13.85	126	0.01	126	13.86	126
	4	6.33	151	0.00	149	6.34	151
	5	7.52	183	0.01	183	7.52	183
	6	3.61	181	0.00	180	3.62	181
	7	1.15	191	0.00	193	1.15	191
	8+	0.53	198	0.00	194	0.53	198
	Total	87.27		0.07		87.34	
	SOP		9,751		7		9,757
4	0	0.63	37	0.32	26	0.95	33
	1	27.99	81	2.93	77	30.93	81
	2	7.54	110	0.27	104	7.81	110
	3	4.07	125	0.10	122	4.17	125
	4	1.60	163	0.02	187	1.61	164
	5	2.17	185	0.01	221	2.18	185
	6	1.01	183	0.01	170	1.02	183
	7	0.32	182	0.01	187	0.33	182
	8+	0.14	213			0.14	213
	Total	45.48		3.66		49.14	
	SOP		4,572		283		4,856
Total	0	0.81	36	0.33	26	1.13	33
	1	65.74	79	3.90	68	69.65	78
	2	36.39	104	6.17	89	42.56	102
	3	19.79	124	2.80	110	22.59	123
	4	8.26	152	0.60	144	8.86	152
	5	10.85	178	0.47	181	11.32	178
	6	4.85	180	0.32	192	5.17	181
	7	1.55	188	0.14	204	1.69	189
	8+	0.77	198	0.13	193	0.91	197
	Total	149.02		14.86		163.88	
	SOP		15,950		1,416		17,366

Table 3.2.11 WESTERN BALTIC HERRING.
Landings in numbers (mill.), mean weight (g.) and SOP (t) by age, quarter and fleet. ***North Sea Autumn spawners***
Division: IIIa Year: 2008 Country: All

Quarter	W-rings	Fleet C Numbers	Fleet C Mean W.	Fleet D Numbers	Fleet D Mean W.	Total Numbers	Total Mean W.
1	1	6.73	40	15.16	31	21.89	34
	2	32.55	82	19.41	85	51.95	83
	3	0.94	102	0.19	110	1.13	103
	4	0.15	129	0.01	131	0.16	129
	5						
	6						
	7	0.26	208			0.26	208
	8+	0.03	201	0.00	158	0.03	199
	Total	40.66		34.77		75.43	
	SOP		3,098		2,130		5,227
2	1	3.42	52	11.44	25	14.86	31
	2	14.39	91	0.01	94	14.40	91
	3	0.31	109	0.00	102	0.31	109
	4	0.01	121	0.00	121	0.01	121
	5	0.05	132	0.00	130	0.05	132
	6	0.01	141	0.00	141	0.01	141
	7	0.00	154	0.00	154	0.00	154
	8+	0.00	164	0.00	164	0.00	164
	Total	18.20		11.46		29.65	
	SOP		1,536		283		1,820
3	0	0.63	31	38.71	15	39.34	15
	1	40.16	76	0.03	75	40.19	76
	2	5.46	108	0.00	108	5.46	108
	3	0.25	123	0.00	126	0.25	123
	4						
	5						
	6						
	7	0.05	191	0.00	193	0.05	191
	8+	0.03	198	0.00	194	0.03	198
	Total	46.57		38.74		85.31	
	SOP		3,708		578		4,286
4	0	3.71	37	42.62	15	46.32	17
	1	8.91	76	0.75	76	9.66	76
	2	0.18	110	0.01	104	0.19	110
	3	0.19	125	0.00	122	0.19	125
	4	0.07	163	0.00	187	0.07	164
	5	0.10	185	0.00	221	0.10	185
	6	0.05	183	0.00	170	0.05	183
	7	0.01	182	0.00	187	0.01	182
	8+	0.01	213			0.01	213
	Total	13.21		43.38		56.59	
	SOP		903		713		1,615
Total	0	4.34	36	81.32	15	85.66	16
	1	59.21	71	27.38	29	86.60	58
	2	52.58	87	19.43	85	72.00	86
	3	1.68	109	0.19	110	1.88	109
	4	0.23	139	0.02	133	0.25	139
	5	0.15	168	0.00	187	0.15	168
	6	0.06	175	0.00	161	0.06	175
	7	0.33	203	0.00	184	0.33	203
	8+	0.06	199	0.00	159	0.07	198
	Total	118.64		128.35		246.99	
	SOP		9,245		3,704		12,949

Table 3.2.12 WESTERN BALTIC HERRING.
Landings in numbers (mill.), mean weight (g.) and SOP (t) by age, quarter and fleet. ***Baltic Spring spawners***
Division: IIIa Year: 2008 Country: All

		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
1	1	1.91	40	4.25	30	6.17	33
	2	23.10	78	10.14	82	33.24	79
	3	13.13	103	4.44	110	17.57	105
	4	2.88	130	0.85	138	3.72	132
	5	3.56	149	0.57	171	4.13	152
	6	2.07	193	0.35	189	2.42	192
	7	2.35	207	0.13	205	2.49	207
	8+	0.28	200	0.15	190	0.42	197
	Total	49.28		20.88		70.16	
	SOP		5,071		1,780		6,851

		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
2	1	0.34	53	1.27	22	1.62	28
	2	7.45	92	0.01	94	7.46	92
	3	1.46	105	0.00	102	1.46	105
	4	0.56	114	0.00	121	0.57	114
	5	0.98	134	0.01	130	0.98	134
	6	0.31	153	0.00	141	0.31	153
	7	0.22	181	0.00	154	0.22	181
	8+	0.12	164	0.00	164	0.12	164
	Total	11.45		1.29		12.74	
	SOP		1,157		30		1,187

		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
3	0	0.19	34	3.76	15	3.95	16
	1	51.81	73	0.03	75	51.84	73
	2	20.03	104	0.01	108	20.04	104
	3	14.91	124	0.01	126	14.91	124
	4	6.92	147	0.00	149	6.93	147
	5	7.72	183	0.01	183	7.72	183
	6	3.77	179	0.00	180	3.77	179
	7	1.22	192	0.00	192	1.22	192
	8+	0.57	199	0.00	195	0.57	199
	Total	107.13		3.82		110.95	
	SOP		11,172		63		11,234

		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
4	0	0.63	37	0.32	26	0.95	33
	1	38.75	77	3.39	77	42.14	77
	2	9.91	104	0.36	101	10.26	104
	3	4.76	122	0.13	122	4.89	122
	4	2.06	150	0.03	168	2.09	151
	5	2.20	184	0.02	206	2.22	184
	6	1.13	175	0.01	157	1.14	175
	7	0.38	190	0.01	194	0.38	190
	8+	0.16	209	0.00	162	0.16	208
	Total	59.98		4.26		64.24	
	SOP		5,639		332		5,971

		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
Total	0	0.82	36	4.08	16	4.90	19
	1	92.82	74	8.95	46	101.76	72
	2	60.48	92	10.51	83	71.00	91
	3	34.25	115	4.58	110	38.84	114
	4	12.42	142	0.89	140	13.31	142
	5	14.45	171	0.60	172	15.05	171
	6	7.28	181	0.37	188	7.65	181
	7	4.18	200	0.14	204	4.32	200
	8+	1.12	197	0.15	190	1.27	196
	Total	227.84		30.26		258.10	
	SOP		23,038		2,205		25,243

Table 3.2.13 **WESTERN BALTIC HERRING.**

Total catch in numbers (mill) and mean weight (g), SOP (tonnes) of *Western Baltic Spring spawners* in Division IIIa and the North Sea in the years 1992-2008.

Year	W-rings	0	1	2	3	4	5	6	7	8+	Total
1992	**Numbers**	109.08	246.00	321.85	174.02	154.47	78.33	55.83	17.91	8.53	1,166.03
	Mean W.	13.9	44.1	87.0	112.9	136.2	166.3	183.5	194.4	203.6	
	SOP	1,516	10,841	27,986	19,653	21,035	13,030	10,243	3,481	1,737	109,523
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	**Numbers**	7.3	104.1	115.6	114.2	48.9	55.7	11.1	10.3	5.2	472.49
corrected	**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	295.2
	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	258.8
	Mean W.	19.2	71.5	91.1	114.5	142.2	171.2	181.4	200.0	196.4	98.0
	SOP	94	7,281	6,472	4,456	1,917	2,590	1,402	900	256	25,368

Data for 1995 to 2001 was revised in 2003.

Table 3.2.14 **WESTERN BALTIC HERRING.**
Landings in numbers (mill.), mean weight (g.) and SOP (t)
by age and quarter from. Western Baltic Spring Spawners
(values from the North Sea, see Table 2.2.1-2.2.5)

Division: IV + IIIa + 22-24 **Year: 2008**

		Division IV		Division IIIa		Sub-division 22-24		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
1	1	0.00	24.00	6.17	32.79	2.89	19.59	9.06	29
	2	0.00	56.03	33.24	79.05	14.66	53.94	47.89	71
	3	0.00	109.83	17.57	104.66	34.04	84.45	51.61	91
	4	0.00	244.00	3.72	131.61	30.39	110.58	34.11	113
	5	0.00	262.00	4.13	151.98	37.98	147.62	42.11	148
	6	0.00	325.00	2.42	192.25	18.39	159.38	20.81	163
	7	0.00	267.00	2.49	207.34	5.70	175.27	8.19	185
	8+	0.00	268.50	0.42	196.72	9.59	187.33	10.02	188
	Total	0.00		70.16		153.65		223.81	
	SOP		0		6,851		18,417		25,267

		Division IV		Division IIIa		Sub-division 22-24		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
2	1	0.00	67.00	1.62	28.35	6.55	20.71	8.17	22
	2	0.06	144.00	7.46	91.69	20.57	49.18	28.09	61
	3	0.06	163.00	1.46	105.05	31.57	71.39	33.08	73
	4	0.12	166.00	0.57	114.33	24.80	88.21	25.48	89
	5	0.05	163.00	0.98	133.79	17.97	100.69	19.00	103
	6	0.06	189.00	0.31	152.56	12.84	118.55	13.21	120
	7	0.13	191.00	0.22	181.12	4.55	132.19	4.90	136
	8+	0.02	210.43	0.12	164.09	5.49	138.37	5.64	139
	Total	0.50		12.74		124.34		137.58	
	SOP		87		1,187		10,281		11,555

		Division IV		Division IIIa		Sub-division 22-24		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
3	0	0.00	0.00	3.95	15.80	1.22	21.54	5.17	17
	1	0.00	71.72	51.84	72.98	17.55	64.29	69.39	71
	2	0.01	128.31	20.04	104.17	13.25	86.61	33.30	97
	3	0.02	142.52	14.91	124.21	11.43	114.22	26.37	120
	4	0.05	159.68	6.93	147.06	7.48	139.04	14.46	143
	5	0.02	179.86	7.72	182.64	5.70	139.92	13.44	165
	6	0.02	199.76	3.77	178.56	2.03	122.97	5.83	159
	7	0.05	219.58	1.22	191.79	1.02	171.78	2.29	184
	8+	0.01	228.86	0.57	198.54	0.67	222.02	1.25	211
	Total	0.19		110.95		60.37		171.51	
	SOP		35		11,234		6,021		17,290

		Division IV		Division IIIa		Sub-division 22-24		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
4	0	0.00	15.02	0.95	33.28	3.49	14.46	4.44	18
	1	0.00	56.03	42.14	77.11	21.42	50.27	63.57	68
	2	0.00	109.83	10.26	103.60	18.64	76.57	28.90	86
	3	0.01	244.00	4.89	122.07	19.13	106.75	24.02	110
	4	0.00	262.00	2.09	150.67	12.55	137.43	14.65	139
	5	0.00	325.00	2.22	184.07	8.82	133.16	11.04	143
	6	0.00	267.00	1.14	174.81	3.53	130.12	4.67	141
	7	0.00	268.00	0.38	190.31	1.43	149.67	1.81	158
	8+	0.00	271.50	0.16	208.22	1.28	178.33	1.44	182
	Total	0.01		64.24		90.29		154.54	
	SOP		3		5,971		8,397		14,371

		Division IV		Division IIIa		Sub-division 22-24		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
Total	0	0.00	0.00	4.90	19.19	4.71	16.29	9.61	18
	1	0.00	0.00	101.76	71.54	48.42	49.52	150.19	64
	2	0.07	141.82	71.00	91.01	67.12	65.22	138.18	79
	3	0.09	164.67	38.84	114.37	96.17	88.14	135.09	96
	4	0.17	165.72	13.31	141.91	75.22	110.52	88.70	115
	5	0.08	167.96	15.05	171.25	70.46	133.22	85.59	140
	6	0.08	192.17	7.65	181.27	36.80	140.31	44.53	147
	7	0.18	199.41	4.32	200.07	12.70	156.68	17.20	168
	8+	0.04	215.85	1.27	195.89	17.04	172.24	18.34	174
	Total	0.70		258.10		428.64		687.43	
	SOP		124		25,243		43,116		68,484

Table 3.2.15 **WESTERN BALTIC HERRING.**
Total catch in numbers (mill) of *Western Baltic Spring Spawners* in Division IIIa+North Sea and in Sub-Divisions 22-24 in the years 1992-2008

Year	W-rings / Area	0	1	2	3	4	5	6	7	8+	Total
1992	**Div. IV+Div. IIIa**	109.1	246.0	321.9	174.0	154.5	78.3	55.8	17.9	8.5	1056.9
	Sub-div. 22-24	36.0	210.7	280.8	190.8	179.5	104.9	84.0	34.8	14.0	1099.5
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
	Sub-div. 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
	Sub-div. 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
	Sub-div. 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
	Sub-div. 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
	Sub-div. 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
	Sub-div. 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
	Sub-div. 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
	Sub-div. 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
	Sub-div. 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
	Sub-div. 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
	Sub-div. 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
	Sub-div. 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
	Sub-div. 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
	Sub-div. 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
	Sub-div. 22-24	9.1	68.2	93.9	107.0	96.1	52.2	20.8	15.0	12.1	474.3
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
	Sub-div. 22-24	4.7	48.4	67.1	96.2	75.2	70.5	36.8	12.7	17.0	428.6

Data for 1995-2001 for the North Sea and Div. IIIa was revised in 2003.

[c] values have been corrected in 2007

Table 3.2.16 **WESTERN BALTIC HERRING.**
Mean weight (g) and SOP (tons) of *Western Baltic Spring Spawners* in Division IIIa+North Sea and in Sub-Divisions 22-24 in the years 1992-2008

Year	Area / W-rings	0	1	2	3	4	5	6	7	8+	SOP
1992	**Div. IV+Div. IIIa**	13.9	44.1	87.0	112.9	136.2	166.3	183.5	194.4	203.6	109,523
	Sub-div. 22-24	19.1	23.3	44.8	77.4	99.2	123.3	152.9	166.2	184.2	84,888
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
	Sub-div. 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
	Sub-div. 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
	Sub-div. 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
	Sub-div. 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
	Sub-div. 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
	Sub-div. 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
	Sub-div. 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
	Sub-div. 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
	Sub-div. 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
	Sub-div. 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
	Sub-div. 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
	Sub-div. 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	44,645
	Sub-div. 22-24	13.6	14.2	48.3	73.3	89.3	115.5	143.6	159.9	170.2	43,725
2006 c	**Div. IV+Div. IIIa**	16.6	36.9	82.9	113.0	142.5	175.2	198.2	209.5	220.0	48,688
	Sub-div. 22-24	21.2	34.0	56.7	84.0	102.2	125.3	143.9	175.8	170.0	41,861
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
	Sub-div. 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
	Sub-div. 22-24	16.3	49.5	65.2	88.1	110.5	133.2	140.3	156.7	172.2	43,116

Data for 1995-2001 for the North Sea and Div. IIIa was revised in 2003.

[c] values have been corrected in 2007

Table 3.2.17 WESTERN BALTIC HERRING.
Transfers of *North Sea autumn spawners* from Div. IIIa to the North Sea
Numbers ('000) and mean weight, SOP in (tonnes) 1992-2008.

Year	W-Rings	0	1	2	3	4	5	6	7	8+	Total
1992	Number	2,298.4	1,408.8	220.3	22.1	10.4	6.6	2.9	1.0	0.4	3,970.9
	Mean W.	12.3	51.8	84.2	131.4	162.0	173.4	185.3	198.4	201.2	
	SOP	28,159	72,985	18,557	2,907	1,683	1,143	533	200	84	126,251
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

Corrections for the years 1991-1998 was made in WG2001, but are NOT included in the North Sea assessment.

Table 3.3.1 **WESTERN BALTIC HERRING. German Acoustic survey (GerAS) on the Spring Spawning Herring in Sub-divisions 21 (Southern Kattegat, 41G0-42G2) - 24 in autumn 1993-2008 (September/October).**

Year	1993	1994	1995	1996	1997	1998	1999	2000	2001*	2002**	2003	2004	2005	2006	2007	2008
Numbers in millions																
W-rings																
0	893	5,475	5,108	1,833	2,859	2,490	5,994	1,009	2,478	4,103	3,777	2,555	3,055	4,159	2,591	2,150
1	492	416	1,675	1,439	1,955	801	1,339	1,430	1,126	838	1,238	969	753	950	560	393
2	437	884	329	590	738	679	287	454	1,227	421	223	592	640	274	278	214
3	530	560	358	434	395	394	233	329	845	575	217	346	401	376	149	209
4	403	444	354	295	162	237	156	202	367	341	260	163	192	353	136	150
5	125	189	254	306	119	100	52	79	132	64	97	143	105	183	88	166
6	55	60	127	119	99	51	8	39	86	25	38	79	90	131	25	102
7	28	24	46	47	33	24	1	6	20	10	9	23	26	85	23	42
8+	13	2	27	19	48	9	2	4	10	13	10	12	17	30	11	19
Total	2,976	8,053	8,277	5,083	6,409	4,785	8,072	3,551	6,290	6,389	5,869	4,882	5,279	6,542	3,860	3,445
3+ group	1,154	1,279	1,166	1,220	856	815	452	658	1,459	1,028	631	766	830	1,159	432	688
Biomass ('000 tonnnes)																
W-rings																
0	12.8	66.9	58.5	16.6	28.5	23.8	71.8	13.8	31.2	38.2	33.9	23.1	33.1	43.9	25.8	24.8
1	19.5	14.5	58.6	46.6	76.4	39.9	51.1	57.5	48.2	34.2	44.8	35.9	30.1	38.8	23.0	17.7
2	21.7	41.0	20.9	29.1	43.5	50.1	22.0	28.4	75.9	30.0	16.1	34.5	48.6	19.7	20.8	12.5
3	33.8	40.7	30.1	31.0	35.9	35.3	27.5	27.7	77.2	56.8	22.0	27.7	36.2	35.9	12.6	17.7
4	25.7	43.0	40.1	21.2	22.3	28.0	16.7	24.1	38.0	40.4	34.2	18.4	22.7	37.4	12.5	14.3
5	12.7	24.2	27.3	37.1	16.7	11.4	6.8	9.3	18.5	9.0	14.6	17.3	14.4	27.2	8.9	16.8
6	7.1	12.3	14.9	16.1	14.0	6.2	0.9	5.6	13.3	3.5	5.7	12.2	14.5	19.9	2.9	8.8
7	2.3	5.3	9.3	6.1	5.3	3.7	0.3	1.2	3.9	1.1	1.3	3.4	5.2	14.6	2.6	3.5
8+	1.8	0.6	6.6	2.9	10.6	2.2	0.5	0.8	2.1	1.9	1.6	2.0	3.6	6.5	1.9	2.0
Total	137.3	248.5	266.3	206.8	253.3	200.5	197.5	168.4	308.1	215.0	174.2	174.6	208.3	243.9	111.0	118.0
3+ group	83.3	126.2	128.2	114.4	104.9	86.8	52.6	68.7	152.9	112.6	79.4	81.1	96.5	141.5	41.4	63.0
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	10.8	10.5	10.0	11.5
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	40.0	40.8	41.0	45.0
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	76.0	71.9	74.8	58.4
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	90.2	95.3	84.6	84.7
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	118.3	106.2	92.0	95.5
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	136.7	148.9	100.9	100.7
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	161.3	151.7	116.8	86.5
7	81.0	225.2	199.6	129.9	160.2	157.2	237.9	204.5	198.5	110.9	156.6	151.0	201.8	171.5	109.3	83.4
8+	137.7	269.1	241.2	154.9	222.3	232.6	218.5	180.7	217.0	142.6	163.3	169.2	213.4	213.9	176.0	103.3
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	39.5	37.3	28.7	34.3

*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

Table 3.3.2 WESTERN BALTIC HERRING. Herring acoustic survey (HERAS) on the Spring Spawning Herring in the North Sea/Division IIIa in 1991-2007 (July).

Year	1991	1992*	1993*	1994*	1995*	1996*	1997	1998	1999**	2000	2001	2002	2003	2004	2005	2006	2007	2008
	Numbers in millions																	
W-rings																		
0		3,853	372	964														112
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
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
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
4	866	1,593	598	501	1,270	141	166	282	135	364	153	524	323	307	201	490	499	333
5	350	556	434	239	255	119	67	111	28	186	96	88	103	184	103	180	154	274
6	88	197	154	186	174	37	69	51	3	56	38	40	25	72	84	27	34	176
7	72	122	63	62	39	20	80	31	2	7	23	18	12	22	37	10	26	45
8+	10	20	13	34	21	13	77	53	1	10	12	17	5	18	21	0.1	14	44
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
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
	Biomass ('000 tonnnes)																	
W-rings																		
0		34.3	1	8.7														
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
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
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
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
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
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
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
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	0.02	1.94	8.65
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
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
	Mean weight (g)																	
W-rings																		
0		8.9	4.0	9.0														6.3
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
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
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
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
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
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
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
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
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

* 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 3.3.3WESTERN BALTIC HERRING.
N20 Larval Abundance Index.
Estimation of 0-Group herring reaching 20 mm in length in Greifswalder Bodden and adjacent waters (March/April to June).

Year	N20 (millions)
1992	1,060
1993	3,044
1994	12,515
1995	7,930
1996	21,012
1997	4,872
1998	16,743
1999	20,364
2000	3,026
2001	4,845
2002	11,324
2003	5,507
2004	5,640
2005	3,887
2006	3,774
2007	1,900
2008	1,600

TABLE 3.6.1 WBSS HERRING. CATCH IN NUMBER

Units : thousands

age	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
0	118958	145090	206102	263202	541302	171144	376795	549774	569599	152581
1	825969	456707	530707	249398	1660683	638877	668616	623072	616124	934545
2	541246	602624	495950	364980	438136	400585	289336	430903	334339	496396
3	564430	364864	415108	382650	226810	199681	276919	182860	246212	186615
4	279767	333993	260950	267033	194870	144155	75283	146685	90259	128625
5	177486	183200	210497	168142	84123	130086	43119	45322	55919	71727
6	46487	139835	102768	118416	60096	65274	39916	23759	15481	38262
7	13241	52660	63922	49504	32878	30705	21211	15400	9478	13777
8	4933	22574	24535	33088	20459	25111	24134	14112	6084	10689

age	2001	2002	2003	2004	2005	2006	2007	2008
0	756285	150271	53489	243554	106906	7946	10721	9610
1	523163	659130	126876	457754	305171	148909	172044	150188
2	488816	281840	264855	197812	319225	187674	184735	138181
3	257837	321311	161251	164766	177833	233214	143904	135093
4	108097	172285	189432	93214	130394	150654	126861	88702
5	68376	57160	103648	91242	60639	98751	64996	85592
6	39092	38532	29117	48957	65695	42459	30199	44530
7	18307	13842	17452	14876	31231	32418	21256	17195
8	6687	8329	8819	11013	12620	17312	14759	18343

TABLE 3.6.2 WBSS HERRING. WEIGHTS AT AGE IN THE CATCH

Units : kg

age	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
0	0.0296	0.0152	0.0154	0.0146	0.0101	0.0106	0.0296	0.0143	0.0111	0.0211
1	0.0348	0.0345	0.0254	0.0370	0.0209	0.0246	0.0275	0.0333	0.0343	0.0255
2	0.0669	0.0673	0.0680	0.0833	0.0684	0.0809	0.0684	0.0663	0.0658	0.0578
3	0.0949	0.0944	0.1020	0.1032	0.0984	0.0970	0.1181	0.0942	0.0981	0.0950
4	0.1234	0.1163	0.1143	0.1221	0.1235	0.1125	0.1342	0.1178	0.1164	0.1301
5	0.1390	0.1417	0.1361	0.1411	0.1520	0.1328	0.1620	0.1367	0.1471	0.1428
6	0.1556	0.1651	0.1679	0.1565	0.1704	0.1369	0.1817	0.1663	0.1566	0.1463
7	0.1709	0.1758	0.1823	0.1705	0.2063	0.1542	0.1967	0.1652	0.1538	0.1583
8	0.1826	0.1915	0.1989	0.1860	0.2170	0.1910	0.2087	0.1870	0.1576	0.1591

age	2001	2002	2003	2004	2005	2006	2007	2008
0	0.0123	0.0105	0.0132	0.00618	0.0140	0.0170	0.0139	0.0178
1	0.0243	0.0213	0.0315	0.02754	0.0272	0.0360	0.0506	0.0644
2	0.0593	0.0700	0.0671	0.06419	0.0721	0.0728	0.0709	0.0785
3	0.0862	0.0968	0.0907	0.10017	0.0938	0.0982	0.0854	0.0957
4	0.1089	0.1196	0.1079	0.10596	0.1106	0.1153	0.1141	0.1153
5	0.1567	0.1400	0.1223	0.13139	0.1228	0.1535	0.1288	0.1399
6	0.1560	0.1876	0.1319	0.15228	0.1493	0.1581	0.1564	0.1474
7	0.1556	0.1814	0.1603	0.16768	0.1619	0.1865	0.1673	0.1680
8	0.1713	0.1717	0.1625	0.15295	0.1736	0.1848	0.1903	0.1739

TABLE 3.6.3 WBSS HERRING. WEIGHTS AT AGE IN THE STOCK

Units : kg

age \ year	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
0	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
1	0.0308	0.0203	0.0156	0.0186	0.0131	0.0181	0.0131	0.0221	0.0211	0.0140
2	0.0528	0.0451	0.0402	0.0529	0.0459	0.0546	0.0515	0.0558	0.0567	0.0431
3	0.0787	0.0818	0.0967	0.0836	0.0708	0.0905	0.1063	0.0829	0.0871	0.0837
4	0.1041	0.1075	0.1079	0.1077	0.1327	0.1170	0.1333	0.1128	0.1081	0.1250
5	0.1245	0.1313	0.1409	0.1392	0.1674	0.1197	0.1662	0.1338	0.1480	0.1436
6	0.1449	0.1593	0.1671	0.1566	0.1892	0.1538	0.1943	0.1678	0.1601	0.1629
7	0.1594	0.1710	0.1827	0.1768	0.2097	0.1467	0.2089	0.1683	0.1439	0.1650
8	0.1640	0.1869	0.1891	0.2028	0.2338	0.1280	0.2263	0.1843	0.1504	0.1831

age \ year	2001	2002	2003	2004	2005	2006	2007	2008
0	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
1	0.0169	0.0164	0.0144	0.0131	0.0126	0.0185	0.0150	0.0290
2	0.0509	0.0637	0.0445	0.0456	0.0514	0.0621	0.0550	0.0710
3	0.0783	0.0905	0.0793	0.0811	0.0800	0.0953	0.0800	0.0910
4	0.1159	0.1239	0.1051	0.1092	0.1066	0.1174	0.1140	0.1130
5	0.1690	0.1736	0.1268	0.1440	0.1322	0.1659	0.1430	0.1480
6	0.1763	0.1983	0.1506	0.1628	0.1573	0.1710	0.1710	0.1630
7	0.1681	0.1980	0.1729	0.1932	0.1677	0.1858	0.1750	0.1850
8	0.1805	0.2036	0.1847	0.2076	0.1820	0.1871	0.1880	0.1880

TABLE 3.6.4 WBSS HERRING. NATURAL MORTALITY

Units : NA

age \ year	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
0	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
1	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
4	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
5	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
6	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
7	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
8	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2

age \ year	2006	2007	2008
0	0.3	0.3	0.3
1	0.5	0.5	0.5
2	0.2	0.2	0.2
3	0.2	0.2	0.2
4	0.2	0.2	0.2
5	0.2	0.2	0.2
6	0.2	0.2	0.2
7	0.2	0.2	0.2
8	0.2	0.2	0.2

TABLE 3.6.5 WBSS HERRING. PROPORTION MATURE

Units : NA

age	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
3	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
4	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
5	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
6	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
7	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
8	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

age	2006	2007	2008
0	0.00	0.00	0.00
1	0.00	0.00	0.00
2	0.20	0.20	0.20
3	0.75	0.75	0.75
4	0.90	0.90	0.90
5	1.00	1.00	1.00
6	1.00	1.00	1.00
7	1.00	1.00	1.00
8	1.00	1.00	1.00

TABLE 3.6.6 WBSS HERRING. FRACTION OF HARVEST BEFORE SPAWNING

Units : NA

age	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
3	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
4	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
5	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
6	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
7	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
8	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1

age	2006	2007	2008
0	0.1	0.1	0.1
1	0.1	0.1	0.1
2	0.1	0.1	0.1
3	0.1	0.1	0.1
4	0.1	0.1	0.1
5	0.1	0.1	0.1
6	0.1	0.1	0.1
7	0.1	0.1	0.1
8	0.1	0.1	0.1

TABLE 3.6.7 WBSS HERRING. FRACTION OF NATURAL MORTALITY BEFORE SPAWNING

Units : NA

age	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
0	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
1	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
2	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
3	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
4	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
5	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
6	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
7	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
8	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25

age	2006	2007	2008
0	0.25	0.25	0.25
1	0.25	0.25	0.25
2	0.25	0.25	0.25
3	0.25	0.25	0.25
4	0.25	0.25	0.25
5	0.25	0.25	0.25
6	0.25	0.25	0.25
7	0.25	0.25	0.25
8	0.25	0.25	0.25

TABLE 3.6.8 WBSS HERRING. SURVEY INDICES

HERAS 3-6 wr - Configuration

min	max	plusgroup	minyear	maxyear	startf	endf
3.00	6.00	NA	1993.00	2008.00	0.58	0.67

Index type : number

HERAS 3-6 wr - Index Values

Units : NA

age	1993	1994	1995	1996	1997	1998	1999
3	1274000000	935000000	1022000000	247000000	787000000	901000000	NA
4	598000000	501000000	1270000000	141000000	166000000	282000000	NA
5	434000000	239000000	255000000	119000000	67000000	111000000	NA
6	154000000	186000000	174000000	37000000	69000000	51000000	NA

age	2000	2001	2002	2003	2004	2005	2006
3	673600000	452300000	1392800000	394600000	726000000	463500000	1780400000
4	363900000	153100000	524300000	323400000	306900000	201300000	490000000
5	185700000	96400000	87500000	103400000	183700000	102500000	180400000
6	55600000	37600000	39500000	25200000	72100000	83600000	27000000

age	2007	2008
3	933000000	843000000
4	499000000	333000000
5	154000000	274000000
6	34000000	176000000

HERAS 3-6 wr - Index Variance (Inverse Weights)

Units : NA

age	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
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

age	2008
3	1
4	1
5	1
6	1

continued TABLE 3.6.8 WBSS HERRING. SURVEY INDICES

GerAS 1-3 wr - Configuration

min	max	plusgroup	minyear	maxyear	startf	endf
1.00	3.00	NA	1994.00	2008.00	0.77	0.83

Index type : number

GerAS 1-3 wr - Index Values

Units : NA

age \ year	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
1	415730	1675340	1439460	1955400	801350	1338710	1429880	-1	837549	1238480
2	883810	328610	590010	738180	678530	287240	453980	-1	421393	222530
3	559720	357960	434090	394530	394070	232510	328960	-1	575356	217270

age \ year	2004	2005	2006	2007	2008
1	968860	752980	950450	560000	392780
2	592360	640060	274460	278000	213500
3	346230	401070	376480	149000	209000

GerAS 1-3 wr - Index Variance (Inverse Weights)

Units : NA

age \ year	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
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

N20 - Configuration

min	max	plusgroup	minyear	maxyear	startf	endf
0.0	0.0	NA	1992.0	2008.0	0.3	0.5

Index type : number

N20 - Index Values

Units : NA

age \ year	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
0	1060	3044	12515	7930	21012	4872	16743	20364	3026	4845	11324	5507	5640	3887

age \ year	2006	2007	2008
0	3774	1900	1600

N20 - Index Variance (Inverse Weights)

Units : NA

age \ year	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

age \ year	2007	2008
0	1	1

TABLE 3.6.9 WBSS HERRING. STOCK OBJECT CONFIGURATION

min	max	plusgroup	minyear	maxyear	minfbar	maxfbar
0	8	8	1991	2008	3	6

TABLE 3.6.10 WBSS HERRING. FLICA CONFIGURATION SETTINGS

```
sep.2       : NA
sep.gradual : TRUE
sr          : FALSE
sr.age      : 0
lambda.age  : 0.1 1 1 1 1 1 1 1 0
lambda.yr   : 1 1 1 1 1
lambda.sr   : 0
index.model : linear linear linear
index.cor   : 1 1 1
sep.nyr     : 5
sep.age     : 4
sep.sel     : 1
```

TABLE 3.6.11 WBSS HERRING. FLR, R SOFTWARE VERSIONS

```
R version 2.8.1 (2008-12-22)

Package  : FLICA
Version  : 1.4-10
Packaged : Sat Mar 21 18:30:56 2009; mpa
Built    : R 2.8.0; ; 2009-03-21 18:30:58; 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  : 3.0
Packaged : Fri Apr  3 09:33:49 2009; mpa
Built    : R 2.8.0; i386-pc-mingw32; 2009-04-03 09:33:52; windows
```

TABLE 3.6.12 WBSS HERRING. STOCK SUMMARY

Year	Recruitment Age 0	TSB	SSB	Fbar (Ages 3-6) f	Landings tonnes	Landings SOP
1991	5003979	616744	310543	0.358	191573	1.000
1992	3652584	541902	322123	0.476	194411	1.000
1993	3109372	464010	295303	0.544	185010	1.000
1994	6182874	377101	231273	0.689	172438	1.000
1995	4050991	318714	183178	0.512	150831	1.000
1996	4472243	273456	134412	0.701	121266	1.000
1997	3991042	275540	150554	0.510	115588	1.000
1998	5585578	272681	121510	0.492	107032	1.000
1999	6439794	289625	128418	0.373	97240	1.000
2000	3444329	294912	141946	0.466	109914	1.000
2001	4448602	319603	162715	0.454	105803	1.000
2002	3057143	351641	201961	0.410	106191	1.000
2003	4039490	266620	162065	0.394	78309	1.000
2004	2655128	281995	167171	0.358	76815	1.000
2005	2226088	286039	165281	0.407	88406	1.000
2006	1813432	314088	192109	0.396	90549	1.000
2007	1259682	248883	161537	0.358	68997	0.988
2008	894443	253761	159406	0.367	68484	1.000

TABLE 3.6.13 WBSS HERRING. ESTIMATED FISHING MORTALITY

Units : f

age	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
0	0.0279	0.047	0.0797	0.0505	0.167	0.0453	0.115	0.121	0.108	0.0526	0.218
1	0.2591	0.174	0.2984	0.1602	0.639	0.3781	0.308	0.351	0.237	0.3197	0.316
2	0.3195	0.372	0.3512	0.4219	0.572	0.3783	0.358	0.407	0.394	0.3714	0.334
3	0.4206	0.371	0.4747	0.5033	0.507	0.5617	0.490	0.403	0.432	0.3998	0.336
4	0.3984	0.474	0.4961	0.6462	0.522	0.7156	0.427	0.526	0.356	0.4225	0.427
5	0.3714	0.496	0.6269	0.7007	0.432	0.8130	0.483	0.497	0.390	0.5344	0.418
6	0.2399	0.565	0.5780	0.9072	0.587	0.7125	0.638	0.541	0.314	0.5076	0.634
7	0.4106	0.468	0.5511	0.6163	0.699	0.6883	0.534	0.547	0.432	0.5103	0.489
8	0.4106	0.468	0.5511	0.6163	0.699	0.6883	0.534	0.547	0.432	0.5103	0.489

age	2002	2003	2004	2005	2006	2007	2008
0	0.0585	0.0154	0.0199	0.0227	0.0220	0.0199	0.0204
1	0.3728	0.0782	0.1833	0.2087	0.2029	0.1833	0.1881
2	0.3409	0.3046	0.2424	0.2760	0.2683	0.2423	0.2487
3	0.3834	0.3339	0.3014	0.3432	0.3336	0.3013	0.3092
4	0.3943	0.4100	0.3608	0.4108	0.3993	0.3607	0.3701
5	0.4218	0.4384	0.3761	0.4282	0.4162	0.3759	0.3858
6	0.4411	0.3954	0.3926	0.4470	0.4345	0.3925	0.4028
7	0.4840	0.3668	0.3608	0.4108	0.3993	0.3607	0.3701
8	0.4840	0.3668	0.3608	0.4108	0.3993	0.3607	0.3701

TABLE 3.6.14 WBSS HERRING. ESTIMATED POPULATION ABUNDANCE

Units : NA

age	1991	1992	1993	1994	1995	1996	1997	1998	1999
0	5003979	3652584	3109372	6182874	4050991	4472243	3991042	5585578	6439794
1	4549372	3605104	2581634	2127100	4354977	2538818	3166531	2634467	3667888
2	2171998	2129499	1837128	1161808	1099199	1394465	1055070	1411769	1124560
3	1801225	1291944	1202461	1058709	623807	507889	782094	603999	769229
4	933200	968392	730181	612447	524004	307557	237112	392196	330430
5	627394	512981	493505	364024	262766	254500	123111	126606	189745
6	239518	354323	255855	215856	147892	139686	92414	62155	63051
7	43085	154275	164950	117524	71335	67321	56088	39982	29617
8	16052	66134	63312	78552	44389	55056	63818	36638	19011

age	2000	2001	2002	2003	2004	2005	2006	2007	2008
0	3444329	4448602	3057143	4039490	2655128	2226088	1813432	1259682	894443
1	4283602	2420957	2650607	2136119	2946679	1928203	1612172	1314150	914810
2	1754449	1887276	1070384	1107396	1198149	1487878	949184	798253	663594
3	620661	990765	1106052	623198	668615	769803	924364	594256	512908
4	408966	340693	579554	617148	365373	404973	447183	542139	359966
5	189480	219453	181977	319882	335317	208547	219874	245593	309473
6	105163	90909	118333	97715	168947	188486	111272	118727	138065
7	37710	51826	39485	62329	53872	93410	98693	58995	65651
8	29257	18930	23759	31497	39883	41055	57638	53461	65021

TABLE 3.6.15 WBSS HERRING. SURVIVORS AFTER TERMINAL YEAR

Units : NA

age	2009
0	NA
1	649225
2	459723
3	423677
4	308239
5	203543
6	172266
7	75561
8	73889

TABLE 3.6.16 WBSS HERRING. FITTED SELECTION PATTERN

Units : NA

age	2004	2005	2006	2007	2008
0	0.0552	0.0552	0.0552	0.0552	0.0552
1	0.5082	0.5082	0.5082	0.5082	0.5082
2	0.6719	0.6719	0.6719	0.6719	0.6719
3	0.8354	0.8354	0.8354	0.8354	0.8354
4	1.0000	1.0000	1.0000	1.0000	1.0000
5	1.0424	1.0424	1.0424	1.0424	1.0424
6	1.0882	1.0882	1.0882	1.0882	1.0882
7	1.0000	1.0000	1.0000	1.0000	1.0000
8	1.0000	1.0000	1.0000	1.0000	1.0000

TABLE 3.6.17 WBSS HERRING. PREDICTED CATCH IN NUMBERS

Units : NA

age \ year	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
0	118958	145090	206102	263202	541302	171144	376795	549774	569599	152581
1	825969	456707	530707	249398	1660683	638877	668616	623072	616124	934545
2	541246	602624	495950	364980	438136	400585	289336	430903	334339	496396
3	564430	364864	415108	382650	226810	199681	276919	182860	246212	186615
4	279767	333993	260950	267033	194870	144155	75283	146685	90259	128625
5	177486	183200	210497	168142	84123	130086	43119	45322	55919	71727
6	46487	139835	102768	118416	60096	65274	39916	23759	15481	38262
7	13241	52660	63922	49504	32878	30705	21211	15400	9478	13777
8	4933	22574	24535	33088	20459	25111	24134	14112	6084	10689

age \ year	2001	2002	2003	2004	2005	2006	2007	2008
0	756285	150271	53489	45230	43121	34157	21452	15629
1	523163	659130	126876	391377	288344	234957	174499	124399
2	488816	281840	264855	234699	326743	203345	156326	132978
3	257837	321311	161251	158477	203827	238958	140817	124284
4	108097	172285	189432	100892	124486	134315	149668	101550
5	68376	57160	103648	95853	66304	68319	70188	90365
6	39092	38532	29117	50043	62036	35800	35159	41766
7	18307	13842	17452	14876	28714	29643	16287	18521
8	6687	8329	8819	11013	12620	17312	14759	18343

TABLE 3.6.18 WBSS HERRING. CATCH RESIDUALS

Units : thousands NA

age \ year	2004	2005	2006	2007	2008
0	1.6836	0.9079	-1.4583	-0.6936	-0.4863
1	0.1567	0.0567	-0.4561	-0.0142	0.1884
2	-0.1710	-0.0233	-0.0802	0.1670	0.0384
3	0.0389	-0.1364	-0.0243	0.0217	0.0834
4	-0.0792	0.0464	0.1148	-0.1653	-0.1353
5	-0.0493	-0.0893	0.3684	-0.0769	-0.0543
6	-0.0219	0.0573	0.1706	-0.1521	0.0641
7	0.0000	0.0840	0.0895	0.2663	-0.0743
8	0.0000	0.0000	0.0000	0.0000	0.0000

TABLE 3.6.19 WBSS HERRING. PREDICTED INDEX VALUES

HERAS 3-6 wr

Units : NA NA

age \ year	1993	1994	1995	1996	1997	1998	1999
3	1174825597	1016025257	597208957	469935736	756729003	617080572	NA
4	561793112	429007990	396633155	206296485	190425267	296144842	NA
5	286302391	201663969	172205693	131433623	78121659	79655213	NA
6	124664870	85613207	71654004	62574134	43374240	30987159	NA

age \ year	2000	2001	2002	2003	2004	2005	2006
3	635442343	1055484031	1144031766	664850931	727965953	816534810	986368646
4	329461198	273671585	475184947	501059799	305923104	328645320	365510811
5	116467534	145104712	120011069	208786922	227553562	136987833	145511751
6	53543422	42772298	62807435	53364867	92431100	99672601	59302405

age \ year	2007	2008
3	647041263	555710453
4	453956297	299634253
5	166675711	208736005
6	64960551	75055786

GerAS 1-3 wr

Units : NA NA

age \ year	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
1	925227	1291674	927643	1223932	983454	1499773	1640061	NA	972616	992118
2	411636	345363	511605	393488	506108	407311	647219	NA	404627	430970
3	460871	270712	210995	344041	284857	354582	293506	NA	529935	310650

age \ year	2004	2005	2006	2007	2008
1	1258201	806753	677679	561152	389128
2	490063	592426	380272	326517	270057
3	342083	380908	460907	304060	260780

continued TABLE 3.6.19 WBSS HERRING. PREDICTED INDEX VALUES

N20

Units : NA NA

year

age	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
0	6158	5174	10409	6509	7545	6547	9144	10596	5794	7005	5130	6897	4525	3790

year

age	2006	2007	2008
0	3088	2147	1524

TABLE 3.6.20 WBSS HERRING. INDEX RESIDUALS

HERAS 3-6 wr

Units : NA

year

age	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
3	0.0810	-0.0831	0.537	-0.6432	0.0392	0.3785	NA	0.0583	-0.847	0.1968
4	0.0625	0.1551	1.164	-0.3806	-0.1373	-0.0489	NA	0.0994	-0.581	0.0984
5	0.4160	0.1699	0.393	-0.0994	-0.1536	0.3318	NA	0.4665	-0.409	-0.3159
6	0.2113	0.7759	0.887	-0.5254	0.4642	0.4983	NA	0.0377	-0.129	-0.4638

year

age	2003	2004	2005	2006	2007	2008
3	-0.522	-0.00270	-0.566	0.591	0.3660	0.417
4	-0.438	0.00319	-0.490	0.293	0.0946	0.106
5	-0.703	-0.21408	-0.290	0.215	-0.0791	0.272
6	-0.750	-0.24841	-0.176	-0.787	-0.6474	0.852

GerAS 1-3 wr

Units : NA

year

age	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
1	-0.800	0.2601	0.439	0.469	-0.205	-0.114	-0.137	NA	-0.1495	0.222	-0.2613
2	0.764	-0.0497	0.143	0.629	0.293	-0.349	-0.355	NA	0.0406	-0.661	0.1896
3	0.194	0.2794	0.721	0.137	0.325	-0.422	0.114	NA	0.0822	-0.358	0.0120

year

age	2005	2006	2007	2008
1	-0.0690	0.338	-0.00206	0.00934
2	0.0773	-0.326	-0.16086	-0.23499
3	0.0516	-0.202	-0.71328	-0.22134

N20

Units : NA

year

age	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
0	-1.76	-0.53	0.184	0.198	1.02	-0.295	0.605	0.653	-0.65	-0.369	0.792	-0.225

year

age	2004	2005	2006	2007	2008
0	0.220	0.0254	0.201	-0.122	0.0486

TABLE 3.6.21 WBSS HERRING. FIT PARAMETERS

	Value	Std.dev	Lower.95.pct.CL	Upper.95.pct.CL
F, 2004	0.36075	0.1975	0.24498	0.53124
F, 2005	0.41076	0.1949	0.28036	0.60181
F, 2006	0.39929	0.1996	0.27000	0.59049
F, 2007	0.36065	0.2114	0.23832	0.54577
F, 2008	0.37013	0.2293	0.23613	0.58017
Selectivity at age 0	0.05517	0.4815	0.02147	0.14178
Selectivity at age 1	0.50818	0.2184	0.33118	0.77976
Selectivity at age 2	0.67192	0.2107	0.44456	1.01556
Selectivity at age 3	0.83543	0.2035	0.56061	1.24498
Selectivity at age 5	1.04241	0.1807	0.73147	1.48553
Selectivity at age 6	1.08823	0.1740	0.77374	1.53055
Terminal year pop, age 0	894441.84149	0.3146	482824.28584	1656971.76234
Terminal year pop, age 1	914808.50544	0.2301	582750.44664	1436077.15180
Terminal year pop, age 2	663592.81555	0.1994	448941.82846	980874.12877
Terminal year pop, age 3	512906.88600	0.1773	362347.58894	726025.18061
Terminal year pop, age 4	359964.57231	0.1738	256027.26947	506096.45443
Terminal year pop, age 5	309471.84907	0.1873	214382.38181	446738.32130
Terminal year pop, age 6	138064.40500	0.2085	91741.74668	207776.50979
Terminal year pop, age 7	65650.18409	0.2455	40576.13612	106218.75524
Last true age pop, 2004	53871.15392	0.3567	26775.01885	108388.39149
Last true age pop, 2005	93408.84018	0.2694	55090.80818	158378.71529
Last true age pop, 2006	98692.24358	0.2446	61100.16492	159412.97305
Last true age pop, 2007	58994.19500	0.2490	36210.72573	96112.82220
Index 1, age 3 numbers, Q	1489.46015	0.1665	1074.81391	2064.07038
Index 1, age 4 numbers, Q	1188.73064	0.1674	856.22207	1650.36688
Index 1, age 5 numbers, Q	972.72139	0.1695	697.80467	1355.94810
Index 1, age 6 numbers, Q	792.34929	0.1735	563.90278	1113.34332
Index 2, age 1 numbers, Q	0.73761	0.1511	0.54857	0.99181
Index 2, age 2 numbers, Q	0.58270	0.1508	0.43362	0.78304
Index 2, age 3 numbers, Q	0.76411	0.1509	0.56850	1.02703
Index 3, age 0 numbers, Q	0.00194	0.0833	0.00165	0.00228

Table 3.7.1 WESTERN BALTIC HERRING. Parameters used for short term prediction and single option tables.

2009 (Intermediate Year)

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
0	2225068	0.30	0.00	0.10	0.25	0.000	0.021	0.016
1	649225	0.50	0.00	0.10	0.25	0.021	0.191	0.050
2	459723	0.20	0.20	0.10	0.25	0.063	0.253	0.074
3	423677	0.20	0.75	0.10	0.25	0.089	0.315	0.093
4	308239	0.20	0.90	0.10	0.25	0.115	0.377	0.115
5	203543	0.20	1.00	0.10	0.25	0.152	0.393	0.141
6	172266	0.20	1.00	0.10	0.25	0.168	0.410	0.154
7	75561	0.20	1.00	0.10	0.25	0.182	0.377	0.174
8	73889	0.20	1.00	0.10	0.25	0.188	0.377	0.183

2010 (Advice Year)

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
0	2225068	0.30	0.00	0.10	0.25	0.000	0.021	0.016
1	-	0.50	0.00	0.10	0.25	0.021	0.191	0.050
2	-	0.20	0.20	0.10	0.25	0.063	0.253	0.074
3	-	0.20	0.75	0.10	0.25	0.089	0.315	0.093
4	-	0.20	0.90	0.10	0.25	0.115	0.377	0.115
5	-	0.20	1.00	0.10	0.25	0.152	0.393	0.141
6	-	0.20	1.00	0.10	0.25	0.168	0.410	0.154
7	-	0.20	1.00	0.10	0.25	0.182	0.377	0.174
8	-	0.20	1.00	0.10	0.25	0.188	0.377	0.183

2011 (Continuation Year)

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
0	2225068	0.30	0.00	0.10	0.25	0.000	0.021	0.016
1	-	0.50	0.00	0.10	0.25	0.021	0.191	0.050
2	-	0.20	0.20	0.10	0.25	0.063	0.253	0.074
3	-	0.20	0.75	0.10	0.25	0.089	0.315	0.093
4	-	0.20	0.90	0.10	0.25	0.115	0.377	0.115
5	-	0.20	1.00	0.10	0.25	0.152	0.393	0.141
6	-	0.20	1.00	0.10	0.25	0.168	0.410	0.154
7	-	0.20	1.00	0.10	0.25	0.182	0.377	0.174
8	-	0.20	1.00	0.10	0.25	0.188	0.377	0.183

Age	Age (in winter rings)	SWt	Weight in the stock (kg)
N	Stock numbers (thousands)	Sel	Exploitation pattern
M	Natural mortality (.yr^{-1})	CWt	Weight in the catch (kg)
Mat	Maturity ogive		
PF	Proportion of fishing mortality (F) before spawning		
PM	Proportion of natural mortality (M) before spawning		

$N_{2009,\ 2010,\ 2011}$ age 0	Geometric mean recruitment (Table 3.6.14) from 2003-2007
N_{2009} age 1-8+	Output from assessment (Table 3.6.15)
Natural Mortality (M)	Arithmetic mean from 2006-2008
Weight in the Catch/Stock (CWt/SWt)	Arithmetic mean from 2006-2008
Selection pattern (Sel)	Arithmetic mean from 2006-2008

Table 3.7.2 WESTERN BALTIC HERRING. Short term prediction single option tables. Left hand tables) stock numbers (N) and fishing mortality (F) in each year. Right hand tables) Spawning stock biomass (SSB), mean fishing mortality (F.bar) and total catch of WBSS herring (Yield).

a). Catch(2010) = Zero

Age	N(2009)	N(2010)	N(2011)	F(2009)	F(2010)	F(2011)
0	2225068	2225068	2225068	0.0161	0.0000	0.0000
1	649225	1622036	1648371	0.1483	0.0000	0.0000
2	459723	339491	983815	0.1961	0.0000	0.0000
3	423677	309357	277951	0.2439	0.0000	0.0000
4	308239	271813	253280	0.2919	0.0000	0.0000
5	203543	188478	222542	0.3043	0.0000	0.0000
6	172266	122929	154313	0.3176	0.0000	0.0000
7	75561	102657	100646	0.2919	0.0000	0.0000
8	73889	91384	158867	0.2919	0.0000	0.0000

Year	SSB	F.bar	Yield
2009	141824	0.2894	45087
2010	131427	0.0000	0
2011	156964	0.0000	0

b). Catch(2010) = 2009 TACs -15% (48 133 t)

Age	N(2009)	N(2010)	N(2011)	F(2009)	F(2010)	F(2011)
0	2225068	2225068	2225068	0.0161	0.0172	0.0172
1	649225	1622036	1620224	0.1483	0.1586	0.1586
2	459723	339491	839498	0.1961	0.2097	0.2097
3	423677	309357	225360	0.2439	0.2608	0.2608
4	308239	271813	195138	0.2919	0.3122	0.3122
5	203543	188478	162870	0.3043	0.3254	0.3254
6	172266	122929	111451	0.3176	0.3397	0.3397
7	75561	102657	71658	0.2919	0.3122	0.3122
8	73889	91384	116269	0.2919	0.3122	0.3122

Year	SSB	F.bar	Yield
2009	141824	0.2894	45087
2010	127438	0.3095	48133
2011	114531	0.3095	49130

c). Catch(2010) = 2009 TACs (56 627 t)

Age	N(2009)	N(2010)	N(2011)	F(2009)	F(2010)	F(2011)
0	2225068	2225068	2225068	0.0161	0.0208	0.0208
1	649225	1622036	1614476	0.1483	0.1914	0.1914
2	459723	339491	812465	0.1961	0.2530	0.2530
3	423677	309357	215815	0.2439	0.3146	0.3146
4	308239	271813	184915	0.2919	0.3766	0.3766
5	203543	188478	152710	0.3043	0.3925	0.3925
6	172266	122929	104214	0.3176	0.4098	0.4098
7	75561	102657	66807	0.2919	0.3766	0.3766
8	73889	91384	109016	0.2919	0.3766	0.3766

Year	SSB	F.bar	Yield
2009	141824	0.2894	45087
2010	126631	0.3734	56627
2011	107364	0.3734	55469

d). Catch(2010) = 2009 TACs +15% (65 121 t)

Age	N(2009)	N(2010)	N(2011)	F(2009)	F(2010)	F(2011)
0	2225068	2225068	2225068	0.0161	0.0245	0.0245
1	649225	1622036	1608435	0.1483	0.2259	0.2259
2	459723	339491	784892	0.1961	0.2987	0.2987
3	423677	309357	206184	0.2439	0.3714	0.3714
4	308239	271813	174711	0.2919	0.4445	0.4445
5	203543	188478	142680	0.3043	0.4634	0.4634
6	172266	122929	97088	0.3176	0.4837	0.4837
7	75561	102657	62046	0.2919	0.4445	0.4445
8	73889	91384	101856	0.2919	0.4445	0.4445

Year	SSB	F.bar	Yield
2009	141824	0.2894	45087
2010	125784	0.4407	65121
2011	100306	0.4407	61135

e). Catch(2010) = 2009 Catch (45 087 t)

Age	N(2009)	N(2010)	N(2011)	F(2009)	F(2010)	F(2011)
0	2225068	2225068	2225068	0.0161	0.0160	0.0154
1	649225	1622036	1622218	0.1483	0.1473	0.1416
2	459723	339491	849067	0.1961	0.1948	0.1873
3	423677	309357	228763	0.2439	0.2422	0.2329
4	308239	271813	198808	0.2919	0.2899	0.2787
5	203543	188478	166543	0.3043	0.3022	0.2905
6	172266	122929	114072	0.3176	0.3154	0.3033
7	75561	102657	73418	0.2919	0.2899	0.2787
8	73889	91384	118891	0.2919	0.2899	0.2787

Year	SSB	F.bar	Yield
2009	141824	0.2894	45087
2010	127719	0.2874	45087
2011	117254	0.2764	45087

f). Fbar(2010) = 0.25

Age	N(2009)	N(2010)	N(2011)	F(2009)	F(2010)	F(2011)
0	2225068	2225068	2225068	0.0161	0.0139	0.0139
1	649225	1622036	1625598	0.1483	0.1281	0.1281
2	459723	339491	865499	0.1961	0.1694	0.1694
3	423677	309357	234635	0.2439	0.2106	0.2106
4	308239	271813	205172	0.2919	0.2521	0.2521
5	203543	188478	172946	0.3043	0.2628	0.2628
6	172266	122929	118647	0.3176	0.2744	0.2744
7	75561	102657	76495	0.2919	0.2521	0.2521
8	73889	91384	123462	0.2919	0.2521	0.2521

Year	SSB	F.bar	Yield
2009	141824	0.2894	45087
2010	128196	0.2500	39808
2011	121656	0.2500	42254

Table 3.7.3 WESTERN BALTIC HERRING. Short-term prediction multiple option table, based on a catch constraint in the intermediate year of 45 087t.

2009 Fmult	Fbar	Landings	SSB	2010 Fmult	Fbar	Landings	SSB	2011 SSB
0.789	0.289	45087	141824	0.000	0.000	0	131427	156964
	-	-	-	0.100	0.029	5044	131049	152385
	-	-	-	0.200	0.058	9967	130672	147943
	-	-	-	0.300	0.087	14772	130295	143635
	-	-	-	0.400	0.116	19463	129921	139457
	-	-	-	0.500	0.145	24043	129547	135403
	-	-	-	0.600	0.174	28514	129174	131472
	-	-	-	0.700	0.203	32879	128802	127658
	-	-	-	0.800	0.232	37141	128432	123958
	-	-	-	0.900	0.260	41303	128062	120369
	-	-	-	1.000	0.289	45367	127694	116887
	-	-	-	1.100	0.318	49336	127326	113510
	-	-	-	1.200	0.347	53212	126960	110233
	-	-	-	1.300	0.376	56998	126595	107054
	-	-	-	1.400	0.405	60695	126230	103970
	-	-	-	1.500	0.434	64307	125867	100977
	-	-	-	1.600	0.463	67835	125505	98074
	-	-	-	1.700	0.492	71282	125144	95257
	-	-	-	1.800	0.521	74649	124784	92524
	-	-	-	1.900	0.550	77939	124425	89872
	-	-	-	2.000	0.579	81154	124067	87298

Catch and SSB are given in tonnes

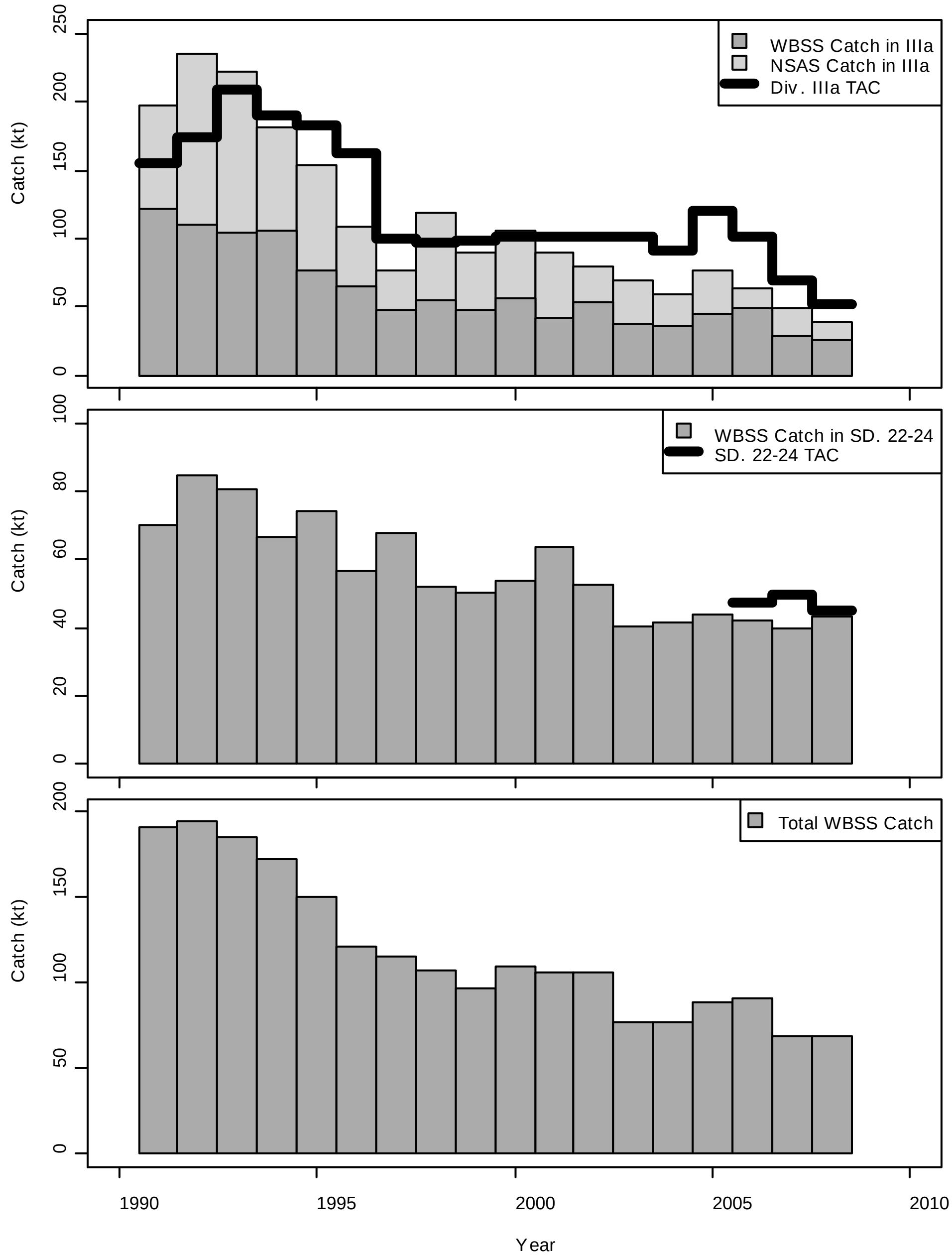


Figure 3.1.1 Western Baltic Spring Spawning Herring. Catches and TACs by area. Top panel) Catches of Western Baltic Spring Spawning (WBSS) and North Sea Autumn Spawning (NSAS) herring in division IIIa, and the total TAC for both stocks. Middle panel) Catches and TACs of WBSS herring in subdivisions 22-24. Bottom panel) Total catch of WBSS herring in Div IVa, Div IIIa and SD 22-24.

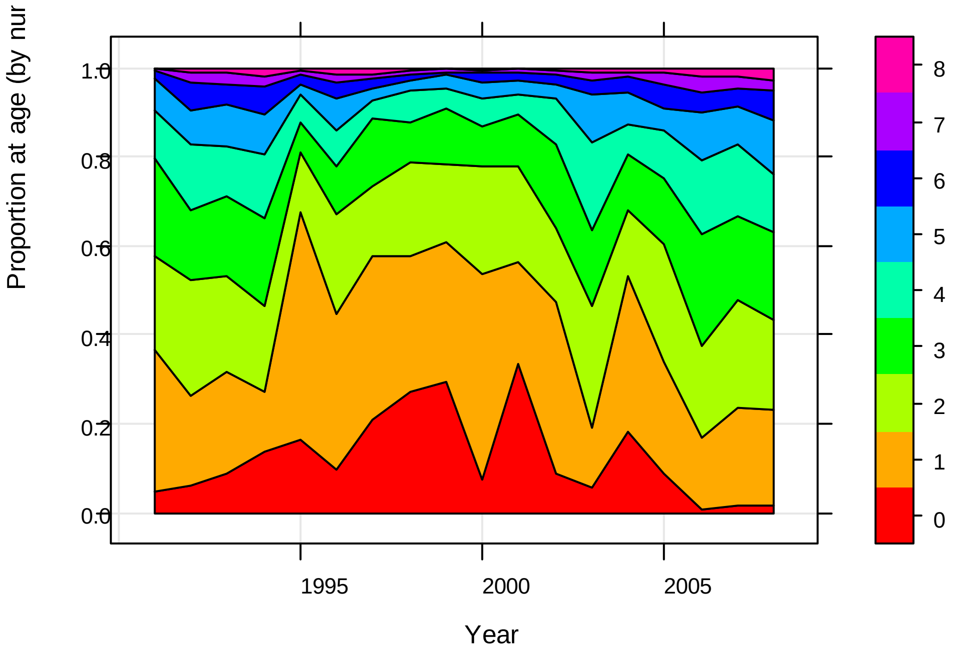


Figure 3.6.1.1 Western Baltic Spring Spawning Herring. Proportion (by numbers) of a given age (in winter rings) in the catch.

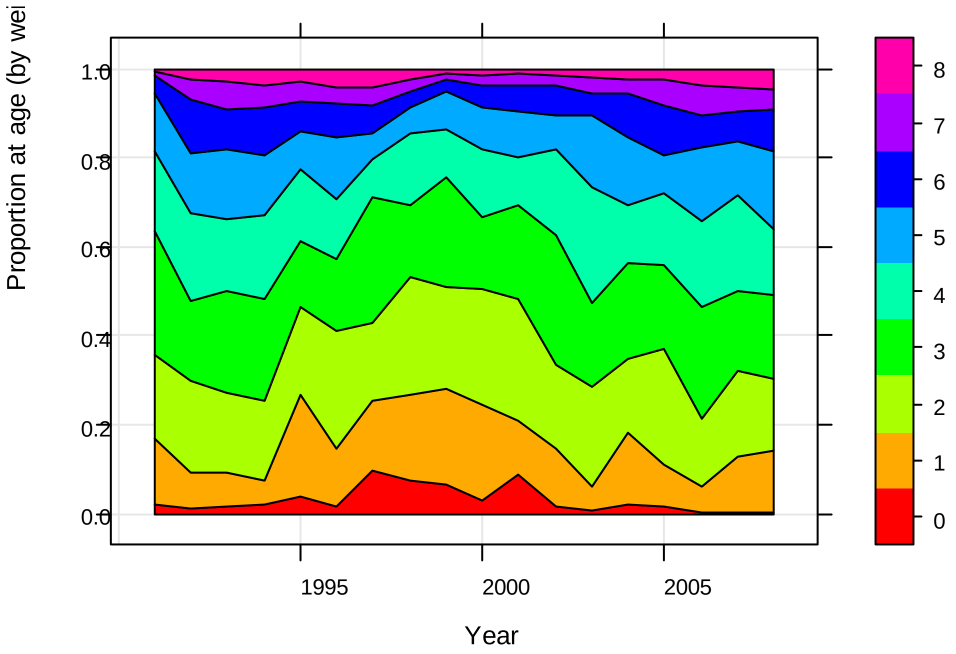


Figure 3.6.1.2 Western Baltic Spring Spawning Herring. Proportion (by weight) of a given age (in winter rings) in the catch.

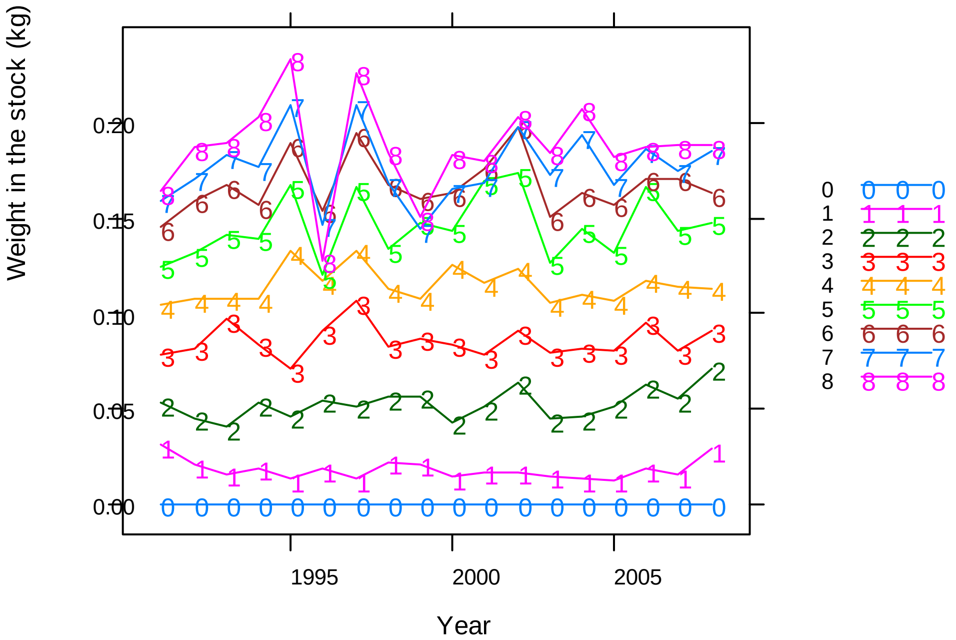


Figure 3.6.1.3 Western Baltic Spring Spawning Herring. Weight at age (in winter rings) in the stock.

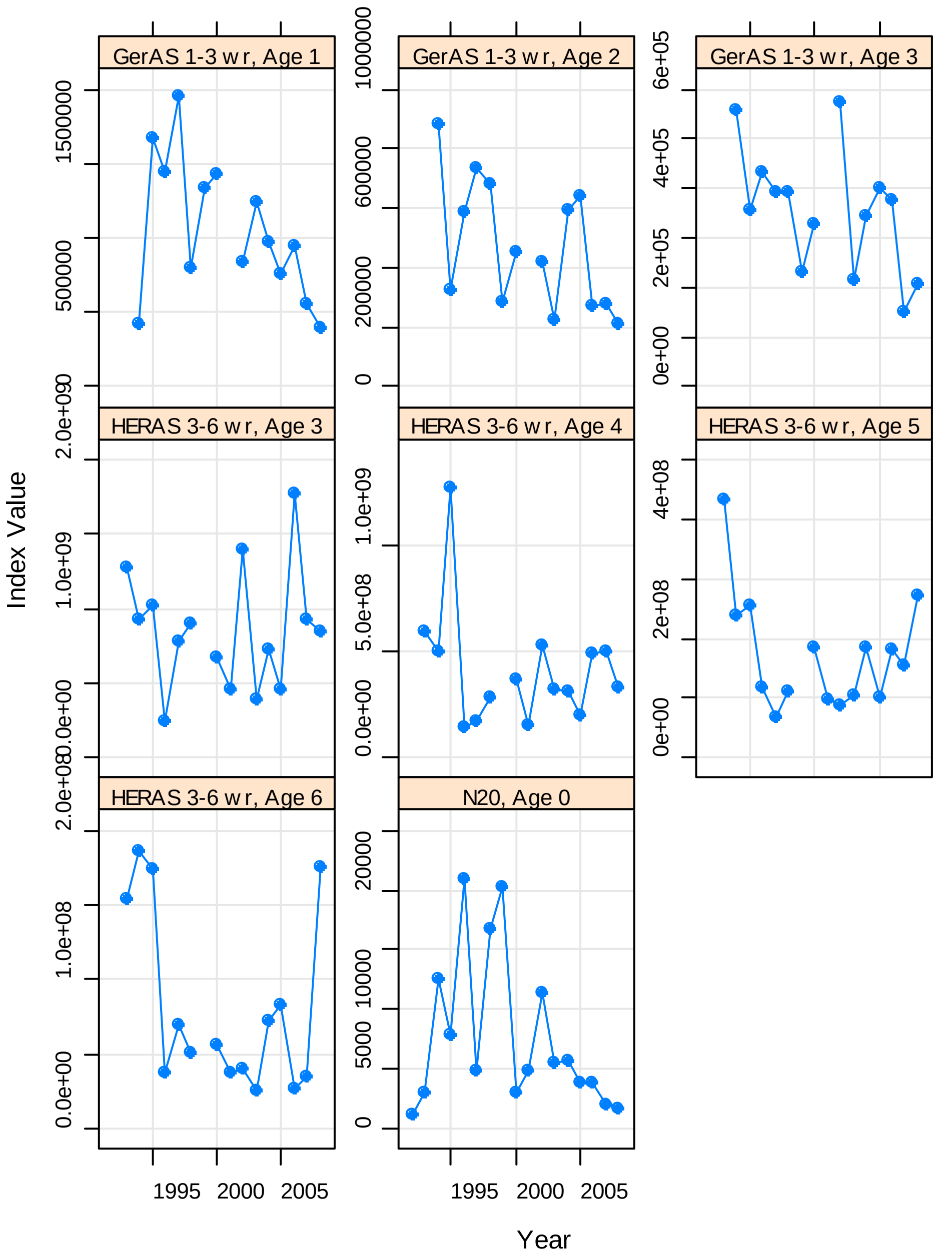


Figure 3.6.1.4 Western Baltic Spring Spawning Herring. Time series of the individual index values used in the assessment, showing the German Acoustic survey (GerAS), the Herring acoustic survey (HerAS) and the N20 larval index.

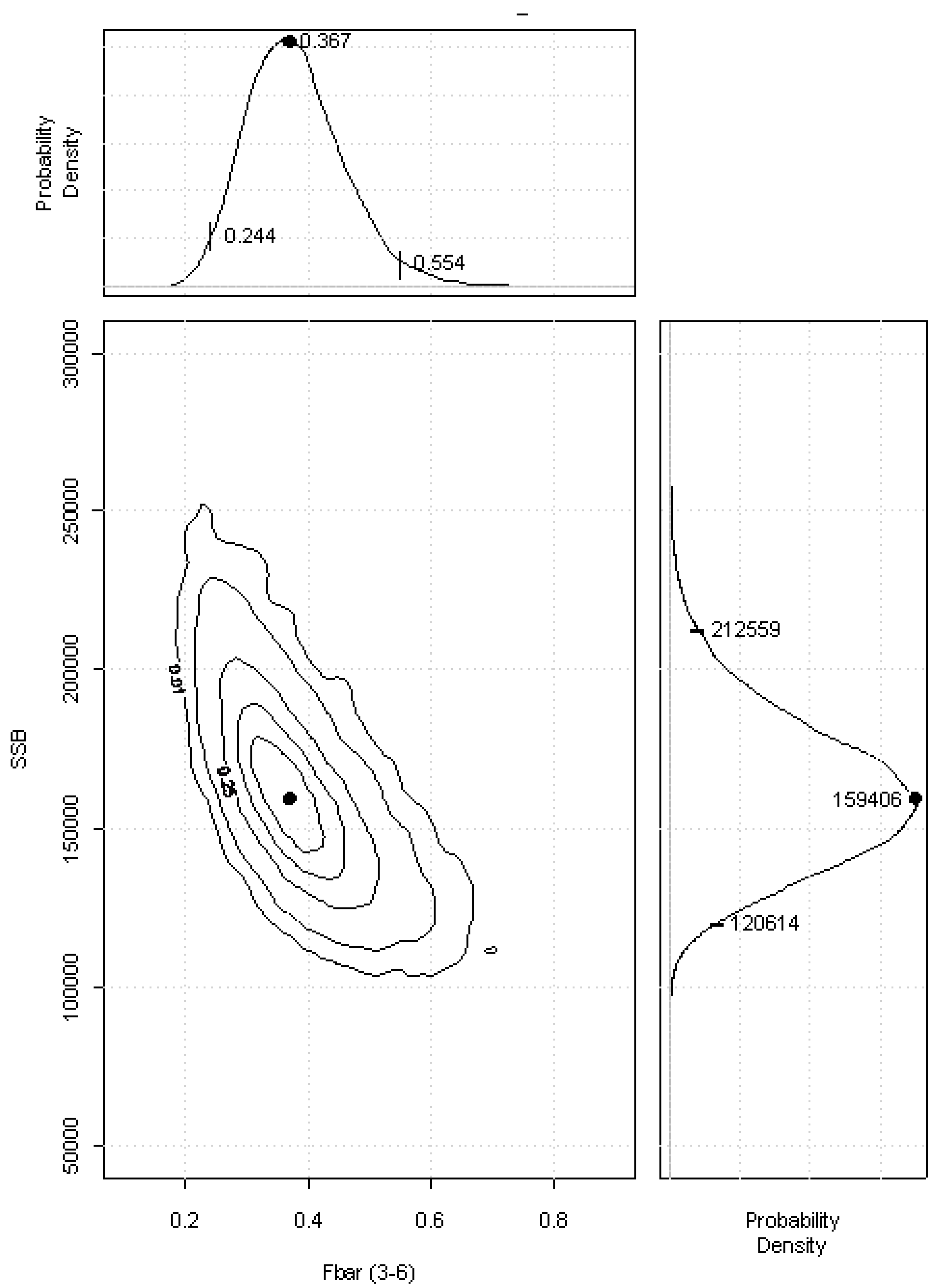


Figure 3.6.4.1 Western Baltic Spring Spawning Herring. "Otolith" plot. The main figure depicts the uncertainty in the estimated spawning stock biomass and average fishing mortality, and their correlation. Contour lines give the 1%, 5%, 25%, 50% and 75% confidence intervals for the two estimated parameters and are estimated from a parametric bootstrap based on the variance-covariance matrix in the parameters returned by FLICA. The plots to the right and top of the main plot give the probability distribution in the SSB and mean fishing mortality respectively. The SSB and fishing mortality estimated by the method is plotted on all three plots with a heavy dot. 95% confidence intervals, with their corresponding values, are given on the plots to the right and top of the main plot.

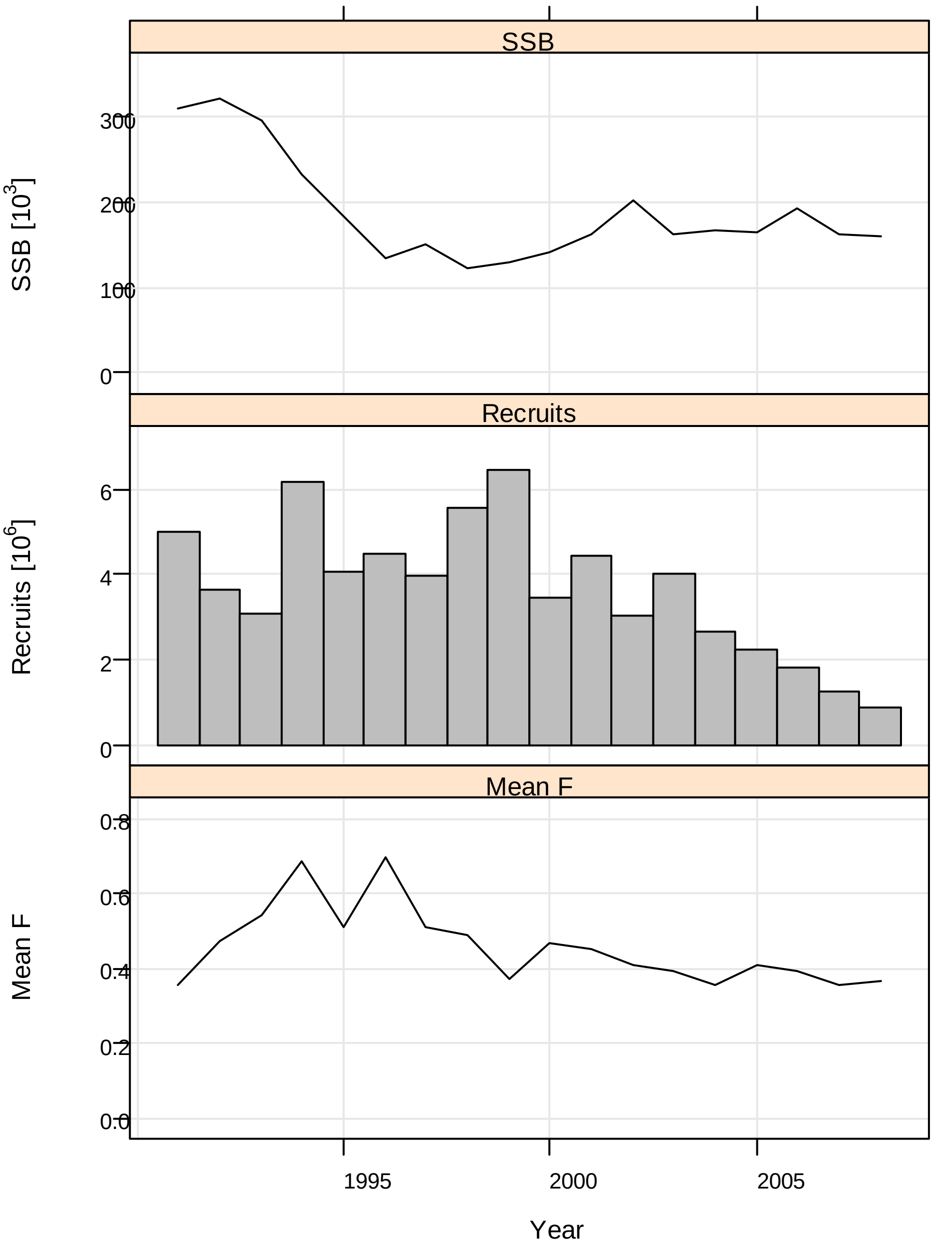


Figure 3.6.4.2 Western Baltic Spring Spawning Herring. Stock summary plot. Top panel: Spawning stock biomass. Second panel: Recruitment (at age 0-wr) as a function of time. Bottom panel:: Mean annual fishing mortality on ages 3-6 ringers as a function of time.

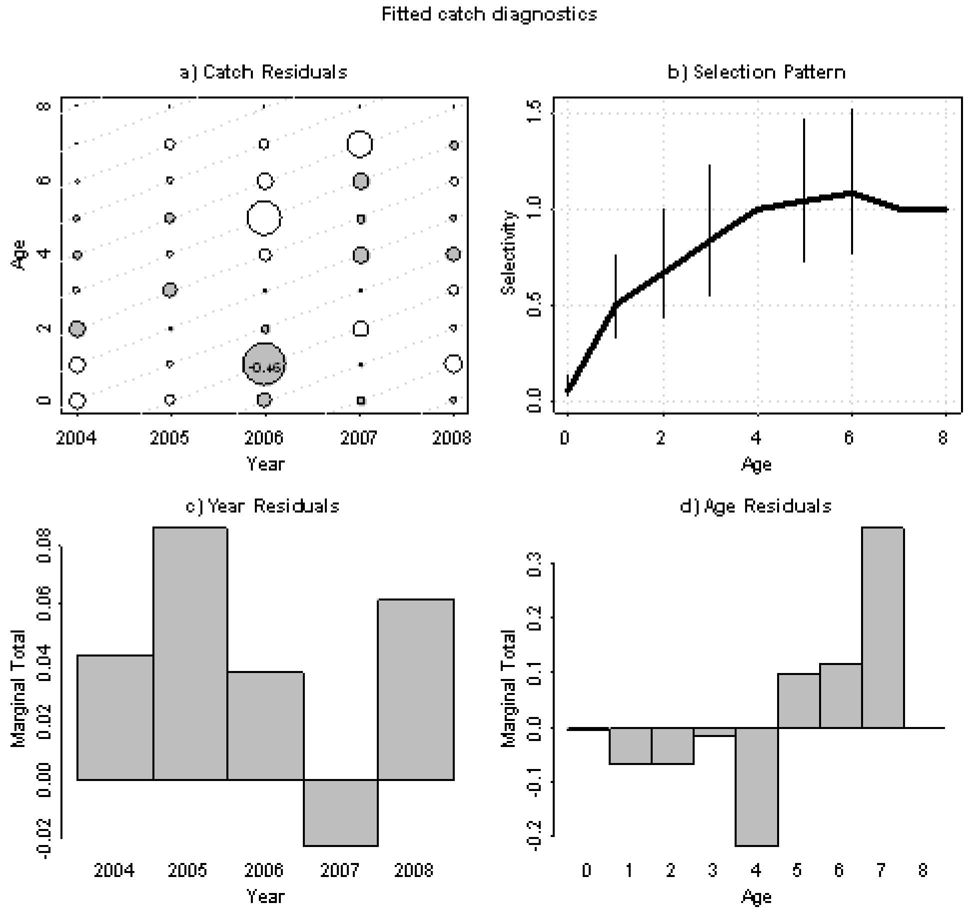


Figure 3.6.4.3 Western Baltic Spring Spawning Herring. Diagnostics of selection pattern. a) Bubbles plot of log catch residuals by age (weighting applied) and year. Grey bubbles correspond to negative log residuals. The largest residual is given. b) Estimated selection parameters (relative to 4 wr) with 95% confidence intervals. c): Marginal totals of residuals by year. d). Marginal totals of residuals by age (wr).

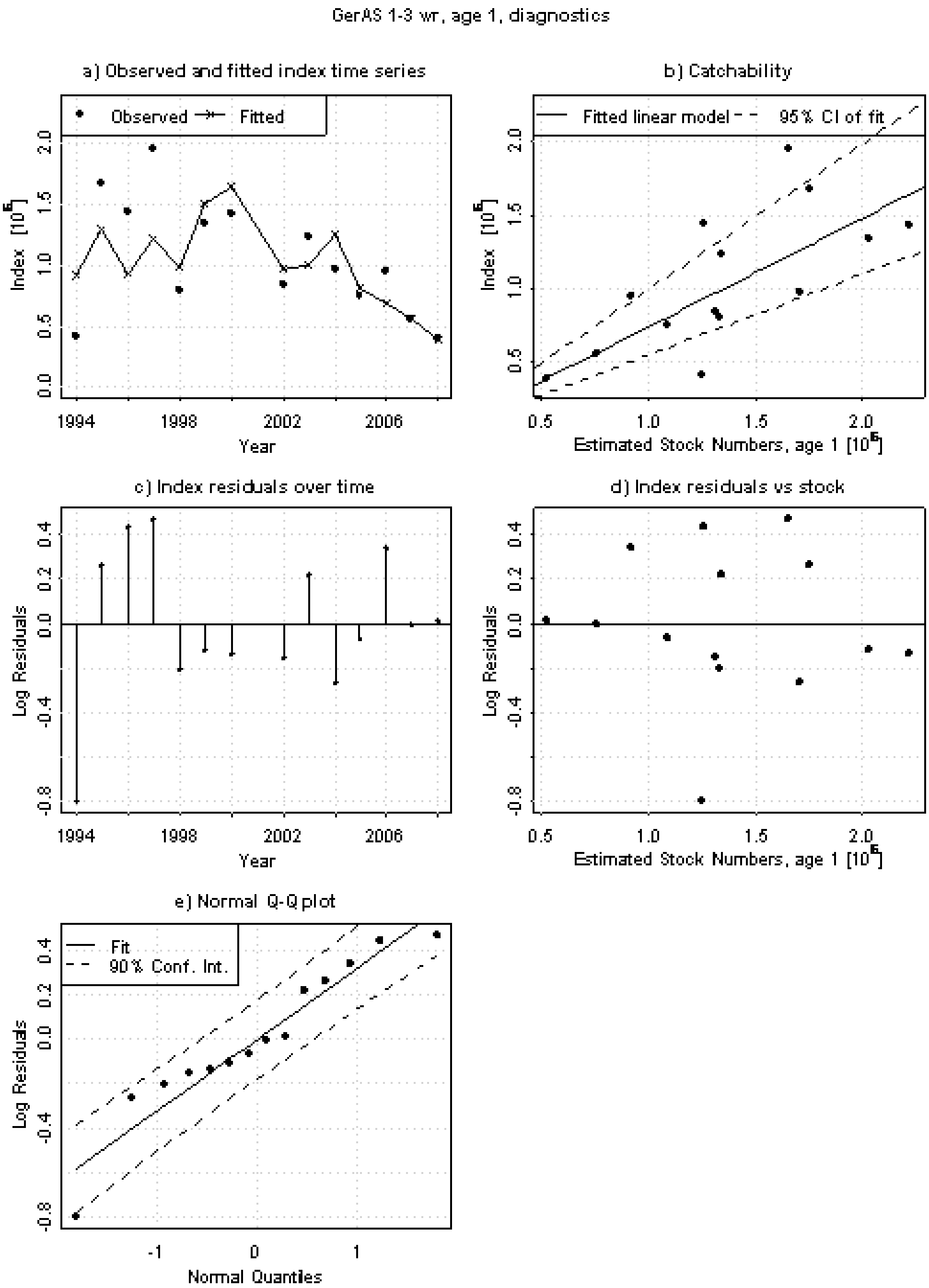


Figure 3.6.4.4 Western Baltic Spring Spawning Herring. Diagnostics of the German acoustic survey in subdivision 21-24 ("Ger AS 1-3 wr") fit at 1 wr from the assessment. a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus FLICA estimates of stock numbers at age. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log residuals of catchability model fitted by FLICA as a function of time. d). Log residuals from the catchability model against stock size at age estimated by the FLICA assessment method. e). Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line).

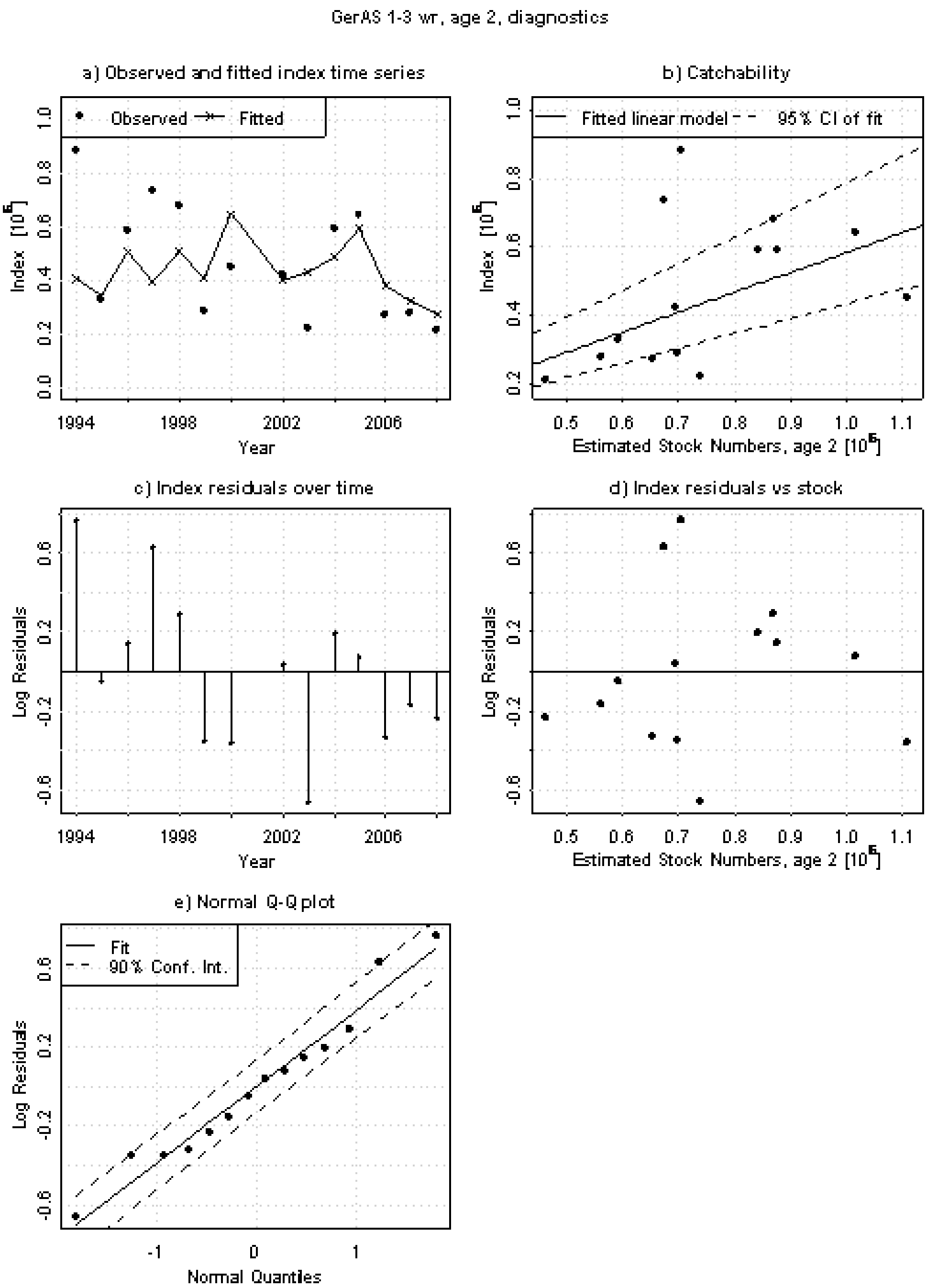


Figure 3.6.4.5 Western Baltic Spring Spawning Herring. Diagnostics of the German acoustic survey in subdivision 21-24 ("Ger AS 1-3 wr") fit at 2 wr from the assessment. a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus FLICA estimates of stock numbers at age. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log residuals of catchability model fitted by FLICA as a function of time. d). Log residuals from the catchability model against stock size at age estimated by the FLICA assessment method. e). Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line).

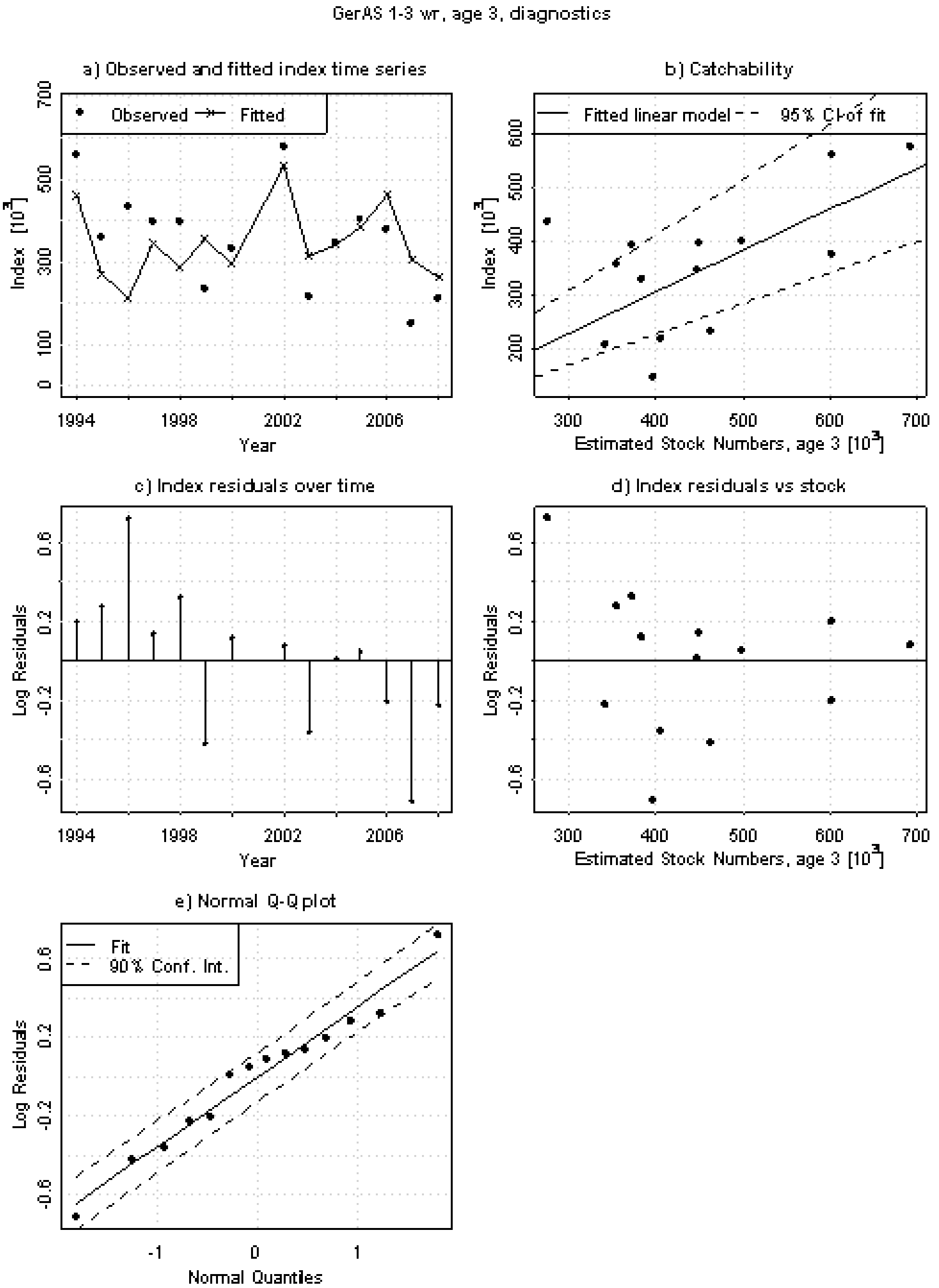


Figure 3.6.4.6 Western Baltic Spring Spawning Herring. Diagnostics of the German acoustic survey in subdivision 21-24 ("Ger AS 1-3 wr") fit at 3 wr from the assessment. a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus FLICA estimates of stock numbers at age. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log residuals of catchability model fitted by FLICA as a function of time. d). Log residuals from the catchability model against stock size at age estimated by the FLICA assessment method. e). Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line).

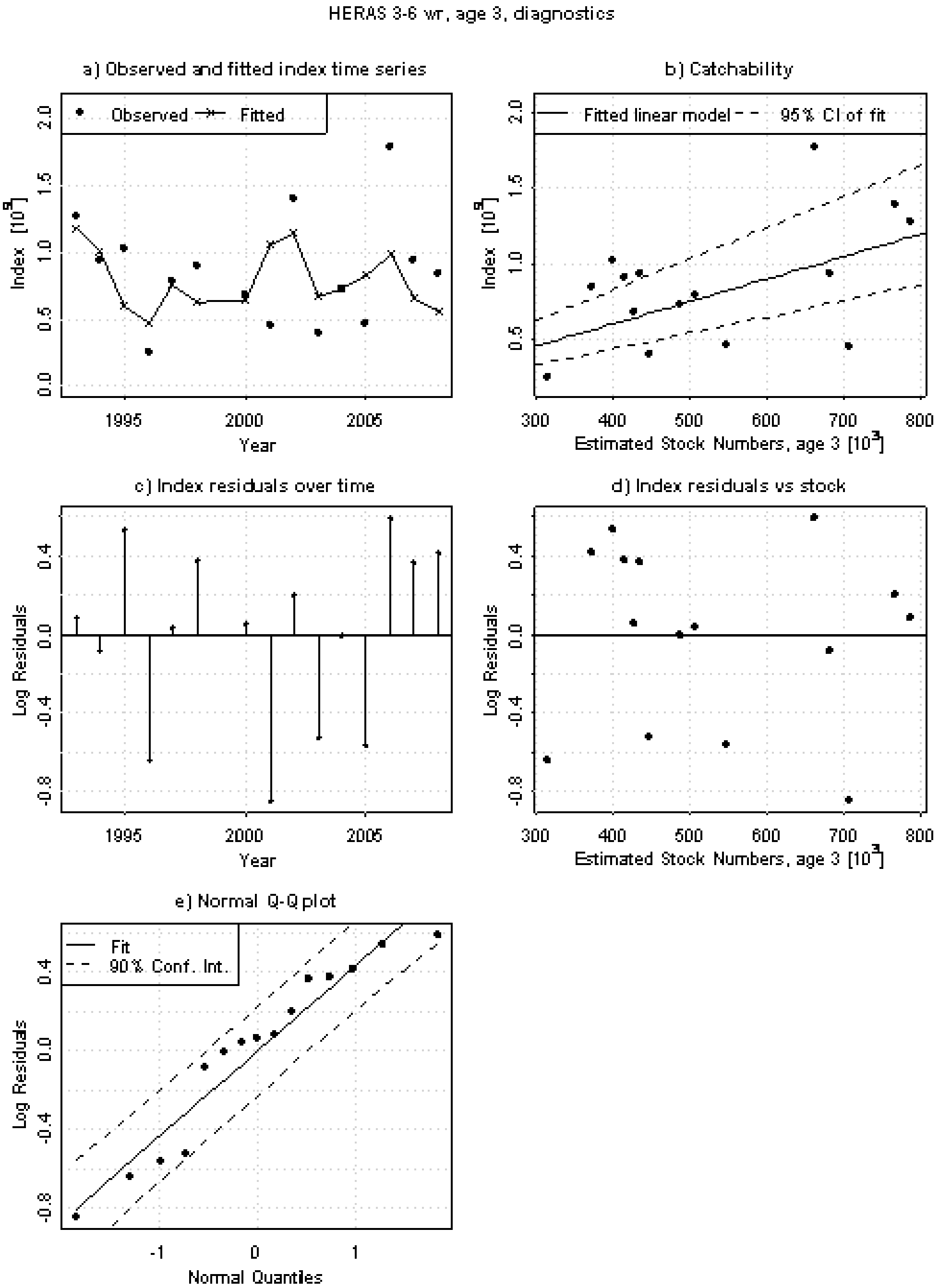


Figure 3.6.4.7 Western Baltic Spring Spawning Herring. Diagnostics of the Herring acoustic survey in the North Sea and division IIIa ("HerAS 3-6 wr") fit at 3 wr from the assessment. a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus FLICA estimates of stock numbers at age. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log residuals of catchability model fitted by FLICA as a function of time. d). Log residuals from the catchability model against stock size at age estimated by the FLICA assessment method. e). Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line).

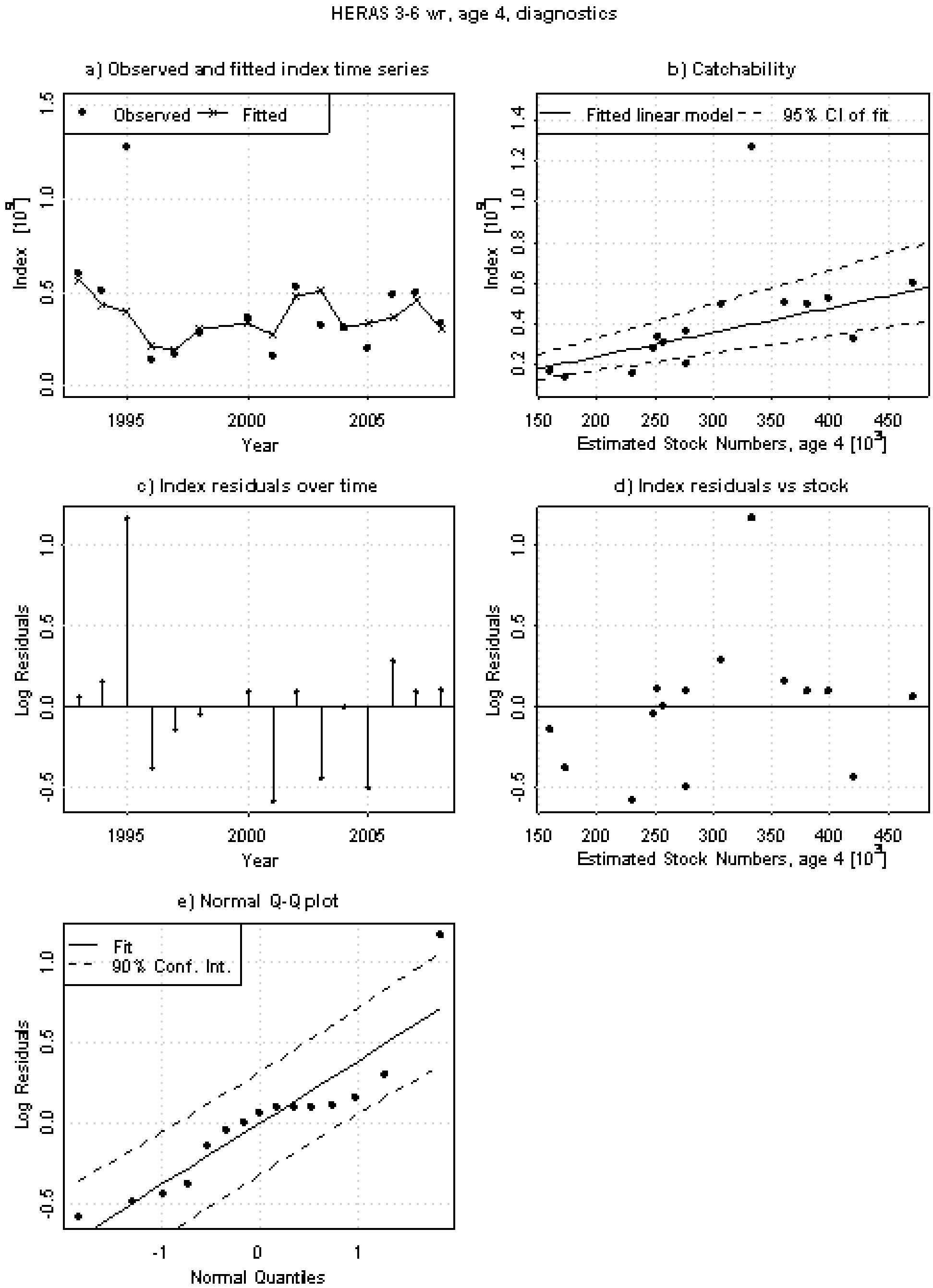


Figure 3.6.4.8 Western Baltic Spring Spawning Herring. Diagnostics of the Herring acoustic survey in the North Sea and division IIIa ("HerAS 3-6 wr") fit at 4 wr from the assessment. a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus FLICA estimates of stock numbers at age. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log residuals of catchability model fitted by FLICA as a function of time. d). Log residuals from the catchability model against stock size at age estimated by the FLICA assessment method. e). Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line).

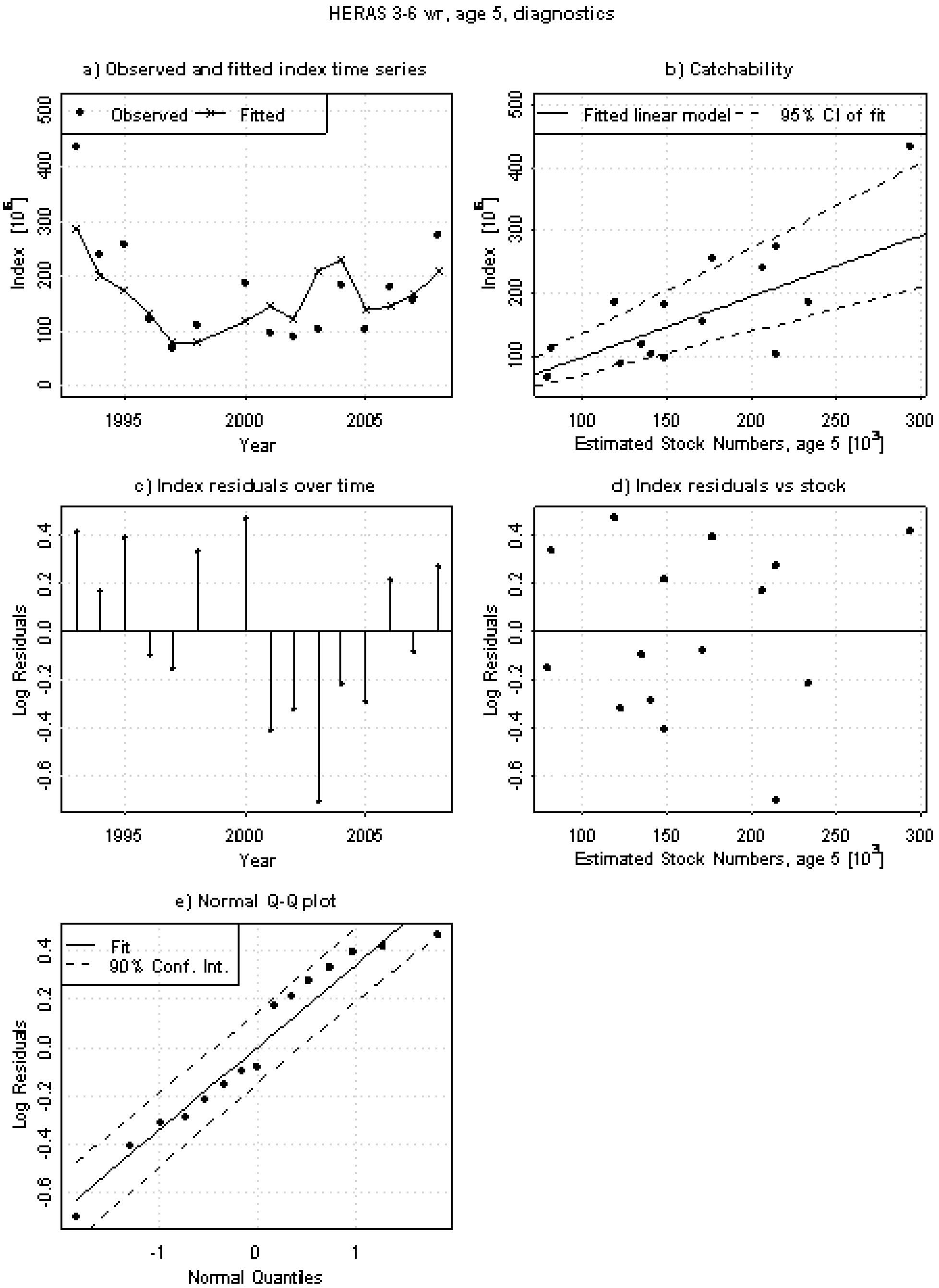


Figure 3.6.4.9 Western Baltic Spring Spawning Herring. Diagnostics of the Herring acoustic survey in the North Sea and division IIIa ("HerAS 3-6 wr") fit at 5 wr from the assessment. a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus FLICA estimates of stock numbers at age. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log residuals of catchability model fitted by FLICA as a function of time. d). Log residuals from the catchability model against stock size at age estimated by the FLICA assessment method. e). Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line).

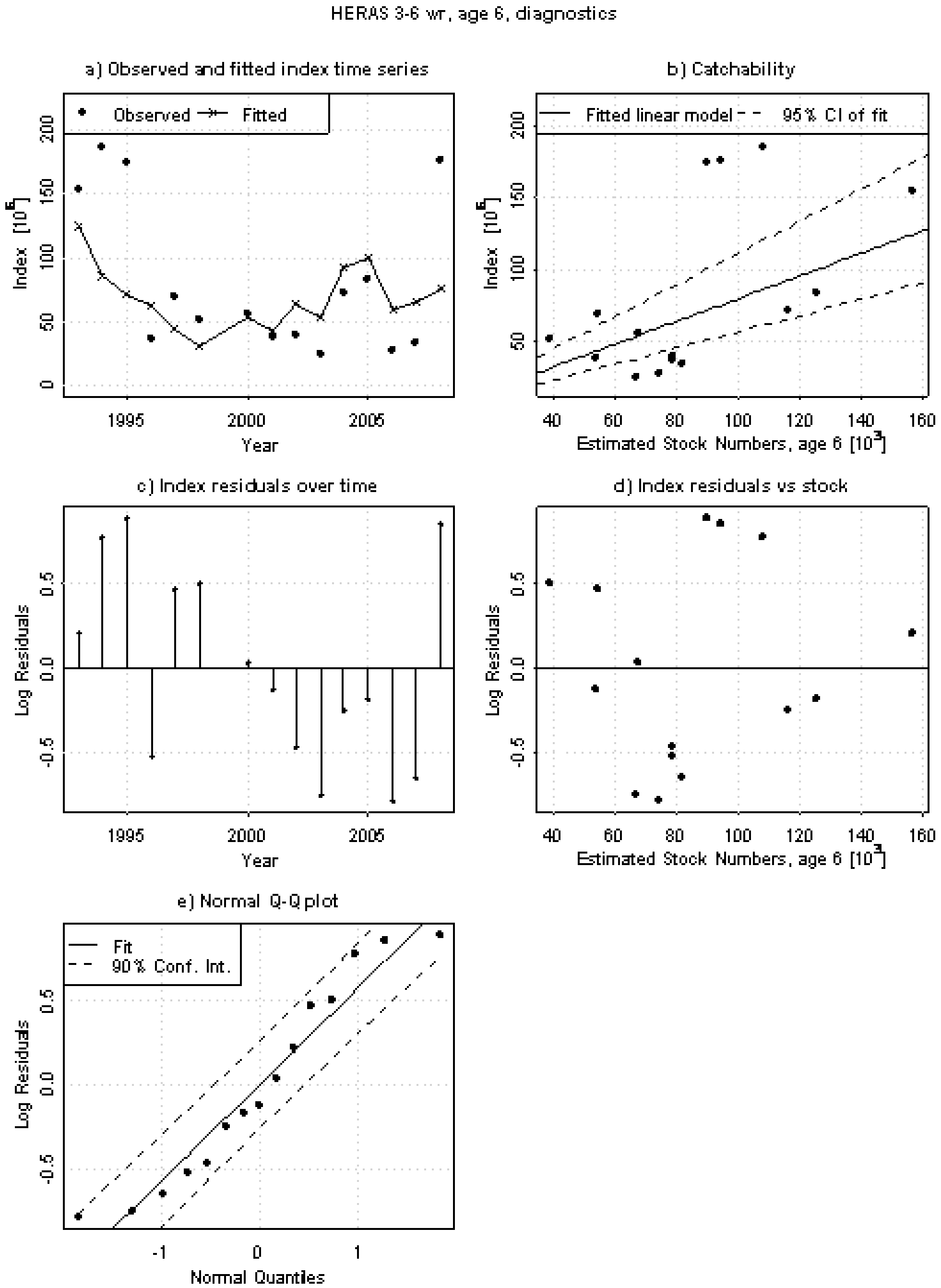


Figure 3.6.4.10 Western Baltic Spring Spawning Herring. Diagnostics of the Herring acoustic survey in the North Sea and division IIIa ("HerAS 3-6 wr") fit at 6 wr from the assessment. a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus FLICA estimates of stock numbers at age. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log residuals of catchability model fitted by FLICA as a function of time. d). Log residuals from the catchability model against stock size at age estimated by the FLICA assessment method. e). Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line).

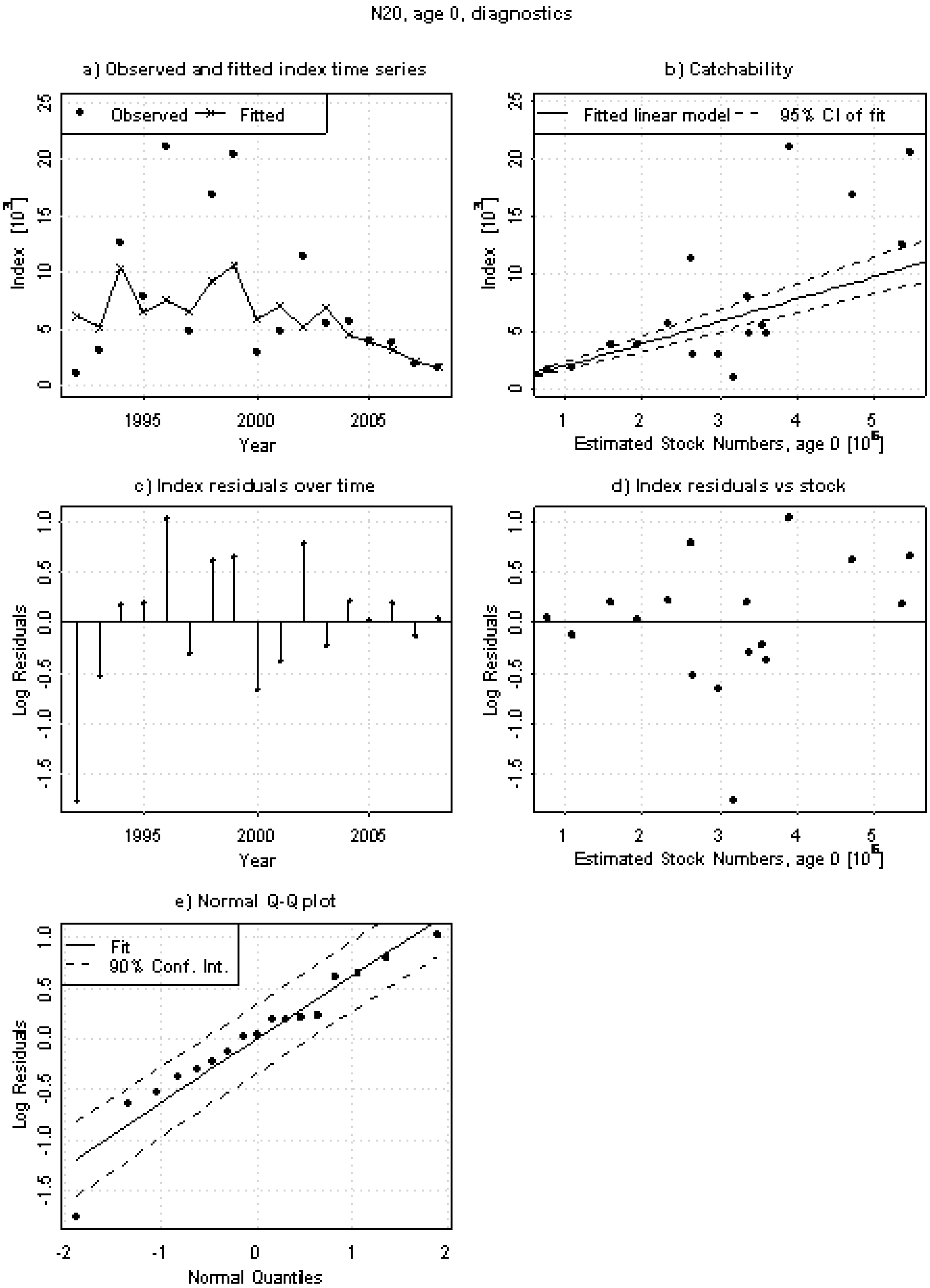


Figure 3.6.4.11 Western Baltic Spring Spawning Herring. Diagnostics of the N20 larval index from the assessment. a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus FLICA estimates of stock numbers at age. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log residuals of catchability model fitted by FLICA as a function of time. d). Log residuals from the catchability model against stock size at age estimated by the FLICA assessment method. e). Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line).

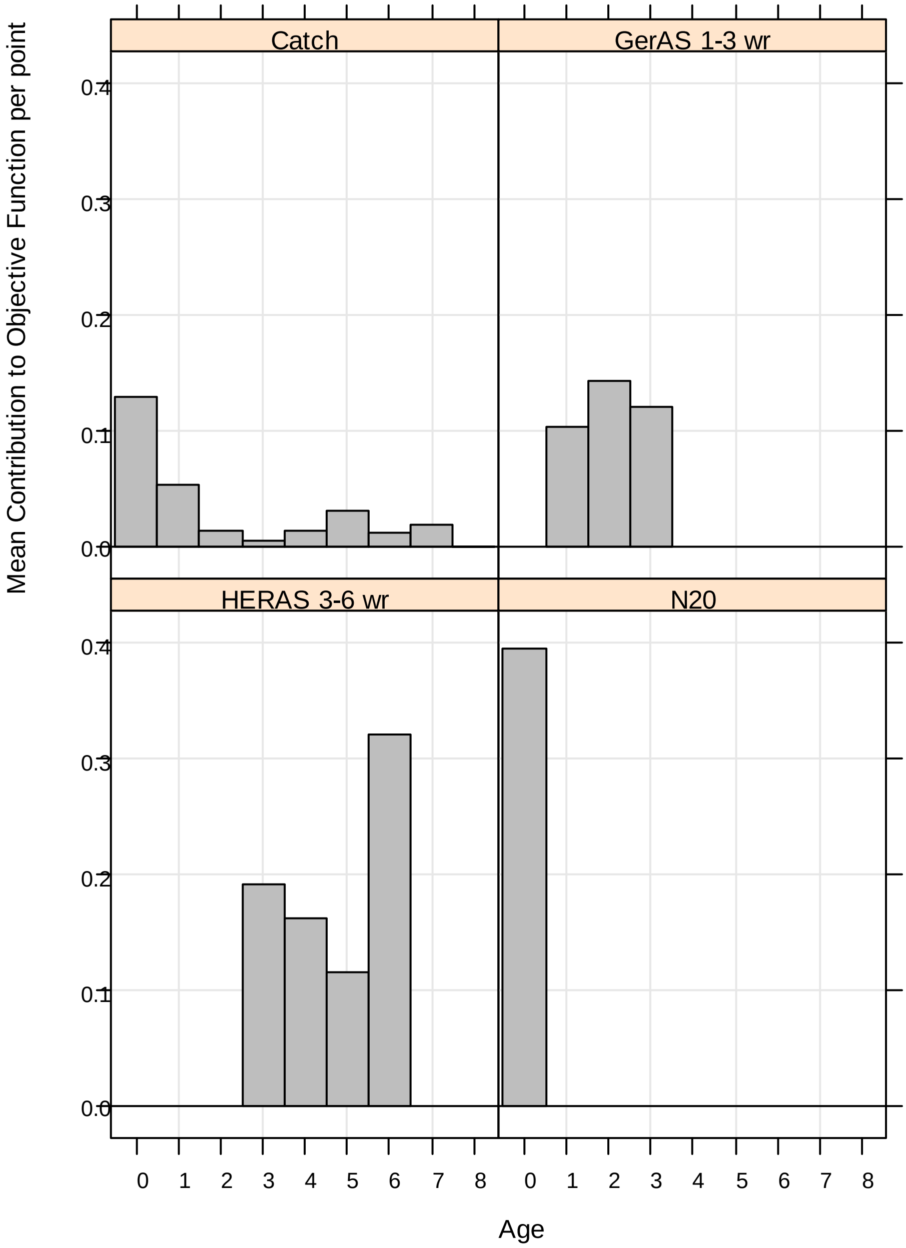


Figure 3.6.4.12 Western Baltic Spring Spawning Herring. Mean contribution of a data point individual information groups (ages in each survey) to the FLICA objective function. The contribution is calculated from the mean of the squared residuals in the corresponding class, and weighted according to the appropriate value employed by the optimiser.

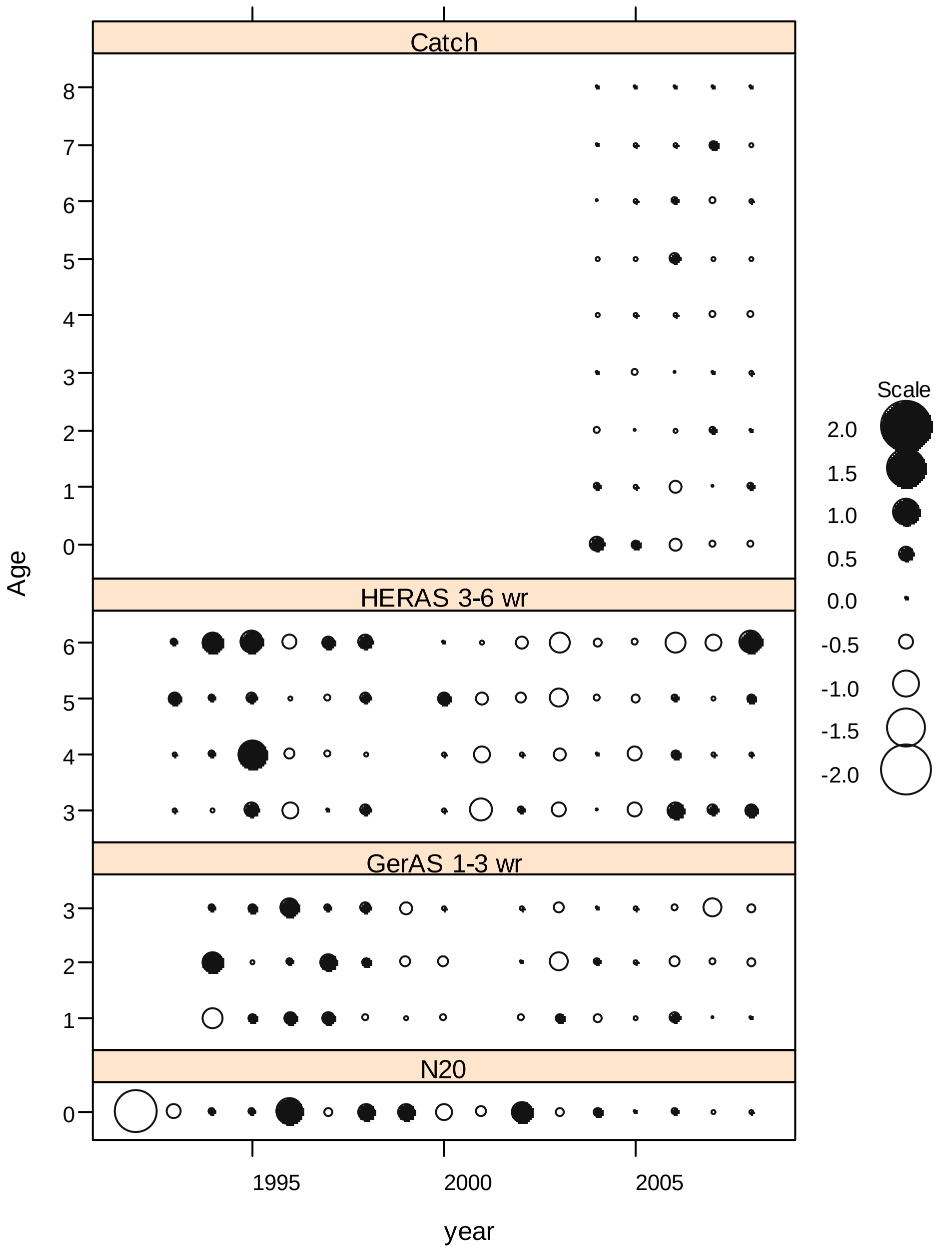


Figure 3.6.4.13 Western Baltic Spring Spawning Herring. Bubble plot showing the weighted residuals for each piece of fitted information. Individual values are weighted following the procedures employed internally with FLICA in calculating the objective function. The bubble scale is consistent between all panels.

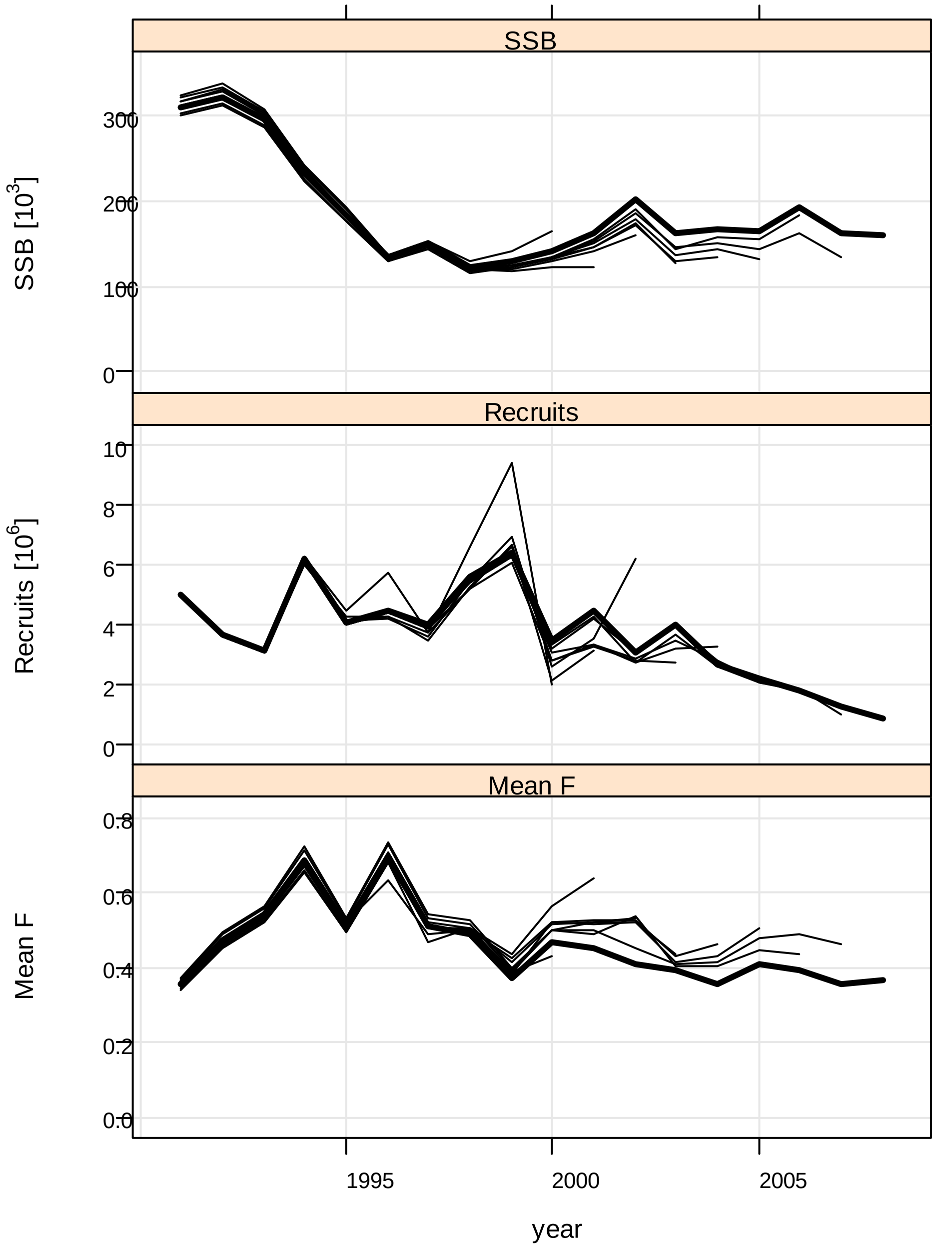
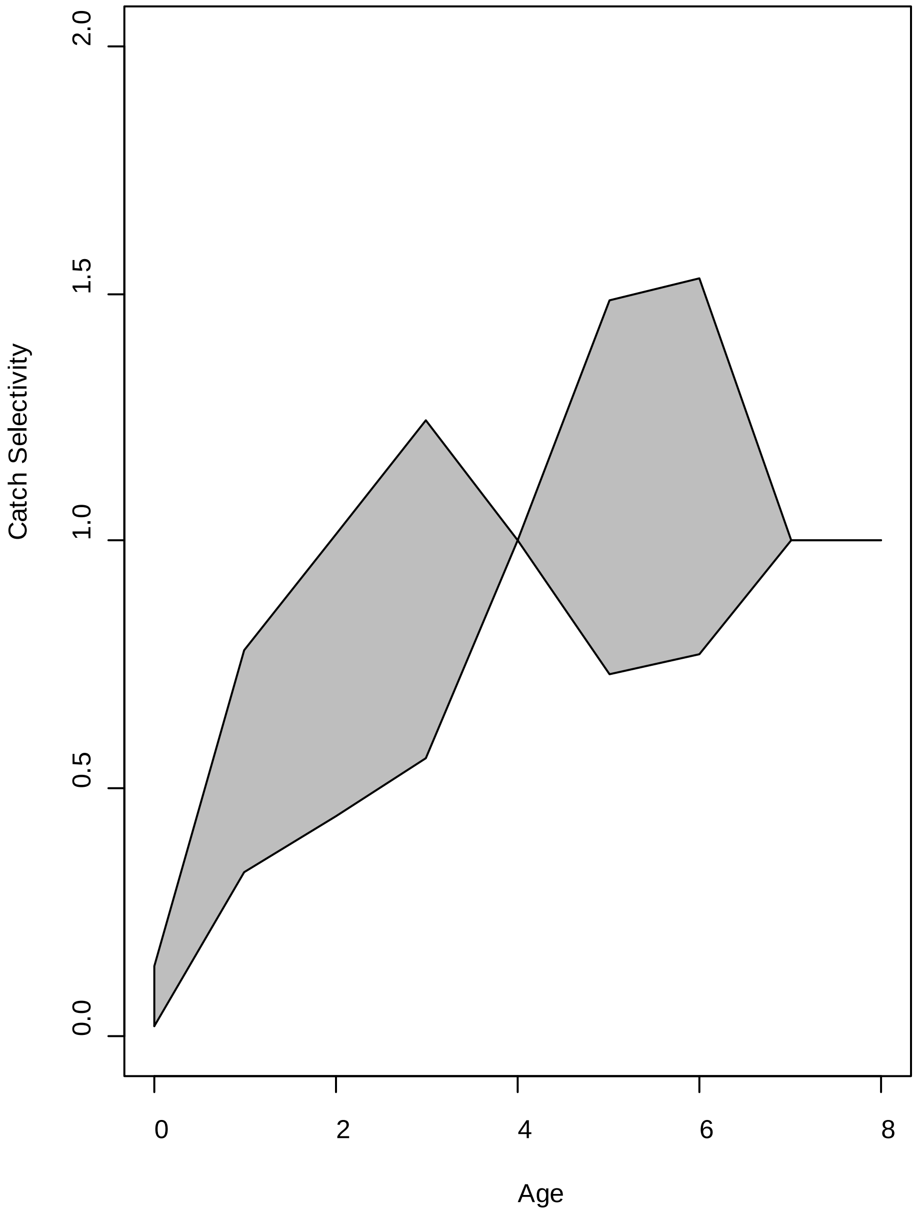


Figure 3.6.4.14 Western Baltic Spring Spawning Herring. Analytical retrospective pattern in the assessment. Top panel: Spawning stock biomass. Middle panel: Recruitment at age 0 wr. Bottom panel: Mean fishing mortality in the ages 3-6 ringer. The heavy black line shows the current assessment.



Catch Selectivity
0.0
0.5
1.0
1.5
2.0
0
2
4
6
8
Age

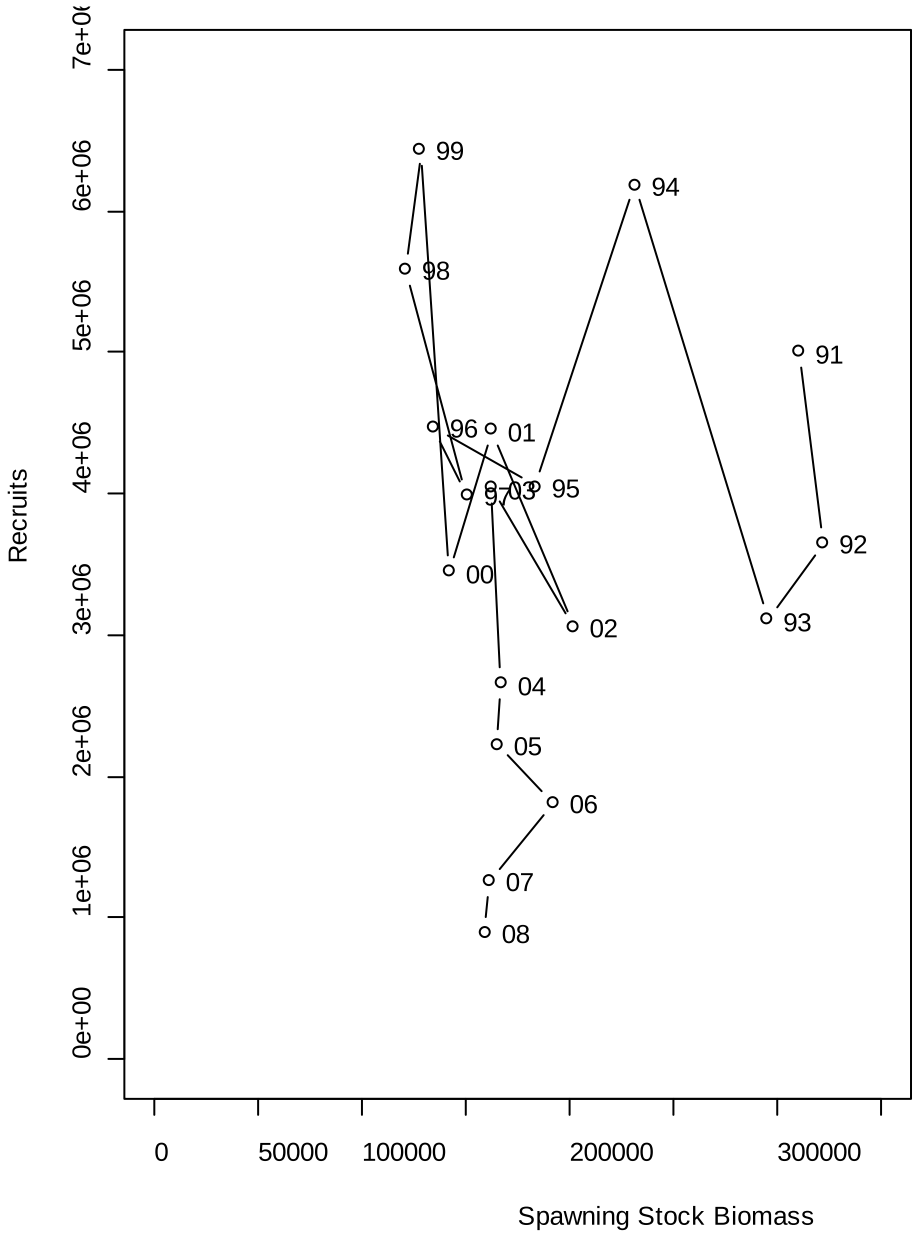


Figure 3.6.4.16 Western Baltic Spring Spawning Herring. Stock-recruitment relationship. Recruitment at age 0-wr (in thousands) is plotted as a function of spawning stock biomass (tonnes) estimated by the assessment. Successive years are joined by the line. Individual data points are labelled with the two-digit year.

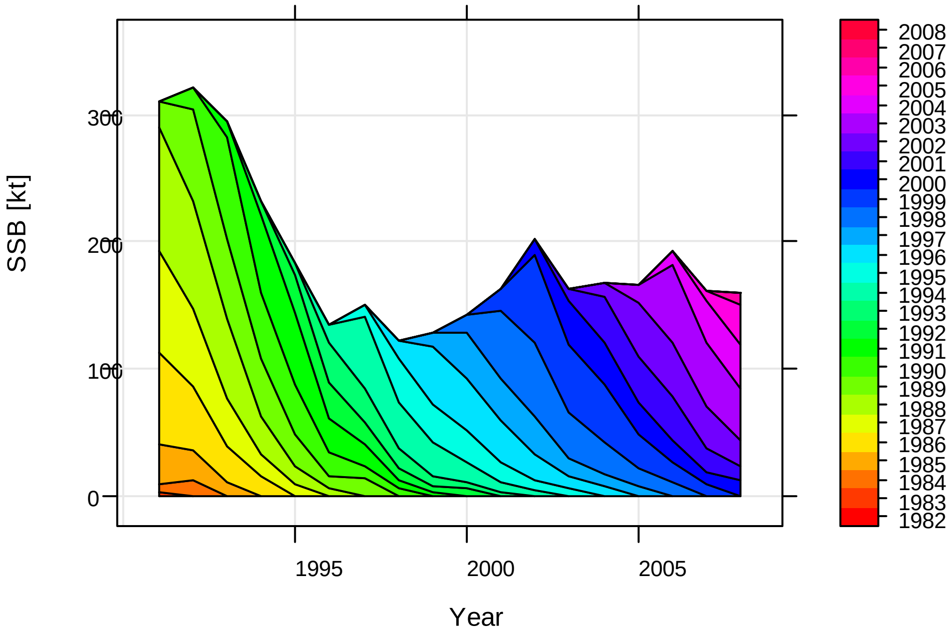


Figure 3.6.5.1 Western Baltic Spring Spawning Herring. Contribution of each cohort (indicated by the colouring scheme, and the key to the right) to the spawning stock biomass.

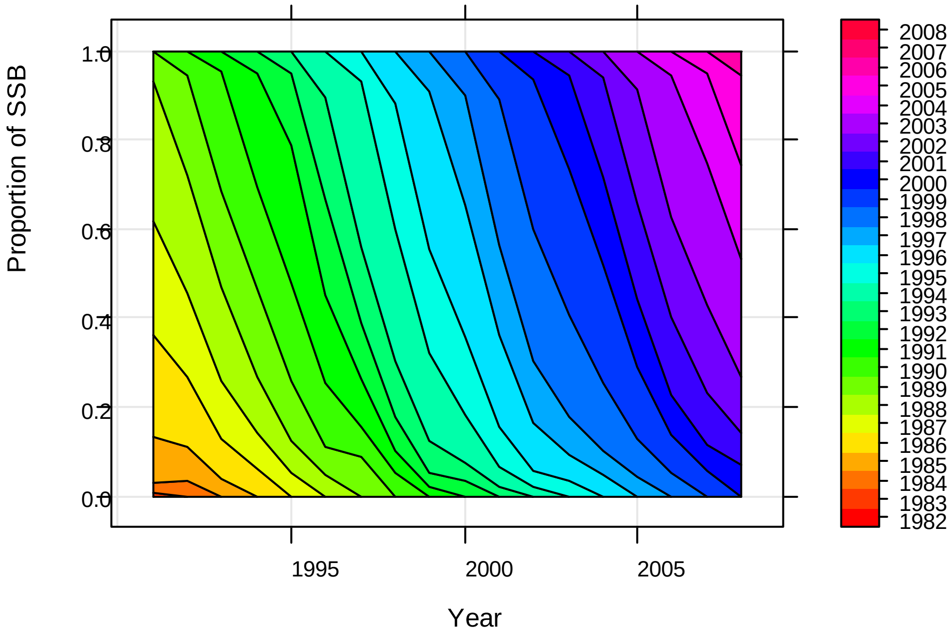


Figure 3.6.5.2 Western Baltic Spring Spawning Herring. Relative contribution by weight of each cohort (indicated by the colouring scheme, and the key to the right) to the spawning stock biomass.

4 Celtic Sea and Division VIIj Herring

Exploratory Assessment with a final assessment presented

The assessment year for this stock runs from the 1st April – 31st March. Unless otherwise stated, year and year class are referred to by the first year in the season i.e. 2008 refers to the 2008/2009 season.

4.1 The Fishery

4.1.1 Advice and management applicable to 2008 - 2009

The TAC is set by calendar year and in 2008 was 7 890 t, and in 2009 is 5 917 t. In 2008, ICES considered the current stock size was uncertain but was likely to be as low as when the stock collapsed in the 1970s. At those recent levels of SSB there was a risk of reduced recruitment. Currently F was uncertain but too high and needed to be reduced. ICES recommended a rebuilding plan be put in place that would reduce catches. If no rebuilding plan was established, there should be no fishing. The rebuilding plan should be evaluated with respect to the precautionary approach.

Rebuilding Plan

The Irish local fishery management committee developed a rebuilding plan for this stock. The Irish authorities submitted the plan to the European Commission in late 2008. STECF (2008) evaluated the plan, noting that it was likely to achieve its aims. The European Commission endorsed the plan, after it being noted in the TAC and quota regulation for 2009. The plan has been submitted to the Pelagic RAC. The RAC is working with the European Commission to develop a formal request for its evaluation by both ICES and STECF.

The plan (cited below) incorporated scientific advice with the main elements of the EU policy statement.

1) For 2009, the TAC shall be reduced by 25% relative to the current year (2008).
2) In 2010 and subsequent years, the TAC shall be set equal to a fishing mortality of $F_{0.1}$.
3) If, in the opinion of ICES and STECF, the catch should be reduced to the lowest possible level, the TAC for the following year will be reduced by 25%.
4) Division VIIaS will be closed to herring fishing for 2009, 2010 and 2011.
5) A small-scale sentinel fishery will be permitted in the closed area, Division VIIaS. This fishery shall be confined to vessels, of no more than 65 feet in length. A maximum catch limitation of 8% of the Irish quota shall be exclusively allocated to this sentinel fishery.
6) Every three years from the date of entry into force of this Regulation, the Commission shall request ICES and STECF to evaluate the progress of this rebuilding plan.
7) When the SSB is deemed to have recovered to a size equal to or greater than B_{pa} in three consecutive years, the rebuilding plan will be superseded by a long-term management plan.

4.1.2 The fishery in 2008/2009

In 2008-2009, 26 vessels took part in the Irish fishery. These are categorised as follows:

- 4 Pelagic refrigerated seawater (RSW) trawlers
- 6 Polyvalent bulk storage trawlers,
- 16 Polyvalent dry hold trawlers.

The fishery took place in the third quarter only in VIIj and in the fourth and first quarters in all three areas. Most vessels under 20 m reported landings of less than 100 t for the season while a number of RSW vessels reported combined landings greater than 1100 t. The term "Polyvalent" refers to a segment of the Irish fleet, entitled to fish for any species to catch a variety of species, under Irish law.

The third quarter fishery took place in one statistical rectangle (31E0) in VIIj, landing a total of 360 t. The fourth quarter fishery began around the 1st October, and lasted until the 2nd week of December. The quarter 4 fishery took place in VIIj, off the south Irish coast, and further east in VIIg and between Cork and Capel Island and also further east in VIIaS.

As part of the rebuilding measures, the fishery was closed in quarter 1, 2009, except for 270 t allocation for a sentinel fishery.

The distribution of the total landings are presented in Figure 4.1.2.1

4.1.3 The catches in 2008/2009

The estimated national catches from 1988–2008 for the combined areas by year and by season (1st April–31st March) are given in Table 4.1.3.1 and Table 4.1.3.2 respectively. The catch, taken during the 2008 season has fallen to the lowest estimate in the entire series, about 5 800 t (Figure 4.1.3.1.). The catch data include discards, until 1997. Official catches reported from other nations are assumed to be taken from other areas and are subtracted as unallocated catches.

There are no recent estimates of discards for this fishery. Anecdotal reports from fishermen suggest that discarding is not a feature of this fishery at present.

4.1.4 Regulations and their effects

The closure of VIIaS, except for a sentinel fishery means that only small dry hold vessels, no more than 65 feet total length, can fish in that area. This closure has meant that the majority of the quota was taken by the larger bulk storage vessels further west, including VIIj. There have been two closures of VIIaS (2002-2003 and 2007-present). Though it is difficult to assess their effectiveness it can be seen that in each period of closure, F has been substantially reduced and SSB grew (Section 4.6). This area, particularly the area off Dunmore East, is important for recruit spawners. It can be expected that the closure allows these fish to spawn at least once, and contribute to SSB through further growth and spawning potential.

4.1.5 Changes in fishing technology and fishing patterns

The stock is exploited by three types of vessels, larger boats with RSW or bulk storage and smaller dry hold vessels. The smaller vessels are confined to the spawning grounds (VIIaS and VIIg) during the winter period. The refrigerated seawater (RSW) tank vessels target the stock inshore in winter and offshore during the summer feeding phase (VIIg), but are not allowed in VIIaS under the terms of the rebuilding plan. In the past season there has been increased fishing VIIj.

The sentinel fishery that was allowed in VIIaS closed area mainly took place in Waterford harbour mouth and roads, rather than upstream.

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 2008. In 2008, there was a strong dominance of 2 ringers (2005 year class) and 4-ringers (2003 year class). This cohort was strong in the previous season as 3-ringers also. The weak 2001/2002 year class has almost disappeared from the catches by now (Table 4.2.1.1). The catch numbers at age for ages 1-9 are presented in Figure 4.2.1.1 and it can be seen that there has been a truncation of older ages in recent years. Due to this truncation a new plus group is now set at 6+ and the yearly mean standardised plot is shown in Figure 4.2.1.2. Both plots show that 2-ringers have been the dominant age in catches in general throughout the series .

The overall proportions at age were similar in all sampled metiers (division*quarter). However, unusually the survey and the commercial fishery did not agree well in terms of proportions at age (Figure 4.2.1.3). The 4-ringers that were so dominant in the commercial catch were less dominant in the survey, and 0-ringers were found in the latter only. Apart from these two age groups, the patterns are similar. The 2003 year class appeared stronger in the fishery that was mainly inshore during the time of the survey.

Unlike recent years, samples from VIIaS within Waterford Harbour and outside were not raised separately. This is because most of the fishing took place outside, on the Roads of Waterford.

Table 4.2.1.2 shows the length frequency data by area and quarter. A similar length range was found in each area.

4.2.2 Quality of catch and biological data

Biological sampling of the catches throughout the region was comprehensive throughout the area exploited by the Irish fishery (Table 4.2.2.1). However no samples accompanied reported landings from the Netherlands, Germany or France. Under the Data Collection Programme 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. The quality of the landings data has improved in most recent years, particularly since 2004, when a low tolerance for water in catches was introduced. In 2008/2009 only preliminary data were available at the time of the working group. Best estimates of small boat catches were used for the VIIaS sentinel fishery. This is because not all the vessels are required to make logbook returns, being less than 10 m in total length.

Discarding was a major feature of the fishery from 1983 to 1997, when the fishery sought fish of a particular roe quality, discarding early stage, spent and young fish. Though discarding (slippage) is thought to be lower in subsequent years, the tight quota situation coupled with market requirements are known to lead to some discarding, particularly of smaller fish. There is no information on misreporting in this fishery in recent years, but it is thought to have decreased.

4.3 Fishery Independent Information

4.3.1 Acoustic Surveys

Since 2005 this survey has had a standard design and is conducted at the same time each year. The surveys carried out from 2002 and 2003 are comparable with the later surveys. This series dates from 1995 and is presented in Table 4.3.1.1.

The acoustic survey of the 2008/2009 season was carried out in October 2008, on the *Celtic Explorer* (O'Donnell, *et al* 2008). The survey track began at the northern boundary of VIIj, covering the SW bays in zig-zags and parallel transects (Figure 4.3.1.1a). As in previous seasons, very little herring was registered in the bays of VIIj Figure (4.3.1.1b). The main broad scale survey in VIIg and VIIaS adapted a parallel transect design and showed the greatest concentrations of herring.

In 2008/2009 the SSB estimate was 90 855 t. This is an increase of about 96%, from the previous year. The current estimate is also much more precise, with a CV of 20 %, the most precise in the series. This estimate is associated with more even distribution of herring than in previous years.

4.3.2 Other surveys

In 2008, a pair trawl survey was conducted, to find juvenile herring (Clarke *et al*. 2008). This was a scoping exercise, to map the distribution of juvenile herring in advance of developing a recruit index for this stock. A new Irish recruit survey is envisaged by the industry initiated plan to rebuild the stock. It is envisaged that a combination of the Northern Ireland GFS and Irish survey of the Celtic Sea and VIIj could be used. GFS surveys could provide useful indices for the component of the stock, if the origin of herring in catches can be identified. Some progress has been made on this (Beggs, 2008 WD).

4.4 Mean weights-at-age and maturity-at-age

The mean weights in the catch and mean weight in the stock at spawning time are presented in Figure 4.4.1.1 and 4.4.1.2 respectively. There has been an overall downward trend in mean weights at age since the mid-1980s. However, the values for 2008/2009 have shown an increase. The 2-ringers have shown an increase since 2005.

Mean weights in the stock at spawning time were calculated from biological samples, for quarters 4 and 1 (Figure 4.4.1.2). A slight increase is evident in these data for the most recent season.

The 1 ringers that are resident in the Celtic Sea appear to have greater than 50% maturity. The Celtic Sea 1 ringers that are present in the Irish Sea have less than 50% maturity (Beggs WD, 2009).

4.5 Recruitment

At present there are no recruitment estimates for this stock that can be used for predictive purposes. The issue of mixing of Irish Sea and Celtic Sea juveniles means that recruitment is not well represented in the catch data.

4.6 Assessment

4.6.1 Exploratory Assessments

This stock was benchmarked in 2007. Problems with conflicting signals in input data and changes in the fishing pattern prevented a final assessment being conducted. The assessment was considered indicative of trends.

A number of further exploratory runs were conducted in 2009 using FLICA. The details of these runs are presented in Table 4.6.1.1. The main settings examined were as follows

- Plus group reduced to 6+ from 7+
- Shortening of the survey time series from 1995-2008 to 2002-2008
- Terminal selection of 1, 1.1, and 1.2.
- Changing the separable period from 6 years to 5 years and 4 years

The catch and survey residual patterns are shown from the 6+ and 7+ runs in Figure 4.6.1.1 and catch diagnostics and selection patterns from each run are presented in Figure 4.6.1.2. The 6+ run shows a better residual pattern, with smaller residuals, and a flat topped selection pattern.

The length of the survey time series was also examined. When the full series from 1995 was used we can see a much improved residual pattern displayed for 2002 onwards (Figure 4.6.1.3). From 2005 a uniform track design has been adopted and the survey timing is fixed in October each year. The residuals for the 2000 and 2001 surveys are the biggest and it was decided to test the removal of these noisy data and use the survey series from 2002 – 2008 in further runs. Some year effects are evident in the shorter time series but the residuals are small overall.

Changing the selection pattern using values of 1, 1.1 and 1.2 for the terminal age was examined and it was found that increasing the selection on the oldest age did not show a significant improvement. For further runs 1 was used because there is no evidence from the fishery that selection is higher for older ages. The precision of the assessment is reduced when the selection on the oldest age is increased.

The reduction of the separable period to 4 and 5 years from 6 years probably led to over parameterisation of the model, and also resulted in an inflated stock size and very low F values. A more precise estimate of SSB is achieved when a longer separable period is used. The SSB confidence limits are narrower using a longer separable period (Figure 4.6.1.4). The separable period of 6 years was used for all other runs.

The estimates of Mean F and SSB for some of the exploratory runs are presented in Figure 4.6.1.4. The perception of the stock is similar for all runs except when the separable period is shortened. The otolith plots produced form the 6+ and 7+ run are presented in Figure 4.6.1.5 and show very similar values. The exploratory runs have shown that using the 6+ data and the survey time series from 2002-2008 produces improved residual patterns.

Historical retrospective assessments are presented in Figure 4.6.1.6. These are based on final "SPALY" ICA exploratory assessments from recent years, with terminal year SSB adjusted to account for poor 1-ringer estimation (see Stock Annex). These show a relatively balanced pattern, with no systematic bias in estimation of stock parameters in recent years. In the historical period there are retrospective patterns, with the 2009 accepted assessment producing a lower (24 000 t) estimate of B_{loss}. This new estimate of B_{loss} is less than 8% lower than B_{lim} (Section 4.9) and is due to the reduction of the plus group to 6+.

The historical retrospectives were performed using the standard procedure for this stock, where the terminal SSB is adjusted by using GM recruitment. The analytical retrospectives and precision estimates (Figures 4.6.1.5 and 4.6.2.5) are not adjusted with GM recruitment. However they were considered to be good indicators of the best ICA run. The decision regarding the best assessment run was based on model fit diagnostics, and not on stock trajectories.

The results from the exploratory assessment show that there is improved consistency and precision in this assessment. The working group has decided to accept this assessment as an analytical assessment. This accepted assessment is largely based on the same settings as those from the previous benchmark. At the time of the benchmark, the series of comparable surveys was too short and the separable period included a marked change in fishing pattern (2003). In 2009, these problems were resolved. The separable period now does not include the changing pattern. Several years of comparable surveys (2002-present) are now available for tuning.

4.6.2 Final assessment

Based on the explorations carried out above a final run was chosen which used plus group at 6+. The input and output data are presented in Table 4.6.2.1 to 4.6.2.1. The survey series from 2002-2008 was used as well as a 6 year separable period with terminal selection set at 1 relative to 3 ring. The diagnostics are presented in Figure 4.6.2.1 to Figure 4.6.2.6.

The analytical retrospective pattern is displayed in Figure 4.6.2.5. The retrospective was fitted as far back as 2003 but excludes the 2004 estimates. A retrospective analysis cannot be extended into earlier years because of the lack of reliable survey data. However it can be seen from the years presented that there is no systematic bias and there is a reasonably tight pattern of evenly balanced retrospective estimations.

4.6.3 State of the stock

The stock appears to have increased in size and is above B_{pa}. F has declined from the peak in 2003, and is estimated to be below $F_{0.1}$. Overall recruitment is around long term mean. The stock is showing signs of recovery. However it is still very dependent on strength of incoming year classes, that cannot be observed until fully recruited.

4.7 Short term projections

4.7.1 Deterministic Short Term Projections

A deterministic short term forecast was performed, using the MFDP software (Smith, 2000). The input data are presented in Table 4.7.1.1. Geometric mean (1995-2006) was used because this represents a period where recruitment has been fluctuating around the mean. Mean weights in the catch and in the stock were calculated as means over the last three years. Recruits (1-ring) are poorly represented in the catch and only one observation of their abundance is available. Yet 50% of these are considered mature and they make an important contribution to the SSB. The population numbers at 1 ring are replaced by geometric mean. Population numbers of 2 ringers in the intermediate season (2009) were calculated by the degradation of geometric mean recruitment (1995-2006) using the equation below.

$N_{t+1} = N_t * e^{-Ft+Mt}$

The short term forecast was performed using the predicted catch in the interim year 2009. This was calculated as the remaining Irish quota for 2009 + the likely Irish catch in quarter 1 of 2010. The 2010 quarter 1 catch was estimated assuming that the TAC would be increased by 15% using the EU TAC Decision Rule for stocks for which STECF advice is that the stock is increasing. The use of Irish catch estimates in the interim year assumes that other countries' catches are unallocated.

The results of the short term projection are presented in Table 4.7.1.2 and Table 4.7.1.3. Fishing according to the proposed rebuilding plan implies catches of 9,227 t in 2010. Only very high catches are associated with SSB < B_{pa} in 2010.

4.7.2 Yield Per Recruit

A yield per recruit analysis was conducted using MFYPR. The yield per recruit curve is presented in Figure 4.7.2.1 and $F_{0.1}$ was estimated to be 0.17.

4.8 Medium term projections

No medium term projections were conducted by the working group.

4.9 Precautionary and yield based reference points

Reference points are defined for this stock, $\mathbf{B_{pa}}$ is currently at 44 000t (low probability of low recruitment) and $\mathbf{B_{lim}}$ at 26 000 t **($\mathbf{B_{loss}}$)** for this stock. $\mathbf{F_{pa}}$ and $\mathbf{F_{lim}}$ are not defined. F_{msy} has not been estimated. However $F_{0.1}$ can be assumed to be a proxy for F_{msy} and was estimated in 2009 to be = 0.17 (Section 4.8).

The historical retrospective analysis (Section 4.6.1) shows that the accepted assessment produces a downward revision (<8%) of the basis for B_{lim}, which is B_{loss}. This is due to the reduction in the plus group. It is not considered necessary to carry out a downward revision of reference points because the revision is small. Also there is some evidence that B_{lim} should be revised upwards, to the point of recruitment impairment estimated by Clarke and Egan (2008). These authors showed a changepoint in a segmented regression at 47 000 t.

4.10 Quality of the Assessment

A final analytical assessment is being proposed. The precision of the assessment estimated through a parametric bootstrap routine are presented for the 6+ assessment and also the 7+ assessment in Figure 4.6.1.5. Both display similar ranges for SSB and mean F for 2-5 ring.

There is improved coherence between the catch at age and the survey data. The survey results are more stable since 2002. Since 2005 a uniform design was adopted. This improved coherence is reflected in better tuning diagnostics.

4.11 Management Considerations

Fishing mortality on this stock was high for many years, well above a long term sustainable level of $F_{0.1}$ = 0.17. In the past three years F has been substantially reduced and is now below $F_{0.1}$ and at its lowest rate in 45 years. This is associated with reduced catches and management actions which led to the closure of the fishery in quarter 1, 2009. In the past two years, ICES has recommended that catches of around 5,000 t would be associated with stock recovery. The current landings estimate (5,700 t) is close to that suggested catch and is the lowest in the series.

The WG is aware of the rebuilding plan proposed by the Irish industry. This envisaged a 25% TAC reduction in 2009, with future catch levels based on an $F_{0.1}$ strategy. The short term forecast conducted by the working group shows that fishing at $F_{0.1}$ would imply catches of over 9,000 t in 2010. It is unclear if management will follow the rebuilding plan. However there is good evidence to show that the stock has increased substantially. Consequently, the current advice for zero catch is no longer justified. The rebuilding plan should continue until 2011 and then if the stock can be shown to have rebuilt, the rebuilding plan will be replaced by a long term management plan.

The measures to protect first time spawners by closing the VIIaS Box should continue until 2011 as set out in the rebuilding plan. The measure has not been in place long enough to assess its benefits fully. Sampling of the sentinel fishery which takes place in this closed area will continue.

4.12 Environment

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 has 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, though anecdotal reports suggest that seals are caught from time to time.

Changes in the environment

Temperatures in this area have been increasing over the last number of decades. There are indications that salinity is also increasing (ICES 2006). It is considered that this could have implications for herring, that is at the southern edge of its distribution in this area. It is known that similar environmental changes have affected the North Sea herring. There is no evidence that changes in the environmental regime in the Celtic Sea has had any effect on productivity of this stock.

Table 4.1.3.1. Celtic Sea and Division VIIj herring. Landings by quota year (t), 1988–2008. (Data provided by Working Group members.) These figures may not in all cases correspond to the official statistics and cannot be used for management purposes.

Year	France	Germany	Ireland	Netherlands	U.K.	Unallocated	Discards	Total
1988	**-**	**-**	**16,800**	**-**	**-**	**-**	**2,400**	**19,200**
1989	**+**	**-**	**16,000**	**1,900**	**-**	**1,300**	**3,500**	**22,700**
1990	**+**	**-**	**15,800**	**1,000**	**200**	**700**	**2,500**	**20,200**
1991	**+**	**100**	**19,400**	**1,600**	**-**	**600**	**1,900**	**23,600**
1992	**500**	**-**	**18,000**	**100**	**+**	**2,300**	**2,100**	**23,000**
1993	**-**	**-**	**19,000**	**1,300**	**+**	**-1,100**	**1,900**	**21,100**
1994	**+**	**200**	**17,400**	**1,300**	**+**	**-1,500**	**1,700**	**19,100**
1995	**200**	**200**	**18,000**	**100**	**+**	**-200**	**700**	**19,000**
1996	**1,000**	**0**	**18,600**	**1,000**	**-**	**-1,800**	**3,000**	**21,800**
1997	**1,300**	**0**	**18,000**	**1,400**	**-**	**-2,600**	**700**	**18,800**
1998	**+**	**-**	**19,300**	**1,200**	**-**	**-200**	**-**	**20,300**
1999		**200**	**17,900**	**1300**	**+**	**-1300**	**-**	**18,100**
2000	**573**	**228**	**18,038**	**44**	**1**	**-617**	**-**	**18,267**
2001	**1,359**	**219**	**17,729**	**-**	**-**	**-1578**	**-**	**17,729**
2002	**734**	**-**	**10,550**	**257**	**-**	**-991**	**-**	**10,550**
2003	**800**	**-**	**10,875**	**692**	**14**	**-1,506**	**-**	**10,875**
2004	**801**	**41**	**11,024**	**-**	**-**	**-801**	**-**	**11,065**
2005	**821**	**150**	**8452**	**799**	**-**	**-1770**	**-**	**8,452**
2006	**-**	**-**	**8,530**	**518**	**5**	**-523**	**-**	**8,530**
2007	**581**	**248**	**8,268**	**463**	**63**	**-1355**	**-**	**8,268**
2008	**503**	**191**	**6,774**	**291**		**-985**	**-**	**6,774**

Table 4.1.3.2. Celtic Sea & Division VIIj herring landings (t) by assessment year (1st April–31st March) 1988/1989-2008/2009. (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	5,793	150		-844	-	5,793

Table 4.2.1.1. Celtic Sea & Division VIIj herring. Comparison of age distributions (percentages) in the catches of Celtic Sea and VIIj herring over the time series.

	1	2	3	4	5	6	7	8	9
1958	1%	3%	25%	20%	10%	18%	12%	7%	4%
1959	1%	27%	2%	20%	12%	6%	19%	4%	8%
1960	2%	53%	18%	3%	10%	3%	4%	3%	3%
1961	3%	22%	44%	8%	3%	7%	4%	2%	7%
1962	1%	16%	17%	41%	7%	3%	7%	3%	5%
1963	0%	52%	13%	4%	21%	3%	1%	3%	3%
1964	12%	25%	28%	11%	3%	14%	2%	1%	4%
1965	0%	56%	8%	13%	3%	4%	10%	1%	6%
1966	5%	15%	46%	8%	10%	4%	3%	7%	3%
1967	5%	26%	13%	32%	6%	6%	3%	4%	4%
1968	8%	35%	25%	7%	14%	3%	3%	1%	3%
1969	4%	40%	24%	14%	5%	8%	2%	1%	1%
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	19%	38%	7%	23%	9%	2%	1%	0%	0%
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%

Table 4.2.1.2. Celtic Sea & Division VIIj herring. Length frequency distributions of the Irish catches (raised numbers in '000s) in the 2008/2009 season in the Celtic Sea and VIIj fishery.

	2008				2009			
	7j Q3	7j Q4	7g Q4	7aS Q4	7j Q1	7g Q1	7aSQ1	Total
18								
18.5				4				4
19			7			3		10
19.5			34			6		40
20	2	7	55	7	0	10	3	85
20.5	5	14	103	4	0	12	2	140
21	12	36	172	26	1	18		265
21.5	9	29	255	45	1	27	2	367
22	23	71	427	82	2	53	6	665
22.5	30	93	951	138	3	66	16	1297
23	80	243	1737	354	7	78	34	2531
23.5	108	328	2288	433	9	104	35	3305
24	152	464	2495	552	13	120	38	3835
24.5	246	749	3074	582	21	134	51	4857
25	309	942	3729	619	26	186	61	5872
25.5	400	1220	3880	634	34	171	61	6401
26	384	1170	2874	526	33	157	40	5184
26.5	269	821	1558	261	23	111	16	3058
27	140	428	669	108	12	88	10	1454
27.5	84	257	317	60	7	48	5	778
28	28	86	165	19	2	36		336
28.5	19	57	48	7	2	11		144
29	12	36	21		1	5		75

Table 4.2.2.1 Celtic Sea & Division VIIj (2008/2009). Sampling intensity of Irish commercial catches. Only Ireland provides samples of this stock.

ICES area	Year	Quarter	Landings (t)	No. Samples	No. aged	No. Measured	Aged/1000 t
VIIg	**2008**	**4**	**3473**	**16**	**1195**	**3607**	**344**
VIIg	**2009**	**1**	**188**	**12**	**293**	**3723**	**1558**
Sub-total			**3661**	**28**	**1488**	**7330**	
VIIaS	**2008**	**4**	**580**	**8**	**594**	**1196**	**1024**
VIIaS	**2009**	**1**	**46**	**2**	**149**	**237**	**3239**
Sub-total			**626**	**10**	**743**	**1433**	
VIIj	**2008**	**3**	**364**	**0**	**516**	**988**	**1417**
VIIj	**2008**	**4**	**1111**	**7**	**516**	**988**	**464**
VIIj	**2009**	**1**	**31**	**0**	**516**	**988**	**16645**
Sub-total			**1506**	**7**	**1548**	**2964**	
Total Celtic Sea			**5794**	**45**	**3779**	**11727**	

Table 4.3.1.1. Celtic Sea & Division VIIj herring. Revised acoustic index of abundance. Total stock numbers-at-age (10^6) estimated using combined acoustic surveys (age refers in winter rings, biomass and SSB in 000's tonnes).

	1995 1996	1996 1997	1997 1998	1998 1999	1999 2000	2000 2001	2001 2002	2002 2003	2003 2004	2004 2005	2005 2006	2006 2007	2007 2008	2008 2009
0	202	3	-	0	-	25	40	0	24	-	2	-	1	99
1	25	164	-	30	-	102	28	42	13	-	65	21	106	64
2	157	795	-	186	-	112	187	185	62	-	137	211	70	295
3	38	262	-	133	-	13	213	151	60	-	28	48	220	111
4	34	53	-	165	-	2	42	30	17	-	54	14	31	162
5	5	43	-	87	-	1	47	7	5	-	22	11	9	27
6	3	1	-	25	-	0	33	7	1	-	5	1	13	6
7	1	15	-	24	-	0	24	3	0	-	1	-	4	5
8	2	0	-	4	-	0	15	0	0	-	0	-	1	
9	2	2	-	2	-	0	52	0	0	-	0	-	0	
														-
Abundance	469	1338	-	656		256	681	423	183	-	312	305	454	769
SSB	36	151		100		20	95	41	20	-	33	36	46	90
CV	53	26		36		100	88	49	34	-	48	35	25	20
Design	AR	AR		AR		AR	AR	AR	AR		R	R	R	R

*AR Adaptive random; R random

Table 4.6.1.1. Celtic Sea and VIIj herring. Settings used in exploratory FLICA assessments.

	Survey Time Series	Selection	Plus Group	Sep period
1	2005-2008	1	7	6
2	2002-2008	1	7	6
3	1995-2008	1.2	7	6
4	1995-2008	1.1	7	6
5	1995-2008	1	7	4
6	1995-2008	1	7	5
7	1995-2008	1	6	6
8	1995-2008	1.1	6	6
9	2002-2008	1	6	6
10	1995-2008	1	6	4
11	1995-2008	1	6	5
12	2002-2008	1	6	5
13	2002-2008	1	6	4
14	2002-2008	1.1	6	6
15	2002-2008	1.2	6	6

TABLE 4.6.2.1.1 Celtic Sea and Division VIIj Herring. CATCH IN NUMBER

Units : thousands

age	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969
1	1642	1203	2840	2129	772	297	7529	57	7093	7599	12197	9472
2	3742	25717	72246	16058	18567	51935	15058	70248	19559	39991	54790	93279
3	33094	2274	24658	32044	19909	13033	17250	9365	59893	20062	39604	55039
4	25746	19262	3779	5631	48061	4179	6658	15757	9924	49113	11544	33145
5	12551	11015	13698	2034	8075	20694	1719	3399	13211	9218	22599	12217
6	55010	34748	19057	14363	21304	9353	12790	25536	21776	26650	15345	28242

age	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
1	1319	12658	8422	23547	5507	12768	13317	8159	2800	11335	7162	39361
2	37260	23313	137690	38133	42808	15429	11113	12516	13385	13913	30093	21285
3	50087	37563	17855	55805	17184	17783	7286	8610	11948	12399	11726	21861
4	26481	41904	15842	7012	22530	7333	7011	5280	5583	8636	6585	5505
5	18763	18759	14531	9651	4225	9006	2872	1585	1580	2889	2812	4438
6	19746	21900	11051	12216	8445	7494	9777	3794	3356	3785	5215	5410

age	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
1	15339	13540	19517	17916	4159	5976	2307	8260	2702	1912	10410	1608
2	42725	102871	92892	57054	56747	67000	82027	42413	41756	63854	26752	94061
3	8728	26993	41121	36258	42881	43075	30962	68399	24634	38342	35019	9372
4	4817	3225	16043	16032	32930	23014	9398	19601	35258	16916	27591	10221
5	1497	1862	2450	2306	8790	14323	5963	8205	8116	28405	10139	4491
6	4492	1939	1872	618	1266	4651	4299	7875	6636	9004	28056	10085

age	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
1	12130	9450	3476	3849	5818	14274	9953	15724	3495	2711	4276	15419
2	35768	79159	61923	37440	41510	34072	77378	62153	26472	37006	9470	30710
3	61737	22591	38244	53040	27102	36086	18952	35816	18532	24444	46243	5766
4	3289	36541	7943	31442	28274	14642	12060	5953	5309	14763	21863	18666
5	3025	3686	16114	8318	13178	15515	5230	4249	1416	5719	8638	7349
6	8665	8772	6195	8720	7405	13305	9787	3771	2061	6628	2151	2495

age	2006	2007	2008
1	1460	8043	1288
2	33894	11028	12468
3	10914	36223	8144
4	2469	5509	15565
5	6261	1365	2328
6	2997	2509	909

TABLE 4.6.2.1.2 Celtic Sea and Division VIIj Herring. WEIGHTS AT AGE IN THE CATCH

Units : kg

age	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969
1	0.096	0.087	0.093	0.098	0.109	0.103	0.105	0.103	0.122	0.119	0.119	0.122
2	0.115	0.119	0.122	0.127	0.146	0.139	0.139	0.143	0.154	0.158	0.166	0.164
3	0.162	0.166	0.156	0.156	0.170	0.194	0.182	0.180	0.191	0.185	0.196	0.200
4	0.185	0.185	0.191	0.185	0.187	0.205	0.215	0.212	0.212	0.217	0.215	0.217
5	0.205	0.200	0.205	0.207	0.210	0.217	0.225	0.232	0.237	0.243	0.235	0.237
6	0.224	0.220	0.222	0.224	0.234	0.241	0.235	0.249	0.250	0.257	0.257	0.252

age	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
1	0.128	0.117	0.132	0.125	0.141	0.137	0.137	0.134	0.127	0.127	0.117	0.115
2	0.162	0.166	0.170	0.174	0.180	0.187	0.174	0.185	0.189	0.174	0.174	0.172
3	0.200	0.200	0.194	0.205	0.210	0.215	0.205	0.212	0.217	0.212	0.207	0.210
4	0.225	0.225	0.220	0.215	0.225	0.240	0.235	0.222	0.240	0.230	0.237	0.245
5	0.240	0.245	0.245	0.245	0.237	0.251	0.259	0.243	0.279	0.253	0.259	0.267
6	0.262	0.261	0.265	0.269	0.264	0.269	0.278	0.271	0.288	0.282	0.273	0.287

age	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
1	0.115	0.109	0.093	0.104	0.112	0.096	0.097	0.106	0.099	0.092	0.096	0.092
2	0.154	0.148	0.142	0.140	0.155	0.138	0.132	0.129	0.137	0.128	0.123	0.129
3	0.194	0.198	0.185	0.170	0.172	0.186	0.168	0.151	0.153	0.168	0.150	0.155
4	0.237	0.220	0.213	0.201	0.187	0.192	0.203	0.169	0.167	0.182	0.177	0.180
5	0.262	0.276	0.213	0.234	0.215	0.204	0.209	0.194	0.188	0.190	0.191	0.201
6	0.279	0.305	0.249	0.256	0.252	0.245	0.224	0.208	0.214	0.219	0.205	0.211

age	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
1	0.097	0.088	0.088	0.093	0.099	0.090	0.092	0.082	0.096	0.089	0.080	0.077
2	0.135	0.126	0.118	0.124	0.121	0.120	0.111	0.107	0.115	0.102	0.130	0.102
3	0.168	0.151	0.147	0.141	0.153	0.149	0.148	0.139	0.139	0.128	0.134	0.142
4	0.179	0.178	0.159	0.157	0.163	0.167	0.168	0.162	0.156	0.146	0.151	0.147
5	0.190	0.188	0.185	0.172	0.173	0.180	0.185	0.177	0.185	0.165	0.159	0.158
6	0.214	0.210	0.210	0.198	0.194	0.191	0.193	0.194	0.201	0.191	0.186	0.174

age	2006	2007	2008
1	0.093	0.074	0.091
2	0.105	0.106	0.120
3	0.127	0.123	0.144
4	0.151	0.141	0.156
5	0.155	0.166	0.172
6	0.168	0.164	0.193

TABLE 4.6.2.1.3 Celtic Sea and Division VIIj Herring. WEIGHTS AT AGE IN THE STOCK

Units : kg

age	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969
1	0.096	0.087	0.093	0.098	0.109	0.103	0.105	0.103	0.122	0.119	0.119	0.122
2	0.115	0.119	0.122	0.127	0.146	0.139	0.139	0.143	0.154	0.158	0.166	0.164
3	0.162	0.166	0.156	0.156	0.170	0.194	0.182	0.180	0.191	0.185	0.196	0.200
4	0.185	0.185	0.191	0.185	0.187	0.205	0.215	0.212	0.212	0.217	0.215	0.217
5	0.205	0.200	0.205	0.207	0.210	0.217	0.225	0.232	0.237	0.243	0.235	0.237
6	0.224	0.220	0.222	0.224	0.234	0.241	0.235	0.249	0.250	0.257	0.257	0.252

age	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
1	0.128	0.117	0.132	0.125	0.141	0.137	0.137	0.134	0.127	0.127	0.117	0.115
2	0.162	0.166	0.170	0.174	0.180	0.187	0.174	0.185	0.189	0.174	0.174	0.172
3	0.200	0.200	0.194	0.205	0.210	0.215	0.205	0.212	0.217	0.212	0.207	0.210
4	0.225	0.225	0.220	0.215	0.225	0.240	0.235	0.222	0.240	0.230	0.237	0.245
5	0.240	0.245	0.245	0.245	0.237	0.251	0.259	0.243	0.279	0.253	0.259	0.267
6	0.262	0.261	0.265	0.269	0.264	0.269	0.278	0.271	0.288	0.282	0.273	0.287

age	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
1	0.115	0.109	0.093	0.104	0.112	0.096	0.097	0.106	0.099	0.092	0.096	0.092
2	0.154	0.148	0.142	0.140	0.155	0.138	0.132	0.129	0.137	0.128	0.123	0.129
3	0.194	0.198	0.185	0.170	0.172	0.186	0.168	0.151	0.153	0.168	0.150	0.155
4	0.237	0.220	0.213	0.201	0.187	0.192	0.203	0.169	0.167	0.182	0.177	0.180
5	0.262	0.276	0.213	0.234	0.215	0.204	0.209	0.194	0.188	0.190	0.191	0.201
6	0.279	0.305	0.249	0.256	0.252	0.245	0.224	0.208	0.213	0.219	0.205	0.211

age	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
1	0.097	0.088	0.088	0.093	0.099	0.090	0.092	0.082	0.096	0.078	0.077	0.074
2	0.135	0.126	0.118	0.124	0.121	0.120	0.111	0.107	0.115	0.100	0.127	0.103
3	0.168	0.151	0.147	0.141	0.153	0.149	0.148	0.139	0.139	0.130	0.133	0.145
4	0.179	0.178	0.159	0.157	0.163	0.167	0.168	0.162	0.156	0.141	0.151	0.143
5	0.190	0.188	0.185	0.172	0.173	0.180	0.185	0.177	0.184	0.156	0.156	0.155
6	0.214	0.210	0.210	0.198	0.194	0.191	0.193	0.194	0.201	0.168	0.187	0.167

age	2006	2007	2008
1	0.085	0.066	0.083
2	0.104	0.102	0.117
3	0.123	0.116	0.140
4	0.153	0.135	0.156
5	0.150	0.151	0.170
6	0.159	0.160	0.180

TABLE 4.6.2.1.4 Celtic Sea and Division VIIj Herring. NATURAL MORTALITY

Units : NA

age	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972
1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
4	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
5	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
6	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1

age	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
4	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
5	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
6	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1

age	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
4	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
5	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
6	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1

age	2003	2004	2005	2006	2007	2008
1	1.0	1.0	1.0	1.0	1.0	1.0
2	0.3	0.3	0.3	0.3	0.3	0.3
3	0.2	0.2	0.2	0.2	0.2	0.2
4	0.1	0.1	0.1	0.1	0.1	0.1
5	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

TABLE 4.6.2.1.5 Celtic Sea and Division VIIj Herring. PROPORTION MATURE

Units : NA

year

age	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972
1	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
2	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
3	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
4	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
5	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
6	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0

year

age	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
1	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
2	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
3	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
4	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
5	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
6	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0

year

age	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
1	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
2	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
3	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
4	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
5	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
6	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0

year

age	2003	2004	2005	2006	2007	2008
1	0.5	0.5	0.5	0.5	0.5	0.5
2	1.0	1.0	1.0	1.0	1.0	1.0
3	1.0	1.0	1.0	1.0	1.0	1.0
4	1.0	1.0	1.0	1.0	1.0	1.0
5	1.0	1.0	1.0	1.0	1.0	1.0
6	1.0	1.0	1.0	1.0	1.0	1.0

TABLE 4.6.2.1.6 Celtic Sea and Division VIIj Herring. FRACTION OF HARVEST BEFORE SPAWNING

Units : NA

year

age	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972
1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
4	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
5	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
6	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2

year

age	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
4	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
5	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
6	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2

year

age	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
4	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
5	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
6	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2

year

age	2003	2004	2005	2006	2007	2008
1	0.551	0.551	0.551	0.551	0.551	0.551
2	0.551	0.551	0.551	0.551	0.551	0.551
3	0.551	0.551	0.551	0.551	0.551	0.551
4	0.551	0.551	0.551	0.551	0.551	0.551
5	0.551	0.551	0.551	0.551	0.551	0.551
6	0.551	0.551	0.551	0.551	0.551	0.551

TABLE 4.6.2.1.7 Celtic Sea and Division VIIj Herring. FRACTION OF NATURAL MORTALITY BEFORE SPAWNING

Units : NA

age	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972
1	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
2	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
3	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
4	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
6	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5

age	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
1	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
2	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
3	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
4	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
6	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5

age	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
1	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
2	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
3	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
4	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
6	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5

age	2003	2004	2005	2006	2007	2008
1	0.5	0.5	0.5	0.5	0.5	0.5
2	0.5	0.5	0.5	0.5	0.5	0.5
3	0.5	0.5	0.5	0.5	0.5	0.5
4	0.5	0.5	0.5	0.5	0.5	0.5
5	0.5	0.5	0.5	0.5	0.5	0.5
6	0.5	0.5	0.5	0.5	0.5	0.5

TABLE 4.6.2.1.8 Celtic Sea and Division VIIj Herring. SURVEY INDICES

FLT02: Celtic revised acoustic (Catch: Millions) (Effort:Unknown) - Configuration

"Celtic Sea and Division VIIj herring . Imported from VPA file."

min	max	plusgroup	minyear	maxyear	startf	endf
2	5	NA	2002	2008	1	1

Index type : number

FLT02: Celtic revised acoustic (Catch: Millions) (Effort:Unknown) - Index Values

Units : NA

age	2002	2003	2004	2005	2006	2007	2008
2	185.2	61.7	-1	137.1	210.5	70	295
3	150.6	60.4	-1	28.2	47.8	220	111
4	29.7	17.2	-1	54.2	13.5	31	162
5	6.6	5.4	-1	21.6	11.0	9	27

FLT02: Celtic revised acoustic (Catch: Millions) (Effort:Unknown) - Index Variance (Inverse Weights)

Units : NA

age	2002	2003	2004	2005	2006	2007	2008
2	1	1	1	1	1	1	1
3	1	1	1	1	1	1	1
4	1	1	1	1	1	1	1
5	1	1	1	1	1	1	1

TABLE 4.6.2.1.9 Celtic Sea and Division VIIj Herring. STOCK OBJECT CONFIGURATION

min	max	plusgroup	minyear	maxyear	minfbar	maxfbar
1	6	6	1958	2008	2	5

TABLE 4.6.2.1.10 Celtic Sea and Division VIIj Herring. FLICA CONFIGURATION SETTINGS

```
sep.2       : NA
sep.gradual : TRUE
sr          : FALSE
sr.age      : 1
lambda.age  : 0.1 1 1 1 1 0
lambda.yr   : 1 1 1 1 1 1
lambda.sr   : 0
index.model : linear
index.cor   : 1
sep.nyr     : 6
sep.age     : 3
sep.sel     : 1
```

TABLE 4.6.2.1.11 Celtic Sea and Division VIIj Herring. FLR, R SOFTWARE VERSIONS

```
R version 2.8.0 (2008-10-20)

Package  : FLICA
Version  : 1.4-10
Packaged : Sat Mar 21 18:30:56 2009; mpa
Built    : R 2.8.0; ; 2009-03-21 18:30:58; 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  : 3.0
Packaged : Tue Mar 10 04:42:26 2009; theussl
Built    : R 2.8.1; i386-pc-mingw32; 2009-03-10 04:42:28; windows
```

TABLE 4.6.2.1.12 Celtic Sea and Division VIIj Herring. STOCK SUMMARY

Year	Recruitment Age 1	TSB	SSB	Fbar (Ages 2-5) f	Landings tonnes	Landings SOP
1958	295674	111049	80195	0.3622	22978	1.1144
1959	872952	136788	75751	0.3110	15086	1.1238
1960	190690	86866	62372	0.4545	18283	1.1314
1961	219996	75743	53403	0.2845	15372	0.7759
1962	565338	115722	63363	0.6025	21552	1.0137
1963	284233	88243	57952	0.4062	17349	1.0017
1964	1081346	167838	81568	0.2492	10599	1.0234
1965	339817	150427	109928	0.2310	19126	1.1620
1966	698800	191997	117893	0.2770	27030	0.9617
1967	714161	198749	122799	0.3490	27658	1.1093
1968	839600	213584	126571	0.3260	30236	0.9937
1969	444838	175960	115838	0.5110	44389	1.0062
1970	215365	123413	88361	0.4508	31727	1.0041
1971	857772	167619	84213	0.6782	31396	1.0385
1972	264810	114782	71860	0.7145	38203	0.9936
1973	291386	89377	52041	0.7200	26936	1.0461
1974	129813	57903	36099	0.7972	19940	1.0226
1975	144961	46838	27093	0.7358	15588	0.9298
1976	175297	46185	25127	0.6312	9771	1.0604
1977	169900	44012	24199	0.5462	7833	0.9983
1978	134846	41317	24991	0.5080	7559	1.0882
1979	238148	52432	26855	0.6465	10321	0.9954
1980	148152	43995	26163	0.6832	13130	0.9302
1981	405081	69031	30448	0.9770	17103	0.9861
1982	671728	105809	45753	0.6890	13000	0.9865
1983	743311	131525	63068	0.6838	24981	0.9551
1984	572200	114119	63283	0.8570	26779	1.0089
1985	516009	110727	62674	0.4930	20426	0.9760
1986	537975	121656	67225	0.6415	25024	0.9992
1987	976622	152372	74366	0.7338	26200	1.0043
1988	393365	112525	72736	0.4080	20447	0.9962
1989	475553	113213	66550	0.5287	23254	0.9984
1990	429569	100664	61268	0.4480	18404	1.0102
1991	180747	72503	49277	0.6798	25562	0.9873
1992	959501	128674	55440	0.9815	21127	1.0467
1993	330034	89460	56811	0.5722	18618	0.9993
1994	702463	122935	65516	0.4272	19300	1.0049
1995	683183	122449	68768	0.5395	23305	0.9979
1996	341631	93401	61634	0.3945	18816	0.9981
1997	372002	84866	51023	0.6055	20496	1.0037
1998	241493	66646	41577	0.6285	18041	1.0016
1999	491902	77305	38675	0.8640	18485	1.0024
2000	434874	72472	36614	0.8892	17191	1.0001
2001	401671	62576	32458	0.8225	15269	1.0064
2002	479767	75869	38846	0.3408	7465	0.9994
2003	105907	45760	29084	0.4740	11536	0.9977
2004	257960	46938	23736	0.5762	12743	1.0080
2005	760084	78292	32302	0.4970	9494	0.9983
2006	265482	63356	38689	0.2770	6944	0.9976
2007	585465	74872	40553	0.2250	7636	0.9998
2008	360168*	77620	70141**	0.1252	5793	0.9995

*Geometric Mean 1995-2006

** SSB Adjusted

TABLE 4.6.2.1.13 Celtic Sea and Division VIIj Herring. ESTIMATED FISHING MORTALITY

Units : f

age \ year	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969
1	0.009	0.002	0.024	0.015	0.002	0.002	0.011	0.000	0.016	0.017	0.023	0.034
2	0.169	0.320	0.300	0.314	0.311	0.339	0.182	0.230	0.199	0.201	0.279	0.437
3	0.400	0.155	0.624	0.223	0.877	0.401	0.190	0.174	0.334	0.342	0.333	0.538
4	0.496	0.407	0.392	0.264	0.573	0.425	0.349	0.252	0.267	0.476	0.321	0.487
5	0.384	0.362	0.502	0.337	0.649	0.460	0.276	0.268	0.308	0.377	0.371	0.582
6	0.384	0.362	0.502	0.337	0.649	0.460	0.276	0.268	0.308	0.377	0.371	0.582

age \ year	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
1	0.010	0.024	0.051	0.135	0.069	0.148	0.127	0.078	0.033	0.078	0.079	0.164
2	0.315	0.416	0.710	0.634	0.733	0.504	0.325	0.292	0.309	0.404	0.552	0.657
3	0.477	0.653	0.709	0.779	0.724	0.869	0.510	0.483	0.537	0.565	0.773	1.153
4	0.512	0.906	0.607	0.643	0.816	0.756	1.017	0.825	0.633	0.913	0.636	1.020
5	0.499	0.738	0.832	0.824	0.916	0.814	0.673	0.585	0.553	0.704	0.772	1.078
6	0.499	0.738	0.832	0.824	0.916	0.814	0.673	0.585	0.553	0.704	0.772	1.078

age \ year	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
1	0.037	0.029	0.055	0.056	0.012	0.010	0.009	0.028	0.010	0.017	0.017	0.008
2	0.489	0.676	0.510	0.398	0.449	0.497	0.308	0.414	0.331	0.626	0.628	0.372
3	0.678	0.718	0.693	0.410	0.639	0.805	0.486	0.488	0.485	0.621	0.951	0.505
4	0.826	0.544	1.298	0.609	0.768	0.823	0.381	0.620	0.476	0.691	1.274	0.786
5	0.763	0.797	0.927	0.555	0.710	0.810	0.457	0.593	0.500	0.781	1.073	0.626
6	0.763	0.797	0.927	0.555	0.710	0.810	0.457	0.593	0.500	0.781	1.073	0.626

age \ year	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
1	0.028	0.022	0.016	0.016	0.039	0.047	0.037	0.064	0.012	0.029	0.035	0.030
2	0.416	0.447	0.341	0.426	0.436	0.606	0.713	0.615	0.248	0.301	0.366	0.316
3	0.481	0.544	0.434	0.593	0.681	0.936	0.908	0.968	0.399	0.519	0.631	0.544
4	0.315	0.556	0.353	0.733	0.702	0.957	0.934	0.787	0.336	0.557	0.677	0.584
5	0.497	0.611	0.450	0.670	0.695	0.957	1.002	0.920	0.380	0.519	0.631	0.544
6	0.497	0.611	0.450	0.670	0.695	0.957	1.002	0.920	0.380	0.519	0.631	0.544

age \ year	2006	2007	2008
1	0.017	0.014	0.008
2	0.176	0.143	0.080
3	0.303	0.246	0.137
4	0.326	0.265	0.147
5	0.303	0.246	0.137
6	0.303	0.246	0.137

TABLE 4.6.2.1.14 Celtic Sea and Division VIIj Herring. ESTIMATED POPULATION ABUNDANCE

Units : NA

age \ year	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967
1	295674	872952	190690	219996	565338	284233	1081346	339817	698800	714161
2	27804	107818	320441	68501	79694	207527	104391	393427	124979	252952
3	109932	17402	57996	175899	37084	43241	109579	64481	231565	75898
4	68932	60308	12199	25437	115175	12634	23708	74183	44357	135785
5	41209	37992	36316	7456	17674	58733	7472	15139	52172	30721
6	180616	119850	50523	52653	46628	26545	55596	113737	85997	88816

age \ year	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977
1	839600	444838	215365	857772	264810	291386	129813	144961	175297	169900
2	258309	301787	158150	78461	308204	92537	93642	44569	45987	56818
3	153271	144704	144445	85460	38340	112301	36363	33321	19951	24615
4	44120	89909	69195	73373	36400	15449	42175	14432	11444	9808
5	76349	28974	49965	37538	26842	17949	7347	16883	6130	3743
6	51842	66979	52583	43823	20413	22719	14684	14048	20867	8961

age \ year	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
1	134846	238148	148152	405081	671728	743311	572200	516009	537975	976622
2	57785	47982	81055	50361	126419	238215	265588	199194	179450	195492
3	31437	31419	23735	34592	19350	57458	89722	118099	99124	84819
4	12437	15041	14627	8973	8940	8046	22946	36734	64160	42826
5	3888	5973	5459	7007	2929	3540	4227	5667	18071	26941
6	8259	7826	10125	8541	8788	3686	3230	1519	2603	8748

age \ year	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
1	393365	475553	429569	180747	959501	330034	702463	683183	341631	372002
2	355804	143369	170150	156458	65382	346931	120478	251378	245839	123659
3	88076	193785	70214	90538	61992	25849	177099	58896	119096	129472
4	31044	44365	97368	35411	39844	19609	12768	89669	27995	63208
5	17016	19182	21601	54710	16048	10087	8087	8434	46551	17801
6	12268	18411	17662	17342	44408	22651	23165	20072	17897	18661

age \ year	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
1	241493	491902	434874	401671	479767	105907	257960	760084	265482	585465
2	134615	85465	172685	154206	138663	174464	37863	91655	271355	96045
3	59842	64513	34532	62732	61747	80164	95656	19453	49516	168577
4	58557	24785	20716	11405	19514	33924	39075	41686	9244	29933
5	27477	26256	8613	7365	4696	12623	17593	17969	21035	6040
6	15440	22516	16118	6537	6835	17139	4808	6220	12007	12045

age \ year	2008
1	360168
2	212473
3	61669
4	107869
5	20788
6	7442

TABLE 4.6.2.1.15 Celtic Sea and Division VIIj Herring. SURVIVORS AFTER TERMINAL YEAR

Units : NA

age \ year	2009
1	NA
2	98648
3	145357
4	44017
5	84239
6	22269

TABLE 4.6.2.1.16 Celtic Sea and Division VIIj Herring. FITTED SELECTION PATTERN

Units : NA

age	2003	2004	2005	2006	2007	2008
1	0.055	0.055	0.055	0.055	0.055	0.055
2	0.580	0.580	0.580	0.580	0.580	0.580
3	1.000	1.000	1.000	1.000	1.000	1.000
4	1.073	1.073	1.073	1.073	1.073	1.073
5	1.000	1.000	1.000	1.000	1.000	1.000
6	1.000	1.000	1.000	1.000	1.000	1.000

TABLE 4.6.2.1.17 Celtic Sea and Division VIIj Herring. PREDICTED CATCH IN NUMBERS

Units : NA

age	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969
1	1642	1203	2840	2129	772	297	7529	57	7093	7599	12197	9472
2	3742	25717	72246	16058	18567	51935	15058	70248	19559	39991	54790	93279
3	33094	2274	24658	32044	19909	13033	17250	9365	59893	20062	39604	55039
4	25746	19262	3779	5631	48061	4179	6658	15757	9924	49113	11544	33145
5	12551	11015	13698	2034	8075	20694	1719	3399	13211	9218	22599	12217
6	55010	34748	19057	14363	21304	9353	12790	25536	21776	26650	15345	28242

age	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
1	1319	12658	8422	23547	5507	12768	13317	8159	2800	11335	7162	39361
2	37260	23313	137690	38133	42808	15429	11113	12516	13385	13913	30093	21285
3	50087	37563	17855	55805	17184	17783	7286	8610	11948	12399	11726	21861
4	26481	41904	15842	7012	22530	7333	7011	5280	5583	8636	6585	5505
5	18763	18759	14531	9651	4225	9006	2872	1585	1580	2889	2812	4438
6	19746	21900	11051	12216	8445	7494	9777	3794	3356	3785	5215	5410

age	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
1	15339	13540	19517	17916	4159	5976	2307	8260	2702	1912	10410	1608
2	42725	102871	92892	57054	56747	67000	82027	42413	41756	63854	26752	94061
3	8728	26993	41121	36258	42881	43075	30962	68399	24634	38342	35019	9372
4	4817	3225	16043	16032	32930	23014	9398	19601	35258	16916	27591	10221
5	1497	1862	2450	2306	8790	14323	5963	8205	8116	28405	10139	4491
6	4492	1939	1872	618	1266	4651	4299	7875	6636	9004	28056	10085

age	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
1	12130	9450	3476	3849	5818	14274	9953	15724	3495	1892	5588	14235
2	35768	79159	61923	37440	41510	34072	77378	62153	26472	39467	10117	21609
3	61737	22591	38244	53040	27102	36086	18952	35816	18532	29653	40974	7465
4	3289	36541	7943	31442	28274	14642	12060	5953	5309	13844	18390	17632
5	3025	3686	16114	8318	13178	15515	5230	4249	1416	4882	7871	7208
6	8665	8772	6195	8720	7405	13305	9787	3771	2061	6628	2151	2495

age	2006	2007	2008
1	2787	5001	1288
2	38007	11099	14077
3	11801	33514	7182
4	2451	6636	14074
5	5251	1258	2539
6	2997	2509	909

TABLE 4.6.2.1.18 Celtic Sea and Division VIIj Herring. CATCH RESIDUALS

Units : thousands NA

age	2003	2004	2005	2006	2007	2008
1	0.36	NA	NA	NA	NA	NA
2	NA	NA	NA	NA	NA	NA
3	NA	NA	NA	NA	NA	NA
4	NA	NA	NA	NA	NA	NA
5	NA	NA	NA	NA	NA	NA
6	NA	NA	NA	NA	NA	NA

TABLE 4.6.2.1.19 Celtic Sea and Division VIIj Herring. PREDICTED INDEX VALUES

Celtic Sea Herring Acoustic

Units : NA NA

age \ year	2002	2003	2004	2005	2006	2007	2008
2	121	144	NA	75	255	93	220
3	80	92	NA	22	71	254	104
4	23	32	NA	39	11	38	154
5	4	10	NA	14	21	6	25

TABLE 4.6.2.1.20 Celtic Sea and Division VIIj Herring. INDEX RESIDUALS

Celtic Sea Herring Acoustic

Units : NA

age \ year	2002	2003	2004	2005	2006	2007	2008
2	0.425	-0.851	NA	0.606	-0.190	-0.286	0.295
3	0.633	-0.422	NA	0.258	-0.390	-0.145	0.067
4	0.249	-0.629	NA	0.340	0.198	-0.207	0.048
5	0.417	-0.633	NA	0.425	-0.648	0.343	0.096

TABLE 4.6.2.1.21 Celtic Sea and Division VIIj Herring. FIT PARAMETERS

	Value	Std.dev	Lower.95.pct.CL	Upper.95.pct.CL
F, 2003	0.52	0.16	0.38	0.71
F, 2004	0.63	0.16	0.46	0.86
F, 2005	0.54	0.19	0.38	0.78
F, 2006	0.30	0.22	0.20	0.46
F, 2007	0.25	0.24	0.15	0.40
F, 2008	0.14	0.28	0.08	0.24
Selectivity at age 1	0.06	0.35	0.03	0.11
Selectivity at age 2	0.58	0.14	0.44	0.77
Selectivity at age 4	1.07	0.11	0.86	1.34
Terminal year pop, age 1	270188.57	0.85	50865.16	1435203.53
Terminal year pop, age 2	212472.30	0.32	113913.52	396304.83
Terminal year pop, age 3	61667.80	0.26	37075.53	102572.19
Terminal year pop, age 4	107868.04	0.25	66123.43	175966.57
Terminal year pop, age 5	20787.44	0.26	12587.42	34329.35
Last true age pop, 2003	12621.90	0.24	7961.68	20009.89
Last true age pop, 2004	17591.60	0.20	11851.66	26111.48
Last true age pop, 2005	17967.65	0.21	11906.14	27115.13
Last true age pop, 2006	21033.83	0.23	13459.60	32870.36
Last true age pop, 2007	6038.73	0.24	3803.14	9588.47
Index 1, age 2 numbers, Q	0.00	0.24	0.00	0.00
Index 1, age 3 numbers, Q	0.00	0.24	0.00	0.00
Index 1, age 4 numbers, Q	0.00	0.25	0.00	0.00
Index 1, age 5 numbers, Q	0.00	0.27	0.00	0.00

Table 4.7.1.1. Celtic Sea & Division VIIj Herring. Inputs to the Short Term Forecast

2009

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
1	360168	1	0.5	0.551	0.5	0.078	7.57E-03	0.086
2	131499.8	0.3	1	0.551	0.5	0.107667	7.96E-02	0.110
3	145357.2	0.2	1	0.551	0.5	0.126333	0.137198	0.131
4	44017.17	0.1	1	0.551	0.5	0.148	0.147265	0.149
5	84238.56	0.1	1	0.551	0.5	0.157	0.137198	0.164
6	22269.35	0.1	1	0.551	0.5	0.166333	0.137198	0.175

2010

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
1	360168	1	0.5	0.551	0.5	0.078	7.57E-03	0.086
2	.	0.3	1	0.551	0.5	0.107667	7.96E-02	0.110
3	.	0.2	1	0.551	0.5	0.126333	0.137198	0.131
4	.	0.1	1	0.551	0.5	0.148	0.147265	0.149
5	.	0.1	1	0.551	0.5	0.157	0.137198	0.164
6	.	0.1	1	0.551	0.5	0.166333	0.137198	0.175

2011

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
1	360168	1	0.5	0.551	0.5	0.078	7.57E-03	0.086
2	.	0.3	1	0.551	0.5	0.107667	7.96E-02	0.110
3	.	0.2	1	0.551	0.5	0.126333	0.137198	0.131
4	.	0.1	1	0.551	0.5	0.148	0.147265	0.149
5	.	0.1	1	0.551	0.5	0.157	0.137198	0.164
6	.	0.1	1	0.551	0.5	0.166333	0.137198	0.175

Table 4.7.1.2. Celtic Sea & Division VIIj Herring. Single catch option table from the Short Term Forecast

Year: 2009 F multiplier: 1.0761 Fbar: 0.1349

Age	F	CatchNos	Yield	StockNos	Biomass	SSNos(Jan)	SSB(Jan)	SSNos(ST)	SSB(ST)
1	0.0081	1847	159	360168	28093	180084	14047	108738	8482
2	0.0857	9349	1031	131500	14158	131500	14158	107964	11624
3	0.1476	18127	2381	145357	18363	145357	18363	121249	15318
4	0.1585	6147	918	44017	6515	44017	6515	38369	5679
5	0.1476	11017	1810	84239	13225	84239	13225	73870	11598
6	0.1476	2912	510	22269	3704	22269	3704	19528	3248
Total		49399	6809	787550	84059	607466	70012	469718	55948

Year: 2010 F multiplier: 1 Fbar: 0.1253

Age	F	CatchNos	Yield	StockNos	Biomass	SSNos(Jan)	SSB(Jan)	SSNos(ST)	SSB(ST)
1	0.0076	1717	148	360168	28093	180084	14047	108772	8484
2	0.0796	8707	961	131424	14150	131424	14150	108262	11656
3	0.1372	10414	1368	89418	11296	89418	11296	75018	9477
4	0.1473	13396	2000	102674	15196	102674	15196	90054	13328
5	0.1372	4152	682	33991	5337	33991	5337	29979	4707
6	0.1372	10155	1777	83145	13830	83145	13830	73331	12197
Total		48541	6936	800820	87902	620736	73855	485417	59850

Year: 2011 F multiplier: 1 Fbar: 0.1253

Age	F	CatchNos	Yield	StockNos	Biomass	SSNos(Jan)	SSB(Jan)	SSNos(ST)	SSB(ST)
1	0.0076	1717	148	360168	28093	180084	14047	108772	8484
2	0.0796	8712	961	131500	14158	131500	14158	108325	11663
3	0.1372	10471	1375	89910	11359	89910	11359	75430	9529
4	0.1473	8327	1244	63824	9446	63824	9446	55979	8285
5	0.1372	9793	1609	80181	12588	80181	12588	70718	11103
6	0.1372	11286	1975	92401	15369	92401	15369	81495	13555
Total		50307	7312	817984	91014	637900	76967	500719	62620

Table 4.7.1.3. Celtic Sea & Division VIIj Herring. Multiple catch option table from the Short Term Forecast

2009

Biomass	SSB	FMult	FBar	Landings
84059	55948	1.0761	0.1349	6809

2010					2011	
Biomass	SSB	FMult	FBar	Landings	Biomass	SSB
87902	63606	0	0	0	97709	72878
.	63218	0.1	0.01	734	97000	71759
.	62833	0.2	0.03	1458	96299	70662
.	62451	0.3	0.04	2174	95608	69586
.	62071	0.4	0.05	2880	94926	68531
.	61694	0.5	0.06	3577	94253	67496
.	61320	0.6	0.08	4266	93588	66482
.	60949	0.7	0.09	4946	92932	65488
.	60580	0.8	0.10	5618	92284	64513
.	60214	0.9	0.11	6281	91645	63557
.	59850	1	0.13	6936	91014	62620
.	59489	1.1	0.14	7583	90391	61700
.	59131	1.2	0.15	8221	89776	60799
.	58775	1.3	0.16	8852	89169	59915
.	58563	1.36	0.17	9227	88808	59393
.	58422	1.4	0.18	9475	88570	59048
.	58071	1.5	0.19	10090	87978	58198
.	57723	1.6	0.20	10697	87394	57365
.	57377	1.7	0.21	11297	86818	56547
.	57034	1.8	0.23	11889	86249	55746
.	56693	1.9	0.24	12474	85687	54959
.	56355	2	0.25	13052	85132	54188

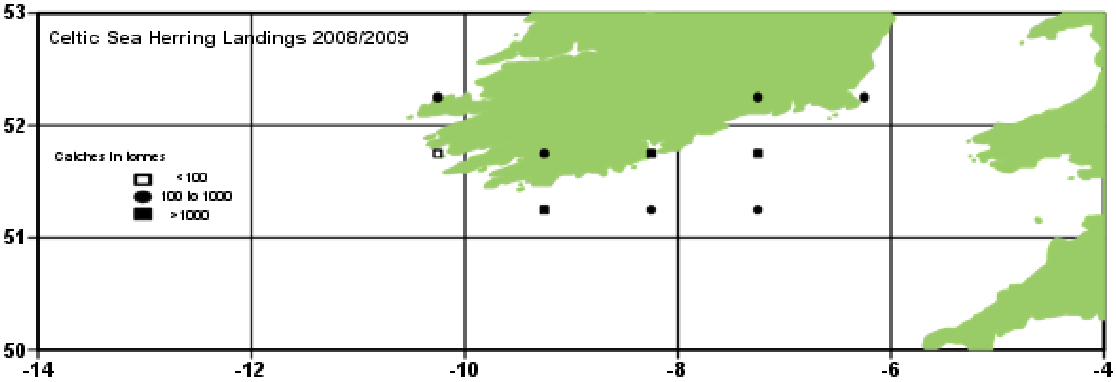


Figure 4.1.2.1. Celtic Sea and VIIj herring. Irish official herring catches by statistical rectangle in 2008/2009.

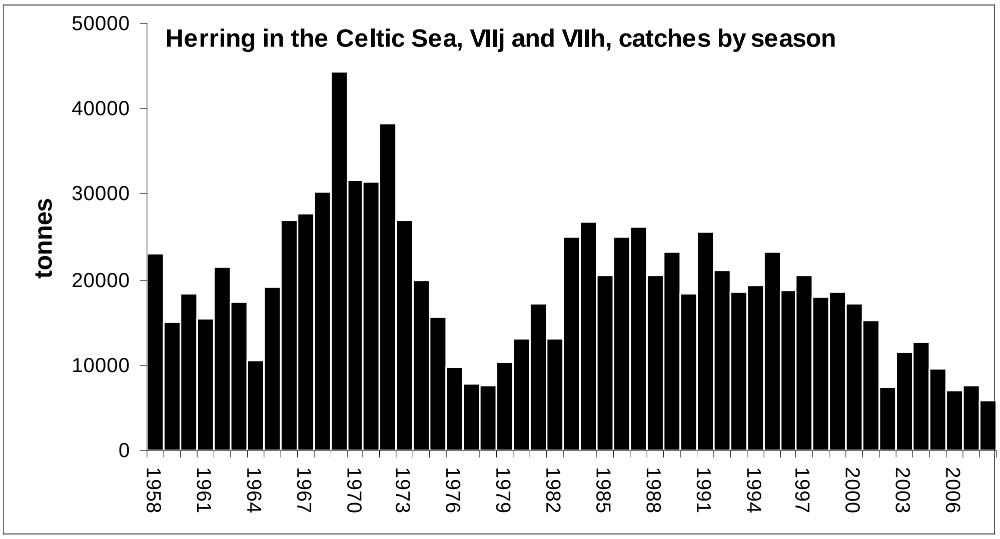


Figure 4.1.3.1 Celtic Sea and Division VIIj – working group estimates of herring landings per season.

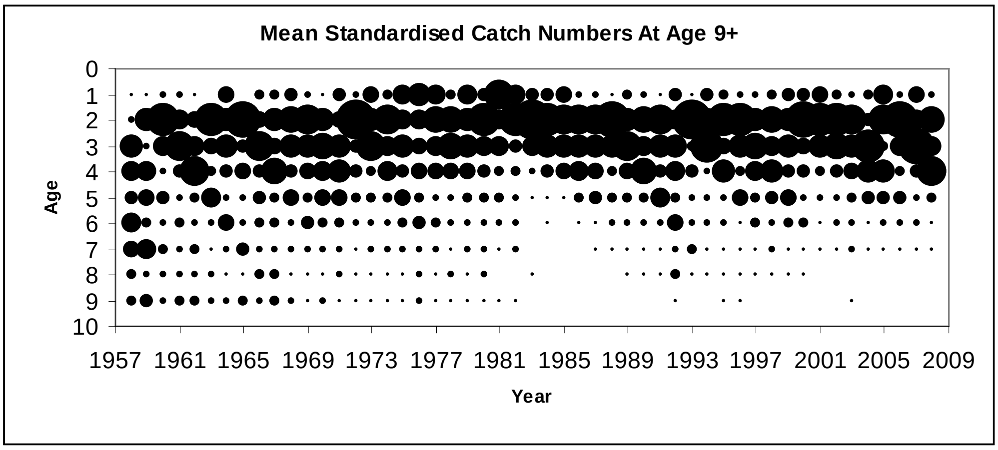


Figure 4.2.1.1. Celtic Sea and Division VIIj. Catch numbers at age standardised by yearly mean. 9-ringer is the plus group.

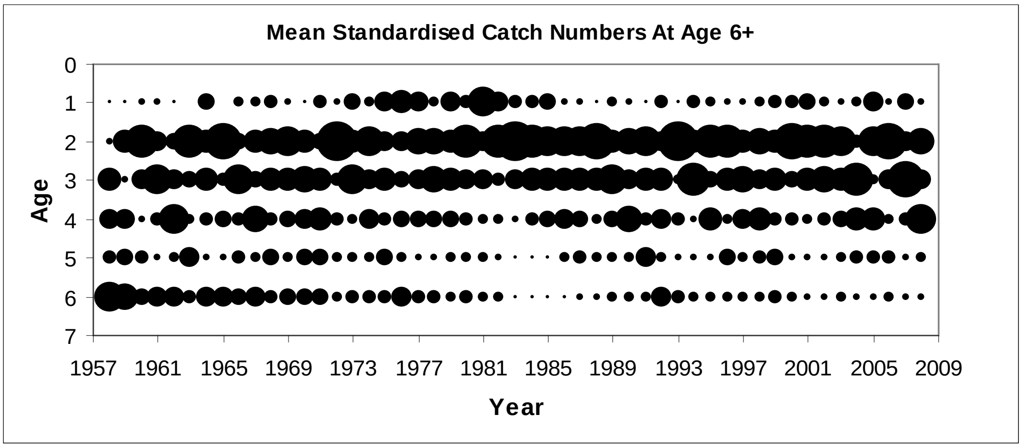


Figure 4.2.1.2. Celtic Sea and Division VIIj. Catch numbers at age standardised by yearly mean. 6-ringer is the plus group.

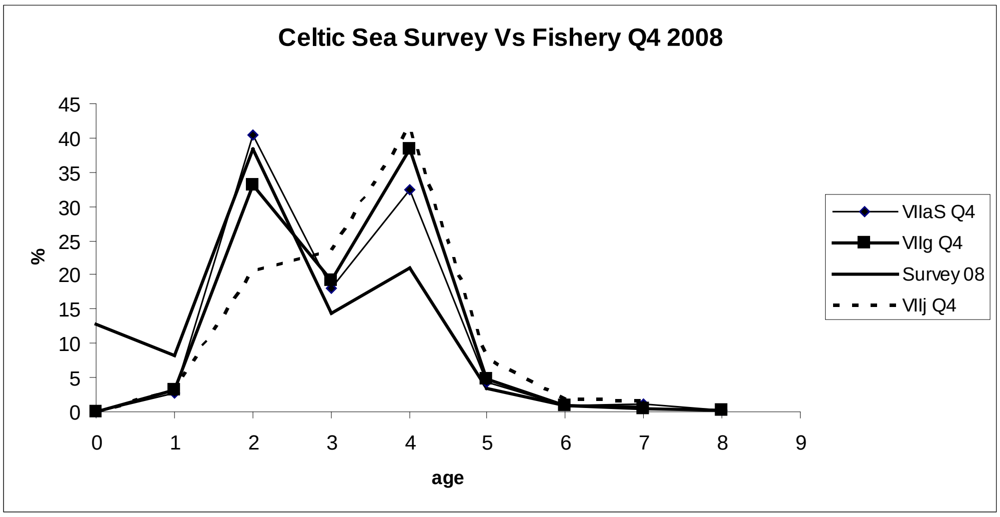


Figure 4.2.1.3. Celtic Sea and VIIj herring. The percentage age composition in the survey and the commercial fishery 2008/2009.

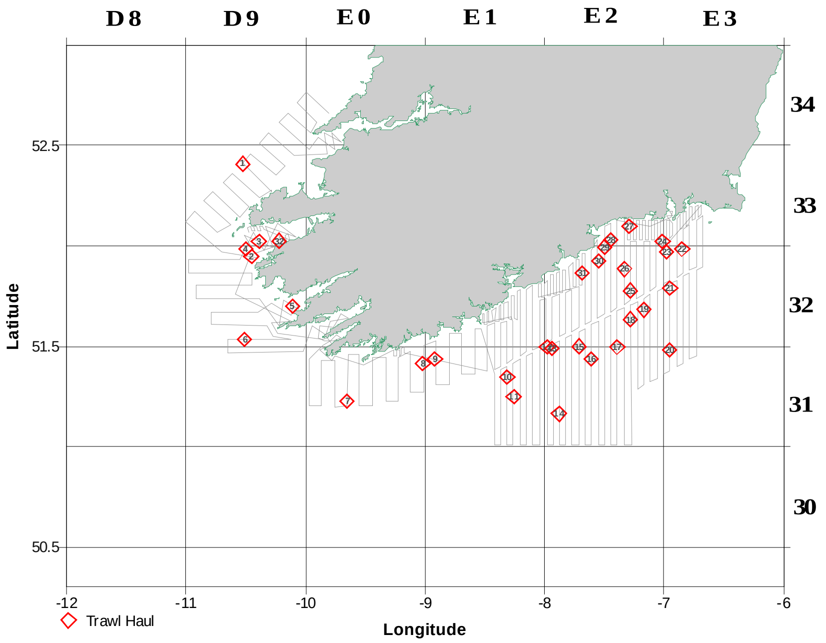


Figure 4.3.1.1a Celtic Sea and VIIj herring. Acoustic survey track and haul positions from acoustic survey, October 2008.

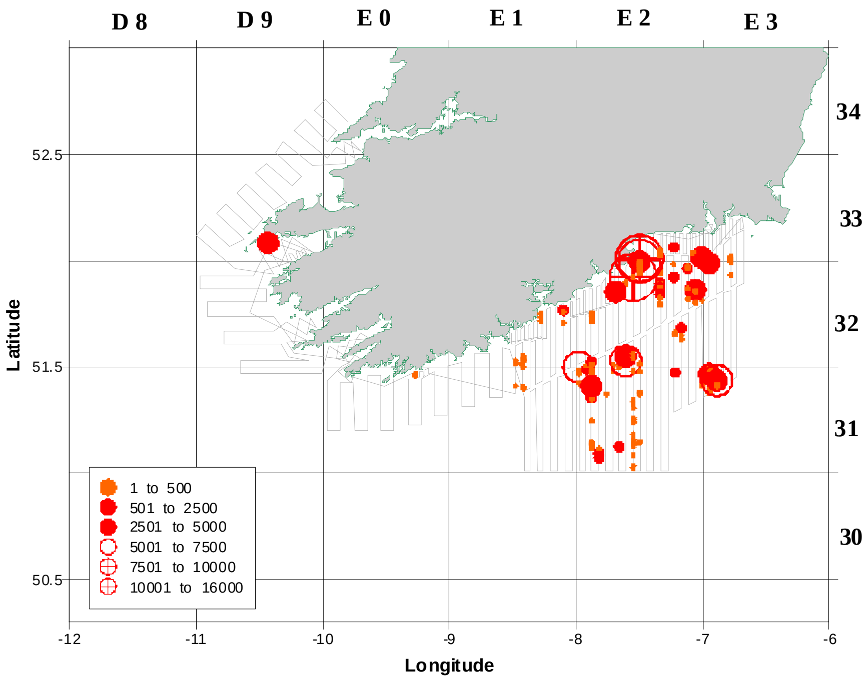


Figure 4.3.1.1b. Celtic Sea and VIIj herring. Acoustic survey 2008, total Sa values attributed to herring.

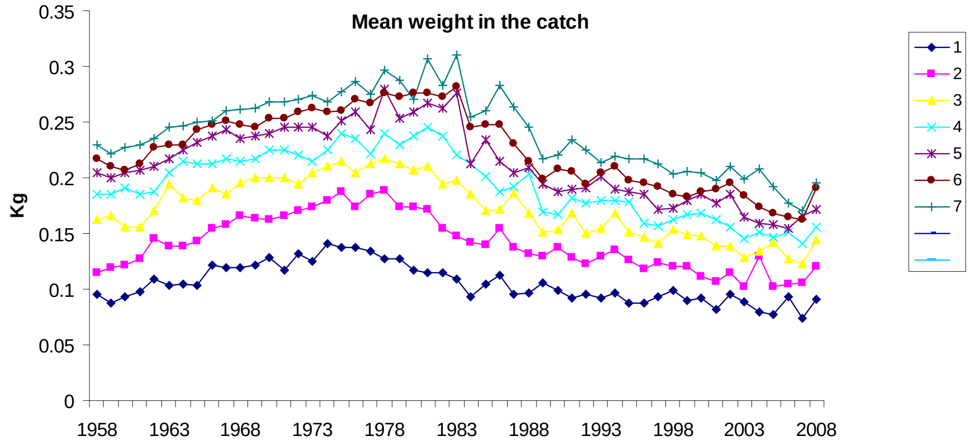


Figure 4.4.1.1. Celtic Sea and VIIj herring. Trends over time in mean weight at age in the catch from 1-9+

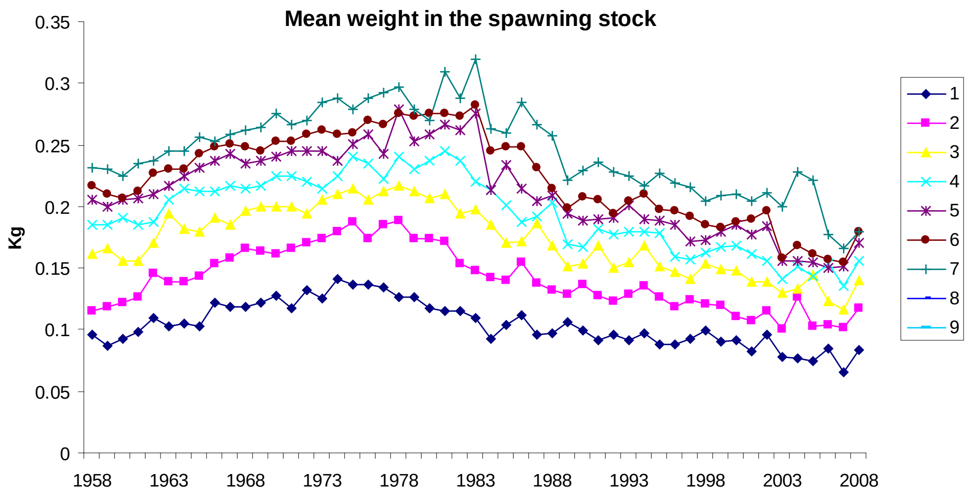
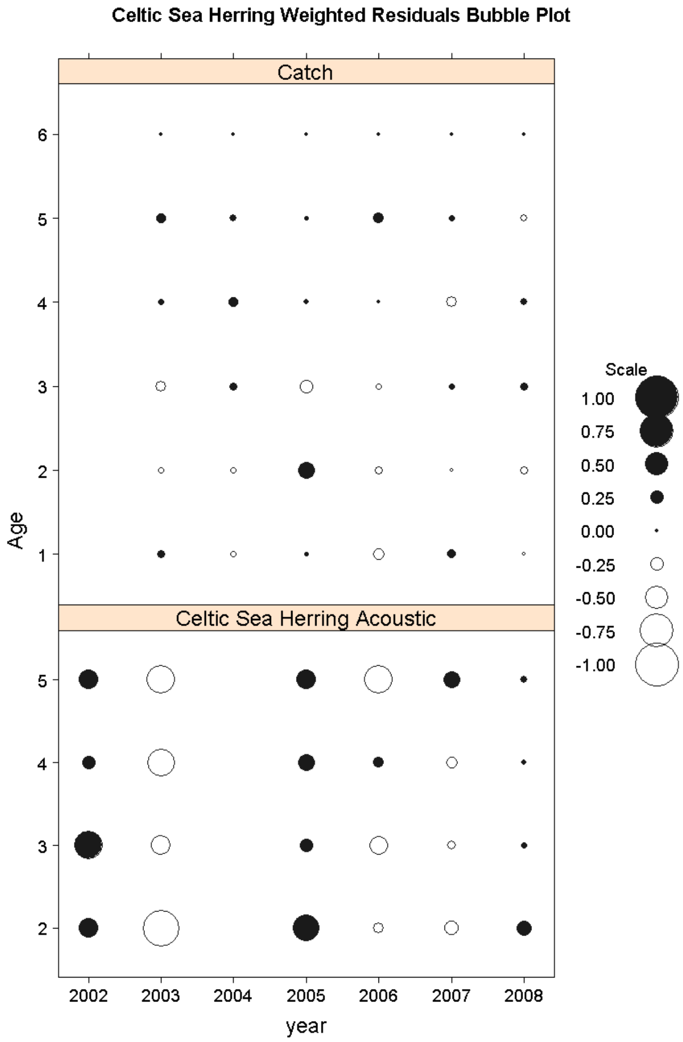


Figure..4.4.1.2. Celtic Sea and VIIj herring. Trends over time in mean weight at age in the stock at spawning time from 1-9+



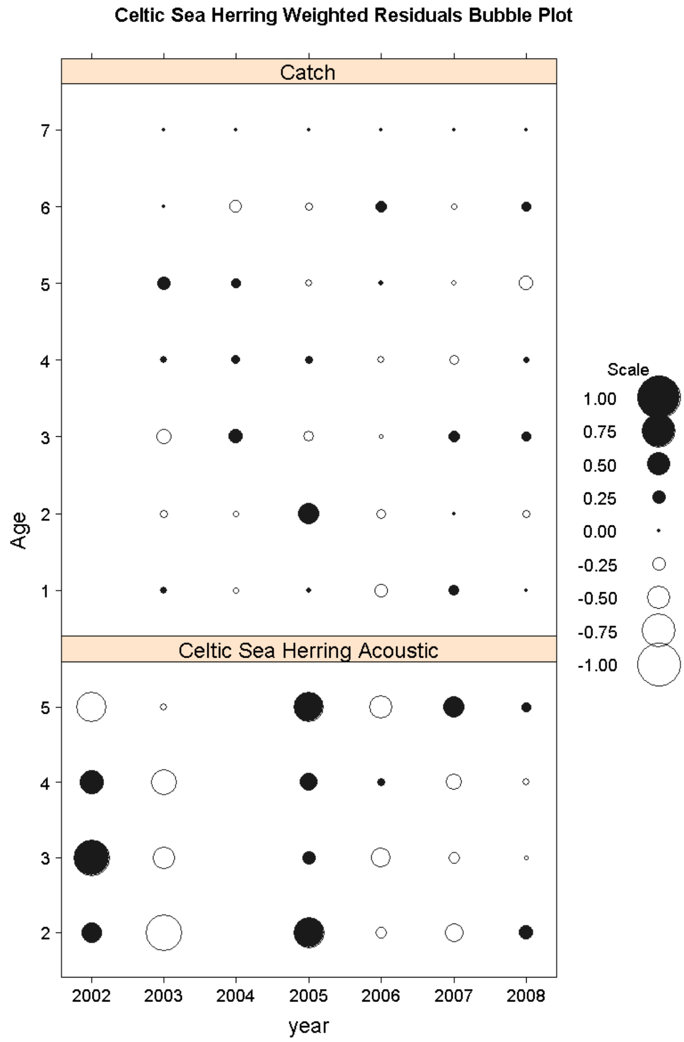


Figure 4.6.1.1. Celtic Sea and VIIj herring. Weighted residuals for FICA assessments using 6+ (left) and 7+ (right).

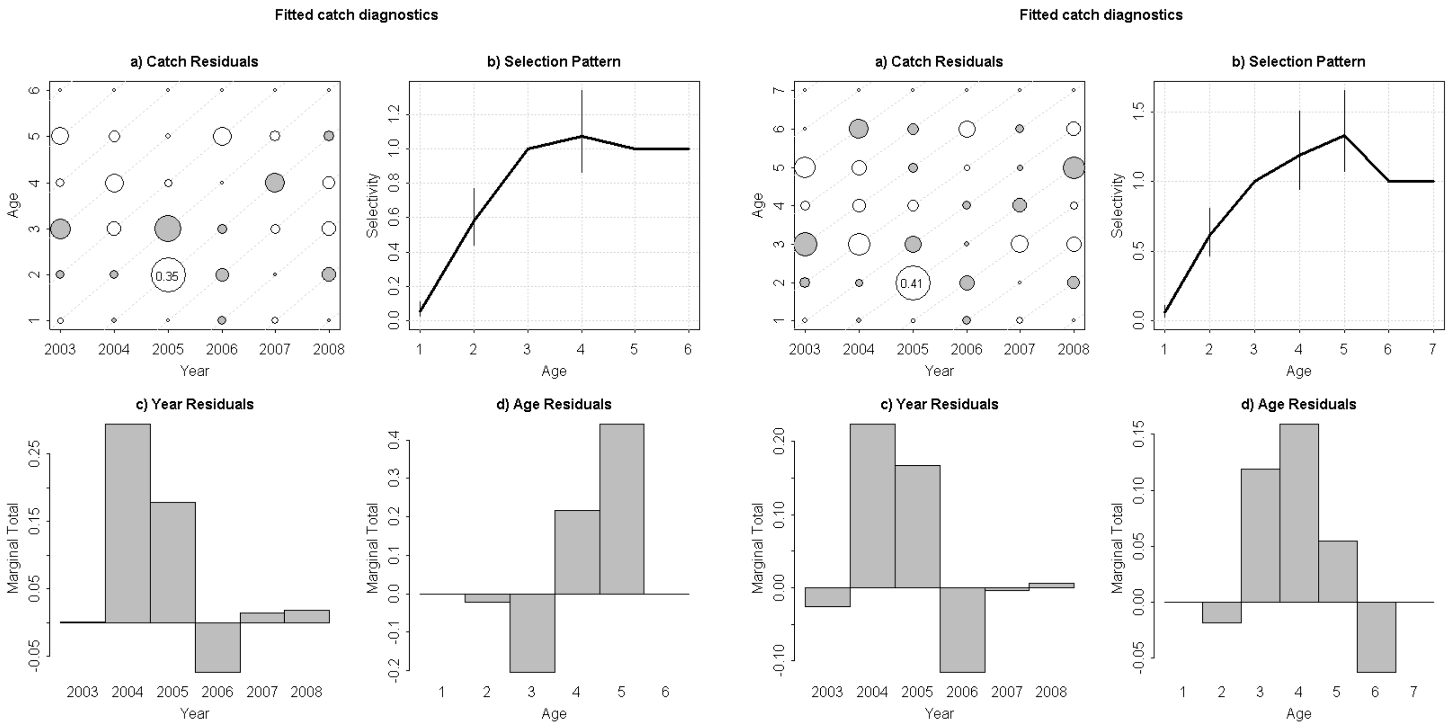


Figure 4.6.1.2. Celtic Sea and VIIj herring. Catch Diagnostics from FICA exploratory runs with 6+ (left) and 7+(right).

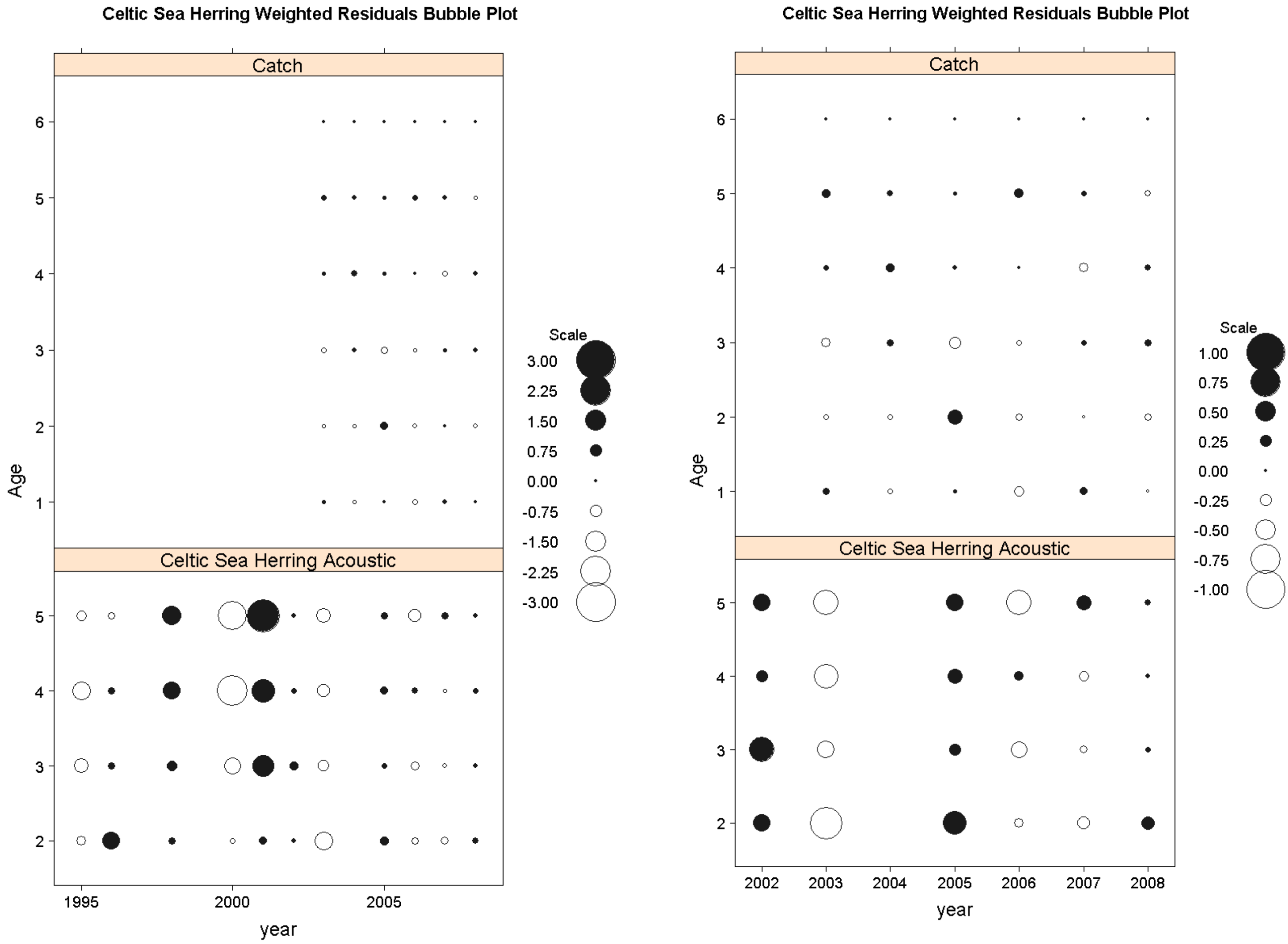
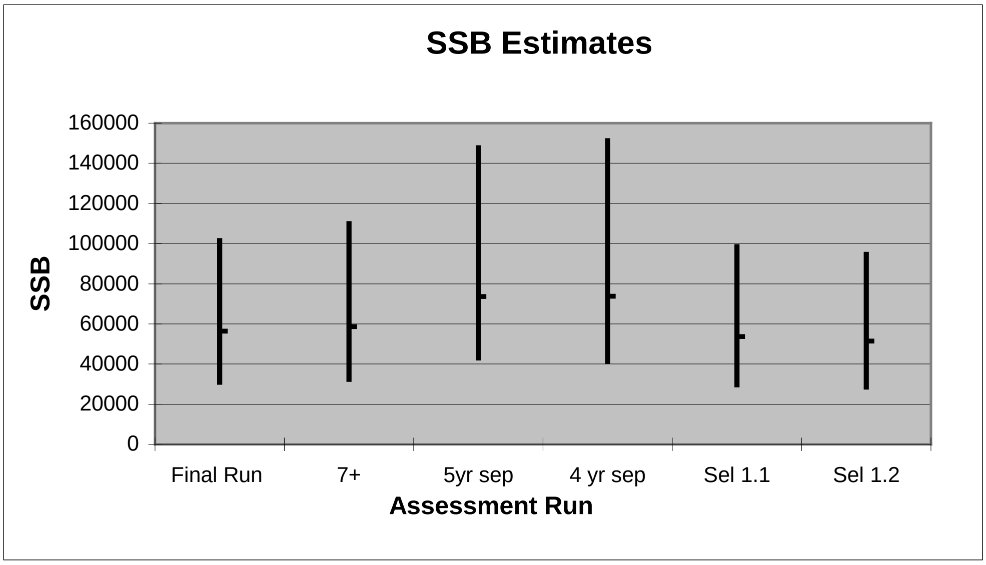


Figure 4.6.1.3. Celtic Sea and VIIj herring. Weighted residuals from FICA exploratory runs with the full survey time series (left) and the 2002-2008 series (right).



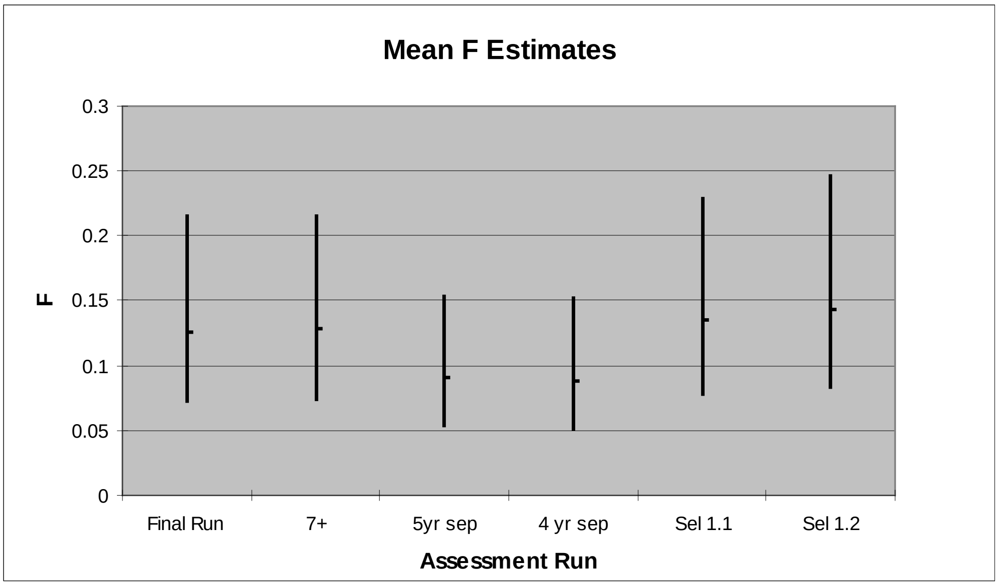


Figure 4.6.1.4. Celtic Sea and VIIj herring. Estimates of SSB (above) and Mean F (below) from parametric bootstrapping, for exploratory assessment runs using different settings.

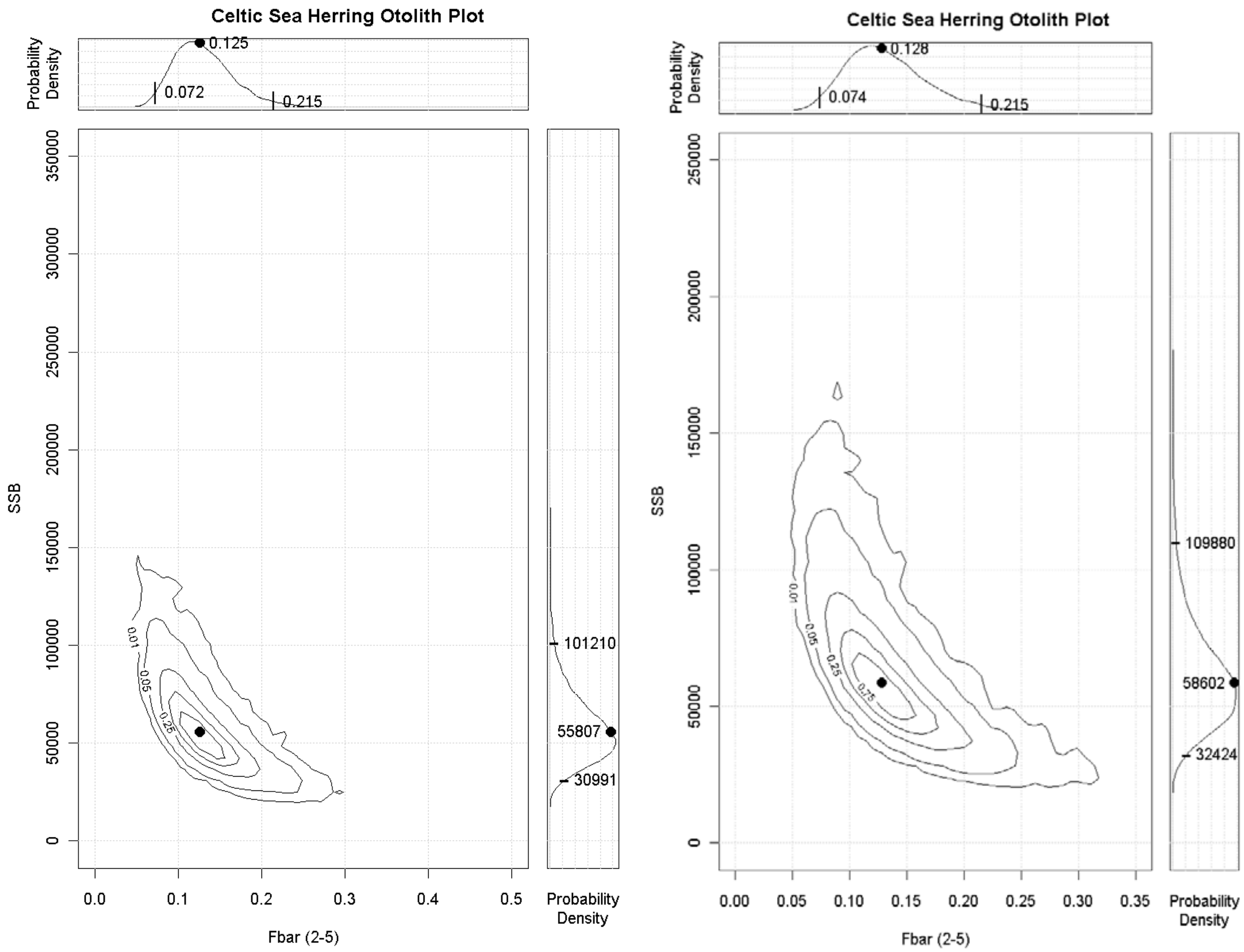
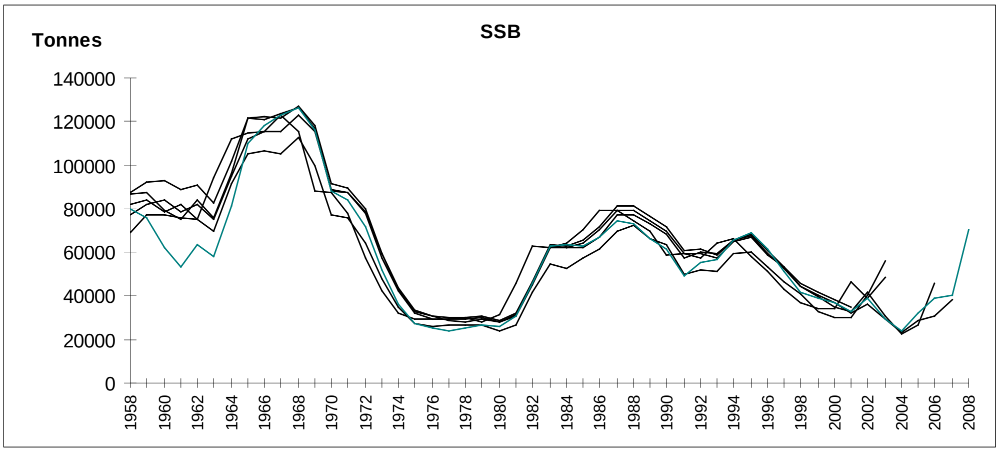
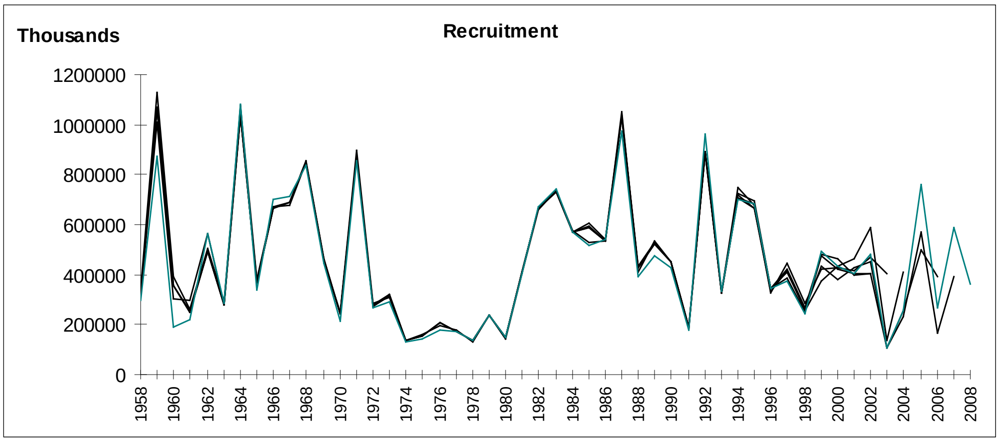


Figure 4.6.1.5. Celtic Sea and VIIj herring. Results of parametric bootstrapping from FLICA for the 6+ assessment (left) and 7+ (right).





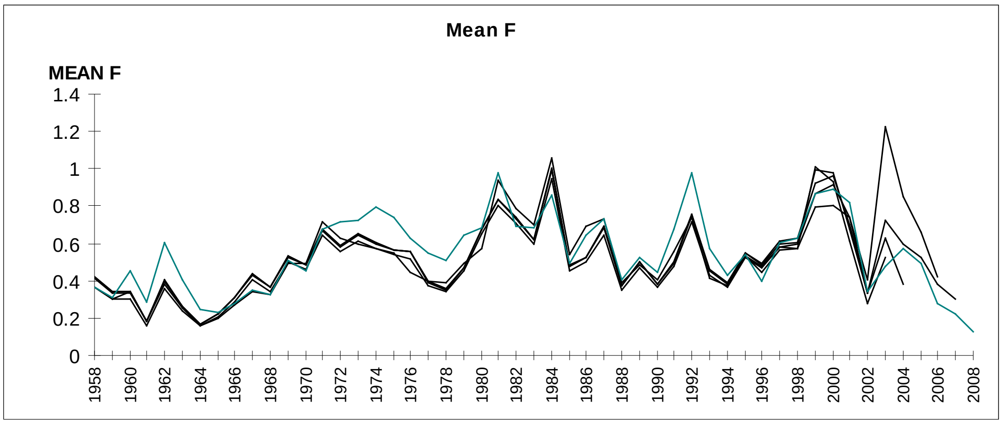


Figure 4.6.1.6. Celtic Sea and VIIj herring. Historical Retrospective based on the final assessment in 2009 and spaly runs in 2004-2008.

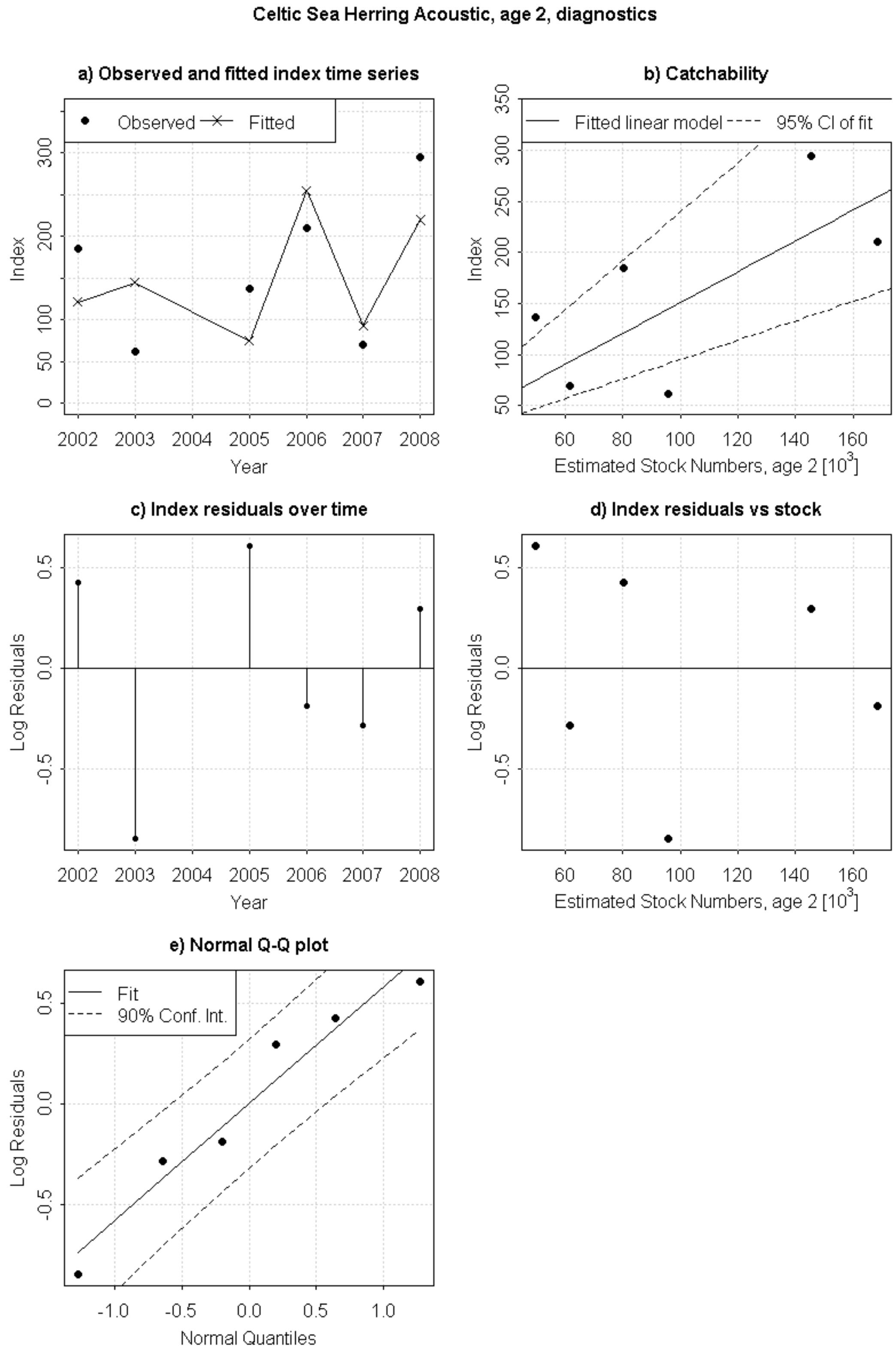


Figure 4.6.2.1. Celtic Sea and VIIj herring. Diagnostics from the Acoustic survey age 2.

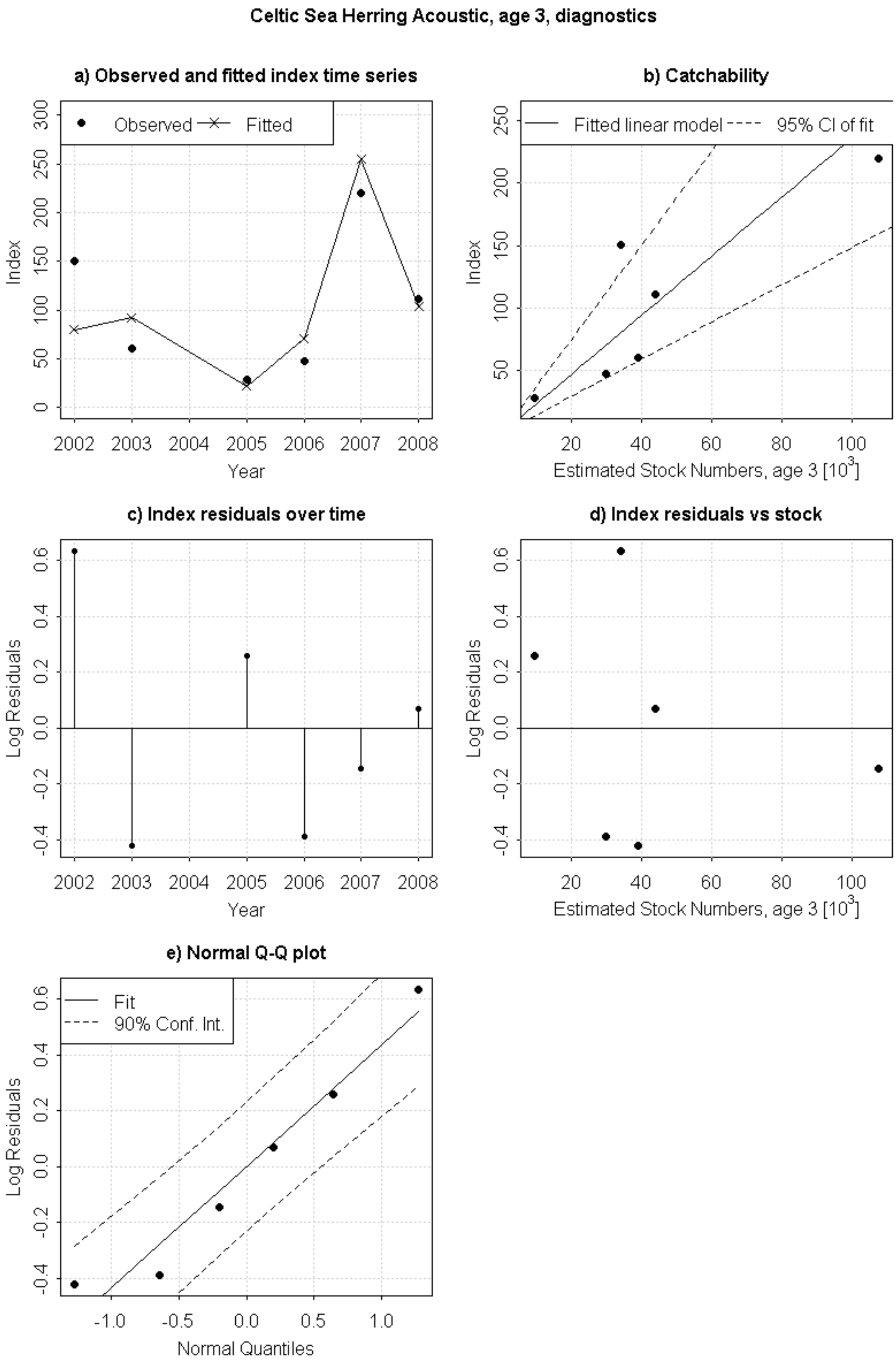


Figure 4.6.2.2. Celtic Sea and VIIj herring. Diagnostics from the Acoustic survey age 3.

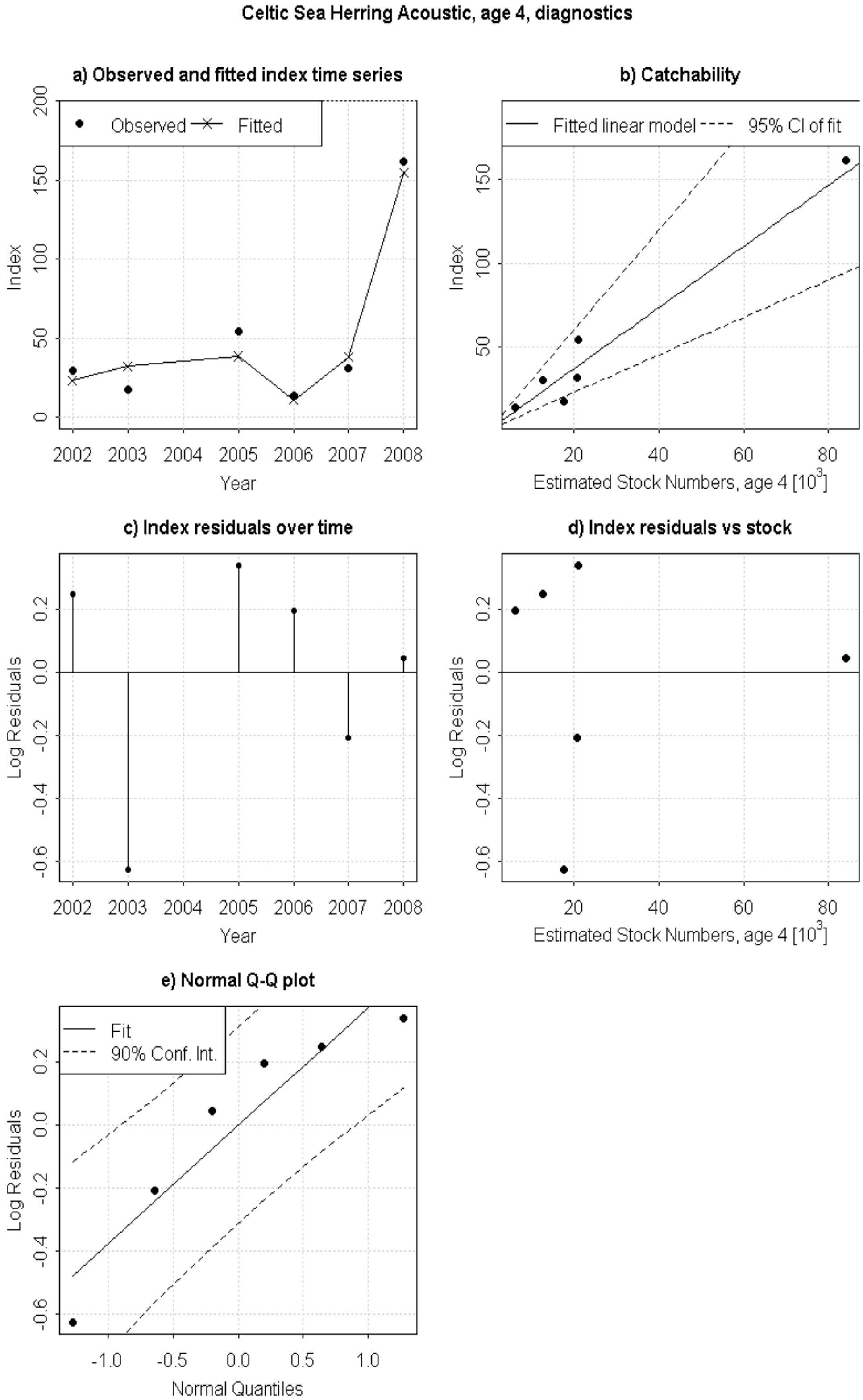


Figure 4.6.2.3. Celtic Sea and VIIj herring. Diagnostics from the Acoustic survey age 4

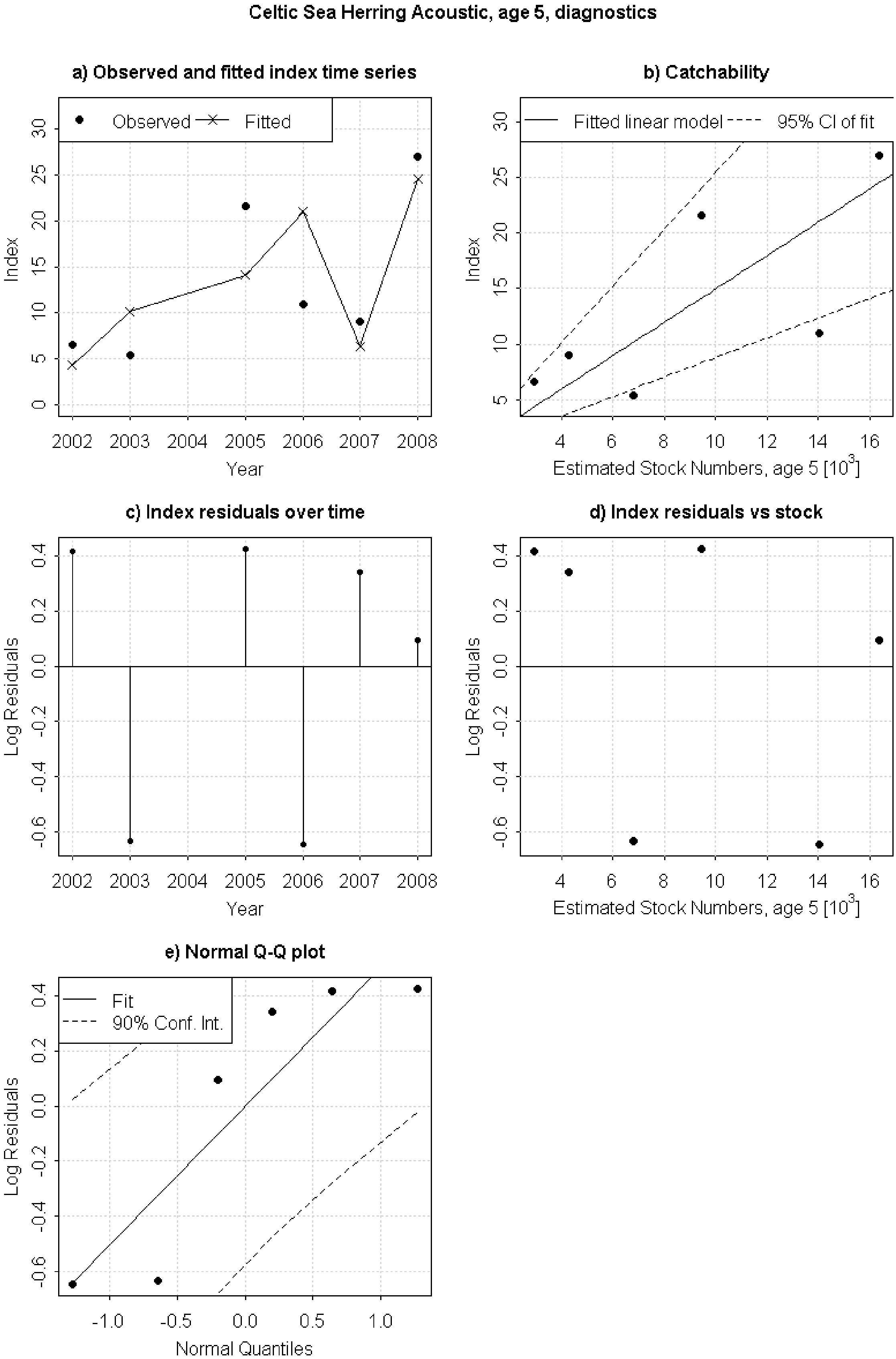


Figure 4.6.2.4. Celtic Sea and VIIj herring. Diagnostics from the Acoustic survey age 5

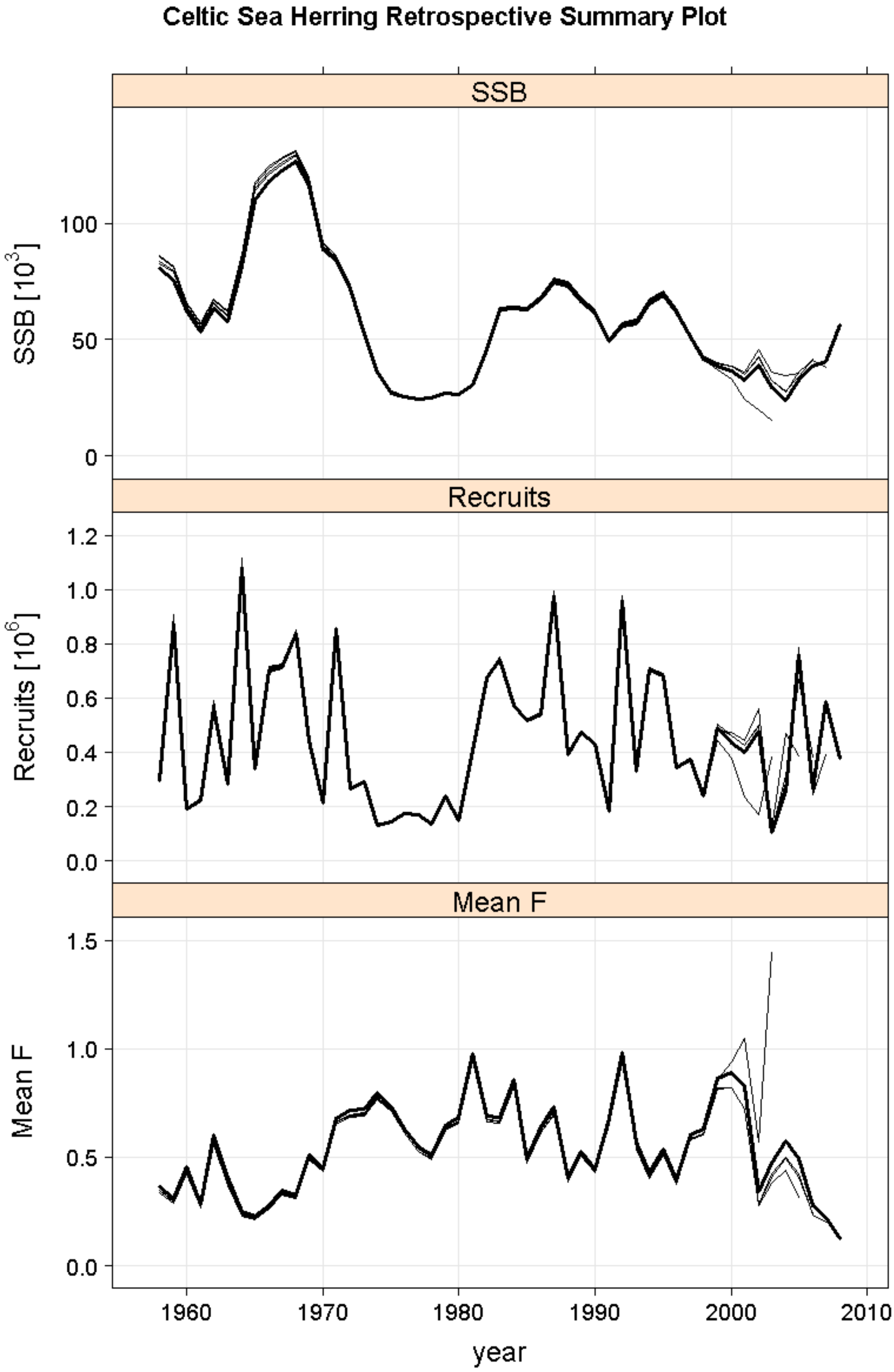


Figure 4.6.2.5. Celtic Sea and VIIj herring. Analytical Retrospective based on the final assessment

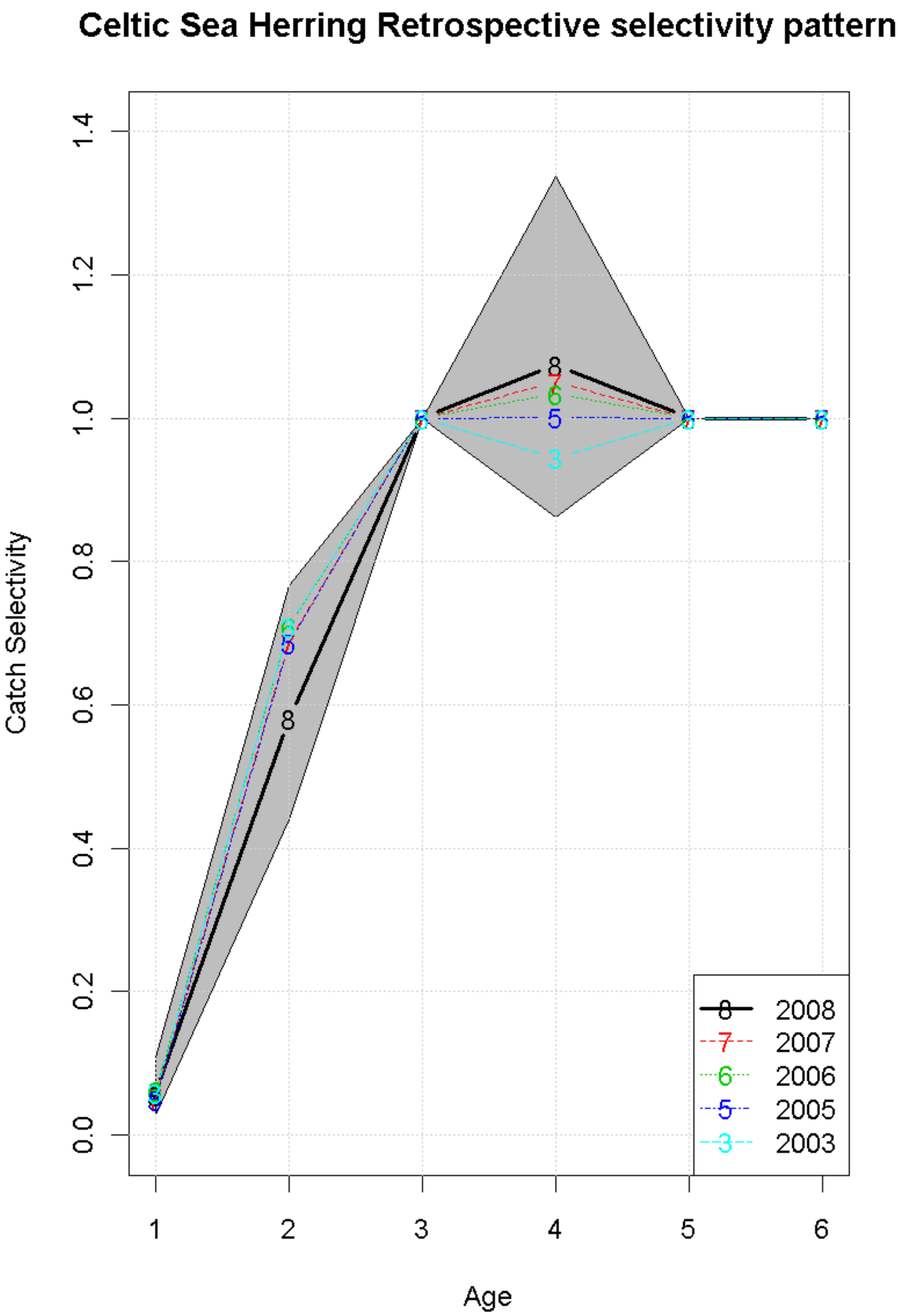
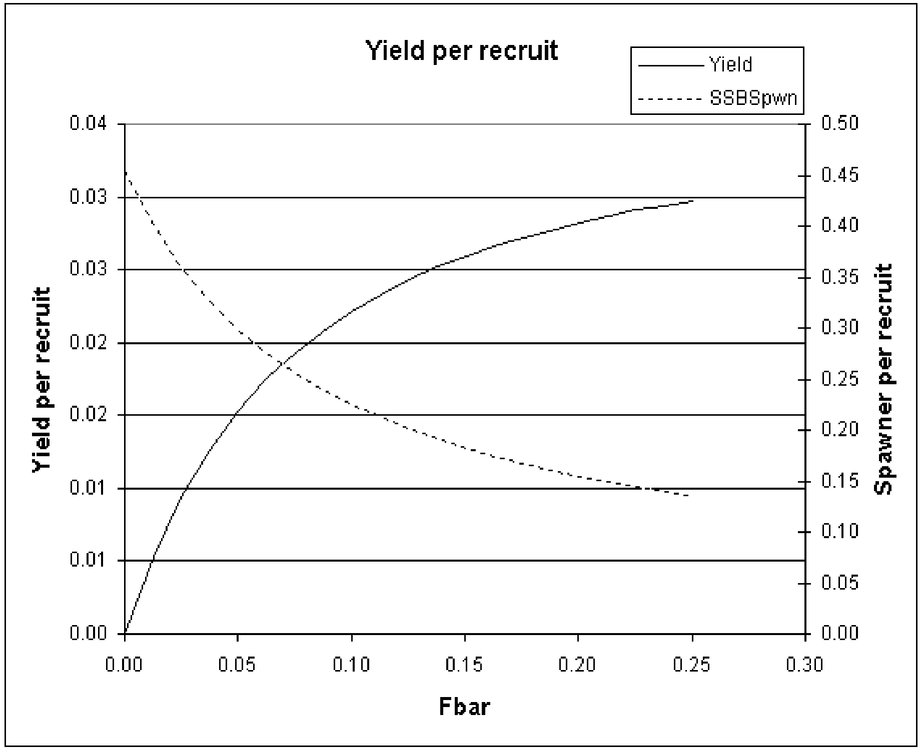
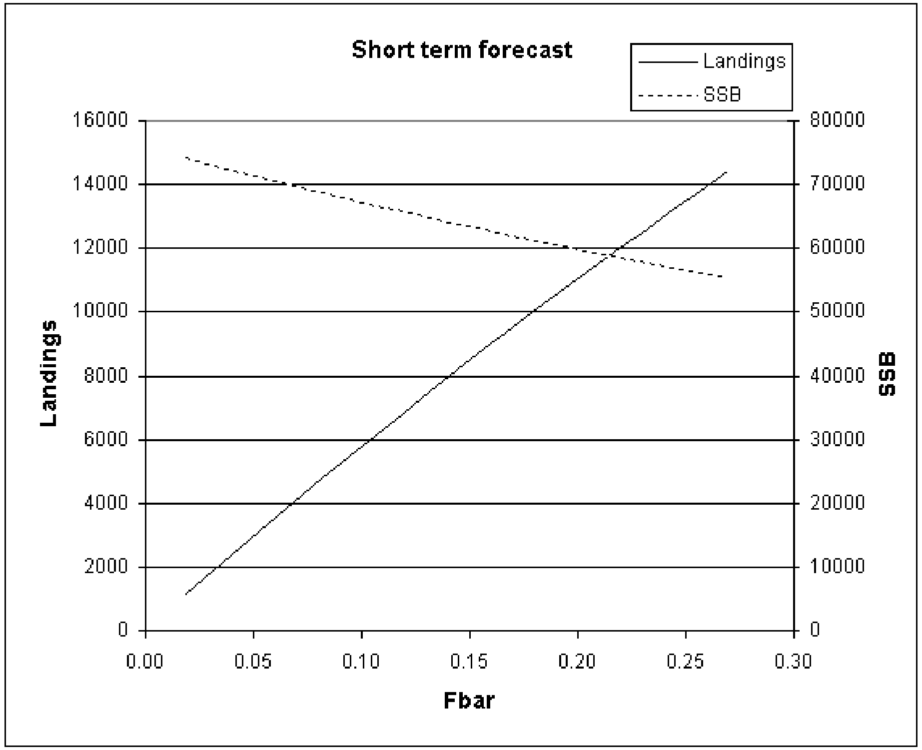


Figure 4.6.2.6. Celtic Sea and VIIj herring. Retrospective selection pattern.





Reference point	F multiplier	Absolute F
Fbar(2-5)	**1**	**0.1253**
FMax	**>=1000000**	
F0.1	**1.3466**	**0.1688**
F35%SPR	**1.5231**	**0.1909**

Figure 4.7.2.1 Celtic Sea and Division VIIj Herring. Yield per Recruit Curve and Short Term Forecast

5 West of Scotland Herring

The location of the area occupied by the stock is shown in Figure 5.1. This is an update assessment.

5.1 The Fishery

5.1.1 ACFM Advice Applicable to 2008 and 2009

ACFM reported in 2008 that the stock was fluctuating at a low level and was being exploited above F_{msy}. Recruitment has been low since 1998, and the 2001 and 2002 year classes were very weak.

There was an agreed assessment in 2008. The basis for the advice continued to be based on the proposed management plan. A slightly different plan was accepted by the European Commission in December 2008 (see Section 5.1.3 below). The assessment is considered to be noisy but unbiased. Medium-term evaluations of the proposed management plan had been carried out assuming the same level of noise as seen in the assessment, so management under this plan was considered by ICES in 2005 (and subsequent years) to be precautionary. Fishing according to the proposed management plan would have implied catches up to 13 000 tonnes in 2009.

The agreed TAC for 2009 is 21 760 t, which is in accordance with the agreed plan (see Section 5.1.3) but not in accordance with the proposed plan. The TAC in 2008 was 27 200 t.

5.1.2 Changes in the VIa (North) Fishery.

Historically, catches have been taken from this area by three fisheries.

i) A Scottish domestic pair trawl fleet and the Northern Irish fleet operated in shallower, coastal areas, principally fishing in the Minches and around the Island of Barra (Figure 5.1) in the south; younger herring are found in these areas. This fleet has reduced in recent years.

ii) The Scottish single boat trawl and purse seine fleets, with refrigerated seawater tanks, targeting herring mostly in the northern North Sea, but also operated in the northern part of VIa (N). This fleet now operates mostly with trawls but many vessels can deploy either gear.

iii) An international freezer-trawler fishery has historically operated in deeper water near the shelf edge where older fish are distributed. These vessels are mostly registered in the Netherlands, Germany, France and England but most are Dutch owned.

In recent years the catch of these last two fleets has become more similar

In 2008, the Scottish trawl fleet fished predominantly in areas similar to the freezer trawler fishery, and hardly in the coastal areas in the southern part of VIa (N). The Northern Irish fleet fished near the Island of Barra. In common with 2006 and 2007, but in contrast to most of the previous years' fisheries, in 2008 83% of the fishery was prosecuted in quarter 3 and 99% of those catches were distributed in the northern part of the area. Prior to 2006 there was a much more even distribution of effort, both temporally and spatially.

5.1.3 Regulations and their affects

COUNCIL REGULATION (EC) No 1300/2008 of 18 December 2008 established a multi-annual management agreement for the stock of herring distributed to the west of Scotland and the fisheries exploiting that stock.

F = 0.25 if SSB > 75 000 t	20% TAC constraint.
F = 0.20 if SSB < 75 000 t but > 62 500 t	20% constraint on TAC change.
F = 0.20 if SSB <62 500 t but > 50 000 t	25% constraint on TAC change
F = 0 if SSB < 50 000 t.	

There is derogation from the above constraints. If STECF considers that the herring stock in the area west of Scotland is failing properly to recover, the TAC constraints may differ from those in the management agreement. This plan is similar but not identical to the proposed plan. The differences and potential impact are discussed below in Section 5.8.

As a result of perceived problems of area misreporting of catch from IVa into VIa (N), Scotland introduced a fishery regulation in 1997 with the aim to improve reporting accuracy. Under this regulation, Scottish vessels fishing for herring were required to hold a license either to fish in the North Sea or in the west of Scotland area (VIa (N)). Only one licensed option could be held at any one time. However in 2004, the requirement to carry only a single licence was rescinded. Area misreporting of catch taken in area IVa into area VIa (N) then increased in 2004 and continued in 2005. It is possible, therefore, that the relaxation of this single area licence contributed to a resurgence in area misreporting at that time. In 2007, as in 2006, there was no misreporting from IVa into VIa (N). New sources of information on catch misreporting from the UK became available in 2006 (see the 2007 HAWG report). This information was associated with a stricter enforcement regime that may have been responsible for the lack of that area misreporting since 2006. However, in 2008 there was again misreporting of some catch from IVa into VIa (N).

The Butt of Lewis box, (a seasonal closure to pelagic fishing of the spawning ground in the north west of the continental shelf in area VIa (N) since the late 1970s (Figure 5.1)) has been opened to fishing following a STECF review in 2007. It has not been possible to show either beneficial or deleterious effects from this closure.

5.1.4 Catches in 2008 and Allocation of Catches to Area for VIa (N)

For 2008 the preliminary report of official catches corresponding to the VIa (N) herring stock unit total 25 216 t, compared with the TAC of 27 200 t. The Working Group's estimates of area misreported and unallocated catches are 9 162 t. Discarding is not perceived to be a problem.

The Working Group’s best estimate of removals from the stock in 2008 is 16 054 t (Table 5.1.1).

5.2 Biological composition of the catch

Catch and sample data, by country and by period (quarter), are detailed in Table 5.2.1. The number of samples used to allocate an age-distribution for the VIa (N) catches have continued at the low level seen over the last few years (except in 2006). There were 13 samples available in 2008, obtained from the Scottish (11), Dutch (1) and English (1) fleets. The Dutch and English fleets each took a similar magnitude of catches in the area, slightly less than half the Scottish catches. The samples available were used to allocate a mean age-structure (using the sample number weighting) to unsampled catches, in the same or adjacent quarters, as no sampling data were available for other quarters. The allocation of age structures 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). As 11 of the 13 samples obtained came from only one of the major fisheries in one quarter (Scotland 3rd quater); it is likely that they are reasonably representative of these catches, but do not fully reflect the entire fishery.

Catch number- and weight-at-age information is given in the ICA stock report section 5.6 (cf Table 5.6.1.1 and 5.6.1.2 respectively). Two larger year classes can be seen clearly in the catch-at-age table: 2000 and 2004 at 7- and 3-ringers respectively in 2008. The 2001, 2002 and 2003 year classes all appear relatively weak, with the 2002 year class the weakest. 1-ring herring in the catch are observed intermittently and are rarely representative of year class strength and are down-weighted in the assessment, (see Section 5.6).

5.3 Fishery Independent Information

5.3.1 Acoustic Survey

The 2008 acoustic survey was carried out from the 27th June to the 16th July 2008 using a chartered commercial fishing vessel (MFV *Chris Andra*). Further details are available in the Report of the Planning Group for International Pelagic Surveys (ICES 2009/LRC:02). The commercial vessel changes through the time series, though year effects seen in the series are not linked to vessel effects. The biomass estimate for VIa (N) from the acoustic survey (Table 5.3.1) has increased by approximately 165% from 2007 (from 298 880 tonnes to 791 350 tonnes), to give the second highest estimate in the time series. The estimate has increased due to increased numbers, but also mean weights (see section 5.4). In 2007 very few fish below 20cm or above 31cm were seen giving a weight/length relationship that had a lower gradient than in previous years. The survey catches in 2008 gave a wider spread (15 to 35 cm) resulting in a more representative weight/length relationship.

In 2008 quite similar year class proportions were seen in the catch and the survey. However, the survey showed slightly higher proportions of 4- and 5-ringers, whereas the catch showed higher proportions of 2-ring fish. There is no basis for concluding which of the sources of data are more reliable, the catch is sparsely and partially sampled and the survey in 2008 appeared to catch fewer 2-ring herring (ICES 2009/LRC:02) (cf. Figure 5.6.2.12 for residuals in the fitted model).

5.4 Mean weights-at-age and maturity-at-age

5.4.1 Mean Weight-at-age

Weights-at-age in the stock from acoustic surveys are given in Table 5.3.1 and weights-at-age in the catches are given in Section 5.6.2 (cf. Table 5.6.2.2) and are used in the assessment. The weights-at-age in the catch are comparable to previous years for older ages, with slightly higher weights from 3- to 6-ring herring. The weights-at-age in the stock are, again, normal for the older ages but slightly higher than normal for the 2-ring herring (cf. Table 5.6.1.3). This is likely a reflection of the more representative catch in the survey in 2008 of older ages and lower than normal catch of 2-ring herring (ICES 2009/LRC:02).

5.4.2 Maturity Ogive

The maturity ogive is obtained from the acoustic survey (Table 5.3.1). The survey provides estimated values for the period 1987 and 1992 to 2008 (cf. Table 5.6.2.5). In 2008, 98% of the 2-ring fish caught were mature, this is the second highest proportion mature at this age since 1992 when measurements began, with the highest value (virtually 100% mature) seen in 2007. The sensitivity of the assessed SSB to the estimated maturity was investigated in 2008 where the assessment was re-run with fraction mature at 2-ring taken from average maturity for the years 2004-2006. This resulted in a 4% reduction of SSB in 2007. This was considered to be negligible in the context of the precision of the estimate of SSB.

5.5 Recruitment

There are no specific recruitment indices for this stock. Although both catch and acoustic survey generally have some catches at 1-ring both the fishery and survey encounter this age group only incidentally. The first reliable appearance of a cohort appears at 2-ring in both the catch and the stock. Thus in predictions, estimates of both 1- and 2-ring herring numbers from the assessment are replaced for prediction years.

5.6 Assessment of VIa (North) herring

5.6.1 Data Exploration and Preliminary Modelling

The ICA assessment (Patterson 1998a), implemented in FLR (Kell 2007) as FLICA, has exhibited substantial revision both up and down over the last few years, largely due to the noisy survey used for tuning the assessment. The model settings were last explored in detail in 2003 (ICES 2003/ACFM:17). In order to establish if different model settings would give improved consistency in the assessment and subsequent advice, the settings of the model were explored particularly with respect to retrospective performance.

Range of model settings evaluated:

- Selection at oldest true age from 0.7 to 1.2 (current value is 1.0)
- Balance of Survey and Catch weighting by varying catch weighting from 0.5 to 2.0 (current value is 1.0)
- Weighting at age: flat or inverse variance (with 1-ring herring down weighted). (Current weightings for catch and survey are flat with 1-ring herring downweighted).

Weightings at age

Age	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9+*
Catch flat	***0.1***	***1.0***	***1.0***	***1.0***	***1.0***	***1.0***	***1.0***	***1.0***	***1.0***
Catch inv var at age	***0.10***	***3.67***	***2.87***	***2.23***	***1.74***	***1.37***	***1.04***	***0.94***	***0.91***
Survey flat	***0.1***	***1.0***	***1.0***	***1.0***	***1.0***	***1.0***	***1.0***	***1.0***	***1.0***
Survey inv var at age	***0.10***	***0.83***	***1.26***	***1.21***	***1.14***	***1.22***	***1.13***	***1.06***	***0.87***

The age dependent weights for catch sampling were taken from the North Sea as no analysis was available. The VIa (N) acoustic survey was analysed for variance at age and the mean over all years from 1992 computed. Earlier surveys had little data on numbers at age and did not give information on variance at age.

Two measures of retrospective performance were selected.

1. Mean deviance between previous assessments and most recent assessment.

$$\sum_{r=1}^{n}(S_{r,t-r-y} - S_{f,t-r-y})/n$$

where y runs from 1 to n.

2. Mean square deviance between previous assessments and most recent assessment.

$$\sum_{r=1}^{n}(S_{r,t-r-y} - S_{f,t-r-y})^2/n$$

Where $S_{r,t-r-y}$ is SSB in the retrospective run r and year t-r-y, where t is the terminal year in the most recent assessment and r the number of years gone back in the retrospective and y the number of years back from the last year in the assessment; $S_{f,t-r-y}$ is the equivalent term for the SSB_f as estimated in the most recent assessment f. For F or R substitute for S.

Figures 5.6.1.1 to 5.6.1.4 show the range of squared deviance plotted against y for the two different types of weightings using two terminal years for data, 2008 and 2009 WG data.

The optimal choice of setting is selected from the assessment that exhibits the minimum overall squared deviation. These are illustrated for different terminal years (2008, 2009) and the two different data set weighting methods (Flat or Age based) in Figures 5.6.1.1 – 5.6.1.4 and optimal choices are:

Model settings		*Optimal choices*		
Catch and survey weighting method	*Data sets*	*Selection at oldest age*	*Weight on Catch*	*Weight on survey*
Flat	*2009*	*0.8*	*85%*	*15%*
Inverse var at age	*2009*	*0.9*	*82%*	*18%*
Flat	*2008*	*1.0*	*69%*	*31%*
Inverse var at age	*2008*	*1.1*	*77%*	*23%*
SPALY	*2009*	*1.0*	*81%*	*19%*

Based on the value of the mean squared retrospective deviation the best option for both 2008 and 2009 is the age weighted method, but the level of weight given to survey / catch is heavily dependent on the terminal year used to do the analysis. The selection at oldest age is not consistent across years or choice of weighting. As the results depend strongly on the year the data is examined there is no basis for changing the selection. A comparison between retrospective performance based on SPALY settings and the optimal 2009 settings (Figure 5.6.1.5) shows only modest improvement, which would be cancelled out had we chosen the 2008 optimal settings for 2009 data. Although it would appear to be better to change to age weighting it is very difficult to establish the values to use and there is no reason to believe that choosing the optimal method from 2009 by this method would hold for 2010. Fit to the catch is more or less identical (Figure 5.6.1.5b). On this basis there seems little justification in proposing a different approach.

We conclude that continuing with the current weighting and model settings is an acceptable solution, until more data, possibly as a result of the extended surveys from SGHERWAY, are available.

5.6.2 Stock Assessment

This is an update assessment using FLICA (Kell 2007, Patterson 1998a) with the same settings as in 2008, with the 8 year separable period moved forward one year to 2001 – 2008, tuned using the complete survey time series (1987, 1991-2008). This uses catch data from 1957 to 2008 giving an assessment of F from 1957 to 2008 and numbers at age from 1 Jan 1957 to 2009. The input data are given in Tables 5.6.2.1-8, the run settings are presented in Tables 5.6.2.9-11.

The results of the assessment are given as stock summary in Table 5.6.2.12 and Figure 5.6.2.1. The output values are in Tables 5.6.2.13-16. Run diagnostics are given in Tables 5.6.2.17–20 and Figures 5.6.2.2-12. The parameter estimates are given in Table 5.6.2.21.

The assessment gives an SSB for 2008 of 91 884 t and a mean fishing mortality (3 to 6-ringers) of 0.16, the summary is given in Figure 5.6.2.1 and Table 5.6.2.12 which illustrate the stock trends from the assessment. The separable model diagnostics (Table 5.6.2.18 and Figure 5.6.2.2) show that the total residuals by age and year between the catch and separable model are reasonably trend-free. The 2000 year class is still reasonably abundant in the catch and survey data in 2008 (7-ringers). A second year class (2004, 3-ringers in 2008) is also reasonably abundant in the catch and survey data in 2008. In 2007, the catch data suggested a slightly better recruitment of the 2004 year class (2-ringers in 2007) whereas the survey suggested it was the 2003 year class (3-ringers in 2007) that was larger. It would now seem that the 2004 year class is the stronger of the two. The fits between survey and assessment are illustrated in Figures 5.6.2.3-11 for ages 1 to 9+ winter rings. The poor fit at age 1 supports the downweighting of this index. The best fits are to middle ages 3-5.

This year's estimate of SSB for 2007 is around 92 000 t, compared with 67 000 t in last year's final assessment run, an increase of 37%. The assessment shows continuing low levels of recruitment (the 2001, 2002 and 2003 year classes are all weak). The tuning diagnostics (Figures 5.6.2.3 to 5.6.2.12 and Table 5.6.2.17-21) show year effects in the survey that the assessment is sensitive to. The assessment fits between negative and positive residuals in the last two years of the assessment. The analytical retrospective (Figure 5.6.2.13) plots show that the assessment is noisy but now shows a reasonably stable but historically low stock level. Although the assessment is noisy, it gives a clear indication of the state of the stock in its historical context.

The outcome of the assessment this year suggests that the SSB is relatively stable at around 15% below the average of the last 20 years, compared with the perception from last year's assessment that it was declining. Catch in 2008 is almost half the 2007 level and with the increased SSB, F has decreased to F=0.16. Recruitment is low for the 2001, 2002 and 2003 year classes (Table 5.6.2.12). The 2004 recruitment currently appears to be around half the level of the last reasonable year class (2000); the 2005 year class appears to be around the same level as the poor 2001 – 2003 year classes. There is insufficient data to evaluate later year classes.

In conclusion, this assessment is driven by a noisy survey, giving the third lowest survey SSB estimate in 2007 to the second highest survey estimate in 2008. Point estimates of SSB and F from the survey are, therefore, not that informative and should be used to indicate medium term trends and used for guidance. The current management agreement that restricts large inter-annual changes in TACs is appropriate for such a noisy assessment.

5.7 Short term projections

5.7.1 Deterministic short-term projections

In 2005 the Working Group tested an HCR applicable to VIa (N) (ICES 2005/ACFM:16), which was accepted by ICES as precautionary. This has formed the basis for the proposed agreement and was implemented in December 2008 by the European Commission. A deterministic short-term projection is presented, which provides options including those based on the management agreement.

Short-term projections were carried out using MFDP (Smith 2000). Input data are stock numbers on 1st January in 2009 from the 2009 ICA assessments (Section 5.6.2, Tables 5.7.1.1), with geometric mean recruitment 1989-2006 replacing recruitment both 1- and 2-ring in 2009. For the selection of this period see productivity section in 2007 WG report. The retrospective assessment of recruitment estimates in the 2003 Working Group (ICES 2003/ACFM:17) showed the substantial revision of 1- and 2-ring herring abundance (1st January survivors) in subsequent assessments, justifying the use of geometric means for these ages. The selection pattern used is taken from the final year of the ICA assessment (Table 5.6.2.16, and Figure 5.6.2.2), and is therefore effectively the mean of last 8 years. For the projections, data for maturity, natural mortality, mean weights-at-age in the catch and in the stock are means of the three previous years (i.e., 2006 - 2008). A TAC constraint of 21 760 t in 2009 is used for the basis for the intermediate year in the projection, this implies an exploitation at F=0.23, close to target F. All the input values are summarised in Table 5.7.1.1.

The results of the short-term projection are given in Tables 5.7.1.2 – 5.7.1.3. For F in accordance with the proposed management plan (SSB2010 < 94 000 t, F =0.25 in 2010 TAC increase of 12%) catches are projected to be 24 420 t, and SSB rises to approximately 96 000 t in 2011.

5.7.2 Yield-per-recruit

Yield-per-recruit analyses were carried out using MFYPR (Smith 2000) to provide yield-per-recruit (Figure 5.7.2.1). The value for $\mathbf{F}_{0.1}$ is 0.17.

5.8 Medium term projections and HCR performance $

In 2005 ICES classed as precautionary a proposed management plan:

"An HCR with the following rule is shown to be sustainable and delivering reasonably high yield

F=0.25	if SSB > 75,000 t Optional year on year TAC constraint.
F=0.2	if SSB < 75,000 t No constraint on TAC.

The rule should be supplemented with a requirement for F = 0 if SSB falls below B_{lim}."

In 2008 COUNCIL REGULATION (EC) No 1300/2008 of 18 December 2008 established a multi-annual management agreement for the stock of herring distributed to the west of Scotland and the fisheries exploiting that stock.

F = 0.25 if SSB > 75 000 t	20% TAC constraint.
F = 0.20 if SSB < 75 000 t but > 62 500 t	20% constraint on TAC change.
F = 0.20 if SSB <62 500 t but > 50 000 t	25% constraint on TAC change
F = 0 if SSB < 50 000 t.	

The agreed rule uses the same trigger points and includes the closure if SSB falls below B_{lim} that ICES requested. However it has additional constraint on year-on-year change in TAC below 75,000t which was not tested. In addition, ICES now provides catch options based on geometric mean recruitment from 1989 to the present (2006 this year, Section 5.7). This period was selected in 2007 following investigations by HAWG on changes in productivity of herring stocks (ICES 2007). Here we provide an exploration of the agreed rule under the new starting conditions, recruitment regimes based on SSB / recruitment 1989-2006, and typical measurement errors observed over the last few years.

5.8.1 Medium term simulation methods

The current investigations use the software STPR3 (Skagen 2003), the same software used to evaluate HCRs for this stock in 2005 (Simmonds and Keltz 2007), and used by WKHMP in 2008 (ICES 2008/ACOM:27). Parameterisation follows the principles used in Simmonds and Keltz (2007) and in the Stock Annex (06), with values updated to account for new data in the assessment input and estimates of SSB and recruits. These are as follows:

- Numbers at age 1 of January 2009 from input to short term forecast (Table 5.7.1.1)
- Precision of starting numbers from the covariance matrix from ICA, except for the variance for 1-ring which is not properly estimated so it was set equal to the variance for 2-ring = 0.117 (equivalent to a CV ~35%) Table 5.8.1.1
- Mean weights for the catch (Table 5.6.2.2) and stock (Table 5.6.2.3) and maturities (Table 5.6.2.5) from 1990 to 2008 were selected randomly as year sets within the simulations. Prior to 1990 the mean weights and maturities for the stock were not well estimated.
- Natural mortality (Table 5.6.2.4) and selection (Table 5.6.2.16) matching the assessment.
- Catch in tonnes without bias (catch is usually not fully taken) with 5% CV to mimic small uncertainty. Options of positive bias (underreporting) were tested to explore the robustness of the rule.
- Assessment error two options tested
    - 25% derived from ICES historic assessment database 2000 to 2008.
    - 30% for robustness testing.
- Stock / Recruit relationship two options (Table 5.8.1.2)
    - Beverton-Holt model fitted to S/R pairs (Table 5.6.2.12, shifted by 2 years) using FLR (Kell 2007) for years 1989-2006 using slope from fit to 1957 to 2006 (Figure 5.8.1.1), as slope on 1989-2006 is unresolved (Figure 5.8.1.2).

– Fitted Hockey-Stick (segmented regression) to S/R pairs (Table 5.6.2.12, shifted by 2 years) for years 1989-2006 with breakpoint at lowest observed biomass at 50 000 t as no breakpoint is found within the observations.

– Stochastic draws lognormal truncated at 1.5 to give correct proportions of numbers of observations in the tails of the probability distribution (Figure 5.8.1.3).

– Recruitment year-year autocorrelation +0.16 (as observed, though not significant)

5.8.2 Medium term simulation results

The results for two S/R model options (run 5 - Hockey-Stick and run 1 Beverton-Holt) are presented in Figure 5.8.2.1. These show that in both cases initial risks are around 8%. These reduce over time to below 5% and continue to reduce to less than 1% as the SSB increases. These initial risks result from the starting conditions, with SSB below equilibrium and variability which can be greater than that in the future due to uncertainty in these numbers from the ICA assessment. The run using the Hockey-Stick S/R assumption assumes slightly higher recruitment at lower stock size, giving faster stock growth, and more rapidly reducing risk of SSB<B_{lim}. The Beverton-Holt S/R assumption allows recruitment to continue to grow with SSB and results in a higher biomass after a number of years and lower risk in the longer term as SSB continues to increase beyond the end of the 10 years illustrated.

In order to explore the robustness of these evaluations we have compared risks of SSB< B_{lim} under a range of different assumptions (Figure 5.8.2.2).

In the medium term all risks decline below 5% and decline to very low levels with the exception of those with positive bias in the catch of 20 and 30% (Runs 10-11).

Results of runs with the two types of year-on-year constraint on TAC (Figure 5.8.2.2a, dotted 20% y-y constraint (runs 1, 3, 5, 7), solid 25% y-y constraint (runs 2, 4, 6, 8)), indicate that risk of SSB< B_{lim} with either of these constraints or the current rule with change at 62 500 t are effectively the same.

Risks are higher if the measurement error is increased from a CV of 25% (Runs (1, 2, 5, 6)) to 30% (Runs (3, 4, 7, 8)). (Figure 5.8.2.2a)

The risk increases when unregulated catch is assumed to increases from 0 to 10, 20 and 30% (Runs 9, 10, 11 respectively) (Figure 5.8.2.2b). Only at the highest level of unregulated catch (30%) never seen in this area do the risks increase to levels approaching 3% in the long term.

In conclusion, the current state of the stock implies about 8% risk of SSB< B_{lim}. Following the agreed management plan the risk is expected to decrease to well below the precautionary limit reference of 5%. The time over which this reduction in risk will occur is dependent on the realised recruitment, though the most plausible assumptions show a rapid decline. The changes to the previously ICES endorsed precautionary management plan are small. Changes to recruitment increase the risks slightly but these are expected to be well below 5%. Therefore it is recommended that the amended plan be accepted as precautionary.

5.9 Precautionary and yield based reference points

B_{lim} is agreed at 50 000t (based on B_{loss}). There are no agreed precautionary reference points for this stock. The agreed management rule has a B_{trig} at 75 000 t.

5.10 Quality of the Assessment

The HAWG considers that this year's assessment is as reliable as last year's. The precision of the assessment estimated through parametric bootstrap is shown in Figure 5.10.1. The influence of model settings has been explored and shown to give some differences but does not change the conclusions that F is below target F and SSB is above B_{pa}. The assessment outcomes were revised upwards from those made last year. SSB, catch and F estimated in last year's assessment and short term forecast are compared with this year's assessment in the text table below.

	2008 REPORT					THIS YEAR			
	Year	SSB	Catch	F 3-6		Year	SSB	Catch	F 3-6
ASSESS 2008	2006	76 813	27 346	0.28	ASSESS 2009	2006	93 270	27 346	0.23
	2007	68 816	29 616	0.40		2007	91 848	29 616	0.29
STF* 2008	2008	68 444*	13 011*	0.20*		2008	91 884	16 054	0.16

*** projected values from the intermediate year in the deterministic short term forecast assuming a catch consistent with management plan. STF refers to values estimated in the first year of the short term forecast in the 2008 report.**

Retrospective analyses of the assessment from 2008 to 2004 (Figure 5.6.2.13) support the perception of a noisy but fairly well balanced assessment. Catches are below TACs; recruitment is low.

5.11 Management Considerations

In the absence of precautionary reference points the state of the stock cannot be evaluated. An analytical assessment shows that SSB (in 2009) is 1.8 times B_{lim}. ICES considers that the stock is currently fluctuating at a low level and is being exploited close to F_{msy}. Recruitment has been low since 1998, and the 2001, 2002 and 2003 year classes are weak.

There has been considerable uncertainty in the amount of landings from this stock in the past. Area misreporting continues to be a problem, with almost all countries taking catches of herring in other areas and reporting it into VIa (N). Increased observer coverage and or use of VMS and electronic log books might reduce these problems.

The assessment is noisy, leading to annual revisions of SSB and F. The management plan has been designed to cope with this by applying a constraint on year-on-year change in TAC. Revisions in SSB can be upwards or downwards, so it is important to maintain the restrictions on change in TAC both when the stock is revised upwards or downwards. Asymmetrical changes in TAC have not been tested and may be significantly more risky than those tested.

The stock identity of herring west of the British Isles was reviewed by the EU-funded project WESTHER. This identified Division VIa (N) as an area where catches comprise a mixture of fish from Divisions VIa (N), VIa (S), and VIIa (N). Concerning the management plan for Division VIa (N), ICES has advised that herring components should be managed separately to afford maximum protection. If there is an increasing catch on the mixed fishery in Division VIa (N), this should be considered in the management of the Division VIa (S) component which is in a depleted state. In 2008 ICES has began to evaluate management for this Division VIa (S) and VIIa (N). It will be a number of years before ICES can provide a fully operational integrated strategy for these units. In this context ICES recommends that the management plan for Division VIa (N) should be continued.

5.12 Ecosystem Considerations

Herring are an important prey species in the ecosystem and also one of the dominant planktivorous fish.

Observers monitor the fisheries. 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 programs have recorded occasional catches of seals and zero catches of cetaceans.

5.13 Changes in the environment

Temperatures in this area have been increasing over the last number of decades. There are indications that salinity is also increasing (ICES 2006). It is considered that this 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 HAWG 2007).

Herring are thought to be a source of food for seals. Grey seals (*Halichoerus grypus*) are common in many parts of the Celtic Seas area. The majority of individuals are found in the Hebrides and in Orkney (SCOS 2005). A recent study (Hammond & Harris 2006) of seal diets off western Scotland revealed that grey seals may be an important predator for cod, herring and sandeels in this area. Common seals (*Phoca vitulina*) are also widespread in the northern part of the ecoregion with around 15,000 animals estimated (SCOS 2005). The numbers of seals in VIa (N) is thought to have increased over the last decades. The seal consumption of herring is estimated with great uncertainty and the impact of increased predation is not known, but there is a possibility that seal predation could influence natural mortality.

Table 5.1.1. Herring in VIa (N). Catch in tonnes by country, 1985-2008. These figures do not in all cases correspond to the official statistics and cannot be used for management purposes.

Country	**1985**	**1986**	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**
Denmark								
Faroes	104	400				326	482	
France	20	18	136	44	1342	1287	1168	119
Germany	5937	2188	1711	1860	4290	7096	6450	5640
Ireland		6000	6800	6740	8000	10000	8000	7985
Netherlands	5500	5160	5212	6131	5860	7693	7979	8000
Norway	4690	4799	4300	456		1607	3318	2389
UK	28065	25294	26810	26894	29874	38253	32628	32730
Unallocated	-502	37840	18038	5229	2123	2397	-10597	-5485
Discards					1550	1300	1180	200
Total	43814	81699	63007	47354	53039	69959	50608	51578
Area-Misreported	-4672	-10935	-18647	-11763	-19013	-25266	-22079	-22593
WG Estimate	39142	70764	44360	35591	34026	44693	28529	28985
Source (WG)	1987	1988	1989	1990	1991	1993	1993	1994

Country	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**
Faroes								
France	818	274	3672	2297	3093	1903	463	870
Germany	4693	5087	3733	7836	8873	8253	6752	4615
Ireland	8236	7938	3548	9721	1875	11199	7915	4841
Netherlands	6132	6093	7808	9396	9873	8483	7244	4647
Norway	7447	8183	4840	6223	4962	5317	2695	
UK	32602	30676	42661	46639	44273	42302	36446	22816
Unallocated	-3753	-4287	-4541	-17753	-8015	-11748	-8155	
Discards		700			62	90		
Total	56175	54664	61271	64359	64995	65799	61514	37789
Area-Misreported	-24397	-30234	-32146	-38254	-29766	-32446	-23623	-19467
WG Estimate	31778	24430	29575	26105	35233*	33353	29736	18322$
Source (WG)	1995	1996	1997	1997	1998	1999	2000	2001

Country	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**
Faroes		800	400	228	1810	570	484	927
France	760	1340	1370	625	613	701	703	564
Germany	3944	3810	2935	1046	2691	3152	1749	2526
Ireland	4311	4239	3581	1894	2880	4352	5129	3103
Netherlands	4534	4612	3609	8232	5132	7008	8052	4133
Norway								
UK	21862	20604	16947	17706	17494	18284	17618	13963
Unallocated		878	-7					
Discards				123	772	163		
Total	35411	36283	28835	29854	31392	34230	33735	25216
Area-Misreported	-11132	-8735	-3581	-7218	-17263	-6884	-4119	-9162
WG Estimate	24556$	32914$	28081$	25021$	14129$	27346	29616	16054
Source (WG)	2002	2003	2004	2005	2006	2007	2008	2009

$Revised at HAWG 2007

Table 5.2.1. Herring in VIa (N). Catch and sampling effort by nations participating in the fishery in 2008.

PERIOD : 1

Country	Sampled Catch	Official Catch	No. of samples	No. measured	No. aged	SOP %
Faroes	0.00	517.00	0	0	0	0.00
Ireland	0.00	1337.00	0	0	0	0.00
Netherlands	0.00	278.00	0	0	0	0.00
Scotland	0.00	132.00	0	0	0	0.00
Period Total	0.00	2264.00	0	0	0	0.00

Sum of Offical Catches : 2264.00
Unallocated Catch : -1615.00
Working Group Catch : 649.00

PERIOD : 2

Country	Sampled Catch	Official Catch	No. of samples	No. measured	No. aged	SOP %
Netherlands	0.00	727.00	0	0	0	0.00
Period Total	0.00	727.00	0	0	0	0.00

Sum of Offical Catches : 727.00
Unallocated Catch : -727.00
Working Group Catch : 0.00

PERIOD : 3

Country	Sampled Catch	Official Catch	No. of samples	No. measured	No. aged	SOP %
England & Wales	1811.00	1811.00	1	93	25	100.05
Faroes	0.00	385.00	0	0	0	0.00
France	0.00	564.00	0	0	0	0.00
Germany	0.00	2526.00	0	0	0	0.00
Netherlands	964.00	3128.00	1	87	25	100.21
Scotland	7062.00	9952.00	11	1847	707	99.99
Period Total	9837.00	18366.00	13	2027	757	100.03

Sum of Offical Catches : 18366.00
Unallocated Catch : -5054.00
Working Group Catch : 13312.00

PERIOD : 4

Country	Sampled Catch	Official Catch	No. of samples	No. measured	No. aged	SOP %
England & Wales	0.00	1859.00	0	0	0	0.00
Faroes	0.00	25.00	0	0	0	0.00
Ireland	0.00	1766.00	0	0	0	0.00
N. Ireland	0.00	204.00	0	0	0	0.00
Scotland	0.00	5.00	0	0	0	0.00
Period Total	0.00	3859.00	0	0	0	0.00

Sum of Offical Catches : 3859.00
Unallocated Catch : -1766.00
Working Group Catch : 2093.00

Total over all Areas and Periods

Country	Sampled Catch	Official Catch	No. of samples	No. measured	No. aged	SOP %
England & Wales	1811.00	3670.00	1	93	25	100.05
Faroes	0.00	927.00	0	0	0	0.00
France	0.00	564.00	0	0	0	0.00
Germany	0.00	2526.00	0	0	0	0.00
Ireland	0.00	3103.00	0	0	0	0.00
N. Ireland	0.00	204.00	0	0	0	0.00
Netherlands	964.00	4133.00	1	87	25	100.21
Scotland	7062.00	10089.00	11	1847	707	99.99
Total for Stock	9837.00	25216.00	13	2027	757	100.03

Sum of Offical Catches : 25216.00
Unallocated Catch : -9162.00
Working Group Catch : 16054.00

Table 5.3.1. Herring in VIa (N). Estimates of abundance, biomass, maturity, weight- and length-at-age from Scottish acoustic surveys. 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).

Age (ring)	Numbers	Biomass	Maturity	weight(g)	Length (cm)
0					
1	47.84	2.6	0.00	54.6	18.2
2	232.57	40.0	0.98	172.1	26.3
3	911.95	174.5	1.00	191.3	27.2
4	668.87	139.3	1.00	208.3	28.0
5	339.92	72.8	1.00	214.3	28.2
6	272.23	58.2	1.00	213.9	28.2
7	720.86	159.0	1.00	220.6	28.5
8	365.89	82.0	1.00	224.2	28.6
9+	263.74	62.9	1.00	238.5	29.2
Immature	53.461	3.3		61.2	18.7
Mature	3770.421	788.1		209.0	28.0
Total	3823.882	791.4	0.99	207.0	27.9

Tables 5.6.2.1. – 5.6.2.21. Herring in VIa (N). Input data, FLICA run settings and results for the maximum-likelihood ICA calculation for the 8 year separable period. N.B. In these tables "age" refers to number of rings (winter rings in the otolith).

TABLE 5.6.2.1 HERRING in VIa (N). CATCH IN NUMBER

Units : Thousands

age \ year	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967
1	6496	15616	53092	3561	13081	55048	11796	26546	299483	211675	207947
2	74622	30980	67972	102124	45195	92805	78247	82611	19767	500853	27416
3	58086	145394	35263	60290	61619	22278	53455	70076	62642	33456	218689
4	25762	39070	116390	22781	33125	67454	11859	26680	59375	60502	37069
5	33979	24908	24946	48881	22501	44357	40517	7283	22265	40908	39246
6	19890	27630	17332	11631	12412	19759	26170	24227	5120	19344	29793
7	8885	17405	16999	10347	5345	24139	8687	18637	22891	5563	11770
8	1427	9857	7372	6346	4814	6147	13662	8797	18925	17811	5533
9	4423	7159	8595	4617	2582	7082	6088	15103	19531	27083	25799

age \ year	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978
1	220255	37706	238226	207711	534963	51170	309016	172879	69053	34836	22525
2	94438	92561	99014	335083	621496	235627	124944	202087	319604	47739	46284
3	20998	71907	253719	412816	175137	808267	151025	89066	101548	95834	20587
4	159122	23314	111897	302208	54205	131484	519178	63701	35502	22117	40692
5	13988	211243	27741	101957	66714	63071	82466	188202	25195	10083	6879
6	23582	21011	142399	25557	25716	54642	49683	30601	76289	12211	3833
7	15677	42762	21609	154424	10342	18242	34629	12297	10918	20992	2100
8	6377	26031	27073	16818	55763	6506	22470	13121	3914	2758	6278
9	10814	26207	24082	31999	16631	32223	21042	13698	12014	1486	1544

age \ year	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
1	247	2692	36740	13304	81923	2207	40794	33768	19463	1708	6216
2	142	279	77961	250010	77810	188778	68845	154963	65954	119376	36763
3	77	95	105600	72179	92743	49828	148399	86072	45463	41735	109501
4	19	51	61341	93544	29262	35001	17214	118860	32025	28421	18923
5	13	13	21473	58452	42535	14948	15211	18836	50119	19761	18109
6	8	9	12623	23580	27318	11366	6631	18000	8429	28555	7589
7	4	8	11583	11516	14709	9300	6907	2578	7307	3252	15012
8	1	1	1309	13814	8437	4427	3323	1427	3508	2222	1622
9	0	0	1326	4027	8484	1959	2189	1971	5983	2360	3505

age \ year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1	14294	26396	5253	17719	1728	266	1952	1193	9092	7635	3569	143
2	40867	23013	24469	95288	36554	82176	37854	55810	74167	35252	18162	81030
3	40779	25229	24922	18710	40193	30398	30899	34966	34571	93910	17264	14943
4	74279	28212	23733	10978	6007	21272	9219	31657	31905	25078	40674	9306
5	26520	37517	21817	13269	7433	5376	7508	23118	22872	13364	12264	24482
6	13305	13533	33869	14801	8101	4205	2501	17500	14372	7529	7121	9281
7	9878	7581	6351	19186	10515	8805	4700	10331	8641	3251	3083	6625
8	21456	6892	4317	4711	12158	7971	8458	5213	2825	1257	1452	4611
9	5522	4456	5511	3740	10206	9787	31108	9883	3327	1089	456	1001

age \ year	2002	2003	2004	2005	2006	2007	2008
1	992	56	0	182	132	131	0
2	38482	33332	6844	9633	6691	34326	7898
3	93975	46866	22223	23237	9186	17755	13039
4	9014	53767	27815	20602	13645	6555	5428
5	18114	7463	45782	10238	41068	14265	3220
6	28016	4345	3916	9783	27782	30566	5689
7	9040	12818	7642	1015	20973	21517	14832
8	1548	9188	8481	1195	3042	13585	8142
9	1423	1408	4008	1431	5089	4243	8969

TABLE 5.6.2.2 HERRING in VIa (N). WEIGHTS AT AGE IN THE CATCH

Units : Kg

age \ year	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968
1	0.079	0.079	0.079	0.079	0.079	0.079	0.079	0.079	0.079	0.079	0.079	0.079
2	0.104	0.104	0.104	0.104	0.104	0.104	0.104	0.104	0.104	0.104	0.104	0.104
3	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130
4	0.158	0.158	0.158	0.158	0.158	0.158	0.158	0.158	0.158	0.158	0.158	0.158
5	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164
6	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170
7	0.180	0.180	0.180	0.180	0.180	0.180	0.180	0.180	0.180	0.180	0.180	0.180
8	0.183	0.183	0.183	0.183	0.183	0.183	0.183	0.183	0.183	0.183	0.183	0.183
9	0.185	0.185	0.185	0.185	0.185	0.185	0.185	0.185	0.185	0.185	0.185	0.185

age \ year	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
1	0.079	0.079	0.079	0.079	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090
2	0.104	0.104	0.104	0.104	0.121	0.121	0.121	0.121	0.121	0.121	0.121	0.121
3	0.130	0.130	0.130	0.130	0.158	0.158	0.158	0.158	0.158	0.158	0.158	0.158
4	0.158	0.158	0.158	0.158	0.175	0.175	0.175	0.175	0.175	0.175	0.175	0.175
5	0.164	0.164	0.164	0.164	0.186	0.186	0.186	0.186	0.186	0.186	0.186	0.186
6	0.170	0.170	0.170	0.170	0.206	0.206	0.206	0.206	0.206	0.206	0.206	0.206
7	0.180	0.180	0.180	0.180	0.218	0.218	0.218	0.218	0.218	0.218	0.218	0.218
8	0.183	0.183	0.183	0.183	0.224	0.224	0.224	0.224	0.224	0.224	0.224	0.224
9	0.185	0.185	0.185	0.185	0.224	0.224	0.224	0.224	0.224	0.224	0.000	0.000

age \ year	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
1	0.090	0.080	0.080	0.080	0.069	0.113	0.073	0.080	0.082	0.079	0.084	0.091
2	0.121	0.140	0.140	0.140	0.103	0.145	0.143	0.112	0.142	0.129	0.118	0.119
3	0.158	0.175	0.175	0.175	0.134	0.173	0.183	0.157	0.145	0.173	0.160	0.183
4	0.175	0.205	0.205	0.205	0.161	0.196	0.211	0.177	0.191	0.182	0.203	0.196
5	0.186	0.231	0.231	0.231	0.182	0.215	0.220	0.203	0.190	0.209	0.211	0.227
6	0.206	0.253	0.253	0.253	0.199	0.230	0.238	0.194	0.213	0.224	0.229	0.219
7	0.218	0.270	0.270	0.270	0.213	0.242	0.241	0.240	0.216	0.228	0.236	0.244
8	0.224	0.284	0.284	0.284	0.223	0.251	0.253	0.213	0.204	0.237	0.261	0.256
9	0.224	0.295	0.295	0.295	0.231	0.258	0.256	0.228	0.243	0.247	0.271	0.256

age \ year	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
1	0.089	0.083	0.106	0.081	0.089	0.097	0.076	0.083	0.049	0.107	0.060	NaN
2	0.128	0.142	0.142	0.134	0.136	0.138	0.130	0.137	0.140	0.146	0.145	0.154
3	0.158	0.167	0.181	0.178	0.177	0.159	0.158	0.164	0.163	0.163	0.160	0.173
4	0.197	0.190	0.191	0.210	0.205	0.182	0.175	0.183	0.183	0.173	0.169	0.195
5	0.206	0.195	0.198	0.230	0.222	0.199	0.191	0.201	0.192	0.160	0.186	0.216
6	0.228	0.201	0.214	0.233	0.223	0.218	0.210	0.215	0.196	0.179	0.200	0.220
7	0.223	0.244	0.208	0.262	0.219	0.227	0.225	0.239	0.205	0.187	0.194	0.199
8	0.262	0.234	0.227	0.247	0.238	0.212	0.223	0.281	0.225	0.245	0.186	0.190
9	0.263	0.266	0.277	0.291	0.263	0.199	0.226	0.253	0.272	0.281	0.294	0.311

age \ year	2005	2006	2007	2008
1	0.108	0.091	0.115	NaN
2	0.133	0.158	0.167	0.170
3	0.163	0.168	0.188	0.206
4	0.184	0.193	0.197	0.231
5	0.211	0.208	0.210	0.231
6	0.226	0.225	0.221	0.249
7	0.234	0.244	0.216	0.253
8	0.256	0.262	0.262	0.284
9	0.250	0.275	0.303	0.288

TABLE 5.6.2.3 HERRING in VIa (N). WEIGHTS AT AGE IN THE STOCK

Units : Kg

age \ year	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968
1	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090
2	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164
3	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208
4	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.233
5	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.246
6	0.252	0.252	0.252	0.252	0.252	0.252	0.252	0.252	0.252	0.252	0.252	0.252
7	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258
8	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269
9	0.292	0.292	0.292	0.292	0.292	0.292	0.292	0.292	0.292	0.292	0.292	0.292

age \ year	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
1	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090
2	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164
3	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208
4	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.233
5	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.246
6	0.252	0.252	0.252	0.252	0.252	0.252	0.252	0.252	0.252	0.252	0.252	0.252
7	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258
8	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269
9	0.292	0.292	0.292	0.292	0.292	0.292	0.292	0.292	0.292	0.292	0.000	0.000

age \ year	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
1	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090
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

age \ year	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
1	0.075	0.052	0.042	0.045	0.057	0.066	0.054	0.062	0.062	0.062	0.064	0.059
2	0.162	0.150	0.144	0.140	0.150	0.138	0.137	0.141	0.132	0.153	0.138	0.138
3	0.196	0.192	0.191	0.180	0.189	0.176	0.166	0.173	0.170	0.177	0.176	0.159
4	0.206	0.220	0.202	0.209	0.209	0.194	0.188	0.183	0.190	0.198	0.190	0.180
5	0.226	0.221	0.225	0.219	0.225	0.214	0.203	0.194	0.198	0.212	0.204	0.189
6	0.234	0.233	0.227	0.222	0.233	0.226	0.219	0.204	0.212	0.215	0.213	0.202
7	0.254	0.241	0.247	0.229	0.248	0.234	0.225	0.211	0.220	0.225	0.217	0.213
8	0.260	0.270	0.260	0.242	0.266	0.225	0.235	0.222	0.236	0.243	0.223	0.214
9	0.276	0.296	0.293	0.263	0.287	0.249	0.245	0.230	0.254	0.259	0.228	0.206

age \ year	2005	2006	2007	2008
1	0.075	0.075	0.075	0.055
2	0.130	0.135	0.168	0.172
3	0.154	0.166	0.183	0.191
4	0.166	0.185	0.191	0.208
5	0.180	0.192	0.195	0.214
6	0.191	0.204	0.195	0.214
7	0.212	0.211	0.202	0.221
8	0.203	0.224	0.203	0.224
9	0.228	0.231	0.214	0.239

TABLE 5.6.2.4 HERRING in VIa (N). NATURAL MORTALITY

Units : NA

age	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971
1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
4	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
5	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
6	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
7	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
8	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
9	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1

age	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
4	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
5	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
6	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
7	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
8	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
9	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1

age	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
4	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
5	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
6	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
7	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
8	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
9	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1

age	2002	2003	2004	2005	2006	2007	2008
1	1.0	1.0	1.0	1.0	1.0	1.0	1.0
2	0.3	0.3	0.3	0.3	0.3	0.3	0.3
3	0.2	0.2	0.2	0.2	0.2	0.2	0.2
4	0.1	0.1	0.1	0.1	0.1	0.1	0.1
5	0.1	0.1	0.1	0.1	0.1	0.1	0.1
6	0.1	0.1	0.1	0.1	0.1	0.1	0.1
7	0.1	0.1	0.1	0.1	0.1	0.1	0.1
8	0.1	0.1	0.1	0.1	0.1	0.1	0.1
9	0.1	0.1	0.1	0.1	0.1	0.1	0.1

TABLE 5.6.2.5 HERRING in VIa (N). PROPORTION MATURE

Units : NA

age \ year	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 \ year	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 \ year	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	0.48	0.19	0.76	0.57	0.85	0.57	0.45	0.93
3	0.96	0.96	0.96	0.96	0.96	1.00	0.96	0.92	0.98	0.94	0.96	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 \ year	2002	2003	2004	2005	2006	2007	2008
1	0.00	0.00	0.00	0.00	0.00	0	0.00
2	0.92	0.76	0.83	0.84	0.81	1	0.98
3	1.00	1.00	0.97	1.00	0.96	1	1.00
4	1.00	1.00	1.00	1.00	1.00	1	1.00
5	1.00	1.00	1.00	1.00	1.00	1	1.00
6	1.00	1.00	1.00	1.00	1.00	1	1.00
7	1.00	1.00	1.00	1.00	1.00	1	1.00
8	1.00	1.00	1.00	1.00	1.00	1	1.00
9	1.00	1.00	1.00	1.00	1.00	1	1.00

TABLE 5.6.2.6 HERRING in VIa (N). FRACTION OF HARVEST BEFORE SPAWNING

Units : NA

age \ year	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971
1	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
2	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
3	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
4	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
5	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
6	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
7	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
8	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
9	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67

age \ year	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
1	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
2	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
3	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
4	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
5	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
6	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
7	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
8	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
9	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67

age \ year	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
2	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
3	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
4	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
5	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
6	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
7	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
8	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
9	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67

age \ year	2002	2003	2004	2005	2006	2007	2008
1	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
3	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
5	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
7	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
9	0.67	0.67	0.67	0.67	0.67	0.67	0.67

TABLE 5.6.2.7 HERRING in VIa (N). FRACTION OF NATURAL MORTALITY BEFORE SPAWNING

Units : NA

year

age	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971
1	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
2	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
3	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
4	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
5	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
6	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
7	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
8	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
9	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67

year

age	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
1	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
2	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
3	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
4	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
5	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
6	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
7	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
8	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
9	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67

year

age	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
2	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
3	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
4	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
5	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
6	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
7	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
8	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
9	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67

year

age	2002	2003	2004	2005	2006	2007	2008
1	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
3	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
5	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
7	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
9	0.67	0.67	0.67	0.67	0.67	0.67	0.67

TABLE 5.6.2.8 HERRING in VIa (N). SURVEY INDICES

FLT01:West Scotland Summer Acoustic Survey (Catch:Thousands)(Effort:Unknown) - Configuration

"Herring in Division VIa (North)(runname:ICAPGF08) . Imported from VPA file."

min	max	plusgroup	minyear	maxyear	startf	endf
1.00	9.00	9.00	1987.00	2008.00	0.52	0.57

Index type : number

FLT01:West Scotland Summer Acoustic Survey (Catch:Thousands)(Effort:Unknown) - Index Values

Units : NA

age \ year	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
1	249100	-1	-1	-1	338312	74310	2760	494150	460630	41220	792320
2	578400	-1	-1	-1	294484	503430	750270	542080	1085090	576460	641860
3	551100	-1	-1	-1	327902	210980	681170	607720	472710	802530	286170
4	353100	-1	-1	-1	367830	258090	653050	285610	450250	329110	167040
5	752600	-1	-1	-1	488288	414750	544000	306760	153000	95360	66100
6	111600	-1	-1	-1	176348	240110	865150	268130	187060	60600	49520
7	48100	-1	-1	-1	98741	105670	284110	406840	169180	77380	16280
8	15900	-1	-1	-1	89830	56710	151730	173740	236580	78190	28990
9	6500	-1	-1	-1	58043	63440	156180	131880	201510	114810	24440

age \ year	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
1	1221700	534200	447600	313100	424700	438800	564000	50200	112300	-1
2	794630	322400	316200	1062000	436000	1039400	274500	243400	835200	126000
3	666780	1388000	337100	217700	1436900	932500	760200	230300	387900	294400
4	471070	432000	899500	172800	199800	1471800	442300	423100	284500	202500
5	179050	308000	393400	437500	161700	181300	577200	245100	582200	145300
6	79270	138700	247600	132600	424300	129200	55700	152800	414700	346900
7	28050	86500	199500	102800	152300	346700	61800	12600	227000	242900
8	13850	27600	95000	52400	67500	114300	82200	39000	21700	163500
9	36770	35400	65000	34700	59500	75200	76300	26800	59300	32100

age \ year	2008
1	47840
2	232570
3	911950
4	668870
5	339920
6	272230
7	720860
8	365890
9	263740

FLT01:West Scotland Summer Acoustic Survey (Catch:Thousands)(Effort:Unknown) - Index Variance (Inverse Weights)

Units : NA

age \ year	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
4	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
5	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
6	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
7	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
8	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
9	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

age \ year	2002	2003	2004	2005	2006	2007	2008
1	10	10	10	10	10	10	10
2	1	1	1	1	1	1	1
3	1	1	1	1	1	1	1
4	1	1	1	1	1	1	1
5	1	1	1	1	1	1	1
6	1	1	1	1	1	1	1
7	1	1	1	1	1	1	1
8	1	1	1	1	1	1	1
9	1	1	1	1	1	1	1

TABLE 5.6.2.9 HERRING in VIa (N). STOCK OBJECT CONFIGURATION

min	max	plusgroup	minyear	maxyear	minfbar	maxfbar
1	9	9	1957	2008	3	6

TABLE 5.6.2.10 HERRING in VIa (N). FLICA CONFIGURATION SETTINGS

```
sep.2       : NA
sep.gradual : TRUE
sr          : FALSE
sr.age      : 1
lambda.age  : 0.1 1 1 1 1 1 1 1 0
lambda.yr   : 1 1 1 1 1 1 1 1
lambda.sr   : 0.01
index.model : linear
index.cor   : 1
sep.nyr     : 8
sep.age     : 4
sep.sel     : 1
```

TABLE 5.6.2.11 HERRING in VIa (N). FLR, R SOFTWARE VERSIONS

```
R version 2.8.1 (2008-12-22)

Package  : FLICA
Version  : 1.4-10
Packaged : Sat Mar 21 18:30:56 2009; mpa
Built    : R 2.8.0; ; 2009-03-21 18:30:58; windows

Package  : FLAssess
Version  : 1.99-102
Packaged : Sun Mar 22 12:18:48 2009; mpa
Built    : R 2.8.0; i386-pc-mingw32; 2009-03-22 12:18:51; windows

Package  : FLCore
Version  : 3.0
Packaged : Tue Mar 10 04:42:26 2009; theussl
Built    : R 2.8.1; i386-pc-mingw32; 2009-03-10 04:42:28; windows
```

TABLE 5.6.2.12 HERRING in VIa (N). STOCK SUMMARY

Year	Recruitment Age 1	TSB	SSB	Fbar (Ages 3-6) f	Landings Tonnes	Landings SOP
1957	1085415	405341	184542	0.2832	43438	0.7258
1958	2129925	498370	200966	0.3315	59669	0.7470
1959	2124103	533658	214361	0.3042	65221	0.7248
1960	628969	428836	248252	0.1948	63759	0.5679
1961	1282671	435629	248296	0.1290	46353	0.5846
1962	2323456	543692	237651	0.2055	58195	0.7727
1963	2128325	576715	261562	0.1830	49030	0.6970
1964	979318	526206	307678	0.1530	64234	0.5774
1965	7855652	1121416	316322	0.1580	68669	0.8586
1966	1065520	850597	427781	0.1920	100619	1.0136
1967	2499919	833400	460184	0.1885	90400	0.8072
1968	4100323	955297	437487	0.1425	84614	0.7964
1969	2998830	984297	475825	0.2415	107170	0.7573
1970	3440170	1002417	444140	0.3580	165930	0.7343
1971	9572399	1515913	316111	0.7885	207167	1.0162
1972	2675839	1116445	443971	0.3648	164756	1.0239
1973	1074339	801989	385359	0.6055	210270	1.0438
1974	1672283	576517	204084	0.9570	178160	1.1255
1975	2101533	434638	107141	0.9092	114001	1.0108
1976	608221	263752	73429	1.0677	93642	0.9984
1977	621969	162995	51907	0.9935	41341	0.9154
1978	913517	170722	48526	0.6768	22156	1.0056
1979	1216369	215915	72378	0.0008	60	1.0011
1980	885405	252213	122146	0.0002	306	1.0007
1981	1660598	364460	131858	0.3622	51420	0.9698
1982	770261	305592	109542	0.6750	92360	1.0347
1983	2977418	426873	81150	0.7138	63523	1.0277
1984	1132203	353359	120051	0.5182	56012	0.9494
1985	1199475	348549	147680	0.3157	39142	1.0058
1986	887707	314089	133119	0.5272	70764	1.0479
1987	2097344	380177	123340	0.3442	44360	0.9725
1988	899294	334214	147822	0.2858	35591	1.0236
1989	844942	318192	163947	0.2480	34026	1.0199
1990	433443	269972	154485	0.3500	44693	0.9889
1991	380590	208207	125793	0.2610	28529	1.0693
1992	792557	217242	102884	0.2858	28985	1.0018
1993	580372	183534	98509	0.2482	31778	0.9912
1994	869256	178629	89016	0.2280	24430	0.9984
1995	631358	159081	71728	0.2660	29575	1.0001
1996	835046	193038	115212	0.1703	26105	1.0477
1997	1491824	216559	75352	0.5070	35233	1.0079
1998	481352	183267	98427	0.4900	33353	0.9992
1999	305133	141290	81928	0.3025	29736	1.0015
2000	1636643	199079	69449	0.2368	18322	0.9997
2001	1090588	221386	113982	0.2410	24556	1.0049
2002	1143083	255345	134943	0.2668	32914	1.0021
2003	434105	214036	133947	0.2315	28081	1.0074
2004	251977	169809	119690	0.1948	25021	1.0172
2005	299915	140337	98238	0.1202	14129	1.0021
2006	554435	163066	93270	0.2272	27346	0.9997
2007	323159	145629	91848	0.2875	29616	1.0004
2008	145843	120613	91884	0.1555	16054	1.0022

TABLE 5.6.2.13 HERRING in VIa (N). ESTIMATED FISHING MORTALITY

Units : f

age	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968
1	0.010	0.012	0.040	0.009	0.016	0.038	0.009	0.044	0.062	0.364	0.139	0.088
2	0.099	0.095	0.107	0.171	0.257	0.261	0.116	0.131	0.069	0.238	0.123	0.146
3	0.321	0.302	0.157	0.138	0.156	0.206	0.251	0.153	0.147	0.168	0.165	0.139
4	0.216	0.351	0.398	0.137	0.099	0.243	0.153	0.181	0.178	0.196	0.268	0.164
5	0.299	0.297	0.353	0.258	0.175	0.168	0.201	0.119	0.203	0.161	0.169	0.137
6	0.297	0.376	0.309	0.246	0.086	0.205	0.127	0.159	0.104	0.243	0.152	0.130
7	0.186	0.407	0.372	0.274	0.153	0.215	0.117	0.113	0.199	0.141	0.204	0.100
8	0.228	0.288	0.269	0.206	0.177	0.235	0.163	0.150	0.144	0.210	0.182	0.146
9	0.228	0.288	0.269	0.206	0.177	0.235	0.163	0.150	0.144	0.210	0.182	0.146

age	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
1	0.020	0.115	0.035	0.367	0.078	0.335	0.138	0.195	0.092	0.040	0.000	0.005
2	0.081	0.112	0.416	0.236	0.502	0.495	0.738	0.774	0.353	0.294	0.001	0.001
3	0.168	0.349	0.983	0.428	0.587	0.772	0.884	1.219	0.607	0.269	0.001	0.000
4	0.214	0.401	0.864	0.299	0.629	0.911	0.855	1.086	0.945	0.535	0.000	0.001
5	0.304	0.375	0.686	0.410	0.594	0.931	0.905	0.892	0.959	0.780	0.000	0.000
6	0.280	0.307	0.621	0.322	0.612	1.214	0.993	1.074	1.463	1.123	0.002	0.000
7	0.326	0.457	0.562	0.487	0.354	0.891	1.044	1.107	0.883	1.003	0.002	0.002
8	0.215	0.315	0.689	0.359	0.573	0.857	0.921	1.042	0.836	0.635	0.001	0.001
9	0.215	0.315	0.689	0.359	0.573	0.857	0.921	1.042	0.836	0.635	0.001	0.001

age	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
1	0.036	0.028	0.044	0.003	0.055	0.062	0.015	0.003	0.012	0.053	0.115	0.011
2	0.323	0.660	0.391	0.232	0.212	0.551	0.284	0.199	0.138	0.166	0.193	0.256
3	0.430	0.604	0.595	0.502	0.308	0.476	0.328	0.311	0.302	0.236	0.156	0.351
4	0.398	0.806	0.501	0.445	0.306	0.410	0.308	0.333	0.215	0.327	0.242	0.204
5	0.307	0.720	0.973	0.457	0.314	0.566	0.269	0.282	0.326	0.462	0.243	0.267
6	0.314	0.570	0.786	0.669	0.335	0.657	0.472	0.217	0.149	0.375	0.403	0.321
7	0.318	0.465	0.753	0.598	1.014	0.187	0.541	0.298	0.152	0.263	0.338	0.298
8	0.365	0.678	0.650	0.469	0.391	0.515	0.371	0.276	0.213	0.299	0.264	0.292
9	0.365	0.678	0.650	0.469	0.391	0.515	0.371	0.276	0.213	0.299	0.264	0.292

age	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
1	0.049	0.003	0.001	0.004	0.001	0.030	0.040	0.003	0.001	0.001	0.001	0.000
2	0.475	0.232	0.351	0.208	0.236	0.170	0.269	0.216	0.121	0.134	0.117	0.098
3	0.338	0.402	0.328	0.228	0.321	0.238	0.357	0.217	0.236	0.262	0.227	0.191
4	0.244	0.163	0.365	0.148	0.365	0.515	0.258	0.245	0.222	0.245	0.213	0.179
5	0.151	0.231	0.193	0.189	0.579	0.434	0.374	0.174	0.271	0.300	0.260	0.219
6	0.260	0.116	0.178	0.116	0.763	0.773	0.221	0.311	0.235	0.260	0.226	0.190
7	0.270	0.266	0.160	0.274	0.817	0.977	0.346	0.119	0.283	0.314	0.272	0.229
8	0.335	0.245	0.294	0.204	0.489	0.483	0.312	0.229	0.222	0.245	0.213	0.179
9	0.335	0.245	0.294	0.204	0.489	0.483	0.312	0.229	0.222	0.245	0.213	0.179

age	2005	2006	2007	2008
1	0.000	0.001	0.001	0.000
2	0.061	0.115	0.145	0.078
3	0.118	0.223	0.282	0.152
4	0.111	0.209	0.265	0.143
5	0.135	0.255	0.323	0.175
6	0.117	0.222	0.280	0.152
7	0.141	0.267	0.338	0.183
8	0.111	0.209	0.265	0.143
9	0.111	0.209	0.265	0.143

TABLE 5.6.2.14 HERRING in VIa (N). ESTIMATED POPULATION ABUNDANCE

Units : NA

year

age	1957	1958	1959	1960	1961	1962	1963	1964	1965
1	1085415	2129925	2124103	628969	1282671	2323456	2128325	979318	7855652
2	913169	395524	774476	750617	229314	464266	822815	776107	344877
3	232469	612663	266509	515616	468872	131373	264873	542654	504347
4	139260	138137	370923	186429	367813	328362	87503	168773	381147
5	137641	101556	87951	225323	147051	301341	233106	67915	127382
6	81042	92315	68267	55931	157503	111694	230547	172463	54534
7	55022	54464	57341	45333	39572	130721	82309	183751	133046
8	7338	41351	32788	35771	31203	30730	95370	66225	148561
9	22744	30033	38227	26025	16736	35405	42499	113697	153318

year

age	1966	1967	1968	1969	1970	1971	1972	1973	1974
1	1065520	2499919	4100323	2998830	3440170	9572399	2675839	1074339	1672283
2	2716521	272376	800018	1381162	1081300	1128222	3400950	682171	365637
3	238570	1585514	178344	511983	943979	716380	551427	1989683	305815
4	356476	165187	1101101	127092	354402	544997	219543	294381	905922
5	288504	265120	114299	845226	92869	214635	207816	147239	141996
6	94125	222205	202626	90137	564442	57736	97813	124822	73552
7	44480	66812	172767	160945	61628	375675	28066	64118	61250
8	98655	34964	49282	141432	105080	35295	193775	15601	40722
9	150013	163029	83571	142389	93471	67154	57792	77270	38135

year

age	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
1	2101533	608221	621969	913517	1216369	885405	1660598	770261	2977418	1132203
2	440179	673625	184197	208688	322998	447333	324156	589580	275638	1047826
3	165039	155923	230141	95878	115201	239161	331153	173825	225850	138121
4	115674	55822	37717	102716	59985	94249	195723	176411	77762	101952
5	329734	44521	17051	13261	54421	54258	85232	118964	71266	42654
6	50667	120730	16503	5916	5500	49230	49082	56756	52394	24362
7	19775	16985	37335	3457	1742	4969	44536	32441	29039	21601
8	22735	6300	5080	13966	1148	1572	4488	29314	18446	12377
9	23735	19337	2737	3435	8347	8583	4547	8545	18549	5477

year

age	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
1	1199475	887707	2097344	899294	844942	433443	380590	792557	580372	869256
2	415230	417628	307016	760256	329838	307223	151172	124793	288511	203237
3	615308	248887	178306	171286	461356	212934	192698	92352	71600	132981
4	68445	370401	126630	105140	102731	279305	137643	135037	53229	41814
5	59093	45606	222520	84207	68185	74994	182290	97774	99658	37747
6	24435	39044	23439	153796	57448	44525	42738	129343	67771	77574
7	11296	15822	18306	13226	112058	44774	27676	25846	84916	47279
8	10746	3708	11869	9647	8883	87139	31142	17854	17363	58633
9	7079	5121	20243	10246	19194	22426	20134	22793	13784	49220

year

age	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
1	631358	835046	1491824	481352	305133	1636643	1090588	1143083	434105	251977
2	318776	232109	306061	548117	171801	107823	600011	400991	420269	159617
3	119397	166302	139659	179159	342726	97247	64387	393648	259682	277014
4	72809	70444	108350	82925	115577	196270	64080	41624	248129	169403
5	32131	45716	54985	68030	44827	80785	138998	46452	29466	181406
6	27101	23970	34238	27876	39887	27893	61453	95941	31148	20551
7	62496	20530	19313	14444	11645	28945	18486	43964	66935	22486
8	32804	48188	14117	7718	4919	7454	23262	12601	29074	46125
9	40277	177233	26764	9090	4262	2341	5277	6855	7692	25632

year

age	2005	2006	2007	2008
1	299915	554435	323159	145843
2	92657	110303	203863	118808
3	107187	64604	72865	130644
4	187377	77997	42325	45002
5	128133	151785	57253	29395
6	131884	101287	106383	37504
7	15380	106134	73431	72730
8	16183	12082	73513	47388
9	14340	28281	19136	70635

TABLE 5.6.2.15 HERRING in VIa (N). SURVIVORS AFTER TERMINAL YEAR

Units : NA

age	2009
1	NA
2	53634
3	81381
4	91844
5	35293
6	22336
7	29164
8	54820
9	92560

TABLE 5.6.2.16 HERRING in VIa (N). FITTED SELECTION PATTERN

Units : NA

age	2001	2002	2003	2004	2005	2006	2007	2008
1	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
2	0.548	0.548	0.548	0.548	0.548	0.548	0.548	0.548
3	1.066	1.066	1.066	1.066	1.066	1.066	1.066	1.066
4	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
5	1.221	1.221	1.221	1.221	1.221	1.221	1.221	1.221
6	1.059	1.059	1.059	1.059	1.059	1.059	1.059	1.059
7	1.277	1.277	1.277	1.277	1.277	1.277	1.277	1.277
8	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
9	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

TABLE 5.6.2.17 HERRING in VIa (N). PREDICTED CATCH IN NUMBERS

Units : NA

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	2001
1	14294	26396	5253	17719	1728	266	1952	1193	9092	7635	3569	367
2	40867	23013	24469	95288	36554	82176	37854	55810	74167	35252	18162	59482
3	40779	25229	24922	18710	40193	30398	30899	34966	34571	93910	17264	12327
4	74279	28212	23733	10978	6007	21272	9219	31657	31905	25078	40674	12149
5	26520	37517	21817	13269	7433	5376	7508	23118	22872	13364	12264	31442
6	13305	13533	33869	14801	8101	4205	2501	17500	14372	7529	7121	12266
7	9878	7581	6351	19186	10515	8805	4700	10331	8641	3251	3083	4349
8	21456	6892	4317	4711	12158	7971	8458	5213	2825	1257	1452	4410
9	5522	4456	5511	3740	10206	9787	31108	9883	3327	1089	456	1001

year

age	2002	2003	2004	2005	2006	2007	2008
1	426	140	68	50	176	130	32
2	43739	40152	12929	4717	10350	23855	7752
3	82457	48011	43781	10826	11742	16299	16779
4	8638	45420	26489	18696	14035	9384	5714
5	11475	6441	33989	15427	32628	15081	4489
6	20949	6004	3387	13896	19195	24803	5024
7	11289	15222	4387	1932	23738	20097	11575
8	2615	5322	7212	1615	2174	16298	6017
9	1423	1408	4008	1431	5089	4243	8969

TABLE 5.6.2.18 HERRING in VIa (N). CATCH RESIDUALS

Units : Thousands NA

year

age	2001	2002	2003	2004	2005	2006	2007	2008
1	-0.942	0.847	-0.917	-Inf	1.288	-0.284	0.008	-Inf
2	0.309	-0.128	-0.186	-0.636	0.714	-0.436	0.364	0.019
3	0.192	0.131	-0.024	-0.678	0.764	-0.246	0.086	-0.252
4	-0.267	0.043	0.169	0.049	0.097	-0.028	-0.359	-0.051
5	-0.250	0.457	0.147	0.298	-0.410	0.230	-0.056	-0.332
6	-0.279	0.291	-0.324	0.145	-0.351	0.370	0.209	0.124
7	0.421	-0.222	-0.172	0.555	-0.643	-0.124	0.068	0.248
8	0.044	-0.524	0.546	0.162	-0.301	0.336	-0.182	0.303
9	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

TABLE 5.6.2.19 HERRING in VIa (N). PREDICTED INDEX VALUES

WoS Summer Acoustic Survey

Units : NA NA

year

age	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
1	682591	NA	NA	NA	117276	258538	185364	284701	207064	273414	489108
2	640701	NA	NA	NA	331472	264432	542572	436236	641347	504743	655656
3	626683	NA	NA	NA	744080	320579	250330	448870	419769	617154	492713
4	510127	NA	NA	NA	574798	575780	222081	182260	284277	309679	423038
5	833771	NA	NA	NA	692875	366926	398408	144400	125511	178955	174010
6	77222	NA	NA	NA	146224	462791	250646	310317	104833	95893	96267
7	56256	NA	NA	NA	94962	90661	302356	168787	236323	72935	51045
8	36773	NA	NA	NA	102246	57725	54858	194496	105959	163522	41013
9	63909	NA	NA	NA	67363	75090	44378	166370	132570	612848	79231

year

age	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
1	155341	97937	535949	357702	374908	142384	82651	98384	181852	NA
2	1217173	361367	233507	1367776	907644	960476	368509	218343	252389	458814
3	661291	1185524	363122	237930	1434755	964354	1049233	422477	240474	262641
4	298401	478423	818273	270575	173497	1052578	732058	840555	331595	174589
5	233044	158619	318932	520439	171204	110955	698716	516563	573076	208343
6	77959	150723	100316	230419	354845	117365	78972	527256	382539	389139
7	34988	39787	111952	65361	152901	238072	81891	58751	378548	252001
8	22490	15736	24953	78158	41793	98139	158607	57764	40871	241293
9	26990	13892	7985	18068	23169	26456	89815	52158	97489	64004

year

age	2008
1	47840
2	277274
3	505343
4	198345
5	115977
6	147159
7	271638
8	166194
9	252432

TABLE 5.6.2.20 HERRING in VIa (N). INDEX RESIDUALS

WoS Summer Acoustic Survey

Units : NA

year

age	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
1	-1.008	NA	NA	NA	1.059	-1.247	-4.207	0.551	0.800	-1.892	0.482
2	-0.102	NA	NA	NA	-0.118	0.644	0.324	0.217	0.526	0.133	-0.021
3	-0.129	NA	NA	NA	-0.819	-0.418	1.001	0.303	0.119	0.263	-0.543
4	-0.368	NA	NA	NA	-0.446	-0.802	1.079	0.449	0.460	0.061	-0.929
5	-0.102	NA	NA	NA	-0.350	0.123	0.311	0.753	0.198	-0.629	-0.968
6	0.368	NA	NA	NA	0.187	-0.656	1.239	-0.146	0.579	-0.459	-0.665
7	-0.157	NA	NA	NA	0.039	0.153	-0.062	0.880	-0.334	0.059	-1.143
8	-0.838	NA	NA	NA	-0.129	-0.018	1.017	-0.113	0.803	-0.738	-0.347
9	-2.286	NA	NA	NA	-0.149	-0.169	1.258	-0.232	0.419	-1.675	-1.176

year

age	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
1	2.062	1.696	-0.180	-0.133	0.125	1.126	1.920	-0.673	-0.482	NA
2	-0.426	-0.114	0.303	-0.253	-0.733	0.079	-0.295	0.109	1.197	-1.292
3	0.008	0.158	-0.074	-0.089	0.001	-0.034	-0.322	-0.607	0.478	0.114
4	0.457	-0.102	0.095	-0.448	0.141	0.335	-0.504	-0.686	-0.153	0.148
5	-0.264	0.664	0.210	-0.174	-0.057	0.491	-0.191	-0.746	0.016	-0.360
6	0.017	-0.083	0.903	-0.553	0.179	0.096	-0.349	-1.239	0.081	-0.115
7	-0.221	0.777	0.578	0.453	-0.004	0.376	-0.281	-1.540	-0.511	-0.037
8	-0.485	0.562	1.337	-0.400	0.479	0.152	-0.657	-0.393	-0.633	-0.389
9	0.309	0.935	2.097	0.653	0.943	1.045	-0.163	-0.666	-0.497	-0.690

year

age	2008
1	0.000
2	-0.176
3	0.590
4	1.216
5	1.075
6	0.615
7	0.976
8	0.789
9	0.044

TABLE 5.6.2.21 HERRING in VIa (N). FIT PARAMETERS

	Value	Std.dev	Lower.95.pct.CL	Upper.95.pct.CL
F, 2001	0.22	0.15	0.16	0.30
F, 2002	0.25	0.15	0.18	0.33
F, 2003	0.21	0.15	0.16	0.29
F, 2004	0.18	0.16	0.13	0.25
F, 2005	0.11	0.16	0.08	0.15
F, 2006	0.21	0.17	0.15	0.29
F, 2007	0.26	0.20	0.18	0.39
F, 2008	0.14	0.24	0.09	0.23
Selectivity at age 1	0.00	0.37	0.00	0.00
Selectivity at age 2	0.55	0.15	0.41	0.73
Selectivity at age 3	1.07	0.13	0.82	1.38
Selectivity at age 5	1.22	0.12	0.96	1.55
Selectivity at age 6	1.06	0.12	0.84	1.33
Selectivity at age 7	1.28	0.12	1.02	1.61
Terminal year pop, age 1	145841.95	2.60	885.52	24019607.83
Terminal year pop, age 2	118807.23	0.34	60791.89	232188.20
Terminal year pop, age 3	130643.13	0.27	76944.66	221816.94
Terminal year pop, age 4	45001.03	0.24	27893.19	72601.68
Terminal year pop, age 5	29393.52	0.23	18868.87	45788.59
Terminal year pop, age 6	37502.81	0.22	24222.56	58064.08
Terminal year pop, age 7	72729.21	0.22	47596.02	111134.05
Terminal year pop, age 8	47386.74	0.22	30675.35	73202.19
Last true age pop, 2001	23261.08	0.28	13359.14	40502.44
Last true age pop, 2002	12599.74	0.22	8150.90	19476.79
Last true age pop, 2003	29073.00	0.20	19578.23	43172.40
Last true age pop, 2004	46124.03	0.19	31766.52	66970.69
Last true age pop, 2005	16181.63	0.19	11183.39	23413.76
Last true age pop, 2006	12080.81	0.18	8539.26	17091.18
Last true age pop, 2007	73511.93	0.19	50907.54	106153.31
Index 1, age 1 numbers, Q	0.57	0.62	0.17	1.89
Index 1, age 2 numbers, Q	2.87	0.19	1.97	4.17
Index 1, age 3 numbers, Q	4.69	0.19	3.23	6.80
Index 1, age 4 numbers, Q	5.03	0.19	3.47	7.30
Index 1, age 5 numbers, Q	4.58	0.19	3.16	6.65
Index 1, age 6 numbers, Q	4.50	0.19	3.10	6.54
Index 1, age 7 numbers, Q	4.36	0.19	2.99	6.35
Index 1, age 8 numbers, Q	4.00	0.19	2.73	5.87
Index 1, age 9 numbers, Q	4.08	0.19	2.80	5.95

Table 5.7.1.1. Herring in VIa (N). Input data for short-term predictions, numbers at age from the assessment with ages 1- and 2-ring in 2008 replaced by geometric mean values - natural mortality (M), proportion mature (Mat), proportion of fishing mortality prior to spawning (PF), proportion of natural mortality prior to spawning (PM), mean weights at age in the stock (SWt), selection pattern (Sel), mean weights at age in the catch (CWt). All biological data are taken as mean of the last 3 years. VIa (N) herring appears to have considerable annual variability in mean weights and in fraction mature. Last year's values are not applicable. N.B. In this table "age" refers to number of rings (winter rings in the otolith).

2009

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
1	629204	1	0	0.67	0.67	0.0682	3.46E-04	6.87E-02
2	231391	0.3	0.93	0.67	0.67	0.158	0.080	0.165
3	81381	0.2	0.99	0.67	0.67	0.180	0.155	0.187
4	91843	0.1	1	0.67	0.67	0.195	0.147	0.207
5	35293	0.1	1	0.67	0.67	0.200	0.176	0.216
6	22335	0.1	1	0.67	0.67	0.204	0.156	0.232
7	29163	0.1	1	0.67	0.67	0.211	0.187	0.238
8	54819	0.1	1	0.67	0.67	0.217	0.147	0.269
9	92560	0.1	1	0.67	0.67	0.228	0.147	0.289

2010

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
1	629204	1	0	0.67	0.67	0.0682	3.46E-04	6.87E-02
2	.	0.3	0.93	0.67	0.67	0.158	0.080	0.165
3	.	0.2	0.99	0.67	0.67	0.180	0.155	0.187
4	.	0.1	1	0.67	0.67	0.195	0.147	0.207
5	.	0.1	1	0.67	0.67	0.200	0.176	0.216
6	.	0.1	1	0.67	0.67	0.204	0.156	0.232
7	.	0.1	1	0.67	0.67	0.211	0.187	0.238
8	.	0.1	1	0.67	0.67	0.217	0.147	0.269
9	.	0.1	1	0.67	0.67	0.228	0.147	0.289

2011

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
1	629204	1	0	0.67	0.67	0.0682	3.46E-04	6.87E-02
2	.	0.3	0.93	0.67	0.67	0.158	0.080	0.165
3	.	0.2	0.99	0.67	0.67	0.180	0.155	0.187
4	.	0.1	1	0.67	0.67	0.195	0.147	0.207
5	.	0.1	1	0.67	0.67	0.200	0.176	0.216
6	.	0.1	1	0.67	0.67	0.204	0.156	0.232
7	.	0.1	1	0.67	0.67	0.211	0.187	0.238
8	.	0.1	1	0.67	0.67	0.217	0.147	0.269
9	.	0.1	1	0.67	0.67	0.228	0.147	0.289

Table 5.7.1.2. Herring in VIa (N). Short-term prediction single option table, with TAC constraint. N.B. In this table "age" refers to number of rings (winter rings in the otolith).

Year:	2009	F multiplier:	1.45	Fbar:	0.23				
Age	F	CatchNos	Yield	StockNos	Biomass	SSNos(Jan)	SSB(Jan)	SSNos(ST)	SSB(ST)
1	0.0003	200	14	629205	42912	0	0	0	0
2	0.08	21971	3627	231391	36606	215194	34044	162841	25761
3	0.16	14943	2798	81381	14657	80432	14486	60483	10893
4	0.15	16861	3489	91844	17900	91844	17900	74423	14505
5	0.18	7600	1644	35293	7075	35293	7075	27805	5574
6	0.16	4325	1003	22336	4564	22336	4564	17941	3666
7	0.19	6622	1575	29164	6160	29164	6160	22731	4802
8	0.15	10064	2708	54820	11907	54820	11907	44422	9648
9	0.15	16993	4904	92560	21082	92560	21082	75004	17083
Total		99580	21760	1267992	162863	621641	117218	485649	91933

YEAR:	2010	F MULTIPLIER:	1	FBAR:	0.16				
Age	F	CatchNos	Yield	StockNos	Biomass	SSNos(Jan)	SSB(Jan)	SSNos(ST)	SSB(ST)
1	0.0003	138	9	629205	42912	0	0	0	0
2	0.08	15395	2541	231355	36600	215160	34038	166800	26388
3	0.16	19956	3736	152633	27489	150853	27169	118893	21413
4	0.15	6944	1437	53181	10365	53181	10365	45058	8782
5	0.18	10340	2237	67100	13451	67100	13451	55757	11178
6	0.16	3411	791	24723	5052	24723	5052	20820	4254
7	0.19	2623	624	16105	3402	16105	3402	13285	2806
8	0.15	2625	707	20106	4367	20106	4367	17035	3700
9	0.15	14060	4057	107674	24525	107674	24525	91227	20778
Total		75493	16139	1302082	168163	654902	122368	528874	99298

YEAR:	2011	F MULTIPLIER:	1	FBAR:	0.16				
Age	F	CatchNos	Yield	StockNos	Biomass	SSNos(Jan)	SSB(Jan)	SSNos(ST)	SSB(ST)
1	0.0003	138	9	629205	42912	0	0	0	0
2	0.08	15397	2542	231391	36606	215194	34044	166826	26392
3	0.16	20686	3873	158218	28495	156372	28163	123242	22196
4	0.15	13970	2890	106985	20851	106985	20851	90643	17666
5	0.18	6399	1384	41525	8324	41525	8324	34506	6917
6	0.16	7023	1628	50897	10400	50897	10400	42862	8758
7	0.19	3116	741	19131	4041	19131	4041	15780	3333
8	0.15	1578	425	12083	2624	12083	2624	10237	2224
9	0.15	13029	3760	99774	22725	99774	22725	84534	19254
Total		81336	17252	1349209	176979	701961	131173	568631	106740

Table 5.7.1.3. Herring in VIa (N). Short-term prediction multiple option table, with TAC constraint.

2008							
BIOMASS	SSB	FMULT	FBAR	LANDINGS			
162863	91933	1.4512	0.2306	21760			

2009					2010		
BIOMASS	SSB	FMULT	FBAR	LANDINGS	BIOMASS	SSB	% CHANGE
168163	108800	0	0	0	191031	129944	-100%
.	107807	0.1	0.0159	1718	189533	127373	-92%
.	106825	0.2	0.0318	3413	188057	124861	-84%
.	105852	0.3	0.0477	5083	186601	122407	-77%
.	104888	0.4	0.0636	6730	185167	120010	-69%
.	103933	0.5	0.0794	8354	183753	117668	-62%
.	102988	0.6	0.0953	9955	182359	115380	-54%
.	102052	0.7	0.1112	11534	180985	113144	-47%
.	101125	0.8	0.1271	13090	179630	110960	-40%
.	100207	0.9	0.143	14625	178295	108826	-33%
.	99298	1	0.1589	16139	176979	106740	-26%
.	98398	1.1	0.1748	17631	175682	104703	-19%
.	97507	1.2	0.1907	19103	174403	102712	-12%
.	96624	1.3	0.2066	20554	173143	100766	-6%
.	95749	1.4	0.2224	21985	171900	98864	1%
.	94883	1.5	0.2383	23396	170675	97006	8%
.	94026	1.6	0.2542	24788	169467	95189	14%
.	93176	1.7	0.2701	26160	168277	93414	20%
.	92335	1.8	0.286	27513	167103	91679	26%
.	91502	1.9	0.3019	28848	165946	89983	33%
.	90677	2	0.3178	30164	164806	88325	39%
Values for catch option table							
168163	108800	0	0	0	191031	129944	-100%
.	98398	1.1	0.17	17631	175682	104703	-20%
.	95749	1.4	0.22	21760	171900	98864	0%
	94252	1.6	0.25	24420	169786	95669	12%
	93181	1.7	0.27	26151	168284	93425	20%
	92520	1.8	0.28	27215	167361	92061	25%
	91602	1.9	0.30	28688	166084	90186	32%
	89006	2.2	0.35	32829	162497	84967	51%

Table 5.8.1.1. Herring in VIa (N). Covariance matrix from ICA used to provide uncertainty of initial numbers for medium term simulations.

age	1	2	3	4	5	6	7	8	9
1	0.117	0.008	0.009	0.008	0.007	0.007	0.007	0.007	0.000
2	0.008	0.117	0.047	0.042	0.037	0.037	0.034	0.032	0.007
3	0.009	0.047	0.073	0.039	0.036	0.035	0.032	0.031	0.032
4	0.008	0.042	0.039	0.060	0.036	0.035	0.033	0.033	0.031
5	0.007	0.037	0.036	0.036	0.051	0.035	0.034	0.034	0.033
6	0.007	0.037	0.035	0.035	0.035	0.050	0.036	0.036	0.034
7	0.007	0.034	0.032	0.033	0.034	0.036	0.047	0.037	0.036
8	0.007	0.032	0.031	0.033	0.034	0.036	0.037	0.049	0.037
9	0.000	0.007	0.032	0.031	0.033	0.034	0.036	0.037	0.049

Table 5.8.1.2. Herring in VIa (N). Parameters of S/R relationships.

Type	equation	a	b	sigma(ln)
B/H 1957-2006	AS/(B+S)	4475	403	0.61
B/H 1989-2006	AS/(B+S)	3260	403	0.477
H-S 1989-2006	A(B-S)/B ….. S<B A ……………S≥B	637	50	0.52

Table 5.8.1.3. Herring in VIa (N). Medium term run details.

Run Number	Period for S/R data	S/R Model	% y-y TAC constraint B_{lim}<SSB<B_{trig}	% random Measurement error	% implementation bias
1	89-2006	B/H	20%	25%	0%
2	89-2006	B/H	25%	25%	0%
3	89-2006	B/H	20%	30%	0%
4	89-2006	B/H	25%	30%	0%
5	89-2006	H-S	20%	25%	0%
6	89-2006	H-S	25%	25%	0%
7	89-2006	H-S	20%	30%	0%
8	89-2006	H-S	25%	30%	0%
9	89-2006	H-S	25%	25%	10%
10	89-2006	H-S	25%	25%	20%
11	89-2006	H-S	25%	25%	30%

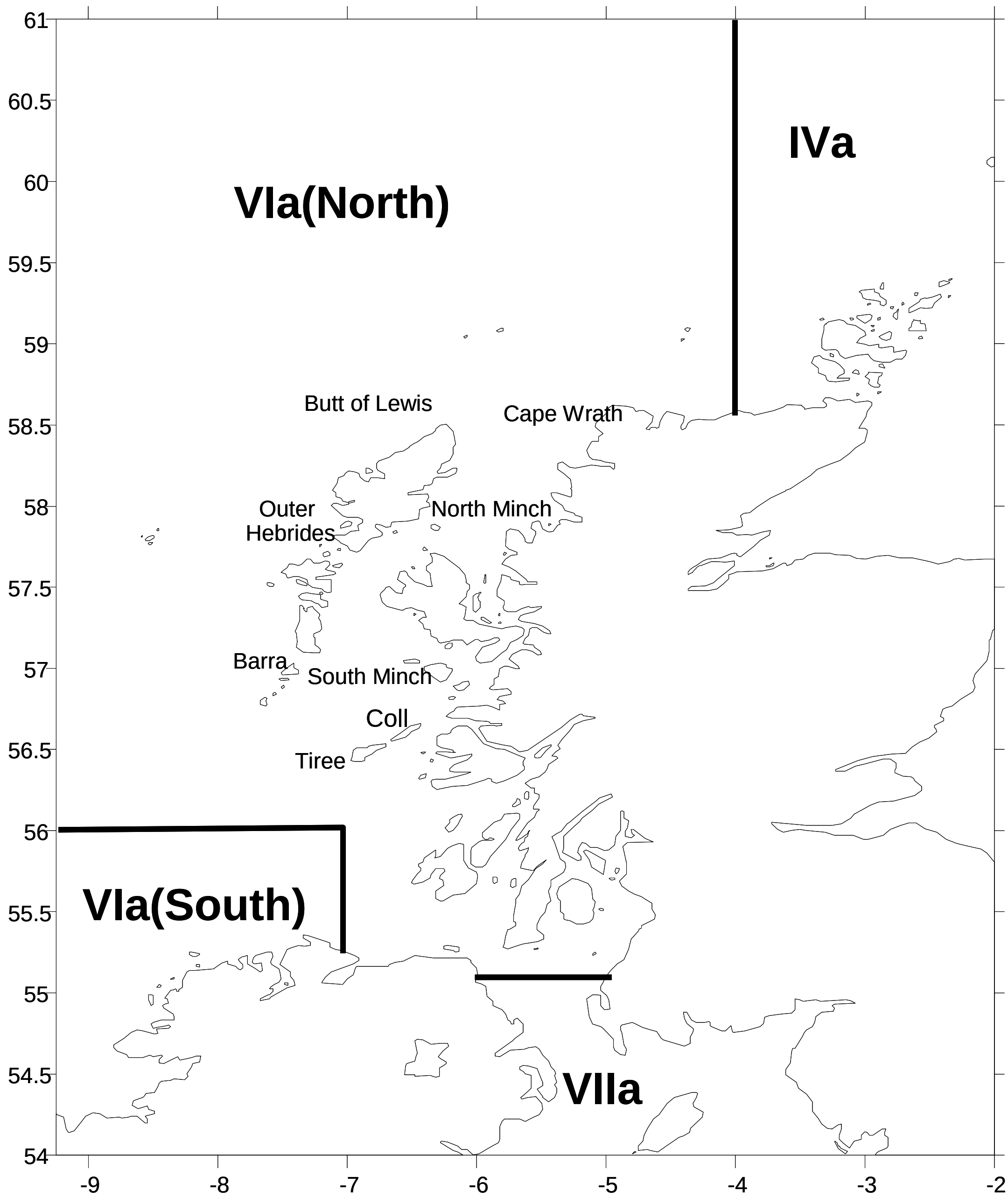


Figure 5.1. Location of ICES area VIa (North) and adjacent areas, with place names.

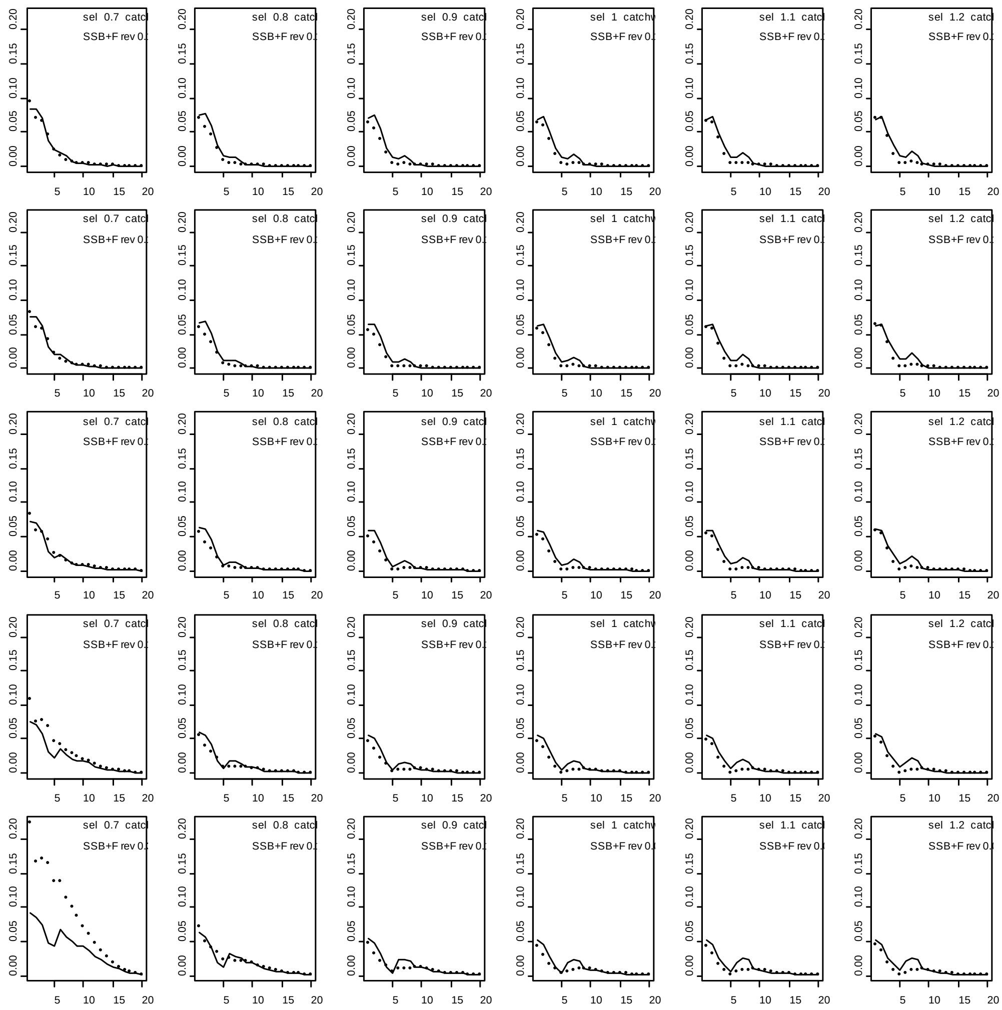


Figure 5.6.1.1. Herring in VIa (N). Mean squared deviance (y axis) between previous and current assessments for the 8 assessment years in the retrospective and years (x axis) previous to the terminal year in the assessment. 2008 WG data with flat weighting at age. SSB (dots) and $F_{3\text{-}6}$ (solid line). Across rows selection at oldest age ranging from 0.7 to 1.2, down columns weighting on catch from 2.0 to 0.5. Minimum is candidate for best settings (see text table section 5.6.1)

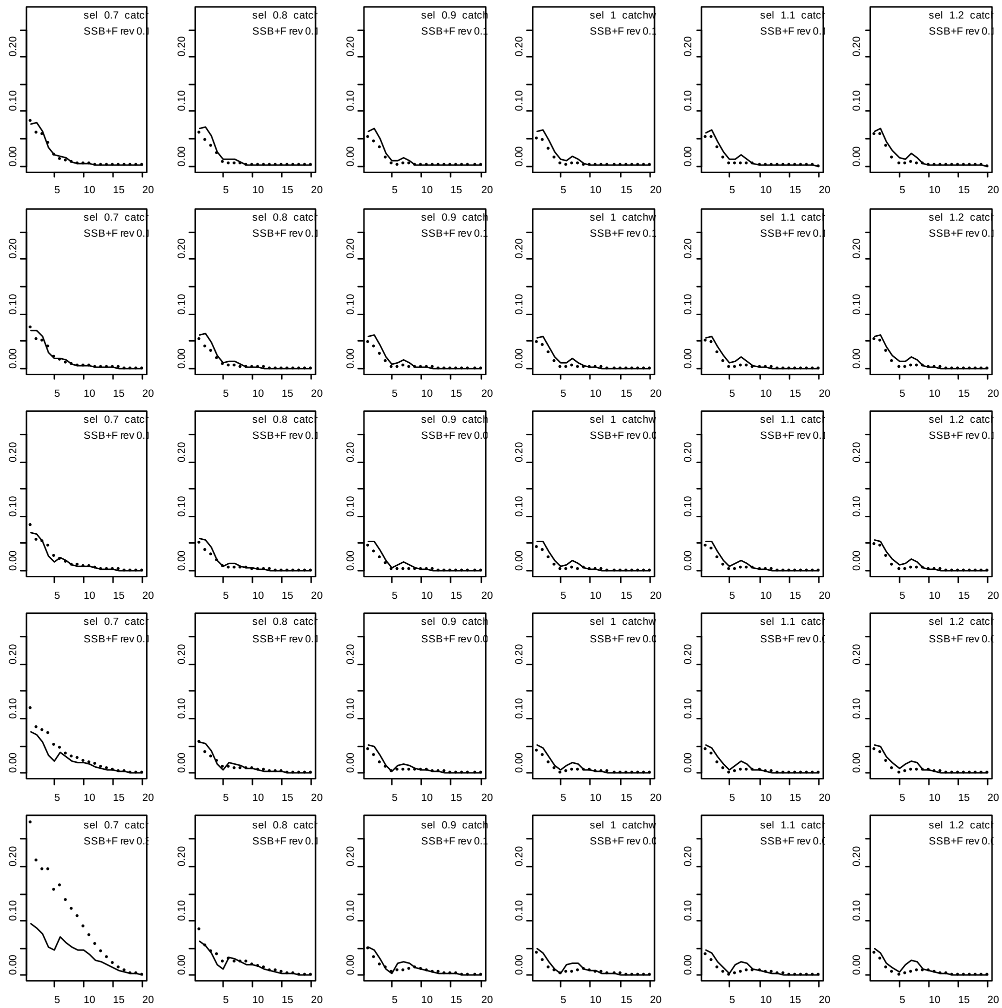


Figure 5.6.1.2. Herring in VIa (N). Mean squared deviance (y axis) between previous and current assessments for the 8 assessment years in the retrospective and years (x axis) previous to the terminal year in the assessment. 2008 WG data with varying weighting at age. SSB (dots) and $F_{3\text{-}6}$ (solid line). Across rows selection at oldest age ranging from 0.7 to 1.2, down columns weighting on catch from 2.0 to 0.5. Minimum is candidate for best settings (see text table section 5.6.1)

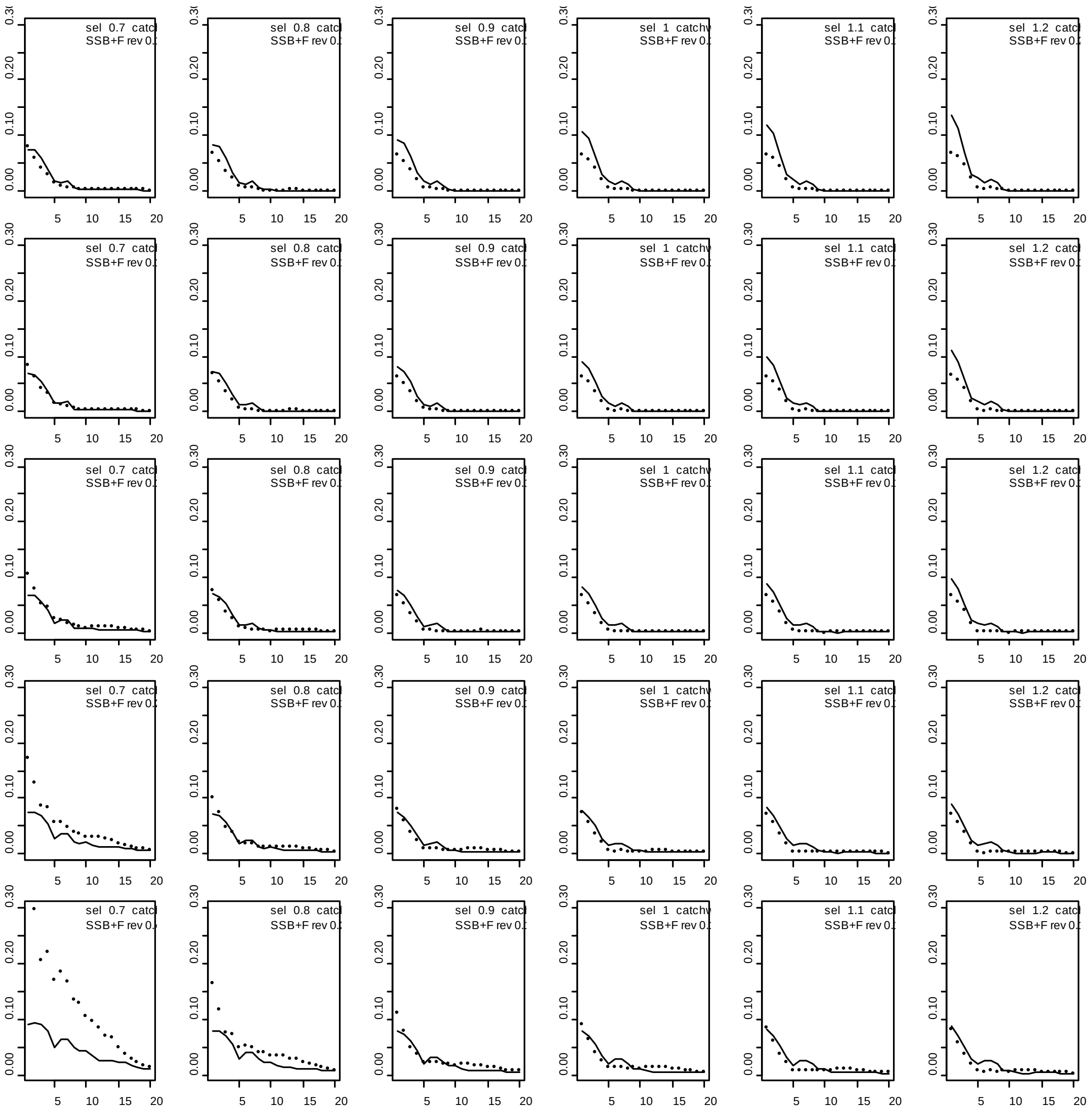


Figure 5.6.1.3. Herring in VIa (N). Mean squared deviance (y axis) between previous and current assessments for the 8 assessment years in the retrospective and years (x axis) previous to the terminal year in the assessment. 2009 WG data with flat weighting at age. SSB (dots) and $F_{3\text{-}6}$ (solid line). Across rows selection at oldest age ranging from 0.7 to 1.2, down columns weighting on catch from 2.0 to 0.5. Minimum is candidate for best settings (see text table section 5.6.1)

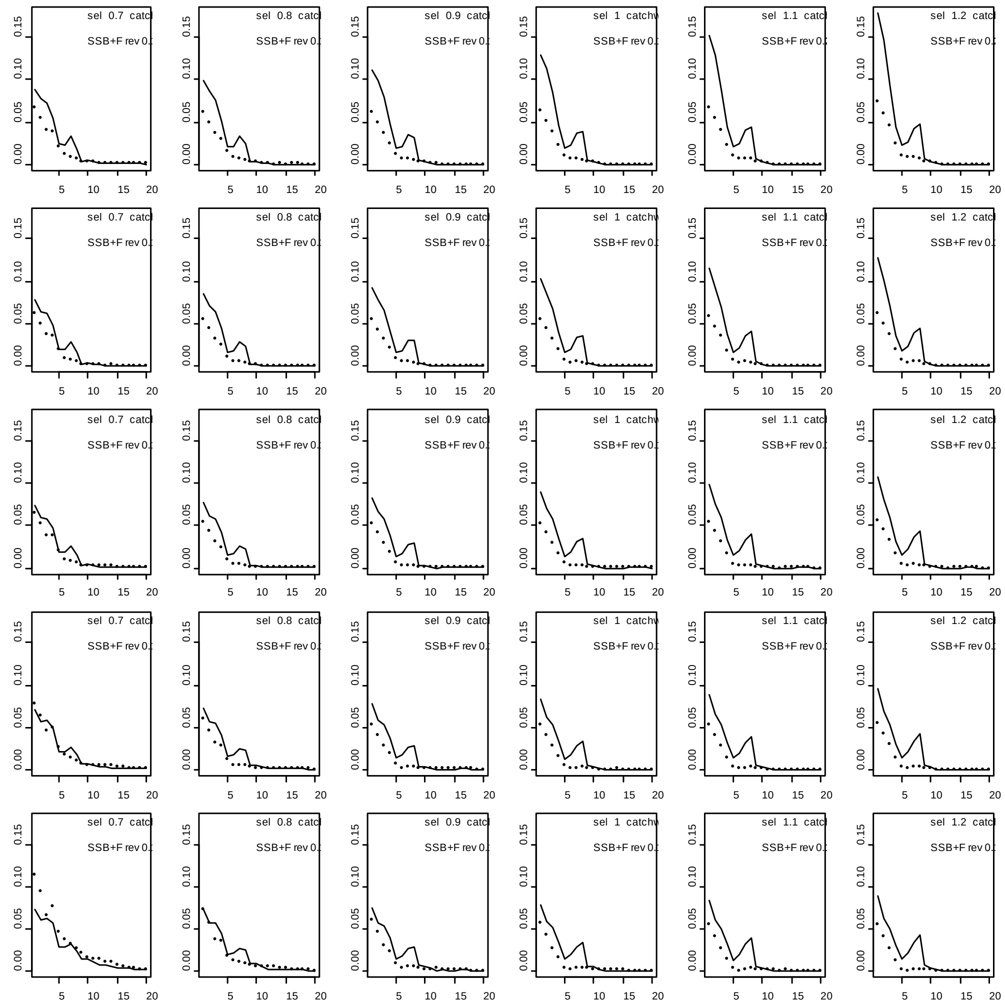


Figure 5.6.1.4. Herring in VIa (N). Mean squared deviance (y axis) between previous and current assessments for the 8 assessment years in the retrospective and years (x axis) previous to the terminal year in the assessment. 2009 WG data with varying weighting at age. SSB (dots) and $F_{3\text{-}6}$ (solid line). Across rows selection at oldest age ranging from 0.7 to 1.2, down columns weighting on catch from 2.0 to 0.5. Minimum is candidate for best settings (see text table section 5.6.1)

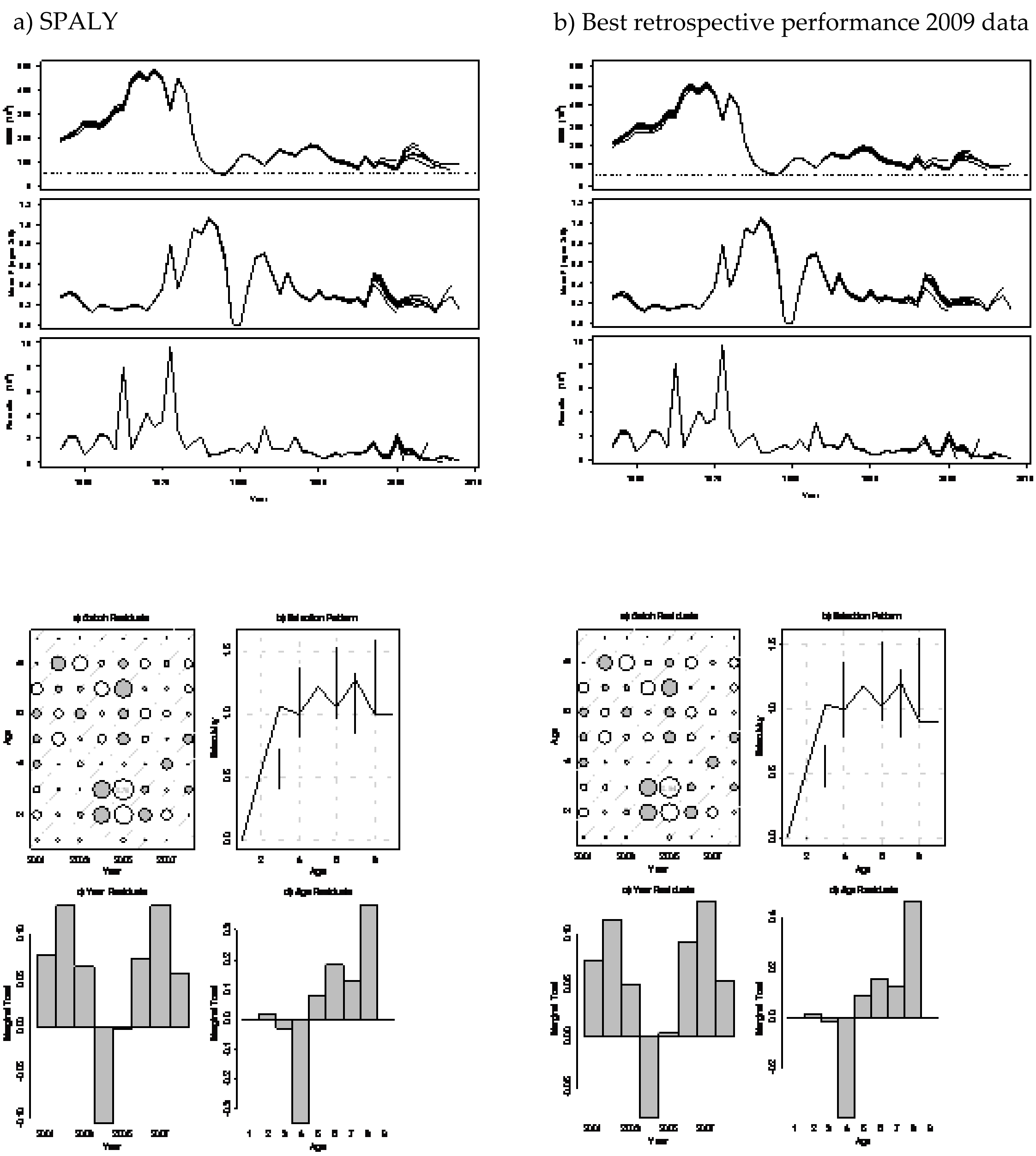


Figure 5.6.1.5. Herring in VIa (N). Comparison between retrospective performance with a) SPALY settings and b) 2009 optimal choices of model settings and fit diagnostics for catch under both circumstances. The fit is very similar and although the restrospective performance can be improved, the settings are not stable across years so no changes are suggested (see section 5.6.1)

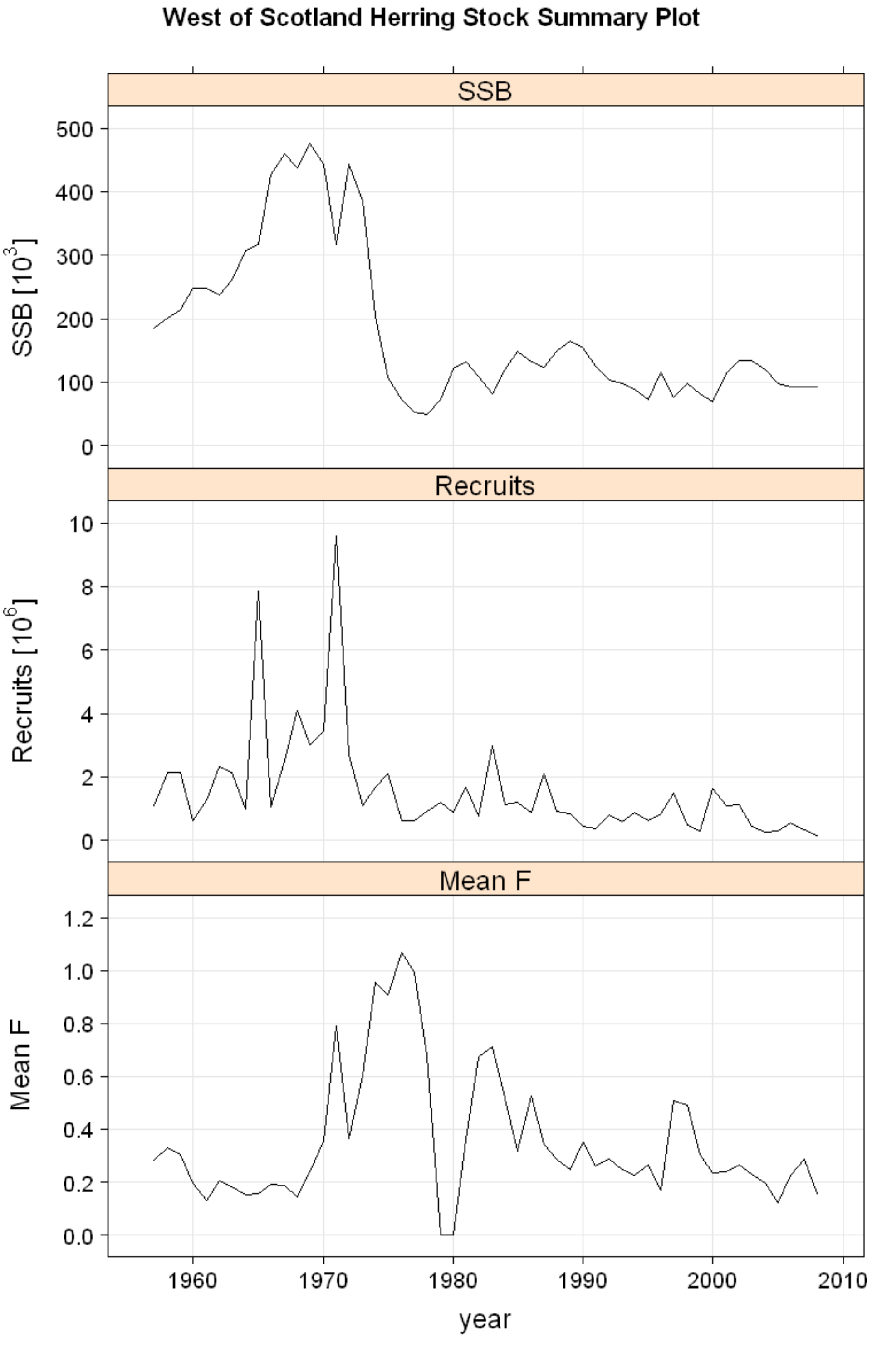


Figure 5.6.2.1. Herring in VIa (N). Illustration of stock trends from the assessment (8 year separable period) 1957-2008. Summary of estimates of landings, spawning stock biomass at spawning time, fishing mortality at F_{3-6}, recruitment at 1-ring, in the final assessment run.

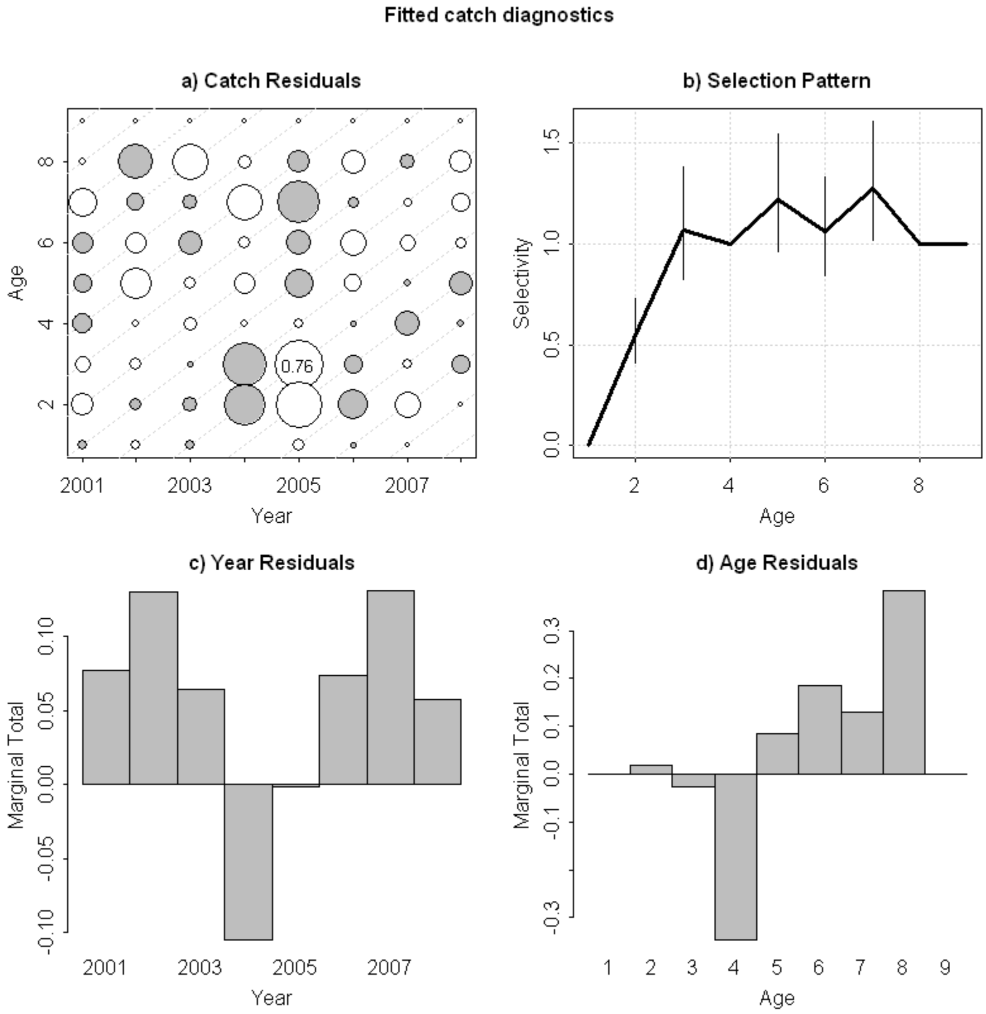


Figure 5.6.2.2. Herring in VIa (N). Illustration of selection patterns diagnostics, from deterministic calculation (8-year separable period). Top left, a bubble plot of selection pattern residuals. Top right, estimated selection (relative to 4-ringers) +/- standard deviation. Bottom, marginal totals of residuals by year and ring.

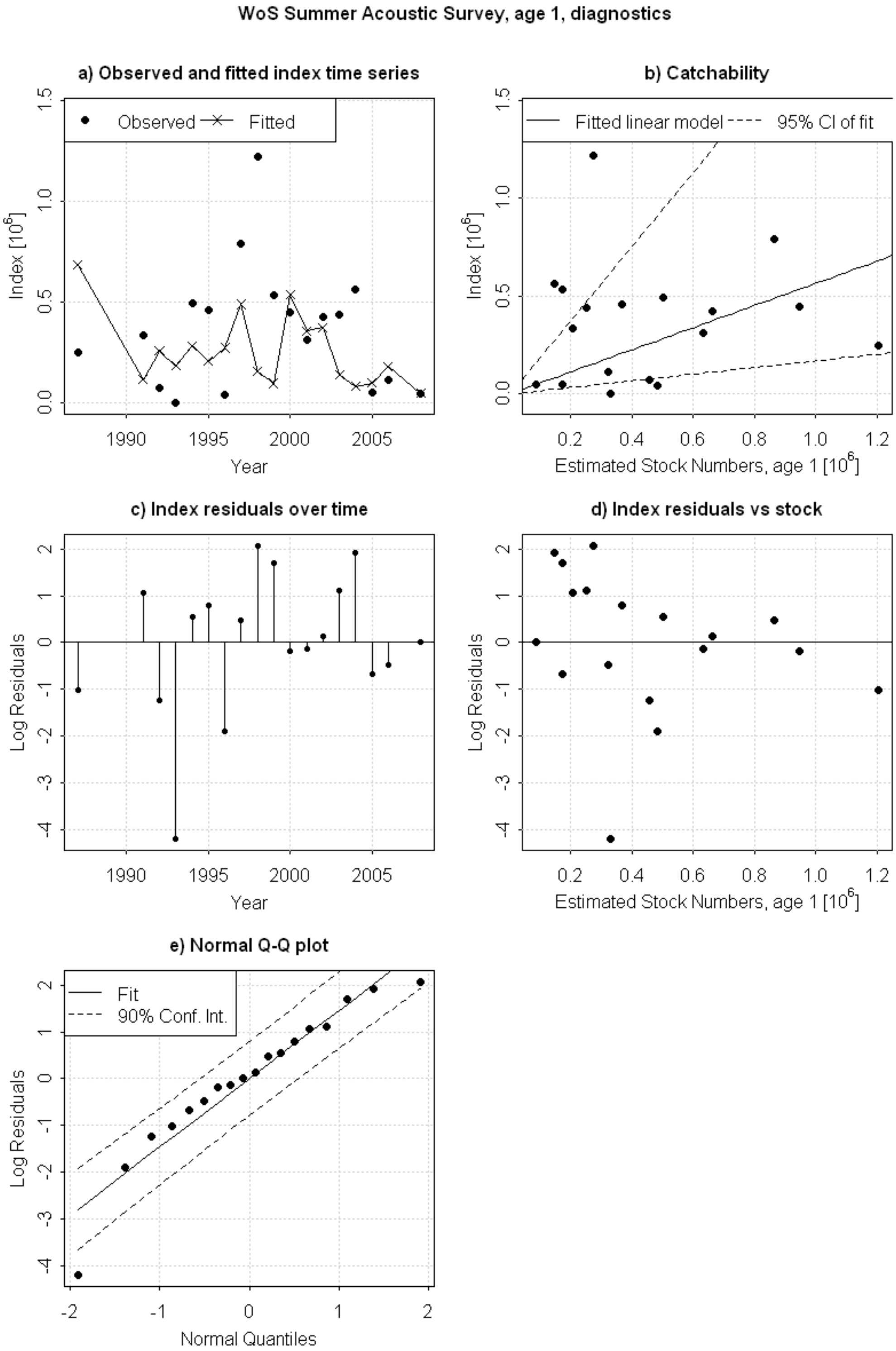


Figure 5.6.2.3. Herring in VIa (N). Illustration of residuals from deterministic calculation (8-year separable period). Diagnostics of the fit of the 1-ring index against the acoustic surveys. Top left, fitted populations (line), and predictions of abundance in each year made from the index observations and estimated catchability (triangles +/- standard deviation), plotted by year. Top right, scatter plot and fitted relationship of abundance from fitted populations of 1-ringers in acoustic surveys. Bottom, residuals, as ln(observed index) - ln(expected index) plotted against expected values and against time. N.B. 1-ringers are down-weighted in the catch and survey in the assessment.

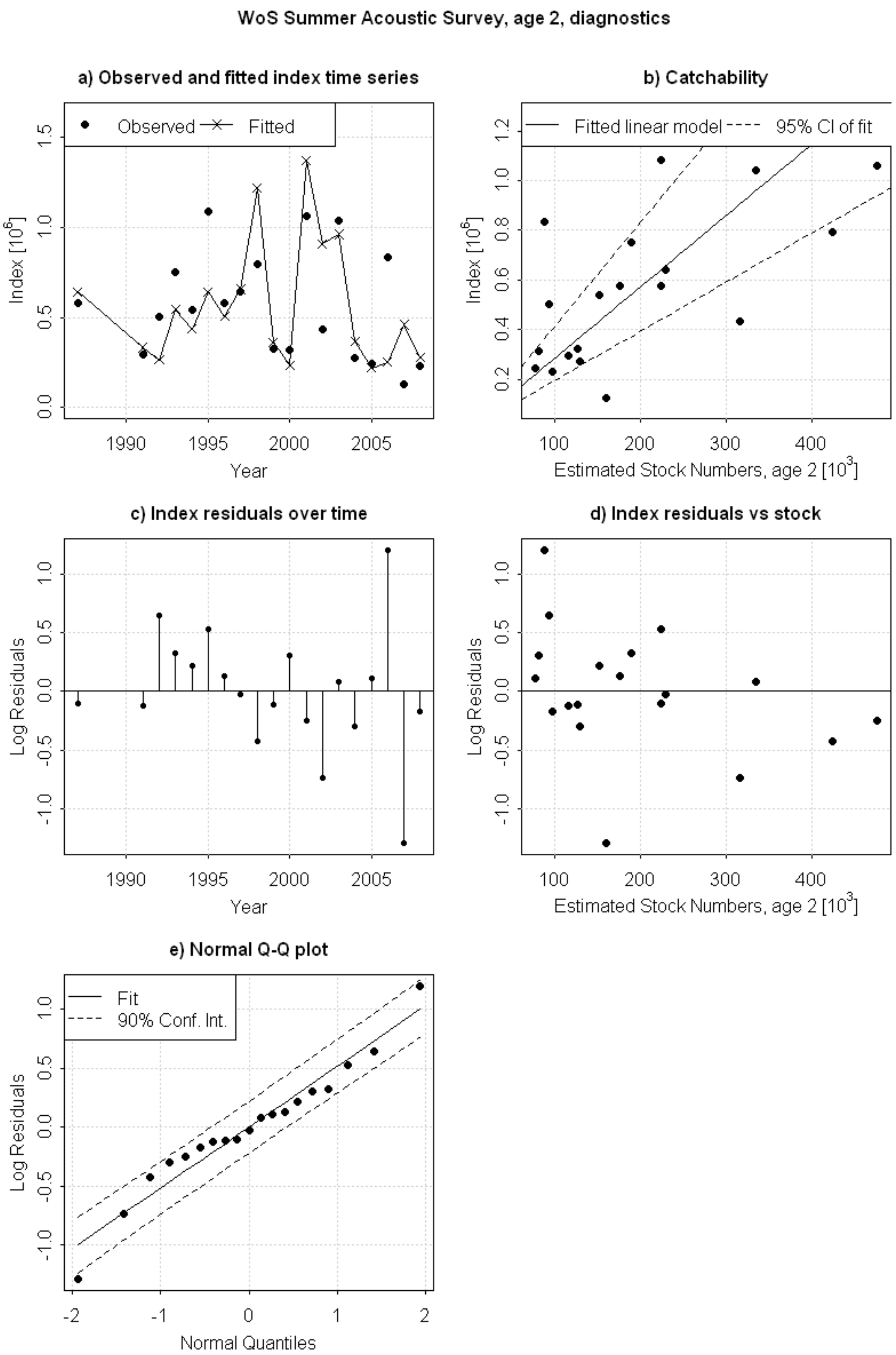


Figure 5.6.2.4. Herring in VIa (N). Illustration of residuals from deterministic calculation (8-year separable period). Diagnostics of the fit of the 2-ring index against the acoustic surveys. Top left, fitted populations (line), and predictions of abundance in each year made from the index observations and estimated catchability (triangles +/- standard deviation), plotted by year. Top right, scatter plot and fitted relationship of abundance from fitted populations of 2-ringers in acoustic surveys. Bottom, residuals, as ln(observed index) - ln(expected index) plotted against expected values and against time.

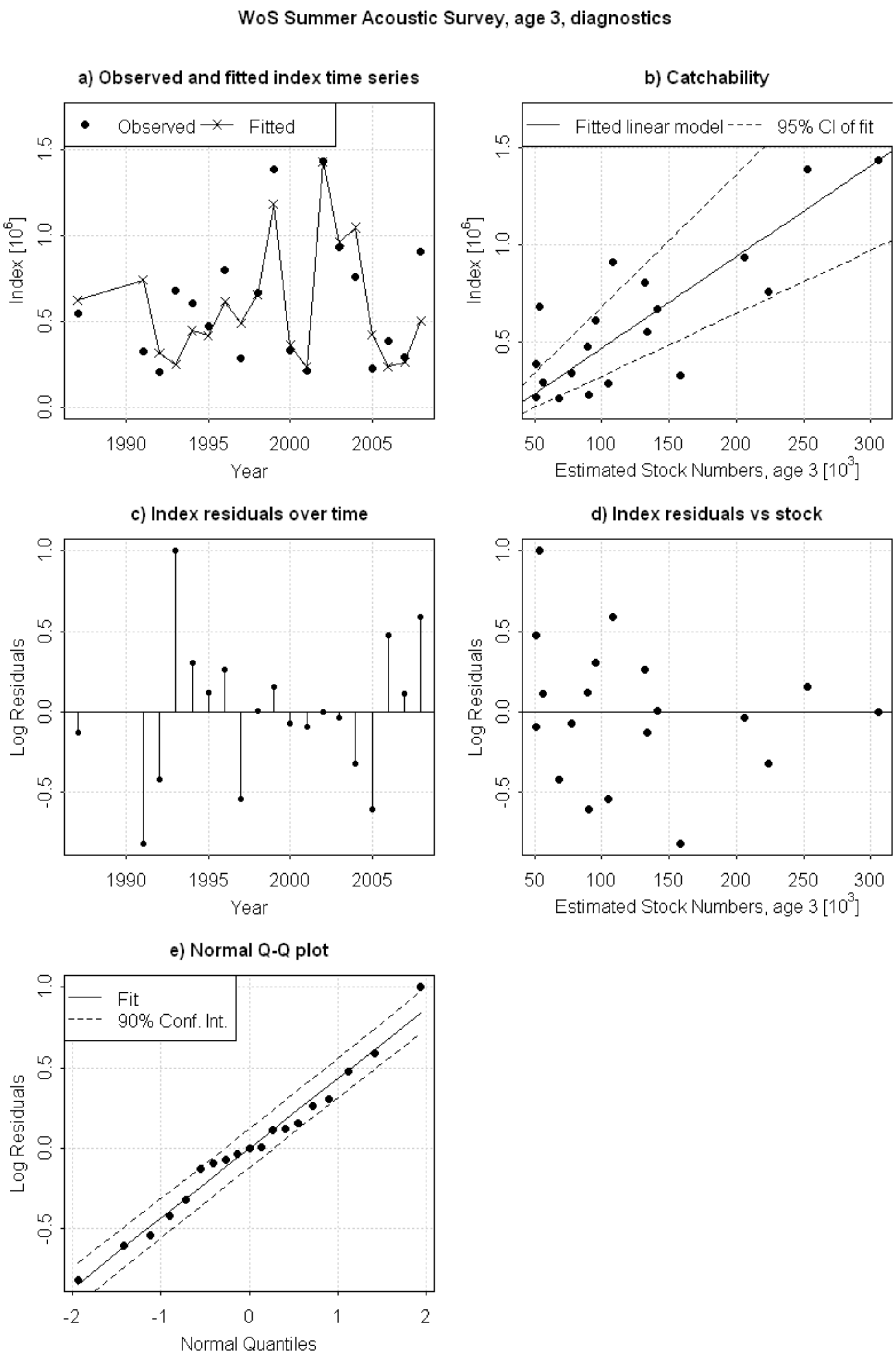


Figure 5.6.2.5. Herring in VIa (N). Illustration of residuals from deterministic calculation (8-year separable period). Diagnostics of the fit of the 3-ring index against the acoustic surveys. Top left, fitted populations (line), and predictions of abundance in each year made from the index observations and estimated catchability (triangles +/- standard deviation), plotted by year. Top right, scatter plot and fitted relationship of abundance from fitted populations of 3-ringers in acoustic surveys. Bottom, residuals, as ln(observed index) - ln(expected index) plotted against expected values and against time.

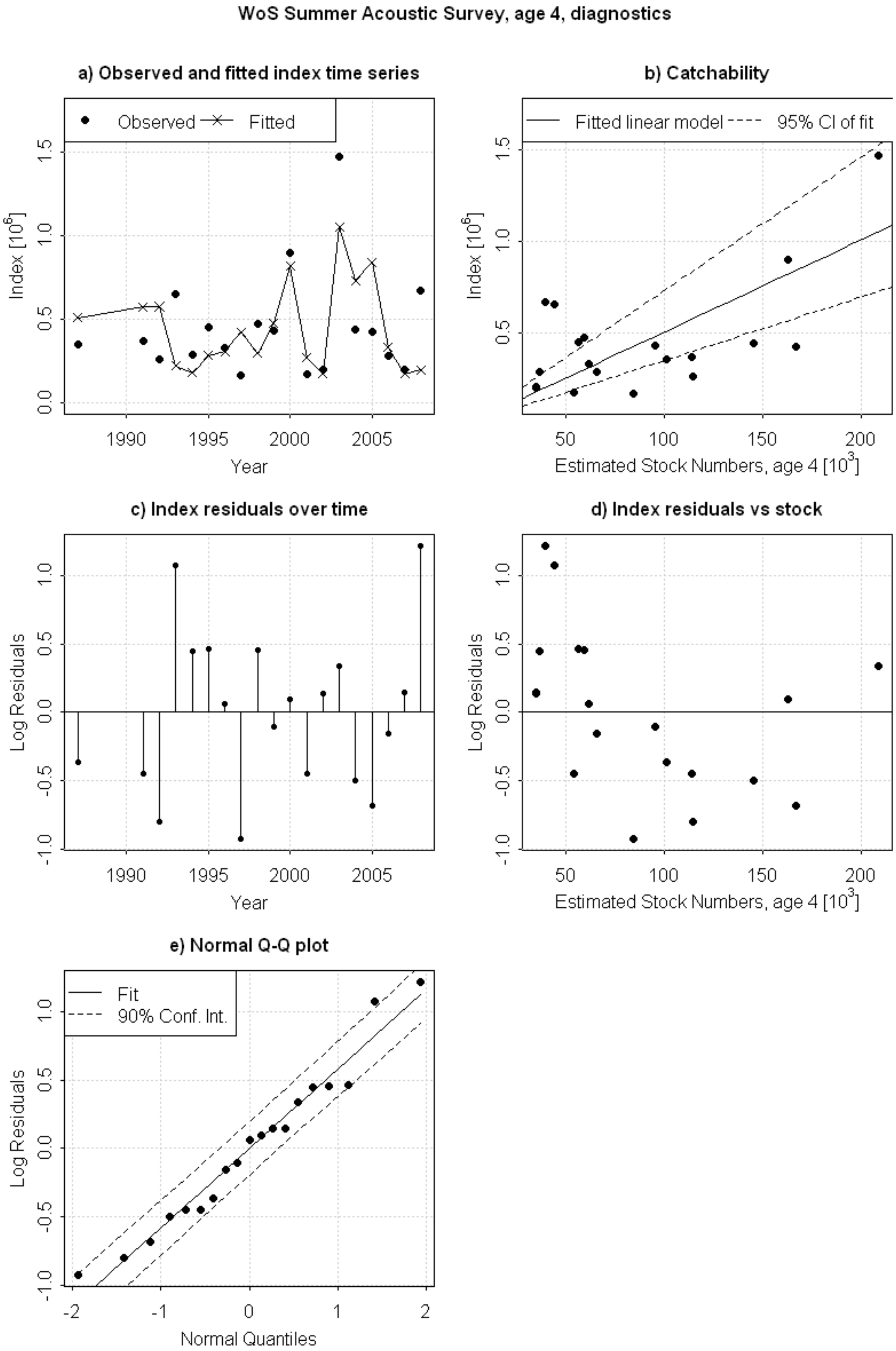


Figure 5.6.2.6. Herring in VIa (N). Illustration of residuals from deterministic calculation (8-year separable period). Diagnostics of the fit of the 4-ring index against the acoustic surveys. Top left, fitted populations (line), and predictions of abundance in each year made from the index observations and estimated catchability (triangles +/- standard deviation), plotted by year. Top right, scatter plot and fitted relationship of abundance from fitted populations of 4-ringers in acoustic surveys. Bottom, residuals, as ln(observed index) - ln(expected index) plotted against expected values and against time.

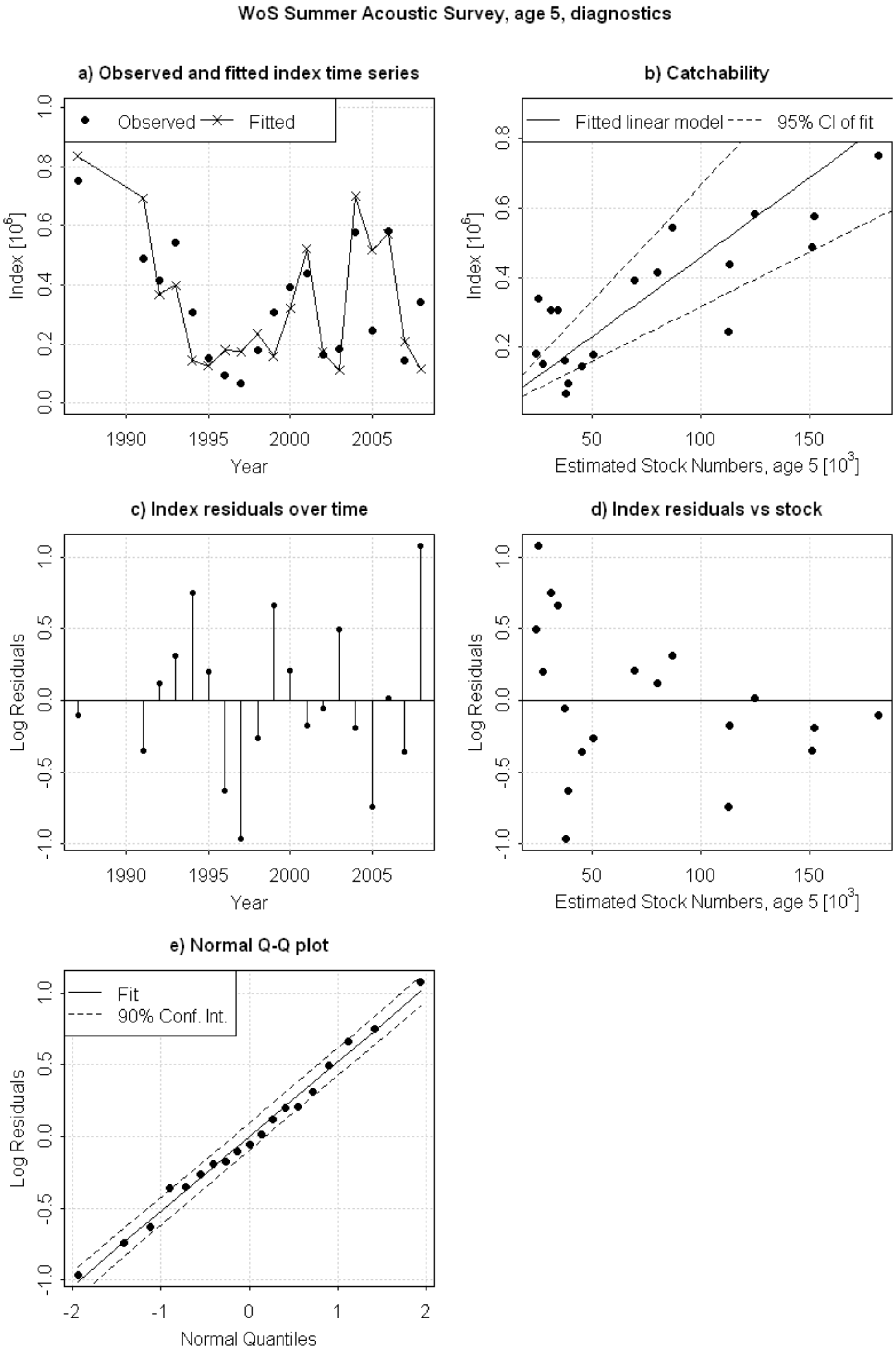


Figure 5.6.2.7. Herring in VIa (N). Illustration of residuals from deterministic calculation (8-year separable period). Diagnostics of the fit of the 5-ring index against the acoustic surveys. Top left, fitted populations (line), and predictions of abundance in each year made from the index observations and estimated catchability (triangles +/- standard deviation), plotted by year. Top right, scatter plot and fitted relationship of abundance from fitted populations of 5 ringers in acoustic surveys. Bottom, residuals, as ln(observed index) - ln(expected index) plotted against expected values and against time.

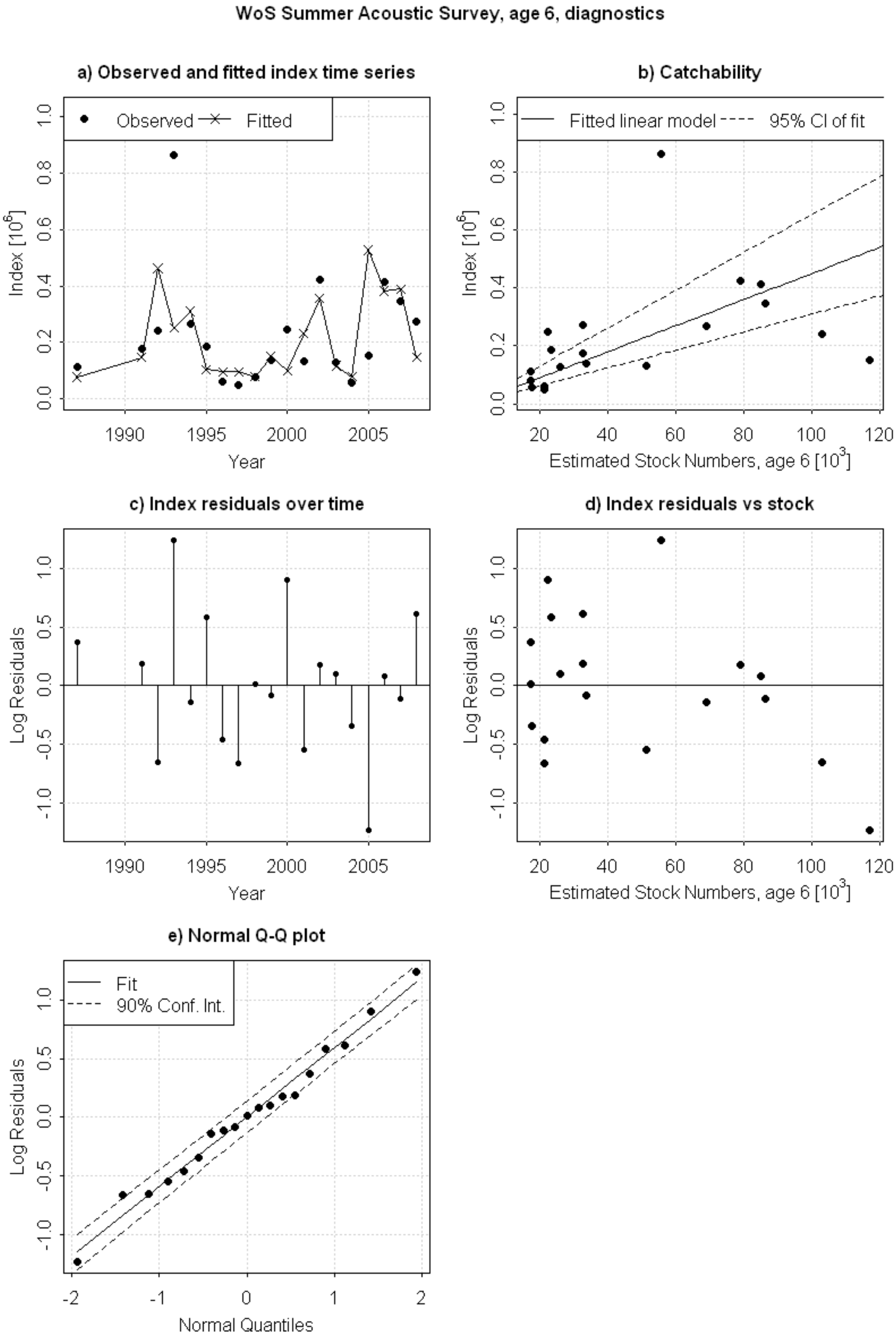


Figure 5.6.2.8. Herring in VIa (N). Illustration of residuals from deterministic calculation (8-year separable period). Diagnostics of the fit of the 6-ring index against the acoustic surveys. Top left, fitted populations (line), and predictions of abundance in each year made from the index observations and estimated catchability (triangles +/- standard deviation), plotted by year. Top right, scatter plot and fitted relationship of abundance from fitted populations of 6 ringers in acoustic surveys. Bottom, residuals, as ln(observed index) - ln(expected index) plotted against expected values and against time.

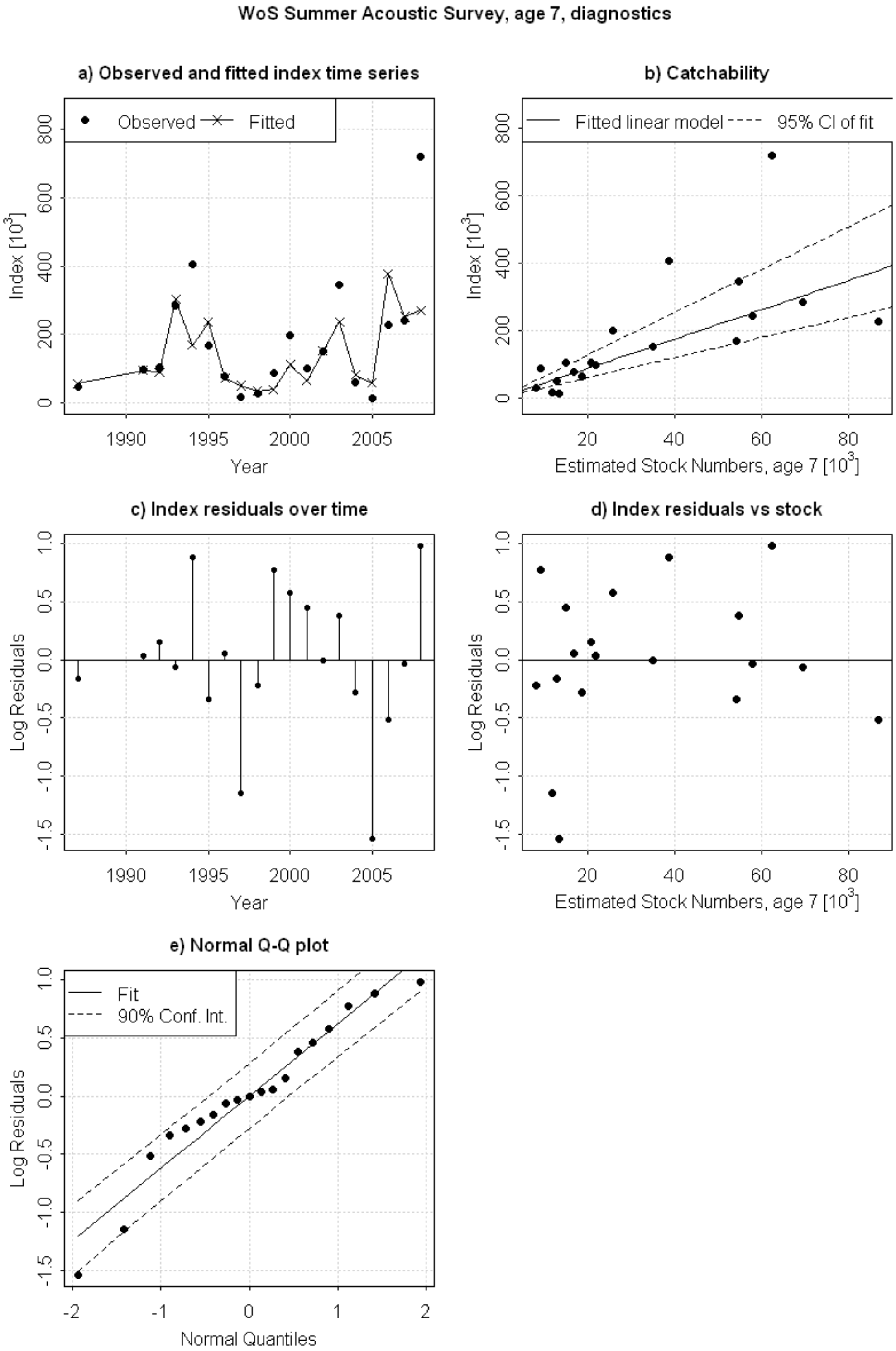


Figure 5.6.2.9. Herring in VIa (N). Illustration of residuals from deterministic calculation (8-year separable period). Diagnostics of the fit of the 7-ring index against the acoustic surveys. Top left, fitted populations (line), and predictions of abundance in each year made from the index observations and estimated catchability (triangles +/- standard deviation), plotted by year. Top right, scatter plot and fitted relationship of abundance from fitted populations of 7 ringers in acoustic surveys. Bottom, residuals, as ln(observed index) - ln(expected index) plotted against expected values and against time.

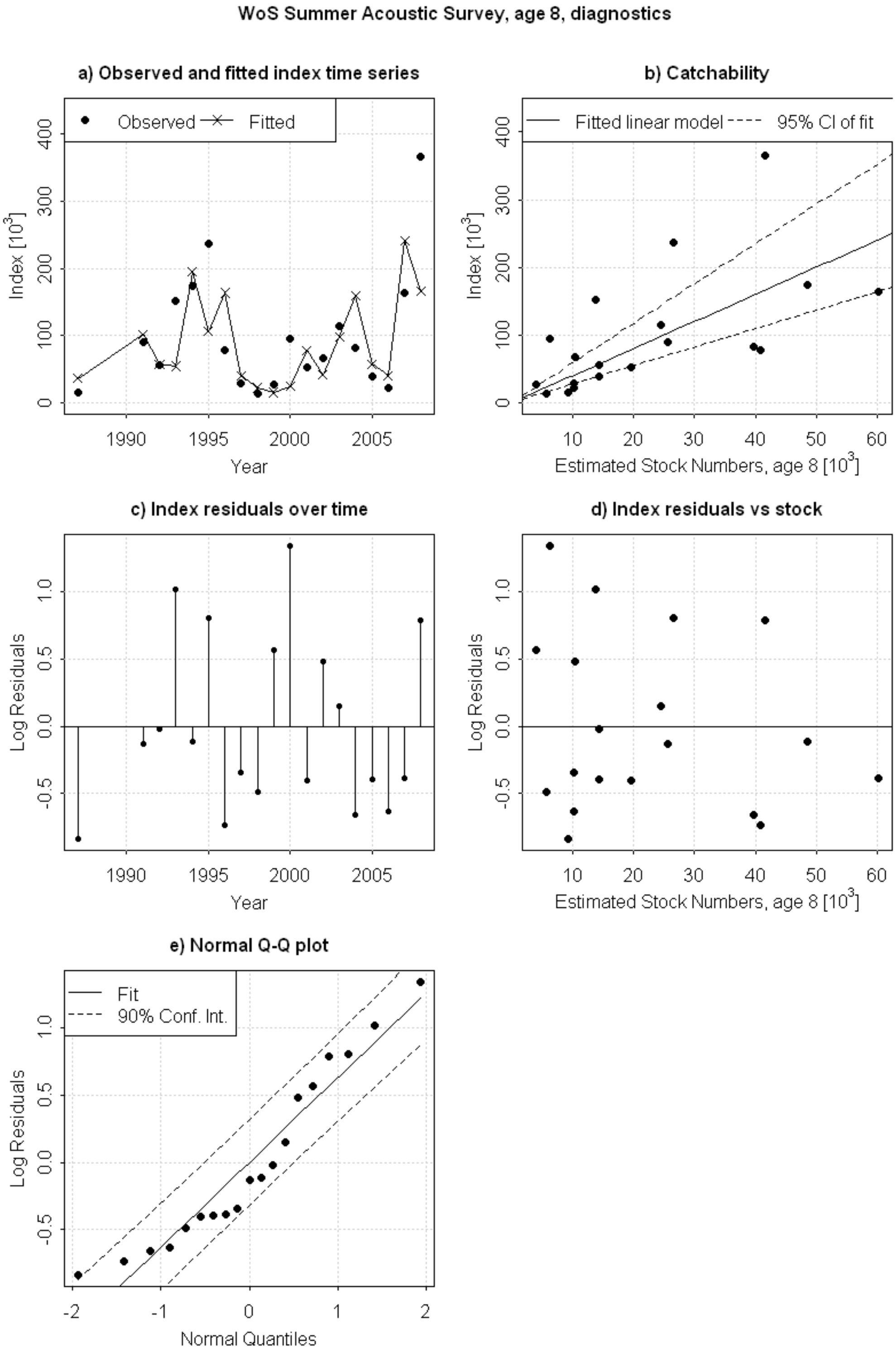


Figure 5.6.2.10. Herring in VIa (N). Illustration of residuals from deterministic calculation (8-year separable period). Diagnostics of the fit of the 8-ring index against the acoustic surveys. Top left, fitted populations (line), and predictions of abundance in each year made from the index observations and estimated catchability (triangles +/- standard deviation), plotted by year. Top right, scatter plot and fitted relationship of abundance from fitted populations of 8 ringers in acoustic surveys. Bottom, residuals, as ln(observed index) - ln(expected index) plotted against expected values and against time.

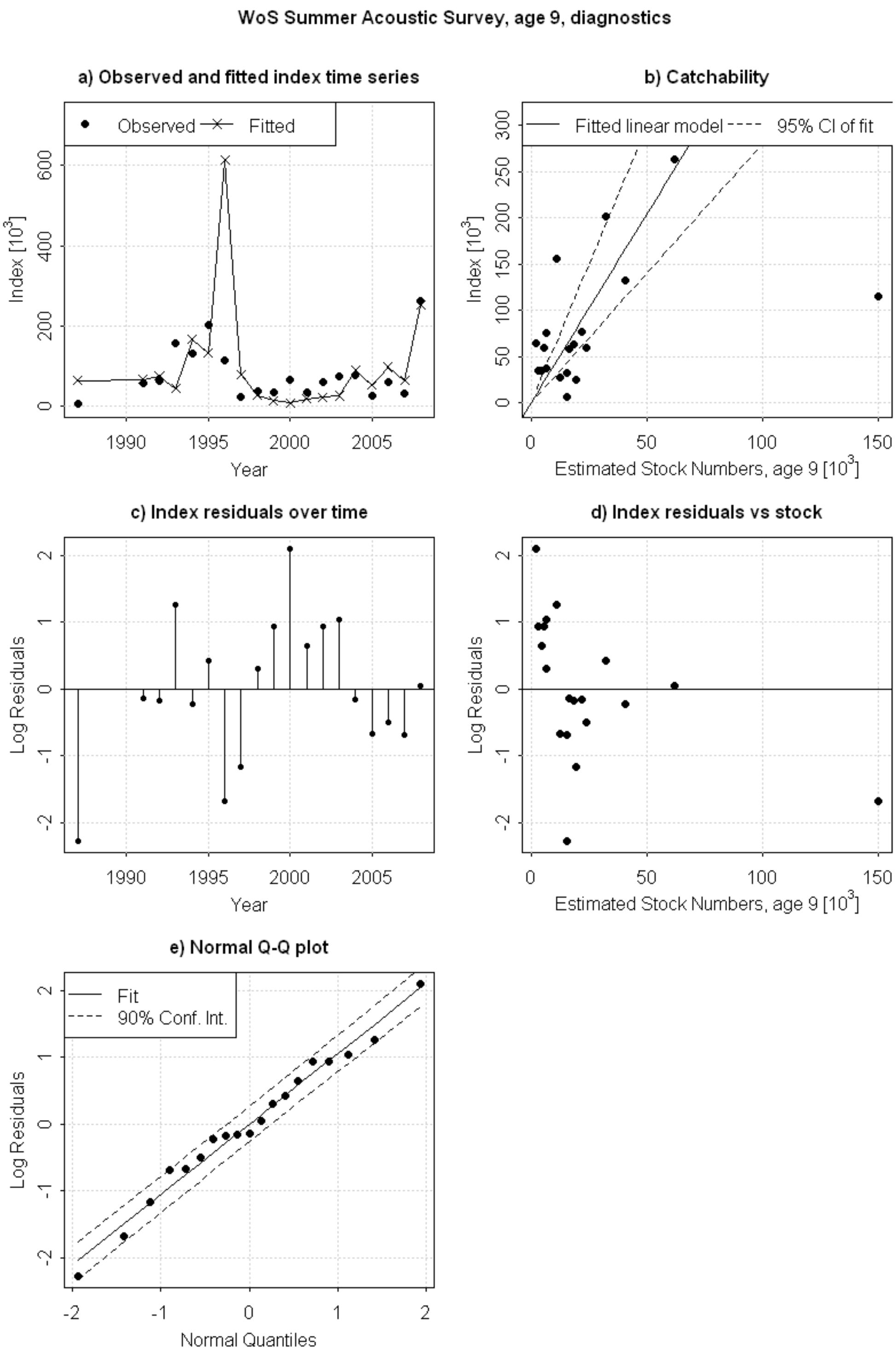


Figure 5.6.2.11. Herring in VIa (N). Illustration of residuals from deterministic calculation (8-year separable period). Diagnostics of the fit of the 9-ring index against the acoustic surveys. Top left, fitted populations (line), and predictions of abundance in each year made from the index observations and estimated catchability (triangles +/- standard deviation), plotted by year. Top right, scatter plot and fitted relationship of abundance from fitted populations of 9 ringers in acoustic surveys. Bottom, residuals, as ln(observed index) - ln(expected index) plotted against expected values and against time.

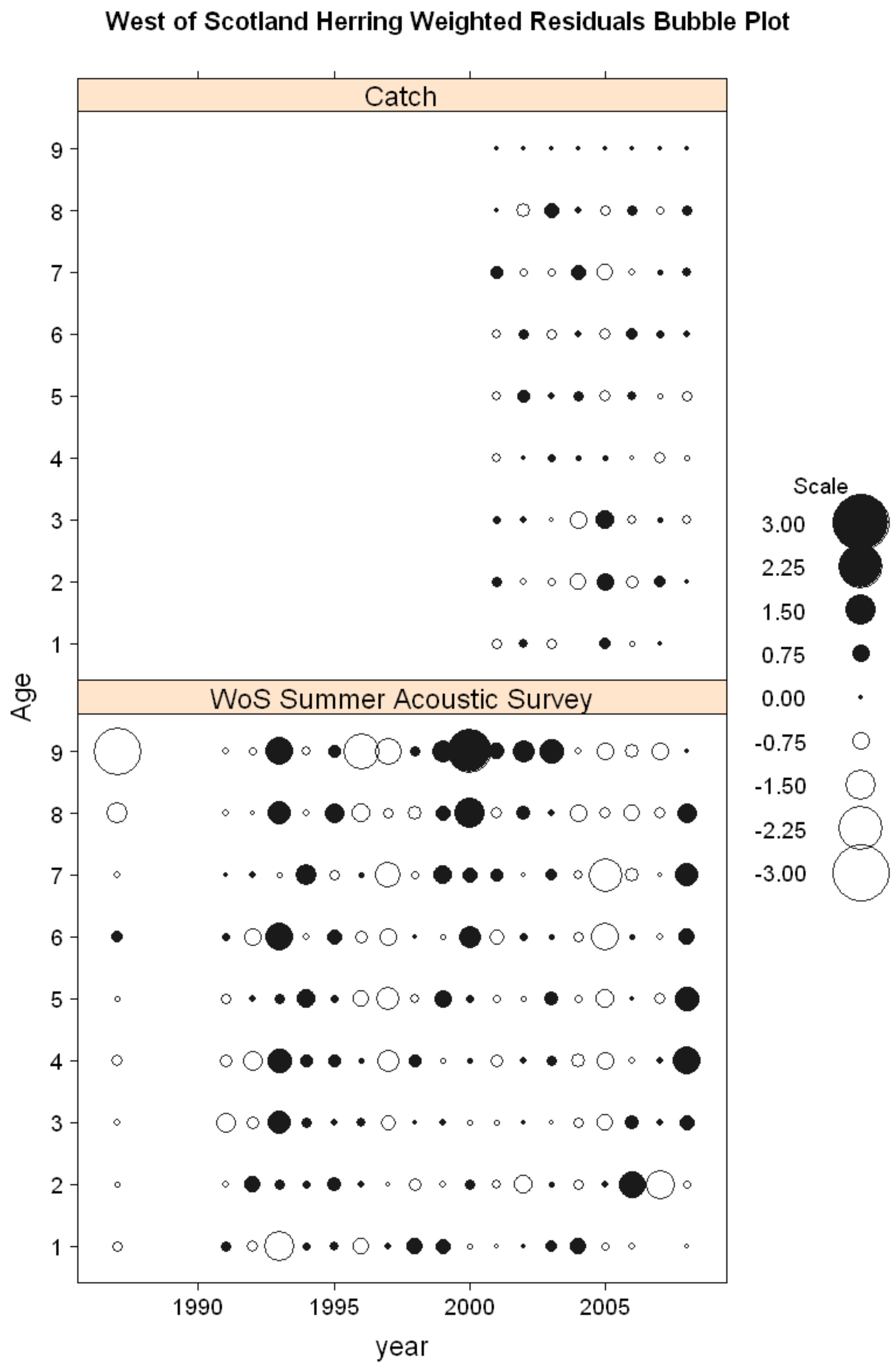


Figure 5.6.2.12. Herring in VIa (N). Comparison of residuals in the catch (top) and survey (bottom) Note the year effects in the survey, particularly in 2005 and 2008. The assessment effectively smoothes an otherwise noisy survey.

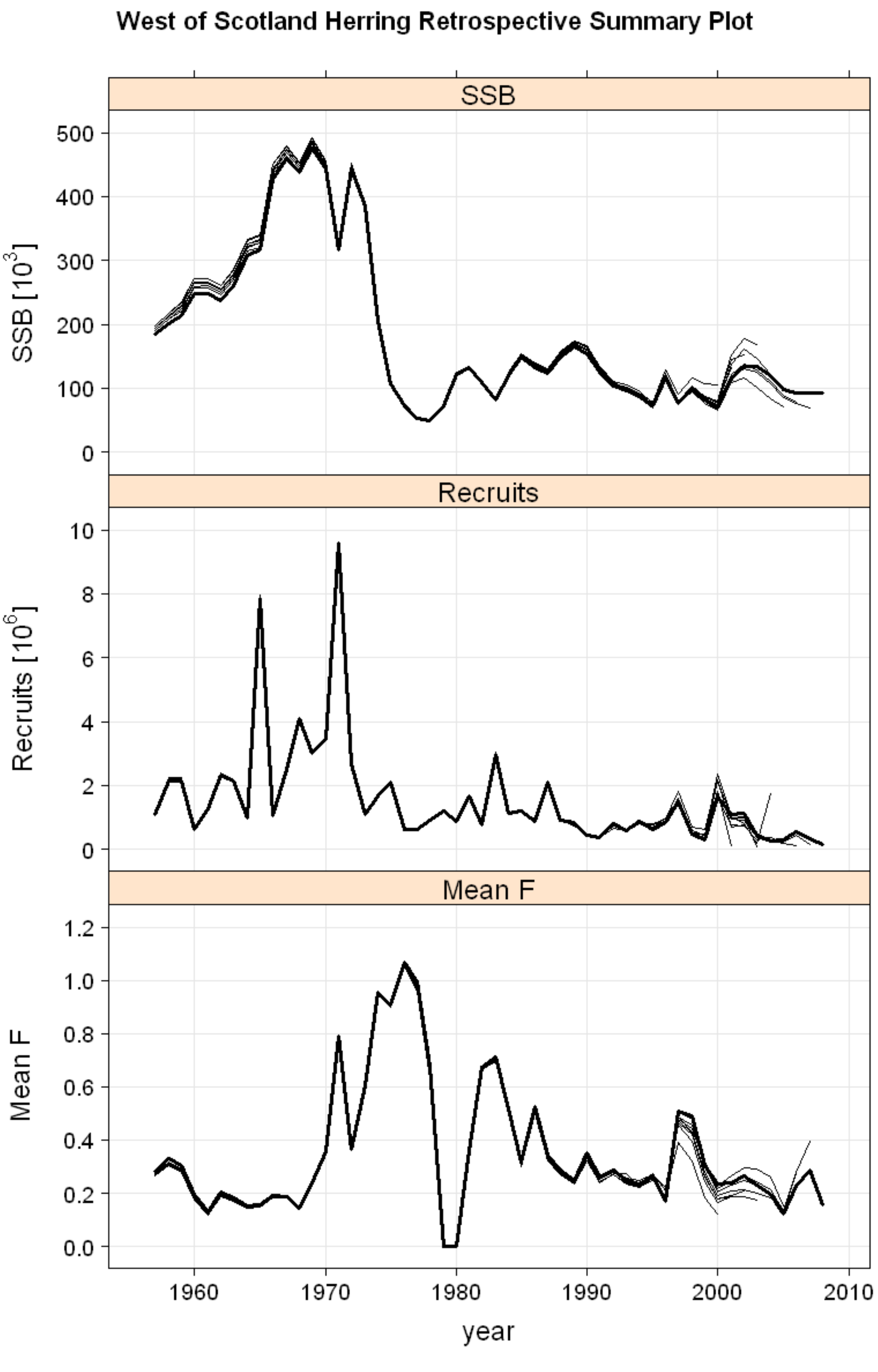
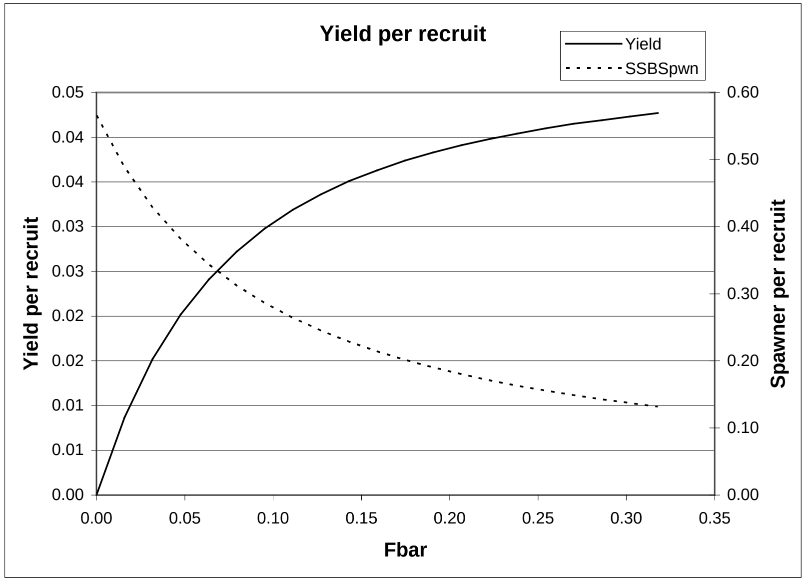
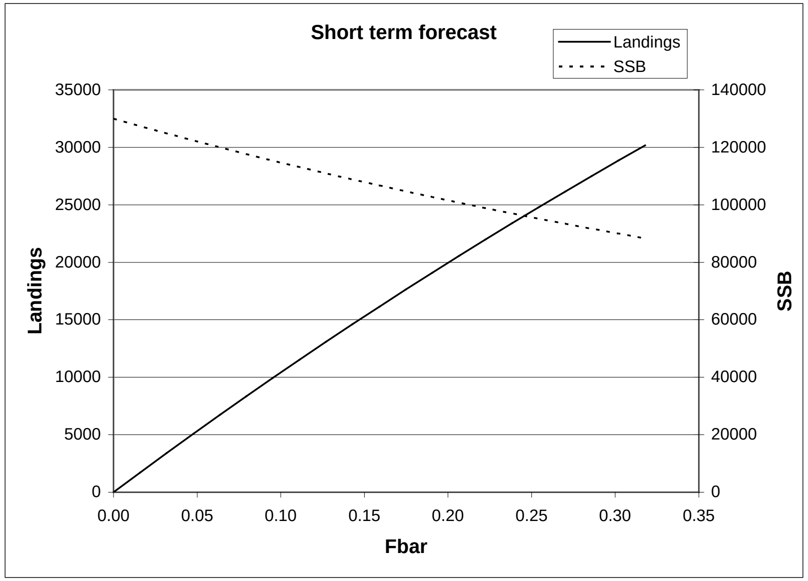


Figure 5.6.2.13. Herring in VIa (N). Analytical retrospective patterns (2008 to 2001) of SSB, mean $F_{3\text{-}6}$ and recruitment from the final assessment.





MFYPR version 2a
Run: TAC
Time and date: 13:17 17/03/2009

Reference point	F multiplier	Absolute F
Fbar(3-6)	1.0000	0.1589
FMax	200.9425	31.9275
F0.1	1.0811	0.1718
F35%SPR	1.1285	0.1793

Weights in kilograms

MFDP version 1a
Run: TAC
West of Scotland Herring
Time and date: 11:08 19/03/2009
Fbar age range: 3-6

Input units are thousands and kg - output in tonnes

Figure 5.7.2.1. Herring in VIa (N). Yield-per-recruit and short-term forecast.

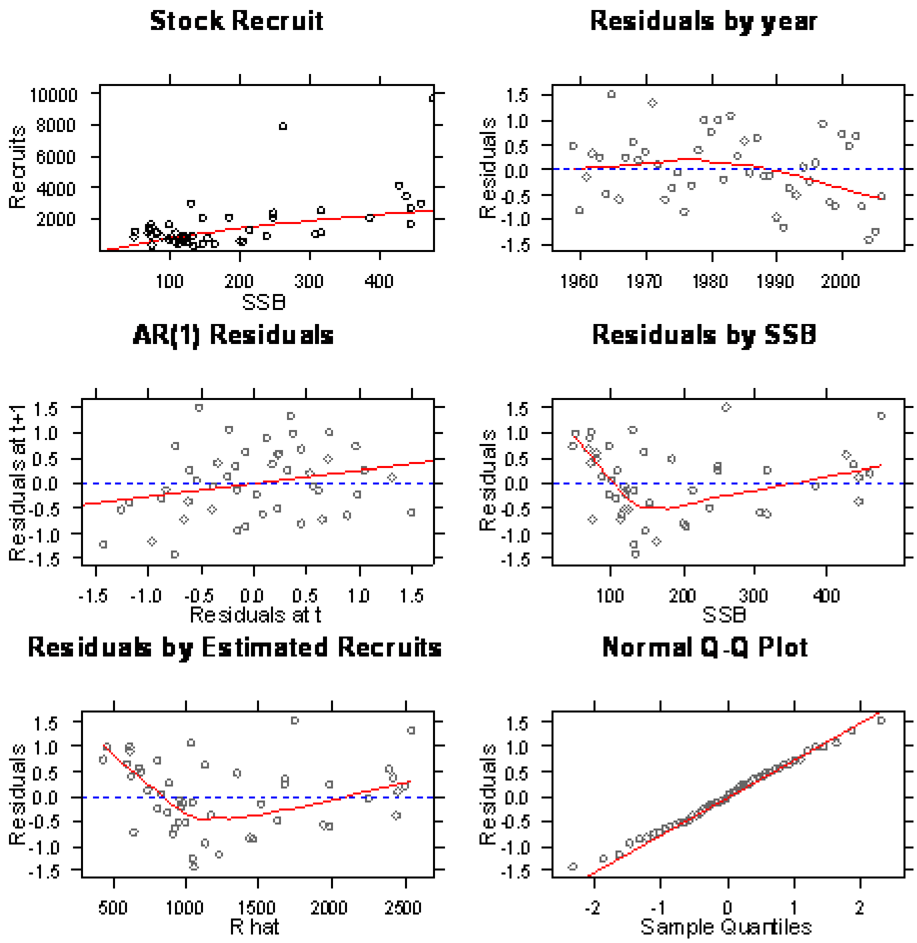


Figure 5.8.1.1. Herring in VIa (N). Fitted Stock / Recruit relationship for full time series, showing slope used for truncated period 1989 onwards

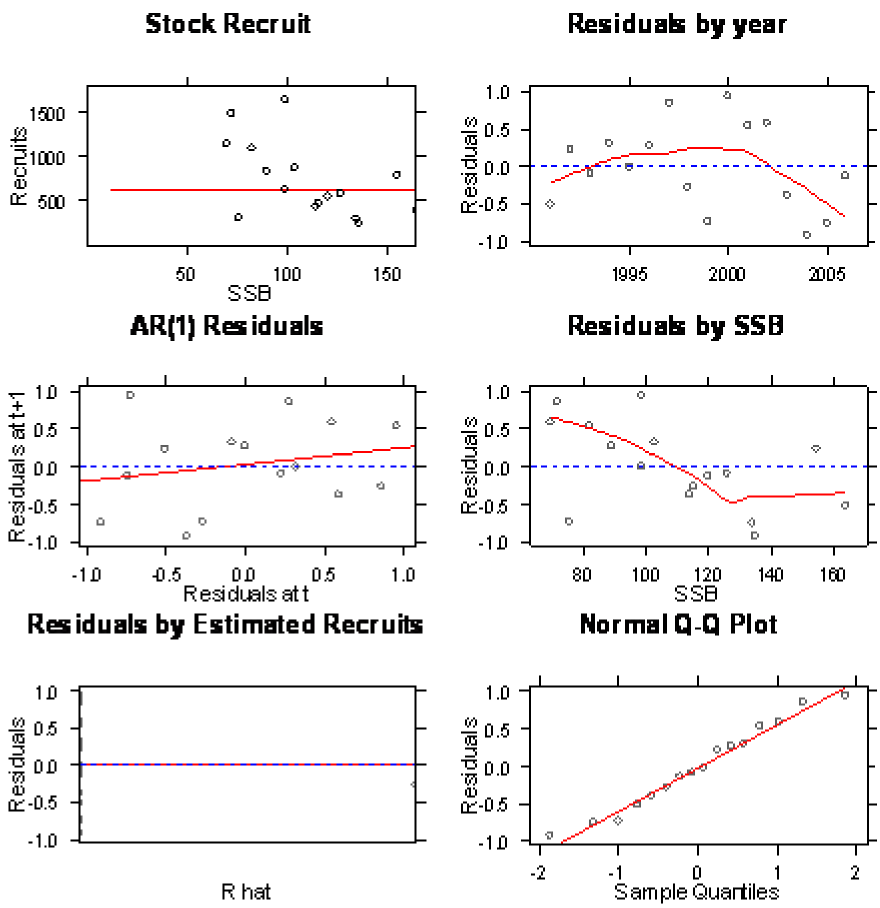


Figure 5.8.1.2. Herring in VIa (N). Fitted Stock / Recruit model to truncated data 1989 -2006 showing no point of inflection of recruitment with SSB. The model used to conform to this fit is a hockey-stick with a point of inflection at lowest observed biomass of 50 000 t.

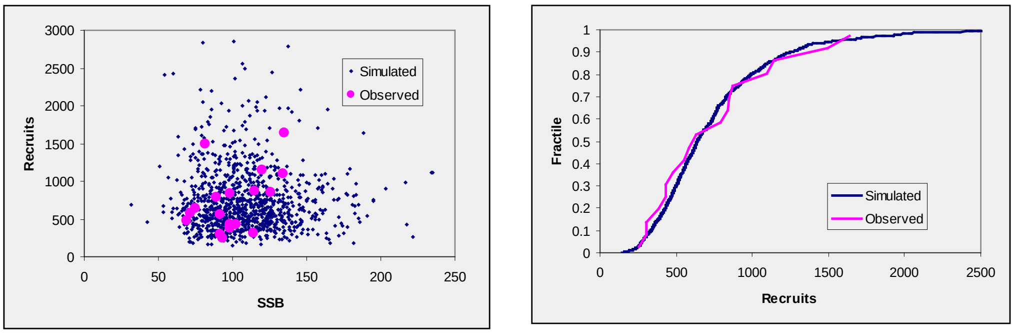


Figure 5.8.1.3. Herring in VIa (N). Comparison of observed (1989-2006) recruitment and medium term simulations with Hockey-Stick Stock / Recruit relationship.

Hockey Stick S/R Relationship run 5 *Beverton –Holt S/R Relationship run 1*

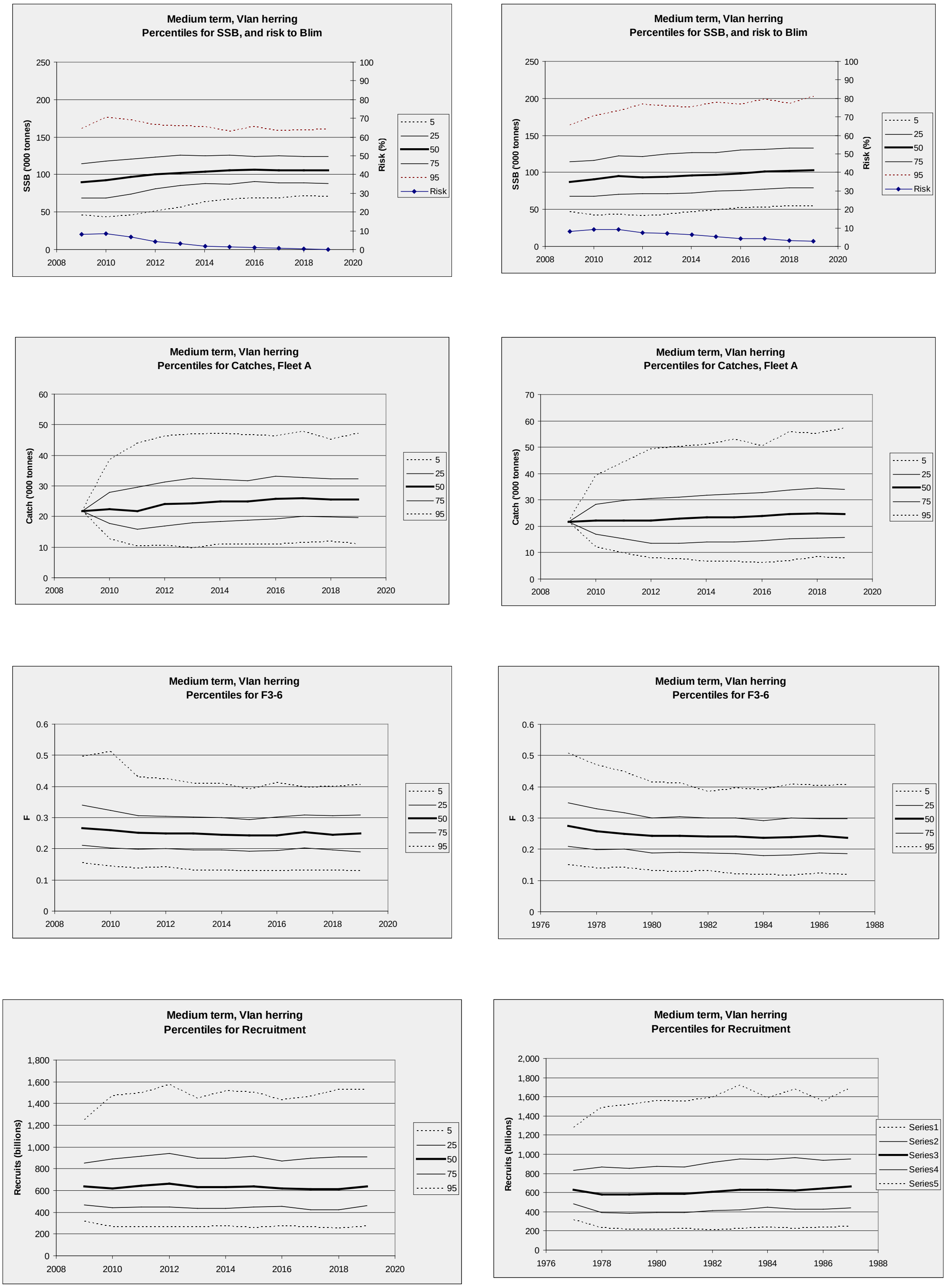
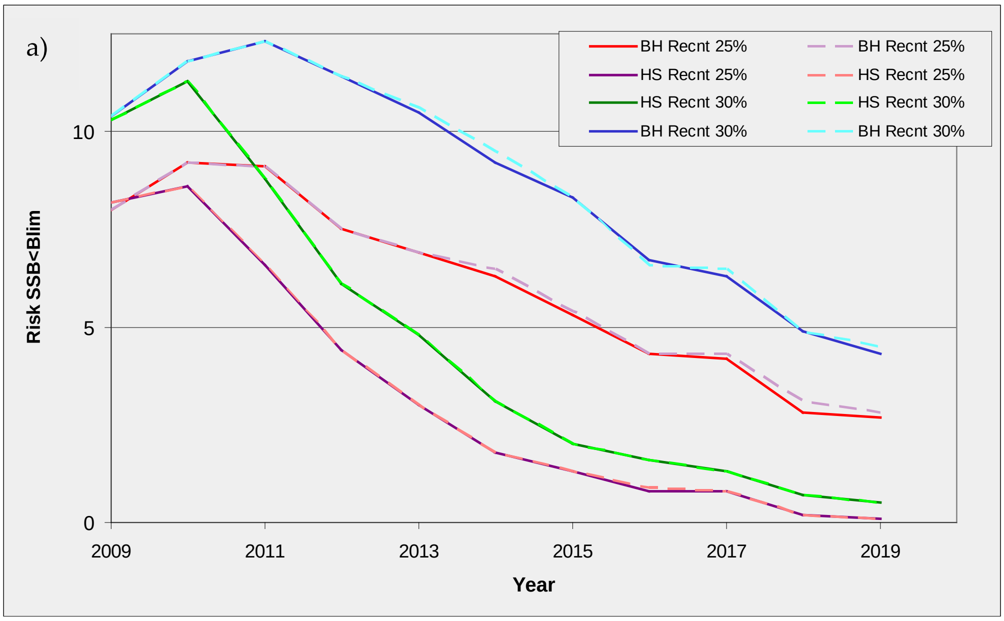


Figure 5.8.2.1. Herring in VIa (N). Results of medium term simulations of EC harvest rule (Section 5.1.3), model parameters in Section 5.8. Results show a) SSB (Risk SSB<Blim), b) Catch, c) F and d) R from 2009 to 2019. Two models are similar with an initial risk (a) reducing with time, more slowly with Beverton-Holt model than Hockey-Stick model. Risk reduces to low level in both cases.



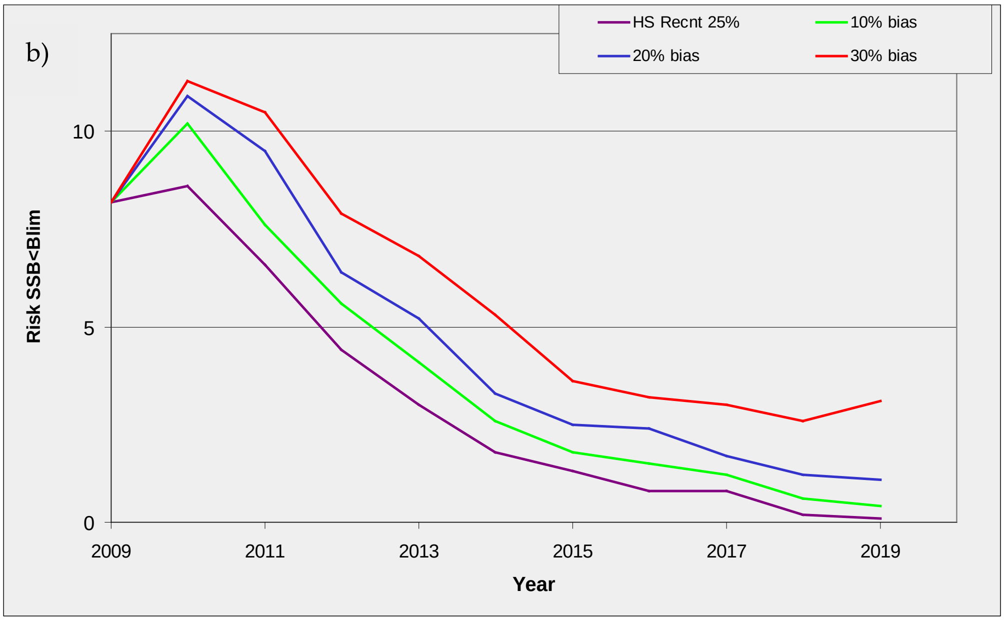


Figure 5.8.2.2. Herring in VIa (N). Risk of SSB< B_{lim} under different model conditions. Results of medium term simulations of EC harvest rule (see Section 5.1.3.), for model parameters given in section 5.8. a) Sensitivity to 20/25% year-on-year constraint on TAC change (dotted / solid lines). Sensitivity to choice of S/R model; Hockey-Stick (runs 9, 10, 11, 12) Beverton-Holt (runs 5, 6, 7, 8). Sensitivity to choice of measurement error (CV of 25% runs 9, 10, 5, 6 or 30% runs 11, 12, 7, 8) b) Sensitivity to over catch 0, 10, 20, 30% bias for the case of the HS model runs 6, 13, 14, 15. In all cases risks fall below 5% but at 30% bias (overcatch) risks are no longer negligible.

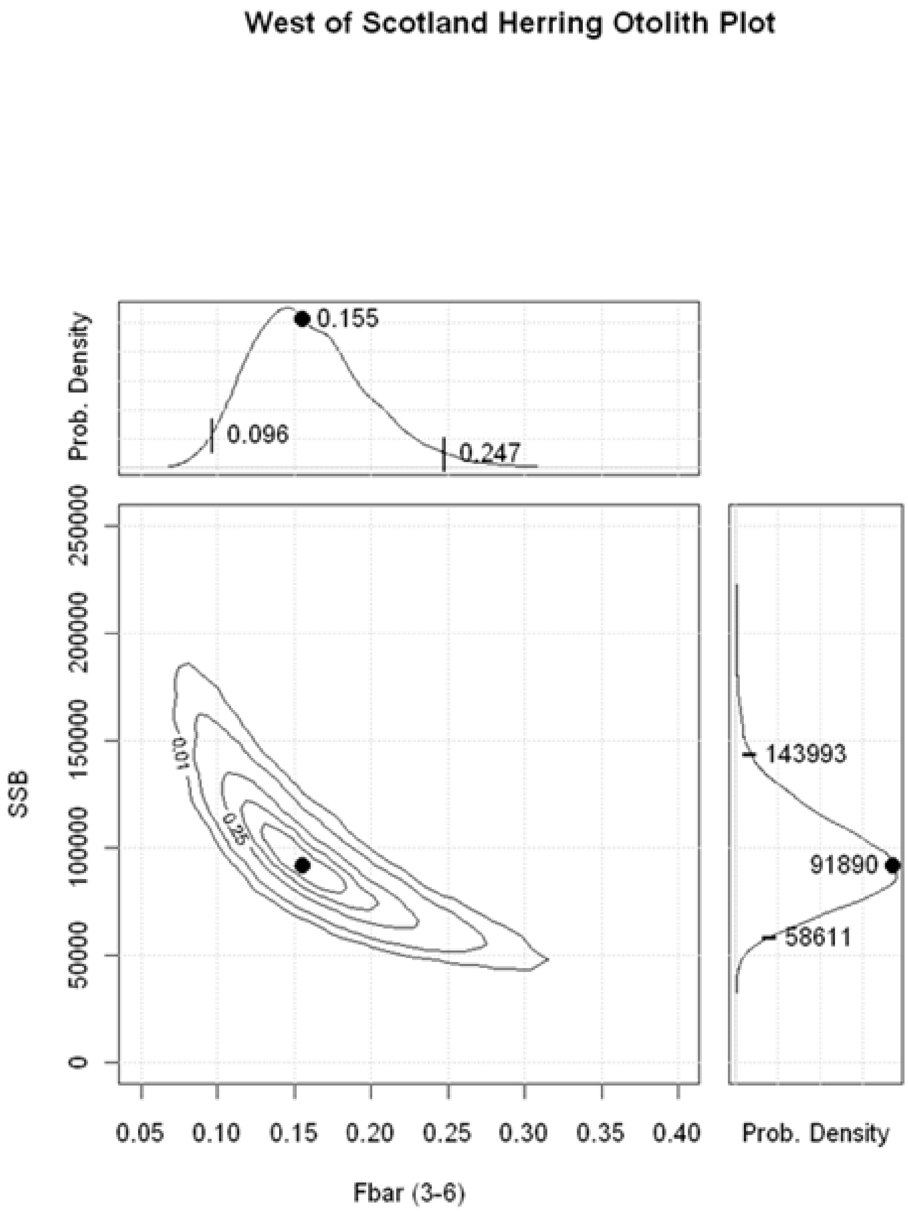


Figure 5.10.1. Herring in VIa (N). Model uncertainty; distribution and quantiles of estimated SSB and F in the terminal year of the assessment. Estimates of precision are based on a parametric bootstrap from the FLICA estimated variance/covariance estimates from the model.

6 Herring in Divisions VIa (South) and VIIb,c

This management unit has existed since 1982 when it was separated from VIa. Until that time, VIIb,c was a separate management unit. The stock area comprises autumn and winter, and spring spawning components. This stock is classified as "SALY" in 2009.

6.1 The Fishery

6.1.1 Advice and management applicable to 2008 – 2009

The TAC for this area in 2008 was 11 642 t with a decrease of 20% to 9 314 t in 2009. For 2009, ICES advised that the updated exploratory assessment available for this stock did not change the perception of the stock and did not give reason to change the advice from 2007. The advice for the fishery in 2009 is therefore the same as the advice given in recent years. A rebuilding plan should be put in place that will reduce catches. The rebuilding plan should be evaluated with respect to the precautionary approach.

6.1.2 Catches in 2008

The working group estimates of landings recorded by each country from this fishery from 1988 – 2008 are given in Table 6.1.2.1 Irish catch estimates for this WG have been based on the preliminary official reported data from the EU Logbook Scheme. The total official catch recorded from logbooks for 2008 was over 10 237 t, compared with 12 675 t in 2007. The total working group estimates of catches in these areas from 1970 –2008 are shown in Figure 6.1.2.1. The working group estimates of catch have declined from about 18 000 t in 2007 to 13 000 t in 2008.

There were no estimates of discards reported for 2008 and anecdotal reports from the industry are that there was some discarding in 2008. Some slippage took place but it is not possible to quantify exact amounts.

The assessment period runs concurrently with the annual quota. In recent years Ireland is the dominant country participating in this fishery. In 2008 all of the catches were reported from quarters 1 and 4 in VIaS with comparatively small catches reported from VIIb, c. In the first quarter the season around the 7th of January and closed on the 7th February. Fishing reopened in the fourth quarter on the 7th October and closed on the 15th of December when the quota was exhausted. The distribution of the landings from this area are presented in Figure 6.1.3.1. The main fishing took place in the northern part of VIaS, with most of the remainder from the southern part. There was very little fishing in VIIbc. Several small landings were taken from the west of Ireland, and almost no fishing took place in the northern part of VIIbc.

A total of 62 boats, categorised as follows caught herring in 2008:

- 1 freezer trawler
- 22 pelagic segment boats with refrigerated seawater (RSW) storage
- 4 polyvalent segment boats with refrigerated seawater storage
- 35 polyvalent segment vessels with bulk storage.

Polyvalent is a term used to define part of the Irish fleet licensed to catch pelagic and demersal fish.

6.1.3 Regulations and their effects

Changes to the management of this stock have influenced the way the fishery is prosecuted in space and time. The RSW vessels do not have access to those spawning grounds within a 12-mile limit. Fish on the spawning grounds are targeted largely by dry hold vessels only.

The quota is allocated to the RSW and polyvalent vessels in different ways. The RSW vessels are given quota on a fixed allocation key. The polyvalent vessels need to "book in" to receive the remaining quota, and must take it in a specified time window. Unused quota is re-assigned to the next time window. This leads to wastage of quota that is not caught and at least partly explains why the Irish quota was not fully taken up in 2008.

6.1.4 Changes in fishing technology and fishing pattern

There have been no significant changes in the fishing technology of the fleets in this area in the very recent past. The pattern of this fishery has changed over time. In the early part of the 20th century the main spawning components were the winter spawners off the north coast, and this was where the main fishery took place. In the 1970s and 1980s the west of Ireland autumn-spawning components were dominant and the fishery was mainly distributed along the coasts of VIIbc and VIaS. More recently the northern grounds are more important again.

The pelagic segment vessels are not allowed to fish herring inside 12 nautical miles of the Irish coast. This means that they tend to fish off the north coast, where the waters are less deep and where herring spawning grounds are further offshore. This exclusion is more enforced than previously.

6.2 Biological composition of the catch

6.2.1 Catch in numbers-at-age

Catch-at-age data for this fishery are available since 1970 and are shown in Table 6.2.1.1 with percentages since 1994 shown in Table 6.2.1.2. In 2008 the fishery has been dominated by 2, 3 and 4 ringers, accounting for 15%, 24% and 35% respectively. One ringers are never well represented in the catch and normally do not show up in the catch until quarter 3. In any case, the abundance of 1-ringer in the catches has been lower in the past three years than at any time in the series. The 2008 age profile shows a a peak in 4 ringers. This follows on from the strong catch of 3 ringers in 2007. The catch numbers at age have been mean standardised and are presented in Figure 6.2.1.1. The low numbers of 1 ringers and the truncation of older ages can be clearly seen.

Four winter ring fish dominate the catch in quarter 1 while in quarter 4, 2, 3 and 4 ringers are found in similar quantities. Sampling data indicates that herring are fully recruited to the fishery at 3 ringers and there is little evidence for 1 ringer fish being an important component of landings in fisheries in this area.

6.2.2 Quality of the catch and biological data

The management of the Irish fishery in recent years has tightened considerably and the accuracy of reported catches is also believed to have improved. The numbers of samples and the associated biological data are shown in Table 6.2.2.1. As Ireland is the main participant in this fishery all of the sampling is carried out by Ireland. The length distributions of the catches taken per quarter by the Irish fleet are shown in Table 6.2.2.2. Only one sample was collected from VIIb, and overall landings in this area are very small. Sampling in this fishery relies heavily on the vessels that concentrate their effort on the inshore grounds.

6.3 Fishery Independent Information

6.3.1 Acoustic Surveys

In 2008, the Irish survey of VIaS, VIIb, c was conducted in July with effort concentrating on summer feeding aggregations. The July 2008 survey track and SA values attributed to herring are shown in Figures 6.3.2.1 and 6.3.2.2 respectively. A primary survey was carried out on the Celtic Explorer and a scoping survey was conducted using a commercial vessel. The purpose of the commercial survey was to determine the extent and distribution of summer feeding aggregations of herring within the survey confines.

The main survey focused on the northwest and west coast of Ireland (ICES Divisions VIaS and VIIb, c). The survey track commenced off the west coast of Ireland at the south-eastern extension and worked in continuity from south to north. Existing survey methodology was followed with acoustic surveying undertaken between 04:00 and 23:00 (daylight hours). The commercial survey focused effort in the ICES areas VIIb and VIaS offshore from known autumn and winter spawning grounds where the fishery is focused in quarters 4 and 1. The vessels also covered the grounds extending to the shelf break and northwards to the 56ºN

A systematic parallel transect design was adopted with a randomised start point. As this was the first of a new survey time series it was deemed important to cover the grounds as intensively as possible to highlight any potential areas of distribution or dense aggregations.

The results of this acoustic survey are not directly comparable with the winter surveys conducted from 2004-2007 (Table 6.3.1.1). It is comparable in time and area with those conducted from 1994-1996 (Table 6.3.1.2). The SSB estimate (43,000 t) was lower than surveys in 1994 and 1995, though in the same range of SSB estimates as the winter surveys conducted in recent years. It remains unclear if the VIaS and VIIbc stock is contained within the area of this survey as herring abundance increased moving towards the boundary with VIaN. This survey is now conducted as part of the PGIPS survey programme (ICES, 2009, LRC:02).

6.4 Mean weights-at-age and maturity-at-age

6.4.1 Mean Weights at Age

The mean weights (kg) at age in the catches in 2008 are based on Irish catches and are very similar to 2007 for ringers 2-6 (Figure 6.4.1.1). These mean weights display quite a stable pattern over the time series. Though there appears to be a slight increase in mean weights of 1 ringers in the past five years. Fluctuations can also be seen in the oldest two ages with a decrease in 8 ringers and a slight increase in 9 ringers in 2008. Generally the oldest and youngest ages are poorly represented in the catch data.

The mean weights in the stock at spawning time have been calculated from Irish samples taken during the main spawning period that extends from October to February (Figure 6.4.1.2). There appears to be a slight decrease in 8 ringers, an increase in 9+ and a more stable pattern in the younger ages.

6.4.2 Maturity Ogive

One ringers are considered to be immature and they do not contribute to the SSB. This corresponds with the constant maturity ogive that is assumed for this stock and used in the assessment.

6.5 Recruitment

There is little information on 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 have been consistently low in the most recent years.

6.6 Stock Assessment

6.6.1 Data Exploration

A detailed analysis of basic data, including age composition of catches, log catch ratios and cohort catch curves was conducted in recent years and is presented in the Stock Annex (annex 7). There has been a truncation in older age groups in recent years, and in most recent years, a paucity of recruits also. Log catch ratios show an upward trend in raw mortality on fully recruited year classes, since the mid 1990s. Catch curves show low mortality on the very large 1981, 1985 and 1988 year classes. These represent three of the biggest year classes recruited to this fishery. Low mortality was evident in the 1970s and increased mortality can be seen from 1990 on.

6.6.2 Assessment

Following the procedure of recent years, a separable VPA was used to screen over four terminal fishing mortalities, 0.2, 0.4, 0.5 and 0.6. This was achieved using the Lowestoft VPA software (Darby and Flatman, 1994). Reference age for calculation of fishing mortality was 3-6 and terminal selection was fixed at 1, relative to 3 winter rings. This assessment is still exploratory, and no assessment has been accepted in recent years.

Four assessments using the separable VPA are presented, based on the four choices of terminal F. Recruitment, SSB and mean F from each run are plotted in Figure 6.6.2.1. This figure is more informative for the converged part of the VPA, but in most recent years has little information on the current stock dynamics. Outputs from separable VPAs with terminal Fs of 0.2, 0.4, 0.5 and 0.6 are presented in Tables 6.6.2.1, 6.6.2.2, 6.6.2.3 and 6.6.2.4 respectively. Residual plots for the four trial assessments are presented in Figure 6.6.2.2. Large residuals can be seen in 1 ringers. A comparison with the previous year's separable VPA runs is shown in Figure 6.6.2.3.

Fishing mortality was highest in series in 1998. Subsequent Fs have been lower but still above the long term average in each case. There was a sharp rise in F in 2006, associated with an increased catch in that year.

Recruitment appears to have shown a declining trend over the last few years with all terminal F values used. A slightly higher level of recruitment is estimated with terminal F=0.2. Each scenario shows recruitment to be at a similar level in the final year and this is calculated using the geometric mean of the recruitment index over the entire time series.

SSB may be declining slightly, assuming terminal F of 0.4, 0.5 or 0.6 and possibly more stable at F values of 0.2. All F values show that SSB at lowest levels in the series and is considerably lower than the current levels of B_{pa} and B_{lim}. There is no evidence in the observed catch numbers at age to suggest that there are strong year classes recruiting to this fishery.

These explorations are only useful as indicators of historic trends. These results are consistent with the preliminary data screening that shows no stronger year classes in the fishery in recent years.

A retrospective assessment was conducted for each of the F scenarios. Using a terminal F = 0.2 (Figure 6.6.2.4) overestimates SSB and underestimates F. Using a terminal F = 0.4 or 0.5 (Figure 6.6.2.5 and 6.6.2.6) displays a much more stable estimation of SSB and the underestimation of F is not as pronounced. The retrospective assessment using F=0.6 (Figure 6.6.2.7) shows SSB to be quite stable, with some tendency to underestimate in most years, and a tendency for mean F to be overestimated.

The results of the retrospective analysis suggest that using a terminal F of 0.4 or 0.5 produces more stable estimates of SSB and F than smaller or larger values. This suggests that recent F has been in the range of 0.4 to 0.5, which is above $F_{0.1}$ estimated most recently in 2006.

6.6.3 State of the Stock

The results of the exploratory assessment suggest that the decline in SSB may be continuing but the current level of SSB is uncertain but is likely to be below B_{pa} and B_{lim}. There is no evidence that large year classes have recruited to the stock in recent years and F appears to have been reduced due to the decrease in catch. The perception of stock trends is consistent, even though the most recent estimates of SSB and F are uncertain.

6.7 Short term projections

In the absence of an agreed assessment, it was not considered informative to carry out any predictions.

6.8 Medium term projections

Yield per recruit analyses were performed in 2006, and it is not considered necessary to update them. The results from this yield per recruit show $F_{0.1}$ = 0.17.

6.9 Precautionary and yield based reference points

As this assessment is still uncertain there was no revision of the precautionary reference points. The precautionary reference points for this stock were discussed in the 1999 Working Group Report (ICES 1999 ACFM:12). The present analysis, although uncertain, presents a similar picture of the stock as that shown in recent years. The SGPRP (ICES 2003/ACFM: 15) has reviewed the methodology for the calculation of biological reference points, and applying a segmented regression to the stock and recruit data from the 2002 HAWG assessment showed that the fit to the stock and recruit data for this stock was not significant. The stock is still likely below Bpa (110 000 t) but the fishing mortality has been relatively stable, over the past number of years.

6.10 Quality of the Assessment

The assessment presented was based on the results from a separable VPA without a tuning index, therefore the estimates of SSB and F for recent years depend on the choice of terminal F. Although landings seem to have been declining in recent years the actual F cannot be determined. Therefore the VPA was run for a range of terminal F values and the current perception of the stock would be highly influenced by that choice. There is no information on recent recruitment levels both because the selectivity of the fishery appears to be low for the juveniles and also the lack of a recruitment index.

The retrospective analysis of the assessment suggests that an F of 0.2 underestimates mean F and SSB. Using the terminal F= 0.4 or F= 0.5 produces a more stable retrospective pattern. The highest F of 0.6 used shows an overestimation of F. Based on this information we can infer that F may be in the region of 0.4 – 0.5.

6.11 Management Considerations

The current catch regime which has been in place for a number of years does not appear to have reduced F below F_{lim}. SSB may be stable at an historical low level, and is declining further in all runs. Though little information on recruitment is available, it is unlikely that it is above average and more likely below average. Certainly every effort should be taken to maintain catches below the current level. The catch target of the local management plan is not likely to be achievable at current stock productivity.

Recent mean F may be well above $F_{0.1}$ and this suggests that F and catch need to be reduced. A rebuilding plan is urgently required and should include further substantial reductions in catches.

6.12 Environment

6.12.1 Ecosystem Considerations

No new information.

6.12.2 Changes in the Environment

No new information.

Table 6.1.2.1. VIa(S) and VIIb,c herring. Estimated Herring catches in tonnes, 1988–2008. These data do not in all cases correspond to the official statistics and cannot be used for management purposes.

Country	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
France	-	-	+	-	-	-	-	-	-	-
Germany, Fed.Rep.	-	-	-	-	250	-	-	11	-	-
Ireland	15000	18200	25000	22500	26000	27600	24400	25450	23800	24400
Netherlands	300	2900	2533	600	900	2500	2500	1207	1800	3400
UK (N.Ireland)	-	-	80	-	-	-	-	-	-	-
UK (England + Wales)	-	-	-	-	-	-	50	24	-	-
UK Scotland	-	+	-	+	-	200	-	-	-	-
Total landings	15300	21100	27613	23100	27150	30300	26950	26692	25600	27800
Unallocated/ area misreported	13800	7100	13826	11200	4600	6250	6250	1100	6900	-700
Discards	-	1000	2530	3400	100	250	700	-	-	50
WG catch	29100	29200	43969	37700	31850	36800	33900	27792	32500	27150

Country	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
France	-	-	-	-	515	-	-	-	-	-	-
Germany, Fed.Rep.	-	-	-	-	-	-	-	-	-	-	-
Ireland	25200	16325	10164	11278	13072	12921	10950	13351	14840	12662	10237
Netherlands	2500	1868	1234	2088	366	-	64	-	353	13	
UK (N.Ireland)	-	-	-	-	-	-	-	-	-	-	-
UK (England + Wales)	-	-	-	-	-	-	-	-	-	-	-
UK Scotland	-	-	-	-	-	-	-	-	6	-	-
Total landings	27700	18193	11398	13366	13953	12921	11014	13351	15199	12675	10237
Area misreported	11200	7916	8448	1390	3873	3581	2813	2880	4353	5129	3103
Unallocated									-353	-13	
Discards	-	-	-	-	-	-	-	-	-	-	-
WG catch	38900	26109	19846	14756	17826	16502	13827	16231	19193	17791	13340

Table 6.2.1.1 VIa(S) & VIIb,c herring. Catch in numbers-at-age (winter rings) from 1970 to 2008.

	1	2	3	4	5	6	7	8	9+
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	24818	66383	14644	7988	5696	5422	2127
1987	12149	44160	80213	41504	99222	15226	12639	6082	10187
1988	0	29135	46300	41008	23381	45692	6946	2482	1964
1989	2241	6919	78842	26149	21481	15008	24917	4213	3036
1990	878	24977	19500	151978	24362	20164	16314	8184	1130
1991	675	34437	27810	12420	100444	17921	14865	11311	7660
1992	2592	15519	42532	26839	12565	73307	8535	8203	6286
1993	191	20562	22666	41967	23379	13547	67265	7671	6013
1994	11709	56156	31225	16877	21772	13644	8597	31729	10093
1995	284	34471	35414	18617	19133	16081	5749	8585	14215
1996	4776	24424	69307	31128	9842	15314	8158	12463	6472
1997	7458	56329	25946	38742	14583	5977	8351	3418	4264
1998	7437	72777	80612	38326	30165	9138	5282	3434	2942
1999	2392	51254	61329	34901	10092	5887	1880	1086	949
2000	4101	34564	38925	30706	13345	2735	1464	690	1602
2001	2316	21717	21780	17533	18450	9953	1741	1027	508
2002	4058	32640	37749	18882	11623	10215	2747	1605	644
2003	1731	32819	28714	24189	9432	5176	2525	923	303
2004	1401	15122	32992	19720	9006	4924	1547	975	323
2005	209	28123	30896	26887	10774	5452	1348	858	243
2006	598	22036	36700	30581	21956	9080	2418	832	369
2007	76	24577	43958	23399	13738	5474	1825	231	131
2008	483	12265	19661	28483	11110	5989	2738	745	267

Table 6.2.1.2 VIa(S) & VIIb,c herring. Percentage age composition (winter rings).

	1	2	3	4	5	6	7	8	9+
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

Table 6.2.2.1 VIa(S) and VIIb,c herring. Sampling intensity of catches in 2008.

ICES area	Year	Quarter	Landings (t)	No. Samples	No. aged	No. Measured	Aged/1000 t
VIaS official	2008	1	4793	15	865	3536	180
VIaS official	2008	4	5077	17	939	3139	185
VIIb	2008	4	364	1	45	194	124
Total North West			10234	65	3653	13544	767

Table 6.2.2.2. VIa(S) and VIIb,c herring. Length distribution of Irish catches/quarter (thousands) 2008.

Length cm	Quarter 1 VIa South	Quarter 4 VIIbc	Quarter 4 VIa South
20			
20.5			
21			
21.5			28
22	9		46
22.5	63		139
23	134		232
23.5	233		335
24	699	10	669
24.5	1102	20	706
25	1684	10	1106
25.5	2275	40	1738
26	3153	69	2723
26.5	3878	276	3745
27	5320	375	4721
27.5	5410	375	4581
28	4156	385	4312
28.5	2194	237	2435
29	923	99	1069
29.5	287	30	353
30	54		130
30.5	27		37
31	9		46
31.5	27		
32			9
32.5			
33	18		
33.5	9		
34			
34.5			
35			
35.5			
36	9		
Nos./t	31670	1926	29132

Table 6.3.1.1. VIa(S) & VIIb,c herring. Time series of acoustic surveys since 1999. The 2008 survey is part of a new summer survey of the Malin Shelf stock complex.

Winter rings	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
0	-	-	5	0	-	0.09	1.28	0	-	-
1	18.99	10.71	22.69	35.7	10.28		7.83	1.6	0.3	12.28
2	104.77	60.88	52.33	14.05	26.26	3.9	56.91	6.9	3.5	83.33
3	32.53	48.96	6.41	24.23	30.02	62.35	93.51	86.7	59.8	64.85
4	11.34	25.57	6.47	14	11.08	54.93	109.87	57.5	21.9	38.02
5	1.65	9.43	2.63	5.79	2.94	80.07	100.8	27.9	11.7	22.04
6	0.94	2.35	1.94	5.7	0.64	47.14	56.54	16	6.35	28.67
7	0.3	1.28	0.12	5.06	0.94	13.81	21.16	4.8	1.86	9.03
8	0.17	0.43	0.24	2.73	0.3	11.77	24.64	4.8	-	4.99
9+	0.11	0.75	0.07	4.07	0.14	-	12.74	1.3	-	2.07
Abundance (millions)	170.8	160.36	97.9	111.33	82.6	274.06	485.29	202.9	105.41	266.85
Total Biomass (t)	23,762	21,048	11,062	8,867	10,300	41,700	71,253	27,770	14,222	44,611
SSB (t)	22,788	20,500	9,800	6,978	9,500	41,300	66,138	27,200	13,974	43,006
CV%	-	-	-	-	-	-	-	49%	44%	34%

Table 6.3.1.1. VIa(S) & VIIb,c herring. Details of all acoustic surveys conducted on this stock.

Year	Type	Biomass	SSB
1994	Feeding phase	-	353,772
1995	Feeding phase	137,670	125,800
1996	Feeding phase	34,290	12,550
1997	-	-	-
1998	-	-	-
1999	Autumn spawners	23,762	22,788
2000	Autumn spawners	21,000	20,500
2001	Autumn spawners	11,100	9,800
2002	Winter spawners	8,900	7,200
2003	Winter spawners	10,300	9,500
2004	Winter spawners	41,700	41,399
2005	Winter spawners	71,253	66,138
2006	Winter spawners	27,770	27,200
2007	Winter spawners	14,222	13,974
2008	Feeding phase	44,611	43,006

Table 6.6.2.1. VIa(S) and VIIb,c herring VPA run with a terminal F value of 0.2

	RECRUITS 1r	SSB	LANDINGS	FBAR 3- 6
1970	417093	140605	20306	0.1657
1971	840935	124426	15044	0.1476
1972	757077	131141	23474	0.1897
1973	552443	170952	36719	0.2697
1974	613024	101218	36589	0.4213
1975	429689	108757	38764	0.4
1976	721943	76291	32767	0.4532
1977	613201	86458	20567	0.2851
1978	1125083	81511	19715	0.2362
1979	1051379	116899	22608	0.2411
1980	570237	113116	30124	0.3453
1981	724411	116812	24922	0.2691
1982	751807	128324	19209	0.1943
1983	2457128	125443	32988	0.3157
1984	1021733	205755	27450	0.1789
1985	1291478	208768	23343	0.1508
1986	983832	245176	28785	0.161
1987	3345049	216039	48600	0.3086
1988	493834	326252	29100	0.244
1989	728143	243615	29210	0.1663
1990	820249	210562	43969	0.2408
1991	506336	179979	37700	0.2281
1992	418367	143988	31856	0.2626
1993	618832	123326	36763	0.3426
1994	805939	102494	33908	0.352
1995	459748	86792	27792	0.4549
1996	836771	64258	32534	0.5724
1997	828177	65604	27225	0.524
1998	533601	53327	38895	1.0014
1999	394353	45801	26109	0.6778
2000	452821	38580	19846	0.5119
2001	469261	36058	14756	0.6012
2002	599118	35335	17826	0.6524
2003	524671	42274	16502	0.5788
2004	583779	46840	13727	0.4955
2005	713483	50420	16231	0.4536
2006	500380	55201	19193	0.5741
2007	263972	54762	17791	0.3596
2008	700934*	49554	13340	0.2797

*Geometric Mean 1970-2007

Table 6.6.2.2. VIa(S) and VIIbc herring VPA run using a terminal F or 0.4.

	RECRUITS 1-r	SSB	LANDINGS	FBAR 3- 6
1970	417326	140862	20306	0.1654
1971	841453	124662	15044	0.1474
1972	757630	131386	23474	0.1895
1973	552932	171346	36719	0.2694
1974	613642	101419	36589	0.4207
1975	430274	108999	38764	0.3993
1976	722986	76484	32767	0.4522
1977	614217	86687	20567	0.2843
1978	1127264	81744	19715	0.2356
1979	1053710	117235	22608	0.2403
1980	571486	113486	30124	0.3442
1981	725825	117262	24922	0.268
1982	753320	128806	19209	0.1936
1983	2461691	125985	32988	0.3144
1984	1023586	206468	27450	0.1782
1985	1293324	209441	23343	0.1502
1986	984980	245905	28785	0.1604
1987	3348270	216737	48600	0.3077
1988	494187	327031	29100	0.2433
1989	728464	244192	29210	0.1659
1990	820393	211061	43969	0.2403
1991	506311	180341	37700	0.2277
1992	418286	144268	31856	0.2623
1993	618669	123544	36763	0.3424
1994	805553	102652	33908	0.3519
1995	459268	86814	27792	0.4549
1996	835238	64232	32534	0.5727
1997	825120	65506	27225	0.5247
1998	529962	53101	38895	1.0047
1999	389351	45422	26109	0.6828
2000	444350	38015	19846	0.5183
2001	451666	35225	14756	0.6152
2002	559187	33858	17826	0.6786
2003	465517	39217	16502	0.6183
2004	482152	41591	13727	0.5528
2005	528908	41693	16231	0.5357
2006	315965	40098	19193	0.7612
2007	146590	33273	17791	0.5633
2008	**651814***	24241	13340	0.5477

***Geometric mean 1970-2007.**

Table 6.6.2.3 VIa(S) and VIIb,c herring VPA run using a terminal F or 0.5

	Recruitment 1r	SSB	Landings	FBAR 3- 6 r
1970	417413	140949	20306	0.1653
1971	841646	124741	15044	0.1473
1972	757833	131469	23474	0.1894
1973	553108	171482	36719	0.2693
1974	613860	101491	36589	0.4205
1975	430475	109085	38764	0.399
1976	723335	76554	32767	0.4519
1977	614550	86768	20567	0.284
1978	1127968	81825	19715	0.2354
1979	1054452	117349	22608	0.2401
1980	571879	113608	30124	0.3438
1981	726268	117410	24922	0.2677
1982	753791	128962	19209	0.1933
1983	2463112	126159	32988	0.314
1984	1024164	206694	27450	0.178
1985	1293903	209653	23343	0.1501
1986	985343	246133	28785	0.1602
1987	3349302	216956	48600	0.3074
1988	494302	327276	29100	0.243
1989	728577	244373	29210	0.1657
1990	820454	211219	43969	0.2402
1991	506319	180457	37700	0.2276
1992	418276	144359	31856	0.2622
1993	618643	123616	36763	0.3423
1994	805485	102706	33908	0.3519
1995	459177	86828	27792	0.4549
1996	834941	64232	32534	0.5727
1997	824524	65490	27225	0.5248
1998	529248	53058	38895	1.0053
1999	388366	45349	26109	0.6837
2000	442687	37906	19846	0.5196
2001	448252	35063	14756	0.618
2002	551525	33569	17826	0.6839
2003	454103	38625	16502	0.6267
2004	462124	40576	13727	0.5656
2005	491885	39988	16231	0.5554
2006	278765	37094	19193	0.8135
2007	123091	28963	17791	0.6344
2008	**643948***	19127	13340	0.6785

***Geometric mean 1970-2007.**

Table 6.6.2.4 VIa(S) and VIIb,c herring VPA run using a terminal F or 0.6

	RECRUITS 1-r	SSB	LANDINGS	FBAR 3- 6
1970	417192	140712	20306	0.1656
1971	841260	124520	15044	0.1475
1972	757549	131244	23474	0.1896
1973	552984	171147	36719	0.2696
1974	613840	101339	36589	0.421
1975	430568	108924	38764	0.3996
1976	723667	76457	32767	0.4523
1977	614967	86709	20567	0.2842
1978	1128975	81811	19715	0.2354
1979	1055574	117408	22608	0.24
1980	572472	113720	30124	0.3434
1981	726921	117565	24922	0.2672
1982	754448	129164	19209	0.1929
1983	2464955	126394	32988	0.3135
1984	1024870	207006	27450	0.1777
1985	1294575	209946	23343	0.1498
1986	985745	246441	28785	0.16
1987	3350412	217245	48600	0.307
1988	494425	327581	29100	0.2428
1989	728696	244594	29210	0.1656
1990	820524	211405	43969	0.24
1991	506334	180589	37700	0.2274
1992	418275	144460	31856	0.2621
1993	618631	123696	36763	0.3422
1994	805447	102766	33908	0.3518
1995	459122	86846	27792	0.4549
1996	834752	64238	32534	0.5728
1997	824137	65484	27225	0.5249
1998	528782	53032	38895	1.0056
1999	387718	45303	26109	0.6843
2000	441591	37835	19846	0.5204
2001	446012	34956	14756	0.6198
2002	546548	33380	17826	0.6875
2003	446693	38239	16502	0.6323
2004	448975	39914	13727	0.5744
2005	467312	38873	16231	0.5691
2006	253905	35112	19193	0.852
2007	107398	26098	17791	0.692
2008	**638235***	15697	13340	0.8072

***Geometric mean 1970-2007.**

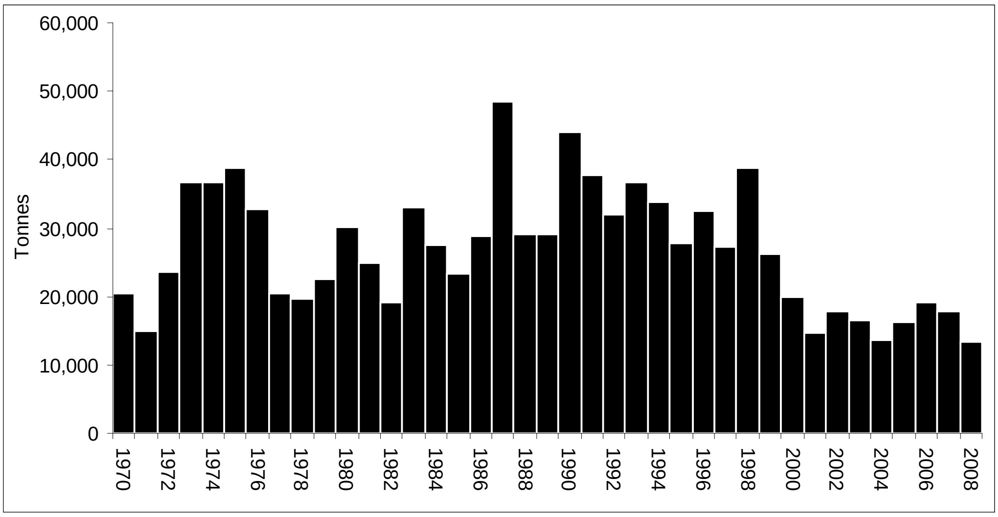


Figure 6.1.2.1. VIa(S) & VIIb,c herring. Working group estimate of catches from 1970-2008.

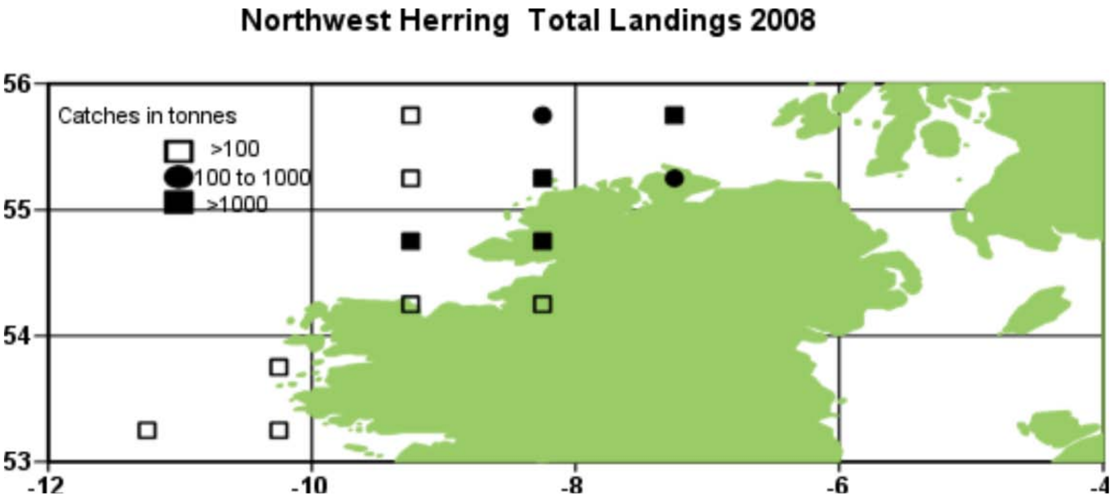


Figure 6.1.3.1. VIa(S) & VIIb,c herring, Herring landings by statistical rectangle in VIaS and VIIbc in 2008.

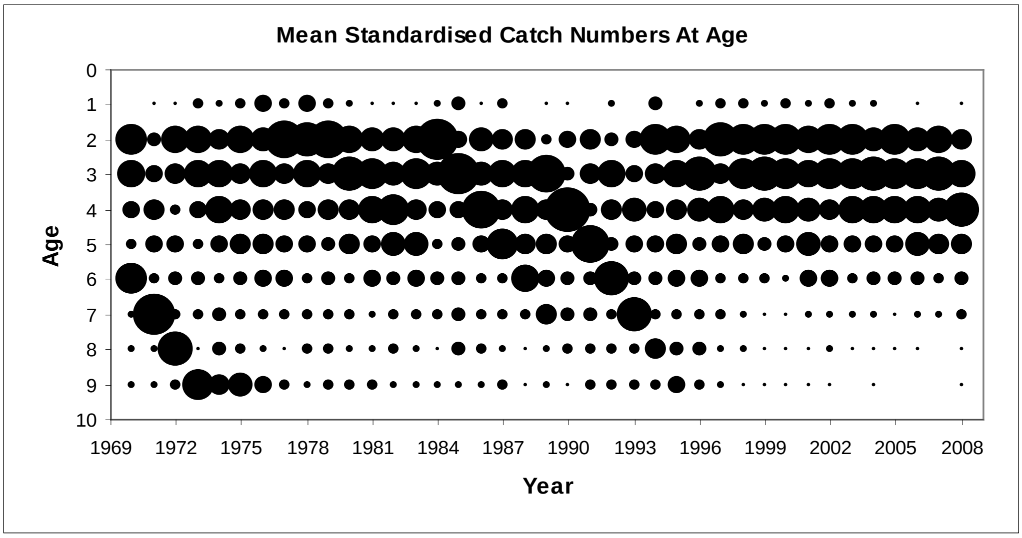


Figure 6.2.1.1 VIa(S) & Division VIIb,c herring. Mean standardised catch numbers at age standardised by year for the fishery. Numbers in thousands.

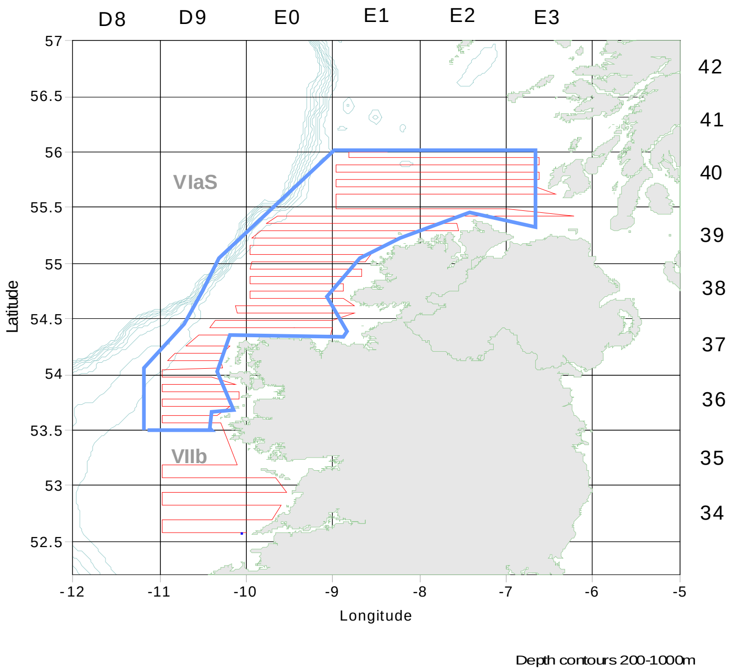


Figure 6.3.2.1. VIa(S) & Division VIIb,c herring. Survey track for acoustic survey conducted in July 2008, in stock area. Conducted as part of Malin Shelf stock complex survey.

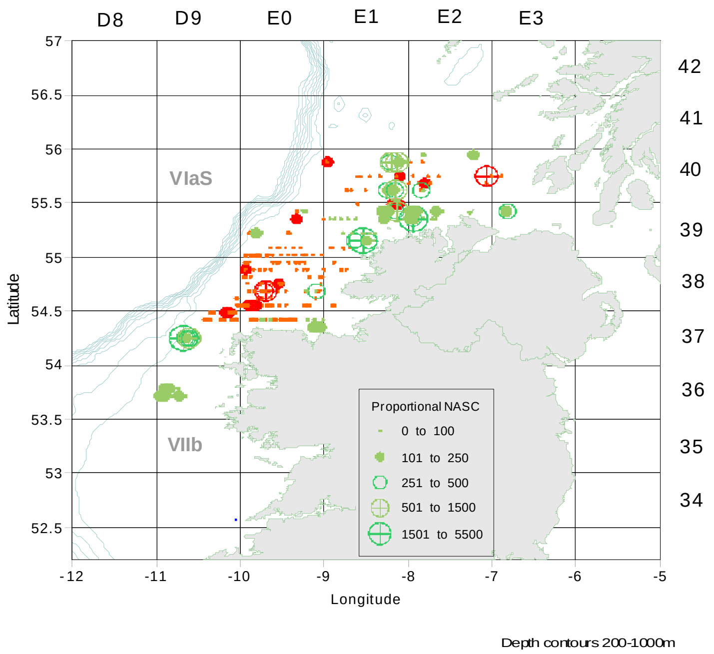


Figure 6.3.2.2. VIa(S) & Division VIIb,c herring. Total NASC (nautical area scattering coefficient) for herring in acoustic survey conducted in July 2008, in stock area. Conducted as part to mixed traces.

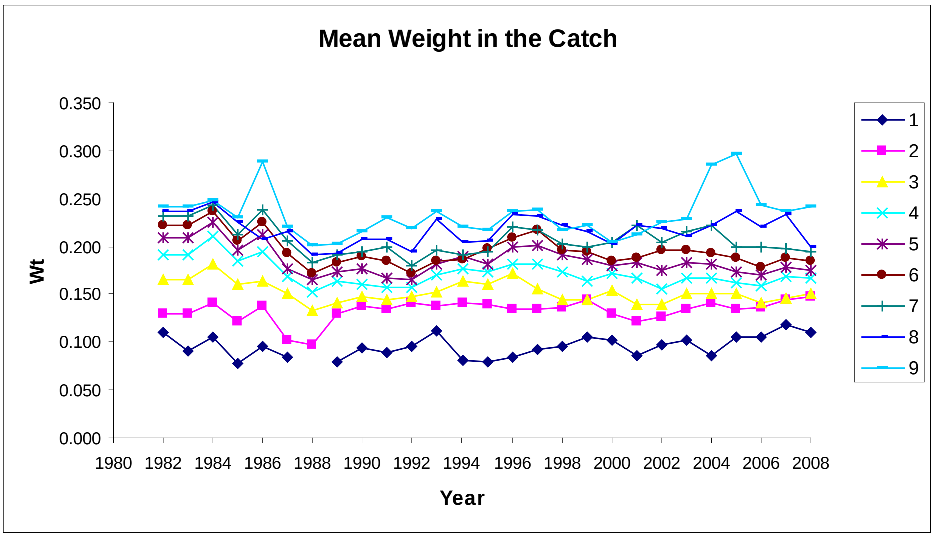


Figure 6.4.1.1 VIa(S) & Division VIIb,c herring. Mean Weights in the Catch (kg).

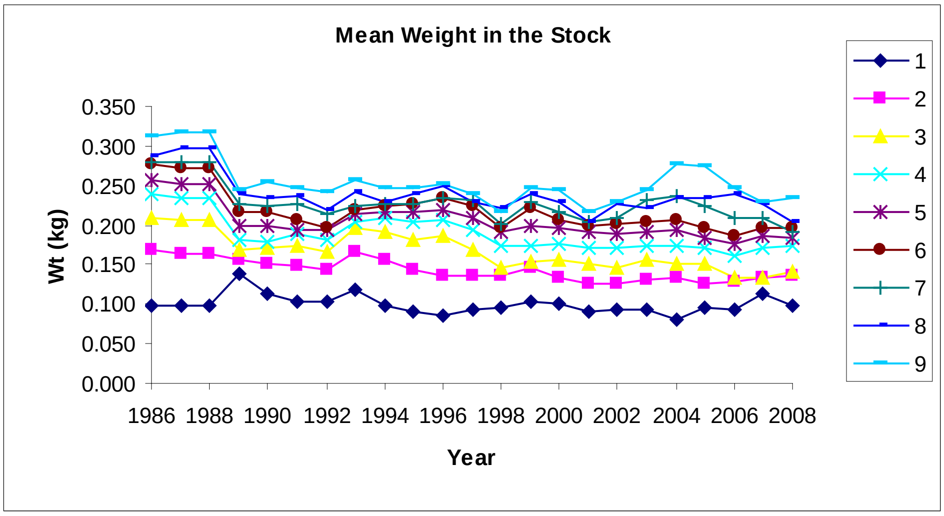


Figure 6.4.1.2 VIa(S) & Division VIIb,c herring. Mean weights in the stock (kg).

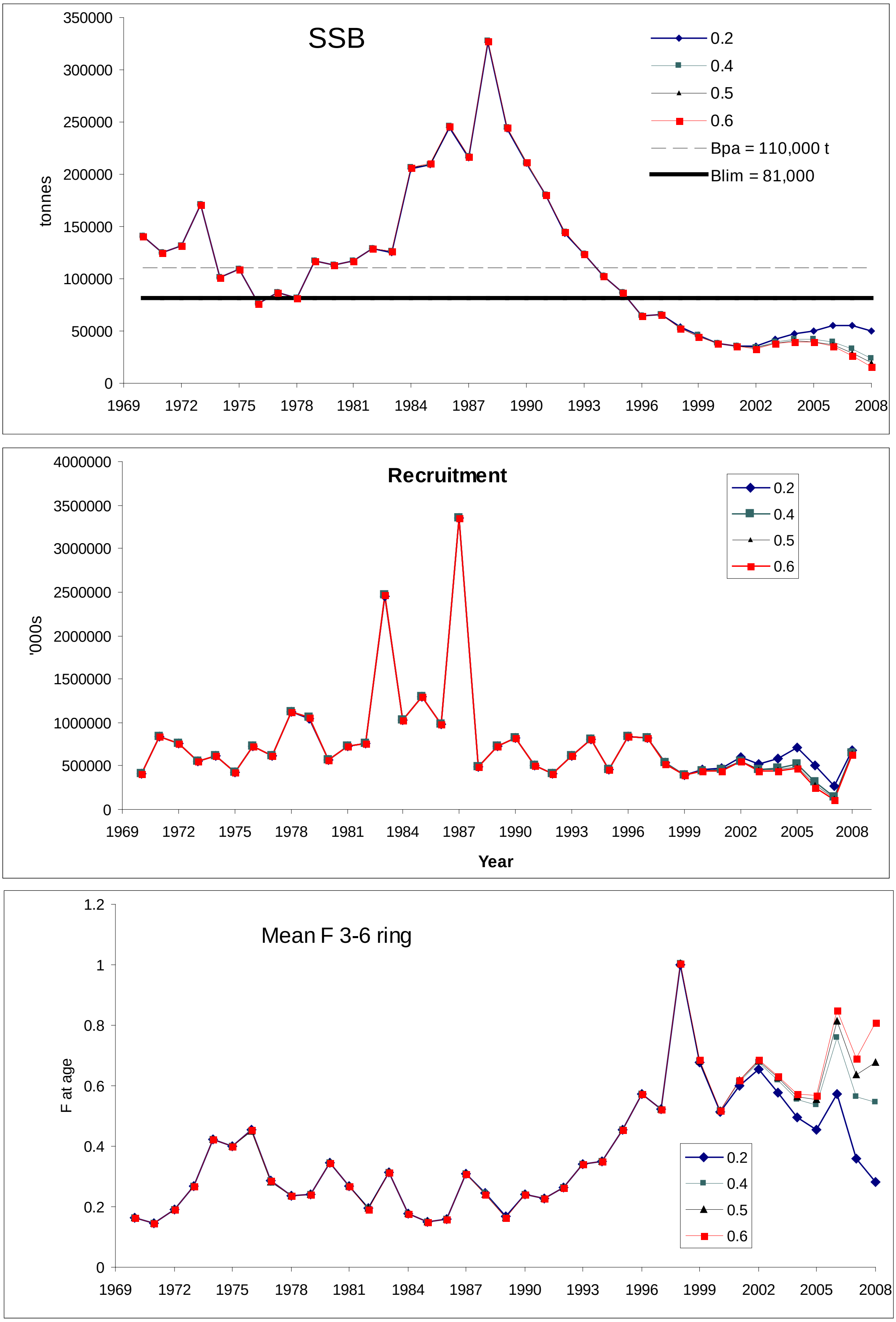


Figure 6.6.2.1. VIa(S) and VIIb,c four separable VPA runs using values of 0.2, 0.4, 0.5 and 0.6 for terminal F.

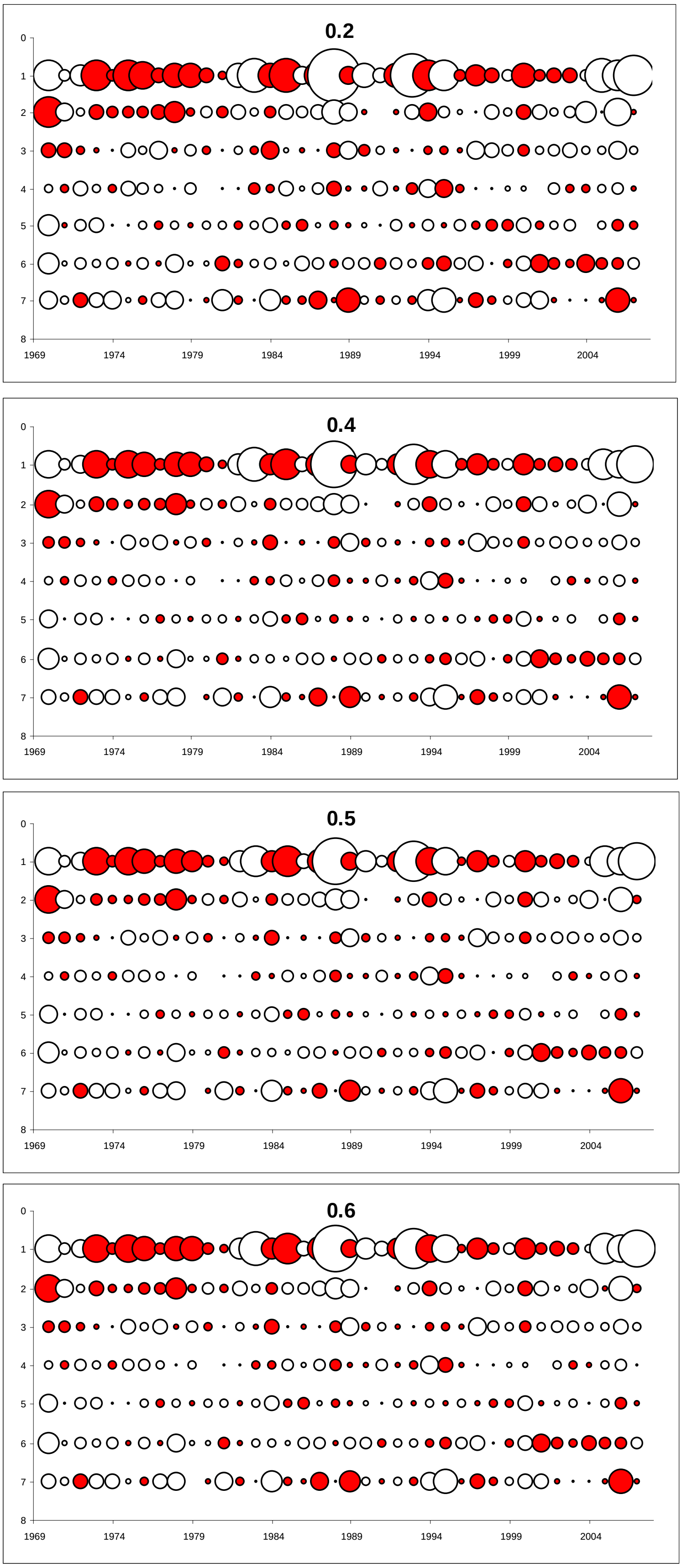


Figure 6.6.2.2. VIa(S) and VIIb,c herring – Residuals from three separable VPA runs using terminal F values of 0.2 , 0.4, 0.5 and 0.6 . Red indicates positive residuals and white indicates negative

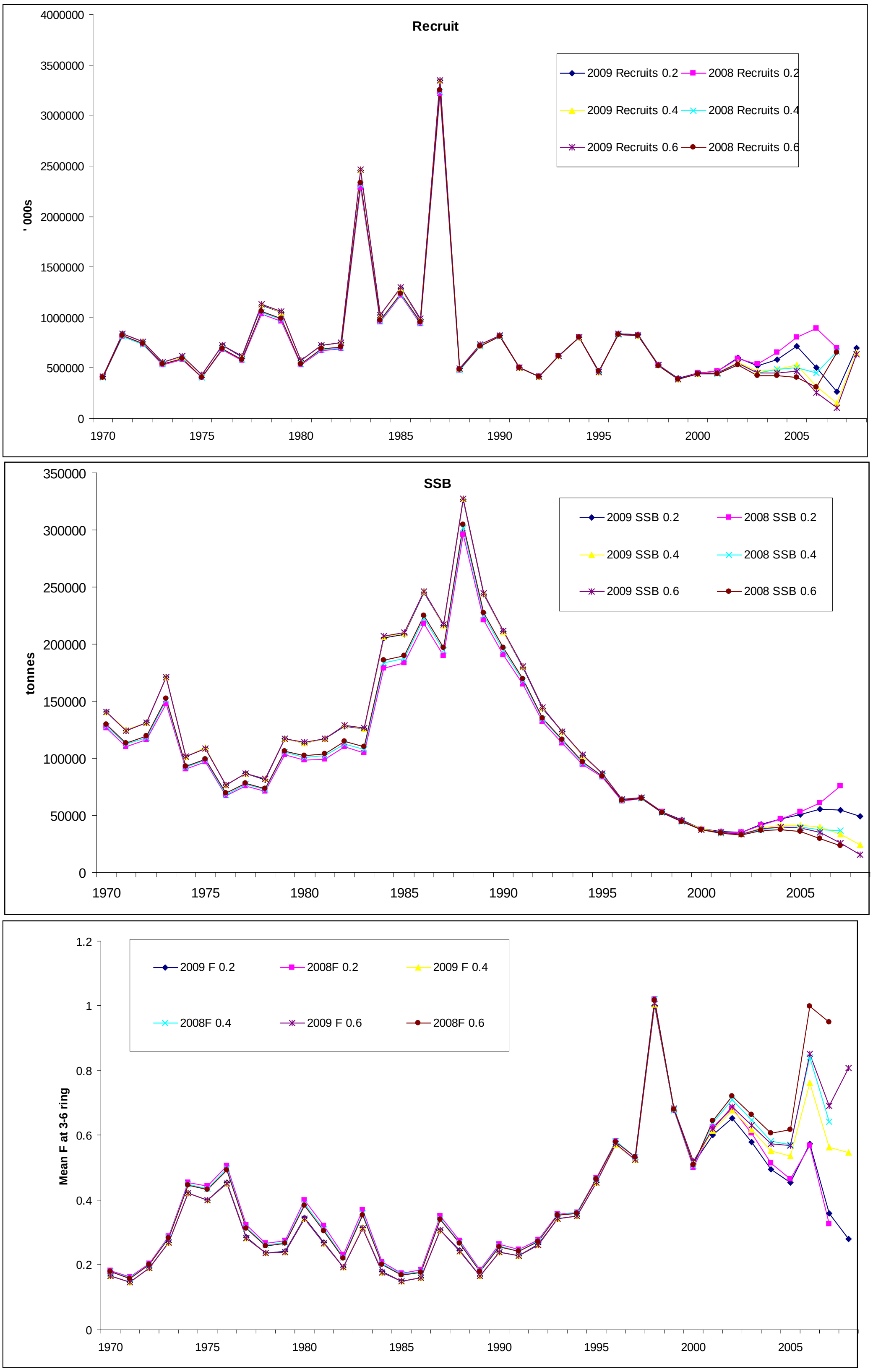
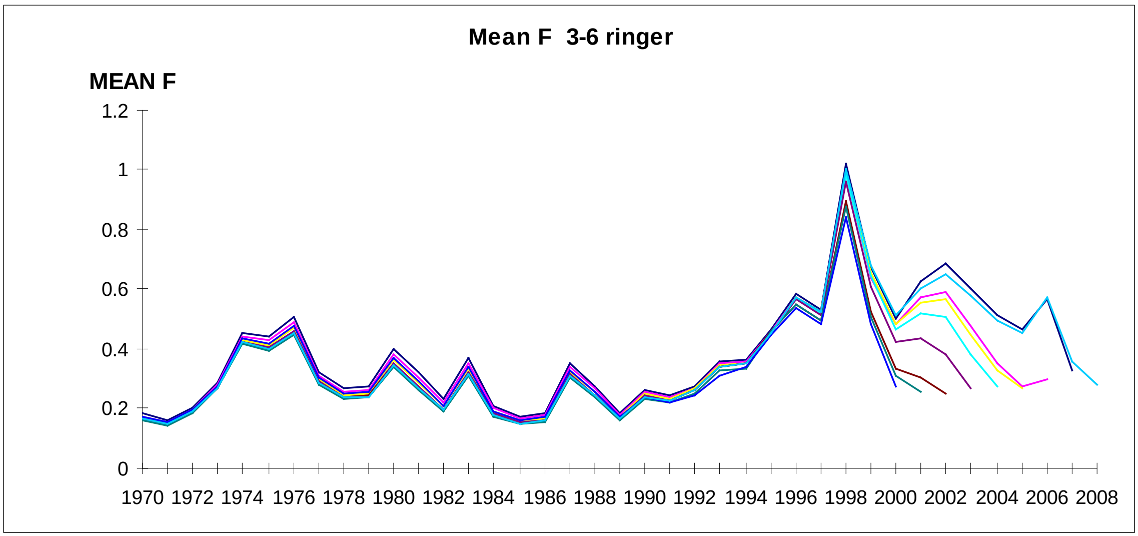
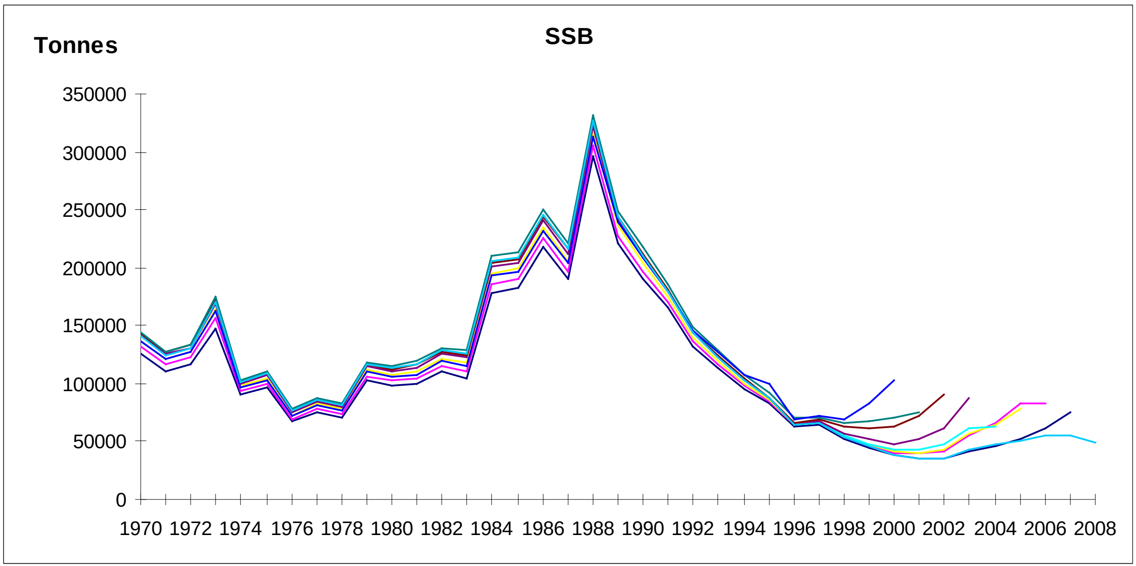


Figure 6.6.2.3. VIa(S) and VIIb,c herring. Comparison of four separable VPA runs of the current working group and the 2008 working group, using values of 0.2, 0.4 and 0.6 for terminal F.





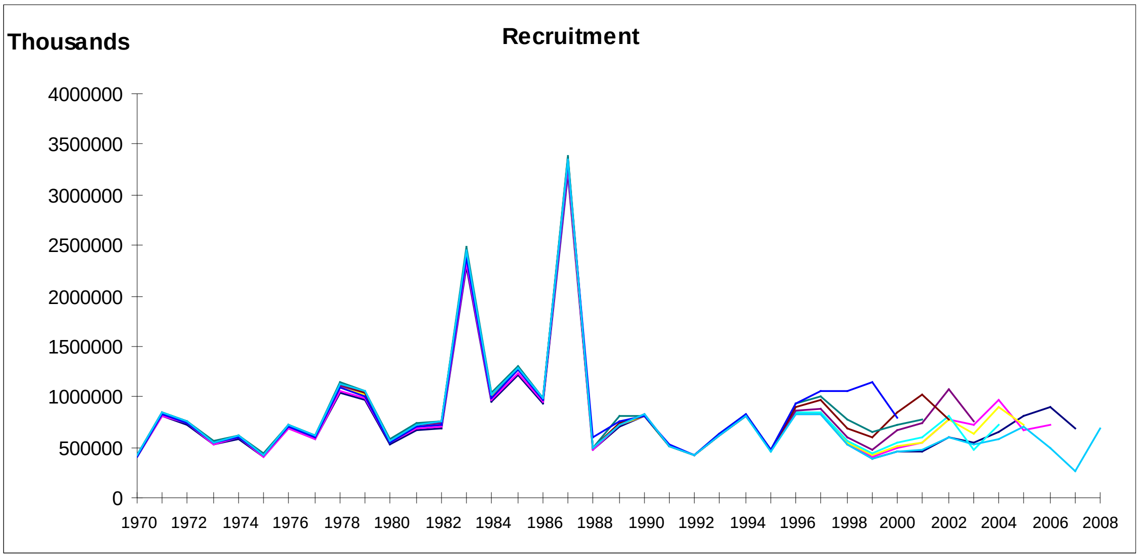


Figure 6.6.2.4. VIa(S) and VIIb,c herring Retrospective assessment using F=0.2.

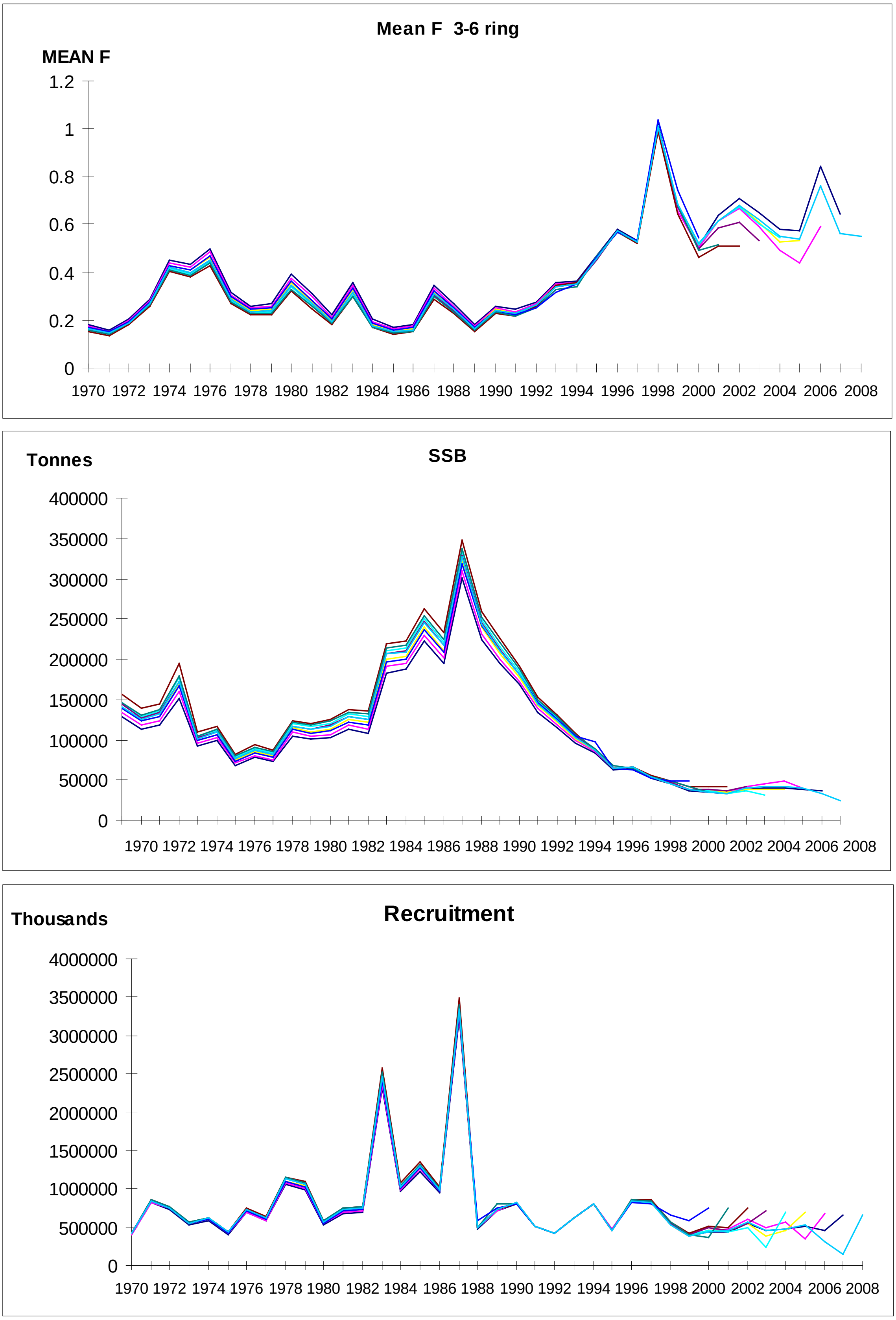


Figure 6.6.2.5. VIa(S) and VIIb,c herring Retrospective assessment using F=0.4.

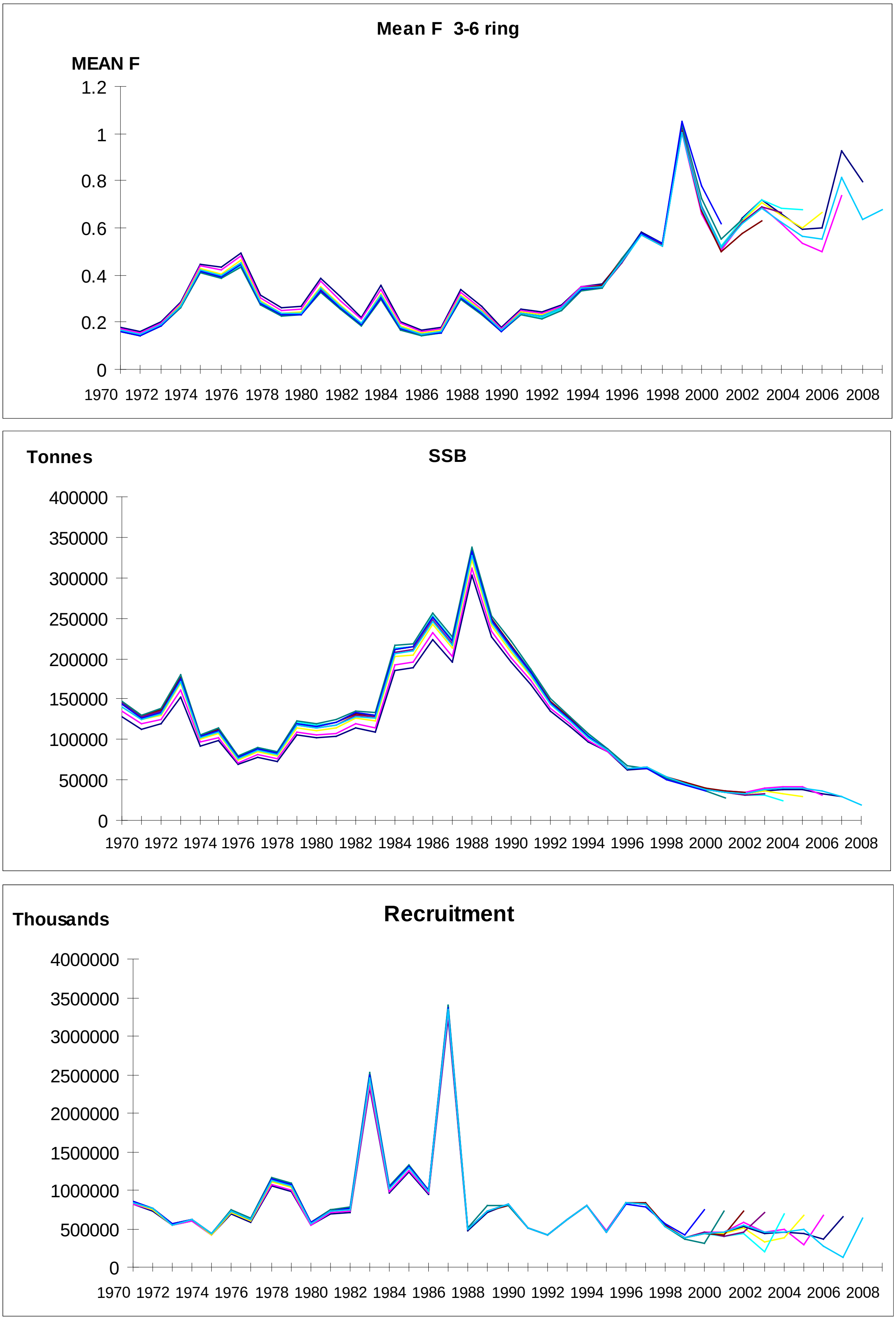


Figure 6.6.2.6 VIa(S) and VIIb,c herring Retrospective assessment using F=0.5.

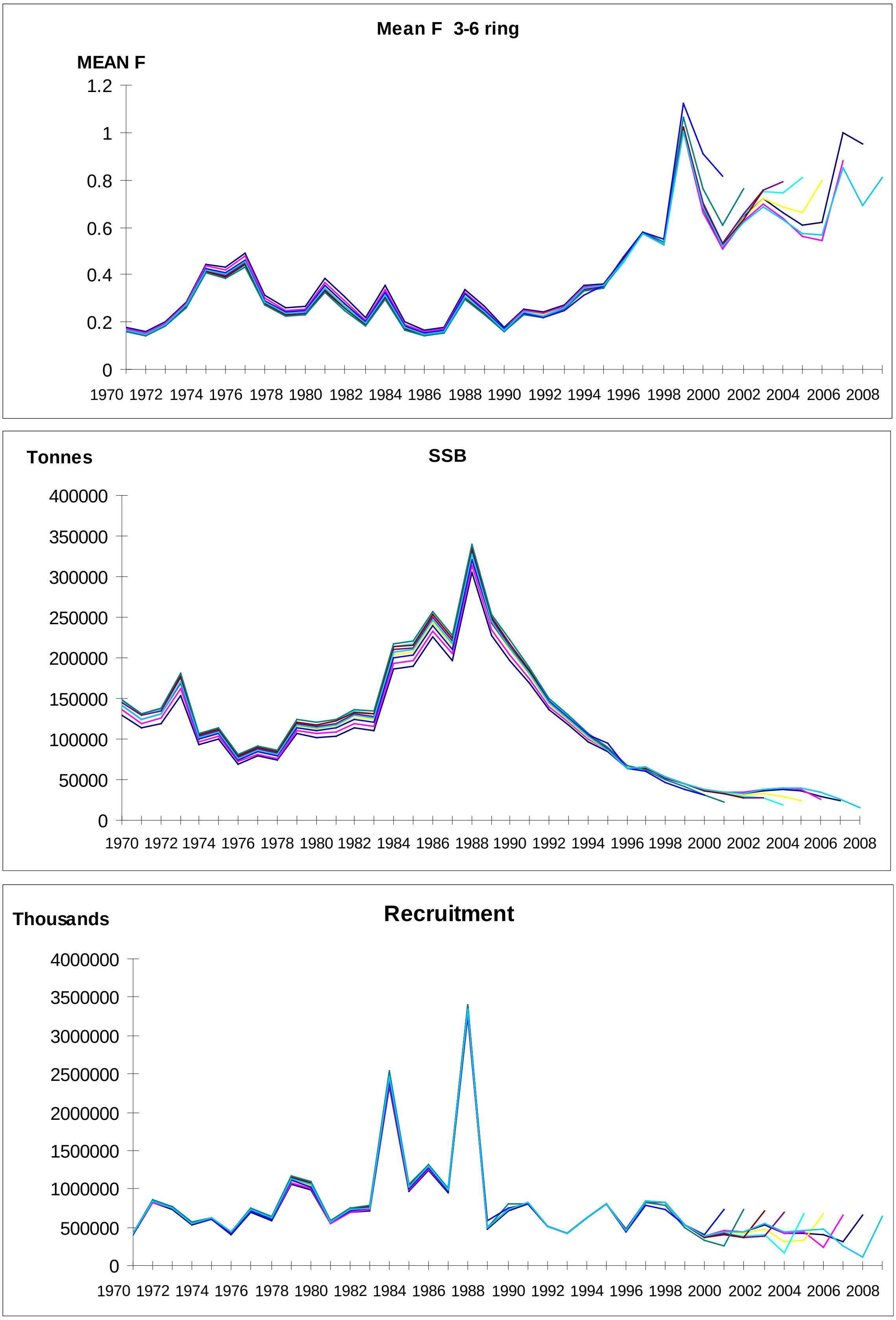


Figure 6.6.2.7. VIa(S) and VIIb,c herring Retrospective assessment using F=0.6.

7 Irish Sea Herring [Division VIIa (North)]

7.1 The Fishery

7.1.1 Advice and management applicable to 2008 and 2009

The WG did not present the results of a final assessment to ACOM in 2008 due to the findings of preliminary data explorations. These explorations suggest that conflicting year effects are present in the acoustic and catch-at-age data, contributing to the poor model fit in the separable period. Though the exact level of the stock was unclear from the analysis, the trends from a two-stage biomass model suggested that the stock remains relatively stable. Acoustic and catch-at-age data both provided possible indications that a strong year class had entered the stock.

ACOM subsequently advised that a TAC of 4 400 t, based on recent catches, be adopted for 2008. This advice was rejected in favour of a *status quo* TAC of 4 800 t, partitioned as 3 500 t to the UK and 1 250 t to the Republic of Ireland.

7.1.2 The fishery in 2008

The catches reported from each country for the period 1986 to 2008 are given in Table 7.1.1, and total catches from 1961 to 2008 in Figure 7.1.1. Reported international landings in 2008 for the Irish Sea amounted to 4 895 t with UK vessels acquiring extra quota through swaps with the Republic of Ireland. The majority of catches in 2008 were taken during the 3rd quarter.

The 2008 VIIa(N) herring fishery opened in August, with the majority of catches taken during August and September by a pair of UK pair trawlers. September through to December saw activity of the Mourne fishery, limited to boats under 40ft. This was the 3rd year of recorded landings for this fishery. In 2008 23 vessels recorded landings of ~153 t, the majority taken during October. The final take up of remaining TAC by the UK pair trawlers also took place during October.

7.1.3 Regulations and their effects

Closed areas for herring fishing in the Irish Sea along the east coast of Ireland and within 12 nautical miles of the west coast of Britain were maintained throughout the year. The traditional gillnet fishery on the Mourne herring, which has a derogation to fish within the Irish closed box, operated successfully again in 2008. The area to the east of the Isle of Man, encompassing the Douglas Bank spawning ground (described in ICES 2001, ACFM:10), was closed from 21st September to 15th November. Boats from the Republic of Ireland are not permitted to fish east of the Isle of Man.

The arrangement of closed areas in Division VIIa(N) prior to 1999 are discussed in detail in ICES (1996/ACFM:10) with a change to the closed area to the east of the Isle of Man being altered in 1999 (ICES 2001/ACFM:10). The closed areas consist of: all year juvenile closures along part of the east coast of Ireland, and the west coast of Scotland, England and Wales; spawning closures along the east coast of the Isle of Man from 21st September- 15th November, and along the east coast of Ireland all year round. The WG recommends that any alterations to the present closures be considered carefully, in the context of this report, to ensure protection for all components of this stock.

The TAC for VIIa(N) is partitioned as 3 500 t to the UK and 1 250 t to the Republic of Ireland.

7.1.4 Changes in fishing technology and fishing patterns

The fishery in area VIIa(N) has not changed in recent years. A pair of UK pair trawlers takes the majority of catches during the 3rd and 4th quarters. A small local fishery continues to record landings on the traditional Mourne herring grounds during the 4th quarter. This fishery has seen increasing catches of herring since 2006 with landings of ~20 t, ~33.5 t in 2007 and ~135 t in 2008.

7.2 Biological Composition of the Catch

7.2.1 Catch in numbers

Catches in numbers-at-age are given in Table 7.2.1 for the years 1972 to 2008 and a graphical representation is given in Figure 7.2.1. The predominant year class in 2008 landings was the 2-ringers followed by the 1-ringers. The catch in numbers at length is given in Table 7.2.2 for 1993 to 2008.

7.2.2 Quality of catch and biological data

There are no estimates of discarding or slippage in the Irish Sea fisheries that target herring. Discarding however is not thought to be a feature of this fishery. Biological sampling remains high for this fishery with all data in 2008 arising from AFBI, Northern Ireland. It should be noted however that the majority of samples are taken from only one fishing unit, the pair of UK vessels operating in the Irish Sea. 19 samples were processed for 2008 with 18 from the 3rd quarter fishery and 1 from the 4th quarter. Further details of sampling are given in Table 7.2.3.

7.2.3 Acoustic surveys

The information on the time-series of acoustic surveys in the Irish Sea is given in Table 7.2.4. As in the last year's assessment, the SSB estimates from the survey are calculated using the (annually varying) maturity ogives from the commercial catch data.

The acoustic survey in 2008 was carried out over the period 27 August to 14 September. A survey design of stratified, systematic transects was employed, as in previous years (Figure 7.2.2.A). The bulk of the acoustic scatter attributed to pelagic fish was identified as sprat, which were abundant around the periphery of the Irish Sea and to the north west of the Isle of Man (Figure 7.2.2.B). However in recent years the ratio of sprat to herring has been seen to increase in favour of the 0-group herring, a trend continued in 2008. 0-group herring were found to be most abundant to the east of the Isle of Man (Figure 7.2.3.B). 1+ herring targets were mostly distributed around the coasts of the Isle of Man (Figure 7.2.3.A). Further 1+ herring targets were found off the western Northern Irish coastline. In general, there are few samples on the age composition of the herring in the acoustic survey data. The survey followed the methods described in Armstrong *et al.*, (ICES 2005 WD 23). Sampling intensity was high during the 2008 survey with 27 successful trawls completed. The length frequencies generated from these trawls highlights the spatial heterogeneous nature of herring age groups in the Irish Sea (Figure 7.2.4)

As in previous years, no herring schools were detected in the area immediately north of the Isle of Man, despite an abundance of early-stage larvae in this area in November (Figure 7.2.5). It is possible that spawning in this area only commences after the acoustic survey.

The estimate of herring SSB of 77 172 t for 2008 is the highest estimate in the time series (Table 7.2.4). The approximate coefficient of variation (CV) of 0.23 is at the lower end of estimates associated with this survey. The biomass estimate of 106 921 t for 1+ ringers is the second highest estimate in the time series, whilst the approximate CV of 0.22 is also at the lower limits of this survey. The age-disaggregated acoustic estimates of the herring abundance, excluding 0-ring fish, is given in Table 7.2.5.

7.2.4 Larvae surveys

Northern Ireland undertook a herring larvae survey over the period 6th to 17th November 2008. The survey followed the methods and designs of previous surveys in the time-series (Annex 8). The production estimate for 2008 in the NE Irish Sea was a reduction on the previous year and below the time-series average (Table 7.2.6). As in previous years herring larvae were found to be most abundant to the south east and north east of the Isle of Man and less abundant in the western Irish Sea.

Of note was the low occurrence of larvae in the area of the traditional Mourne spawning ground, where last year larvae had been caught. Signs of the expansion of a spawning component in this area in recent years are evident from the fishery operating here. As such larvae would be expected in the area. The low occurrence of larvae caught during the survey may therefore suggest a timing mis-match between larvae emergence and sampling.

7.3 Mean weight, maturity and natural mortality-at-age

Mean weights-at-age in the 3rd quarter catches (for the whole time-series 1961 to present) have been used as estimates of stock weights at spawning time (Table 7.3.2). Maturity-at-age (in the catches) for each year (1961 to 2008) are given in Table 7.3.3. As in previous years, natural mortality per year was assumed to be 1.0 on 1-ringers, 0.3 for 2-ringers, 0.2 for 3-ringers and 0.1 for all older age classes (Annex 8). Mean weights-at-age have shown a general downward trend in the last 22 years.

7.4 Recruitment

An estimate of total abundance of 0-ringers and 1-ringers is provided by the Northern Ireland acoustic survey. However, there is evidence that a proportion of these are of Celtic Sea origin (Brophy and Danilowicz, 2002). Separation of the trawl catches of 0-groups into autumn and winter spawning components, based on otolith microstructure and shape analysis was presented to the working group in 2008 by Beggs *et al*. (ICES 2008 WD4). It is hoped that repeating this procedure annually could result in a survey index of recruitment for the Irish Sea stock that could be used directly in the assessment. Such an index may also be of use in the Celtic Sea assessment, as it would provide an estimate of juveniles resident in the Irish Sea originating from this management area.

7.5 Stock Assessment

7.5.1 Data exploration and preliminary modelling

2008 data were added to the Northern Irish larvae series (NINEL), the Northern Irish acoustic survey (total biomass, SSB and age-structured indices) and the catch-at-age data derived from the landings.

During the 2008 WG, comparisons between total mortality rates estimated from the acoustic and catch-at-age data highlighted a divergence in estimates. The acoustic survey was shown to have higher estimates of total mortality due to year effects in the LnCatch ratios at ages 2-7. This divergence was considered to be associated with the variation in migration of herring enter the spawning area of the Irish Sea.

An exploratory SPALY assessment in 2009 confirmed that problems concerning residual patterns in the separable period of ICA remain. Therefore the results of the run are not presented, as they are not considered reliable for SSB and F during the separable period.

2008 acoustic survey estimates suggest that SSB is at higher levels than at anytime in the 14 year time-series, while 1-ringer+ biomass is also high. Numbers-at-age in the acoustic survey suggest the strong 2005 year class (1-ringers in 2007) is still present in the survey area as 2-ringers. This year class was also observed in the acoustic survey as a high abundance of 0-groups in 2006. Microstructure analysis of the 0-group otoliths classified approx. 90% of these juveniles in the eastern Irish Sea as "autumn" spawners Beggs *et al.*, (ICES 2008 WD4). The 2005 strong year-class has now been tracked successfully over 3 years of the survey. Recruitment estimates of 0-group herring from the acoustic survey also remain high. The highest estimate of 0-group herring in the time-series was observed in 2008, with the majority of biomass found in the eastern Irish Sea. This area has historically been associated with autumn spawning juveniles.

The strong 2005 year class was not as evident in the catch-at-age data from the 2008 fishery. Catch-at-age data did confirm the presence of relative high proportions of 5 and 6-ringers as also observed in the acoustic numbers-at-age.

Results of a microstructure analysis of 1-ringer+ fish were presented to the WG (ICES 2009 WD01). The study shows that "winter" spawners, of which the majority are thought to be of Celtic Sea origin, are present in the pre-spawning aggregations sampled in the Irish Sea during the acoustic survey. As previously suggested these fish are present in high proportions as 1-ringers but were also found as 2 and 3-ringers in varying proportions. The presence of these "winter" spawners has major implications for the estimates of 1-ringer+ biomass and SSB, as well as confounding traditional cohort type assessment methods, such as ICA.

7.5.2 Two-stage biomass model

In 2009 it was decided not to run the model in light of the SALY status of the stock assessment (see Annex 8).

7.5.3 Conclusion to explorations

The exploratory analysis to date suggests that the current configuration of ICA is unsuitable as an assessment method for the Irish Sea stock. Exploration of proportion-at-age data in 2007 suggests that conflicting year effects were present in the acoustic and catch-at-age data. These conflicting signals were contributing to the poor model fit in the separable period as shown by the large year residuals. In 2008 comparisons of the total mortality rates estimated from the acoustic and catch-at-age data suggested a conflicting signal with divergence in the estimates. Extensive mixing between fish of different seasonal origins during the acoustic survey introduces further residuals during the separable period. As a consequence of these effects recent estimates of SSB and F are unreliable, although trends in SSB and F during the converged period of the VPA are considered reliable.

Number-at-age data reveal the high portions of 1-and 2-ringers in the stock. The presence of the high numbers of 2-ringers currently in the stock can be substantiated by the strong recruitment event observed in 2005. This evidence suggests that a large year class is present in the fishery. The results of the microstructure study presented to the group suggest that Celtic Sea winter spawners are present in considerable numbers in the Irish Sea during the acoustic survey and fishery. The use of stock identity techniques to quantify their proportions at age is recommended.

7.5.4 Stock assessment

From the exploratory analysis it was considered that the current configuration of ICA is unsuitable for the assessment of this stock and therefore no runs are presented.

7.6 Stock and Catch Projection

7.6.1 Deterministic short-term predictions

The Working Group decided that there was no basis for undertaking short-term predictions of stock size.

7.6.2 Yield-per-recruit

The Working Group decided that there was no basis for yield-per-recruit analysis.

7.7 Medium-term predictions of stock size

The Working Group decided that there was no basis for undertaking medium-term projections of stock size.

7.8 Reference points

The estimation of $\mathbf{B}_{pa}$ (9 500 t) and $\mathbf{B}_{lim}$ (6 000 t) were not revisited this year. There were no new points to add to the discussions and deliberations presented in 2000 (ICES 2000/ACFM:12). There is no precautionary F value for this stock.

7.9 Quality of the assessment

An assessment of the stock was not conducted in 2009 in light of the exploratory analysis and the SALY (same advice as last year) status.

7.10 Management considerations

Given the historical landings from this stock and the knowledge that fishing pressure is mostly confined to one pair of UK vessels it can be assumed that fishing pressure and activity has not varied considerably in recent years. The catches have been close to TAC levels and the main fishing activity has not varied considerably as shown from landing data (Figure 7.1.1).

Acoustic data indicate that a strong year class may be present in the stock. Recent estimates of 0-group herring biomass suggest continued strong recruitment. The growth of the Mourne fishery suggests that this stock or sub-component is under a state of expansion. The acoustic survey provides estimates of numbers-at-age, however the 1 to 3-ringers in the area are a mixture of at least two adjacent stocks (Celtic Sea and VIIa(N))(Beggs *et al.*, ICES 2009 WD01). Splitting of numbers-at-age into separate spawning components, based on otolith techniques could result in estimates more appropriate for the Irish Sea assessment.

Therefore the maintenance of catch levels at current levels 4 800 t, in the short-term, is considered precautionary.

A review of the model (ICA) configuration currently employed in the assessment of this stock is considered in light of the knowledge concerning the dynamics of this stock. The management and assessment of this stock is currently being evaluated under SGHERWAY.

7.11 Environment

7.11.1 Ecosystem Considerations

No additional information presented (see Annex 8)

7.11.2 Changes in Environment

No additional information presented (see Annex 8)

Table 7.1.1 Irish Sea Herring Division VIIa(N). Working group catch estimates in tonnes by country, 1987-2008. The total catch does not in all cases correspond to the official statistics and cannot be used for management purposes.

COUNTRY	1987	1988	1989	1990	1991	1992	1993	1994	1995
Ireland	1 200	2 579	1 430	1 699	80	406	0	0	0
UK	3 290	7 593	3 532	4 613	4 318	4 864	4 408	4 828	5 076
Unallocated	1 333	-	-	-	-	-	-	-	-
Total	5 823	10 172	4 962	6 312	4 398	5 270	4 408	4 828	5 076

Country	1996	1997	1998	1999	2000	2001	2002	2003	2004
Ireland	100	0	0	0	0	862	286	0	749
UK	5 180	6 651	4 905	4 127	2 002	4 599	2 107	2 399	1 782
Unallocated	22	-	-	-	-	-		-	-
Total	5 302	6 651	4 905	4 127	2 002	5 461	2 393	2 399	2 531

Country	2005	2006	2007	2008
Ireland	1 153	581	0	0
UK	3 234	3821	4 629	4895
Unallocated	-	-		
Total	4 387	4 402	4 629	4895

Table 7.2.1 Irish Sea Herring Division VIIa(N). Catch-at-age (thousands) by year.

	Age (rings)							
Year	1	2	3	4	5	6	7	8+
1972	40640	46660	26950	13180	13750	6760	2660	1670
1973	42150	32740	38240	11490	6920	5070	2590	2600
1974	43250	109550	39750	24510	10650	4990	5150	1630
1975	33330	48240	39410	10840	7870	4210	2090	1640
1976	34740	56160	20780	15220	4580	2810	2420	1270
1977	30280	39040	22690	6750	4520	1460	910	1120
1978	15540	36950	13410	6780	1740	1340	670	350
1979	11770	38270	23490	4250	2200	1050	400	290
1980	5840	25760	19510	8520	1980	910	360	230
1981	5050	15790	3200	2790	2300	330	290	240
1982	5100	16030	5670	2150	330	1110	140	380
1983	1305	12162	5598	2820	445	484	255	59
1984	1168	8424	7237	3841	2221	380	229	479
1985	2429	10050	17336	13287	7206	2651	667	724
1986	4491	15266	7462	8550	4528	3198	1464	877
1987	2225	12981	6146	2998	4180	2777	2328	1671
1988	2607	21250	13343	7159	4610	5084	3232	4213
1989	1156	6385	12039	4708	1876	1255	1559	1956
1990	2313	12835	5726	9697	3598	1661	1042	1615
1991	1999	9754	6743	2833	5068	1493	719	815
1992	12145	6885	6744	6690	3256	5122	1036	392
1993	646	14636	3008	3017	2903	1606	2181	848
1994	1970	7002	12165	1826	2566	2104	1278	1991
1995	3204	21330	3391	5269	1199	1154	926	1452
1996	5335	17529	9761	1160	3603	780	961	1364
1997	9551	21387	7562	7341	1641	2281	840	1432
1998	3069	11879	3875	4450	6674	1030	2049	451
1999	1810	16929	5936	1566	1477	1989	444	622
2000	1221	3743	5873	2065	558	347	251	147
2001	2713	11473	7151	13050	3386	936	650	803
2002	179	9021	1894	1866	2395	953	474	343
2003	694	4694	3345	2559	882	2945	872	605
2004	3225	8833	5405	2161	623	213	673	127
2005	8692	13980	10555	3287	1422	415	292	368
2006	5669	15253	8198	6318	1325	605	262	246
2007	20290	18291	4980	1655	1062	325	122	111
2008	8939	18974	7487	2696	2082	1761	328	216

Table 7.2.2 Irish Sea Herring Division VIIa(N). Catch at length data 1993-2008. Numbers of fish in thousands. Table amended with 1990-1992 year-classes removed (see Annex 8).

LENGTH	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
14																
14.5																
15																
15.5							10								16	
16			21	21	17		19	12	9					2		
16.5			55	51	94		53	49	27			13	1	44	33	1
17		84	139	127	281	26	97	67	53			25	39	140	69	3
17.5		59	148	200	525	30	82	97	105			84	117	211	286	11
18		69	300	173	1022	123	145	115	229			102	291	586	852	34
18.5		89	280	415	1066	206	135	134	240	36		114	521	726	2088	64
19	39	226	310	554	1720	317	234	164	385	18		203	758	895	2979	85
19.5	75	241	305	652	1263	277	82	97	439	0	29	269	933	1246	3527	108
20	75	253	326	749	1366	427	218	109	523	0	73	368	943	984	3516	100
20.5	57	270	404	867	1029	297	242	85	608	18	215	444	923	1443	2852	133
21	130	400	468	886	1510	522	449	115	1086	307	272	862	1256	1521	3451	192
21.5	263	308	782	1258	1192	549	362	138	1201	433	290	1007	1380	1621	2929	217
22	610	700	1509	1530	2607	1354	1261	289	1748	1750	463	1495	1361	2748	3821	271
22.5	1224	785	2541	2190	2482	1099	2305	418	1763	1949	600	2140	1448	3629	3503	229
23	2016	1035	4198	2362	3508	2493	4784	607	2670	2490	1158	2089	1035	4358	4196	322
23.5	2368	1473	4547	2917	3902	2041	4183	951	2254	1552	1380	2214	1256	2920	3697	264
24	2895	2126	4416	3649	4714	3695	4165	1436	3489	1029	1273	2054	1276	3679	3178	259
24.5	2616	2564	3391	4077	4138	2769	3397	1783	4098	758	1249	2269	1083	2431	2136	204
25	2207	3315	3100	4015	5031	2625	2620	2144	5566	776	1163	1749	1086	3438	1503	148
25.5	2198	3382	2358	3668	3971	2797	1817	1791	4785	1335	1211	1206	584	2198	952	114
26	2216	3480	2334	2480	3871	3115	1694	1349	3814	1570	1140	823	438	1714	643	78
26.5	2176	2617	1807	2177	2455	2641	1547	840	2243	1552	1573	587	203	605	330	42
27	2299	2391	1622	1949	1711	2992	1475	616	1489	776	1607	510	165	445	147	23
27.5	2047	1777	990	1267	1131	1747	867	479	644	433	1189	383	60	155	72	10
28	1538	1294	834	906	638	1235	276	212	496	162	726	198	45	104	33	12
28.5	944	900	123	564	440	170	169	58	179	108	569	51	18	9	26	1
29	473	417	248	210	280	111	61	42	10	36	163		12	46		
29.5	160	165	56	79	59	92		12	0	36	129				7	
30	83	9	40	32	8	84		6	9		43					
30.5	15	27	5	0	5	3					43					
31	4		1	2							43					
31.5																
32																
32.5																
33																
33.5																
34																

Table 7.2.3 Irish Sea Herring Division VIIa(N). Sampling intensity of commercial landings in 2008.

Quarter	Country	Landings (t)	No. samples	No. fish measured	No. fish aged
1	Ireland	0	-	-	-
	UK (N. Ireland)	0.095	0	0	0
	UK (Isle of Man)	0	-	-	-
	UK (Scotland)	0	-	-	-
	UK (England & Wales)	0	-	-	-
2	Ireland	0	-	-	-
	UK (N. Ireland)	0	-	-	-
	UK (Isle of Man)	*	-	-	-
	UK (Scotland)	0	-	-	-
	UK (England & Wales)	0	-	-	-
3	Ireland	0	-	-	-
	UK (N. Ireland)	4131	18	2790	888
	UK (Isle of Man)	*	-	-	-
	UK (Scotland)	0	-	-	-
	UK (England & Wales)	0	-	-	-
4	Ireland	0	-	-	-
	UK (N. Ireland)	764	1	135	50
	UK (Isle of Man)	*	-	-	-
	UK (Scotland)	0	-	-	-
	UK (England & Wales)	0	-	-	-

*** no information, but catch is likely to be negligible**

Table 7.2.4 Irish Sea Herring Division VIIa(N). Summary of acoustic survey information for the period 1989-2008. Small clupeoids include sprat and 0-ring herring unless otherwise stated. CVs are approximate. Biomass in t. All surveys carried out at 38kHz except December 1996, which was at 120kHz.

YEAR	AREA	DATES	HERRING BIOMASS	CV	HERRING BIOMASS	CV	SMALL CLUPEOIDS	CV
			(1+years)		(SSB)		biomass	
1989	Douglas Bank	25/09-26/09			18,000	-	-	-
1990	Douglas Bank	26/09-27/09			26,600	-	-	-
1991	W. Irish Sea	26/07- 8/08	12,760	0.23			66,000[1]	0.20
1992	W. Irish Sea + IOM E. coast	20/07-31/07	17,490	0.19			43,200	0.25
1994	Area VIIa(N)	28/08 – 8/09	31,400	0.36	25,133	-	68,600	0.10
	Douglas Bank	22/09-26/09			28,200	-	-	-
1995	Area VIIa(N)	11/09-22/09	38,400	0.29	20,167	-	348,600	0.13
	Douglas Bank	10/10-11/10		-	9,840	-	-	-
	Douglas Bank	23/10-24/10			1,750	0.51	-	-
1996	Area VIIa(N)	2/09-12/09	24,500	0.25	21,426	0.25	-[2]	-
1997	Area VIIa(N)-reduced	8/09-12/09	20,100	0.28	10,702	0.35	46,600	0.20
1998	Area VIIa(N)	8/09-14/09	14,500	0.20	9,157	0.18	228,000	0.11
1999	Area VIIa(N)	6/09-17/09	31,600	0.59	21,040	0.75	272,200	0.10
2000	Area VIIa(N)	11/09-21/09	40,200	0.26	33,144	0.32	234,700	0.11
2001	Area VIIa(N)	10/09-18/09	35,400	0.40	13,647	0.42	299,700	0.08
2002	Area VIIa(N)	9/09-20/09	41,400	0.56	25,102	0.83	413,900	0.09
2003	Area VIIa(N)	7/09-20/09	49,500	0.22	24,390	0.24	265,900	0.10
2004	Area VIIa(N)	6/09-10/09, 15/09-16/09, 28/09-29/09	34,437	0.41	21,593	0.41	281,000	0.07
2005	Area VIIa(N)	29/08 -14/09	36,866	0.37	31,445	0.42	141,900	0.10
2006	Area VIIa(N)	30/08 – 9/09	33,136	0.24	16,332	0.22	143,200	0.09
2007	Area VIIa(N)	29/08 - 13/09	120,878	0.53	51,819	0.42	204,700	0.09
2008	Area VIIa(N)	27/08 – 14/09	106,921	0.22	77,172	0.23	252,300	0.12

[1] sprat only; [2]Data can be made available for the IoM waters only

Table 7.2.5 Irish Sea Herring Division VIIa(N). Age-disaggregated acoustic estimates (thousands) of herring abundance from the Northern Ireland surveys in September (ACAGE).

AGE (RINGS)	1	2	3	4	5	6	7	8+
1994	66.8	68.3	73.5	11.9	9.3	7.6	3.9	10.1
1995	319.1	82.3	11.9	29.2	4.6	3.5	4.9	6.9
1996	11.3	42.4	67.5	9	26.5	4.2	5.9	5.8
1997	134.1	50	14.8	11	7.8	4.6	0.6	1.9
1998	110.4	27.3	8.1	9.3	6.5	1.8	2.3	0.8
1999	157.8	77.7	34	5.1	10.3	13.5	1.6	6.3
2000	78.5	103.4	105.3	27.5	8.1	5.4	4.9	2.4
2001	387.6	93.4	10.1	17.5	7.7	1.4	0.6	2.2
2002	391	71.9	31.7	24.8	31.3	14.8	2.8	4.5
2003	349.2	220	32	4.7	3.9	4.1	1	0.9
2004	241	115.5	29.6	15.4	2.1	2.3	0.2	0.2
2005	94.3	109.9	97.1	17	8	0.8	0.6	5.8
2006	374.7	96.6	15.6	10.0	0.5	0.4	0.5	0.5
2007	1316.7	251.3	46.6	21.1	20.8	1.2	0.7	0.6
2008	475.7	452.4	114.2	39.1	26.4	17.1	4.3	0.6

Table 7.2.6 Irish Sea Herring Division VIIa(N). Larval production (10^{11}) indices for the Manx component. Table amended with Douglas Bank time series removed (see Annex 8).

YEAR	Northeast Irish Sea					
		Isle of Man			Northern Ireland	
	Date	Production	SE	Date	Production	CV
1989	-	-	-	-	-	-
1990	-	-	-	-	-	-
1991	-	-	-	-	-	-
1992	20 Nov	128.9	-	-	-	-
1993	22 Nov	1.1	-	17 Nov	38.3	0.48
1994	24 Nov	12.5	-	16 Nov	71.2	0.12
1995	-	-	-	28 Nov	15.1	0.62
1996	26 Nov	0.3	-	19 Nov	4.7	0.30
1997	1 Dec	35.9	-	4 Nov	29.1	0.11
1998	1 Dec	3.5	-	3 Nov	5.8	1.02
1999	-	-	-	9 Nov	16.7	0.57
2000	-	-	-	11 Nov	35.5	0.12
2001	11 Dec	198.6	-	7 Nov	55.3	0.55
2002	6 Dec	19.8	-	4 Nov	31.5	0.47
2003	-	-	-	9 Nov	15.8	0.58
2004	-	-	-	30 Oct	22.7	0.48
2005	-	-	-	6 Nov	26.4*	0.57
2006	-	-	-	6 Nov	43.8	0.70
2007	-	-	-	6 Nov	12.6	0.67
2008	-	-	-	6 Nov	16.8	0.98

SE = Standard Error *2005 Index value amended

Table 7.3.2 Irish Sea Herring Division VIIa(N). Mean weights-at-age in the catch.

Year	Weights-at-age (g) Age (rings)							
	1	2	3	4	5	6	7	8+
1985	87	125	157	186	202	209	222	258
1986	68	143	167	188	215	229	239	254
1987	58	130	160	175	194	210	218	229
1988	70	124	160	170	180	198	212	232
1989	81	128	155	174	184	195	205	218
1990	77	135	163	175	188	196	207	217
1991	70	121	153	167	180	189	195	214
1992	61	111	136	151	159	171	179	191
1993	88	126	157	171	183	191	198	214
1994	73	126	154	174	181	190	203	214
1995	72	120	147	168	180	185	197	212
1996	67	116	148	162	177	199	200	214
1997	64	118	146	165	176	188	204	216
1998	80	123	148	163	181	177	188	222
1999	69	120	145	167	176	188	190	210
2000	64	120	148	168	188	204	200	213
2001	67	106	139	156	168	185	198	205
2002	85	113	144	167	180	184	191	217
2003*	81	116	136	160	167	172	186	199
2004	73	107	130	157	165	187	200	205
2005	67	103	136	156	166	180	191	209
2006	64	105	131	149	164	177	184	211
2007	67	112	135	158	173	183	199	227
2008	71	110	135	153	156	182	196	206

*** Average for the preceding five years**

Table 7.3.3 Irish Sea Herring Division VIIa(N). Maturity ogive (maturity in the catch).

YEAR	AGE (RINGS)							
	1	2	3	4	5	6	7	8+
1961	0.00	0.22	0.63	1.00	1.00	1.00	1.00	1.00
1962	0.00	0.24	0.83	0.92	1.00	1.00	1.00	1.00
1963	0.00	0.34	0.88	0.89	1.00	1.00	1.00	1.00
1964	0.00	0.53	0.81	1.00	1.00	1.00	1.00	1.00
1965	0.00	0.61	0.90	1.00	1.00	1.00	1.00	1.00
1966	0.00	0.47	0.91	1.00	1.00	1.00	1.00	1.00
1967	0.02	0.37	0.75	0.83	1.00	1.00	1.00	1.00
1968	0.00	0.88	0.94	0.94	1.00	1.00	1.00	1.00
1969	0.00	0.71	0.92	0.94	1.00	1.00	1.00	1.00
1970	0.02	0.92	0.94	0.96	1.00	1.00	1.00	1.00
1971	0.15	0.87	0.97	0.98	1.00	1.00	1.00	1.00
1972	0.11	0.88	0.90	1.00	1.00	1.00	1.00	1.00
1973	0.12	0.77	0.89	0.97	1.00	1.00	1.00	1.00
1974	0.36	0.99	0.96	1.00	1.00	1.00	1.00	1.00
1975	0.40	0.99	1.00	0.94	1.00	1.00	1.00	1.00
1976	0.07	0.96	0.98	1.00	1.00	1.00	1.00	1.00
1977	0.03	0.92	0.96	1.00	1.00	1.00	1.00	1.00
1978	0.04	0.81	0.88	0.91	1.00	1.00	1.00	1.00
1979	0.00	0.84	0.81	0.78	1.00	1.00	1.00	1.00
1980	0.20	0.88	0.95	0.95	1.00	1.00	1.00	1.00
1981	0.19	0.89	0.90	0.94	1.00	1.00	1.00	1.00
1982	0.10	0.80	0.89	0.91	1.00	1.00	1.00	1.00
1983	0.02	0.73	0.88	0.90	1.00	1.00	1.00	1.00
1984	0.00	0.69	0.83	0.93	1.00	1.00	1.00	1.00
1985	0.14	0.62	0.71	0.88	1.00	1.00	1.00	1.00
1986	0.31	0.73	0.66	0.81	1.00	1.00	1.00	1.00
1987	0.00	0.85	0.91	0.87	1.00	1.00	1.00	1.00
1988	0.00	0.90	0.96	0.99	1.00	1.00	1.00	1.00
1989	0.07	0.63	0.93	0.95	1.00	1.00	1.00	1.00
1990	0.06	0.66	0.90	0.95	1.00	1.00	1.00	1.00
1991	0.04	0.30	0.74	0.82	1.00	1.00	1.00	1.00
1992	0.28	0.48	0.72	0.81	1.00	1.00	1.00	1.00
1993	0.00	0.46	0.99	1.00	1.00	1.00	1.00	1.00
1994	0.19	0.68	0.99	0.97	1.00	1.00	1.00	1.00
1995	0.10	0.86	0.94	0.99	1.00	1.00	1.00	1.00
1996	0.02	0.60	0.96	0.83	1.00	1.00	1.00	1.00
1997	0.04	0.82	0.95	1.00	1.00	1.00	1.00	1.00
1998	0.30	0.83	0.97	0.99	1.00	1.00	1.00	1.00
1999	0.02	0.84	0.95	0.97	1.00	1.00	1.00	1.00
2000	0.14	0.79	0.99	1.00	1.00	1.00	1.00	1.00
2001	0.15	0.54	0.88	0.97	1.00	1.00	1.00	1.00
2002	0.02	0.92	0.95	0.98	1.00	1.00	1.00	1.00
2003*	0.11	0.76	0.95	0.97	1.00	1.00	1.00	1.00
2004	0.11	1.00	0.97	1.00	1.00	1.00	1.00	1.00
2005	0.20	0.97	0.99	1.00	1.00	1.00	1.00	1.00
2006	0.19	0.89	1.00	1.00	1.00	1.00	1.00	1.00
2007	0.16	0.94	0.98	1.00	1.00	1.00	1.00	1.00
2008	0.16	0.84	1.00	1.00	1.00	1.00	1.00	1.00

*Average for the preceding nine years.

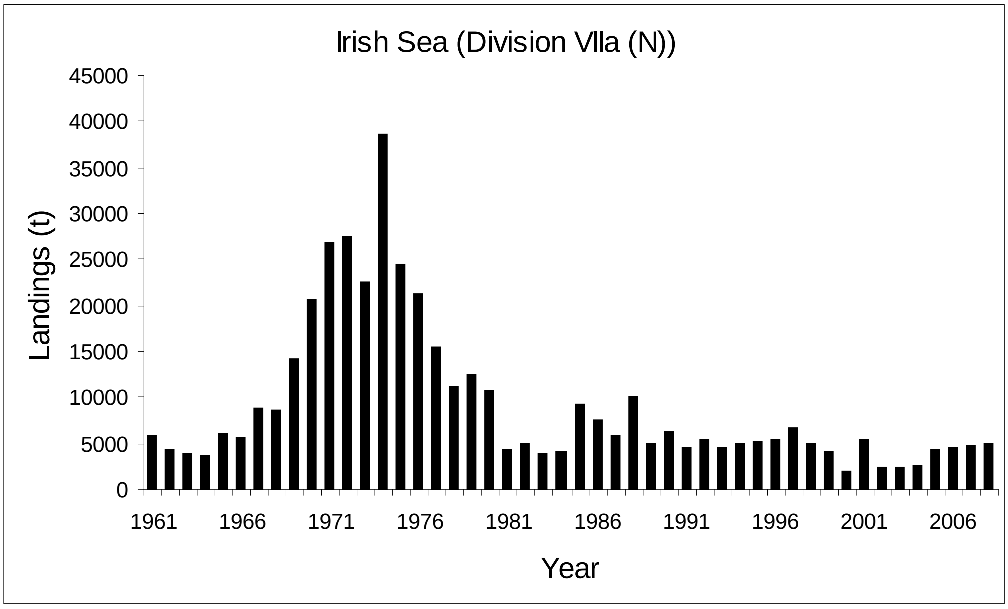


Figure 7.1.1 **Irish Sea herring VIIa(N). Landings of herring from VIIa(N) from 1961 to 2008.**

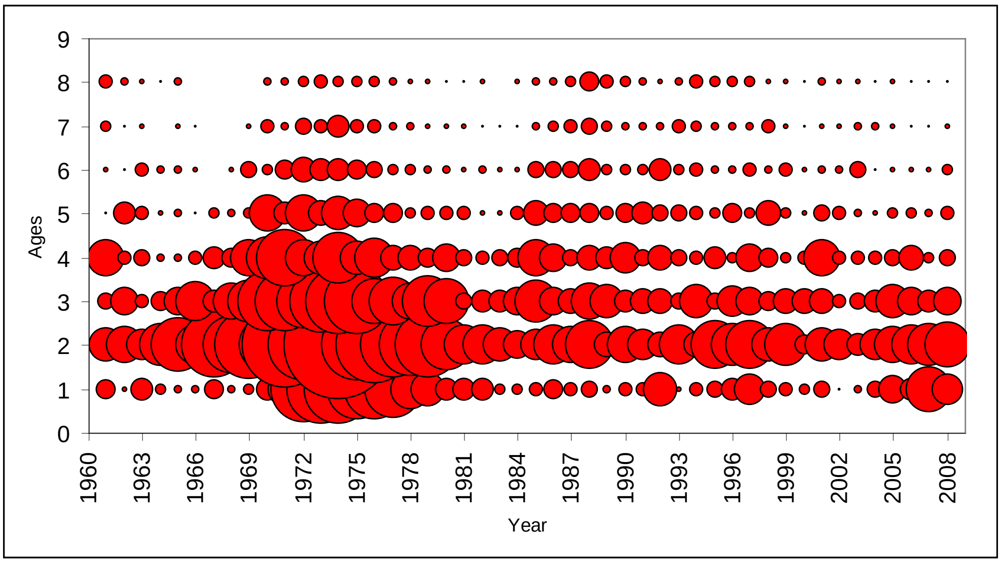


Figure 7.2.1 **Irish Sea herring VIIa(N). Landings (catch-at-age) of herring from VIIa(N) from 1961 to 2008.**

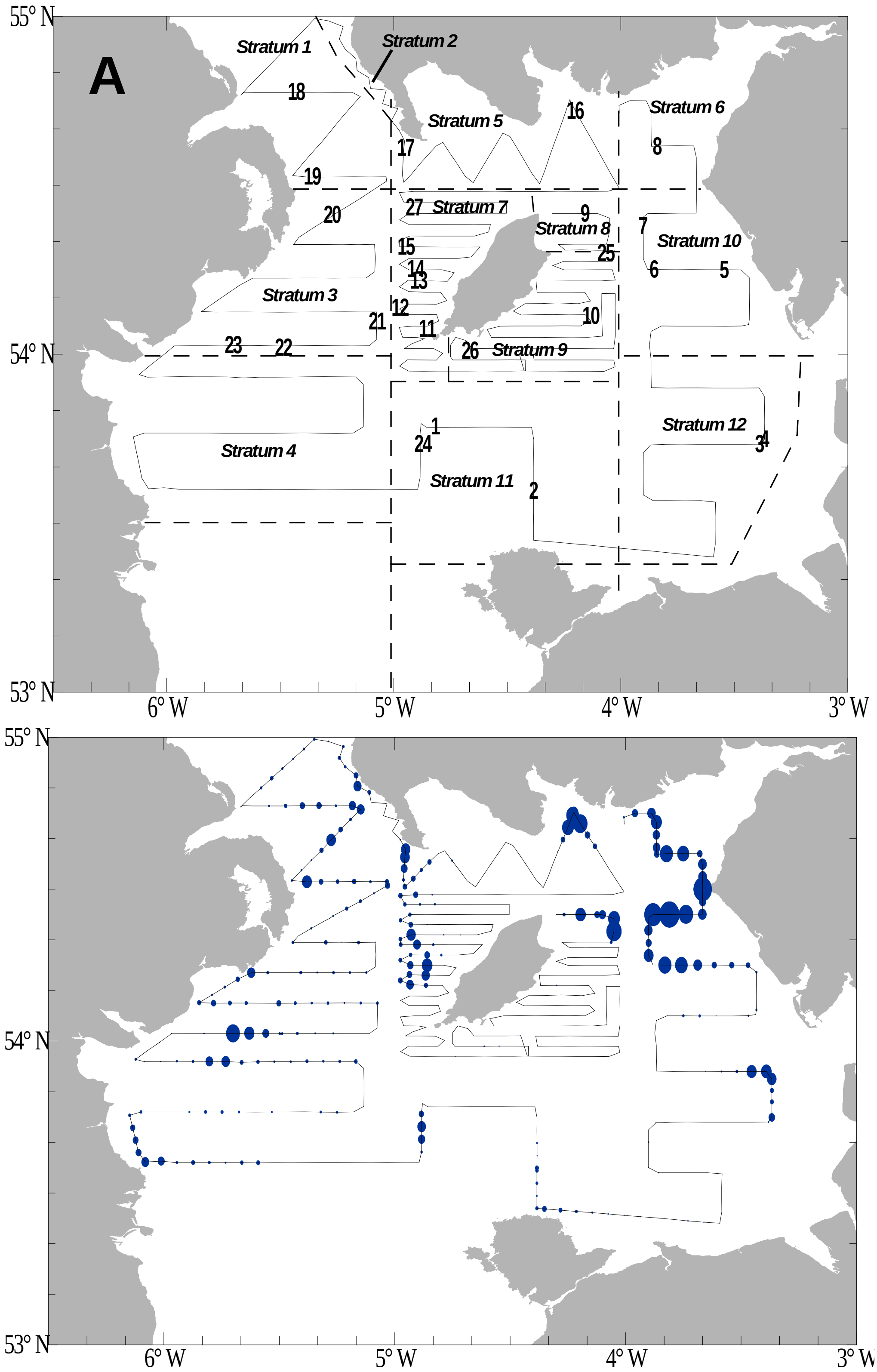


Figure 7.2.2 Irish Sea herring VIIa(N). (A) Transects, stratum boundaries and trawl positions for the 2008 acoustic survey; (B) Density distribution of sprats (size of ellipses is proportional to square root of the fish density (t n.mile^{-2}) per 15-minute interval). Maximum density was 800 t n.mile^{-2}.

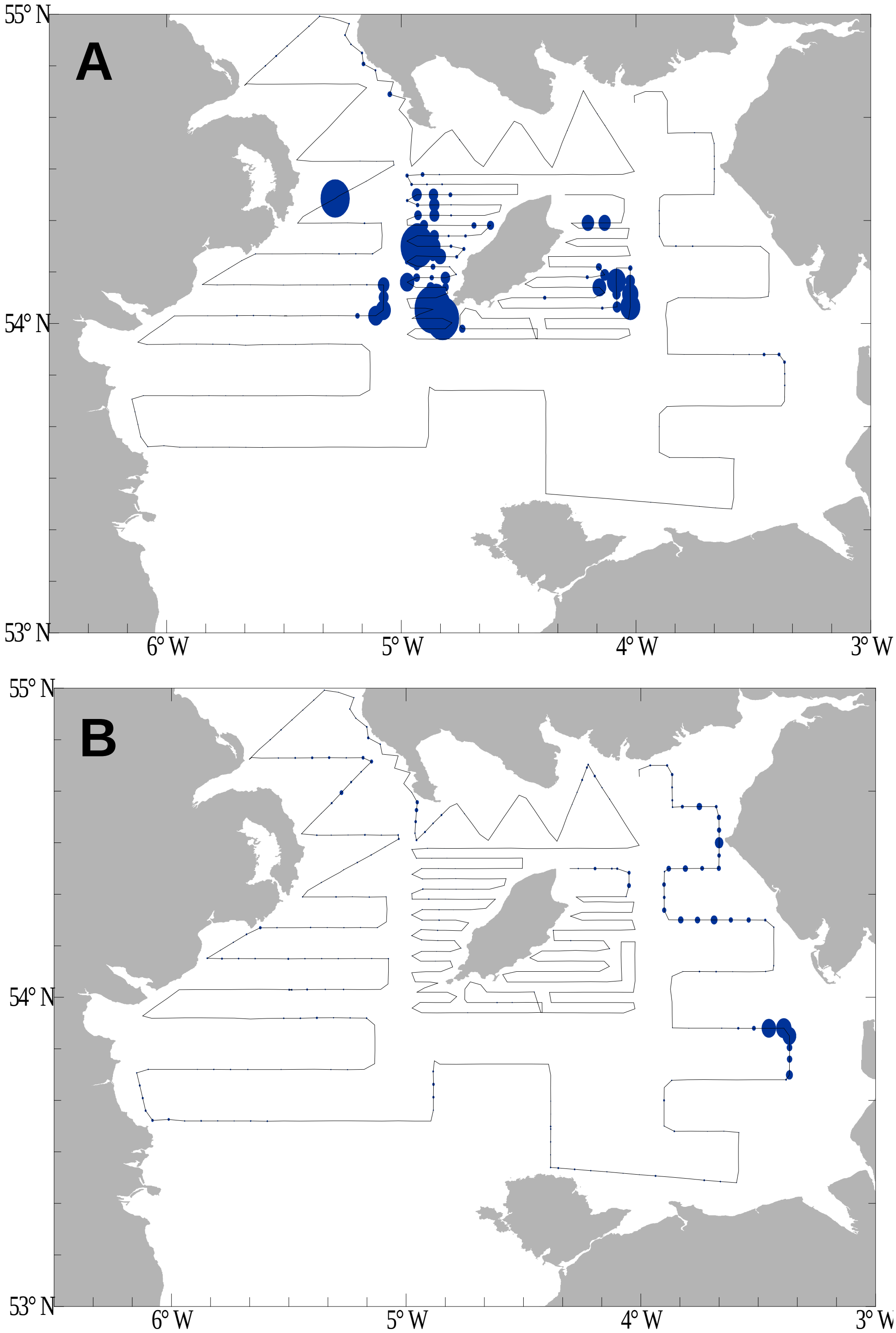


Figure 7.2.3 **Irish Sea herring VIIa(N). (A) Density distribution of 1-ring and older herring (size of ellipses is proportional to square root of the fish density (t n.mile^{-2}) per 15-minute interval). Maximum density was 2 670 t n.mile^{-2}. (B) Density distribution of 0-ring herring. Maximum density was 450 t n.mile^{-2}. Note: same scaling of ellipse sizes on above figures.**

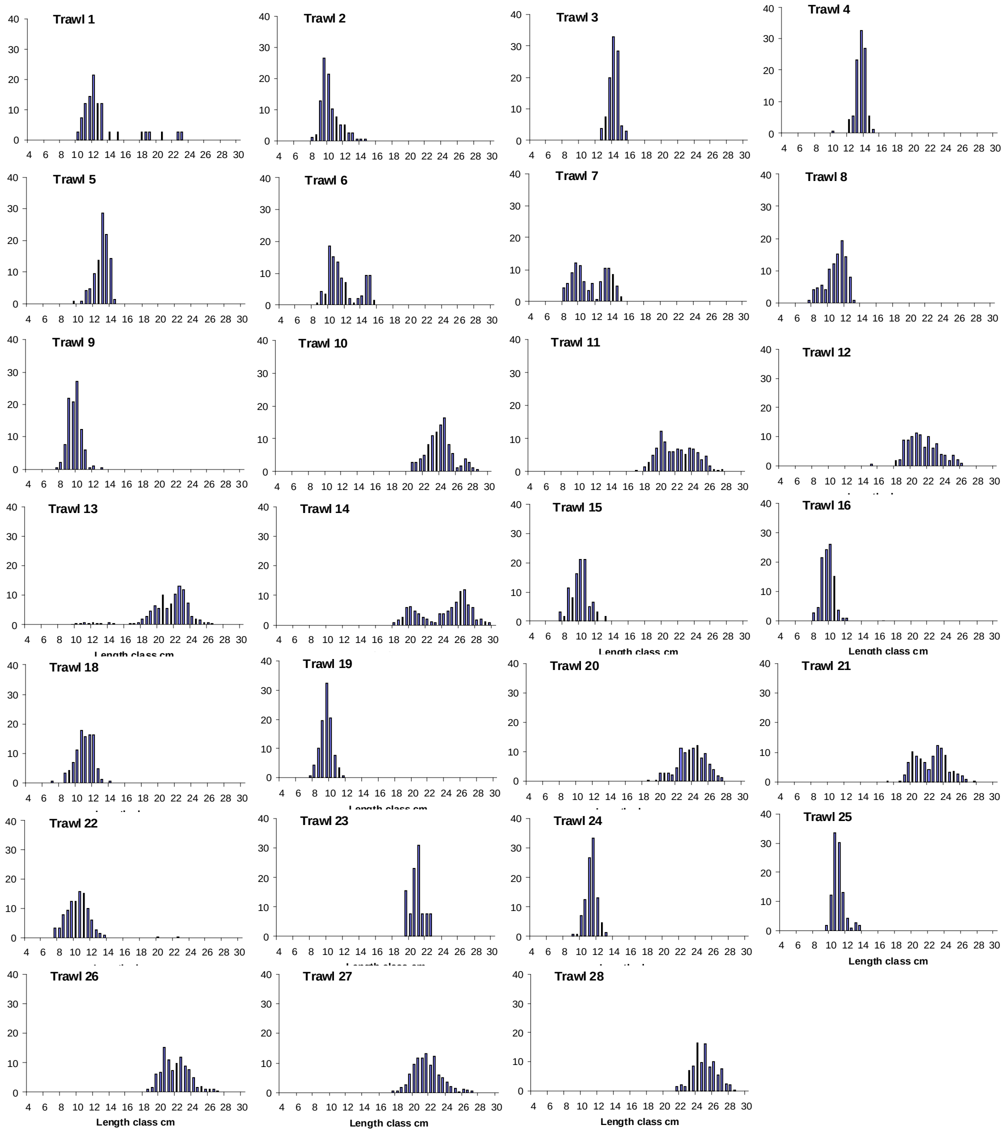


Figure 7.2.4 Irish Sea herring VIIa(N). Percentage length compositions of herring in each trawl sample in the September 2008 acoustic survey.

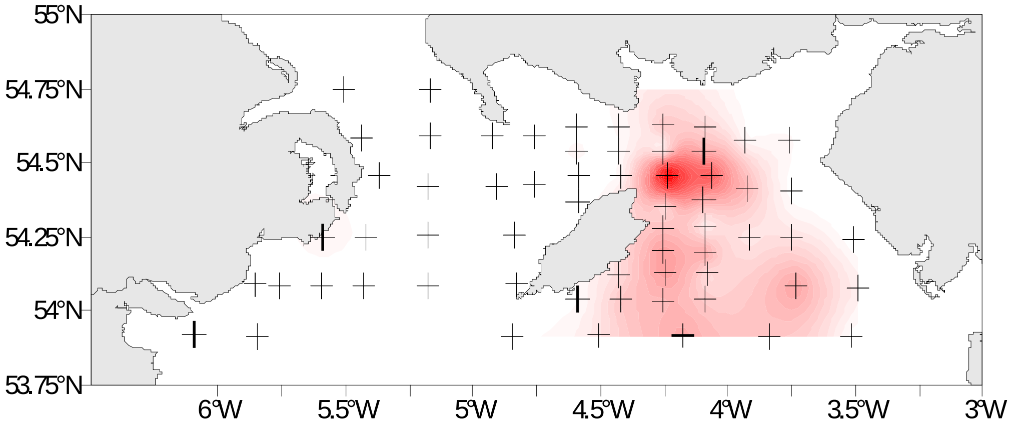


Figure 7.2.5 Irish Sea herring VIIa(N). Estimates of larval herring abundance in the Northern Irish Sea, 6th to 17th November 2008. (maximum abundance = 71.01 per m2).

8 Sprat in the North Sea

8.1 The Fishery

8.1.1 ACFM Advice Applicable to 2008 and 2009

There have never been any explicit management objectives for this stock. The TAC set for 2008 was 175 000 t. A mid-year revise did not change the TAC in 2008. For 2008, the by-catch quota of herring (EU fleet) was set at 18 806 t. For 2009 a preliminary TAC of 170 000 t is set and a revised mid-year advice is expected. For 2009, the by-catch quota of herring (EU fleet) was set at 15 985 t.

Catches in 2008

Catch statistics for 1996–2008 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. In 1996 total landings were 137.000 t and have since been in the range of 61.000 t (2008) to 208.000 t (2005). As in previous years sprat from the fjords of western Norway are not included in the catches for the North Sea, due to uncertainties in stock identity. Annual catches of Norwegian fjord sprat have ranged between 400 t (2004) and 3 300 t (1996, 1999) in this period. Total catches for the North Sea in 2008 were 61 083 t, the lowest for the entire time series. The Danish catches represent more than 95% of the total catches. The Norwegian sprat fishery caught 1 266 t of sprat.

The catches by year, quarter, and area show the same picture as last year, with the largest amount taken in IVb and in IVc. Only small catches were landed in the first two quarters in 2008 (Table 8.1.2). Quarterly and annual distribution of catches per rectangle for Subarea IV show a fishery located in the mid-southern North Sea in the first and second quarter, while the central-eastern areas are targeted in the second half of the year (Figures 8.1.1a-d and Figure 8.1.2).

8.1.2 Regulations and their effects

The Norwegian vessels are not allowed to fish in the Norwegian zone until the quota in the EU-zone has been taken. They are not allowed to fish in the 2nd and 3rd quarters in the EU and the Norwegian zone. There is a maximum vessel quota of 800 t. A herring by-catch of up to 10% in biomass is allowed in Norwegian sprat catches. A by-catch of up to 20% in biomass of herring is allowed in the Danish sprat catches. Sprat cannot be fished without by-catches of herring except in years with high sprat abundance or low herring recruitment. Management of this stock should consider management advice given for herring in Subarea IV, Division VIId, and Division IIIa. A decrease in recruitment for the North Sea herring autumn spawners and a probable high incoming sprat year class may potentially result in a fishery for sprat with less by-catch of herring.

Most sprat catches are taken in an industrial fishery where catches are limited by herring by-catch restrictions.

In 2007 a new quota regulation (IOK) for the Danish vessels was implemented and realized from 2008 and onwards. The regulation gives quotas to the vessel, but these can be traded or sold. A large number of small vessels have been taken out of the fishery and their quotas sold to larger vessels. Today the Danish fleet is therefore dominated by large vessels.

8.1.3 Changes in fishing technology and fishing patterns

No changes in fishing technology and fishing patterns of importance for the sprat fisheries in the North Sea have been reported.

8.2 Biological composition of the catch

Only data on by-catch from the Danish fishery were available to the Working Group (Table 8.2.1). The Danish sprat fishery has recently been conducted with a by-catch of herring. The total amount of herring caught as by-catch in the sprat fishery has mainly been less than 10 % but increased to 11 % in 2008.

The Danish biological sampling from 1996 and onwards is considered reliable due to the changes in the Danish sampling scheme and the estimated quarterly landings at age in numbers for the period are presented in Table 8.2.2. In 2008 the one-year old sprat contributed 44% of the total landings, which is the second lowest value since 1996 (2004: 35%, all other years: 51-96%). 2-year olds contributed in 2008 with 41% of the total landing, leaving 13% of the contribution to 0-, 3- and 4-year olds.

Mean-weight-at-age (g) in the landings in 2008 was lower than the 2007 values for all year classes (Table 8.2.3). But the lower values are more in accordance with the years before 2007.

Denmark, Norway and UK-Scotland provided age data of commercial landings in 2008 for all quarters fished (Table 8.2.4). These data were used to raise the landings data from the North Sea. The landings by UK-England were minor and unsampled. The sampling level (no. per 1000 t) in 2008 was similar to 2007 considering number of samples (0.4) and number aged (2008: 16, 2007: 18), but decreased considering the number measured. In 2008 40 sprat per 1000 t were measured compared to 57 per 1000 t in 2007. In Denmark the provisions in the EU regulation 1639/2001 and the amendment 1581/2004 have been implemented. This provision requires 1 sample per 2000 t landed. This sampling level is lower than the guidelines (1 sample per 1000 t) previously used by the HAWG but as the main fishery was carried out in a limited area and a limited season, the recommended sampling level can be regarded as adequate.

8.3 Fishery Independent Information

8.3.1 IBTS (February)

The calculation of this index can be found in the stock annex.

Sprat of age 1 and 2 were found in the south-east, with the highest concentrations in the more central parts of the distribution area (Figure 8.3.1a-c) and Division IVc.

8.3.2 Acoustic Survey

The sprat was in 2008 almost exclusively found in the eastern and southern parts of the North Sea, with highest abundances mainly in the central southern part (Figure 8.3.2). Total abundance was estimated to 25 125 million individuals and total biomass 271 000 t which is a reduction by more than 20 % in terms of biomass when compared to last year and the lowest estimate for the period 2003-2008 (ICES CM 2009/LCR:02). In 2008, as in most recent years the majority of the stock consists of mature sprat. In 2007 roughly 1/3 of the sprat biomass was immature fish. The estimated strength of the 1-year-olds in 2008 (the 2007 year class) is the lowest since 2002. The sprat stock is dominated by 1- and 2-year old fish representing more than 95% of the biomass.

	ABUNDANCE (millions)					BIOMASS (1000 t)				
Year/Age	0	1	2	3+	sum	0	1	2	3+	sum
2008	0	17165	7410	549	25125	0.0	160.6	101.2	8.6	270.4
2007*	0	37250	5513	1869	44631	0.0	258.0	66.2	28.5	352.7
2006*	0	21862	19916	760	42537	0.0	158.9	265.2	11.8	435.9
2005*	0	69798	2526	350	72674	0.0	474.6	32.8	5.9	513.3
2004*	17401	28940	5312	367	52019	19.3	266.6	73.3	6.3	365.5
2003*	0	25294	3983	338	29615	0.0	198.4	61.1	6.0	265.5
2002	0	15769	3687	207	19664	0.0	166.8	55.1	3.7	225.6
2001	0	12639	1812	110	14561	0.0	96.5	23.5	1.8	121.8
2000	0	11569	6407	180	18156	0.0	100.4	92.4	2.8	195.6
1999	0	353	5	0	358	0.0	3.3	0.0	0.0	3.3
1998	17	5365	960	37	6379	0.1	48.2	14.1	0.8	63.2

***Re-calculated by the means of FishFrame (ICES 2009/LRC:02)**

8.3.3 Survey indices

The time series of the different survey indices for all ages and 1-year-old sprat are shown in Figure 8.3.3 and 8.3.4.

The survey indices for North Sea sprat is often strongly influenced by a few large hauls. A quantification of the importance of each haul to the index has been made by estimating the cumulative contribution of each hauls. The cumulative index ranks the 300-450 individual haul contributions to the IBTS Q1 sprat age 1 survey index (Figure 8.3.5). Individual hauls for each year are sorted by size and aggregated to calculate a cumulative distribution. For all years in the IBTS survey the largest 10 hauls contribute to 35-85% of the survey index. In the 2009 IBTS Q1 the largest haul contributes approximately 30% to the index. In exceptional years more than 50% of the index was driven by a single haul.

Estimates of the distribution of the IBTS Q1 indices are available from the ICES DATRAS database, based on a resampling from the original individual haul data ("bootstrapping"). Confidence intervals based on these resampled estimates (Figure 8.3.6) are extremely broad. The upper confidence limit ranges from 30% to 4600% greater than the value of the index estimated by ICES, with a median value of 250%. The lower confidence limit ranges from 20% to 90% less than the value estimated by ICES, with a median value of 40%. HAWG therefore concludes that the uncertainties in the value of this index are extremely broad, and dominate the dynamics of the index itself. There are no combinations of years in this time series where it is possible to say that there is a statistically significant difference in the estimated abundance of sprat.

Management stocks

North Sea sprat is considered as an independent stock. This management approach has been tested by including IBTS survey data from the subdivisions VIId and IIIa (Figure 8.3.7a-c) for comparison of the CPUE for each statrec at which data are available. Data from subdivision VIId have been sampled during the French (2007) and Dutch (2008 and 2009) IBTS surveys. The North Sea management stock is framed by the red line. No distinct separation is obvious between North Sea sprat and sprat in VIId, whereas IIIa sprat and North Sea sprat show a lesser overlap.

8.4 Mean weights-at-age and maturity-at-age

Data on maturity by age, mean weight- and length-at-age during the 2008 summer acoustic survey are presented in the PGIPS report (ICES 2009/LRC:02).

8.5 Recruitment

The IBTS (February) 1-group index is used as a recruitment index for this stock.

The 2005 index of 1-group (2004 year class) was the highest for the time series until this year (see Table 8.3.1). The high level of the 1-group in 2005 was seen in most samples and not only confined to a few single hauls. This year class was abundant as 3-group in 2007, and in 2008 it was above, but near the average for the 4-group. In 2009 the incoming 1-group (2008 year class) is estimated to be the highest for the whole time series, both in absolute and relative terms, but this estimate should be considered as preliminary. The index is also dominated by a few large hauls (see also 8.3.3).

8.6 Assessment of sprat in the North Sea

Previous exploratory assessments of this stock have been performed using the CSA method (ICES HAWG 2008). Generally, this method has given very poor results: the results are highly sensitive to the ratio of the survey catchabilities, *s*, and this parameter cannot be firmly estimated, either internally within the model or from external information. Similarly, the uncertainty associated with the corresponding estimates of biomass are extremely large, ranging over more than an order of magnitude – it is therefore not possible to say, with this method, whether the stock size of this population is less than one million tonnes, or greater than 10 million tonnes.

This method is therefore clearly inappropriate for the task at hand, and the results meaningless in an advice content. The decision was therefore made not to perform or report any such runs this year.

This stock will be the subject of a benchmark assessment in September 2009, as part of the WKSHORT workshop.

8.7 North Sea Sprat Forecasts

In previous years, a catch prediction for the assessment year was provided on the basis of a linear regression of catch (as estimated by landings) versus the IBTS sprat index summed over all age groups. Following issues raised in HAWG 2008, and subsequent discussions during this meeting, HAWG concluded that such an approach had no scientific merit, for three reasons.

Firstly, the fishery is limited in some years by the TAC, whilst in other years it is not. The fishery is also opportunistic in nature, and the intensity of the North Sea sprat fishery is greatly influenced by the quotas set for other preferred industrial species, such as sandeel. It is therefore not reasonable to expect a consistent relationship between stock size and catch.

Secondly the traditional catch regression also includes all years from 1984 onwards – however, there are concerns about the quality of landing information prior to 1996 and this information was not used in previous exploratory assessments.

Finally, as highlighted elsewhere in this report (Section 8.3.3), the uncertainty associated with the IBTS estimate of stock-size is extremely high, due to the fact that it is driven by a few large catches. Making a catch prediction based on this index value would therefore seem unwise.

Given these problems, HAWG concluded that this approach has no meaning in an advice context. No forecast for this stock is presented.

8.8 Quality of the Assessment

No quantitative assessment is presented for this stock.

Uncertainties in the survey indices make the current understanding of the dynamics of this stock extremely poor. HAWG recommends that the detailed study of improved or alternative assessment methods (e.g. length based assessment) and the use of additional information sources (e.g. acoustic surveys, catch per unit effort) are required in order improve our level of understanding and ability to adequately manage this stock.

8.9 State of the Stock

Precautionary reference points have not been defined for this stock and the available information is inadequate to estimate the absolute stock size. Relative trends in abundance from indices suggest that the stock has dropped appreciably from its mid 2000s high, and is now in the lower quartile of observed values. (Figures 8.3.3-4).

8.10 Management Considerations

8.11 Ecosystem Considerations

Multispecies investigations have demonstrated that sprat is one of the important prey species in the North Sea ecosystem. Many of the plankton-feeding fish have recruited poorly in recent years (e.g. herring, sandeel, Norway pout). The implications of the environmental change for sprat and the influence of the sprat fishery for other fish species and sea birds, are at present unknown.

The zooplankton community structure that is sustaining the sprat stocks appears to be changing, and there has been a long-term decrease in total zooplankton abundance in the northern North Sea (Reid et al., 2003; Beaugrand, 2003; ICES, 2006). However, sprat is mainly distributed in the southern North Sea where these trends have not been observed (ICES, 2006).

8.12 Changes in the environment

Temperatures in this area have been increasing over the last number of decades. It is considered that this may have implications for sprat, although it is not possible to quantify either the magnitude or direction of such changes.

Table 8.1.1. North Sea sprat. Catches (' 000 t) 1996-2008. See ICES CM 2006/ACFM:20 for earlier catch data. Catch in fjords of western Norway excluded.
(Data provided by Working Group members except where indicated). These figures do not in all cases correspond to the official statistics and cannot be used for management purposes.
The IVb catches for 2000-2007 divided by IVbW and IVE can be found in ICES CM 2008/ACOM:02

Country	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
		Division IVa											
Denmark	0.3			0.7		0.1	1.1		*		*	0.8	*
Sweden						0.1							
Total				0.7		0.2	1.1		*		*	0.8	*
		Division Ivb											
Denmark	76.5	93.1	119.3	160.3	162.9	143.9	126.1	152.9	175.9	204.0	79.5	55.5	51.4
Norway	52.8	3.1	15.3	13.1	0.9	5.9	*		0.1		0.8	3.7	1.3
Sweden	0.5		1.7	2.1		1.4				*			
UK(Scotland)				1.4								0.1	
Total		96.2	136.3	176.9	163.8	151.2	126.1	152.9	176.0	204.1	80.3	59.3	52.7
		Division IVc											
Denmark	3.9	5.7	11.8	3.3	28.2	13.1	14.8	22.3	16.8	2.0	23.8	20.6	8.1
Netherlands				0.2									
Norway		0.1	16.0	5.7	1.8	3.6					9.0	2.9	
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	*
UK(Scotland)													0.2
Total		7.2	28.0	10.8	32.0	18.7	16.4	23.6	18.3	3.6	33.4	23.8	8.4
		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
Netherlands				0.2									
Norway	52.8	3.2	31.3	18.8	2.7	9.5	*		0.1		9.8	6.7	1.3
Sweden	0.5		1.7	2.1		1.5				*			
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	*
UK(Scotland)				1.4								0.1	0.2
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

* < 50 t

Table 8.1.2. North Sea sprat. Catches (tonnes) by quarter. Catches in fjords of Western Norway excluded. Data for 1996-1999 in ICES CM 2007/ACFM :11
The IVb catches for 2000-2007 divided by IVbW and IVE can be found in ICES CM 2008/ACOM:02

Year	Quarter	Area				Total
		IVaW	IVaE	IVb	IVc	
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
	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
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

* < 0.5 t

Any inconsistency in total catches is due to rounding errors.

Table 8.2.1. North Sea sprat. Species composition in the Danish sprat fishery in tonnes and percentage of the total catch. Data is reported for 1998-2008.

	Year	Sprat	Herring	Horse mack.	Whiting	Haddock	Mackerel	Cod	Sandeel	Other	Total
Tonnes	1998	129 315	11 817	573	673	6	220	11	2 174	1 188	145 978
Tonnes	1999	157 003	7 256	413	1 088	62	321	7	4 972	635	171 757
Tonnes	2000	188 463	11 662	3 239	2 107	66	766	4	423	1 911	208 641
Tonnes	2001	136 443	13 953	67	1 700	223	312	4	17 020	1 142	170 862
Tonnes	2002	140 568	16 644	2 078	2 537	27	715	0	4 102	800	167 471
Tonnes	2003	172 456	10 244	718	1 106	15	799	11	5 357	3 509	194 214
Tonnes	2004	179 944	10 144	474	334		4 351	3	3 836	1 821	200 906
Tonnes	2005	201 331	21 035	2 477	545	4	1 009	16	6 859	974	234 250
Tonnes	2006	103 236	8 983	577	343	25	905	4	5 384	576	120 033
Tonnes	2007	74 734	6 596	168	900	6	126	18	6	253	82 807
Tonnes	2008	61 093	7 928	26	380	10	367	0	23	1 735	71 563
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

Table 8.2.2 North Sea Sprat. Catch in numbers (millions) by quarter and by age 1996-2008.

Year	Quarter	Age						
		0	1	2	3	4	5+	Total
1996	1		524.7	4 615.4	2 621.9	316.4	11.3	8 090
	2		1.9	241.5	32.7	15.5	0.3	292
	3		400.5	100.7	22.9	0.3		524
	4		1 190.7	1 069.0	339.6	5.6		2 605
	Total		2 117.8	6 026.6	3 017.1	337.8	11.6	11 511
1997	1		74.4	314.0	229.2	55.3	2.5	675
	2		11.3	47.8	34.9	8.4	0.4	103
	3		1 991.9					1 992
	4	127.6	3 597.2	996.2	117.8	58.1		4 897
	Total	127.6	5 674.8	1 358.1	381.9	121.8	2.8	7 667
1998	1		683.2	537.2	18.3	0.1		1 239
	2		70.9	55.3	1.8			128
	3	74.2	3 356.6	693.3				4 124
	4	772.4	4 822.4	2 295.1	483.5	39.5		8 413
	Total	846.6	8 933.1	3 580.9	503.6	39.6		13 904
1999	1		728.1	2 226.0	554.2	86.6	9.2	3 604
	2		38.6	58.4	18.1	2.6		118
	3		12 919.0	38.9				12 958
	4	105.0	2 143.2	211.5				2 460
	Total	105.0	15 828.9	2 534.8	572.3	89.2	9.2	19 139
2000	1		559.2	3 177.3	797.5	247.5	72.0	4 854
	2		6.8	107.4	60.1	12.8	0.5	188
	3		9 928.9	1 111.9	77.8			11 119
	4		1 153.7	129.2	9.0			1 292
	Total		11 648.7	4 525.8	944.4	260.3	72.6	17 452
2001	1		746.3	3 197.7	1 321.9	22.2		5 288
	2		15.9	66.2	26.1			108
	3	0.4	3 338.8	299.9				3 639
	4	1 205.0	4 178.7	1 224.6	261.9			6 870
	Total	1 205.4	8 279.8	4 788.4	1 609.9	22.2		15 906
2002	1		104.7	400.3	30.2	11.2		546
	2		13.7	27.9	2.4	0.6		45
	3	40.9	5 745.6	582.1	42.3	4.1		6 415
	4	415.0	4 578.0	626.2	119.8	3.1		5 742
	Total	455.9	10 441.9	1 636.5	194.8	19.0		12 748
2003	1		1 953.9	1 218.9	85.3	11.3		3 269
	2		41.8	46.3	4.7	0.6		93
	3	1.1	3 481.3	772.0	42.9			4 297
	4	539.3	7 051.8	1 115.1	93.8	36.5	21.9	8 858
	Total	540.4	12 528.7	3 152.3	226.6	48.4	21.9	16 518
2004	1		16.5	214.0	26.3	1.6	0.6	259
	2		22.1	14.9	3.0	0.1		40
	3	210.0	3 661.9	558.2	31.4			4 462
	4	15 674.4	5 582.8	632.1	59.2			21 949
	Total	15 884.4	9 283.2	1 419.2	119.8	1.8	0.6	26 709
2005	1		2 476.5	268.5	13.8	2.2		2 761
	2		499.6	23.4	4.3	4.9		532
	3		11 920.2	192.3	7.6			12 120
	4	302.5	7 467.9	191.1				7 962
	Total	302.5	22 364.3	675.3	25.7	7.0		23 375
2006	1		1 559.2	5 119.1	95.7	2.3		6 776
	2		5.8	21.5	0.2			27
	3		3 077.8	625.0	129.1			3 832
	4		2 048.5	416.0	85.9			2 550
	Total		6 691.2	6 181.6	310.8	2.3		13 186
2007	1		12.1	57.4	17.3			87
	2		3.9	18.5	5.6			28
	3		1 025.3	194.5	17.7	25.3		1 263
	4	858.6	4 047.6	1 066.0	150.9			6 123
	Total	858.6	5 088.8	1 336.5	191.4	25.3		7 501
2008	1		356.0	170.9	8.4	1.0		536
	2		7.8	2.7	0.1			11
	3	1.7	444.3	1 225.8	189.9	29.3		1 891
	4	486.3	1 812.5	1 032.8	147.5	13.9		3 493
	Total	488.0	2 620.5	2 432.2	345.9	44.2		5 931

Table 8.2.3 North Sea Sprat. Mean weight (g) by quarter and by age for 1996 - 2008.

Year	Quarter	Age						SOP
		0	1	2	3	4	5+	Tonnes
1996	1		3.9	9.3	14.9	15.3	16.1	88 807
	2		6.9	8.4	11.6	20.0	15.2	2 735
	3		11.6	14.2	18.2	21.5		6 501
	4		12.1	15.9	17.2	20.5		37 359
Weighted mean			10.0	10.5	15.1	15.6	16.0	135 401
1997	1		8.0	10.0	15.0	17.0	19.0	8 161
	2		8.0	10.0	15.0	17.0	19.0	1 243
	3		14.2					28 285
	4	3.7	11.9	16.4	19.1	19.6		63 083
Weighted mean		3.7	12.7	14.7	16.3	18.2	19.0	100 772
1998	1		5.6	6.0	8.7	15.0		7 232
	2		5.6	6.0	8.3			743
	3	3.7	14.7	15.3				60 149
	4	4.1	10.6	13.8	16.3	14.6		94 173
Weighted mean		4.0	11.7	12.8	16.0	14.7		162 297
1999	1		3.3	8.7	12.5	14.4	16.3	30 168
	2		3.1	10.1	13.6	15.4		993
	3		10.0	18.3				129 383
	4	4.4	11.0	14.4				27 126
Weighted mean		4.4	9.8	9.4	12.5	14.4	16.3	187 670
2000	1		4.2	10.1	10.7	10.2	10.5	46 192
	2		3.3	9.0	10.2	12.8	10.5	1 767
	3		11.9	11.9	11.0			132 563
	4		11.9	11.9	11.0			15 403
Weighted mean			11.6	10.6	10.7	10.3	10.5	195 925
2001	1		3.3	9.7	12.9	16.5		50 794
	2		3.3	10.3	12.9			1 071
	3	4.0	12.0	15.3				44 656
	4	3.8	11.6	12.6	19.1			73 444
Weighted mean		3.8	11.0	10.8	13.9	16.5		169 965
2002	1		7.0	12.0	14.0	13.0		61 057
	2		5.3	11.2	12.5	12.4		4 231
	3	2.0	10.9	15.0	15.0	24.0		721 732
	4	3.9	12.0	15.0	15.7	24.0		679 018
Weighted mean		3.7	11.2	13.4	14.9	14.8		1 466 038
2003	1		3.6	9.4	11.0	15.0		19 599
	2		3.1	9.9	11.0	15.0		648
	3	3.0	13.0	16.0	13.0			58 169
	4	4.6	10.8	14.8	16.9	15.0	18.0	97 670
Weighted mean		4.6	10.3	12.9	13.8	15.0	18.0	176 085
2004	1		3.6	10.3	13.8	16.6	16.1	2 663
	2		6.0	8.5	7.3	10.2		282
	3	4.5	11.9	17.0	20.0			54 639
	4	4.0	11.4	14.6	18.3			136 653
Weighted mean		4.0	11.0	10.9	14.5	16.8	16.1	194 238
2005	1		4.6	8.9	12.1	16.0		13 995
	2		4.8	6.5	9.8	10.0		2 641
	3		8.9	9.9	18.6			107 531
	4	4.1	10.7	12.0				83 515
Weighted mean		4.1	8.9	10.0	13.6	11.8		207 682
2006	1		4.3	7.7	9.6	13.0		47 293
	2		3.7	8.1	11.2			198
	3		9.8	12.5	16.1			40 053
	4		9.8	12.5	16.1			26 658
Weighted mean			8.5	8.5	14.1	13.0		114 202
2007	1		4.0	9.0	12.0			829
	2		4.0	9.0	12.0			244
	3		12.0	17.0	13.0	17.0		16 603
	4	5.1	10.9	13.5	16.3			66 150
Weighted mean		5.1	11.1	13.8	15.5	17.0		83 826
2008	1		4.2	7.8	10.3	10.0		2 930
	2		3.9	7.5	8.7			52
	3	2.0	11.1	11.4	12.9	14.6		21 759
	4	3.7	10.4	13.1	13.8	14.0		36 362
Weighted mean		3.7	9.6	11.9	13.2	14.3		61 102

Table 8.2.4. **North Sea Sprat.** Sampling for biological parameters in 2008.

Country	Quarter	Landings ('000 tonnes)	No. samples	No. measured	No. aged
Denmark	1	1.616	3	457	95
	2	0.051	5	47	0
	3	21.787	9	957	428
	4	36.129	6	689	239
	Total	59.583	23	2150	762
UK (England & Wales)	1	0.032			
	2	*			
	3				
	4	0.008			
	Total	0.040			
UK (Scotland)	1				
	2				
	3				
	4	0.192	1	244	38
	Total	0.192	1	244	38
Norway	1	1.266	3	300	198
	2				
	3				
	4				
	Total	1.266	3	300	198
Total North Sea		60.889	26	2450	960

* < 1 t

Table 8.3.1. North Sea sprat. Abundance indices by age from IBTS (February) from 1984-2009.

Year	Age					
	1	2	3	4	5+	Total
1984	233.76	329.00	39.61	6.20	0.29	608.86
1985	376.10	195.48	26.76	3.80	0.35	602.49
1986	44.19	73.54	22.01	1.23	0.24	141.21
1987	542.24	66.28	19.14	1.92	0.24	629.82
1988	98.61	884.07	61.80	6.99	0.00	1 051.46
1989	2 314.22	476.29	271.85	5.47	1.65	3 069.48
1990	234.94	451.98	102.16	28.06	2.22	819.37
1991	676.78	93.38	23.33	2.63	0.12	796.24
1992	1 060.78	297.69	43.25	7.23	0.53	1 409.48
1993	1 066.83	568.53	118.42	6.07	0.34	1 760.19
1994	2 428.36	938.16	92.16	3.59	0.50	3 462.77
1995	1 224.89	1 036.40	87.33	2.52	0.76	2 351.90
1996	186.13	383.53	146.84	18.28	0.74	735.53
1997	591.86	411.95	179.55	15.52	2.24	1 201.13
1998	1 171.05	1 456.51	305.91	15.75	3.38	2 952.60
1999	2 534.53	562.10	80.35	4.83	0.45	3 182.25
2000	1 058.20	851.58	274.71	43.89	0.88	2 229.27
2001	883.06	1 057.00	185.47	17.55	0.35	2 143.42
2002	1 152.33	812.45	91.63	11.93	0.38	2 068.72
2003	1 842.26	309.92	44.49	2.21	0.04	2 198.92
2004	1 593.89	495.70	78.24	3.50	1.54	2 172.87
2005	3 053.46	267.89	36.39	0.87	0.00	3 358.60
2006	421.80	1 212.87	92.38	8.26	0.07	1 735.39
2007	1 053.68	1 339.83	274.81	11.18	0.01	2 679.52
2008	1 432.45	769.17	96.89	6.86	0.02	2 305.38
2009*	3 468.18	251.18	23.60	1.71	0.46	3 745.13

* Preliminary

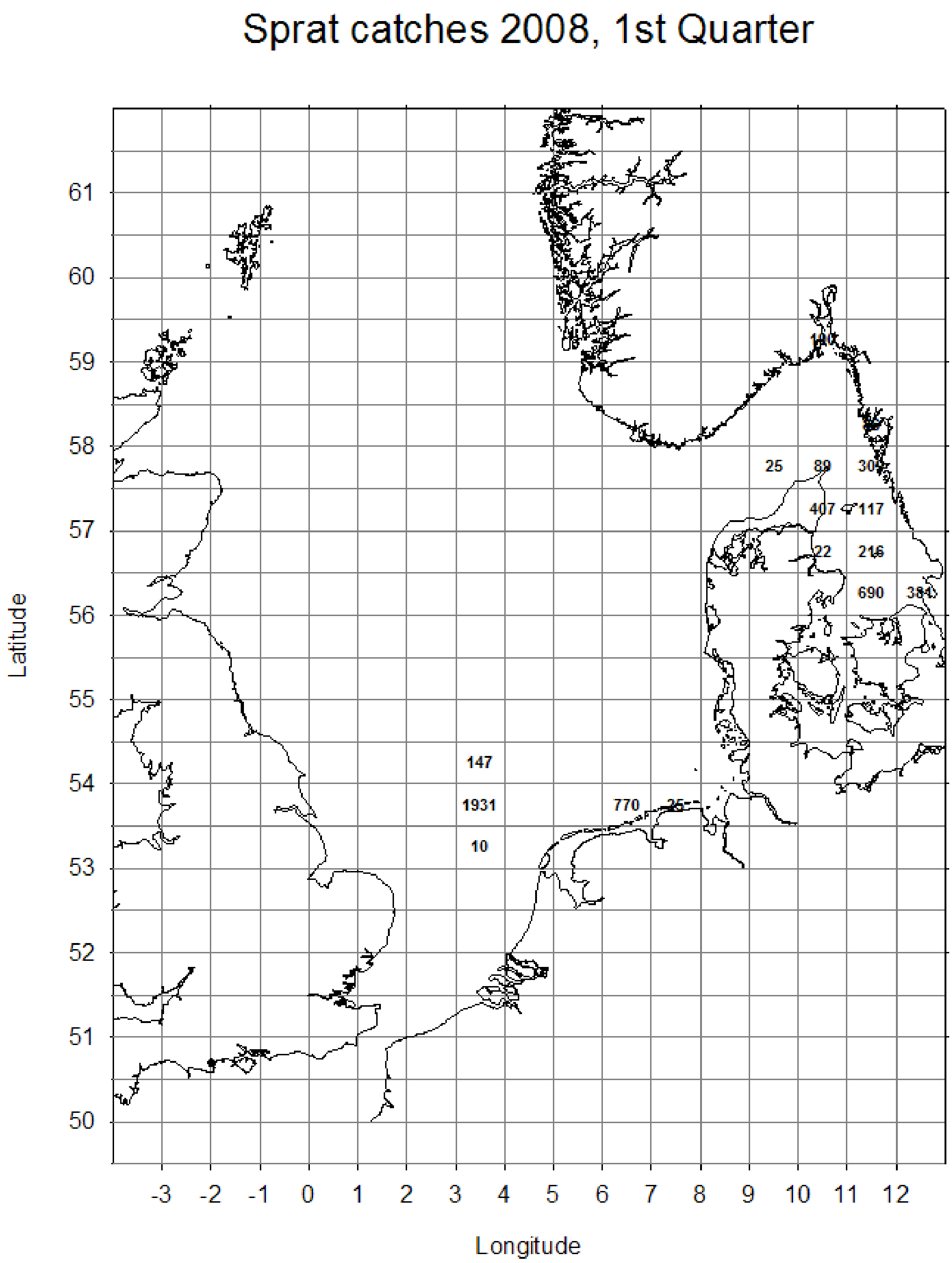


Figure 8.1.1a **Sprat catches in the North Sea (in tonnes) in 2008 by statistical rectangle. Working group estimates (if available). a.: 1st quarter**

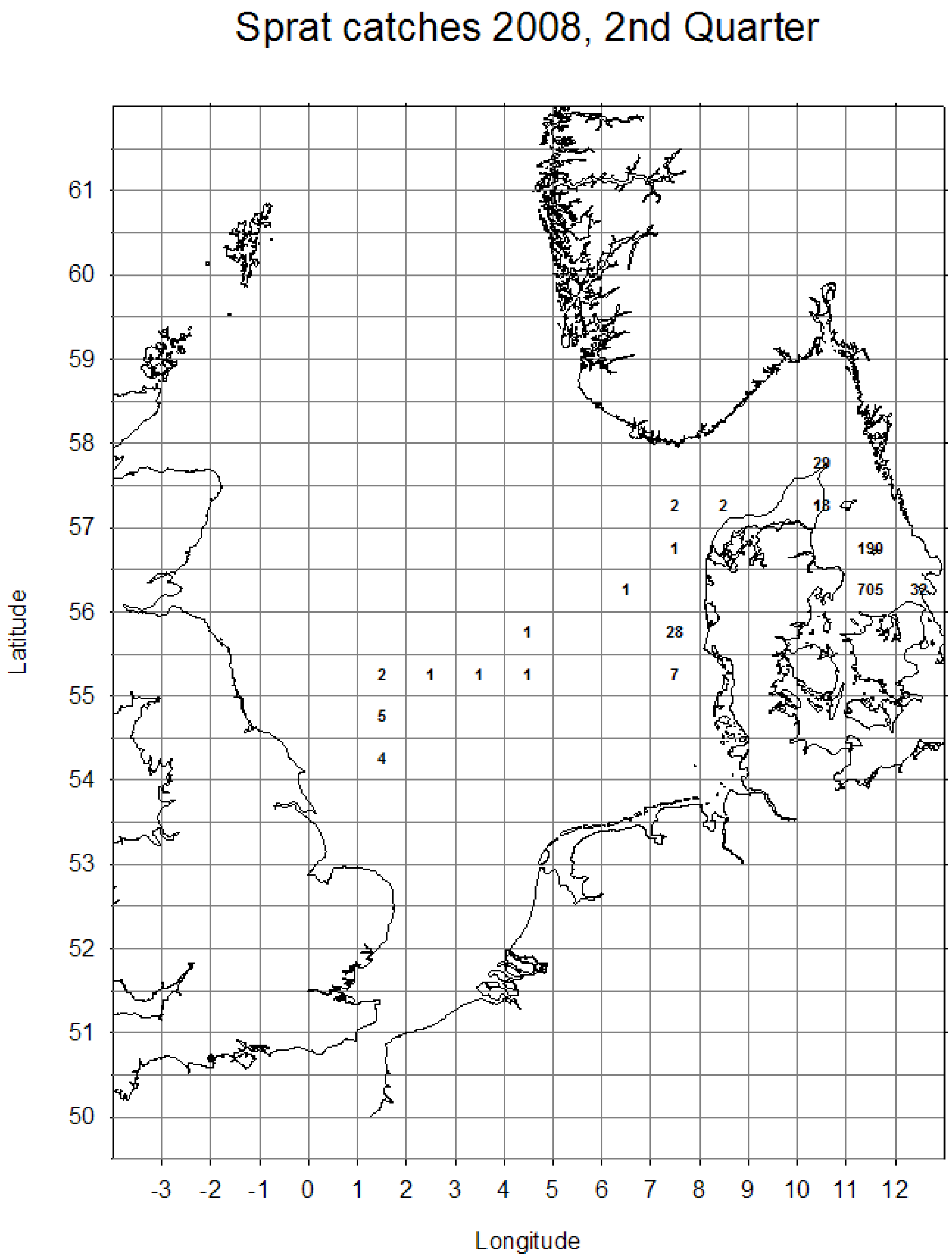


Figure 8.1.1b **Sprat catches in the North Sea (in tonnes) in 2008 by statistical rectangle. Working group estimates (if available). b.: 2nd quarter**

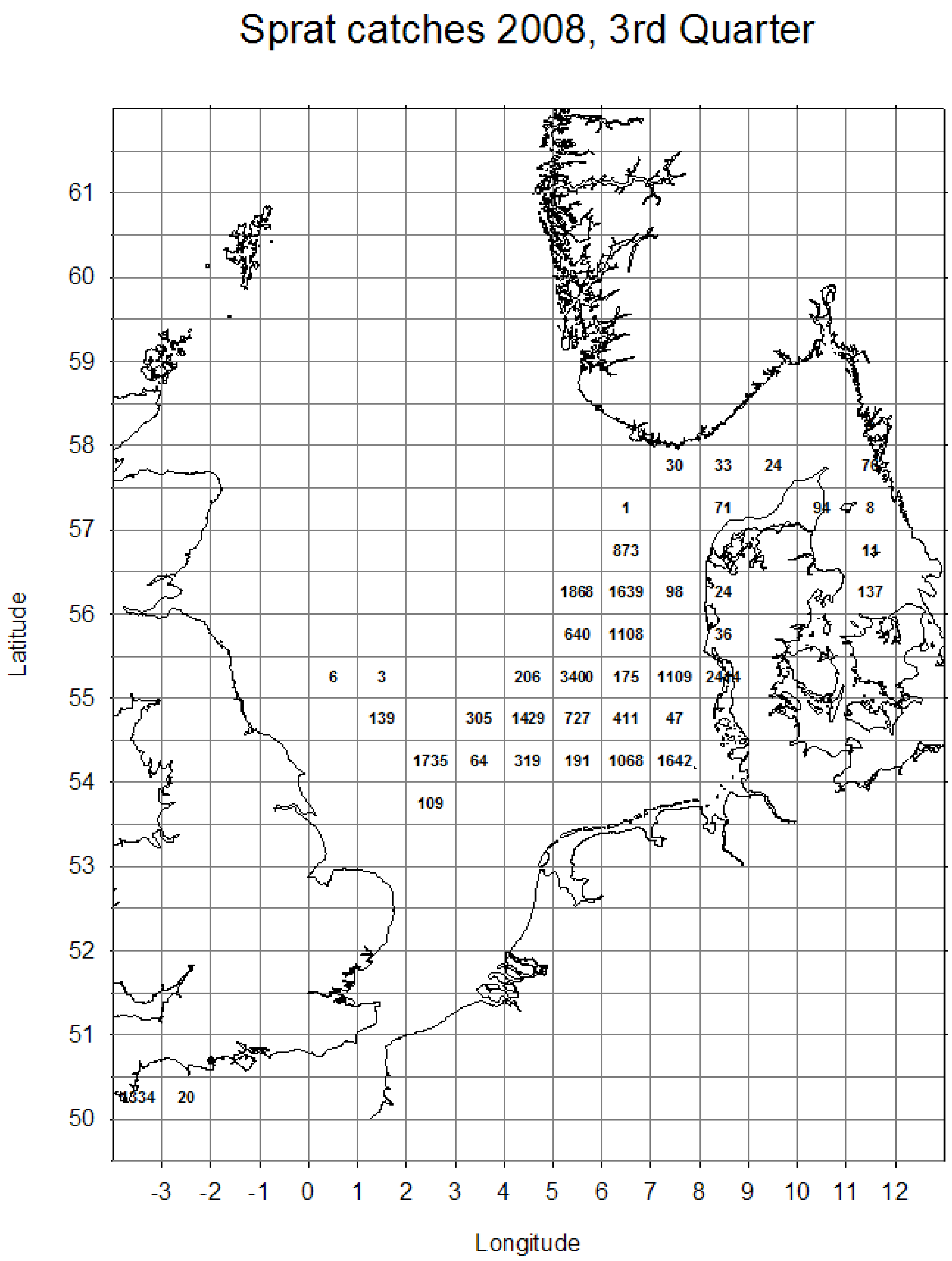


Figure 8.1.1c **Sprat catches in the North Sea (in tonnes) in 2008 by statistical rectangle. Working group estimates (if available). c.: 3rd quarter**

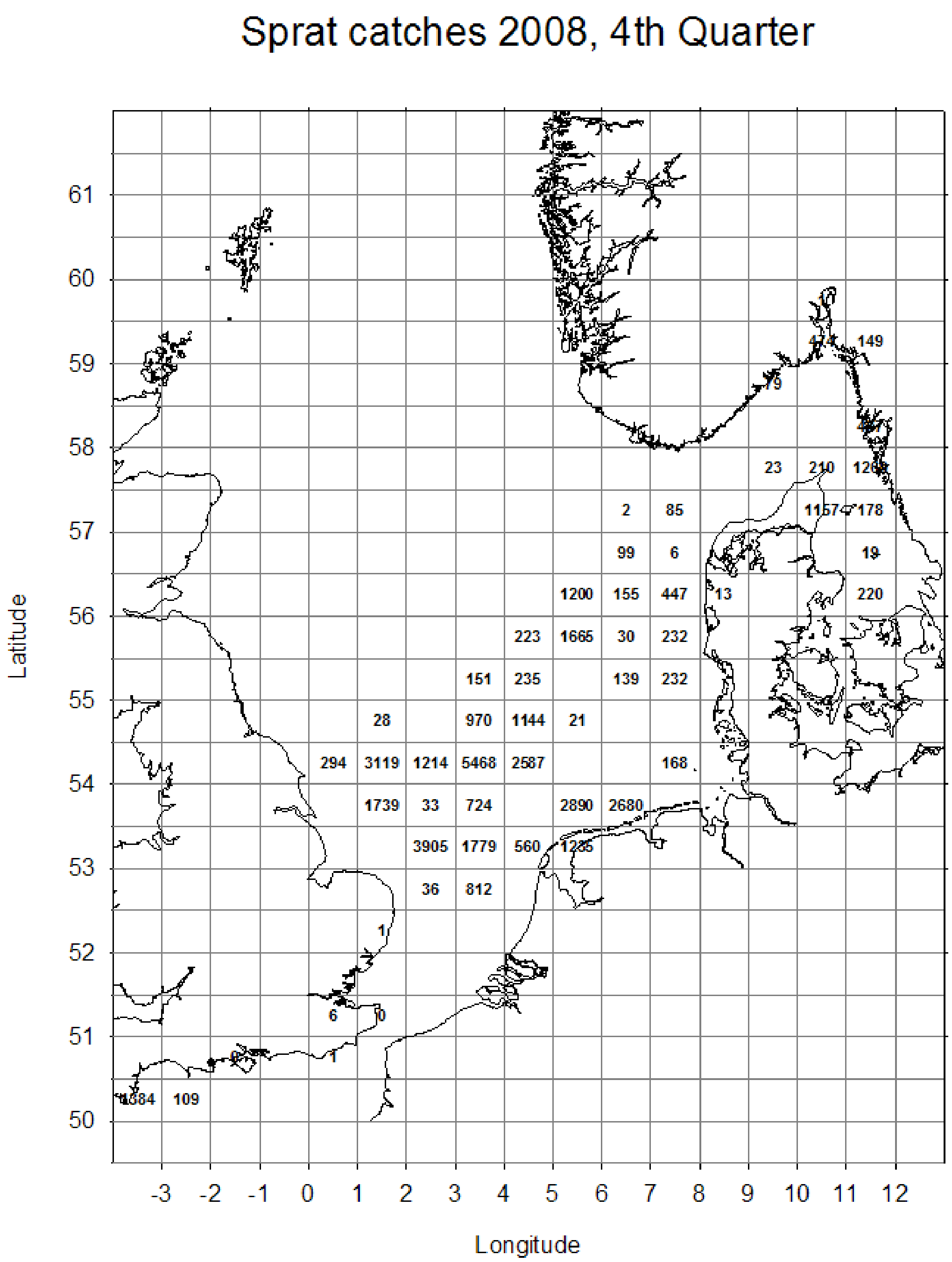


Figure 8.1.1d Sprat catches in the North Sea (in tonnes) in 2008 by statistical rectangle. Working group estimates (if available). d.: 4th quarter

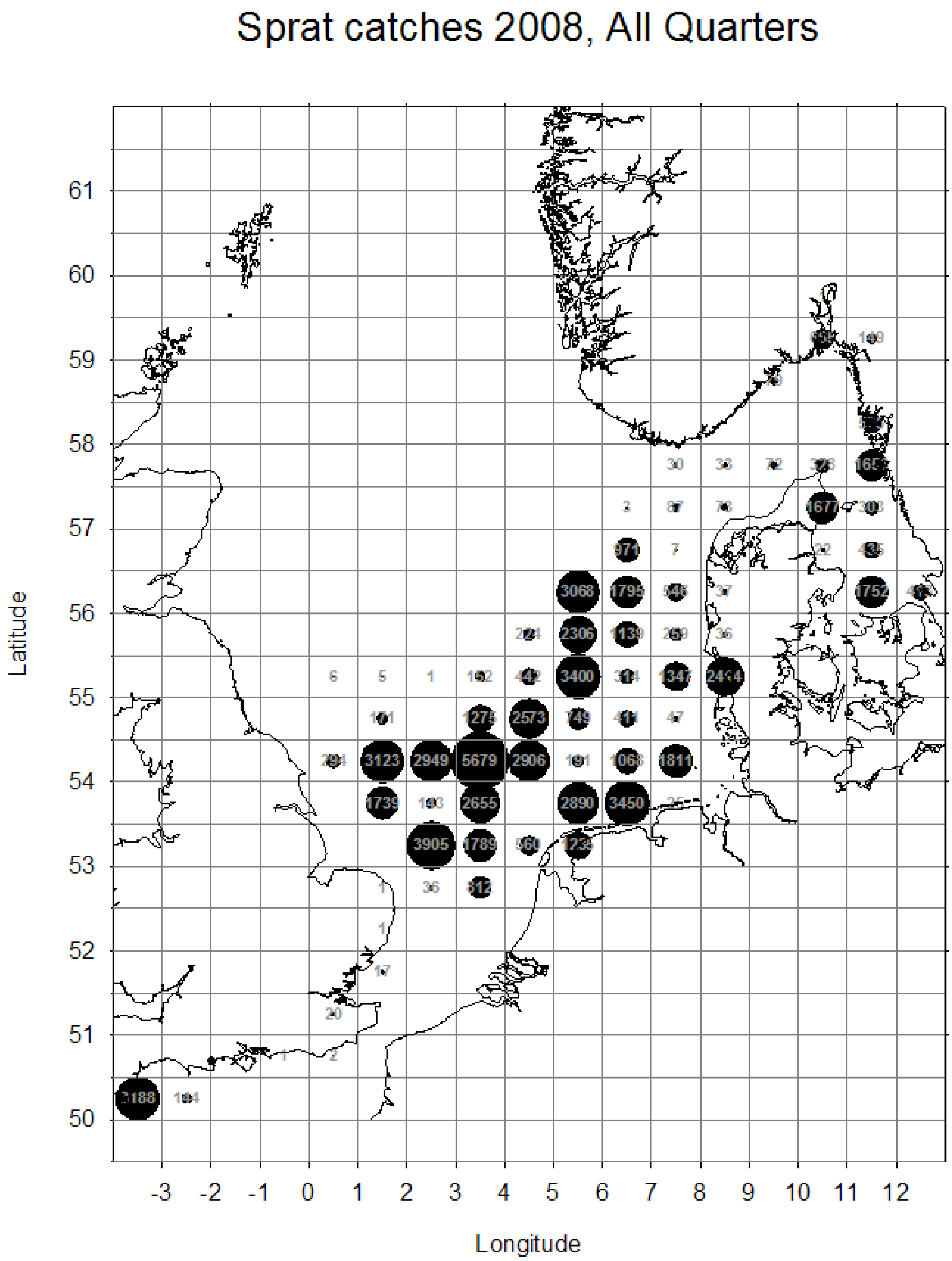


Figure 8.1.2 **Sprat catches in the North Sea (in tonnes) in 2008 by statistical rectangle. Working group estimates (if available). e: all quarters**

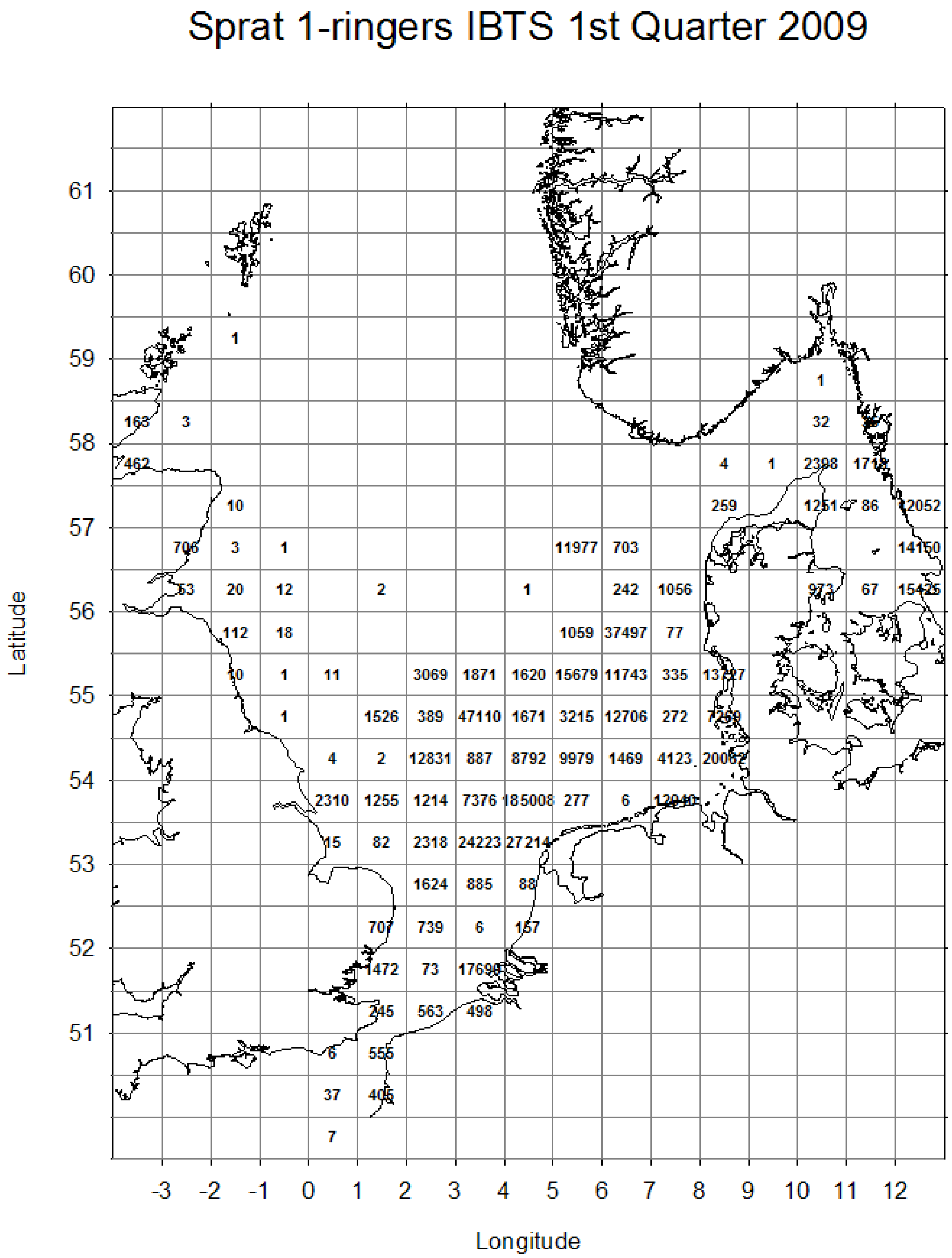


Figure 8.3.1a Distribution of 1-ringers in the IBTS (February) 2009 in the North Sea and Division IIIa (Mean number per hour per rectangle).

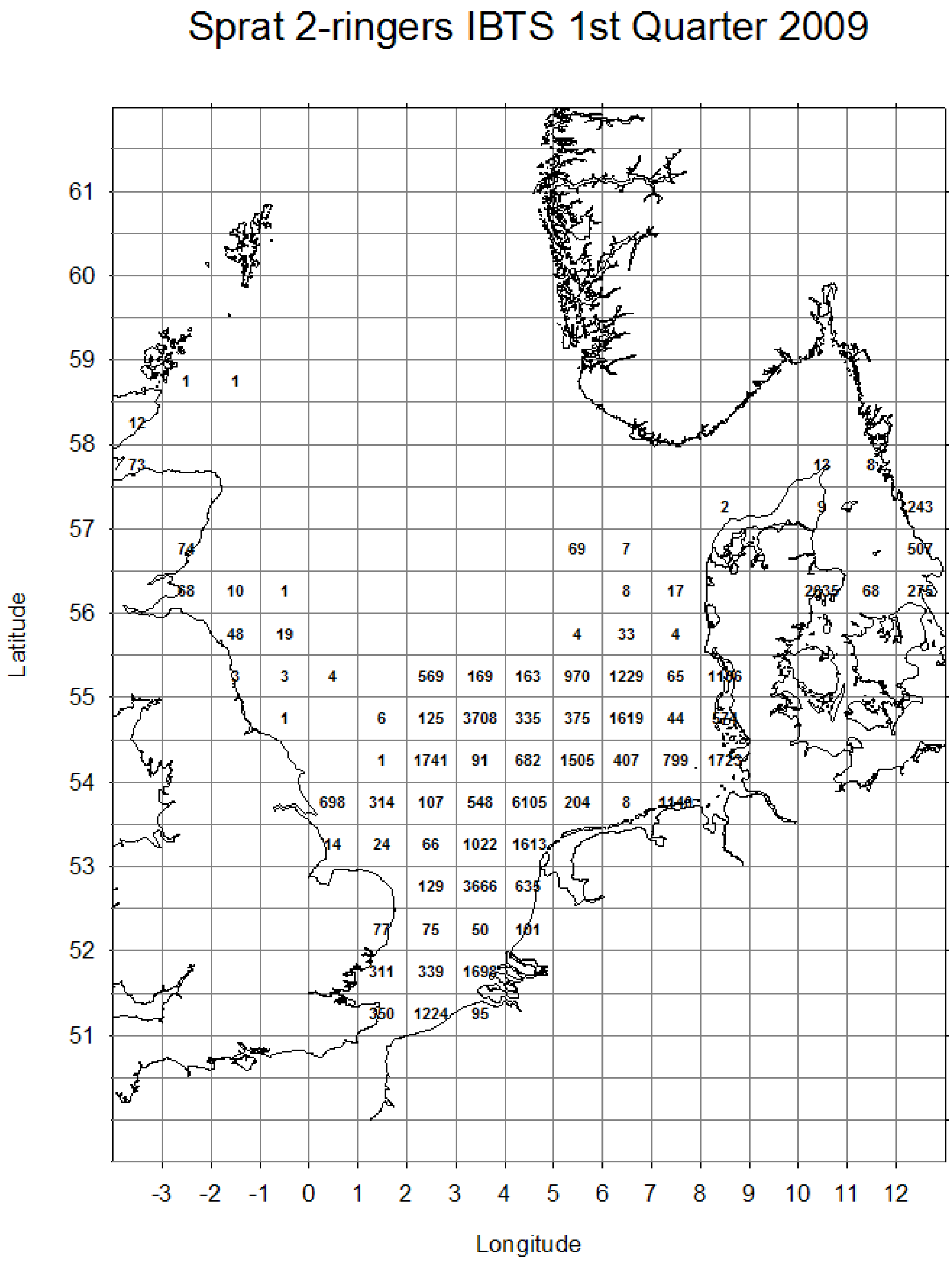


Figure 8.3.1b Distribution of 2-ringers in the IBTS (February) 2009 in the North Sea and Division IIIa (Mean number per hour per rectangle).

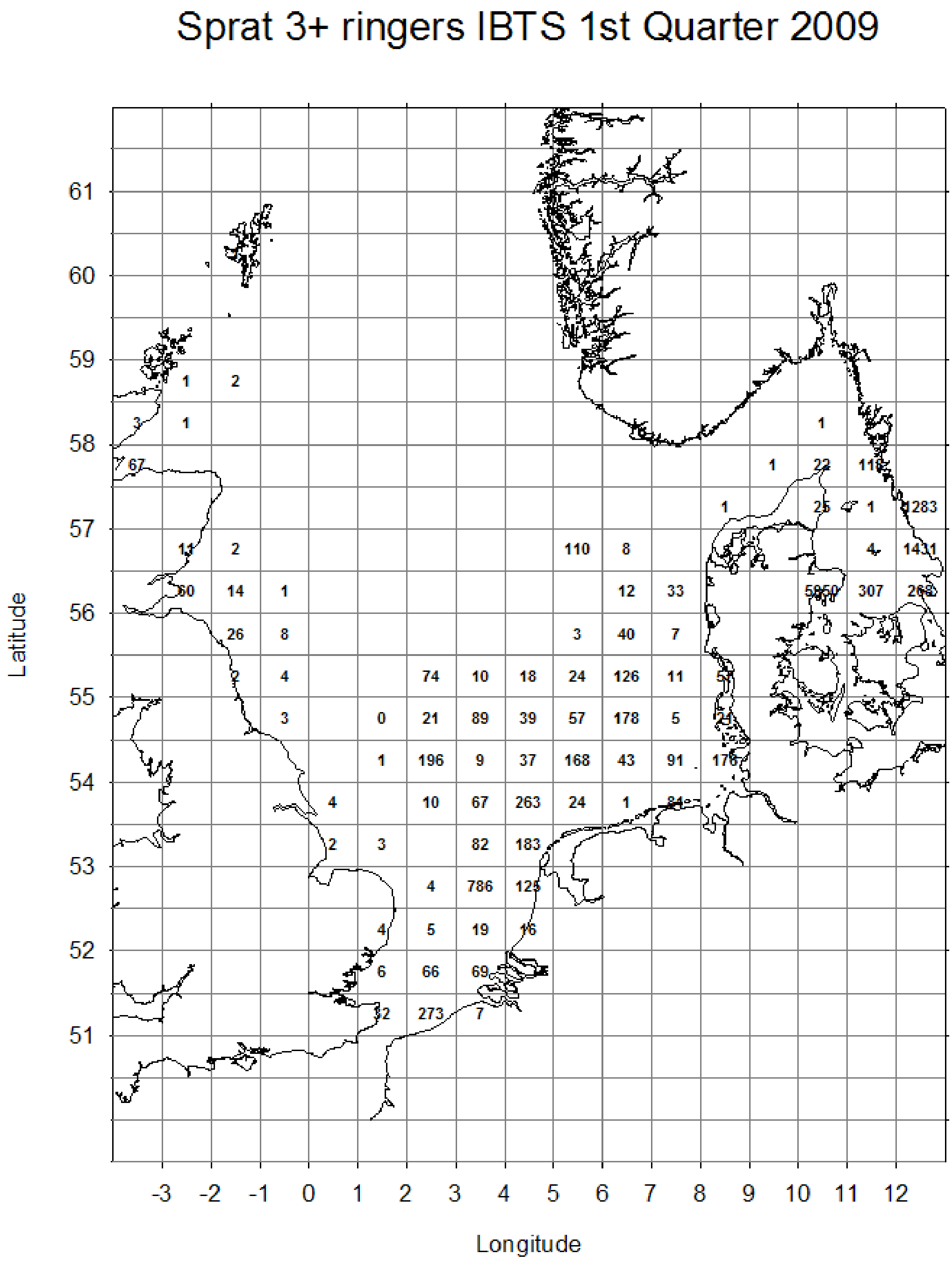


Figure 8.3.1c Distribution of 3-ringers in the IBTS (February) 2009 in the North Sea and Division IIIa (Mean number per hour per rectangle).

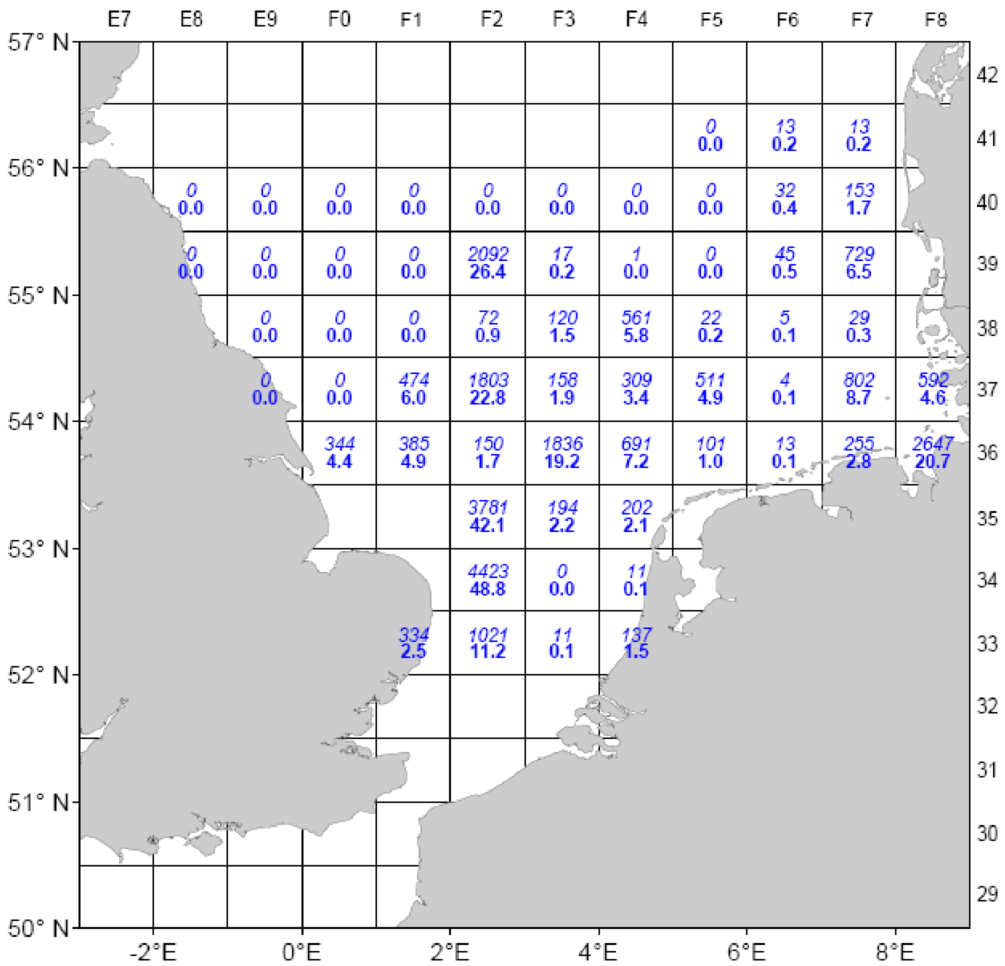


Figure 8.3.2 **North Sea Sprat. Abundance (upper figure, in millions) and biomass (lower figure, in 1000 t) per statistical rectangle as obtained by the herring acoustic survey 2008.**

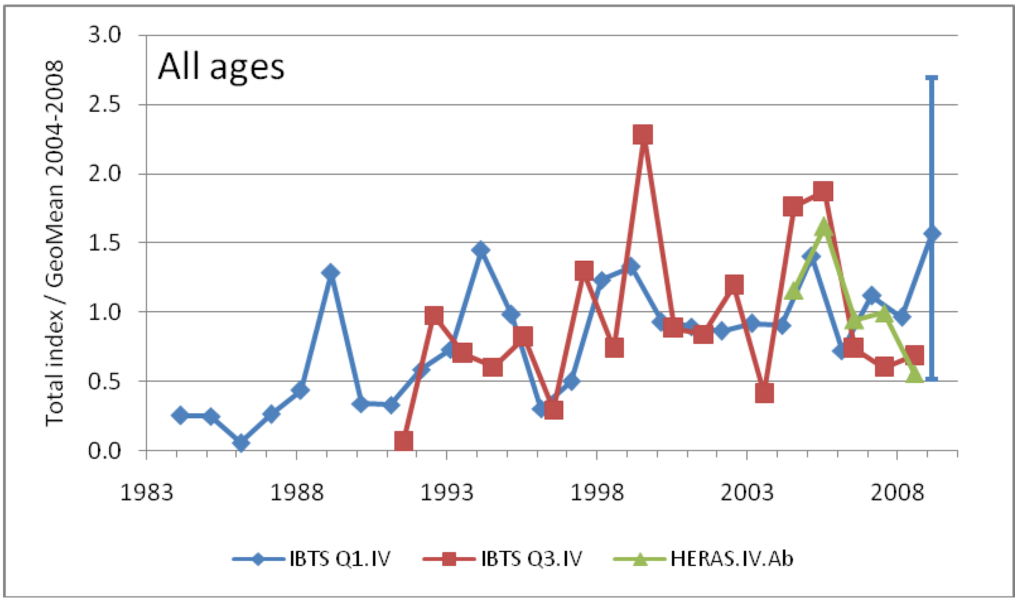


Figure 8.3.3 North Sea sprat. Normalized IBTS Q1, Quarter 3 and HERAS acoustic survey indices for the abundance of North Sea sprat. All indices are normalized by their geometric mean over the common period from 2004-2008. For the IBTS survey in Q1-2009 the standard deviation is presented with error bars.

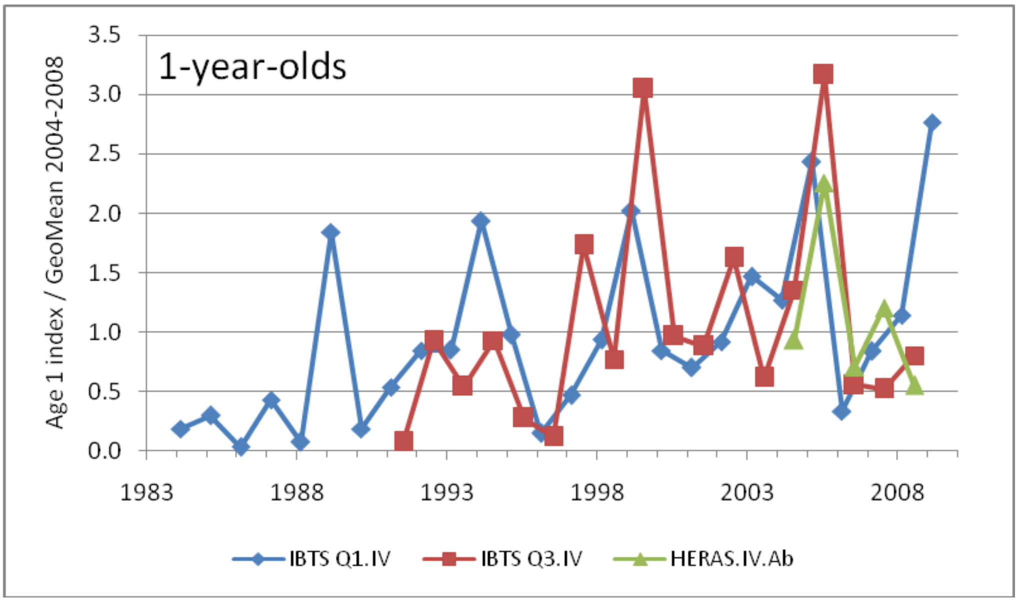


Figure 8.3.4. North Sea sprat. Normalized IBTS Q1, Quarter 3 and HERAS acoustic survey indices for age 1 North Sea sprat. All indices are normalized by their geometric mean over the common period from 2004-2008.

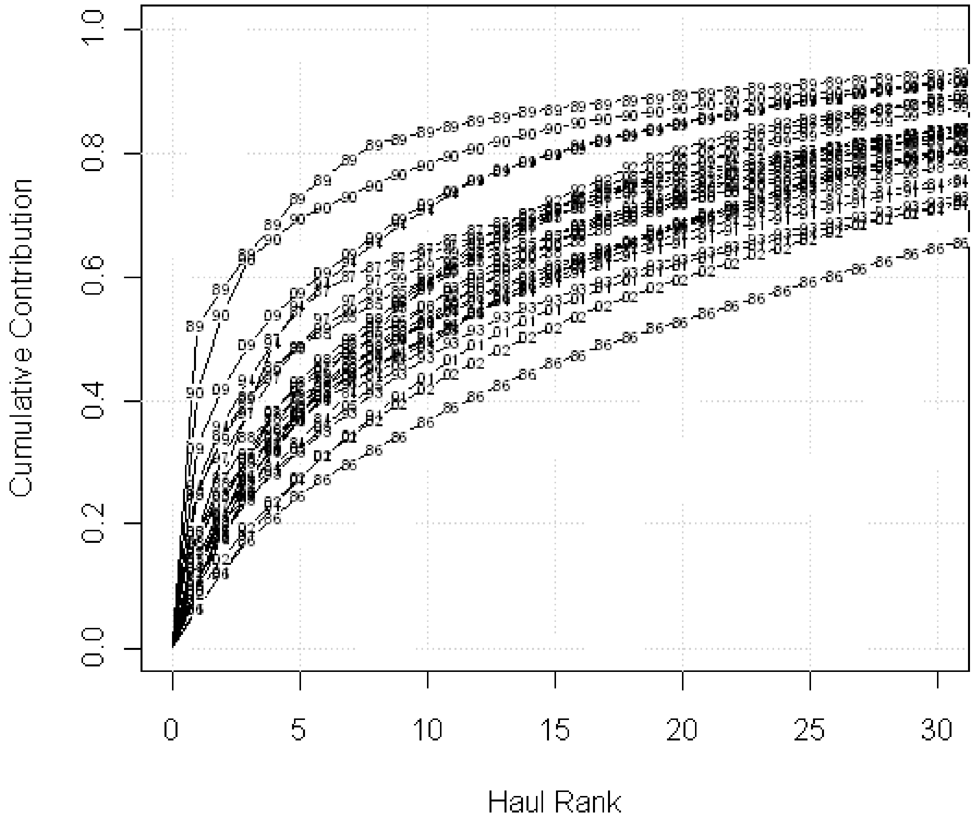


Figure 8.3.5 **North Sea sprat. Normalized cumulative-distribution of the per-haul contribution to the IBTS q1 sprat age 1 survey index. The 300-450 individual hauls contributions to the IBTS index in each year are sorted by size and then aggregated to calculate a cumulative-distribution. The plot shows only the contribution for the 30 largest hauls. Numbers on each line indicate the year for the survey.**

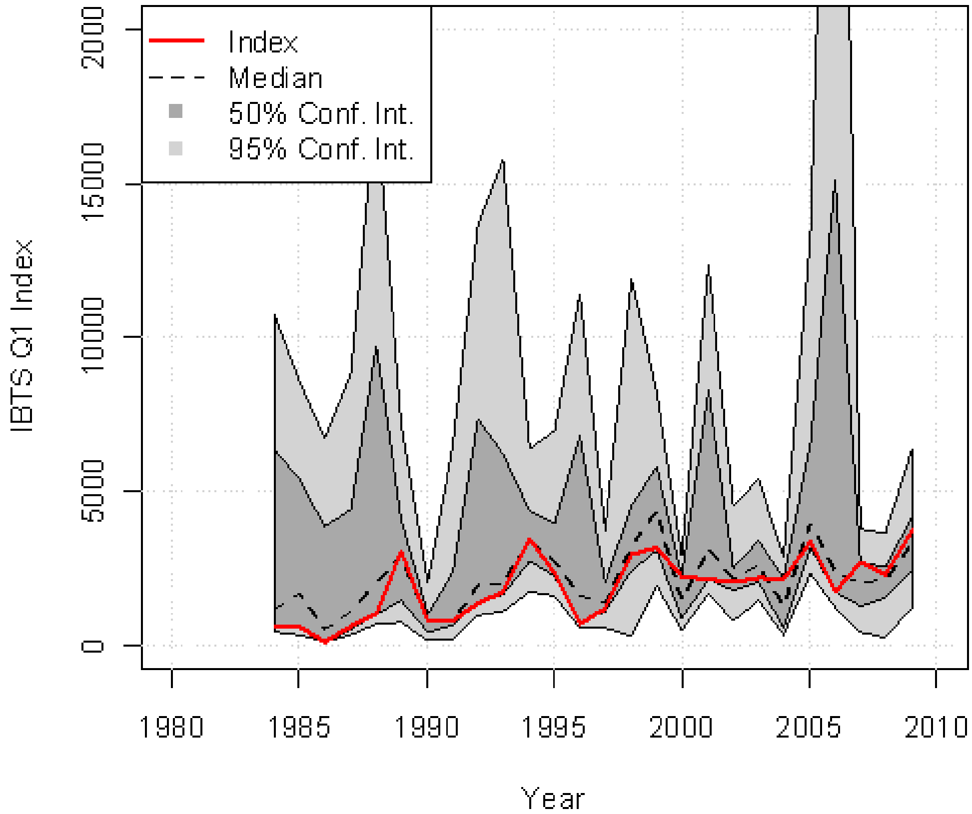


Figure 8.3.6 North Sea sprat. Time series of IBTS Q1 index values with estimates of uncertainty. Confidence intervals are estimated by the DATRAS database, based on bootstrapping of the raw haul data.

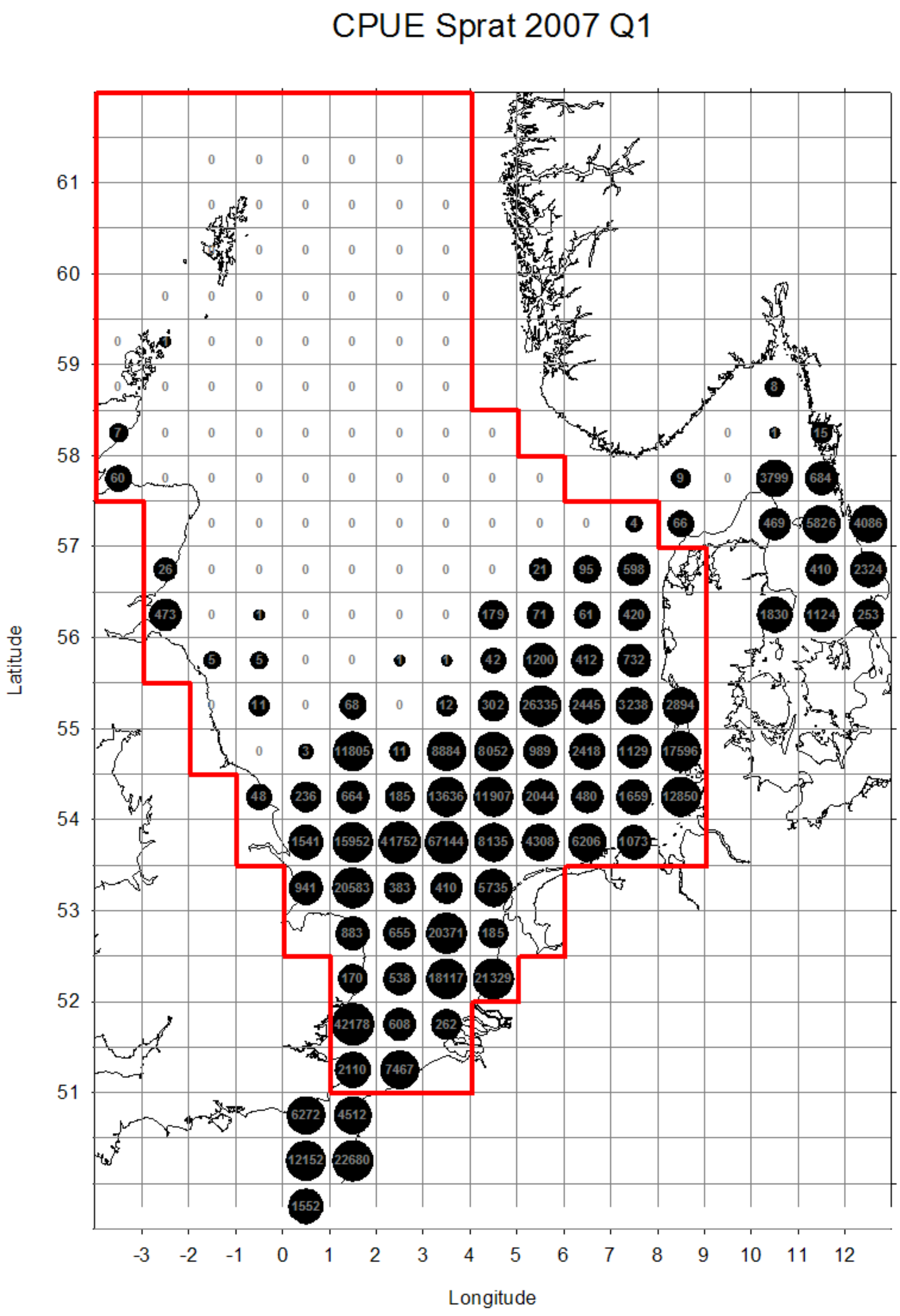


Figure 8.3.7a North Sea sprat. Comparison of the sprat CPUE in 2007 Q1 in the North Sea, Kattegat/Skagerrak and the English Channel. The red line encircles the North Sea sprat management stock. Data from the Channel has been sampled by the French IBTS survey.

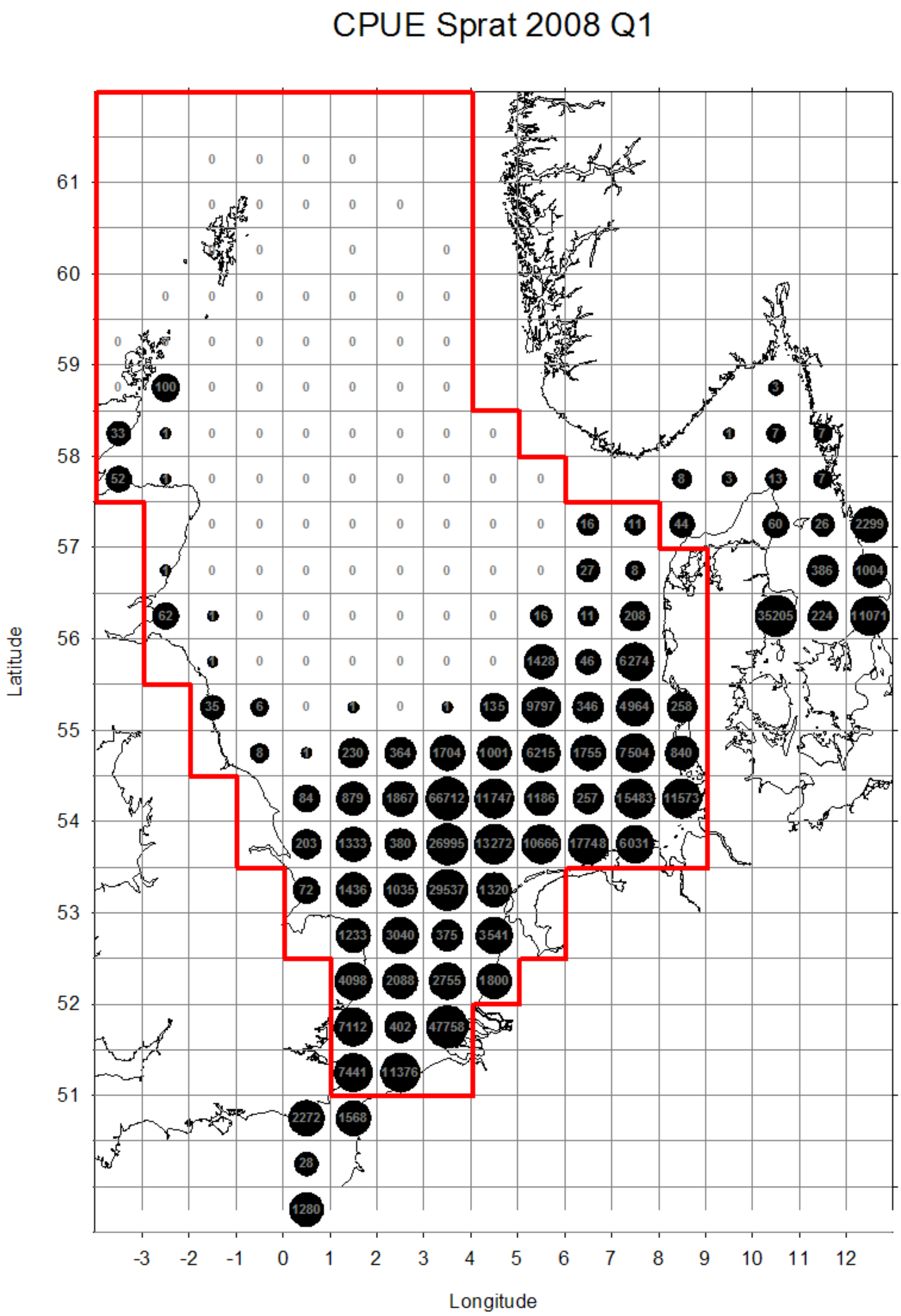


Figure 8.3.7b North Sea sprat. Comparison of the sprat CPUE in 2008 Q1 in the North Sea, Kattegat/Skagerrak and the English Channel. The red line encircles the North Sea sprat management stock. Data from the Channel has been sampled by the Dutch IBTS survey.

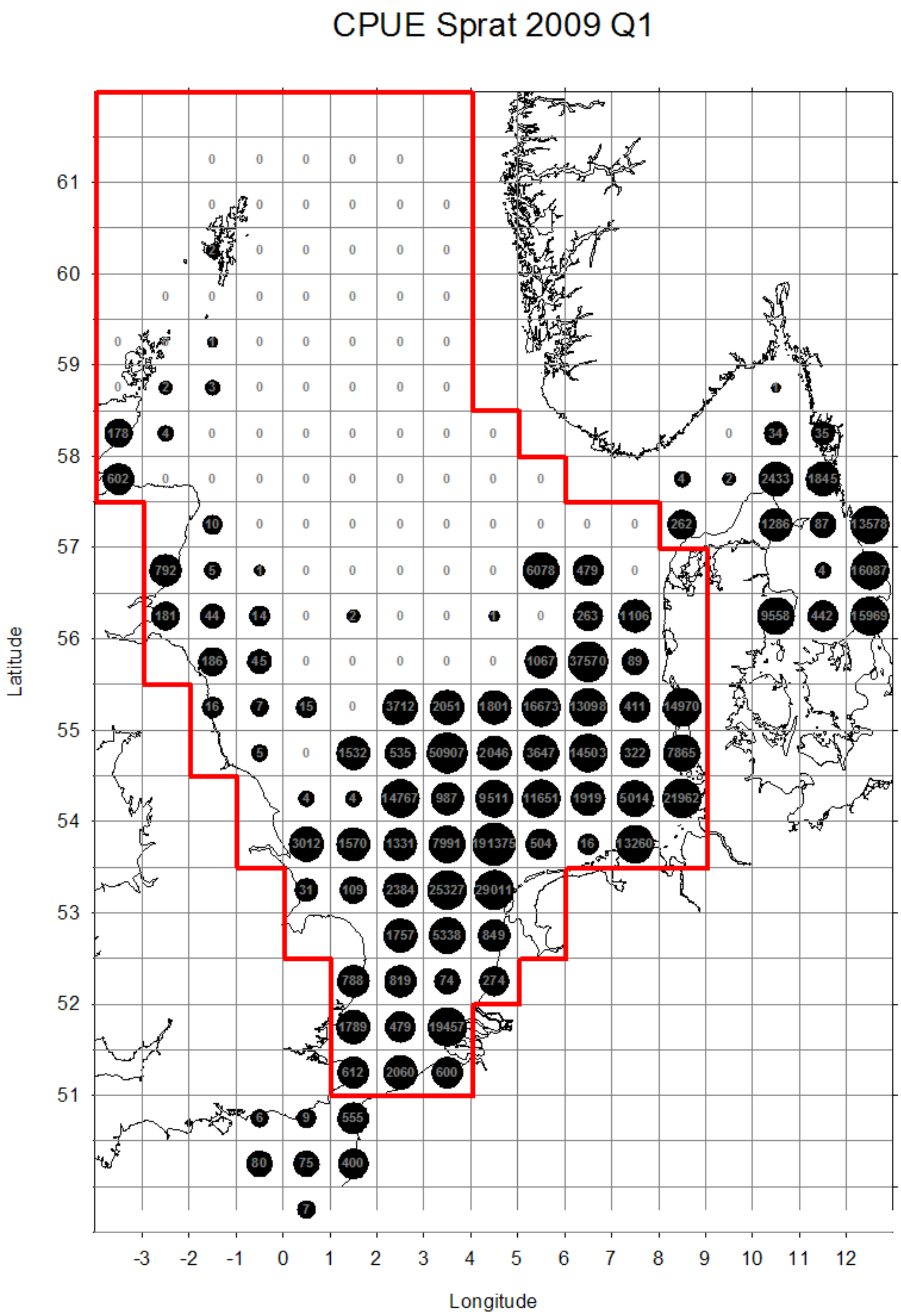


Figure 8.3.7c North Sea sprat. Comparison of the sprat CPUE in 2009 Q1 in the North Sea, Kattegat/Skagerrak and the English Channel. The red line encircles the North Sea sprat management stock. Data from the Channel has been sampled by the Dutch IBTS survey.

9 Sprat in Division IIIa

9.1 The Fishery

9.1.1 ICES advice applicable for 2008 and 2009

The ACFM advice on sprat management is that exploitation of sprat will be limited by the restrictions imposed on fisheries for juvenile herring. This is a result of sprat being fished mainly together with juvenile herring. The sprat fishery is controlled by a herring by-catch quota as well as by-catch percentage limits (Norway and Denmark: respectively max 10% and 20% by-catch of herring in weight). No advice on sprat TAC has been given in recent years.

For 2008 the sprat TAC was set at 52 000 t. The by-catch of herring for the EU fleet was 11 470 t. For 2009, the TAC for sprat is set at 52 000 t and the by-catch quota of herring for the EU fleet at 8 373 t.

9.1.2 Landings

The total landings decreased from 15 700 t in 2007 to 9 100 t in 2008 (Table 9.1.1) which is the lowest landings reported. The table presents the landings from 1996 onwards. The data from 1996 and onwards are considered reliable in this context due to the implementation of the new Danish monitoring scheme. The data prior to 1996 can be found in the HAWG report from 2006 (ICES 2006/ACFM:20).

In general, there were sprat landings in all quarters (Table 9.1.2, see Figures 8.1.1–8.1.2). In 2008 more than 80% of the total landings were taken in the 1st and 4th quarter. In the Norwegian fishery landings were taken in the 1st and 4th quarter, all as part of the fishery for “anchovy”-production (large sprat).

9.1.3 Fleets

Fleets from Denmark, Norway and Sweden carry out the sprat fishery in Division IIIa.

The Danish sprat fishery consists of trawlers using a 16 mm mesh size codend, and all landings are used for fishmeal and oil production. Some of the sprat landings from Denmark and Sweden are by-catches from the herring fishery using 32 mm mesh size codends. There is a Swedish fishery (mainly pelagic trawlers, but also a few purse seiners) directed at herring for human consumption, with by-catches of sprat.

The Norwegian sprat fishery in Division IIIa is a coastal/fjord purse seine fishery for human consumption.

9.1.4 Regulations and their effects

Sprat cannot be fished without by-catches of herring except in years with high sprat abundance or low herring recruitment. Management of this stock should consider management advice given for herring in Subarea IV, Division VIId, and Division IIIa.

Most sprat catches are taken in an industrial fishery where catches are limited by herring by-catch restrictions.

9.1.5 Changes in fishing technology and fishing patterns

No changes in fishing technology and fishing patterns of importance for the sprat fisheries in IIIa have been reported.

The new Danish quota system (IOK) has also been implemented in 2008 in IIIa (c.f. section 8.1.3).

9.2 Biological Composition of the Catch

9.2.1 Catches in number and weight-at-age

In 2008 the total numbers of sprat is at the same level as in 2006 and 2007 (Table 9.2.1). In 2008 the majority of the landing (in numbers) is 0-year olds, contribution 44% of the total number of landed sprat. This is the highest 0-year contribution in the period from 2000 and onwards. 1- and 2-year olds contribute respectively 23% and 19% to the landed numbers of sprat. Landings of 5+ age group was in 2008 (2%) the highest in the period given. Data for 1996-2003 is presented in ICES CM 2007/ACFM:11.

Denmark and Sweden provided biological samples from all quarters. No Norwegian samples were collected. Landings in 2008, for which samples were collected, were raised using a combination of Swedish and Danish samples, without any differentiation in types of fleets. Details on the sampling for biological data per country, area and quarter are shown in Table 9.2.3. 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, except for 2007 where the mean weight-at-age were the largest in the period. Mean weights-at-age for 1996-2003 are presented in ICES CM 2005/ACFM:16.

9.3 Fishery-independent information

Acoustic estimates of sprat have been available from the ICES co-ordinated Herring Acoustic Surveys in Division IIIa since 1996. At the time of the surveys, sprat has mainly been recorded in the Kattegat (ICES CM 2009/LRC:02).

In 2008 sprat was only observed in the Kattegat (ICES squares 41G1-G2, 42G0-G2, 43G0-G1 and 44G1). The total abundance was estimated to 775 million individuals - a decrease from 6 319 million sprat in 2007. The biomass was estimated to 12 000 t. Two-year old sprat dominated (~ 60%) and half of them were immature (ICES CM 2009/LRC:02).

The IBTS (February) sprat indices for 1984-2009 are presented in Table 9.3.1.

The preliminary total IBTS index for 2009 doubled compared to the 2008 index mainly due to high abundance of 1-group sprat.

9.4 Mean weight-at-age and length-at-maturity

Data on maturity by age, mean weight- and length-at-age during the 2008 summer acoustic survey are presented in the PGIPS report (ICES 2009/LRC:02).

9.5 Recruitment

For this stock, the IBTS index for 1-group sprat in the first quarter is considered the most suitable recruitment index (Table 9.3.1). The 1-group index for 2009 is well above the average for the time series, and makes 86% of the total index. This is the highest dominance of 1-group ever observed. In 2008 the 1-group index contributed less than 10% of the total index. The procedure for the survey did not differ from previous years. However, the index does not fully reflect strong and weak cohorts seen in the catch. This has also been expressed in a previous working group report (ICES 1998/ACFM:14), and may be linked to difficulties in age determination and/or methodological issues related to the way the indices are estimated (see 3.1.7).

9.6 State of the Stock

No assessment of the sprat stock in Division IIIa has been presented since mid-1980ies and this year is no exception. Various methods have been explored without success (ICES CM 2007/ACFM:11).

The signal in the IBTS (February) index for 2009 indicates an increase in the sprat stock due to a good incoming year class.

9.7 Projection of Catch and Stock

No assessment is presented for this stock.

9.8 Reference Points

No precautionary reference points are defined for this stock.

9.9 Management Considerations

Sprat in Division IIIa 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. In the last years the sprat fisheries has not been limited by the sprat quota, since this quota has not been taken.

9.10 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, as a prey species for both fish and seabirds. Many of the plankton feeding fish have recruited poorly in recent years (e.g. herring, sandeel, Norway pout). The implications for sprat in IIIa are at present unknown.

9.11 Changes in the environment

Temperatures in the area have increased over the last years. It is considered that this may have implications for sprat.

Table 9.1.1 Division IIIa sprat. Landings in ('000 t) 1996-2008.
(Data provided by Working Group members). These figures do not in all cases correspond to the official statistics and cannot be used for management purposes.

	Skagerrak				Kattegat			Div. IIIa
Year	Denmark	Sweden	Norway	**Total**	Denmark	Sweden	**Total**	**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

* < 50 t

Table 9.1.2. Division IIIa sprat. Landings of sprat ('000 t) by quarter by countries, 2000-2008. Data for 1996-1999 in ICES CM 2007/ACFM:11 (Data provided by the Working Group members)

	Quarter	Denmark	Norway	Sweden	Total
2000	1	4.1	0.1	2.3	6.5
	2			1.9	1.9
	3	4.8	0.1		4.9
	4	3.8	0.7	2.3	6.8
	Total	12.7	0.9	6.4	20.0
2001	1	2.5		2.6	5.2
	2	6.6		0.1	6.7
	3	10.2		0.1	10.2
	4	0.9	1.4	4.8	7.1
	Total	20.2	1.4	7.6	29.1
2002	1	3.8		1.4	5.2
	2	2.1		0.4	2.4
	3	5.9		0.1	6.0
	4	1.7		2.4	4.1
	Total	13.4		4.3	17.7
2003	1	3.5	0.1	1.7	5.3
	2	0.6		0.8	1.4
	3	1.0		0.7	1.7
	4	5.0	0.8	2.3	8.1
	Total	10.2	0.8	5.5	16.5
2004	1	3.1		1.4	4.5
	2	0.6		0.9	1.5
	3	3.7		0.4	4.1
	4	6.9	1.1	3.8	11.9
	Total	14.4	1.1	6.5	22.0
2005	1	6.5		1.7	8.1
	2	4.6		0.1	4.7
	3	18.6	0.7	0.8	20.1
	4	2.1		5.2	7.3
	Total	31.9	0.7	7.7	40.3
2006	1	5.4	0.2	2.7	8.3
	2	0.2		0.2	0.3
	3	1.3		0.1	1.4
	4	0.9	0.1	1.5	2.5
	Total	7.8	0.3	4.4	12.5
2007	1	2.3	0.4	0.4	3.1
	2	0.7		0.6	1.3
	3	5.1	*	0.2	5.4
	4	1.8	1.2	3.0	5.9
	Total	9.9	1.6	4.2	15.7
2008	1	2.3	0.2	0.6	3.1
	2	0.7		0.4	1.0
	3	0.4		0.2	0.6
	4	2.5	0.7	1.2	4.4
	Total	5.8	0.9	2.4	9.1

* < 50 t

Table 9.2.1 **Division IIIa sprat**. Landed numbers (millions) of sprat by age groups in 2004-2008. The landed numbers in 1996-2003 can be found in the ICES CM 2007/ACFM:11.

	Quarter	Age						Total
		0	1	2	3	4	5+	
2004	1		539.6	39.3	47.2	20.7	8.0	654.8
	2		36.7	22.3	44.9	11.8	1.1	116.8
	3	10.0	254.4	19.4	4.1	2.4		290.3
	4	874.0	366.8	33.0	24.9	3.4	0.3	1302.3
	Total	883.9	1197.5	113.9	121.1	38.3	9.3	2364.2
2005	1		1609.1	185.6	25.5	17.4	5.1	1842.7
	2		827.1	19.2	0.6			846.9
	3	1.8	1557.0	91.3	9.9	12.9		1672.9
	4	11.5	447.4	60.5	7.3	4.0	0.7	531.3
	Total	13.4	4440.6	356.6	43.3	34.2	5.8	4893.9
2006	1		219.8	433.3	93.7	16.6	10.3	773.7
	2		7.5	17.8	1.6	0.3		27.2
	3		9.4	55.8	13.7	2.8	1.3	83.1
	4	4.0	38.5	71.6	18.4	0.9	0.7	134.0
	Total	4.0	275.2	578.5	127.4	20.6	12.3	1018.0
2007	1		61.2	47.5	120.9	12.5	1.8	243.9
	2		26.1	17.8	53.5	4.9	0.5	102.9
	3		401.1	22.8	12.3	3.2		439.3
	4	33.4	248.6	57.0	50.5	6.6	1.1	397.1
	Total	33.4	737.0	145.1	237.2	27.2	3.4	1183.3
2008	1		3.1	127.1	41.0	36.7	15.0	222.8
	2		0.4	45.6	15.7	7.2	1.9	70.8
	3	71.5	33.4	2.7	1.0	0.8	1.1	110.5
	4	386.7	203.9	28.7	10.6	8.1	6.9	644.9
	Total	458.2	240.8	204.1	68.3	52.8	24.9	1049.0

Table 9.2.2. **Division IIIa sprat.** Quarterly mean weight-at-age (g) in the landings for the years 2000-2007. The equivalent data for 1996-2003 can be found in ICES CM 2007 /ACFM: 11. (Danish and Swedish data)

Year	Age						
	Quarter	0	1	2	3	4	5+
2004	1		4.6	14.6	17.8	17.3	17.3
	2		7.0	13.6	16.7	17.0	19.5
	3	3.0	14.1	16.7	20.0	21.4	
	4	3.5	16.8	19.9	22.2	20.9	28.0
Weighted mean		3.5	10.4	16.3	18.4	17.8	17.9
2005	1		3.0	14.6	16.3	20.3	21.1
	2		5.4	11.7	26.8		
	3	2.9	11.9	14.6	15.4	11.0	
	4	3.3	13.1	19.1	20.1	21.1	23.1
Weighted mean		5.0	7.6	15.4	17.1	17.2	21.5
2006	1		5.0	12.2	15.4	15.2	18.5
	2		7.0	13.3	16.3	22.0	
	3		11.2	17.4	20.3	18.6	22.8
	4	4.3	16.1	19.6	21.4	23.8	26.6
Weighted mean		4.3	6.8	13.6	16.8	16.1	19.4
2007	1		2.3	12.3	16.3	17.0	25.2
	2		6.1	17.1	20.6	21.9	20.4
	3		12.0	13.0	17.0	17.6	
	4	7.9	14.1	20.3	23.4	22.6	26.2
Weighted mean		7.9	11.5	15.9	18.4	19.3	25.2
2008	1		5.6	11.7	15.5	18.1	18.3
	2		8.0	12.5	17.1	19.3	22.2
	3	3.4	7.9	21.1	21.5	25.3	22.5
	4	3.4	9.2	20.7	21.4	25.2	22.8
Weighted mean		3.4	9.0	13.3	16.9	19.5	20.0

Table 9.2.3 **Division IIIa sprat.** Sampling commercial landings for biological samples in 2008.

Country	Quarter	Landings (tonnes)	No. samples	No. meas.	No. aged
Denmark	1	2 253	4	529	153
	2	671	5	163	56
	3	446	1	77	
	4	2 459	3	336	147
	Total	5 829	13	1 105	356
Norway	1	190			
	2				
	3				
	4	704			
	Total	894			
Sweden	1	637	3	697	697
	2	350			
	3	189			
	4	1 213	11	539	539
	Total	2 389	14	1 236	1 236
Denmark		5 829	51	4 501	955
Norway		894			
Sweden		2 389	18	1 226	1 225
	Total	9 112	69	5 727	2 180

Table 9.3.1. **Division IIIa sprat**. IBTS (February) indices of sprat per age group 1984-2009.

Year	No Rect	No hauls	Age Group					
			1	2	3	4	5+	Total
1984	15	38	5 675.45	868.88	205.10	79.08	63.57	6 892.08
1985	14	38	2 157.76	2 347.02	392.78	139.74	51.24	5 088.54
1986	15	38	628.64	1 979.24	2 034.98	144.19	37.53	4 824.58
1987	16	38	2 735.92	2 845.93	3 003.22	2 582.24	156.64	11 323.95
1988	13	38	914.47	5 262.55	1 485.07	2 088.05	453.13	10 203.26
1989	14	38	413.94	911.28	988.95	554.53	135.79	3 004.48
1990	15	38	481.02	223.89	64.93	61.11	45.69	876.65
1991	14	38	492.50	726.82	698.11	128.36	375.44	2 421.23
1992	16	38	5 993.64	598.71	263.97	202.90	76.04	7 135.25
1993	16	38	1 589.92	4 168.61	907.43	199.32	239.64	7 104.92
1994	16	38	1 788.86	715.84	1 050.87	312.65	70.11	3 938.32
1995	17	38	2 204.07	1 769.53	35.19	44.96	4.23	4 057.98
1996	15	38	199.30	5 515.42	692.78	111.98	173.75	6 693.23
1997	16	41	232.65	391.23	1 239.13	139.14	134.51	2 136.67
1998	15	39	72.25	1 585.22	619.76	1 617.71	521.52	4 416.46
1999	16	42	4 534.96	355.24	249.86	44.25	313.52	5 497.83
2000	16	41	292.32	737.80	59.69	51.79	23.21	1 164.80
2001	16	42	6 539.48	1 144.34	676.71	92.37	45.87	8 498.77
2002	16	42	1 180.52	1 035.71	89.96	58.85	12.93	2 377.96
2003	17	46	462.64	1 247.49	1 172.13	382.29	123.17	3 387.72
2004	16	41	402.87	49.00	156.62	86.57	27.48	722.54
2005	17	50	3 314.17	1 563.16	470.84	837.09	538.37	6 723.63
2006	17	45	1 323.59	11 855.76	1 753.92	299.05	159.23	15 391.55
2007	18	46	774.11	306.63	250.81	42.08	13.74	1 387.37
2008	17	46	150.85	982.68	132.54	228.48	107.70	1 602.26
2009*	17	46	2 686.72	124.46	259.15	29.60	37.43	3 137.36

* Preliminary

10 Stocks with insufficient data

Two stocks with very low research intensity were poorly described in previous reports in devoted sections or chapters. These were Clyde herring (Section 5.11 in ICES 2005a) and sprat in VIId,e (Section 9 in ICES 2005). The advice on these stocks cannot be improved at present. In this section only the times series are maintained. For most recent advice refer to the appropriate sections in the HAWG report (ICES CM 2005/ACFM:18).

There was sampling of the catch in 2008 for Clyde herring, with one sample available in quarter 4. The catch of Clyde herring in 2008 was low (Table 10.1). The 2008 Clyde herring catch was on a par with the 2007 catch and, again, slightly higher than in recent years.

The catches of sprat in VIId and VIIe were nearly doubled in 2008 compared to the past years (Table 10.2). Landings have not been at the level of 2008 since 1999.

Table 10.1 Herring from the Firth of Clyde. Catch in tonnes by country, 1955–2008. Spring and autumn-spawners combined.

Year	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968
All Catches														
Total	4 050	4 848	5 915	4 926	10 530	15 680	10 848	3 989	7 073	14 509	15 096	9 807	7 929	9 433

Year	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	
All Catches														
Total	10 594	7 763	4 088	4 226	4 715	4 061	3 664	4 139	4 847	3 862	1 951	2 081	2 135	

Year	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Scotland	2 506	2 530	2 991	3 001	3 395	2 895	1 568	2 135	2 184	713	929	852	608	392
Other UK	-	273	247	22	-	-	-	-	-	-	-	1	-	194
Unallocated[1]	262	293	224	433	576	278	110	208	75	18	-	-	-	-
Discards	1 253	1 265	2 308[3]	1 344[3]	679[3]	439[4]	245[4]	-[2]	-[2]	-[2]	-[2]	-[2]	-[2]	-[2]
Agreed TAC			3 000	3 000	3 100	3 500	3 200	3 200	2 600	2 900	2 300	1 000	1 000	1 000
Total	4 021	4 361	5 770	4 800	4 650	3 612	1 923	2 343	2 259	731	929	853	608	586

Year	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	
Scotland	598	371	779	16	1	78	46	88	-	-	+	163	54	
Other UK	127	475	310	240	0	392	335	240	-	318	512	458	622	
Unallocated[1]	-	-	-	-	-	-	-	-	-	-	-	-		
Discards	-	-	-	-	-	-	-	-	-	-	-	-		
Agreed TAC	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	800	800	
Total	725	846	1089	256	1	480	381	328	0	318	512	621	676	

[1]Calculated from estimates of weight per box and in some years estimated by-catch in the sprat fishery

[2]Reported to be at a low level, assumed to be zero, for 1989-1995.

[3]Based on sampling.

[4]Estimated assuming the same discarding rate as in 1986

Table 10.2. Sprat VIId,e. Nominal catches in tonnes of sprat in VIId,e from 1985-2008

	1985	1986	1987	1988	1989	1990	1991	1992
Denmark		15	250	2 529	2 092	608		
France	14		23	2	10			35
Netherlands								
UK (Engl.&Wales)	3 771	1 163	2 441	2 944	1 319	1 508	2 567	1 790
Total	3 785	1 178	2 714	5 475	3 421	2 116	2 567	1 825
Country	**1993**	**1994**	**1995**	**1996**	**1997**	**1998***	**1999***	**2000***
Denmark								
France	2	1	0					18
Netherlands							1	1
UK (Engl.&Wales)	1 798	3 177	1 515	1 789	1 621	2 024	3 559	1 692
Total	1 800	3 178	1 515	1 789	1 621	2 024	3 560	1 711
Country	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**
Denmark								
France								
Netherlands								
UK (Engl.&Wales)	1 349	1 196	1 377	836	1 635	1 974	1819	3366
Total	1 349	1 196	1 377	836	1 635	1 974	1819	3366
* Preliminary								

11 Working Documents

WD 01 Beggs,S., Schon,P.J., McCurdy,W., Peel,J., McCorriston, P., McCausland,I.: Seasonal Origin of 1-ring+ Herring in the Irish Sea (VIIaN) Management Area During the Annual Acoustic Survey. AFBI, Belfast, N. Ireland, UK.

WD 02 Brunel, Dickey-Collas, M. :Recruitment-environment relationships in North Sea herring revisited : looking for limiting factors using quantile regression. Wageningen IMARES, IJmuiden, The Netherlands.

WD 03 Aloysius, T.M., van Helmond Harriët M.J. van Overzee: Estimates of discarded herring by Dutch flagged vessels 2003-2008 Wageningen IMARES, IJmuiden, The Netherlands.

WD 04 Dickey-Collas, M., Bolle, L.J., van Beek J.K.L., Erftemeijer P.L.A.: How variable is the interannual transport of herring larvae in the southern North Sea?, Wageningen IMARES, IJmuiden, The Netherlands.

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WD 06 Gröhsler, T.: Fisheries & Stock assessment data in the Western Baltic in 2008. vTI-OSF, Rostock, Germany.

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WD 08 Harma, C., Clarke M., Brophy D.: Relative strength of autumn spawners in Celtic Sea herring over time, Marine Institute, Rinville, Oranmore, Galway, Ireland.

WD 09 Clarke, M., Egan A, Molloy J.: Developing a recruit index for Celtic Sea herring, Marine Institute, Rinville, Oranmore, Galway, Ireland.

WD 10 Bierman, S. M., Dickey-Collas,M., van Damme, C. J. G.,. van Overzee, H. M. J., Pennock, I M. G. Tribuhl, S. V. Wageningen IMARES, IJmuiden, The Netherlands. L. A. W. Clausen, L.A.W.: Mixing of North Sea herring spawning components in the summer catch, is there a consistent pattern?

WD 11 Dickey-Collas, M., Clarke, M., Slotte, A., (Conveners): Linking Herring': do we really understand plastic? Wageningen IMARES, IJmuiden, The Netherlands. Marine Institute, Galway, Ireland. A. Slotte: IMR, Bergen, Norway.

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ANNEX 1: List of Participants

Herring Assessment Working Group South of 62° N [HAWG]

17-25 March 2009

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Annex 2 - Recommendations

HAWG 2009 makes the following recommendations:

RECOMMENDATION	ACTION
The FLICA assessment method cannot be maintained in its current form, due to its inclusion of the proprietary NAG optimisation libraries. HAWG and ICES should develop a roadmap for the succession of this method, with the aim of employing an alternative implementation or assessment model in the next round of benchmark assessments.	ACOM, ICES Secretariat, WGMG
HAWG recommends that spatial data and information on sampling coverage and precision needs to be provided.	PGCCDBS and DCF
HAWG recommends that all metiers with substantial catch should be sampled (including by-catches in the small meshed fishery). (see Section 2.2.2).	National labs, PGCCDBS
HAWG recommends to describe the methods, parameters and settings underlying the IBTS sprat indices; furthermore, all sprat IBTS indices need to be revised by focussing on 10 to 150 m depth.	ICES Secretariat
HAWG encourages the development of guidance on the sampling of landings of flagged vessels landing into different states under the DCF.	PGCCDBS and North Sea RCM
Fleet definitions of the fishery in Div. IIIa (see Section 3.1.2): HAWG recommends an exploration of whether the discrepancy identified between the Swedish and Danish fleet definition of vessels operating in Div. IIIa have any effect on the raising of the input data during HAWG and in the end have a clear definition of the fleets exploiting the stock and in particular the samples taken from these fleets.	National laboratories
It has long been recognized by this working group that a recruit index is required for Celtic Sea herring. To achieve this HAWG makes a three-fold recommendation: 1. Update the NI GFS survey data for 0- and 1-ring herring. In order to segregate these by season of spawning otolith techniques should be used. This could provide an index of recruitment for Irish Sea herring and of the abundance of Celtic Sea emigrants in the Irish Sea.	PGCCDBS, PGIPS, IBTSWG

2. The 1-quarter trawl survey, using GOV trawl, conducted in 2009, should continue in subsequent years. 3. The time allocated to VIIj in the q-4 Celtic Sea acoustic survey has rarely encountered substantial herring abundance. Sacrificing this VIIj acoustic ship time would not jeopardize the existing acoustic index. However the ship time saved could be re-allocated to the q-1 trawl survey mentioned in point 2 above.	
The WESTHER project has demonstrated that fish of several different stocks mix in the VIaN area. HAWG recommends the splitting of survey abundances by spawning season be implemented in 2009 and subsequent years. This should be implemented for each of the three constituent surveys of the Malin Shelf.	HAWG, PGIPS, PGCCDBS
HAWG recommends that discrepancies at the area level in the output of conventional used systems and InterCatch should be elucidated in detail between stock-coordinators and ICES InterCatch team. Furthermore, routines should be implemented in InterCatch to report on CATON, WECA and CANUM for area IIIa, and for NSAS and WBSS spawners separately.	ICES InterCatch

Annex 3– Stock Annex North Sea Herring

Quality Handbook	ANNEX: hawg-her47d3

Stock specific documentation of standard assessment procedures used by ICES.

Stock:	North Sea Autumn Spawning Herring (NSAS)
Working Group:	Herring Assessment WG for the Area south of 62°N
Date:	22 March 2009
Authors:	C. Zimmermann, J. Dalskov, M. Dickey-Collas, H. Mosegaard, P. Munk, J. Nichols, M. Pastoors, N. Rohlf, E.J. Simmonds, D. Skagen, N. Payne, M. Payne

A. General

A.1. Stock definition:

Autumn spawning herring distributed in ICES area IV, Division IIIa and VIId. Mixing with other stocks occurs especially in Division IIIa (with Western Baltic Spring Spawning herring). Genetic studies have failed to prove that the stock is not one unit (Mariani *et al*., 2005; Reiss *et al*., 2009).

A.2. Fishery

North Sea Autumn Spawners are exploited by a variety of fleets, ranging from small purse seiners to large freezer trawlers, of different nations (Norway, Denmark, Sweden, Germany, The Netherlands, Belgium, France, UK, Faroe Islands). The majority of the fishery takes place in the Shetland-Orkney area and northern North Sea in the 2nd and 3rd quarter, and in the English Channel (Division VIId) in the 4th quarter. Juveniles are caught in Division IIIa and as by-catch in the industrial fishery in the central North Sea. For management purposes, 4 fleets are currently defined: Fleet A is harvesting herring for human consumption in IV and VIId, but includes herring by-catches in the Norwegian industrial fishery; fleet B is the industrial (small mesh, <32 mm mesh size) fleet of EU nations operating in IV and VIId. North Sea Autumn spawners are also caught in IIIa in fleets C (human consumption) and D (small mesh).

A.3. Ecosystem aspects:

Herring is the key pelagic species in the North Sea and is thus considered to have major impact as prey and predator to most other fish stocks in that area.

The North Sea is semi-enclosed and situated on the continental shelf of North-western Europe and is bounded by England, Scotland, Norway, Sweden, Denmark, Germany, the Netherlands, Belgium and France. It covers an area of ~750 000 km^2 of which the greater part is shallower than 200 m. It is one of the most diverse coastal regions in the world, with a variety of coastal habitats (fjords, estuaries, deltas, banks, beaches, sandbanks and mudflats, marshes, rocks and islands), and four ecological seasons. It is a highly productive (>300 gC m^{-2} yr^{-1}) ecosystem but with primary productivity varying considerably across the sea. The highest values of primary productivity occur in the coastal regions, influenced by terrestrial inputs of nutrients, and in areas such as the Dogger Bank and tidal fronts. Changes observed in trophic structure are indicative of a trend towards a decreasing resilience of this ecosystem. This trend is partially a response to inter-annual changes in the physical oceanography of the North Atlantic.

Herring are an integral and important part of the pelagic ecosystem in the North Sea. As plankton feeders they form an important part of the food chain up to the higher trophic levels. Both as juveniles and as adults they are an important source of food for some demersal fish and for sea mammals. Over the past century the top predator, man, has exerted the greatest influence on the abundance and distribution of herring in the North Sea. Spawning stock biomass has fluctuated from estimated highs of around 4.5 million tonnes in the late 1940s to lows of less than 100 000 tonnes in the late 1970s (Simmonds 2007). The species has demonstrated robustness in relation to recovery from such low levels once fishing mortality is curtailed in spite of recruitment levels being adversely affected (Payne *et al*., 2009, Nash *et al*., 2009).

Their spawning and nursery areas, being near the coasts, are particularly sensitive and vulnerable to anthropogenic influences. The most serious of these is the ever increasing pressure for marine sand and gravel extraction and the development of wind farms. This has the potential to seriously damage and to destroy the spawning habitat and disturb spawning shoals and destroy spawn if carried out during the spawning season. It also has the potential to destroy traditional spawning grounds which are currently unused but likely to be recolonised. Similarly, trawling at or close to the bottom in known spawning areas can have the same detrimental effects. It is possible that the disappearance of spawning on the western edge of the Dogger bank could well be attributable to such anthropogenic influences.

In more recent years the oil and gas exploration in the North Sea has represented a potential threat to herring spawning although great care has been taken by the industry to restrict their activities in areas and at times of known herring spawning activity.

By-catch and Discard

By-catch consists of the retained 'incidental' catch of non-target species and discard is a deliberately (or accidentally) abandoned part of the catch returned to the sea as a result of economic, legal, or personal considerations. This section therefore deals with these two elements of the fishery, looking specifically at fishery-related issues. Cetacean, seabird and other threatened, rare and iconic species which may form part of a by-catch are considered separately in the next section. All discarding is illegal for Norwegian vessels and slippage and high grading is now illegal for EU vessels if quota is still available and the fish are above minimum landing size.

Incidental Catch: The incidental catch of non-target species in the North Sea pelagic herring fishery in general is considered to be low (Borges *et al*., 2008). A study by Pierce *et al.* (2002) investigated incidental catch from commercial pelagic trawlers over the period January to August 2001. The target species, herring, accounted for 98% by weight of the overall catch with an overall incidental catch of 2.3% made up of mackerel, haddock, horse mackerel and whiting. However, onboard sampling over 2002 by Scottish and German observers found substantial discards of herring, taken as by-catch in the mackerel fishery over the 3rd and 4th quarters, after herring quotas had been exhausted. This was not found in a study of the Dutch fleet (Borges *et al*., 2008) when the herring fishery was found to be relatively "clean".

Discards and slipping: The indications are that large-scale discarding is not widespread in the directed North Sea herring fishery. A number of direct-observer surveys have been conducted on Scottish, Dutch and Norwegian pelagic trawlers, (Napier *et al*, 1999; 2002; Borges *et al*., 2008). The overall discard rate was less than 5% of the landed catch. It is likely that there are different discard rates between the specific fishing types. There is disagreement about the amount of slippage compared to discarding by the differing fleets (**slippage**- fish released from the nets whilst still in the water but still resulting in the mortality of the majority of pelagic fish, **discarding**- fish dumped back into the sea after having been brought on board). For both pursers and trawlers 'poor' fish quality was a significant cause of discarding. The strength of year classes influences discarding behaviour, particularly of undersized fish. The influence of strong herring year classes was apparent in the composition of discards with smaller, younger fish accounting for a high proportion of the fish discarded in 2001. In the mid 2000s the stronger recruitment of mackerel has probably lead to the increase in discarding of smaller mackerel.

Ecosystem Considerations. The incidental non-target fish catch by directed North Sea herring fisheries appears to be low (ca. 2%), mainly consisting of mackerel when fishing mixed shoals. Thus it is likely that the impact of incidental fish catches is negligible. The discard of unwanted herring, mostly in the form of high-grading to improve catch quality and grade sizes of fish between 2-4 years of age is low and now illegal in both the EU and Norway. Discarding is thought to be reducing.

Interactions with Rare, Protected or charismatic mega fauna: Interactions between the directed North Sea herring fishery with rare, protected or charismatic mega fauna species are, in general, considered to be low. Species which may interact with the fishery are considered below.

Cetacean by-catch: Since 2000, the Sea Mammal Research Unit (SMRU) of St. Andrew's University in Scotland, under contract to DEFRA, has carried out a number of surveys to estimate the level of by-catch in UK pelagic fisheries. SMRU, in collaboration with the Scottish Pelagic Fishermen's Association, placed observers on board thirteen UK vessels for a total of 190 days at sea, covering 206 trawling operations around the UK. No cetacean by-catch was observed in the herring pelagic fishery in the North Sea. Pierce (2002) also reports that no by-catches of marine mammals were observed over 69 studies hauls and considers that the underlying rate for marine mammals in the pelagic fisheries studies (pelagic trawls in IVa and VIa) is no more than 0.05 (i.e. five events per 100 hauls) and may well be considerably lower than this. Consequently, the cetacean by-catch by the pelagic trawl fishery can be regarded as negligible. This was also confirmed by an UK observer programme ended in 2003 (Northridge, pers. Comm.).

Other than the above, there are no reliable estimates of by-catch for pelagic trawl fisheries, though observations have been made and by-catch rates have been established for several fisheries. Data are now collected routinely through the DRF and have yet to be analysed. Kuklik and Skóra (2003) refer to a single record of a harbour porpoise (*Phocoena phocoena*) by-caught in a herring trawl in the Baltic. Observations in several other pelagic trawl fisheries were reported by Morizur *et al*. (1999) and Couperus (1997). All appear to agree that incidental catches of cetaceans in the Dutch pelagic trawl fishery are largely restricted to late-winter/early-spring in an area along the continental slope southwest of Ireland, so outside the North Sea.

Seal by-catch: The by-catch of seals in directed pelagic herring fishery in the North Sea is reported to be "very rare" (Aad Jonker, pers. comm.). Independent verification also confirms this to be so, with perhaps one animal being caught by the whole North Sea fleet a year (Bram Couperus (IMARES, pers. comm.). Northridge (2003) observed 49 seals taken in 312 pelagic trawl tows throughout UK waters and reports that the fishery in North-western Scotland has the highest observed seal by-catch levels of UK pelagic trawl fisheries, possible amounting to dozens per year. Although not confirmed, it was assumed that the majority were grey seal *Halichoerus grypus*. This species is mainly distributed around the Orkneys and Outer Hebrides – out of a UK population of 129 000, only around 7 000 and 5 900 are distributed off the Scottish and English North Sea coasts respectively (SCOS, 2002), and so by-catch rates in the North Sea are likely to be substantially less than off the NW Scottish coast. The eastern Atlantic population of the Grey seal is not considered to be threatened.

Other by-catch: Sharks are occasionally caught by pelagic trawlers in the North Sea, although this is rare with a maximum of two fish per trip (Aad Jonker, pers. comm.). Survival rates are apparently high, sharks are released during or after the cod-end is being emptied. The species are unknown, although blue shark *Prionace glauca*, which preys primarily upon schooling fishes such as anchovies, sardines and herring, are known to have been caught by pelagic trawls off the SW English coast (Bram Couperus (IMARES), pers. comm.). Gannets (*Morus bassanus*), which frequently dive at and around nets, were observed by Napier *et al.* (2002) entangled in the nets but were not present in samples. Actual mortality rates of caught gannets have not been assessed in detail, and some have been observed alive after release from the gear. An extrapolation from observed mortalities corresponds to around 560 gannet deaths per year, although this is based on a relatively low sample frame. Seabird by-catch in the North Sea is considered to be comparatively rare. In the NW Scotland, 1-3 birds may be caught, especially in grounds off St. Kilda (Aad Jonker (former freezer trawler skipper), pers. comm.). IMARES observers in the North Sea only recorded one incident of seabird by-catch over 10 trips (Bram Couperus, pers. comm.).

B. Data

B.1. Commercial catch:

Commercial catch is obtained from national laboratories of nations exploiting herring in the North Sea. Since 1999 (catch data 1998), these labs have used a spreadsheet to provide all necessary landing and sampling data, which was developed originally for the Mackerel Working Group (WGMHSA) and further adapted to the special needs of the Herring Assessment Working Group. The current version used for reporting the 2007 catch data was v1.6.4. This method is now run in parallel with INTERCATCH, which is maintained by ICES. INTERCATCH is still in development and thus HAWG uses both. The data in the exchange spreadsheets are allocated samples to catch using the SALLOCL-application (Patterson, 1998). This programme gives the needed standard outputs on sampling status and biological parameters. It also clearly documents any decisions made by the species co-ordinators for filling in missing data and raising the catch information of one nation/quarter/area with information from another data set.

In addition, commercial catch and sampling data were stored and processed using the Intercatch-software for the first time during the WG in 2007. While at that time larger discrepancies up to 5 % between the SALLOCL routines and Intercatch did occur, INTERCATCH performed quite well in 2008. The estimates of CANON, CATON and WECA were highly comparable. However INTERCATCH is still not completely satisfactory in terms of flexibility and outputs. Thus both methods are still being used.

The "wonderful table". The following figure explains were the estimates in the wonderful table are derived from:

Year		2007	2008	
Sub-Area IV and Division VIId: TAC (IV and VIId)				
Recommended Divisions IVa,b 1	22			
Recommended Divisions IVc, VIId	14			
Expected catch of spring spawners				
Agreed Divisions IVa,b 2	TAC human consumption in IVa and b	303.5	174.6	Total TAC for human consumption in North Sea
Agreed Div. IVc, VIId	TAC human consumption in IVc and VIId	37.5	26.7	
Bycatch ceiling in the small mesh fishery	TAC industrial fishery	31.9	18.8	
CATCH (IV and VIId)				
National landings Divisions IVa,b 3		326.8		
Unallocated landings Divisions IVa,b		21.9		
Discard/slipping Divisions IVa,b 4		0.1		
Total catch Divisions IVa,b 5		348.8		
National landings Divisions IVc, VIId 3		34.3		
Unallocated landings Divisions IVc,VIId		4.7		
Discard/slipping Divisions IVc, VIId 4		-		
Total catch Divisions IVc, VIId		39.0		
Total catch IV and VIId as used by ACFM 5		**387.8**		Herring caught in the North Sea
CATCH BY FLEET/STOCK (IV and VIId) 10				
North Sea autumn spawners directed fisheries (Fleet A)		379.6		NS catch human consumption
North Sea autumn spawners industrial (Fleet B)		7.1		NS catch industrial fishery
North Sea autumn spawners in IV and VIId total		**386.7**		
Baltic-IIIa-type spring spawners in IV		1.1		Catch of WBSS in IV, estimated by splitting
Coastal-type spring spawners		0.0		e.g. spring spawner in river estuaries (Thames, Wash)
Norw. Spring Spawners caught under a separate quota in IV 20		0.7		direct information from Norway
Division IIIa: TAC (IIIa)				
Predicted catch of autumn spawners	22			
Recommended spring spawners	22			
Recommended mixed clupeoids				
Agreed herring TAC		69.4	51.7	
Agreed mixed clupeoid TAC				
Bycatch ceiling in the small mesh fishery		15.4	11.5	
CATCH (IIIa)				
National landings		47.3		
Catch as used by ACFM		47.4		
CATCH BY FLEET/STOCK (IIIa) 10				
Autumn spawners human consumption (Fleet C)		16.4		
Autumn spawners mixed clupeoid (Fleet D) 19		3.4		
Autumn spawners other industrial landings (Fleet E)				Catch of NSAS in IIIa, estimated by splitting
Autumn spawners in IIIa total		**19.8**		
Spring spawners human consumption (Fleet C)		25.3		
Spring spawners mixed clupeoid (Fleet D) 19		2.3		
Spring spawners other industrial landings (Fleet E)				
Spring spawners in IIIa total		**27.6**		
North Sea autumn spawners Total as used by ACFM		**406.5**		

Transparency of data handling by the Working Group. The current practice of data handling by the Working Group is that the data received by the co-ordinators is available in a folder called "archive". These high-resolution data are not reproduced in the report. The archived data contains the disaggregated dataset (disfad), the allocations of samples to unsampled catches (alloc), the aggregated dataset (sam.out) and (in some cases) a document describing any problems with the data in that year. Since 2007, the corresponding datasets are also stored in Intercatch, where they are accessible to the stock coordinators only.

Current methods of compiling fisheries assessment data. The stock co-ordinator is responsible for compiling the national data to produce the input data for the assessments. In addition to checking the major task involved is to allocate samples of catch numbers, mean length and mean weight-at-age to unsampled catches. There are at present no defined criteria on how this should be done, but the following general process is implemented by the species co-ordinators. Searches are made for appropriate samples by gear (fleet), area and quarter. If an exact match is not available the search will move to a neighbouring area if the fishery extends to this area in the same quarter. More than one sample may be allocated to an unsampled catch, in this case a straight mean or weighted mean of the observations may be used. If there are no samples available the search will move to the closest non-adjacent area by gear (fleet) and quarter, but not in all cases.

The Working Group acknowledges the effort some members have made to provide "corrected" data, which in some cases differ significantly from the officially reported catches. Most of this valuable information is gathered on the basis of personal knowledge of the fishery and good relations between the scientist responsible and the fishermen. In addition the Working Group recognises and would like to highlight the inherent conflict of interest in obtaining details of unallocated catches by country and increasing the transparency of data handling by the Working Group.

B.2. Biological

Catch-at-age data (catch numbers-at-age, mean weights-at-age in the catch, mean length-at-age) is derived from the raised national figures received from the national laboratories. The data are obtained either by market sampling or by onboard observers, and processed as described above. For information on recent sampling levels and nations providing samples, see Sec. 2.2. of the most recent HAWG report.

Mean weights-at-age in the stock and proportions mature (maturity ogive) are derived from the June/July international acoustic survey (see next paragraph).

B.3. Surveys

B.3.1 Acoustic: ICES Co-ordinated Acoustic Surveys for herring in North Sea, Skagerrak and Kattegat

The ICES Coordinated acoustic surveys started in 1979 around Orkney and Shetland with first major coverage in 1984. An index derived from that survey has been used in assessments since 1994 with the time-series data extending back to 1989. The survey was extended to IIIa to include the overlapping Western Baltic spring spawning stock in 1989, and the index has been used with a number of other tuning indices since 1991. The early survey had occasionally covered VIa (North) during the 1980s and was extended westwards in 1991 to cover the whole of VIa (North). Since 1991, this survey provides the only tuning index for VIa (North) herring and from 2008 for the whole Malin Shelf, By carrying out the co-ordinated survey at the same time from the Kattegat to Donegall all herring in these areas are covered simultaneously, reducing uncertainly due to area boundaries as well as providing input indices to three distinct stocks. The surveys are co-ordinated under ICES Planning Group for International Pelagic Surveys (PGIPS).

The acoustic recordings are carried out using Simrad EK60 38 kHz sounder echo-integrator with transducers mounted on the hull, drop keel or towed bodies. Prior to 2006, Simrad EK500 and EY500 were also used. Further data analysis is carried out using either BI500, Echoview or Echoann software. The survey track is selected to cover the area giving a basic sampling intensity over the whole area based on the limits of herring densities found in previous years. A transect spacing of 15 nautical miles is used in most parts of the area with the exception of some relatively high density sections, east and west of Shetland, north of Ireland in the Skagerrak where short additional transects were carried out at 7.5 nautical miles spacing, and in the southern area, where a 30 nautical miles transect spacing is used.

The following target strength to fish length relationships have been used to analyse the data:

herring TS = 20 log L - 71.2 dB

sprat TS = 20 log L -71.2 dB

gadoids TS = 20 log L - 67.5 dB

mackerel TS = 21.7 log L - 84.9 dB

Data are reported through standardised data exchange format and uploaded into the FishFrame database, currently held at DTU Aqua, Charlottenlund, Denmark. National estimates are aggregated through Fishframe during PGIPS to calculate global estimates for the North Sea, the Malin Shelf and the western Baltic Sea. The exchange format currently holds information on the ICES statistical rectangle level, with at least one entry for each rectangle covered, but more flexible strata are accommodated by allowing multiple entries for abundance belonging to different strata. Data submitted consists of the ICES rectangle definition, biological stratum, herring abundance by proportion of autumn spawners (North Sea and VIa North) and Spring spawners (Western Baltic, age and maturity, and survey weight (survey track length). Data are presented according to the following age/maturity classes: 1 immature (maturity stage 1 or 2), 1 mature (maturity stage 3+), 2 immature, 2 mature, 3 immature, 3 mature, 4, 5, 6, 7, 8, 9+. In addition to proportions at age data on mean weights and mean length are reported at age/maturity by biological strata. Data are combined using an effort weighted mean based on survey effort reported as number of nautical miles of cruise track per statistical rectangle. A combined survey report is produced annually. Apart from the Biomass index for 1-9+-ringers, mean weights at age in the catch and proportions mature are derived from the survey to be used in the NSAS assessment.

B.3.2 International Bottom Trawl Survey:

The International Bottom Trawl Survey (IBTS) started out as a Young Herring Survey (IYHS) in 1966 with the objective of obtaining annual recruitment indices for the combined North Sea herring stocks. It has been carried out every year since, and it was realized that the survey could provide recruitment indices not only for herring, but for roundfish species as well. Examination of the catch data from the 1st quarter IBTS showed that these surveys also gave indications of the abundances of the adult stages of herring, and subsequently the catches have been used for estimating 2-5+

ringer abundances. The surveys are carried out in 1st quarter (February) and in 3rd quarter (August-September) using standardized procedures among all participants. The standard gear is a GOV trawl, and at least two hauls are made in each statistical rectangle. In 2007 the IBTS was extended into English Channel. In addition, historical IBTS indices have been updated from 2004 onwards (in 2007).

In 1977 sampling for late stage herring larvae was introduced at the IBTS 1st quarter, using Isaccs-Kidd Midwater trawls. These catches appeared as a good indicator of herring recruitment, however examination of IKMT performance showed deficiencies in its catchability for herring larvae, and a more applicable gear, a ring net (MIK) was suggested as an alternative gear. Hence, gear type was changed in the mid 90'ies, and the MIK has been the standard gear of the programme since. This ring net is of 2 meter in diameter, has a long two-legged bridle, and is equipped with a black netting of 1.5 mm mesh size. Two oblique hauls per ICES statistical rectangle are made during night.

Indices of 2-5+ ringer herring abundances in the North Sea (1st quarter). Fishing gear and survey practices were standardised from 1983, and herring abundance estimates of 2-5+ ringers from 1983 onwards has shown the most consistent results in assessments of these age groups. This series is used in North Sea herring assessment. Catches in Division IIIa are not included in this index. These estimates are determined by the standard IBTS methodology developed by the ICES IBTS working group.

Index of 1-ringer recruitment in the North Sea (1st quarter). The 1-ringer index of recruitment is based on trawl catches in the entire survey area, hence, all 1-ringer herring caught in Division IIIa is included in this index. Indices are calculated as an area weighted mean over means by ICES statistical rectangle, and are available for year classes 1977 to recent. The Downs herring hatch later than the other autumn spawned herring and generally appears as a smaller sized group during the 1st quarter IBTS. A recruitment index of smaller sized 1-ringers is calculated using the standard procedure, but solely based on abundance estimates of herring <13 cm (ICES CM 2000/ ACFM:10, and ICES CM 2001/ ACFM:12).

MIK index of 0-ringer recruitment in the North Sea (1st quarter). The MIK catches of late stage herring larvae are used to calculate an 0-ringer index of autumn spawned herring in the North Sea, this represents recruitment strength (Nash & Dickey-Collas 2005). A flowmeter at the gear opening is used for estimation of volume filtered by the gear, and using this information together with information on bottom depth, the density of herring larvae per square meter is estimated. The mean herring density in statistical rectangles is raised to mean within subareas, and based on areas of these subareas an index of total abundance is estimated (see also ICES 1996/Asses:10). The series estimates for subareas as well as the total index.

B.3.3. Larvae:

Surveys of larval herring have a long tradition in the North Sea. Sporadic surveys started around 1880, and available scientific data goes back to the middle of the 20th century. The co-ordination of the International Herring Larvae Surveys in the North Sea and adjacent waters (IHLS) by ICES started in 1967, and from 1972 onwards all relevant data are achieved in a data base (ICES PGIPS). The surveys are carried out annually to map larval distribution and abundance (Schmidt *et al*., 2009). Larval abundance estimates are of value as relative indicators of the herring spawning biomass in the assessment.

Nearly all countries surrounding the North Sea have participated in the history of the IHLS. Most effort was undertaken by the Netherlands, Germany, Scotland, England, Denmark and Norway. A number of other nations have contributed occasionally. A sharp reduction in ship time and number of participating nations occurred in the end of the 1980s. Since 1994 only the Netherlands and Germany contribute to the larvae surveys, with one exception in 2000 when also Norway participated.

Larvae Abundance Index (LAI): The total area covered by the surveys is divided into 4 sub areas corresponding to the main spawning grounds. These sub areas have to be sampled in different given time intervals. The sampling grid is standardized and stations are approximately 10 nautical miles apart. The standard gear is a GULF III or GULF VII sampler (Nash *et al.*, 1998). Newly hatched larvae less than 10 mm total length (11 mm for the Southern North Sea) are used in the index calculation. To estimate larval abundance, the mean number of larvae per square meter obtained from the Ichthyoplankton hauls is raised to rectangles of 30x30 nautical miles and the corresponding surface area. These values are summed up within the given unit and provide the larval abundance per unit and time interval.

Multiplicative Larval Abundance Index (MLAI): The traditional LAI and LPE (Larval Production Estimates) rely on a complete coverage of the survey area. Due to the substantial decline in ship time and sampling effort since the end of the 80s, these indices could not be calculated in their traditional form since 1994. Instead, a multiplicative model was introduced for calculating a Multiplicative Larvae Abundance Index (MLAI, Patterson & Beveridge, 1995). In this approach the larvae abundances are calculated for a series of sampling units. The total time series of data are used to estimate the year and sampling unit effects on the abundance values. The unit effects are used to fill unsampled units so that an abundance index can be estimated for each year.

Calculation of the linearised multiplicative model was done using the equation:

ln(Indexyear,LAI unit) = MLAIyear + MLAI_{LAI} unit + uyear, LAI unit

where MLAIyear is the relative spawning stock size in each year, MLAI_{LAI} unit are the relative abundances of larvae in each sampling unit and year, LAI unit are the corresponding residuals (Gröger *et al.*, 1999, 2000). The unit effects are converted such that the first sampling unit is used as a reference (Orkney/Shetland 01-15.09.72) and the parameters for the other sampling units are redefined as differences from this reference unit. The model is fitted to abundances of larvae less than 10 mm in length (11 mm for SNS). The MLAI is updated annually and represent all larval data since 1972. The time series is used as a biomass index in the herring assessment.

B.4. Commercial CPUE

Not used for pelagic stocks.

B.5. Other relevant data

B.5.1 Separation of North Sea Autumn Spawners and IIIa-type Spring Spawners

North Sea Autumn Spawners and IIIa-type Spring Spawners occur in mixtures in fisheries operating in Divisions IIIa and IVaE (ICES, 1991/Assess:15; Clausen *et al.*, 2007): mainly 2+ ringers of the Western Baltic spring-spawners and 0-2-ringers from the North Sea autumn-spawners, including winter-spawning Downs herring. In addition, several local spawning stocks have been identified with a minor importance for the herring fisheries (ICES, 2001/ACFM 12).

The method of separating herring in Norwegian samples, using vertebral counts as described in former reports of this Working Group (ICES 1990/ Assess:14) assumes that for autumn spawners, the mean vertebral count is 56.5 and for Spring spawners 55.80. The fractions of spring spawners (fsp) are estimated from the formula (56.50-v)/(56.5-55.8), where v is the mean vertebral count of the (mixed) sample with the restriction that the proportion should be one if fsp>=1 and zero if fsp<=0. The method is quite sensitive to within-stock variation (e.g. between year classes) in mean vertebral counts.

Experience within the Herring Assessment Working Group has shown that separation procedures based on size distributions often will fail. The introduction of otolith microstructure analysis in 1996-97 (Mosegaard & Popp-Madsen, 1996) enables an accurate and precise split between three groups, autumn, winter and spring-spawners. However, different populations with similar spawning periods are not resolved with the present level of analysis. Different stock components that are not easily distinguished by their otolith microstructure (OM), are considered to have different mean vertebral counts (vs) as, e.g., winter-spawning Downs herring: 56.6 (Hulme, 1995), and the small local stocks, the Skagerrak winter/spring-spawners: 57 (Rosenberg and Palmén, 1982). Further, the estimated stock specific mean vs count varies somewhat among different studies; North Sea: 56.5, Western Baltic Sea: 55.6 (Gröger & Gröhsler, 2001) and North Sea: 56.5, Western Baltic Sea: 55.8 (ICES 1992/H:5). Comparison between separation methods using frequency distributions of vertebral counts and otolith microstructure showed reasonable correspondence. Using this information the years from 1991 to 1996 was reworked in 2001, applying common splitting keys for all years by using a combination of the vertebral count and otolith microstructure methods (ICES, 2001/ACFM:12). From 2001 and onwards, the otolith-based method only has been used for the Division IIIa.

Different methods of identifying herring stocks in the Division IIIa and Subdivisions 22-24 were evaluated in EU CFP study project (EC study 98/026). The study involved several inter-calibration sessions between microstructure readers in the different laboratories involved with the WBSS herring. After the study was finished a close collaboration concerning reader interpretations has been kept between the Danish and Swedish laboratories. Sub-samples of the 2002 and 2003 Danish, Swedish, and German microstructure analyses were double-checked by the same Danish expert reader for consistency in interpretation. The overall impression is an increasingly good agreement among readers (Clausen *et al*., 2007).

New molecular genetic approaches for stock separation are being developed within the EU-FP5 project HERGEN (EU project QLRT 200-01370). Sampling of spawning aggregations during spring, autumn and winter has been carried out in 2002 and in 2003 in Division IIIa and in the Western Baltic at more than 10 different locations. Preliminary results point at a substantial genetic variation between North Sea and Western Baltic herring (Bekkevold *et al*., 2005; 2007; Ruzzante *et al*., 2006) .

After the introduction of otolith microstructure analysis in 1996 it was discovered that in the western Baltic a small percentage of the herring landings might consist of autumn-spawners individuals. Before molecular genetic methods became available for Atlantic herring the existence of varying proportions of autumn spawners in Subdivisions 22–24 in different years was considered a potential problem for the assessment.

C. Historical Stock Development

C.1 Model used:

A benchmark assessment for North Sea herring was carried out in 2006. Following the benchmark investigation in 2006, the tool for the assessment of North Sea herring is ICA. However, the environment to execute the ICA has changed from the original ICA software into FLR (now called FLICA). Justification of the choice of assessment model, catch and survey weightings and the length of separable period are found in HAWG 2006 and Simmonds (2003; 2009). After extensive testing HAWG assumes there are no differences between the old ICA and FLICA. Thus FLICA was used to carry out the assessments after 2008.

The assessment has the same set-up and basic assumption as the assessment that was carried out last year. Input data are given in Tables 2.6.2.2. The ICA programme operates by minimising the following general objective function:

$$\sum \lambda_c \left(C-\hat{C}\right)^2 + \sum \lambda_i \left(I-\hat{I}\right)^2 + \sum \lambda_r \left(R-\hat{R}\right)^2$$

which is the sum of the squared differences for the catches (separable model), the indices (catchability model) and the stock-recruitment model.

The final objective function chosen for the stock assessment model was:

$$\begin{aligned}
&\sum_{a=0,y=1997}^{a=8,y=2002} \lambda_a (\ln(\hat{C}_{a,y}) - \ln(C_{a,y}))^2 + \\
&\sum_{y=1979}^{y=2002} \lambda_{mlai} \cdot (\ln(q_{mlai}.\hat{SSB}_y^K) - \ln(MLAI_y))^2 + \\
&\sum_{a=1,y=1983^{**}}^{a=5+,y=2003} \lambda_{a,ibtsa} (\ln(q_{a,ibtsa} \cdot \hat{N}_{a,y}) - \ln(IBTS_{a,y}))^2 + \\
&\sum_{a=1,y=1989}^{a=9+,y=2002} \lambda_{a,acoust} (\ln(q_{a,acoust} \cdot \hat{N}_{a,y}) - \ln(ACOUST_{a,y}))^2 + \\
&\sum_{y=1977}^{y=2003} \lambda_{mik} (\ln(q_{mik} \cdot \hat{N}_{0,y}) - \ln(MIK_y))^2 + \\
&\sum_{y=1960}^{y=2002} \lambda_{ssr} (\ln(\hat{N}_{0,y+1}) - \ln\left(\frac{\alpha\, \hat{SSB}_y}{\beta + \hat{SSB}_y}\right))^2
\end{aligned}$$

** except for 1 ring IBTS which runs from 1979 to 2002

with the following variables:

a,y	age (rings) and year
C	Catch at age (rings)
$\hat{C}$	Estimated catch at age (rings) in the separable model
$\hat{N}$	Estimated population numbers
$\hat{SSB}$	Estimated spawning stock size
MLAI	MLAI index (biomass index)
ACOUST	Acoustic index (age disaggregated)
IBTS	IBTS index (1-5+ ringers)
MIK	MIK index (0-ringers)
q	Catchability
k	power of catchability model
α, β	parameters to the Beverton stock-recruit model

λ Weighting factor

Software used: FLICA, based on ICA (Patterson, 1998; Needle, 2000; Kell *et al.*, 2007)

Model Options chosen:

The model settings should be as follows (as determined by the last benchmark, HAWG 2006)

FLICA control settings	Settings	Description
sr	TRUE	Stock and recruitment relationship
sr.age	1	age at recruitment
lambda.age	0.1 0.1 3.67 2.87 2.23 1.74 1.37 1.04 0.94 0	Weighting matrices for catch-at-age; for aged surveys; for SSB surveys
lambda.yr	1 1 1 1 1	Relative weights by year
lambda.sr	0.1	weight for the SRR term in the objective function
index.model	power linear linear linear	Catchability model for each survey
index.cor	False	Are the age-structured indices are correlated across ages
sep.nyr	5	Number of years for separable model
sep.age	4	Reference age for fitting the separable model
sep.sel	1	Selection on last true reference age

Input data types and characteristics:

Type	*Name*	*Year range*	*Age range*	*Variable from year to year Yes/No*
Caton	***Catch in tonnes***			
Canum	***Catch at age in numbers***	***1960-2008***	***1-9+***	***Yes***
Weca	***Weight at age in the commercial catch***	***1960-2008***	***1-9+***	***Yes***
West	***Weight at age of the spawning stock at spawning time.***	***1960-2008***	***1-9+***	***Yes (3 year running mean)***
Mprop	***Proportion of natural mortality before spawning***	***1960-2008***	***1-9+***	***No***
Fprop	***Proportion of fishing mortality before spawning***	***1960-2008***	***1-9+***	***No***
Matprop	***Proportion mature at age***	***1960-2008***	***1-9+***	***Yes***
Natmor	***Natural mortality***	***1960-2008***	***1-9+***	***No***

Tuning data:

TYPE	NAME	YEAR RANGE	AGE RANGE (WR)
Tuning fleet 1	***IBTS Q1***	***1984-2009***	***1-5***
Tuning fleet 2	***MIK***	***1992-2009***	***0***
Tuning fleet 3	***Acoustic***	***1989-2008***	***1-9+***
Tuning fleet 4	***MLAI***	***1973-2008***	***SSB***

C.2 Variance and weighting factors for ICA

In the ICA model a fixed set of inverse variance weights for surveys and catch at age have been used. In the benchmark assessment in 2006 (ICES 2006/ACFM:20) the weighting factors of the indices used in ICA were fixed and have been used with the same values since. This reflects a slight change from a major investigation in 2001 carried out by the Study Group on Evaluation of Current Assessment Procedures for North Sea herring (SGEHAP, ICES 2001/ACFM:22). The original weighting factors were derived from the survey and catch data by methods given in ICES 2001/ACFM:22 and Simmonds (2003). The variance used is the variance of the natural logarithm of the estimates of the index based on a 2 stage bootstrap procedure. The choice matches the use of a maximum log likelihood method with a lognormal error distribution used within the ICA model. All indices are treated in the same manner. The individual station estimates at all ages are bootstrapped using a simple resampling with replacement procedure. This provides a variance covariance estimate of estimates of indices at age for each index assuming identically independently distributed samples. (iid)

As the spatial distributions are correlated and the sampling on the surveys are non-random in space, the spatial autocorrelation was taken into account using geostatistics. The methodology is described in Rivoirard *et al*. (2000), who provide the formulae and methods required to estimate variograms and calculate the estimation variance. Petitgas and Lafont (1997) provide the free software (EVA2) that has been used here for calculating the estimation variance for all the surveys. The iid estimates are corrected to provide overall estimates of variance covariance estimates across ages for each survey. The mean variance covariance estimate for the survey timeseries was calculated to provide one average variance/covariance matrix per survey.

ICA does not explicitly deal with covariance (in common with many assessment models) but it does allow modification of weights at age to account for this in a general way. The concept is to reduce the inverse variance factor by an amount that accommodates the covariance. The limits are: for zero correlation a factor of unity; for 100% covariance over n ages weights of 1/n. In both surveys the 1 to 2 group estimates are effectively independent and can be given weighting due to the full inverse variance weight, for subsequent ages the weighting has been implemented here for intermediate values of covariance to give the *W*age weighting factors at age:

$$W_{age} = \frac{1}{\mathrm{var}_{age}}\{n - \sum \mathrm{cov}_{age,age-1}\}/\{\mathrm{cov}_{age,age-1}/\sum 1/\mathrm{cov}_{age,age-1}\}$$

Where var_{age} is the variance of ln(estimate at age)

cov is covariance (age, age-1)

n is the number of ages in the correlated sequence

The resulting correlation correction factors are given in Table 2.6.7.3 in HAWG Report 2008.

The weighting factors used since 2006 (ICES 2006/ACFM:20) are given in Table 1 and can be compared with the old weighting factors derived under SGEHAP (ICES 2001/ACFM:22). The major difference is a slight general reduction in survey weights relative to the catch. Among the surveys the resulting spread of weights is generally similar to the earlier values, reducing with age, more steeply with the IBTS than the acoustic. The major difference is the MIK weighting which is reduced to about 1/3 of the previous value. The change is caused by the recent extended analysis. The difference between the previous analysis and this one was that in the earlier work the geostatistical analysis of spatial variance was limited to only a few recent years in each series. This resulted quite accidentally and unknowingly in selecting years from the MIK index that were very precise.

Table 1: North Sea herring. New weighting factors (ICES 2006 /ACFM:20) based on bootstrap of survey data. Old weights are included for comparison

	Catch		*Acoustic*		*IBTS*		*MIK*		*MLAI*	
Age	*Old*	*New*	*Old*	*New*	*Old*	*New*	*Old*	*New*	*Old*	*New*
0	*0.10*	*0.10*					*2.05*	*0.63*		
1	*0.10*	*0.10*	*0.74*	*0.63*	*0.67*	*0.47*				
2	*3.17*	*3.67*	*0.75*	*0.62*	*0.24*	*0.28*				
3	*2.65*	*2.87*	*0.64*	*0.17*	*0.06*	*0.01*				
4	*1.94*	*2.23*	*0.27*	*0.10*	*0.03*	*0.01*				
5	*1.31*	*1.74*	*0.14*	*0.09*	*0.03*	*0.01*				
6	*0.97*	*1.37*	*0.13*	*0.08*						
7	*0.75*	*1.04*	*0.12*	*0.07*						
8	*0.55*	*0.94*	*0.07*	*0.07*						
9	*0.54*	*0.91*	*0.07*	*0.05*						
SSB									*0.65*	*0.60*

D. Short-Term Projection

The short-term prediction method was substantially modified in 2002. Following the review by SGEHAP (ICES 2001/ACFM:22), which recommended that a simple multi-fleet method would be preferable, the complex split-factor method used for a number of years prior to 2002 has not been used since. The multi-fleet, multi-option, deterministic short-term prediction programme (MFSP) was accepted by ACFM in 2002 and further refined in 2003. It has been used routinely to perform short term predictions for this stock since then.. The good agreement between predicted biomass for the acintermediate year and SSB taken from the assessment one year after demonstrates that the current prediction procedure for stock numbers is working well.

Method

The procedure and programme used (MFSP Skagen; WD to HAWG 2003) was the same as has been used since 2003. For the North Sea herring, managers have agreed to constrain the total outtake at levels of fishing mortalities for ages 0-1 and 2-6, and need options to show the trade-off between fleets within those limits. The MFSP program was developed to cover these needs.

Input data

Fleet Definitions

The current fleet definitions are:

North Sea

Fleet A: Directed herring fisheries with purse seiners and trawlers. By-catches in industrial fisheries by Norway are included.

Fleet B: Herring taken as by-catch under EU regulations.

Division IIIa

Fleet C: Directed herring fisheries with purse seiners and trawlers

Fleet D: By-catches of herring caught in the small-mesh fisheries

The fleet definitions are the same as last year.

In some years, it has been agreed that Norway can take parts of its IIIa quota in the North Sea. When estimating the expected catch in the intermediate year, it is assumed that this transfer takes place, hence the assumed catch by the C-fleet of both stocks combined is reduced and the catch by the A-fleet increased with the agreed amount.

Input Data for Short Term Projections: All the input data for the short term projections are shown in Table 2.7.1, which is the input file for the predictions.

Stock Numbers: For the start of the intermediate year the stock numbers at age by 1. Jan that year are taken from the prediction made by ICA.

Recruitment: For the prediction years, the recruitment has in recent years been set to the geometric mean of the recruitments of the year classes from 2001 onwards, as estimated in this year's assessment. The low recruitment was assumed because all the year classes from 2001 onwards have been poor except for 2008 year class. Analysis of the time series of SSB and recruitment data by the SGRECVAP (ICES CM 2006/LRC:03) clearly indicates a shift in the recruitment success in 2001. The underlying cause for the change in 2001 is not clear, but there is no evidence to justify an assumption of long term average recruitment in the near future. Consequently, the advice is adapted to the current low recruitment regime.

Fishing Mortalities: Selection by fleet at age is calculated by splitting the total fishing mortality in the last assessment year at each age (from the assessment output) proportional to the catches by fleets at that age. These selections at age were used for all years in the prediction.

Mean weights in the catch by fleet: The 3 year average mean weights at age for each fleet are used for all prediction years, unless there are indications that some year class has abnormal growth.

Mean Weights at age in the stock: The weights at age applied in the last assessment year were used for all predictions years. These are running averages of the raw data. In previous years, the procedure was different, to account for the special growth of the 2000 year class.

Maturity at age: The 3 years average maturity was used.

Natural Mortality: Equal to those assumed in the assessment.

Proportion of M and F before spawning: Standard values of 0.67 for both.

Prediction

Assumptions for the intermediate year.

A-fleet: The TAC for the A fleet has been over-fished every year since 2003, and it is assumed that this will be the case in the intermediate year as well. Unless there are strong indications of a change in practise, the percentage assumed is the average over the last 3 years.

The catches by the B-fleet have been well below the by-catch quota for the B-fleet. The quota has been reduced recently, and the fraction used has increased. Therefore, the same fraction as last year is assumed. Also the C and D fleets have catches well below the quota, partly because the quota also includes WBSS herring. For 2009, the same fraction as in 2008 was assumed; previously a 3 year average has been used in some cases.

Points of interpretation:

- In years when Norway is allowed to transfer some of its quota in IIIa to IV, this transfer is assumed in the predictions

Management Option Tables for the TAC year

The EU-Norway agreement on management of North Sea herring was updated in 2008, to adapt to the present reduced recruitment, accounting for the results by WKHMP. The revised rule specifies fishing mortalities for juveniles (F_{0-1}) and for adults (F_{2-6}) not to be exceeded, at 0.05 and 0.25 respectively, for the situation where the SSB is above 1.5 million tonnes. When the SSB is below 1.5 million tonnes. Moreover, the current agreement has a constraint on year-to-year change of 15% in TAC, F is reduced to give

$F_{2-6} = 0.25-(0.15*(1500-SSB)/700)$,

with allowance for a stronger reduction in TAC if necessary.

Furthermore, there is a constraint at 15% change in the TAC from one year to the next.

- The F_{0-1} and F_{2-6} stated in the rule are assumed to apply to the total F summed over all fleets.
- The SSB referred to is taken to be the SSB in the prediction year, i.e. the fishing mortalities for 2010 should reflect its consequence for SSB in 2010.

Catches by the C and D fleet influence the fishing opportunities for the B-fleet in particular, since the NSAS herring caught by these fleets mostly are at age 0-2. The assumed catch of NSAS herring by the C and D fleets is derived according to a likely TAC for WBSS herring in a three step procedure:

1. The fraction of the total TAC for WBSS that is taken in Division IIIa is assumed to be the same as last year, giving an expected catch of WBSS in Division IIIa.

2. The WBSS caught in Division IIIa is allocated to the C and D fleets assuming the same share as last year. The total expected catch of WBSS in IIIa is split accordingly, which gives expected catch of WBSS by fleet.

3. Using the ratio between NSAS and WBSS in the catches by each fleet, the total catch by fleet and the catch of NSAS by fleet are derived from the catch of WBSS by fleet.

These expected catches of NSAS by the C and D fleets are used as catch constraints in the prediction.

The basis for deriving these catches is weak. The main purpose is to provide realistic assumptions on the impact of these fleets when predicting the catches for the North Sea fleets. The effect of other assumptions for the C and D fleet should be calculated if needed, but are not presented in the advice.

The catches for the A and B fleets are derived according to the harvest rule.

When the harvest rule leads to SSB below the trigger biomass (1.5 million tonnes), an iterative procedure is needed to find a fishing mortality and a corresponding SSB in accordance with the rule. At present, this is done manually by scanning over ranges of F for the A and B fleet.

E. Medium-Term Projections – *–are made as needed.*

Model used: 10 year stochastic prediction Software used: STPR3 has been used as a standard in the past, as it allows for independent regulations of two 'flles' (fisheries)

Initial stock size: As for the short term prediction, but with random variation according the variance-covariance matrix taken from the ICA assessment

Natural mortality: Constant as in the assessment

Maturity: As in the short term prediction

F and M before spawning: Constant values : 0.67 for both.

Weight at age in the stock: Obtained each projection year by drawing a historical year randomly and using the weights from that year.

Weight at age in the catch: As weight at age in the stock.

Exploitation pattern: As for short term forecast. Fleet A separately, fleets B-C-D merged.

Intermediate year assumptions: As for short term prediction

Stock recruitment model used: Beverton Holt or Hockey stick

Uncertainty models used:

Initial stock size: See above

Natural mortality: Constant

Maturity: Constant

F and M before spawning: Constant

Weight at age in the stock: See above

Weight at age in the catch: See above

Exploitation pattern: Constant

Intermediate year assumptions: Constant

Stock recruitment model used: Log-normal variation around a stock-recruit function with fixed parameters. Opportunity to truncate the distribution.

F. Long-Term Projections – *–not done since 1996(?)*

G. Biological Reference Points

The precautionary reference points for this stock were adopted in 1998. The situation has now arisen that North Sea herring is nominally being managed by a precautionary management plan, although the SSB is now below the precautionary biomass reference point. We consider that the critical issue is identifying the risk of SSB falling below Blim. The following section is adapted from ICES WKHMP (ICES CM 2008 (ACOM:27)) and explores and discusses the issues about precautionary status of the management of North Sea herring.

The Blim

The 1998 Study Group on Precautionary Approach to Fisheries Management (ICES CM 1998/ACFM:10.) determined reference points for North Sea herring that were adopted by ACFM (ICES CM 1998/ACFM:10.). The Blim (800 000 tonnes) was set at a level below which the recruitment may become impaired and was also the formally used MBAL. In 2007, WKREF (ICES CM 2007/ACFM:05) explored limit reference points for North Sea herring and concluded that there is no basis for changing Blim. A low risk of SSB falling below Blim is therefore the basis of ICES precautionary advice.

Fpa and Bpa

The target and trigger points used in the management plan (which began in 1997) were recommended by the Study Group on Precautionary Approach to Fisheries Management and adopted by ACFM as the precautionary reference points. This means that the precautionary reference points were taken from the already existing management plan. In the management plan, the target fishing mortalities were intended as targets and not as bounds. The higher inflection point (B trigger) in the earlier rule (1.3 million tonnes) was derived largely as a compromise, allowing higher exploitation at higher biomass but reflecting an ambition to maintain the stock at a high level, by reducing the fishing mortality at an early stage of decline. This trigger was changed in November 2008 to 1.5 million tonnes after WKHMP and consultation with the stakeholders. Thus currently the trigger and Bpa are different at 1.5 million tonnes and 1.3 million tonnes respectively.

Concept of a management plan (harvest control rule)

In a harvest control rule, parameters (trigger and targets) serve as guidance to actions according to the state of the stock (ICES Study Group on the Precautionary Approach, ICES CM 2002/ACFM:10). These should be chosen according to management objectives, one of which should be to have a low risk of bringing the SSB to unacceptably low levels. In the evaluation of a harvest rule, one will use simulations with a 'virtual stock' which as far as possible resembles the stock in question, and the risk is evaluated as the probability of the virtual SSB being below the Blim value. Within the constraints needed to keep the risk to Blim low, parameters of the rule will be chosen to serve other management objectives, e.g. to ensure a high long term yield and stable catches over time. Such a management plan would be classed by ICES as precautionary provided the risk of SSB being below Blim is sufficiently low.

Concept of precautionary reference points

Conceptually, precautionary reference points (Bpa) are different from parameters in a harvest control rule. In the precautionary approach, as interpreted by ICES, the function of the reference points is to ensure that the SSB is above the range where recruitment may be impaired or the stock dynamics is unknown. The real limit is represented by Blim, while the Bpa takes assessment uncertainty into account, so that if SSB is estimated at Bpa, the probability that it is below Blim shall be small. The Flim is the fishing mortality that corresponds to Blim in a deterministic equilibrium. The Fpa is related to Flim the same way as Bpa is related to Blim (ICES Study Group on the Precautionary Approach 2002b). In the advisory practice, Fpa has been the basis for the advice unless the SSB has been below Bpa, where a reduction in F has been advised. Furthermore, Fpa and Bpa are currently used to classify the state of stock and rate of exploitation relative to precautionary limits. Precautionary reference points are used by ICES to provide advice and classify the state of the stock in the absence of other information, such as extensive evaluations of management plans.

ICES will accept that a harvest control rule is in accordance with the precautionary approach as long as it implies a low risk to being below Blim, even if other reference points may be exceeded occasionally. When a rule is regarded as precautionary, ICES gives its advice according to the rule. If the rule is followed, then ICES classifies exploitation as precautionary. Within this framework, other precautionary reference points generally will be redundant. However, the precautionary reference points may also be used to classify the stock with respect to precautionary limits, which may lead to a conflicting classification. This discrepancy is still unresolved. For North Sea herring in the present situation, with a reduced recruitment, the SSB may be expected to be below 1.3 million tonnes most of the time. The management plan will reduce fishing mortality accordingly. Following the acceptance by ACFM that the management plan is precautionary (and the findings of WKHMP), **HAWG considers that the parameters of the management plan should take primacy over the management against precautionary reference points Fpa or Bpa**.

H. Other Issues

H.1 Biology of the species in the distribution area

The herring (*Clupea harengus*) is a pelagic species which is widespread in its distribution throughout the North Sea. The herring's unique habit is that it produces benthic eggs which are attached to a gravely substrate on the seabed (Geffen 2009). This points strongly to an evolutionary history in which herring spawned in rivers and at some later date re-adapted to the marine environment(Geffen 2009). The spawning grounds in the southern North Sea are in fact located in the beds of rivers which existed in geological times and some groups of spring spawning herring still spawn in very shallow inshore waters and estuaries. Spawning typically occurs on coarse gravel (0.5-5 cm) to stone (8-15 cm) substrates and often on the crest of a ridge rather than hollows. For example, in a spawning area in the English Channel, eggs were found attached to flints 2.5-25 cm in length, where these occurred in gravel, over a 3.5 km by 400m wide strip.

As a consequence of the requirement for a very specific substrate, spawning occurs in small discrete areas in the near coastal waters of the western North Sea (Schmidt *et al.*, 2009). They extend from the Shetland Isles in the north through into the English Channel in the south. Within these specific areas actual patches of spawn can be extremely difficult to find.

The fecundity of herring is length related and varies between approximately 10 000 and 60 000 eggs per female (Damme *et al* in press). This is a relatively low fecundity for teleosts, probably because. The age of first maturity is 3 years old (2 ringers) but the proportion mature at age may vary from year to year dependent on feeding conditions. Over the past 15 years the proportion mature at age 3 years (2 ringers) has ranged from 47% to 86% and for 4 year old fish (3 winter ringers) from 63% to 100%. Above that age, all are considered to be mature.

The benthic eggs take about three weeks to hatch dependant on the temperature. The larvae on hatching are 6 mm to 9 mm long and rise due to buoyancy changes to become planktonic (Dickey-Collas *et al*, 2009). Their yolk sac lasts for a few days during which time they will begin to feed on phytoplankton and small zooplankton. Their planktonic development lasts around three to four months during which time they are passively subjected to the residual drift which takes them to various coastal nursery areas on both sides of the North Sea and into the Skagerrak and Kattegat (Heath *et al*., 1997).

Herring continue to be mainly planktonic feeders throughout their life history although there are numerous records of them taking small fish, such as sprat and sandeels, on an opportunistic basis. Calanoid copepods, such as *Calanus*, *Pseudocalanus* and *Temora* and the Euphausids, *Meganyctiphanes* and *Thysanoessa* still form the major part of their diet during the spring and summer (Hardy, 1924; Savage, 1937; Bainbridge and Forsyth, 1972; Last, 1989) and are responsible for the very high fat content of the fish at this time. They also consume fish eggs (Segers *et al*., 2007).

In the past, herring age has been determined by using the annual rings on the scales. In more recent years the growth rings on the otolith have proved more reliable for age determination. Herring age is expressed as number of winter rings on the otolith rather than age in years as for most other teleost species where a nominal 1 January birthdate is applied. Autumn spawning herring do not lay down a winter ring during their first winter and therefore remain as ‘0’ winter ringers until the following winter. When looking at year classes, or year of hatching, it must be remembered that they were spawned in the year prior to their classification as ‘0’ winter ringers.

North Sea herring comprise both spring and autumn spawning groups, but the major fisheries are carried out on the offshore autumn spawning fish. The spring spawners are found mainly as small discrete coastal groups in areas such as The Wash, the Thames estuary, Danish Fjords and the now extinct Zuiderzee herring. Juveniles of the spring spawning stocks are found in the Baltic, Skagerrak and Kattegat, and may also be found in the North Sea as well as Norwegian coastal spring spawners.

The main autumn spawning begins in the northern North Sea in August and progresses steadily southwards through September and October in the central North Sea to November and as late as January in the southern North Sea and eastern English Channel. The widespread but discrete location of the herring spawning grounds throughout the western North Sea has been well known and described since the 19th century (Heincke, 1898; Bjerkan, 1917). This led to considerable scientific debate and eventually to investigation and research on stock identity. The controversy centred on whether or not the separate spawning grounds represented discrete stocks or ‘races’ within the North Sea autumn spawning herring complex (McQuinn, 1997). Resolution of this issue became more urgent as the need for the introduction of management measures increased during the 1950’s. The International Council for the Exploration of the Sea (ICES) encouraged tagging and other racial studies and a review of all the historic evidence to resolve this problem and innovative approaches to assessing mixed and connective stocks (Secor *et al*., 2009; Kell *et al*., 2009). The conclusions were the basis for establishing the working hypothesis that the North Sea autumn spawning herring comprise a complex of at least four spawning components each with separate spawning grounds, migration routes and nursery areas. There is mixing between these components during the summer

The main four spawning components are:

- The Orkney/Shetland component which spawn from July to early September in the Orkney Shetland area. Nursery areas for fish up to two years old are found along the east coast of Scotland and also across the North Sea and into the Skagerrak and Kattegat.
- The Buchan component which spawn from August to early September off the Scottish east coast. Nursery areas for fish up to two years old are found along the east coast of Scotland and also across the North Sea and into the Skagerrak and Kattegat.
- The Banks or central North Sea component, which derive their name from their former spawning grounds around the western edge of the Dogger Bank. These spawning grounds have now all but disappeared and spawning is confined to small areas along the English east coast, from the Farne Islands to the Dowsing area, from August to October. The juveniles are found along the east coast of England, down to the Wash, and also off the west coast of Denmark.
- The Downs component which spawns in very late Autumn through to February in the southern Bight of the North Sea and in the eastern English Channel. The drift of their larvae takes them north-eastwards to nursery areas along the Dutch coast and into the German Bight (Burd 1985).

At certain times of the year, individuals from the three stock units may mix and are caught together as juveniles and adults but they cannot be readily separated in the commercial catches other than using otolith methods (Clausen *et al*, 2007). However North Sea autumn spawning herring are managed as a single unit with the understanding that they comprise of many spawning components.

A further complication is that juveniles of the North Sea stocks are found, outside the North Sea, in the Skagerrak and Kattegat areas and are caught in various fisheries there. The proportions of juveniles of North Sea origin, found in these areas varies with the strength of the year class, with higher proportions in the Skagerrak and Kattegat when the year class is good.

Recruitment strength is determined during the larval phase (Nash & Dickey-Collas 2005) and this is likely to occur prior to the larvae being 20mm in length (Oeberst *et al*., 2009).

H.2 Historic stock development and history of the fishery

Over many centuries the North Sea herring fishery has been a cause of international conflict sometimes resulting in war, but in more recent times in bitter political argument. There have also been fundamental changes in the nature of the fisheries (Poulsen, 2006). These have been driven both by changes in catching power and in response to changes in market requirements, particularly the demand for fish meal and oil. Most of these changes have resulted in greater exploitation pressures that increasingly led to the urgent need to ensure a more sustainable exploitation of North Sea herring. Such pressures really began to exert themselves for the first time during the 1950's when the spawning stock biomass of North Sea autumn spawning herring fell from 5 million tonnes in 1947 to 1.4 million tonnes by 1957 (Simmonds 2007, 2009). That period also witnessed the decline and eventual disappearance of a traditional autumn drift net fishery in the southern North Sea (Burd, 1978).

The annual landings from 1947 through to the early 1960's were high, but stable, averaging around 650 000t (Cushing and Bridger, 1966). Over the period 1952-62, the high fishing mortality (F 0.4 ages 2-6) resulted in a rapid decline in the spawning stock biomass from around 5 million tonnes to 1.5 million tonnes. Recruitment over this period was reasonable, but there were fewer and fewer year classes present in the adult stock, a clear indication that the stocks were being over-fished and that they were also being impacted by the developing industrial fishery in the eastern North Sea.

This period witnessed the complete collapse of the historic East Anglian autumn drift net fishery, which was based entirely on the Downs stock moving south to the Southern Bight and eastern English Channel to spawn. The reasons for that failure have been attributed both to high mortality of the juveniles in the North Sea industrial fisheries, and to heavy fishing by bottom trawlers on the spawning concentrations, in the English Channel, during the 1950's. Such intensive trawling, on vulnerable spawning fish, not only generated a high mortality but also disturbed spawning aggregations, destroyed the spawn and damaged the substrate on which successful spawning depends.

Fishing mortality on the herring in the central and northern North Sea began to increase rapidly in the late 1960's and had increased to F1.3 ages 2-6, or over 70% per year of those age classes, by 1968. Landings peaked at over 1 million tonnes in 1965, around 80% of which were juvenile fish. This was followed by a very rapid decline in the SSB and the total landings. By 1975 the SSB had fallen to 83 500 t, although the total landings were still over 300 000t (Simmonds 2007). At the same time, spawning in the central North Sea had contracted to the grounds off the east coast of England whilst spawning grounds around the edge of the Dogger Bank were no longer used. This heralded the serious decline and near collapse of the North Sea autumn spawning herring stock which led to the moratorium on directed herring fishing in the North Sea from 1977 to 1981 (Cushing, 1992).

International larvae surveys and acoustic surveys were used to monitor the state of the stocks during the moratorium. By 1980 these surveys were indicating a modest recovery in the SSB from its 1977 low point of 52 000 t. By 1981 the SSB had increased to over 200 000 t. Prior to the moratorium there had been no control, other than market forces, on catches in the North Sea directed herring fishery. Once the fishery reopened in 1981 the North Sea autumn spawning herring stock was managed by a Total Allowable Catch (TAC) constraint. It should be noted that the TAC was only applied to the directed herring fishery in the North Sea which exploited mainly adult fish for human consumption. Targeted fishing for herring for industrial purposes was banned in the North Sea in 1976 but there was a 10% by-catch allowance in the fisheries for other species, including the small meshed fisheries for industrial purposes, mainly for sprat. Following the re-opening of the now controlled fishery the SSB steadily increased, peaking at 1.3 million tonnes in 1989. Annual recruitment, measured as '0'group fish, was well above the long-term average over this period. The 1985 year class was the biggest recorded since 1960 and the third highest in the records dating back to 1946. Landings also steadily increased over this period reaching a peak of 876 000 tonnes in 1988. This resulted from a steady increase in fishing mortality to $F_{ages\ 2\text{-}6} = 0.6$ (ca. 45%) in 1985 and a high by-catch of juveniles in the industrial fisheries for sprat. Following a period of four years of below average recruitment (year classes 1987-91), SSB fell rapidly to below 500 000 tonnes in 1993. Fishing mortality increased rapidly averaging $F_{ages\ 2\text{-}6}=0.75$ (ca. 52%) over the period 1992–95 and recorded landings regularly exceeded the TAC. The North Sea industrial fishery for sprat developed rapidly over this period with the annual catch increasing from 33 000 tonnes in 1987 to 357 000 tonnes by 1995. With the 10% by-catch limit as the only control on the catch of immature herring, there was a consequent high mortality on juvenile herring which averaged 76% of the total catch in numbers of North Sea autumn spawners over this period.

During the summer of 1991 the presence of the parasitic fungus *Ichthyophonus* spp was noted in the North Sea herring stock. All the evidence suggested that the parasite was lethal to herring and that its occurrence could have a significant effect on natural mortality in the stock and ultimately on spawning stock biomass. High levels of infection were recorded in the northern North Sea north of latitude 60°N whilst infection rates in the southern North Sea and English Channel were very low. Efforts were made to estimate the prevalence of the disease in the stock through a programmeme of research vessel and commercial catch sampling. This led to estimates of annual mortality up to 16% (Anon., 1993) which was of the same order as the estimate of fishing mortality at the time. It was recognised that the behavioural changes and catchability of infected fish affected the reliability of the estimate of prevalence of the disease in the population. The uncertainty about the effect on stock size varied between estimates of 5% to 10% and 20%. Continued monitoring of the progress of the disease showed that by 1994 the prevalence in the northern North Sea had fallen from 5% in 1992 to below 1% and confirmed that the infection did not appear to be spreading to younger fish. Ultimately it was concluded that the disease had caused high mortality in the northern North Sea during 1991 and subsequently declined to the point where by 1995 the disease induced increase in natural mortality was insignificant.

The increased fishing pressure during the first half of the 1990's and the disease induced increase in natural mortality led to serious concerns about the possibilities of a stock collapse similar to that in the late 1970's. Reported landings continued at around 650 000 tonnes per year whilst the spawning stock began to decline again from over 1 million tonnes in 1990. The assessments at that time were providing an over optimistic perception of the size of the spawning stock and, for example, it was not until 1995 that it was realised that the SSB in 1993 had already fallen below 500 000 tonnes. This was well below the minimum biologically accepted level of 800 000 tonnes (MBAL) which had been set for this stock at that time.

H.3 Management and ICES advice

In 1996, the total allowable catches (TACs) for Herring caught in the North Sea (ICES areas IV and Division VIId) were changed mid-year with the intention of reducing the fishing mortality by 50% for the adult part of the stock and by 75% for the juveniles. For 1997, the regulations were altered again to reduce the fishing mortality on the adult stock to 0.25 and for juveniles to less than 0.1 with the aim of rebuilding the SSB up to 1.1 million t in 1998 (Simmonds 2007).

According to the EU and Norway agreement adopted in December 1997, efforts should be made to maintain the SSB above the MBAL (Minimum Biologically Acceptable Level) of 800 000 tonnes. An SSB reference point of 1.3 million has been set above which the TACs will be based on an F= 0.25 for adult herring and F= 0.12 for juveniles. If the SSB falls below 1.3 million tonnes, other measures will be agreed and implemented taking account of scientific advice. The management agreement was revised in 2004 and now reads:

The stock is managed according to the EU-Norway Management agreement which was updated inNovember 2008, the relevant parts of the text are included here for reference:

1. Every effort shall be made to maintain a minimum level of Spawning Stock Biomass (SSB) greater than 800,000 tonnes (Blim).
2. Where the SSB is estimated to be above 1.5 million tonnes the Parties agree to set quotas for the directed fishery and for bycatches in other fisheries, reflecting a fishing mortality rate of no more than 0.25 for 2 ringers and older and no more than 0.05 for 0 - 1 ringers.
3. Where the SSB is estimated to be below 1.5 million tonnes but above 800,000 tonnes, the Parties agree to set quotas for the direct fishery and for bycatches in other fisheries, reflecting a fishing mortality rate on 2 ringers and older equal to:

    0.25-(0.15*(1,500,000-SSB)/700,000) for 2 ringers and older, and no more than 0.05 for 0 - 1 ringers
4. Where the SSB is estimated to be below 800,000 tonnes the Parties agree to set quotas for the directed fishery and for bycatches in other fisheries, reflecting a fishing mortality rate of less than 0.1 for 2 ringers and older and of less than 0.04 for 0-1 ringers.
5. Where the rules in paragraphs 2 and 3 would lead to a TAC which deviates by more than 15 % from the TAC of the preceding year the parties shall fix a TAC that is no more than 15 % greater or 15 % less than the TAC of the preceding year.
6. Notwithstanding paragraph 5 the Parties may, where considered appropriate, reduce the TAC by more than 15 % compared to the TAC of the preceding year.
7. Bycatches of herring may only be landed in ports where adequate sampling schemes to effectively monitor the landings have been set up. All catches landed shall be deducted from the respective quotas set, and the fisheries shall be stopped immediately in the event that the quotas are exhausted.
8. The allocation of the TAC for the directed fishery for herring shall be 29 % to Norway and 71 % to the Community. The bycatch quota for herring shall be allocated to the Community.
9. A review of this arrangement shall take place no later than 31 December 2011.
10. This arrangement enters into force on 1 January 2009.

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

H.4 Sampling of commercial catch

Sampling of commercial catch is conducted by the national institutes. HAWG has recommended for years that sampling of commercial catches should be improved for most of the stocks. In January 2008, a new directive for the collection of fisheries data was implemented for all EU member states (Commission Regulations 2008/949/EC, 2008/199 and 2008/665). The provisions in the "data directive" define specific sampling levels. As most of the nations participating in the fisheries on herring assessed here have to obey this data directive, the definitions applicable for herring and the area covered by HAWG are given below:

AREA	SAMPLING LEVEL PER 1000 T CATCH		
Baltic area (IIIa (S) and IIIb-c)	*1 sample of which*	*100 fish measured and*	*50 aged*
Skagerrak (IIIa (N))	*1 sample*	*100 fish measured*	*100 aged*
North Sea (IV and VId):	*1 sample*	*50 fish measured*	*25 aged*
NE Atlantic and Western Channel ICES areas II, V, VI, VII (excluding d) VIII, IX, X, XII, XIV	*1 sample*	*50 fish measured*	*25 aged*

Exemptions to the above mentioned sampling rules are:

Concerning lengths:

(1) the national programmeme of a Member State can exclude the estimation of the length distribution of the landings for stocks for which TACs and quotas have been defined under the following conditions:

(i) the relevant quotas must correspond to less than 5 % of the Community share of the TAC or

to less than 100 tonnes on average during the previous three years;

(ii) the sum of all quotas of Member States whose allocation is less than 5 %, must account for

less than 15 % of the Community share of the TAC.

If the condition set out in point (i) is fulfilled, but not the condition set out in point (ii), the relevant Member States may set up a coordinated programme to achieve for their overall landings the implementation of the sampling scheme described above, or another sampling scheme, leading to the same precision.

Concerning ages:

(1) the national programmeme of a Member State can exclude the estimation of the age distribution of the landings for stocks for which TACs and quotas have been defined under the following conditions:

(i) the relevant quotas correspond to less than 10 % of the Community share of the TAC or to

less than 200 tonnes on average during the previous three years;

(ii) the sum of all quotas of Member States whose allocation is less than 10 %, accounts for less than 25 % of the Community share of the TAC.

If the condition set out in point (i) is fulfilled, but not the condition set out in point (ii), the relevant Member States may set up a coordinated programmeme as mentioned for length sampling.

If appropriate, the national programmeme may be adjusted until 31 January of every year to take into account the exchange of quotas between Member States;

H.5 Terminology

The WG uses "rings" rather than "age" or "winter rings" throughout the report to denominate the age of herring, with the intention to avoid confusion. It should be observed that, for autumn spawning stocks, there is a difference of one year between "age" and "rings". HAWG in 1992 (ICES 1992/Assess:11) stated that

"The convention of defining herring age rings instead of years was introduced in various ICES working groups around 1970. The main argument to do so was the uncertainty about the racial identity of the herring in some areas. A herring with one winter ring is classified as 2-years-old if it is an autumn spawner, and one-year-old if it is a spring spawner. Recording the age of the herring in rings instead of in years allowed scientists to postpone the decision on year of birth until a later date when they might have obtained more information on the racial identity of the herring.

The use of winter rings in ICES working groups has introduced a certain amount of confusion and errors. In specifying the age of the herring, people always have to state explicitly whether they are talking about rings or years, and whether the herring are autumn- or spring spawners. These details tend to get lost in working group reports, which can make these reports confusing for outsiders, and even for herring experts themselves. As the age of all other fish species (and of herring in other parts of the world) is expressed in years, one could question the justification of treating West-European herring in a special way. Especially with the present trend towards multispecies assessment and integration of ICES working groups, there might be a case for a uniform system of age definition throughout all ICES working groups.

However, the change from rings to years would create a number of practical problems. Data files in national laboratories and at ICES would have to be adapted, which would involve extra costs and manpower. People that had not been aware of the change might be confused when comparing new data with data from old working group reports. Finally, in some areas (notably Division IIIa), the distinction between spring- and autumn spawners is still hard to make, and scientists preferred to continue using rings instead of years.

The Working Group discussed at length the various consequences of a change from rings to years. The majority of the Group felt that the advantages of such a change did not outweigh the disadvantages, and it was decided to stick to the present system for the time being."

The text table below gives an example for the correlation between age, rings and year class for the different spawning types in late 2002:

Year class (autumn spawners)	2001/2002	2000/2001	1999/2000	1998/1999
Rings	0	1	2	3
Age (autumn spawners)	1	2	3	4
Year class (spring spawners)	2002	2001	2000	1999
Rings	0	1	2	3
Age (spring spawners)	0	1	2	3

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Annex 4 – Stock Annex Western Baltic Spring Spawning Herring

Quality Handbook	ANNEX: HAWG-herring WBSS

Stock specific documentation of standard assessment procedures used by ICES and relevant knowledge of the biology.

Stock	Western Baltic Spring spawning herring (WBSS)
Working Group:	Herring Assessment Working Group for the Area South of 62º N
Date:	25.03.2009
Authors:	M. Cardinale, J. Dalskov, T. Gröhsler, H. Mosegaard, M. van Deurs, J. Gröger

A. General

A.1. Stock definition and biology

Stocks

Herring caught in Division IIIa and the eastern North Sea is a mixture of two stocks: North Sea Autumn Spawners (NSAS) and Western Baltic Spring Spawners (WBSS). All spring-spawning herring in the eastern part of the North Sea (IVa and b east), Skagerrak (Subdivision 20), Kattegat (Subdivision 21) and the Western Baltic (Subdivisions 22, 23 and 24) are treated as one stock, WBSS. The main spawning area of the WBSS is considered to be Greifswalter Bodden at Rügen (therefore also referred to as the Rügen-herring) (ICES, 1998), whereas NSAS utilizes spawning areas mainly along the British east coast (e.g. Burd, 1978; Zijlstra, 1969). The assessment also takes into account the few Norwegian Spring Spawners (NSS) caught in IVa north.

The contribution of Downs-herring to the mix-area of Division IIIa is likely to be relatively small (un-published data from otolith readings, DIFRES), and Downs-herring are therefore included under NSAS for the stock assessment of herring in Division IIIa and Subdivisions 22-24.

In the Western Baltic almost solely WBSS are being caught (few autumn spawners, however, have been observed). The majority of 2+ ringers, however, migrate out of the area during quarter 2, to feed in Division IIIa and the North Sea and return in quarter 1 (Biester, 1979; Nielsen *et al*., 2001; van Deurs and Ramkaer, 2007).

In the Kattegat and the eastern Skagerrak, mainly 2+ ringers of the WBSS and 0 to 2-ringers from the NSAS are being caught (ICES, 2004; ICES WD, 2006). The area provides a nursery habitat for juvenile NSAS (also other areas in the North Sea function as nursery areas), that assumable have drifted into the area as larvae (Burd, 1978; Heath *et al*, 1997). 0-1 ringer WBSS mainly uses nursery areas in Subdivision 22-24 and start to occur in the southern Kattegat as 1-ringers. The largest concentrations of herring during June/July seem to appear along the southern edge of the Norwegian Trench and in the area to the east of Læsø, in Kattegat (ICES, 2005; ICES, 2006). In 3rd quarter large concentrations of 2+ ringers of the WBSS are found in the southern Kattegat and Subdivision 23 as they aggregate for the over-wintering, which mainly takes place in Subdivision 23 (Nielsen *et al*., 2001; Clausen *et al*., 2006).

In the eastern North Sea and the western Skagerrak mainly 2+ ringers from WBSS and 1 to 2-ringer NSAS are being caught (Clausen *et al*., 2006). Peak catches of WBSS occur in quarter 3, during which the spawning stock of WBSS feed in these areas (ICES, 2002). According to the herring acoustic survey (ICES, 2006) the largest concentrations of herring in this area occur along the transition zone between the Skagerrak and the North Sea (ICES, 2006). Some 2+ ringer NSAS are caught in 1st and 4th quarter, since part of the NSAS spawning stock over-winter in the Norwegian trench in this area. (Burd, 1978; Cushing and Bridger, 1966; Clausen *et al*., 2006).

In historic time several local late winter and spring spawning populations in the Skagerrak and the Kattegat has been described (e.g. Ackerfors, 1977; Rosenburg and Palmen, 1982). The largest of these seems to have reached extinction decades ago (ICES, 2004). Local spawning events during spring in a rather large number of fjords on the coast of Skagerrak and Kattegat, and both in Denmark, Sweden, and Norway are known still to occur regularly (HERGEN, EU project QLRT 200-01370, final report), but have been considered of minor importance for the herring fisheries (ICES, 2001). Recent genetic and morphological studies confirmed that these local spawning areas belong to distinct spawning populations (Bekkevold *et al*., 2005) and bear witness of a more complex composition of multiple populations than previously assumed. The migration behaviour of these populations is basically unknown and the methods for splitting them from the Rügen-herring in catches are still associated with large uncertainties (HERGEN, EU project QLRT 200-01370, final report). Also on the German coast of the Western Baltic we find more than the spawning grounds of Rügen. E.g. the spring spawning grounds of the Sleich Fjord (Kühlmorgen-Hille, 1983). It is unknown whether herring visiting spawning grounds in the Sleich Fjord belong to the Rügen-herring or should be considered an independent population. However, results presented by Biester (1979) and the population diversity found by Bekkevold *et al*. (2005) indicates that they too are likely to be genetically distinct from the Rügen-herring.

Methods for stock separation

Experience within the Herring Assessment Working Group has shown that stock separation procedures based on size distributions often will fail.

The method for separating herring stocks in Norwegian samples, using vertebral counts (VC), as described in former reports of this Working Group (ICES 1991/ Assess:15), assumes that for NSAS, the mean vertebral count is 56.5 and for WBSS 55.8. The fractions of spring spawners (fsp) are estimated from the formula (56.50-v)/(56.5-55.8), where v is the mean vertebral count of the (mixed) sample with the restriction that the proportion should be one if fsp>=1 and zero if fsp<=0. The method is quite sensitive to within-stock variation (e.g. between year classes) in mean VC. The mean VC, of the previous mentioned local spring-spawners from the Norwegian Skagerrak fjords (it should be emphasised that this is not the Norwegian Spring Spawners alias Atlantic-Scandio Herring), is higher than for the NSAS (Rosenberg and Palmén, 1982; van Deurs, 2005), and will bias fsp estimates if present in the samples. The Norwegian samples used in the stock assessment are from the eastern North Sea. The local Norwegian spring spawners therefore only constitute a problem if they migrate to feeding areas in the eastern North Sea. Inconclusive results from a study of the tag pratsite *A. simplex* in herring, indicates that this may be the case (van Deurs and Ramkaer, 2007).

The introduction of otolith microstructure analysis in 1996-97 (Mosegaard and Popp-Madsen, 1996) enables an accurate and precise split between three groups, autumn, winter and spring-spawners. Today this method is applied for the stock separation in all Danish and Swedish IIIa samples. However, different populations with similar spawning periods are not resolved with the present level of analysis. Different stock components that are not easily distinguished by their otolith microstructure (OM) are considered to have different mean vertebral counts (VC): E.g. the local Skagerrak winter/spring-spawners: 57 (Rosenberg and Palmén, 1982); Western Baltic Sea: 55.6 – 55.8 (Gröger and Gröhsler, 2001; ICES 1992/H:5). It should, however, be noted that the estimated stock specific mean VC varies somewhat among different studies, and the VC alone is not likely to be a successful tool for distinguishing between separate spring spawning populations in an assessment context .

Comparison between separation methods using frequency distributions of vertebral counts and otolith microstructure showed reasonable correspondence. Using this information the years from 1991 to 1996 was reworked in 2001, applying common splitting keys for all years by using a combination of the vertebral count and otolith microstructure methods (ICES, 2001). From 2001 and onwards, the otolith-based method only has been used for the Division IIIa.

Different methods of identifying herring stocks in the Division IIIa and Subdivisions 22-24 were recently evaluated in an EU CFP study project (EC study 98/026). The study involved several inter-calibration sessions between microstructure readers in the different laboratories involved with the WBSS herring. After the study was finished a close collaboration concerning reader interpretations has been kept between the Danish and Swedish laboratories. Sub-samples of the 2002 and 2003 Danish, Swedish, and German microstructure analyses were double-checked by the same Danish expert reader for consistency in interpretation. The overall impression is an increasingly good agreement among readers.

New molecular genetic approaches for stock separation are being developed within the EU-FP5 project HERGEN (EU project QLRT 200-01370, final report). Sampling of spawning aggregations during spring, autumn and winter has been carried out in 2002 and in 2003 in Division IIIa and in the Western Baltic at more than 10 different locations. The results point at a substantial genetic variation between North Sea and Western Baltic herring. As mentioned earlier, significant variation has also been found among spawning populations in Division IIIa and subdivision 22-24, which indicates the presence of multiple distinct spring spawning populations or sub-populations (Bekkevold *et al*., 2005). However, the substantial overlap in the genetic profiles of these sub-populations results in large uncertainties when attempting to estimate the proportional contribution of the individual spring spawning populations to the mix in Division IIIa.

For Subdivisions 22, 23 and 24 it is assumed that all individuals caught belong to the WBSS. However, after the introduction of OM analysis in 1996/97 it was discovered that in the western Baltic a small percentage of the herring landings might consist of autumn spawning individuals. Before molecular genetic methods became available for Atlantic herring the existence of varying proportions of autumn spawners in Subdivisions 22–24 in different years was considered a potential problem for the assessment, since they were thought to belong to the NSAS. Today the molecular genetic methods have revealed that they are more closely related to the WBSS than to the NSAS (HERGEN, EU project QLRT 200-01370, final report). Therefore, with the present genetic perception in mind, when herring with OM indicating autumn hatch are found in subdivisions 22-24 these are treated as belonging to the WBSS stock.

OM analysis for stock splitting is a relatively time consuming method, furthermore, its potential for making splits, between the recently discovered complexity of different spring spawning populations, is very limited (un-published results, DIFFRES). Time has therefore been put into developing new, and more time efficient methods, for stock splitting. Under the EU-FP5 project HERGEN (EU project QLRT 200-01370, final report) a promising and time effective method based on otolith morphology are being developed. So far this work has showed that individual stocks and local populations display significantly different edge pattern of lobe formation in the otolith (the work was conducted on the saggitae otolith). The procedure involves photographing the shapes of the otolith edge and subsequent analysis in the photo treatment software Image Pro plus 5.0. However, so far the technique does not provide a way to efficiently split between spring spawning population in the mix-area of IIIa.

A.2. Fishery

Fleet definitions

The fleet definitions used since 1998 for the fishery in Division IIIa are:

- **Fleet C**: directed fishery for herring in which trawlers (with 32 mm minimum mesh size) and purse seiners participate.
- **Fleet D**: All fisheries in which trawlers (with mesh sizes less than 32 mm) and small purse seiners, fishing for sprat along the Swedish coast and in the Swedish fjords, participate. For most of the landings taken by this fleet, herring is landed as 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.

In SDs 22–24 most of the catches are taken in a directed fishery for herring and some as by-catch in a directed sprat fishery. All landings from SDs22–24 are treated as one fleet.

Historical German fishing pattern

The overall German fishing pattern has changed in the last few years. Until 2000 the dominant part of German herring catches were caught in the passive fishery by gillnets and trapnets around the Rügen Island. Since 2001 the activities in the trawl fishery increased. Recently the landings by trawl reached a level of more than 50 % of the total landings (2003: 63 %, 2004: 52 %, 2005: 57 % and 2006: 64 %). The change in fishing pattern was caused by requirements for a fish factory on Rügen Island established in 2003 which can process 50 000 t per year.

Investigation of new Danish fleet/metier description and the possibilities of improving the advice for the mixed stocks in IIIa (The IMHERSKA EU-project (Clausen *et al.*, 2006))

An ecosystem approach to fisheries management should consider conservation of intra-specific variation due to population structure and life history variation. Knowledge of stock integrity is of unequivocal importance for sustainable fisheries management, since variable compositions in mixed areas together with asynchronous population dynamics may lead to over-fishing of individual stocks if not all components are managed to ensure (or achieve) sustainable exploitation.

A descriptive analysis of the Danish fleet dynamics during the last decade, in terms of the distribution of herring catches over fleets and at the overall activity of the vessels targeting herring in Division IIIa, together with an investigation of the fleet/metier specific exploitation of the individual stocks in Division IIIa was performed in the IMHERSKA EU project (Clausen *et al*., 2006).

For the descriptive analysis of the Danish fleet dynamics during the last decade, the fisheries identified in Ulrich and Andersen (2004) was modified accordingly, to get as much consistency with the previous HAWG work. Fisheries were identified using a 3-steps method using multivariate analysis of landings profile (target species) and trips descriptors (mesh size, season, and area). The data were based on logbook data and though considerable misreporting is suspected to take place between Division IIIa and the North Sea, the geographical patterns described below is believed to illustrate the fishery behaviour in general terms.

Figure A.2.1 illustrates the distribution of Danish herring landings in Division IIIa by vessel type and homeport (fleet) in 2004. From this 4 fleets were identified and Figure 3.1.2 shows the distribution of herring landings by fleet over selected years:

1) OTB_NSSK: trawlers from North Sea and Skagerrak harbours (Skagen included). This fleet is referred to as the Northern fleet.
2) PSB_NSSK: purse-seines from North Sea and Skagerrak harbours.
3) OTB_KAWB: trawlers from North Sjælland and Western Baltic (Subdivisions 22-24) harbours. This fleet is referred to as the Southern fleet.
4) OTH: all other vessels recorded for having caught herring in Division IIIa at least once a year. Given its low importance, this fleet is not kept further in the analysis.

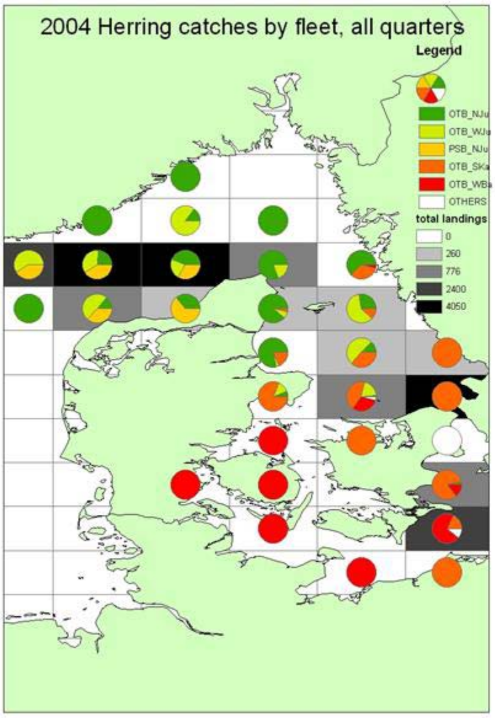

Figure A.2.1 Danish landings in IIIa by vessel and homeport.

The spatial and temporal distribution of the two main stocks (NSAS and WBSS respectively) in the Subdivisions IVaE, IIIaN, IIIaS and Subdivisions 22-24 based on analysis of herring catch compositions from both commercial and scientific sampling in the period from 1999 to 2004 appear to be following certain patterns in terms of seasonality which in turn allow predictions of the mix of herring in the area. Furthermore, by using the above four fleets/metiers and disaggregating those further into industrial or commercial activities and looking at the stock composition in their catches within different seasons, stock selective metiers was identified (a stock selective metier was defined as: a metier with 80% or more of its landings constituting the same stock). Identifying such patterns, both in terms of the life-stage spatiality of WBSS and NSAS in division IIIa and adjacent areas, and in terms of fleets activity and inter-stock selectivity was a necessary prerequisite for any use of improved fleet- and stock-based management objectives. We have thus demonstrated that a more precise advice for the mixed stock in IIIa using elaborate fleet- and stock-based desegregations could be implemented. A projection method for predicting both stock- and metier-specific Fs is being developed accordingly.

Historical Danish fishing pattern

The general dynamics of the Danish herring activities in Division IIIa can be summed up as the following points:

- During the first half of the 1990-ties, the activity was relatively local. The fleets were mostly fishing in their immediate waters. For some of the vessels mainly participating in the small meshed fisheries the fishery for herring for human consumption was a minor but stable activity.
- The second half of the 1990-ties was a period of extension. Both the Southern and Northern trawling fleets extended their activity to the Baltic, and decreased meanwhile their industrial activities in the Kattegat and Skagerrak, which induced reduced by-catches of herring. In the same period, the large purse seiners (most of the vessels are polyvalent) increased significantly their geographical mobility, with a majority of their effort being spent outside the traditional Danish fishing grounds in the North Sea and Division IIIa as they participated in fishery for blue whiting and Norwegian spring spawning herring.

The Swedish fleet definition is based on mesh size of the gear as for the Danish fleet. However, a recent change in the Swedish industrial fishery has occurred, as the Swedish industrial fishery has rapidly declined during the 1990´s and it is currently no longer operating in the area. Therefore, there is no difference in age structure of the Swedish landings between vessel using different mesh sizes since both are basically targeting herring for human consumption.

Changes in fishing technology and fishing patterns

Since 2001, the fishing pattern has changed in the German fleet. In former years, the main catch of herring was taken in the passive gears, bottom-set gillnets and trapnets. Recently the landings by trawl have reached a level of more than 50% of the total landings (2003: 63%, 2004: 52%, 2005: 57% and 2006: 64%). This change is due to requirements from a new fish factory on the Rügen Island.

The Swedish industrial fishery rapidly declined during the 1990s and it is currently no longer operating in the area. Therefore, 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.

A descriptive analysis of the Danish fleet dynamics during the last decade, in terms of the distribution of herring catches over fleets and at the overall activity of the vessels targeting herring in IIIa, was performed in the IAMHERSKA (Improved Advice for the Mixed HERring stocks in the Skagerrak and Kattegat (ICES Division IIIa)) project (Ulrich-Rescan and Andersen 2006 WD 1 in ICES CM 2006/ACFM: 20). During the second half of the nineties, both the southern and northern trawling fleets extended their activity to the Baltic, and decreased meanwhile their industrial activities in the Kattegat and Skagerrak, which induced reduced by-catches of herring. In the same period, the large purse seiners (most of the vessels are polyvalent) increased significantly their geographical mobility, with a majority of their effort being spent outside the traditional Danish fishing grounds in the North Sea and Division IIIa as they participated in fisheries for blue whiting and Norwegian spring spawning herring.

The full consequence of the implementation of the ITQ system for herring is yet unknown as vessels still are changing status. However, a change in the behaviour in the Danish herring fishery indicates that vessels without an ITQ for herring are targeting a mixed sprat and herring fishery and land their catch for industrial purposes, whereas vessels with an ITQ for herring are primarily participating in the herring fishery for human consumption.

A.3. Ecosystem aspects

Recent results from the HERGEN research-project on herring (HERGEN, EU project QLRT 200-01370, final report) reveals an increase in genetic distance between herring populations in the Baltic and successive populations in subdivisions 24, 22, 21, and 20 and finally the North Sea where genetic distance reach a maximum constant difference to the Baltic. Further, genetic differences are larger among populations within the Division IIIa and Western Baltic than among populations in the North Sea. The results also suggests that the herring spawning in spring on local spawning areas in the fjords of both the Western Baltic, the Kattegat, and the Skagerrak should be regarded as distinct spawning populations (or sub-populations) rather than as "strayers" from the Rügen-herring population. Furthermore, the contribution of these local spring spawning populations are considerable (Bekkevold *et al*., 2005; HERGEN, EU project QLRT 200-01370, final report).

By comparing five different Baltic herring stocks, temperature and SSB was shown as a the main predictors contributing to explain recruitment in the whole Baltic Sea, (Cardinale *et al*. 2009) except for Western Baltic herring where the Baltic Sea Index was the selected proxy in the final model. However, Baltic Sea Index is also known to be related to SST in the area.

B. Data

B.1. Commercial catch

Misreporting to fishing area still occurs. There is uncertainty about where the Danish landings for human consumption, reported from Division IIIa were actually taken. There is a high probability that these catches have been taken in the North Sea. Therefore, some of these catches have been transferred to the North Sea. Lastly, some landings reported as taken in the Triangle (Gilleleje, DK - Kullen, S - Helsingborg, S - Helsingør, DK), may have been taken outside this area and listed under the Kattegat.

There is at present no information about the relevance of local herring stocks/populations in relation to the fisheries and their possible influence on the stock assessment. Recent evidence from genetic differentiation among spawning aggregations in the Skagerrak suggests a potential high representation of these local spawning stocks (Bekkevold *et al.*, 2005). Other results suggest that at least the mature proportion of the different stock components to a large extent shares migration patterns and feeding areas (Ruzzante *et al.*, 2006; van Deurs and Ramkaer, 2007).

B.2. Biological parameters for assessment

Mean weights-at-age in the catch in the 1st quarter were used as stock weights.

In order to check if this is a valid assumption and represents the actual weights in the stock, the index was compared to the average weights in the catch by age during the whole year. The relationship followed the expected pattern where the weight of the younger age classes in the catch are somewhat higher than in the stock as these are taken as an average over the whole year allowing for growth. From age-class 4 the relation between weight in catch and weight in stock followed a 1:1 line as expected. Thus the use of weight in the catch in quarter 1 is a sound indicator for the weight in the stock and does not give a biased representation of the stock.

The proportion of F and M before spawning was assumed constant between years. F-prop was set to be 0.1 and M-prop 0.25 for all age groups.

Natural mortality was assumed constant at 0.2 for all years and 2+ ringers. A predation mortality of 0.1 and 0.2 was added to the 0 and 1 ringers, which resulted in an increase in their natural mortality to 0.3 and 0.5, respectively (Table 3.6.4). The estimates of predation mortality were derived as a mean for the years 1977–1995 from the Baltic MSVPA (ICES 1997/J:2).

The maturity ogive was assumed constant between years:

W-rings	0	1	2	3	4	5	6	7	8+
Maturity	**0.00**	**0.00**	**0.20**	**0.75**	**0.90**	**1.00**	**1.00**	**1.00**	**1.00**

B.3. Surveys

The summer Danish acoustic survey in Division IIIa is part of an annual survey covering the North Sea and Division IIIa in July-August. R/V DANA conducted the survey in Division IIIa. For each sub area the mean back scattering cross section was estimated for herring, sprat, gadoids and mackerel by the TS relationships given in the Manual for Herring Acoustic Surveys in ICES Division III, IV, and IVa (ICES 2002/G:02). **Used in the final assessment**.

The first joint acoustic survey was carried out with R/V 'Solea' in Subdivisions 22-24 in October 1987. Since 1989 the survey was repeated every year as a part of an international hydracoustic survey in the Baltic. The survey has been revised in 2007 and it now includes also SD 21. **Used in the final assessment**.

The IBTS 3rd quarter survey in Division IIIa is part of the North Sea and Div. IIIa bottom trawl survey carried out in the 1st and 3rd quarter. The IBTS has been conducted annually in the 1st quarter since 1977 and 3rd quarters from 1991. From 1983 and onwards the survey was standardised according to the IBTS manual (ICES 2002/D:03). During the HAWG 2002 the IBTS survey data (both quarter) were revised from 1991 to 2002. Historical catch rates are heavily skewed and therefore the survey indices by winter rings 1-5 were calculated as geometric means from observed abundances ($n \cdot h^{-}$

[1]) at age at trawl stations. However, inspections of the distributions of CPUE ($n \cdot h^{-1}$) reveals that they are characterized by a relatively large number of low values, including true zeroes, but also occasional catches comprising large number of individuals. Statistical inference based on such data is likely to be inefficient or wrong unless an appropriate distribution is carefully chosen Generally, a quasi-Poisson distribution (with a log-link function in order to constraint the estimates of CPUE to be positive) and a so called zero inflated models (Minami *et al*. 2006; Martin *et al*., 2005) are used. While quasi-Poisson can treat zeroes and non-zeroes in the same models, zero-inflated models are expressed in two parts: the probability of being in a 'perfect-state' (e.g., no catch), and the probability of being in an 'imperfect-state' where positive events (e.g., catch) may occur (Minami *et al*. 2006). The perfect-state is usually modeled with a logistic, and a quasi-Poisson or a negative binomial distribution is assumed for the imperfect state. Those models are usually referred to as zero-inflated (ZIP and ZINB) models. Zero-inflated models are also attractive because they make a distinction between covariates associated with the perfect state (no catch) and covariates associated with the imperfect state in which catch can occur, but is not certain. Analysis is ongoing to test the use of ZIP and ZINB for estimating catch at age from IBTS dataset to be included in the next benchmark assessment. Thus, the IBTS indices were not used in the final assessment from 2008 and onwards. **Not used in the final assessment**.

The German herring larvae monitoring started in 1977 and takes place every year from March/April to June in the main spawning grounds of the spring spawning herring in the Western Baltic. These are the Greifswalder Bodden and adjacent waters. For the calculation of the number of larvae per station and area unit, the methods of Smith and Richardson (1977) and Klenz (1993) were used and projected to length-classes. Further details concerning the surveys and the treatment of the samples are given in Brielmann (1989), Müller and Klenz (1994) and Klenz (2002). Data revision was made in 2007 with a new method in calculating number at 20mm. There was a high correlation between the indices N20 and HA_1 which are based on significantly different methods, areas and periods. Thus, results suggest that the index N20 is a suitable estimator of the new year-class of the spring spawning herring in ICES subdivision 22 – 24 (Oeberst *et al*, 2007, WD 7 in HAWG 2008 report). The time series now starts in 1992. **Used in the final assessment.**

B.4. Commercial CPUE

None

B.5. Other relevant data

None

C. Historical Stock Development

Model used: ICA
Software used: FLICA

Model Options chosen:
No of years for separable constraint: 5
Reference age for separable constraint: 4
Constant selection pattern model: yes
S to be fixed on last age: 1.0
First age for calculation of reference F: 3
Last age for calculation of reference F: 6
Relative weights-at-age: 0.1 for 0-group, all others 1
Relative weights by year: all 1
Catchability model used: for all indices linear
Survey weighting: Manual all 1
Estimates of the extent to which errors in the age-structured indices are correlated across ages: all 1
No shrinkage applied

Input data types and characteristics:

Type	Name	Year range	Age range	Variable from year to year Yes/No
Caton	**Catch in tonnes**	**1991- last data year**	**0-8+**	**Yes**
Canum	**Catch-at-age in numbers**	**1991- last data year**	**0-8+**	**Yes**
Weca	**Weight-at-age in the commercial catch**	**1991- last data year**	**0-8+**	**Yes**
West	**Weight-at-age of the spawning stock at spawning time.**	**1991- last data year**	**0-8+**	**Yes, assumed as the Mw in the catch first quarter**
Mprop	**Proportion of natural mortality before spawning**	**1991- last data year**	**0-8+**	**No, set to 0.25 for all ages in all years**
Fprop	**Proportion of fishing mortality before spawning**	**1991- last data year**	**0-8+**	**No, set to 0.1 for all ages in all years**
Matprop	**Proportion mature at age**	**1991- last data year**	**0-8+**	**No, constant for all years**
Natmor	**Natural mortality**	**1991- last data year**	**0-8+**	**No, constant for all years**

Presently used Tuning data:

Type	Name	Year range	Age range
Tuning fleet 1	**Danish Acoustic Survey Div. IIIa**	**1990 – last year data**	**3-6**
Tuning fleet 2	**German Acoustic Survey SDs 22-24**	**1993 – last year data**	**1-3**
Tuning fleet 3	**N20 larval survey, Greifswalder Botten**	**1992 – last year data**	**0**

D. Short-Term Projection

Model used: Age structured

Software used: MFDP 1a

Initial stock size: ICA estimates of population numbers were used except for

- the numbers of 0-ringers in the last two years and the start year of the projection, where a geometric mean of the recruitment over the period of 5 years was taken
- the numbers of 1-ringers in the start of the projection, was taken as the projected 0-ringers in 2008

Natural mortality: The same values as in the assessment is used for all years

Maturity: The same values as in the assessment is used for all years

F and M before spawning: The same ogives as in the assessment is used for all years

Weight-at-age in the stock: Average weight of the three last years

Weight-at-age in the catch: Average weight of the three last years

Exploitation pattern: Average weight of the three last years not rescaled to the last year (Catch constraint)

Intermediate year assumptions: Status quo fishing mortality

Stock recruitment model used: None

Procedures used for splitting projected catches: Not relevant

E. Medium-Term Projections

Model used: HCS

Software used: HCS

Initial stock size: ICA estimates of population numbers were used

Natural mortality: The same values as in the assessment is used for all years

Maturity: The same values as in the assessment is used for all years

F and M before spawning: The same values as in the assessment is used for all years

Weight-at-age in the stock: Average weight of the three last years

Weight-at-age in the catch: Average weight of the three last years

Exploitation pattern: Average weight of the three last years

Intermediate year assumptions: Status quo fishing mortality

Stock recruitment model used: Hockey stick

Uncertainty models used:

1) Initial stock size:
2) Natural mortality:
3) Maturity:
4) F and M before spawning:
5) Weight-at-age in the stock:
6) Weight-at-age in the catch:
7) Exploitation pattern:
8) Intermediate year assumptions:
9) Stock recruitment model used:

F. Long-Term Projections

Model used: none

Software used:

Maturity:

F and M before spawning:

Weight-at-age in the stock:

Weight-at-age in the catch:

Exploitation pattern:

Procedures used for splitting projected catches:

G. Biological Reference Points

There are no precautionary approach reference points for this stock. Based on yield per recruit analysis and simulation carried out during HAWG (2007) and WKHMP (2008), a proxy for long term maximum sustainable exploitation rate should be a level of fishing mortality should not exceed F = 0.25.

Risk assessment performed in 2007

To address the issue of risk assessment with respect to simulation based optimizations carried out for IIIa herring in section 3.8 we implemented the following risk definition as given in the SGRAMA report of 2006 (ICES 2006/RMC:04) which is risk in a juridical sense:

$$\begin{aligned} \text{Risk} &= \text{P(harmful event)} \times \text{severity of harmful event} \\ &= \text{P(lower SSB limit undercut)} \times \text{EL} \end{aligned} \quad (1)$$

with expected loss (EL) being defined as

$$\text{EL} = \text{E}[\text{SSB}_{\text{lower limit}} - \text{SSB}_{\text{estimated}} \mid \text{SSB}_{\text{estimated}} < \text{SSB}_{\text{lower limit}}] \ . (2)$$

While this definition of risk is not only implemented as part of many national constitutions (for instance, of the German constitution; Schuldt 1997, Schulte 1999, Schulz *et al.* 2001) but is also commonly used in engineering, in natural or environmental sciences or in medicine (see, for instance, Burgmann 2004), in mathematical sciences however P (harmful event) is often solely used as a definition for risk. As we aim at specifying costs or loss from a political and economic perspective, Eq. (1) turns out to be the appropriate risk measure, as it contains a probability term specifying the chance or likelihood of a harmful event and a severity term quantifying the magnitude of the loss. Further information on the theory underlying risk assessment and risk management can be found in Burgmann (2004), Francis and Shotton (1997) and Lane and Stephenson (1997). For a formal treatment of quantitative risk assessment and management see McNeil (2005).

H. Other Issues

None

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Annex 5 – Stock Annex Herring in the Celtic Sea and VIIj

Quality Handbook Herring in Celtic Sea and VIIj

Stock specific documentation of standard assessment procedures used by ICES.

Stock: Herring in the Celtic Sea and VIIj

Working Group: Herring Assessment Working Group for the area south of 62^0

Date:

Authors: Afra Egan and Maurice Clarke

A. General

The herring (*Clupea harengus*) to the south of Ireland in the Celtic Sea and in Division VIIj comprise both autumn and winter spawning components. For the purpose of stock assessment and management, these areas have been combined since 1982. The inclusion of VIIj was to deal with misreporting of catches from VIIg. The same fleet exploited these stocks and it was considered more realistic to assess and manage the two areas together. This decision was backed up by work by the ICES Herring Assessment Working Group (HAWG) in 1982 that showed similarities in age profiles between the two areas. In addition, larvae from the spawning grounds in the western part of the Celtic Sea were considered to be transported into VIIj (ICES, 1982). Also it was concluded that Bantry Bay in VIIj, was a nursery for fish of south coast (VIIg) origin (Molloy, 1968).

A study group examined stock boundaries in 1994 and recommended that the boundary line separating this stock from the herring stock of VIaS and VIIb be moved southwards from latitude 52°30'N to 52°00'N (ICES, 1994b). However, a recent study (Hatfield, *et al* 2007) examined the stock identity of this and other stocks around Ireland. It concluded that the Celtic Sea stock area should remain unchanged.

Some juveniles of this stock are present in the Irish Sea for their first year or two of life. Juveniles, which are believed to have originated in the Celtic Sea move to nursery areas in the Irish Sea before returning to the spawn in the Celtic Sea. This has been verified through herring tagging surveys, conducted in the early 1990s, (Molloy, *et al* 1993) and studies examining otolith microstructure (Brophy and Danilowicz, 2002). Age distribution of the stock suggests that recruitment in the Celtic Sea occurs first in the eastern area and follows a westward movement. After spawning herring move to the feeding grounds offshore (ICES, 1994). In VIIj herring congregate for spawning in autumn but little is known about where they reside in winter (ICES, 1994). A schematic representation of the movements and migrations is presented in Figure 1. Figure 2 shows the oceanographic conditions that will influence these migrations.

The management area for this stock comprises VIIaS, VIIg, VIIj, VIIk and VIIh. Catches in VIIk and VIIh have been negligible in recent years. The linkages between this stock and herring populations in VIIe and VIIf are unknown. The latter are managed by a separate precautionary TAC. A small herring spawning component exists in VIIIa, though its linkage with the Celtic Sea herring stock area is also unknown.

A.2. Fishery

Historical fishery development

Coastal herring fisheries off the south coast of Ireland have been in existence since at least the seventeenth century (Burd and Bracken, 1965). These fisheries have been an important source of income for many coastal communities in Ireland. There have been considerable fluctuations in herring landings since the early 1900s.

In the Celtic Sea, historically, the main fishery was the early summer drift net fishery and the Smalls fishery which also took place in the summer. In 1933 several British vessels, mainly from Milford Haven, began to fish off the coast of Dunmore East and the winter fishery gained importance. The occurrence of the world war changed the pattern of the herring fishery further with little effort spent exploiting herring in the immediate post war years (Burd and Bracken, 1965). Landings of herring off the south west coast increased during the 1950s.

In 1956 Dunmore East was considered as the top herring port in Ireland with over 3,000 t landed. This herring was mainly sold to the UK or cured and sent to the Netherlands (Molloy, 2006). During this time many boats from other European countries began to exploit herring in this area during the spawning period. This continued until the 1960s when catches began to fall. In 1961 the Irish fishery limits changed whereby non-Irish vessels were prohibited from fishing in the inshore spawning grounds (Molloy, 1980). Consequently, continental fleets could no longer exploit herring on the Irish spawning grounds. They had to purchase herring from Irish vessels in order to meet requirements (Molloy, 2006).

During the period from 1950-1968 the fleet exploiting the stock changed from mainly drift and ring nets to trawls. Further fluctuations in the landings were evident during this time with high quantities of herring landed from 1966 – 1971 (Molloy, 1972). In the mid-sixties, the introduction of mid-water pair trawling led to greater efficiency in catching herring and this method is still employed today. Overall the 1960s saw a rise in herring landings with 1969 seeing a rise to 48,000t. The North Sea herring fisheries were becoming depleted and several countries were turning to Ireland to supply their markets. Prices also increased and additional vessels entered the fleet (Molloy, 1995). Increases in effort led to increased catches initially but this did not continue and the decline of the fishery began.

Fishery in recent years

In the past, fleets from the UK, Belgium, The Netherlands and Germany as well as Ireland exploited Celtic Sea herring. In recent years however this fishery has been prosecuted entirely by Ireland. This fishery is managed by the Irish "Celtic Sea Herring Management Advisory Committee", established in 2000 and constituted in law in 2005.

The Irish quota is managed by allocating individual quotas to vessels on a weekly basis. Participation in the fishery is restricted to licensed vessels and these licensing requirements have been changed. Previously, vessels had to participate in the fishery each year to maintain their licence. Since 2004 this requirement has been lifted. This has been one of the contributing factors to the reduction in number of vessels participating in the fishery in recent seasons (ICES, 2005b). Fishing is restricted to the period Monday to Friday each week, and vessels must apply a week in advance before they are allowed to fish in the following week. Triennial spawning box closures are enshrined in EU legislation (Figure 3).

The stock is exploited by two types of vessels, larger boats with RSW storage and smaller dry hold vessels. The smaller vessels are confined to the spawning grounds (VIIaS and VIIg) during the winter period. The refrigerated seawater (RSW) tank vessels target the stock inshore in winter and offshore during the summer feeding phase (VIIg). There has been less fishing in VIIj in recent seasons.

The fleet can be classified into four categories of vessels:

Category 1:	"Pelagic Segment".	Refrigerated seawater trawlers
Category 2:	"Polyvalent RSW Segment".	Refrigerated seawater or slush ice trawlers
Category 3:	"Polyvalent Segment".	Varying number of dry hold pair trawlers,
Category 4:	Drift netters.	A negligible component in recent years, very small vessels

The term "Polyvalent" refers to a segment of the Irish fleet, entitled to fish for any species to catch a variety of species, under Irish law. Since 2002 fishing has taken place in quarter 3, targeting fish during the feeding phase on the offshore grounds around the Kinsale Gas Fields. These fish tend to be fatter and in better condition than winter-caught fish. In 2003 the fishery opened in July on the Labadie Bank and caught large fish. In 2004-2006 it opened in August and in 2007 and 2008 in September. Only RSW and bulk storage vessels can prosecute this fishery. Traditional dry-hold boats are unable to participate.

In recent years, the targeting fleet has changed. The fleet size has reduced but an increasing proportion of the catch is taken by RSW and bulk storage vessels and less by dry-hold vessels. There has been considerable efficiency creep in the fishery since the 1980s with greater ability to locate fish.

A.3. Ecosystem aspects

The ecosystem of the Celtic Sea is described in ICES WGRED (2007). The main hydrographic features of this area as they pertain to herring are presented in Figure 2.

Temperatures in this area have been increasing over the last number of decades. There are indications that salinity is also increasing (ICES, 2006). Herring are found to be more abundant when the water is cooler while pilchards favour warmer water and tend to extend further east under these conditions (Pinnegar, *et al* 2002).

However, studies have been unable to demonstrate that changes in the environmental regime in the Celtic Sea have had any effect on productivity of this stock.

Herring larval drift occurs between the Celtic Sea and the Irish Sea. The larvae remain for a period as juveniles before returning to the Celtic Sea. Catches of herring in the Irish Sea may therefore impact on recruitment into the Celtic Sea stock (Molloy, 1989). Distinct patterns were evident in the microstructure and it is thought that this is caused by environmental variations. Variations in growth rates between the two areas were found with Celtic Sea fish displaying fastest growth in the first year of life. These variations in growth rates between nursery areas are likely to impact recruitment (Brophy and Danilowicz, 2002). Larval dispersal can further influence maturity at age. In the Celtic Sea faster growing individuals mature in their second year (1 w.

ring) while slower growing individuals spawn for the first time in their third year (2 winter ring). The dispersal into the Irish Sea which occurs before recruitment and subsequent decrease in growth rates could thus determine whether juveniles are recruited to the adult population in the second or third year (Brophy and Danilowicz, 2003).

The spawning grounds for herring in the Celtic Sea are well known and are located inshore close to the coast. These spawning grounds may contain one or more spawning beds on which herring deposit their eggs. Individual spawning beds within the spawning grounds have been mapped and consist of either gravel or flat stone (Breslin, 1998). Spawning grounds tend to be vulnerable to anthropogenic influences such as dredging and sand and gravel extraction. The main spawning grounds are displayed in Figure 4, whilst the distributions of spawning and non-spawning fish are presented in Figure 5.

By Catch

By catch is defined as the incidental catch of non target species. There are few documented reports of by catch in the Celtic Sea herring fishery. A European study was undertaken to quantify incidental catches of marine mammals from a number of fisheries including the Celtic Sea herring fishery. Small quantities of non target whitefish species were caught in the nets. Of the non target species caught whiting was most frequent (84% of tows) followed by mackerel (32%) and cod (30%). The only marine mammals recorded were grey seals (*Halichoerus grypus*). The seals were observed on a number of occasions feeding on herring when the net was being hauled and during towing. They appear to be able to avoid becoming entangled in the nets. It was considered unlikely by Berrow, *et al* 1998, that this rate of incidental catch in the Celtic Sea would cause any decline in the Irish grey seal population. Results from this project also suggested that there was little interaction between the fishing vessels and the cetaceans in this area. Occasional entanglement may occur but overall incidental catches of cetaceans are thought to be minimal (Berrow, *et al* 1998). The absence of any other by caught mammals does not imply that by catch is not a problem only that it did not occur during this study period (Morizur, *et al* 1999).

Discards

Catch is divided into landings (retained catch) and discards (rejected catch). Discards are the portion of the catch returned to the sea as a result of economic, legal, or personal considerations (Alverson *et al* 1994). In the 1980s a roe (ovary) market developed in Japan and the Irish fishery became dependent on this market. This market required a specific type of herring whose ovaries were just at the point of spawning. A process developed whereby large quantities of herring were slipped at sea. This type of discarding usually took place in the early stages of spawning and was reduced by the introduction of experimental fishing (Molloy, 1995). This market peaked in 1997 and has been in decline since with no roe exported in recent years. Markets have changed with the majority of herring going to the European fillet market.

Presently there are no estimates of discards for this fishery used in assessments. Berrow, *et al* 1998 also looked at the issue of discarding during the study on by catch. The discard rate was found to be 4.7% and this compares favourably with other trawl fisheries. Possible reasons for discarding were thought to be the market requirements for high roe content and high proportions of small herring in the catch. Overall this study indicated that the Celtic Sea herring fishery is very selective and that discard rates are well within the figures estimated for fishery models.

Since the demise of the roe fishery, it is considered that the incentive to discard is less. However it is known that discarding still takes place, in response to a constrained market situation.

B. Data

B.1. Commercial Catch

The commercial catch data are provided by national laboratories belonging to the nations that have quota/fisheries for this stock. In recent years, only Ireland has been catching herring in this area, and the data are derived entirely from Irish logbook data. Figure 6 shows the trends in catches over the time series. Ireland acts as stock coordinator for this stock. Commercial catch at age data are submitted in Exchange sheet v 1.6.4. These data are processed either using SALLOCL (Patterson, 1998b), or using *ad hoc* spreadsheets, usually the latter. The relevant files are placed on the ICES archive each year.

Intercatch

Since 2007, InterCatch, which is a web-based system for handling fish stock assessment data, was also used. National fish stock catches are imported into InterCatch. Stock coordinators then allocate sampled catches to unsampled catches, aggregate them to stock level and download the output. The InterCatch stock output can then be used as input for the assessment models. The comparisons to date have been very good and it is envisaged that this system will replace SALLOCL and other previously used systems.

B.2 Biological

Sampling Protocol

Sampling is performed as part of commitments under the EU Council Regulation 1639/2001.Sampling (of the Irish catches) is conducted using the following protocol

- Collect a sample from each pair of boats that lands. Depending on the size range a half to a full fish box (depending on size range) is sufficient. If collecting from processor make sure sample is ungraded and random.
- Record the boat name, ICES area, fishing ground, date landed for each sample. If possible find out roughly how much the boat landed.
- Randomly take 75 fish for ageing. Record length in 0.5cm, weight, sex, maturity (use maturity scale for guideline). Extract otolith taking care not to break tip, store it in otolith tray. Make sure the tray is clean and dry.
- Record a tally for the 75 aged fish under “Aged Tally” on datasheet.
- Measure the remaining fish and record a tally on the measured component of datasheet

Ageing Protocol

Celtic Sea herring otoliths are read using a stereoscopic microscope, using reflected light. The minimum level of magnification (15x) is used initially and is then increased to resolve the features of the otolith. Herring otoliths are read within the range of 20x – 25x. The pattern of opaque (summer) and translucent (winter) zones is viewed. The winter (translucent) ring at the otolith edge is counted only in otoliths from fish caught after the 1st April. This "birth date" is used because the assessment year for Celtic Sea and Division VIIj herring runs from this date to the 31st March of the following year (ICES, 2007). This ageing and assessment procedure is unique in ICES. A fish of 2 winter rings is a 3 year old. This naming convention applies to all ICES herring stocks where autumn spawning is a significant feature.

Age composition in the catch

In recent years there is a decreasing proportion of older fish present in the catch. Figure 7 shows the age composition of the catches over the time series. It is clear that there is a truncation of older age classes in recent years.

Precision in Ageing

Precision estimates from the ageing data were carried out in the HAWG in 2007, for the 2006/2007 season (ICES, 2007). Results found that CVs are highest on youngest and oldest ages that are poorly represented in the fishery. The main ages present in the fishery had low CVs, of between 5% and 13%, which is considered a very good level of precision. In the third and the fourth quarter, estimates of 1 wr on CS herring were also remarkably precise. An overall precision level of 5% was reached in Q1 and Q4 in the 2007/2008 season.

Mean Weights and Natural Mortality

An extensive data set on landings is available from 1958. Mean weights at age in the catch in the 4th and 1st quarter are used as stock weights. Trends in mean weights at age in the catches are presented in Figure 8, and for weights in the spawning stock in Figure 9. Clearly there has been a decline in mean weights since the early 1980s, to the lowest values observed.

The natural mortality is based on the results of the MSVPA for North Sea herring. Natural mortality is assumed to be as follows:

1 ringer	1
2 ringer	0.3
3 ringer	0.2
4 and subsequent ringer	0.1

Maturity Ogive

Clupea harengus is a determinate one-batch spawner. In this stock, the assessment considers that 50% of 1 ringers are mature and 100% of two ringers mature. The maturity ogive calculated from acoustic survey data in 2007 shows that 58% of 1 ringers are mature and 99% of 2 ringers. Lynch (*in prep*) has also shown that more than 50% of 1 ringers are mature in recent years. It is to be noted that the fish that recruit to the fishery as 1-ringers are probably precocious early maturing fish. Late maturing 1-ringers may not be recruited. Thus maturity at 1-ringer in the population as a whole may be different to that observed in the fishery. Late maturing 1-, 2- and even 3-ringers may recruit from the Irish Sea.

B.3. Surveys

Acoustic

Acoustic surveys have been carried out on this stock from 1990-1996, and again from 1998-2008. During the first period, two surveys were carried out each year designed to estimate the size of the autumn and winter spawning components. The series was interrupted in 1997 due to the non-availability of a survey vessel. Since 2005, a uniform design, randomised survey track, uniform timing and the same research vessel have been employed. A summary of the acoustic surveys is presented in Table 1.

Revision of acoustic time series

A review of the acoustic survey programme was conducted to check the internal consistency of the previous surveys and produce a new refined series for tuning the assessment (Doonan, unpublished). The old survey abundance at age series is presented in Table 2 and the revised survey time series is shown in the Table 3 (ICES, 2006).

The surveys were divided into two series, early and late, based on how far from the south coast of Ireland the transects extended. The early group, 1990-91 to 1994-95, extended to about 15 nautical miles offshore with two surveys, one in autumn and another in winter. This design aimed to survey spawning fish close inshore with two surveys, the results of which could be added, the two legs covering the two main spawning seasons. The off shore limits were extended in 1995 and some of these surveys had more fish off shore than close inshore. This changed the catchability, suggesting the later series should be separated from the earlier one. Consequently the years before 1995 were removed. This is not considered to be a problem because the earlier series would contribute little to the assessment anyway.

The autumn surveys did not cover the southwest Irish coast of VIIj in all years (3 years missing). In order to correct for this, the missing values were substituted with the mean of the available western bays SSB estimates, 7 800 t (11 values, range from 0 to 16 000 t). Numbers-at-age in these surveys were adjusted upwards by the ratio of the adjusted SSB in the SW to the south coast SSB. The current time series included autumn surveys only.

Analysis errors were found in the surveys from 1998 onwards. The 2003 biomass (SSB, 85 500 t) was re-analysed after the discovery of errors in the spreadsheets used to estimate biomass. The errors affected the calculation of the weighted mean of the integrated backscatter when positive samples had lengths shorter than the base one (here, 15 minutes) and the partitioning of the backscatter for a mixture of species. Also, no account was taken of different sampling frequencies within a 10x20 minute cell (the analysis unit). The 2003 SSB came mainly from two cells that included an intensive survey in Waterford Harbour and these cells had an SSB of about 68 000 t, which was reduced to 7 300 t when all errors were corrected. There were some minor corrections in three other cells. The revised total biomass was 24 000 t and the revised spawning biomass was 22 700 t.

In addition, the cell means took no account of the implicit sampling area of transects so that the biomass coming from a large sample value depended on the number of transects passing through the cell. The data were re-analysed using mean herring density by transect as the sample unit and dividing the area into strata based on transect spacing. Areas with no positive samples were excluded from the analysis (since they have zero estimates). Zigzags in bays were analysed as before. For each stratum, a mean density was obtained from the transect data (weighted by transect length) and this was multiplied by the stratum area to obtain a biomass and numbers-at-age. The overall total was the sum of the strata estimates. The same haul assignments as in the original analysis were used. At the same time, a CV was obtained based on transect mean densities, i.e. a survey sample error. For surveys before 1998 and the western part survey in 2002, a CV was estimated using;

$$\sqrt{\log(1.3^2)/n}$$

where n is the number of positive sample values (15 minute of survey track) from Definite and Probably Herring categories. This was based on the data from the autumn surveys in 1998, 2000, 2001, 2002, and 2005.

Current acoustic survey implementation

The acoustic data are collected using the Simrad ER60 scientific echosounder. The Simrad ES-38B (38 KHz) split-beam transducer is mounted within the vessels drop keel or in the case of a commercial vessel mounted within a towed body. The survey area is selected to cover area VIIj, and the Celtic Sea (areas VIIg and VIIaS). Transect spacing in these surveys has varied between 1 to 4 nmi. For bays and inlets in the southwest region (VIIj) a combined zigzag and parallel transect approach was used to best optimise coverage. Offshore transect extension reached a maximum of 12 nmi, with further extension where necessary to contain fish echotraces within the survey area.

The data collected is scrutinised using Echoview® post processing software. The allocated echo integrator counts (S_a values) from these categories were used to estimate the herring numbers according to the method of Dalen and Nakken (1983). The following target strength to fish length relationships is used for herring.

TS = 20logL – 71.2 dB per individual (L = length in cm)

Acoustic Survey Time Series

The acoustic survey design has been standardised and the timing has been consistent each year since 2005. The 2002 and 2003 surveys had similar timing and are comparable to the uniform time series. In the benchmark assessment (2007) the time series used was from 1995-2006. At the time of the benchmark, there were not enough comparable consistent surveys available for tuning. In 2009, four consistent surveys (2005-2009) and two additional fairly consistent surveys (2002-2003) were available. This shorter series from 2002-2008 is considered the most consistent available.

Irish Groundfish Survey

The IGFS is part of the western IBTS survey and has been carried out on the *RV Celtic Explorer* since 2003. The utility of the IGFS as a tuning series was investigated (Johnston and Clarke, 2005 WD). Strong year effects were evident in the data. Herring were either caught in large aggregations or not at all. The signals from this survey were very noisy, but when a longer time series is developed, it will at least provide qualitative information. The absence of the 2001 year class was supported in the survey data in 2004.

French EVHOE Survey

The Herring Assessment Working group in 2006 had access to data from the French EVHOE quarter 4 western IBTS survey (GOV trawl). The French survey series is from 1997 to 2005 and displayed very variable observed numbers at age between years. Consequently, further exploration of the series was not performed.

UK Quarter 1 survey

The UK quarter 1 survey was also explored and strong year and age effects, particularly at 2- and 5-ringers were found. Due to strong year and age effects and because it was discontinued in 2002 this survey is considered unsuitable as a recruit index (ICES 2006:ACFM 20).

While these data are useful for comparisons between surveys, as with the Irish data, at the moment it is difficult to see how these data can be used in an assessment. The data, particularly towards the end of the time series are very noisy and the absence of very small (juvenile) fish, particularly 1 ringers for the majority of time series is not encouraging (Johnston and Clarke, 2005).

Irish and Dutch juvenile herring trawl surveys

Juvenile herring surveys were carried out from 1972 – 1974 by Dutch and Irish scientists. These surveys aimed to get information on the location and distribution of young herring. They were also used to examine if young herring surveys in the Irish Sea could provide abundance indices for either the Irish Sea or Celtic Sea stocks. Further young fish surveys were carried out in the Irish Sea from 1979 – 1988. They were discontinued when it was decided that it was not possible to use the information as recruitment indices for the Celtic Sea or Irish Sea stocks despite earlier beliefs (Molloy, 2006). This was because it was not known what proportion of the catches should be assigned to each stock.

Northern Ireland GFS surveys

These surveys take place in quarters 1 and 3 each year. Armstrong et al (2004) presented a review of these surveys. They are likely to be useful if the natal origin can be established. Further work in this area is required to examine if this survey can be used as a recruit index for Celtic Sea Herring.

Larval Surveys

Herring larval surveys were conducted in the Celtic Sea between October and February from 1978 to 1985 with one further survey carried out in 1989. These surveys provided information on the timing of spawning and on the location of the main spawning events as well as on the size of autumn and winter spawning components of the stock. The larval surveys carried out after the fishery reopened in 1982 showed an increase in the spawning stock (Molloy, 1995).

The surveys covered the south coast and stations were positioned 8 nautical miles apart in a grid formation. A Gulf III sampler, with 275 μm mesh was used to collect the samples. The total abundance of <10mm larvae (prior to December 15th) or <11mm (after December 15th) was calculated by raising the numbers per m^2 by the area represented by each station. The mean abundance of <11mm larvae in December – February gave the winter index which when multiplied by 1.465 and added to the Autumn index to give a single index of the whole series (Grainger *et al* 1982). Larval surveys have not been undertaken in this area since 1989 and until the acoustic survey became established, no survey was available to tune the assessment.

B.4. Commercial CPUE

In the 1960s and 1970s CPUE (Catch per unit effort) data from commercial herring vessels were used as indices of stock abundance because there were no survey data available. These data provided an index of changes that were occurring in the fishery at the time. CPUE data were used to tune the assessment (Molloy, 2006). However it is likely that the decline in the stock in the 1970s was not picked up in the CPUE until it was at an advanced stage. It is now demonstrated that CPUE data does not provide an accurate index of herring abundance, as they are a shoaling fish.

C. Historical Stock Development

Time Periods in the Fishery

This fishery can be divided into time periods. A number of factors have changed in this fishery overtime such as the markets, discards and the water allowance. These changes have implications for the trustworthiness of the catch data used in the assessment. The time periods are presented in the Table 4. The recent biological history of the stock is presented in Table 5. It is clear that growth rate has changed over time. Mean length and mean weight at age have declined by about 15% and 30% respectively since the late 1970s. Fish are shorter and lighter at age now than at any time in the series. Trends in mean weights in the catch and in the stock are presented in Figure 8 and Figure 9.

Exploration of basic data

Data exploration consisted of examining a number of features of the basic data. These analyses included log catch ratios, cohort catch curves in survey and catch at age series. Log catch ratios were constructed for the time series of catch at age data, as follows:

log[C(a,y)/C(a+1,y+1)]

These are presented in Figure 10. It can be seen that 1-ringers, and the oldest ages, have a noisy signal, being poorly represented in the catches. There was an increase in ratios in 1998, that seems quite abrupt. Overall there is a trend towards greater mortality in recent years. The increased mortality visible in the older ages corresponds with the truncation in oldest ages in the catch at age profile. It can also be seen that the gross mortality signal was low in 2002, corresponding to the big decrease in catch in that year. The signal increased again in 2003, concomitant with increasing catch.

Cohort catch curves across all ages were constructed using the catch at age data and are presented in Figure 11. The total mortality (Z) over ages 2-7 for the cohorts 1958-1997 is presented in Figure 12 and in Table 6. Fluctuations are evident with an increasing trend in recent years. Total mortality was low for cohorts 1956 to 1964. Cohorts in the late 1960s seem to display higher Z, but those from 1975 to 1982 displayed the highest Z (0.6 to 1.1). The most recent year classes for which enough observations are available (1991-1997) show higher Z again, in the range about 0.6 to 1.0. Cohort catch curves were also constructed from the catch at age data across ages 2-5 (Figure 13) and the survey data for year classes where enough data were available (Figure 14). A secondary peak corresponding to the 2003/2004 season is obvious in the cohort catch curves. The same patterns in raw mortality are visible, but the Zs from the acoustic survey are somewhat higher than those from the commercial data. This may be explained as differing catchability between the two, and it should be noted when interpreting the assessment results below.

In conclusion only the cohorts from before the stock collapsed and a few from the late 1980s contributed many of the older fish that appear in the catches. Raw mortality signals, from cohort catch curves suggest that some of the recent year classes have displayed a higher total mortality.

Assessments 2007, 2008 and 2009

In 2007, a benchmark assessment used a variety of models including ICA (Patterson, 1998), separable VPA, XSA, CSA and Bayesian catch at age methods. In addition an analysis of long term dynamics of recruitment was conducted. Simulations of various fishing mortalities were conducted based on stock productivity. Though no final model formulation was settled upon, the assessment provided information on trends. ICA was preferred to XSA because it is more influenced by younger ages that dominate the stock and fishery, and because of consistency. The settings that had been used before 2007 were found to produce the most reasonable diagnostics.

In 2007 it was considered that the assumption that a constant separable pattern could be used may not have been valid and it was recommended that future benchmark work should consider models that allow for changes in selection pattern.

Also in 2007 a reduction of the plus group to 7+ was recommended. This change did not achieve better diagnostics in 2007, but exploratory assessments in 2008 did find that this change improved the diagnostics.

In 2008 and 2009, the working group continued to explore different assessment settings in ICA. The working group treated these explorations as extensions of the benchmark of 2007. In 2008 ICA was replaced by FLICA and the same stock trajectories were found in each.

In 2009 a final analytical assessment was proposed and was conducted using FLICA(flr-project.org). This assessment was based on exploratory work done in 2008 and 2009. The refinements to the benchmark assessment of 2007 were as follows:

- Further reduction of plus group to 6+
- Exclusion of acoustic surveys before 2002, because a sufficient series of comparable surveys was now available.

The assessment showed improved precision and coherence between the catch at age and the survey data. The survey residuals were lower since 2002 which is reflected in better tuning diagnostics. The stock trajectories, based on this assessment are presented in Figure 15.

The model formulation used for ICA in the 2007 benchmark and the final assessment carried out in 2009 are presented in the table below.

ICA Settings	2007 Benchmark	Final Assessment 2009
Separable period	6 years (weighting = 1.0 for each year)	6 years (weighting = 1.0 for each year)
Reference ages for separable constraint	3	3
Selectivity on oldest age	1.0	1.0
First age for calculation of mean F	2	2
Last age for calculation of mean F	6	5
Weighting on 1 ringers	0.1	0.1

Weighting on other age classes	1.0	1.0
Ages for acoustic abundance estimates	2-5	2-5
Plus group	7	6

Estimation of terminal year SSB

In this stock the procedure for calculation of terminal year SSB is different to other stocks. Recruits (1-ring) are poorly represented in the catch and only one observation of their abundance is available. Yet 50% of these are considered mature and they make an important contribution to the SSB. Therefore an adjustment is made, by replacing 1-ring abundance from ICA.out with GM recruitment. Examination of recent patterns shows that recruitment has fluctuated around the average 1995-2006. Therefore the GM recruitment estimate 1995-2006 is used. SSB is recalculated using GM estimate*stock weight at 1-ring*maturity at 1-ring.

Input data types and characteristics:

TYPE	NAME	YEAR RANGE	AGE RANGE	VARIABLE FROM YEAR TO YEAR YES/NO
Caton	Catch in tonnes	1958-2008	1-6 +	Yes
Canum	Catch at age in numbers	1958-2008	1-6 +	Yes
Weca	Weight at age in the commercial catch	1958-2008	1-6+	Yes
West *	Weight at age of the spawning stock at spawning time.	1958-2008	1-6+	Yes
Mprop	Proportion of natural mortality before spawning	1958-2008	1-6 +	No
Fprop	Proportion of fishing mortality before spawning	1958-2008	1-6 +	No
Matprop	Proportion mature at age	1958-2008	1-6 +	No
Natmor	Natural mortality	1958-2008	1-6 +	No

* mean weights in the stock in the new plus group were re-weighted using catch numbers at age.

Tuning data:

TYPE	NAME	YEAR RANGE	AGE RANGE
Acoustic Survey	CSHAS	2002-2008	2-5

Analysis of productivity over time

To account for the influence of the ecosystem on the productivity of this herring stocks (ICES, 2007, Chapter 1) the methods of Nash and Dickey-Collas (2005) were applied. The recruit per spawner ratio was calculated. These calculations formed the basis for the detection of periods of high and low production of the stock (Figure 17).

The next step was to calculate the net and surplus production of the whole stock, including the recruits and the growth of all non-recruits, the natural and the fishing mortality. To subtract the influence of the spawning stock biomass a hockey stick and a Ricker stock recruitment relationship were fitted to the data to obtain the residuals of the recruits of a given year. The residuals were used to remove the year effect from the estimation of the stock size and to gain the net production and the surplus production respectively without the effect of the SSB on the number of recruits. Contrary to ICES (2007, Technical Minutes) the stock recruit model is not presented. This is because the model is not considered a good fit to the data and because the aim of this analysis is to examine recruitment, having removed the effect of SSB.

The data used in this analysis was derived from the assessment outputs from the HAWG in 2006 (ICES HAWG, 2006, Table 1.8.3.1).

Calculation of the surplus production

$$Ps = Br + Bg - M$$

where Br is the biomass of the recruits, Bg the gain of biomass due to growth of all fish excluding the recruits and M the natural mortality. The net production equals the surplus production minus the fishing mortality (F).

The Celtic Sea herring stock had a low productivity throughout the whole time series, compared to other stocks (ICES, 2007). The net and surplus production is very noisy displaying neither clear trend. The impact of a varying F was tested using the Hockey Stick stock recruitment relationship. The stock showed variable production over time (Figure 17). It can be seen that $F_{0.1}$ is associated with high though variable surplus production over the series, whilst F's greater than 0.4 are associated with reduced productivity in the most recent years. This analysis demonstrates the benefits of harvesting at F around $F_{0.1}$. Exploitation in the range of recent F (~0.7-1.2) is detrimental to stock productivity.

D. Short-Term Projection

Short term forecasts were routinely performed until 2004. There was no final assessment from 2005-2008 and therefore no short term forecast was conducted. A forecast was again carried out in 2009. The method used was the "Multi fleet Deterministic Projection" software (Smith, 2000). A short-term projection is carried out under the following assumptions. Recruitment was set at geometric mean, either for the entire time series, minus the most recent two years or as in 2008, from 1995-2006. This value was around 360 million fish, and was considered a good proxy for recruitment strength in recent years. This is because the recent recruitments have fluctuated about this value. Mean weights in the catch and in the stock were calculated as means over the last three years. Selection is taken from the most recent assessment. Population number of 2 ringers in the intermediate season was calculated by the degradation of geometric mean recruitment (1995-2006) using the equation below, following the same procedure as in previous years.

$$N_{t+1} = N_t * e^{-F_t+M_t}$$

E. Medium-Term Projections

Yield per recruit analyses have been conducted for this stock since the mid 1960s, though not necessarily every year. Recent analyses have used the "Multi Fleet Yield Per Recruit" software. A comparison of the results is shown in the table below. Based on the most recent yield per recruit $F_{0.1}$ is estimated to be 0.17 (Figure 19).

Table 7 presents estimates of $F_{0.1}$ from the literature and from yield per recruit analyses conducted over time. $F_{0.1}$ estimates from the YPR analysis have been in the range 0.16-0.19. F_{max} has been undefined in recent studies but earlier work suggested values of around 0.45, based on the good recruitment regime of the 1960s.

F. Long-Term Projections

In 2007, a number of possible management scenarios were tested using the stochastic simulation tool FPRESS (Codling and Kelly, 2005). This tool is used to test the robustness of harvest control rules.

G. Biological Reference Points

B_{pa} is set at 44 000 t and B_{lim} at 26 000 t. F reference points are not defined for this stock.

B_{pa} is based on a low probability of low recruitment and B_{lim} set at $B_{loss.}$ (ICES, 2001).

Reference points are defined for this stock, B_{pa} is currently at 44 000t (low probability of low recruitment) and B_{lim} at 26 000 t (B_{loss}) for this stock. F_{pa} and F_{lim} are not defined. F_{msy} has not been estimated. However $F_{0.1}$ can be assumed to be a proxy for F_{msy} and was estimated in 2009 to be = 0.17.

The reference points for this stock have not been revised in recent years. There is some evidence that B_{lim} should be revised upwards, to the point of recruitment impairment estimated by Clarke and Egan (2008). These authors showed a changepoint in a segmented regression at 47 000 t.

H.1. Biology of the species in the distribution area

Herring shoals migrate to inshore water to spawn. Their spawning grounds are located in shallow waters close to the coast and are well known and well defined. This stock can be divided into autumn and winter spawning components. Spawning begins in October and can continue until February. A number of spawning grounds are located along the South coast, extending from the Saltee Islands to the Old Head of Kinsale. These grounds include Baginbun Bay, Dunmore East Co Waterford, around Capel and Ballycotton Islands and around the entrance to Cork Harbour (Molloy, 2006). The areas surrounding the Daunt Rock and old Head of Kinsale have also been recognised as spawning grounds (Breslin, 1998). These spawning grounds are shown in Figure 2 and.5.

Herring are benthic spawners and deposit their eggs on the sea bed usually on gravel or course sediments. The yolk sac larvae hatch and adopt a pelagic mode of life.

When referring to spawning locations the following terminology is used (Molloy, 2006)

- A spawning bed is the area over which the eggs are deposited
- A spawning ground consists of one or more spawning beds located in a small area.

- A spawning area is comprised of a number of spawning grounds in a larger area

Spawning grounds are typically located in high energy environments such as the mouth of large rivers and areas where the tidal currents are strong. Herring shoals return to the same spawning grounds each year (Molloy, 2006).

Herring produce benthic eggs that are adhered to the bottom substrate where they remain until hatching. Fertilized eggs hatch into larvae in 7-10 days depending on the water temperature[1]. The size of the egg determines the size of the larvae. Larger eggs have a greater chance of survival but this must be balanced against environmental conditions and the inverse relationship between fecundity and egg size (Blaxter and Hunter, 1982).

A study on fecundity of Celtic Sea herring, conducted in the 1920s found that the eggs produced by spring spawners were 25% bigger than those autumn spawners but were less numerous (Farran, 1938). Later studies of Celtic Sea herring fecundity by Molloy (1979), found that there were two spawning populations with the autumn one being most important.

The relationship between fecundity and length has been calculated for both spawning components of Celtic Sea herring. The regression equations are as shown in Hay *et al* 2001, are as follows:

Autumn spawning component: Fecundity = 5.1173 L – 56.69 (n=53)

Winter spawning component: Fecundity = 3.485 L – 35.90 (n=37)

The larval phase is an important period in the herring life cycle. Larvae use their oil globule for food and to provide buoyancy. Currents transport the newly hatched larvae to areas in the Celtic Sea or to the Irish Sea (Molloy, 2006). The conditions experienced during the larval phase as well as during juvenile phase are likely to have some influence on the maturation of Celtic Sea herring. Fast growing juveniles can recruit to the population a year earlier than slow growing juveniles. Faster growth may also lead to increased fecundity (Brophy and Danilowich, 2003). Fluctuating environmental conditions play an important role in the growth and survival of herring in this area.

The juveniles tend to remain close inshore, in shallow waters for the first two years of their lives, in nursery areas. There are many of these nursery areas around the coast. The minimum landing size for herring is 20cm and therefore these juvenile herring are not caught by the fishery in the early stages of their life cycle (Molloy, 2006).

Celtic Sea herring have undergone changes in growth patterns and a declining trend in mean weights and lengths can be seen over time. It is important to detect these changes from a management perspective because changes can have an impact on the estimation of stock size. Growth has an impact on factors such as maturity and recruitment (Molloy, 2006). Trends in mean weights and lengths are currently being examined over the time series and possible links to environmental factors investigated (Lynch *in prep*).

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[1] http://www.gma.org/herring/biology/life_cycle/default.asp

The locations of spawning and non spawning fish in the Celtic Sea as shown in Figure 5. This is based on the knowledge of fishermen and shows spawning herring are found close inshore and non spawning fish found in areas further off shore.

H.2. Management and ICES Advice

The assessment year is from 1st April to 31st March. However for management purposes, the TAC year is from 1st January to 31st December.

The first time that management measures were applied to this fishery was during the late 1960s. This was in response to the increasing catches particularly off Dunmore East. The industry became concerned and certain restrictions were put in place in order to prevent a glut of herring in the market and a reduction in prices. Boat quotas were introduced restricting the nightly catches and the number of boats fishing. Fishing times were specified with no weekend fishing and herring could not be landed for the production of fishmeal. A minimum landing size was also introduced (Molloy, 1995).

The TAC (total allowable catch) system was introduced in 1972, which meant that yearly quotas were allocated. This continued until 1977 until the fishery was closed. During the closure a precautionary TAC was set for Division VIIj. This division was not assessed analytically (ICES, 1994). After the closure of this fishery a new management structure was implemented with catches controlled on a seasonal basis and individual boat quotas were put in place (Molloy 1995).

This fishery is still managed by a TAC system with quotas allocated to boats on a weekly basis. Participation in the fishery is restricted to licensed vessels. A series of closed areas have been implemented to protect the spawning grounds, when herring are particularly vulnerable. These spawning box closures were implemented under EU legislation.

The committee set up to manage the stock has the following objectives.

- To build the stock to a level whereby it can sustain annual catches of around 20,000 t.
- In the event of the stock falling below the level at which these catches can be sustained the Committee will take appropriate rebuilding measures.
- To introduce measures to prevent landings of small and juvenile herring, including closed areas and/or appropriate time closures.
- To ensure that all landings of herring should contain at least 50% of individual fish above 23 cm.
- To maintain, and if necessary expand the spawning box closures in time and area.
- To ensure that adequate scientific resources are available to assess the state of the stock.
- To participate in the collection of data and to play an active part in the stock assessment procedure.

The Irish Celtic Sea Herring Management Advisory Committee has developed a rebuilding plan for this stock. This Committee proposes that this plan be put forward for Council Regulation for 2009 and subsequent years. The plan incorporates scientific advice with the main elements of the EU policy statement on fishing opportunities for 2009, local stakeholder initiatives and Irish legislation.

Proposed Rebuilding plan

1) For 2009, the TAC shall be reduced by 25% relative to the current year (2008).
2) In 2010 and subsequent years, the TAC shall be set equal to a fishing mortality of $F_{0.1}$.
3) If, in the opinion of ICES and STECF, the catch should be reduced to the lowest possible level, the TAC for the following year will be reduced by 25%.
4) Division VIIaS will be closed to herring fishing for 2009, 2010 and 2011.
5) A small-scale sentinel fishery will be permitted in the closed area, Division VIIaS. This fishery shall be confined to vessels, of no more than 65 feet length. A maximum catch limitation of 8% of the Irish quota shall be exclusively allocated to this sentinel fishery.
6) Every three years from the date of entry into force of this Regulation, the Commission shall request ICES and STECF to evaluate the progress of this rebuilding plan.
7) When the SSB is deemed to have recovered to a size equal to or greater than B_{pa} in three consecutive years, the rebuilding plan will be superseded by a long-term management plan.

Table 8 shows the history of the ICES advice, implemented TACs and ICES' estimates of removals from the stock. It can be seen that the implemented TAC has been set higher than the advice in about 50% of years since the re-opening of the fishery in 1983. The tendency for the TAC to be set higher than the advice has also increased in recent years. It can also be seen that ICES catch estimates have been lower than the agreed TAC in most years.

H.4. Terminology

The WG uses "rings" rather than "age" or "winter rings" throughout the report to denominate the age of herring, with the intention to avoid confusion. It should be observed that, for autumn spawning stocks, there is a difference of one year between "age" and "rings". HAWG in 1992 (ICES 1992/Assess:11) stated that

"The convention of defining herring age rings instead of years was introduced in various ICES working groups around 1970. The main argument to do so was the uncertainty about the racial identity of the herring in some areas. A herring with one winter ring is classified as 2-years-old if it is an autumn spawner, and one-year-old if it is a spring spawner. Recording the age of the herring in rings instead of in years allowed scientists to postpone the decision on year of birth until a later date when they might have obtained more information on the racial identity of the herring.

The use of winter rings in ICES working groups has introduced a certain amount of confusion and errors. In specifying the age of the herring, people always have to state explicitly whether they are talking about rings or years, and whether the herring are autumn- or spring spawners. These details tend to get lost in working group reports, which can make these reports confusion for outsiders, and even for herring experts themselves. As the age of all other fish species (and of herring in other parts of the world) is expressed in years, one could question the justification of treating West-European herring in a special way. Especially with the present trend towards multispecies assessment and integration of ICES working groups, there might be a case for a uniform system of age definition throughout all ICES working groups.

However, the change from rings to years would create a number of practical problems. Data files in national laboratories and at ICES would have to be adapted, which would involve extra costs and manpower. People that had not been aware of the change might be confused when comparing new data with data from old working group reports. Finally, in some areas (notably Division IIIa), the distinction between spring- and autumn spawners is still hard to make, and scientists preferred to continue using rings instead of years.

The Working Group discussed at length the various consequences of a change from rings to years. The majority of the Group felt that the advantages of such a change did not outweigh the disadvantages, and it was decided to stick to the present system for the time being."

The text table below gives an example for the correlation between age, rings and year class for the different spawning types in late 2002:

YEAR CLASS (AUTUMN SPAWNERS)	2001/2002	2000/2001	1999/2000	1998/1999
Rings	0	1	2	3
Age (autumn spawners)	1	2	3	4
Year class (spring spawners)	2002	2001	2000	1999
Rings	0	1	2	3
Age (spring spawners)	0	1	2	3

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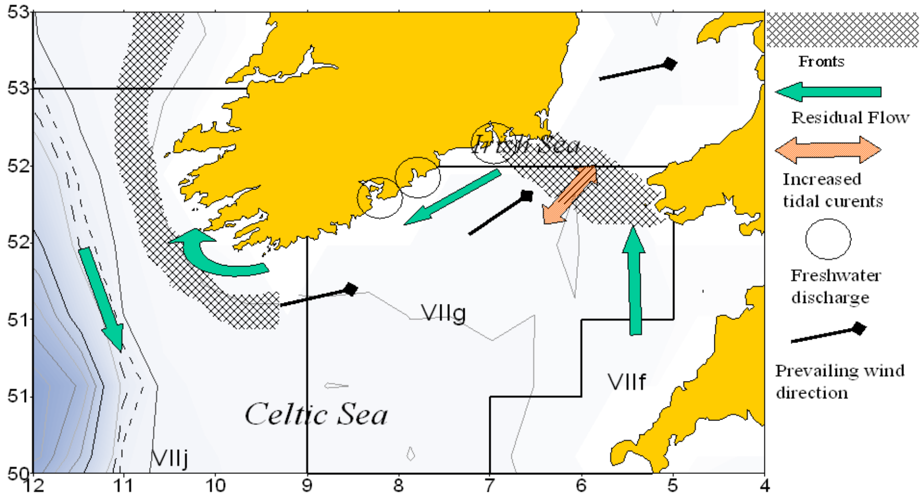


Figure 1. Herring in the Celtic Sea and VIIj. Schematic presentation of the life cycle of Celtic Sea and VIIj Herring (ICES, 2005c, SGRESP).

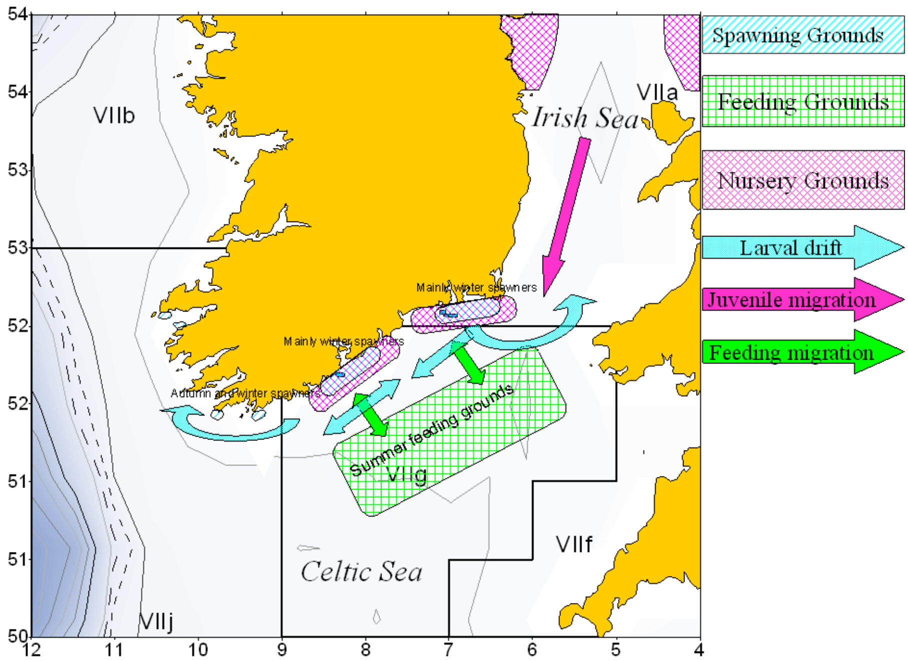


Figure 2. Herring in the Celtic Sea and VIIj. Schematic presentation of prevailing oceanographic conditions in the Celtic Sea and VIIj (ICES, 2005c, SGRESP).

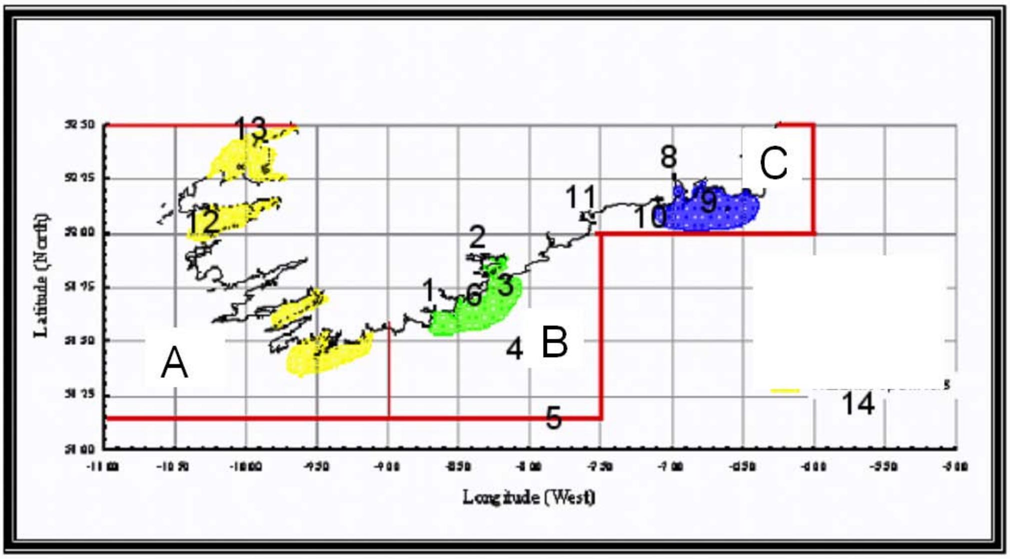


Figure 3. Herring in the Celtic Sea and VIIj. Areas mentioned in the text and spawning boxes A, B and C, south of Ireland. One of these boxes is closed each season, under EU legislation. 1 Courtmacsherry, 2 Cork Harbour, 3 Daunt Rock, 4 Kinsale Gas Field (Rigs), 5 Labadie Bank, 6 Kinsale, 8 Waterford Harbour, 9, Baginbun Bay, 10, Tramore Bay/ Dunmore East, 11, Ballycotton Bay, 12, Valentia Island, 13 Kerry Head to Loop Head, 14, The Smalls. The spawning boxes A-C correspond to ICES Divisions VIIj, VIIg and VIIaS respectively.

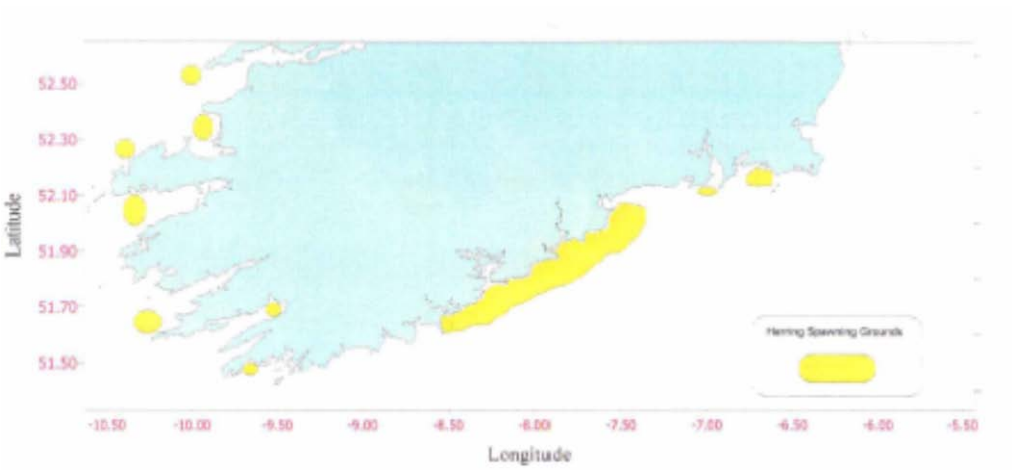


Figure 4. Herring in the Celtic Sea and VIIj. Spawning ground of herring along the south coast of Ireland, inferred from information on the Irish herring fishery (Breslin, 1998).

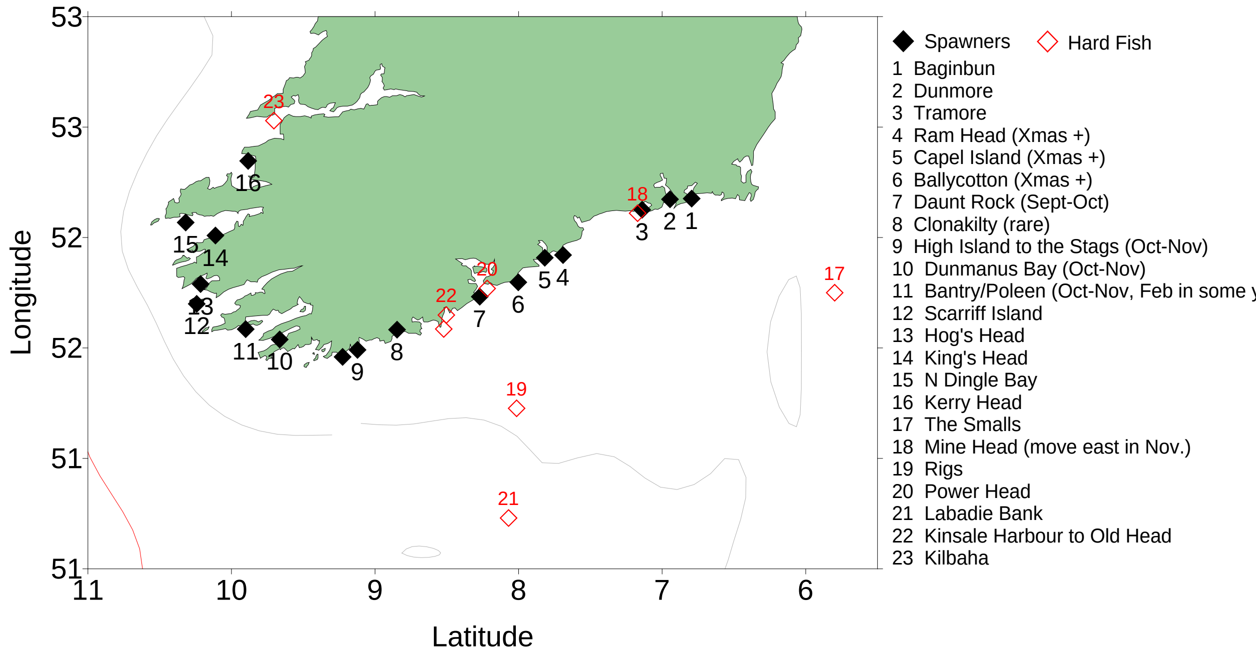


Figure 5. Herring in the Celtic Sea and VIIj. Location of spawning (closed symbol) and non spawning (open symbol) herring in the Celtic Sea and SW of Ireland, based on expert fishemens' knowledge.

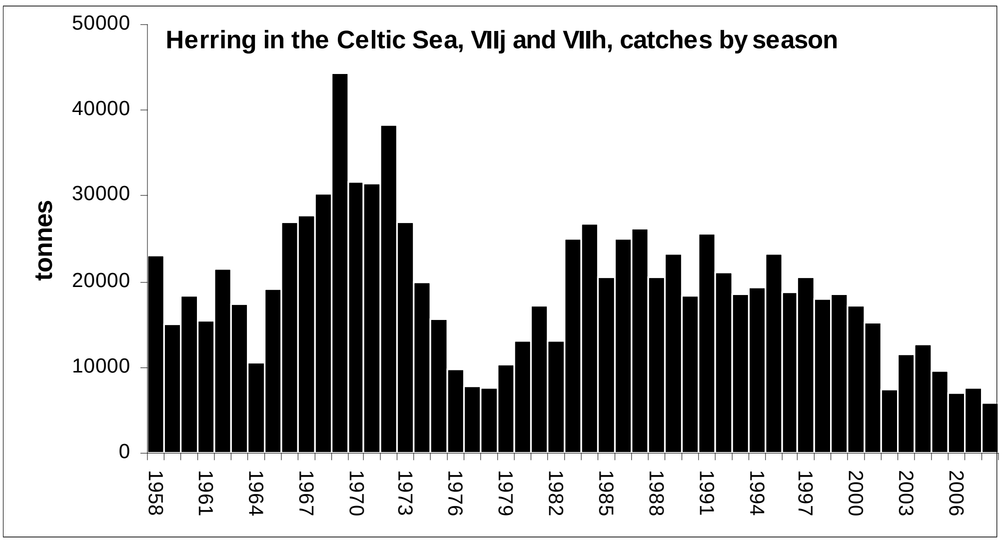


Figure .6. Herring in the Celtic Sea and VIIj. ICES estimates of herring catches (tonnes) per season 1958/1959 to 2008/2009.

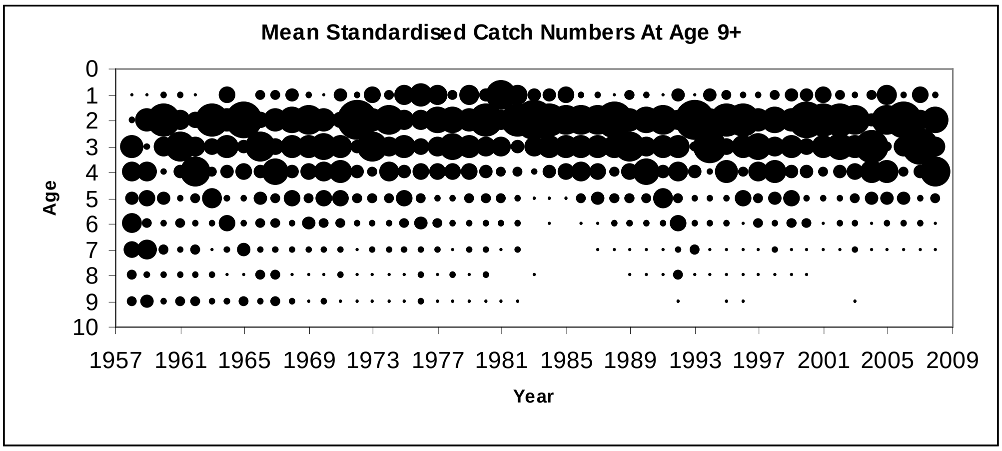


Figure 7. Herring in the Celtic Sea and VIIj. Catch numbers at age standardised by yearly mean.

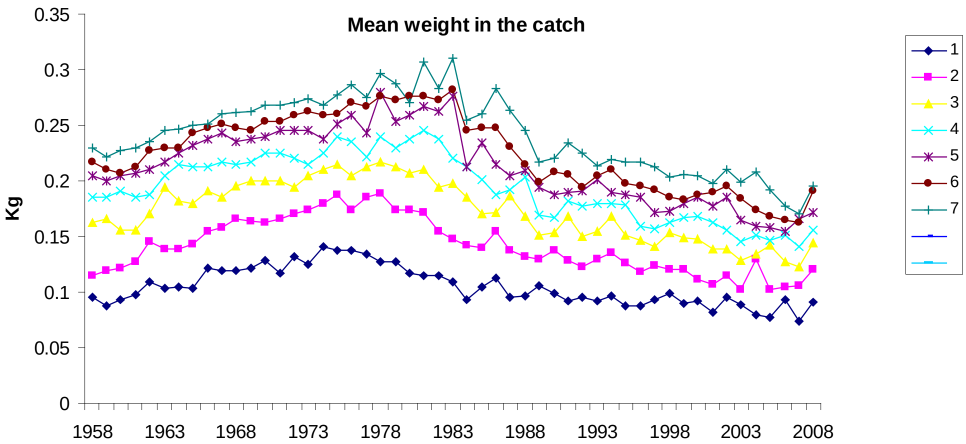


Figure 8. Herring in the Celtic Sea and VIIj. Trends over time in mean weights in the catch.

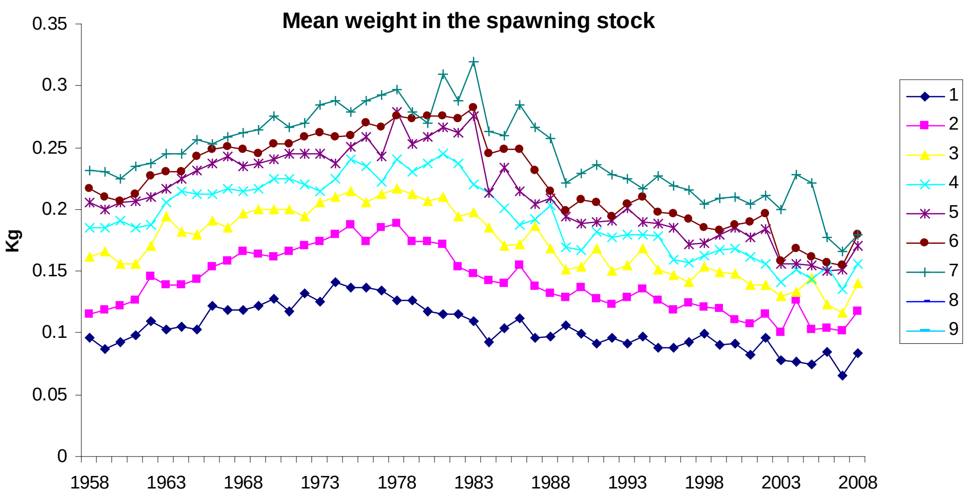
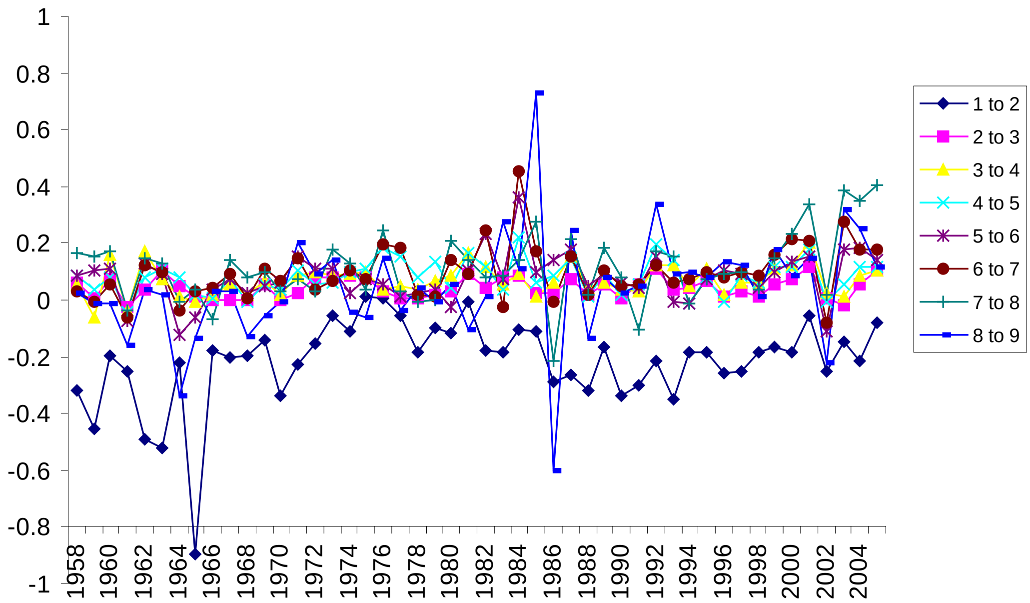


Figure 9. Herring in the Celtic Sea and VIIj. Trends over time in mean weights in the stock at spawning time.



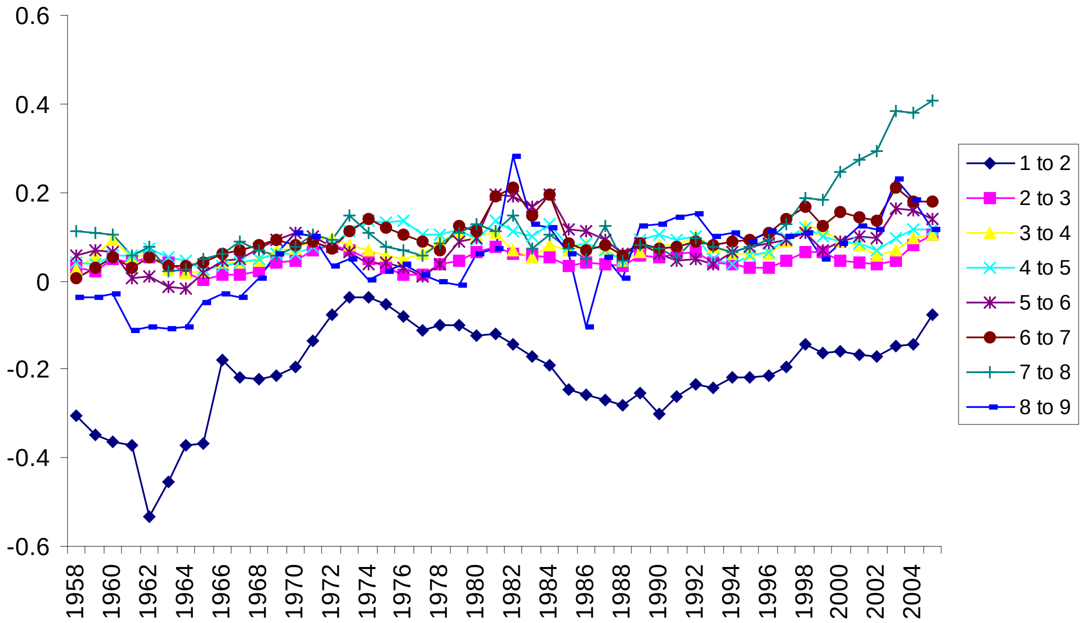


Figure 10. Herring in the Celtic Sea and VIIj. Log catch ratios (above) and log catch ratios smoothed with a 4 year moving average for each age group for the time series 1958-2006. Evidence of a change in selection pattern visible in upper panel in 2003.

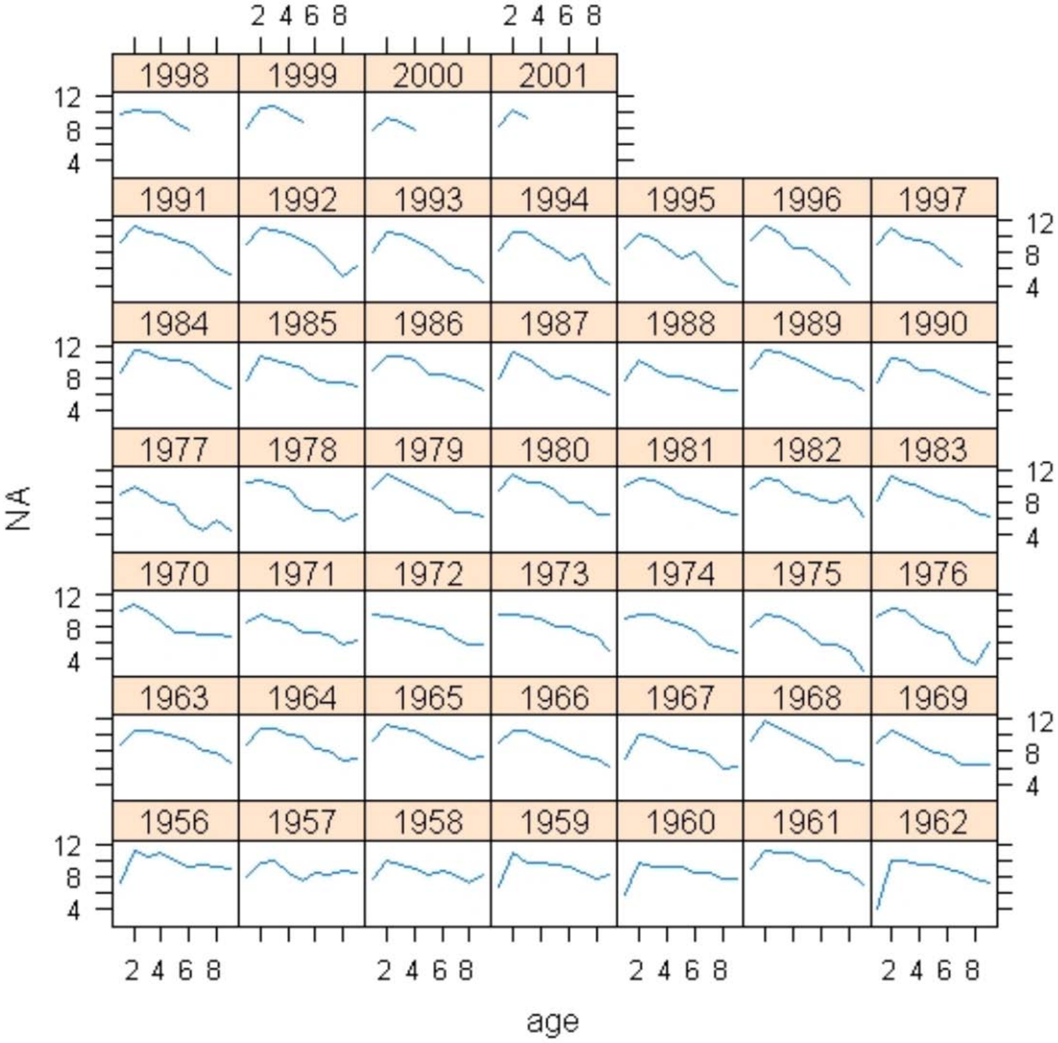


Figure 11. Herring in the Celtic Sea and VIIj. Cohort catch curves for the time series of catch at age data. Age in winter rings on the horizontal axis and log transformed catch numbers at age on the vertical axis.

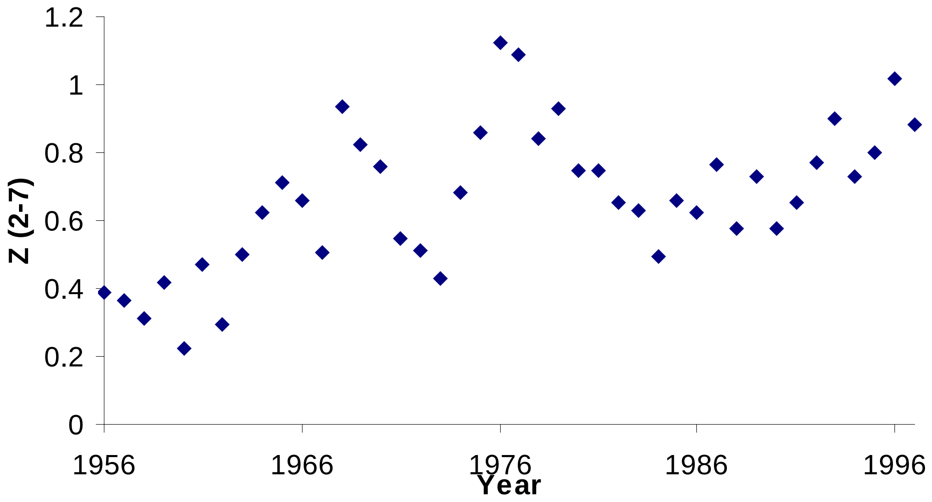


Figure 12: Herring in the Celtic Sea and VIIj. Total mortality (Z) estimated from cohort catch curves (2-7 ringer) for cohorts 1958 to 1997.

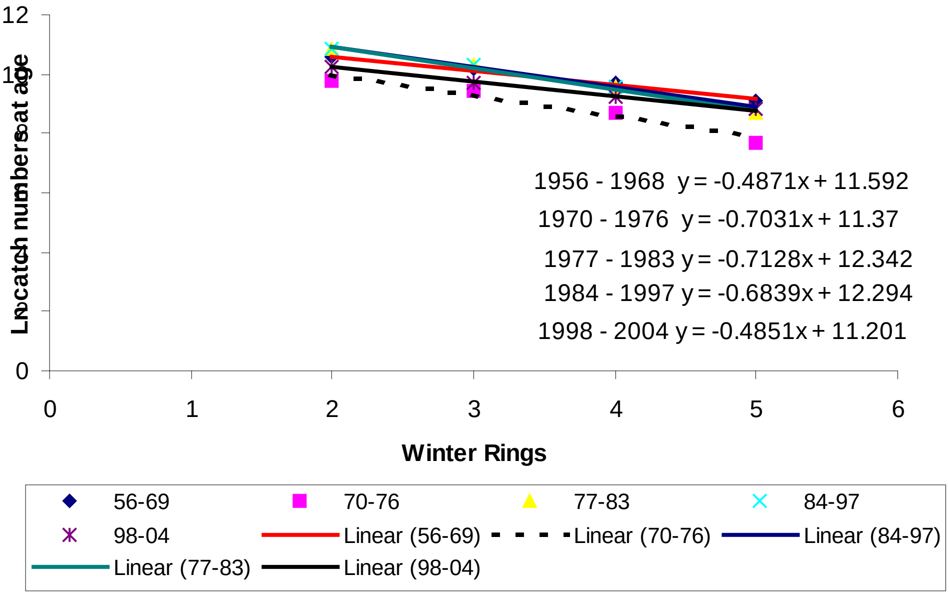


Figure 13. Herring in the Celtic Sea and VIIj. Cohort catch curves (2-5 ringer), averaged over several year classes, from catch at age data.

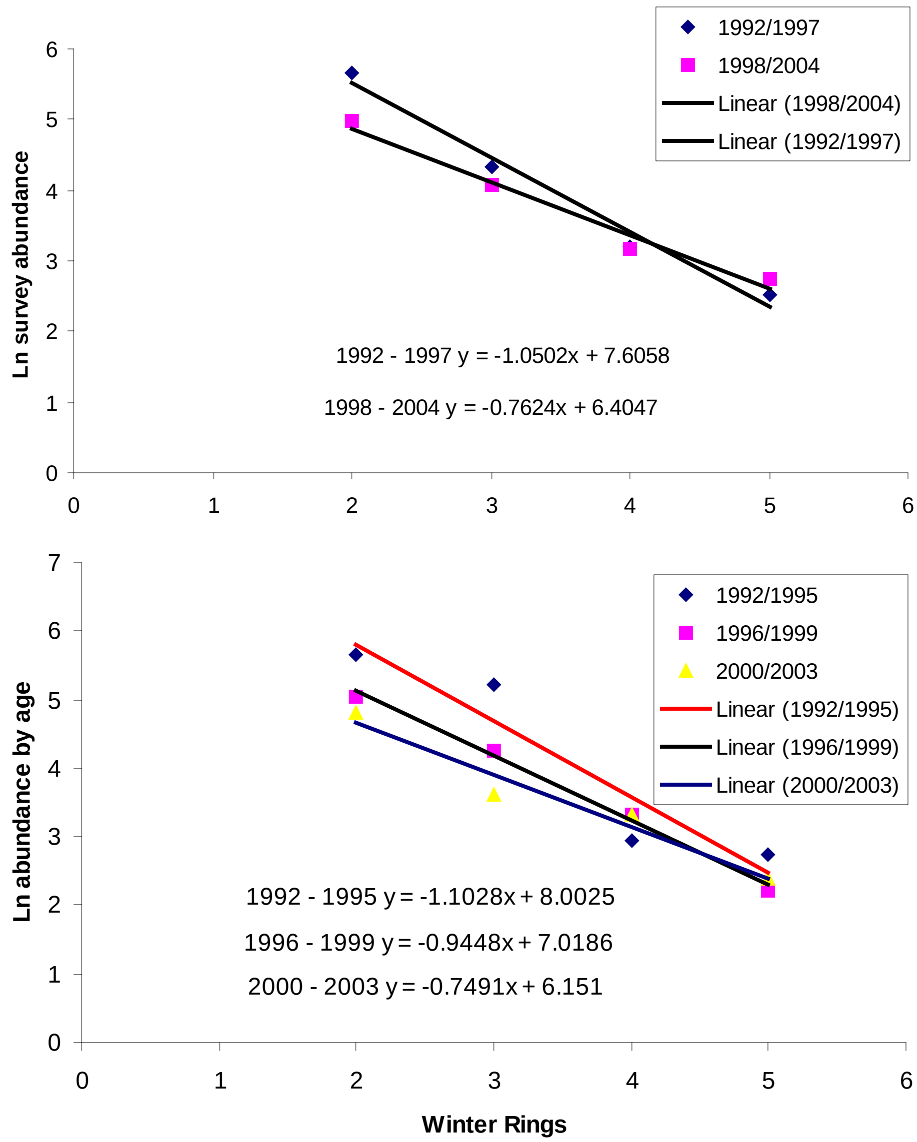


Figure 14. Herring in the Celtic Sea and VIIj. Cohort catch curves (2-5 ring) based on acoustic survey abundance. Upper panel shows means for two periods, and below for three time periods, over the same series of surveys

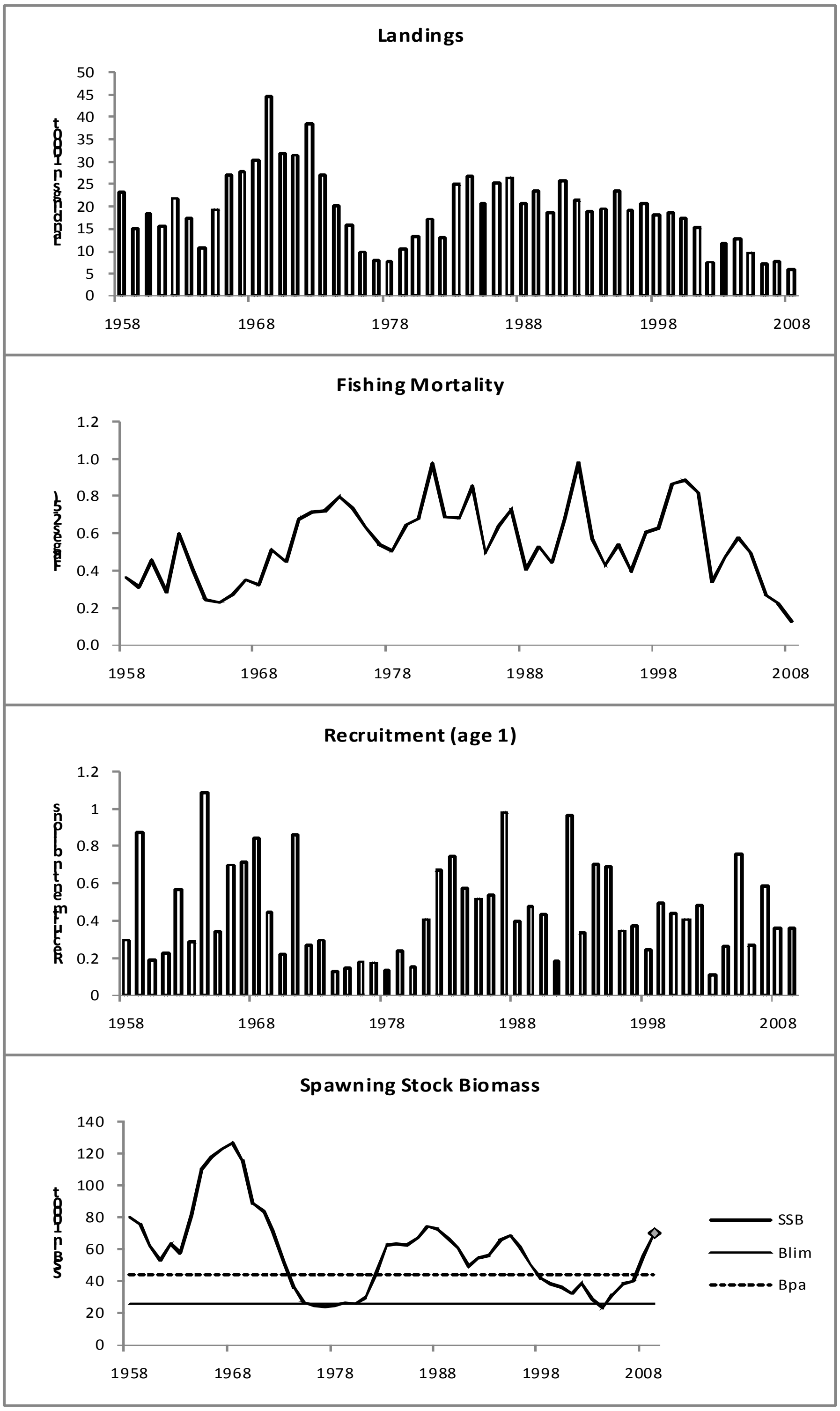


Figure 15. Herring in the Celtic Sea and VIIj. SSB, F and recruitment (1-ringer) from proposed final run. Note SSB in the terminal year is adjusted according to the protocol for this stock.

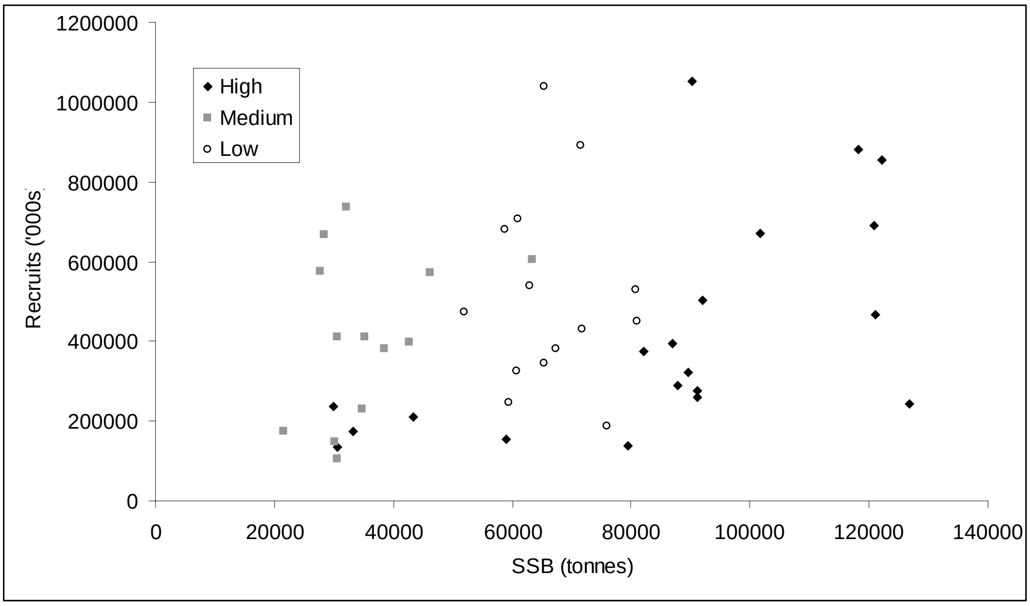


Figure 16. Herring in the Celtic Sea and VIIj. Stock recruit relationship from ICA base case runs. Data classified according to quality of input data, see Table 4.

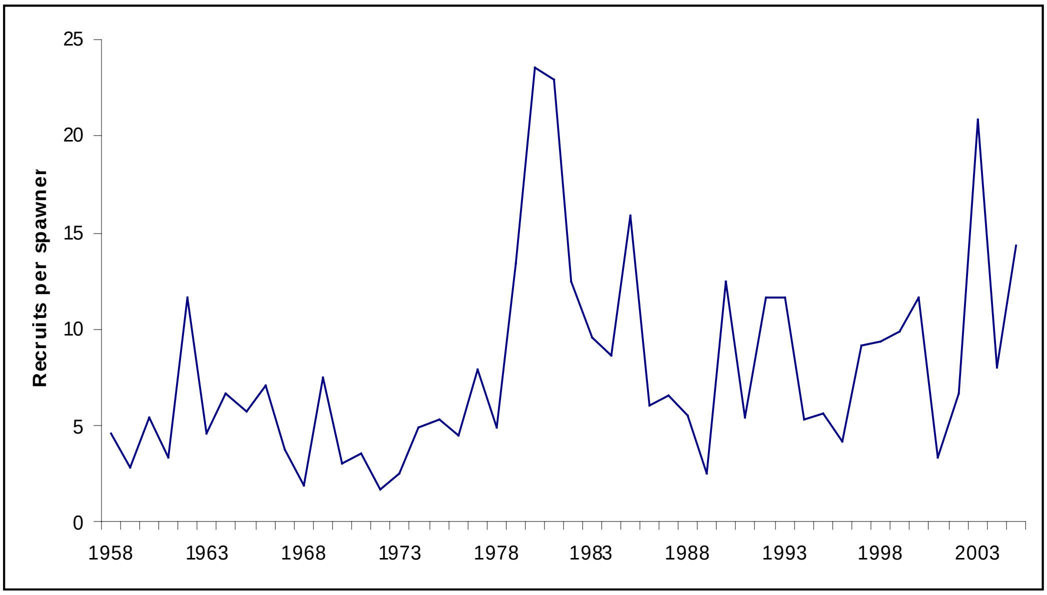


Figure 17. Herring in the Celtic Sea and VIIj. Recruits per spawner, in '000s/tonnes

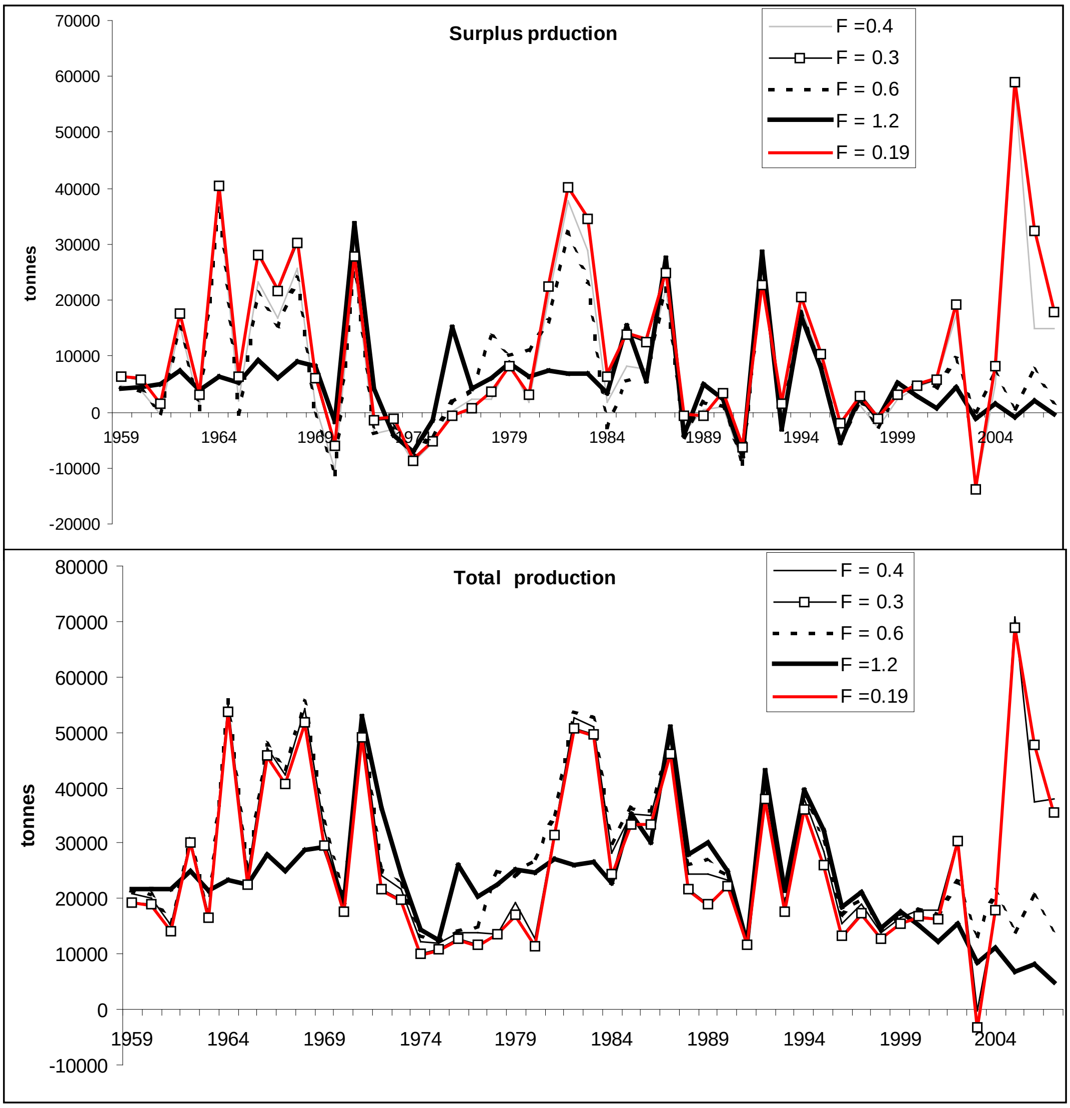


Figure 18. Herring in the Celtic Sea and VIIj. Total and surplus production in the time series over a range of fishing mortalities.

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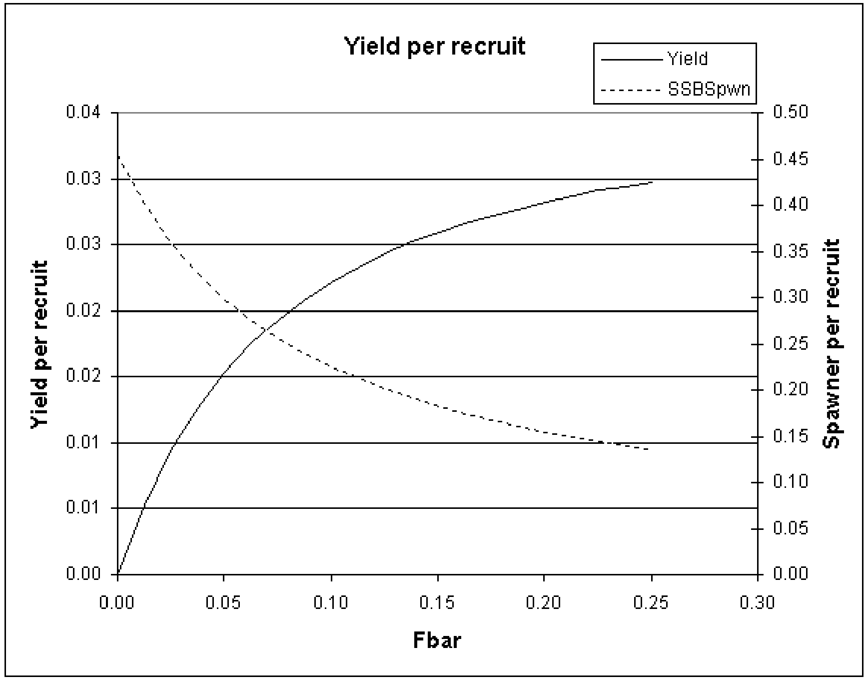

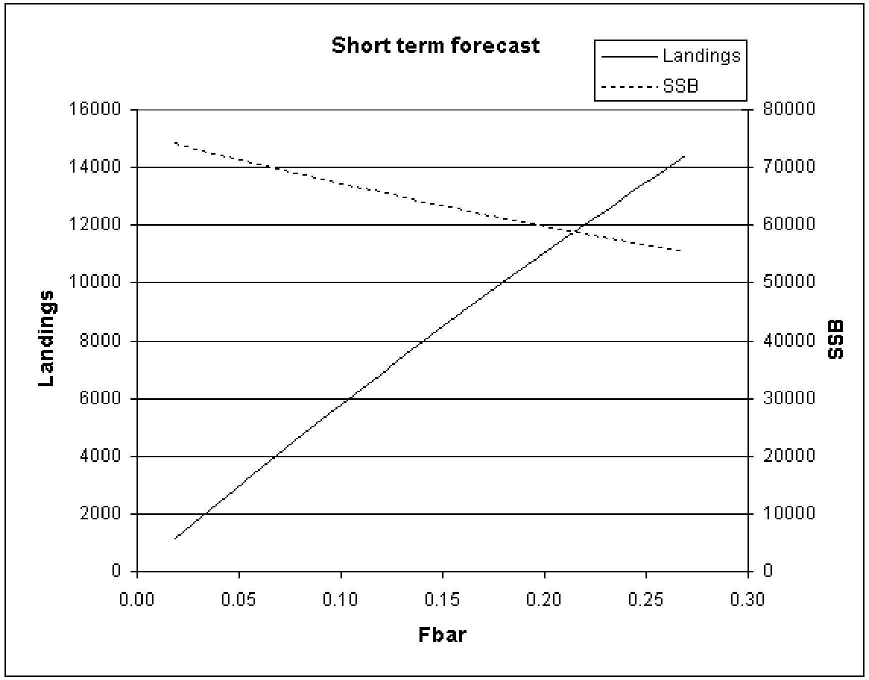

Figure 19. Herring in the Celtic Sea and VIIj. Yield per recruit carried out in 2009

Reference point	F multiplier	Absolute F
Fbar(2-5)	**1**	**0.1253**
FMax	**>=1000000**	
F0.1	**1.3466**	**0.1688**
F35%SPR	**1.5231**	**0.1909**

Table 1. Herring in the Celtic Sea & Division VIIj. Acoustic surveys of Celtic Sea and VIIj herring, by season. Number of surveys per season and type indicated along with biomass and SSB estimates. Shaded sections show surveys not used in tuning, in most recent assessment.

Season	No.	Type	Survey Timing	SSB
1990/1991	2	Autumn and winter spawners	Oct and Jan/Feb	-
1991/1992	2	Autumn and winter spawners	Nov/Dec and Jan	-
1992/1993	2	Autumn and winter spawners	Nov and Jan	-
1993/1994	2	Autumn and winter spawners	Nov and Jan	-
1994/1995	2	Autumn and winter spawners	Nov and Jan	-
1995/1996	2	Autumn and winter spawners	Nov and Jan	36
1996/1997	1	Autumn and winter spawners	Oct/Nov and Jan	151
1997/1998	-	No survey		-
1998/1999	1	Autumn spawners	Nov and Jan	100
1999/2000	1	Feeding phase	July	-
1999/2000	1	Winter-spawners	Nov and Jan	-
2000/2001	2	Autumn and winter spawners	Oct and Jan	20
2001/2002	2	Pre-spawning	Sept and Oct	95
2002/2003	1	Pre-spawning	Sept/Oct	41
2003/2004	1	Pre-spawning	Oct/Nov	20
2004/2005	1	Pre-spawning	Nov/Dec	-
2005/2006	1	Pre-spawning	Oct	33
2006/2007	1	Pre-spawning	Oct	36
2007/2008	1	Pre-spawning	Oct	46
2008/2009	1	Pre-spawning	Oct	90

Table 2. Herring in the Celtic Sea & Division VIIj. Original acoustic survey abundance at age as used by ICES until HAWG 2006.

	1990	1991	1992	1993	1994	1995	1996*	1997	1998*	1999**	1999	2000	2001	2002	2003	2004	2005	2006
	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2000	2001	2002	2003	2004	2005	2005	2007
0	205	214	142	259	41	5	3	-	-	13	-	23	19	0	25	26	13	-
1	132	63	427	217	38	280	134	-	21	398	23	18	30	41	73	13	54	21
2	249	195	117	438	127	551	757	-	157	208	97	143	160	176	323	29	125	211
3	109	95	88	59	160	138	250	-	150	48	85	36	176	142	253	32	26	48
4	153	54	50	63	11	94	51	-	201	8	16	19	40	27	61	16	50	14
5	32	85	22	26	11	8	42	-	109	1	21	7	44	6	16	3	20	11
6	15	22	24	16	7	9	1	-	32	1	8	3	23	8	5	1	5	1
7	6	5	10	25	2	8	14	-	30	0	2	2	17	3	2	0	1	-
8	3	6	2	2	3	9	1	-	4	0	1	0	11	0	0	0	-	-
9+	2	-	1	2	1	5	2	-	1	0	0	1	23	0	0	0	-	-
Total	904	739	882	1107	399	1107	1253		705	677	252	250	542	404	758	119	292	305
Biomass (000't)	103	84	89	104	52	135	151		111	58	30	33	80	49	89	13	33	37
SSB (000't)	91	77	71	90	51	114	146		111	23	26	32	74	39	86	10	30	36

* Autumn survey

** Summer survey

Table 3. Herring in the Celtic Sea & Division VIIj. Revised acoustic series as used by HAWG since 2006. Shaded colums show surveys excluded from tuning in 2009, where timing and design of earlier surveys were not considered comparable with the sufficiently long series of subsequent surveys.

1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
202	3	-	0	-	25	40	0	24	-	2	-	1	99
25	164	-	30	-	102	28	42	13	-	65	21	106	64
157	795	-	186	-	112	187	185	62	-	137	211	70	295
38	262	-	133	-	13	213	151	60	-	28	48	220	111
34	53	-	165	-	2	42	30	17	-	54	14	31	162
5	43	-	87	-	1	47	7	5	-	22	11	9	27
3	1	-	25	-	0	33	7	1	-	5	1	13	6
1	15	-	24	-	0	24	3	0	-	1	-	4	5
2	0	-	4	-	0	15	0	0	-	0	-	1	
2	2	-	2	-	0	52	0	0	-	0	-	0	
													-
469	1338	-	656		256	681	423	183	-	312	305	454	769
36	151		100		20	95	41	20	-	33	36	46	90
53	26		36		100		49	34	-	48	35	25	20
AR	AR		AR		AR	AR	AR	AR		R	R	R	R

Table 4. Herring in the Celtic Sea & Division VIIj. Rudimentary history of the Irish fishery since 1958.

Time period	1958-1977	1977-1983	1983-1997	1998-2004	2004-2007
Type of fishery	Cured fish	Closure	Herring roe	Fillet/whole fish	Fillet/whole fish
Quality of catch data	High	Medium	Low	Medium/low	High
Source of catch data	Auction data	Auction data	Skipper logbook estimate	Skipper logbook estimate	Weighbridge landings
Discard Levels	Low	Low	High	Medium	Medium
Incentive to discard	None	None	Maturity stage	Size grade, market vs. quota	
Alloowance for water*	na	na	na	20%*	2%*

*** RSW only. These vessels are more dominant in recent years.**

Table 5. Celtic Sea and VIIj herring. Biological history of the stock.

	1958-1972	1973-1977	1978-1980	1981-1983	1984-1995	1996-2008
MW 2-ring (kg) median	0.146	0.181	0.179	0.158	0.135	0.115
ML 2-ring (cm) median	26.4	27.5	27.1	26.3	25.2	24.4
Z (cohort catch curve)	0.22 - 0.93	0.42 - 1.12	0.74 - 0.93	0.62 - 0.74	0.49 - 0.89	0.48 - 1.01
GM recruitment 10^6	448	167	168	587	514	340
Recruitment anomaly	positive	negative	negative	positive	positive	both
SSB (000 t)	53 - 126	27 to 52	25 - 26	30 - 63	49 - 68	24 - 70
F (2-5 r)	0.23 - 0.71	0.55 - 0.80	0.50 - 0.68	0.68 - 0.87	0.40 - 0.98	0.12 - 0.88

Table 6. Celtic Sea and VIIj herring. Total mortality Z estimated from cohort catch curves.

Cohort	Z (2-7 ring)	Cohort	Z (2-7 ring)
1956	0.39	1977	1.09
1957	0.37	1978	0.84
1958	0.31	1979	0.93
1959	0.42	1980	0.75
1960	0.22	1981	0.75
1961	0.47	1982	0.65
1962	0.30	1983	0.63
1963	0.50	1984	0.50
1964	0.62	1985	0.66
1965	0.71	1986	0.62
1966	0.66	1987	0.76
1967	0.51	1988	0.58
1968	0.93	1989	0.73
1969	0.82	1990	0.57
1970	0.76	1991	0.65
1971	0.55	1992	0.77
1972	0.51	1993	0.90
1973	0.43	1994	0.73
1974	0.68	1995	0.80
1975	0.86	1996	1.02
1976	1.12	1997	0.88

Table 7. Celtic Sea and VIIj herring. Estimates of estimates of $F_{0.1}$ and F_{max} from the literature and HAWG work.

	$F_{0.1}$	F_{max}	MSY	Comments	Reference
1965	-	>0.5	12 – 15 000 t	Years for calculation had lower recruitment	Burd and Bracken, 1965
1969	-	~0.45	22 000 t	Years for calculation had higher recruitment	Molloy, 1969
1974	-	>0.5	14 000 *	Fmsy calculated for periods of high and low recruitment	Corten, 1974
1983	0.16			Yield/Biomass ratio	HAWG, 1983
1990	0.16				HAWG, 1990
1994	0.16				HAWG, 1994
1995	0.16				HAWG, 1995
1996	0.16				HAWG, 1996
1997	0.1				HAWG, 1997
1999	<0.2				HAWG, 1999
2000	<0.2				HAWG, 2000
2002	0.17			MFYPR software	HAWG, 2002
2003	0.17			MFYPR software	HAWG, 2003
2004	0.17			MFYPR software	HAWG, 2004
2007	0.19			MFYPR software	HAWG, 2007
2009	0.17			MFYPR software	HAWG 2009

*endorses Molloy (1969) provided that recruitment is at level 1966 – 1969

Table 8 Celtic Sea and VIIj herring. Advice history.

ICES Advice	Predicted catch corresp. to advice	Agreed TAC	Official Landings	Discards	Estimated Catch[1]
NEAFC TAC		32	20	-	19.74
Reduce F, TAC ? 25,000		25	16	-	15.13
TAC between 10,000 and 12,000		10.8	10	-	8.2
No Fishing	0	0	8	-	3.0
No Fishing	0	0	8	-	7.1
TAC set for VIIj only, No fishing in Celtic Sea	0	6	10	-	12.1
TAC set for VIIj only, No fishing in Celtic Sea		6	9	-	9.2
TAC set for VIIj only, No fishing in Celtic Sea		6	17	-	16.8
TAC		8*	10	-	9.5
TAC		8*	22	4.0	22.18
TAC	13	13	20	3.6	19.7
TAC	13	13	16	3.1	16.23
No specific TAC, preferred overall catch 17,000t		17	13	3.9	23.3
Precautionary TAC	18	18	18	4.2	27.3
TAC	13	18	17	2.4	19.2
TAC	20	20	18	3.5	22.7
TAC	15	17.5	17	2.5	20.2
TAC (TAC excluding discards)	15 (12.5)	21	21	1.9	23.6
TAC	27	21	19	2.1	23
Precautionary TAC (including discards)	20–24	21	20	1.9	21.1
Precautionary TAC (including discards)	20–24	21	19	1.7	19.1
No specific advice	-	21	18	0.7	19
TAC	9.8	16.5–21	21	3	21.8
If required, precautionary TAC	< 25	22	20.7	0.7	18.8
Catches below 25	< 25	22	20.5	0	20.3
F = 0.4	19	21	19.4	0	18.1
F < 0.3	20	21	18.8	0	18.3
F < 0.34	17.9	20	19	0	17.7
F<0.35	11	11	11.5	0	10.5
Substantially less than recent catches	-	13	12	0	10.8
60% of average catch 1997–2000	11	13	12	-	11
60% of average catch 1997–2000	11	13	10	-	8
Further reduction 60% avg catch 2002–2004	6.7	11	9	-	8.5
No fishing without rebuilding plan	--	9.3	9.6	-	8.2
No targeted fishing without rebuilding plan	--	7.9	7.8		6.7
No targeted fishing without rebuilding plan	--	5.9			

*** TAC from 1st Oct – 31st Mar**

1) Calendar year

Annex 6 – Stock Annex Herring in VIaN

Quality Handbook	ANNEX: Hawg-her47d3

Stock specific documentation of standard assessment procedures used by ICES.

Stock:	Herring in VIa (North)
Working Group:	Herring Assessment WG for the Area south of 62°N
Date:	25 March 2008
Authors:	E.M.C. Hatfield, E.J. Simmonds and A. Edridge

A. General

A.1. Stock definition

The stock is distributed over ICES Division VIa (N). Some of the larger adults typically found close to the shelf break may be caught in division Vb.

A.2. Fishery

The dominant fleet fishing in VIa (N) since 1957 has been the Scottish fleet. In the early years the Scottish fishery was prosecuted using a mixture of vessel size and gear, including gill nets, ring-nets and trawls. The boats were small, and targeted the coastal stock, primarily fishing in the winter. Until 1970 the only other nations fishing in this area on a regular basis were the former German Federal Republic, and to a much lesser extend the Netherlands. These fleets operated in deeper water near the shelf edge.

In 1970 a large increase in exploitation occurred with the entry of fleets from Norway and the Faroes, and an increased Netherlands catch. In addition, considerably smaller catches were taken by France and Iceland.

Throughout this period juvenile herring catches from the Moray Firth, in the north-east of Scotland, were included in the VIa catch figures, as tagging programs showed there to be some links between herring spawning to the west of Scotland and the Moray Firth juveniles.

Prior to 1982 herring stocks in ICES Area VIa were assessed as one stock, along with the herring by-catch from the sprat fishery in the Moray Firth. In the 1982 herring assessment working group report, and in subsequent years, Area VIa was split into a northern and a southern area at 56°N (ICES, 1982).

In 1979 and 1981 the fishery was closed. After re-opening the nature of the fishery changed to an extent, with fewer Scottish boats targeting the coastal stock than before the closure. The Scottish domestic pair trawl fleet and the Northern Irish fleet operated in shallower, coastal areas, principally fishing in the Minches and around the Island of Barra in the south; younger herring are found in these areas. Since 1986 Irish trawlers have operated in the south of the area, from the VIa (S) line up to the south-western Hebrides. The Scottish and Norwegian purse seine fleets targeted herring mostly in the northern North Sea, but also operated in the northern part of VIa (N). An international freezer-trawler fishery operated in deeper water near the shelf edge where older fish are distributed. These vessels are mostly registered in the Netherlands, Germany, France and England. In recent years the catch of these fleets has become more similar and has been dominated by younger adults resulting from increased recruitment into the stock.

In recent years the Scottish fleet has changed to a predominantly purse-seine fleet to a trawl fleet. Norwegian vessels fish less in the area than in the past. Scottish catches still comprise around half of the total, the rest is dominated by the offshore, international fishery.

A recent EU-funded programme WESTHER has elucidated stock structures of herring throughout the western seaboard of the British Isles using a combination of morphometric measurements, otolith structure, genetics and parasite loads. The results provide information on mixing of stocks within and beyond VIa (N).

A.3. Ecosystem aspects

Herring are an important prey species in the ecosystem and also one of the dominant planktivorous fish.

Herring fisheries tend to be clean with little bycatch of other fish. Scottish discard observer programs since 1999 indicate that discarding of herring in these directed fisheries are at a low level. These discard observer programs have recorded occasional catches of seals and zero catches of cetaceans.

B. Data

B.1. Commercial catch

Commercial catch is obtained from national laboratories of nations exploiting herring in VIa (N). Since 1999 (catch data 1998), these labs have used a spreadsheet to provide all necessary landing and sampling data, which was developed originally for the Mackerel Working Group (WGMHSA) and further adapted to the special needs of the Herring Assessment Working Group. The current version used for reporting the 2002 catch data was v1.6.4. The majority of commercial catch data of multinational fleets was provided on these spreadsheets and further processed with the SALLOCL-application (Patterson, 1998a). This program gives the needed standard outputs on sampling status and biological parameters. It also clearly documents any decisions made by the species co-ordinators for filling in missing sampling data and raising the catch information of one nation/quarter/area with information from another data set.

Transparency of data handling by the Working Group. The current practice of data handling by the Working Group is that the data received by the co-ordinators is available in a folder called "archive". These high-resolution data are not reproduced in the report. The archived data contains the disaggregated dataset (disfad), the allocations of samples to unsampled catches (alloc), the aggregated dataset (sam.out) and (in some cases) a document describing any problems with the data in that year.

Current methods of compiling fisheries assessment data. The species co-ordinator is responsible for compiling the national data to produce the input data for the assessments. In addition to checking the major task involved is to allocate samples of catch numbers, mean length and mean weight-at-age to unsampled catches. There are at present no defined criteria on how this should be done, but the following general process is implemented by the species co-ordinators. Searches are made for appropriate samples by gear (fleet) area quarter, if an exact match is not available the search will move to a neighbouring area if the fishery extends to this area in the same quarter. More than one sample may be allocated to an unsampled catch, in this case a straight mean or weighted mean of the observations may be used. If there are no samples available the search will move to the closest non-adjacent area by gear (fleet) and quarter, but not in all cases.

Until 2003 the VIa(N) catch data extended back to the early 1970s; since 1986 the series has run from 1976 to present. In 2004 the data set was extended back to 1957. Details are given below.

Historic Catches from 1957 to 1975

The working group has obtained preliminary estimates of catch and catch-at-age for the period 1957 to 1975. These have been estimated from records of catch presented in HAWG reports from 1973, 1974, 1981 and 1982. Intervening reports were also consulted to check for changes or updates during the period. Catch-at-age data were available from 1970 to 1975 from the 1982 Working Group report, and catches-at-age for the period 1957 to 1972 were estimated from paper records of catch-at-age by national fleets for 1957 to 1972, held at FRS Marine Laboratory Aberdeen. The fishing practices of national fleets were established for the period 1970 to 1980 from catches in VIa and VIa (N) recorded in the 1981 and 1982 Working Group reports respectively. This procedure suggested that, on average, more than 90% of catch by national fleet could be fully assigned to either VIa (N) or VIa (S). The remaining catch was assigned assuming historic proportions. During this period catches were split into autumn and spring spawning components; anecdotal information on trials to verify this separation suggests it was not a robust procedure. Currently about 5% of herring in VIa (N) is found to be spent at the time of the acoustic surveys in July, and thought to be spring spawning herring. However, at present the Working Group assesses VIa (N) herring as one stock, regardless of spawning stock affiliation. In the earlier period higher proportions were allocated as spring spawners. Currently the designated 'spring spawning' component is not included in the catch at age matrix, but the catch tones express the full amount giving rise to SoP differences in the early years. Similarly, a small Moray Firth juvenile fishery was also included in VIa (N) catch in earlier years because it was thought that these juveniles were part of the VIa (N) stock. Separating this component in the historic data was difficult, and as the fishery ceased in the very early 70s this has no implications for current allocation of these fish. The Moray Firth is, geographically, part of IVa (ICES stat. rectangles 44E6, 44E7, 45E6) and is now managed as part of that area. Currently there are no juvenile herring catches from the Moray Firth. Full details of the analysis carried out is provided as an appendix (Appendix 11) to the 2004 Working Group report. Further investigations are required before determining the correct actions concerning the 'spring spawners' in early period. The consequence of this is to slightly reduce the apparent stock size in the early years, when is already at an all time high. It has no implications for fitting of any survey data, or influence on the Blim reference point, however, it might further increase the high R seen at high SSB in a S/R relationship.

Allocation of catch and misreporting

This fishery has had a strong tradition of misreporting before 2000, though this has reduced in recent years. It is believed that the shortfall between the TAC and the catch was used to misreport catches from other areas (from IVa to the east and from VIa (S) to the south). In the past, fishery-independent information confirmed that large catches were being reported from areas with low abundances of fish, and informal information from the fishery and from other sources confirmed that most catches of fish recorded between 4°W and 5°W were most probably misreported North Sea catches. The problem was detailed in the Working Group report in 2002

(ICES 2002/ACFM:12). Improved information from the fishery in 1998 - 2002 allowed for re-allocation of many catches due to area misreporting (principally from VIa (N) to IVa (W)). This information was obtained from only some of the fleets

As a result of perceived problems of area misreporting of catch from IVa into VIa (N), Scotland introduced a fishery regulation in 1997 with the aim to improve reporting accuracy. Under this regulation, Scottish vessels fishing for herring were required to hold a license either to fish in the North Sea or in the west of Scotland area (VIa (N)). Only one licensed option could be held at any one time. However in 2004, the requirement to carry only a single licence was rescinded. Area misreporting of catch taken in area IVa into area VIa (N) then increased in 2004 and continued in 2005. It is possible, therefore, that the relaxation of this single area licence contributed to a resurgence in area misreporting. In 2007, as in 2006, there was no misreporting from IVa into VIa (N). New sources of information on catch misreporting from the UK became available in 2006 (see the 2007 HAWG report). This information was associated with a stricter enforcement regime that may be responsible for the lack of that area misreporting since 2006.

The Butt of Lewis box, (a seasonal closure to pelagic fishing of the spawning ground in the north west of the continental shelf in area VIa(North) since the late 1970s was opened to fishing in 2008 following a STECF review in 2007. It has not been possible to show either beneficial or deleterious effects from this closure.

Catches are included in the assessment. Biases and sampling designs are not documented. Discards are not included, though data from some fleets suggest these are very minor. Slippage and high grading are not recorded.

B.2. Biological

Catch-at-age data (catch numbers-at-age, mean weights-at-age in the catch, mean length-at-age) are derived from the raised national figures received from the national laboratories. The data are obtained either by market sampling or by onboard observers, and processed as described in Section B.1 above. For information on recent sampling levels and nations providing samples, see Section 2.2. in the most recent HAWG report.

Proportions mature (maturity ogive) and mean weights-at-age in the stock derived from the acoustic survey (see next section) have been used since 1992 and 1993, respectively. Prior to these years, time-invariant values derived from ??? were used.

Biological sampling of the catches was extremely poor in recent history (particularly in 1999). This was particularly the case for the freezer trawler fishery that takes the larger component of the stock based around the shelf break. The lack of samples was due in part to the fact that national vessels tend to land in foreign ports, avoiding national sampling programs. The same fleet is thought to high grade. The long length of fishing trips makes observer programs difficult. Even when samples are taken, age determination is limited for most nations.

Sampling has improved over the last few years. The number of age readings per 1,000 t of catch increased from the low in 1999 of 52 to a high in 2001 of 93. Numbers have decreased again since then to 57 per 1,000 t in 2003. From 1999 to 2003 the sampling has been dominated by Scotland (ranging between 70 and 98% of the age readings), except in 2001, when only 43% of the age determination was on Scottish landings in VIa (N).

Natural mortality (M) varies with age (expressed in number of winter rings) according to the following:

Rings	M
1	1
2	0.3
3	0.2
4+	0.1

Those values have been held constant from 1957 to date. Those values correspond to estimates for North Sea herring based on recommendations by the Multi-species WG (Anon. 1987a) that were applied to adjacent areas (Anon. 1987b).

B.3. Surveys

B.3.1 Acoustic survey

An acoustic survey has been carried out for VIa (N) herring in the years 1987, 1991-2003

Biomass estimated from the acoustic survey tends to be variable. Herring are found in similar area each year, namely south of the Hebrides off Barra Head, west of the Hebrides and along the shelf edge.

The stock is highly contagious in its spatial distribution, which explains some of the high variability in the time series. Effort stratification has improved with knowledge of the distribution and this may be less of a problem in more recent years. The survey uses the same target strength as for the North Sea surveys and there is no reason to suppose why this should be any different. Species identification is generally not a great problem.

B.3.2 Larvae survey

Larvae surveys for this stock were carried out from 1973 to 1993. Larval production estimates (LPE) and a larval abundance index (LAI) were produced for the time series. These values were used in the assessment, the LPE until 2001. However, in 2002 it was decided that the LAI had no influence on the assessment and has not been used since. Documentation of this survey time-series is given in ICES CM 1990/H:40.

B.4. Commercial CPUE

Not used for pelagic stocks

B.5. Other relevant data

C. Historical Stock Development

An experimental survey-data-at-age model was formulated at the 2000 HAWG. In 1999 and 1998 a Bayesian modification to ICA was used to account for the uncertainty in misreporting.

Model used: FLICA Software R / ICA (Patterson 1998b)

Model Options chosen:

Separable constraint over last 8 years (weighting = 1.0 for each year)

Reference age = 4

Constant selection pattern model

Selectivity on oldest age = 1.0

First age for calculation of mean F = 3

Last age for calculation of mean F = 6

Weighting on 1-rings = 0.1; all other age classes = 1.0

Weighting for all years = 1.0

All indices treated as linear

No S/R relationship fitted

Lowest and highest feasible F = 0.02 and 0.5

All survey weights equal i.e., 1.0 with the exception of 1 ringers in the acoustic survey weighted to 0.1.

Correlated errors assumed i.e., = 1.0

No shrinkage applied

Input data types and characteristics:

Type	Name	Year range	Age range	Variable from year to year Yes/No
Caton	Catch in tones	1957 - last data year	NA	Yes
Canum	Catch at age in Numbers	1957 - last data year	1-9+	Yes
Weca	Weight at age in the commercial catch	1957-1972 1973-1981 1982-1984 1985-last data year	1-9+ 1-9+ 1-9+ 1-9+	No No No Yes
West	Weight at age of the spawning stock at spawning time.	1957 - 1992 1993-last data year	1-9+ 1-9+	No Yes
Mprop	Proportion of natural mortality before spawning	1957-last data year	NA	No
Fprop	Proportion of fishing mortality before spawning	1957-last data year	NA	No
Matprop	Proportion mature at age	1957 - 1991 1992-last data year	1-9+ 1-9+	No Yes
Natmor	Natural mortality	1957 - last year	1-9+	No

Tuning data:

Type	Name	Year Range	Age Range
Tuning fleet 1	VIa (N) Acoustic Survey	1987,	1–9+
		1991– last data year	1–9+

D. Short-Term Projection

Model used: Age structured Software used: MFDP ver 1a

Initial stock size: Taken from the last year of the assessment. 1- and 2-ring recruits taken from a geometric mean for the years 1976 to one year prior to the last year.

Maturity: Mean of the last three years of the maturity ogive used in the assessment.

F and M before spawning: Set to 0.67 for all years.

Weight at age in the stock: Mean of the last three years in the assessment.

Weight at age in the catch: Mean of the last three years in the assessment.

Exploitation pattern: Mean of the previous eight years, scaled by the Fbar (3-6) to the level of the last year (eight because this is the assessment model assumption of 8 years separable period).

Intermediate year assumptions: **TAC** constraint. Stock recruitment model used: None used

Procedures used for splitting projected catches: Not relevant

E. Medium-Term Projections (done intermittently)

Model used: STPR as described in Skagen (2003)

Initial stock size: Population parameters Terminal year survivors from ICA assessment with recruits replaced as in short term projections (D above). Drawn from a multivariate lognormal distribution with mean equal to the values estimated in the stock assessment model, and with covariance as estimated in the same model fit. Geometric mean recruitment for 1- and 2-ringers is used to replace the values in the assessment for the first projected year, covariance at age 2 retained and used for age 1 and 2.

Natural mortality: Mean of the last three years in the assessment.

Maturity: drawn randomly by year from 1990 to present.

F and M before spawning: Set to 0.67 for all years.

Weight at age in the stock: drawn randomly by year from 1990 to present.

Weight at age in the catch: drawn randomly by year from 1990 to present.

Exploitation pattern: from the eight year separable model

Intermediate year assumptions: TAC constraint

Stock recruitment model used: Variable Hockey-Stick or Beverton Holt fitted to recent data (1989 on) , but other options tested for robustness max year three years prior to the assessment.

G. Biological Reference Points

The report of SGPRP (ICES 2003/ACFM:15) proposed a Blim of 50,000 t for VIa (N) herring. This is calculated from the values in the converged part of the VPA (1976-1999) and the Working Group endorsed this value in 2003 (ICES 2003/ACFM:17).

Suggested Precautionary Approach reference points:

B_{LIM} is 50,000 t	B_{PA} be set at 75,000 t

Technical basis:

B_{LIM}: B_{LOSS} Estimated SSB for sustained recruitment	Bpa: 1.5 * Blim

H. Other Issues

H.1 Biology of the species in the distribution area

The Atlantic herring, *Clupea harengus*, is numerically one of the most important pelagic species in North Atlantic ecosystems with widespread distribution around the Scottish coast. Within the Northeast Atlantic they are encountered from the north of Biscay to Greenland, and east into the Barents Sea. It is thought that herring stocks comprise many reproductively isolated subpopulations through specific spawning grounds and seasons (e.g. autumn and spring spawners), but the taxonomic status of these subpopulations remains unclear.

Herring are demersal spawners and produce dense beds of benthic eggs deposited on gravelly substrates. This behaviour is considered to be an evolutionary remnant of herrings' river spawning past. Each female produces a single batch of eggs per year, releasing a ribbon of eggs that adheres to the benthos; the male sheds milt while swimming a few centimetres above the female. This particular behaviour renders herring vulnerable to anthropogenic activity such as offshore oil and gas industries and gravel extraction.

The eggs take about three weeks to hatch, dependant on the temperature. The larvae on hatching are 6-9mm long and are immediately planktonic. Their yolk sac lasts for about a week during which time they will begin to feed on phytoplankton and crustacean larvae. Their planktonic development lasts around three to four months during which time they are passively subjected to the residual drift which takes them to coastal nurseries. The habitats of juveniles are primarily pelagic, and hydrographical features such as temperature and the depth of thermocline, as well as abundance of zooplankton affect their distribution. Adult fish are pelagic and found mostly in continental shelf seas to depths up to 200m. They form large shoals with diurnal migration patterns through the water column which can be associated with the availability of prey and stage of maturity. In the winter the feeding activity and growth are very slow. Herring can reach 40cm in length and have a maximum lifespan of 10 years although most herring range between 20-30cm and are less than 7 years.

Assessing age and year class for herring can be problematic due to the extended spawning season of autumn spawners from September to January. Using the convention of January 1st as the birthday, 0-group refer to fish born between 3 and 18 months ago but 0-group autumn spawners belong to a different class from 0-group spring spawners. Time series of a stock's age structure helps its management and it is vital that they are extended for all the '*West of Scotland*' herring components in the

VIaN (North), VIaS (South) and VIb areas. The stock identity of herring west of the British Isles was reviewed by the EU-funded project WESTHER, which identified VIaN as an area where catches comprise a mixture of fish from Areas VIaN, VIaS, and VIIaN. ICES current advice is that herring components should be managed separately to afford maximum protection, but a study group will be convened in 2008 (SGHERWAY) to evaluate the WESTHER recommendations.

There are many hypotheses as to the cause of the irregular cycles shown in the productivity of herring stocks (weights-at-age and recruitment), but in most cases it is thought that the environment plays a key role (through prey, predation and transport). The VIaN herring stock has shown a marked decline in productivity during the late 1970s and has remained at a low level since then. ICES identifies that the VIaN stock is currently fluctuating at low levels and is being exploited above F_{msy} .

Historically, the stock in this area has been affected by three fisheries:

A Scottish domestic pair trawl fleet and the North Irish fleet operated in shallower, coastal areas, principally fishing in the Minches and around the Island of Barra in the South where younger herring are encountered. This fleet has reduced in the last years.

The Scottish single-boat trawl and purse-seine fleets, with refrigerated seawater tanks, targeting herring mostly in the northern North Sea, but also operating in the northern part of VIaN. This fleet now operates mostly with trawls but many vessels can deploy either gear.

An international freezer-trawler fishery has historically operated in deeper water near the shelf edge where older fish are distributed. These vessels are mainly registered in the Netherlands, Germany, France, and England but most are Dutch owned.

In recent years the age structure of the catch of these last two fleets has become more similar.

In addition to being a valuable protein resource for humans, herring represent an important prey item for many predators including cod and other large gadoids, dogfish and sharks, marine mammals and sea birds. Because the trophic importance of herring puts its stocks under immense pressure from constant exploitation, it is important that management takes into account all anthropogenic, environmental and biological variables.

H.2 Terminology

The WG uses "rings" rather than "age" or "winter rings" throughout the report to denominate the age of herring, with the intention to avoid confusion. It should be observed that, for autumn spawning stocks, there is a difference of one year between "age" and "rings". HAWG in 1992 (ICES 1992/Assess:11) stated that:

"The convention of defining herring age rings instead of years was introduced in various ICES working groups around 1970. The main argument to do so was the uncertainty about the racial identity of the herring in some areas. A herring with one winter ring is classified as 2-years-old if it is an autumn spawner, and one-year-old if it is a spring spawner. Recording the age of the herring in rings instead of in years allowed scientists to postpone the decision on year of birth until a later date when they might have obtained more information on the racial identity of the herring.

The use of winter rings in ICES working groups has introduced a certain amount of confusion *and errors. In specifying the age of the herring, people always have to state explicitly whether they are talking about rings or years, and whether the herring are autumn- or spring spawners. These details tend to get lost in working group reports, which can make these reports confusing for outsiders, and even for herring experts themselves. As the age of all other fish species (and of herring in other parts of the world) is expressed in years, one could question the justification of treating West-European herring in a special way. Especially with the present trend towards multispecies assessment and integration of ICES working groups, there might be a case for a uniform system of age definition throughout all ICES working groups.*

However, the change from rings to years would create a number of practical problems. Data files in national laboratories and at ICES would have to be adapted, which would involve extra costs and manpower. People that had not been aware of the change might be confused when comparing new data with data from old working group reports. Finally, in some areas (notably Division IIIa), the distinction between spring- and autumn spawners is still hard to make, and scientists preferred to continue using rings instead of years.

The Working Group discussed at length the various consequences of a change from rings to years. The majority of the Group felt that the advantages of such a change did not outweigh the disadvantages, and it was decided to stick to the present system for the time being. "

The text table below gives an example for the correlation between age, rings and year class for the different spawning types in late 2002:

Year class (autumn spawners)	**2001/2002**	**2000/2001**	**1999/2000**	**1998/1999**
Rings	0	1	2	3
Age (autumn spawners)	1	2	3	4
Year class (spring spawners)	2002	2001	2000	1999
Rings	0	1	2	3
Age (spring spawners)	0	1	2	3

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Annex 7 - Stock Annex Herring in Division VIa South and VIIbc

Quality Handbook	ANNEX: Herring VIaS and VIIb, c

Stock specific documentation of standard assessment procedures used by ICES.

Stock:	Herring in VIaS and VIIb, c
Working Group:	Herring Assessment Working Group for the area south of 62^0N
Date:	March 2008
Authors:	Afra Egan and Maurice Clarke

A. General

The herring to the northwest of Ireland comprise both autumn and winter/spring spawning components. The age distribution of the catch and vertebral counts were used to distinguish these components (Bracken, 1964, Kennedy, 1970). Spawning takes place from September until March and may continue until April (Molloy and Kelly, 2000). Spawning in VIIb has traditionally taken place in the autumn and in VIaS, later in the autumn and in the winter.

For the purpose of stock assessment and management, these areas have been separated from VIaN since 1982 and are split at 56° N. This split is based on work carried out by working groups in the late 1970s and early 1980s which found that the stocks exploited off the west coast of Scotland were biologically different from those off the north coast of Ireland. A second new assessment area was also recommended by the 1981 Working Group (ICES CM 1981). The Irish landings were taken mainly in the southern part of VIa and in VIIb, c. These catches were found to be biologically very similar with respect to age composition and spawning. It was decided at the 1981 working group to combine the areas and conduct a joint assessment (Molloy, 2006).

A herring tagging experiment was carried out in 1992 in order to investigate the movements and annual migrations of herring around the Irish Coast. 20,000 herring were tagged in total with 10,000 of these off the west coast. Some fish moved northwards and were recaptured along the north coast between July and February, in the main fishing areas. 90% of the fish tagged along the west coast were recovered from the Donegal Bay area. The maturity stages of the recaptured fish, suggests that the fish were migrating inshore towards spawning grounds (Molloy, *et al* 1993). There were no returns from north of Donegal although it is possible that there may not have been much fishing activity in the area at this time (Molloy and Kelly, 2000).

Assessment and biology

A study group on herring assessment and biology in the Irish Sea and adjacent areas met in 1994 (ICES, 1994). This meeting highlighted the problems associated with the assessment of herring stocks around Ireland. This group recommended that the boundary line separating this stock from the herring stock of VIaS and VIIb be moved southwards from latitude 52°30′N to 52°00′N (ICES, 1994). A Schematic presentation of the life cycle of herring to the west and northwest of Ireland is shown in Figure

A.1. The spawning, nursery and feeding grounds are shown as well as the direction of larval drift and migration.

WESTHER

WESTHER was an EU-funded project, to review, the stock identity of herring west of the British Isles. A number of factors were examined including.

Morphometrics and meristic characteristics

Internal parasites

Otolith microstructure and microchemistry

Genetics

Results from this project identified distinct spawning grounds and spawning components. It was recommended that the stocks to the west of the British Isles should be managed as two stocks, the Malin Shelf stock and the Celtic Sea stock. Management plans should be fleet and area based in order to prevent the local depletion of any population unit in the areas (WESTHER, Q5RS-2002-01056). Further work on the management of these stocks will be conducted by SGHERWAY which are due to meet in late 2008.

A.2. Fishery

Development of this fishery

In the early 1900s the main herring fisheries in Ireland were located off the Donegal coast. Donegal matje herring was important in supplying the German markets. Herring fisheries, which took place every spring and summer off the coast of Donegal, have been under scientific observation since 1921, with very little scientific work carried out prior to this. The fishing grounds were well known and were located between ten and forty miles offshore. Fishing during this time was split into three well defined time periods.

1) December/January
2) May (main fishing took place)
3) September/October

During the 1930s many of the major herring markets disappeared (Molloy, 1995). In contrast to the rapid expansion experienced in the Celtic Sea the revival of the northwest fishery occurred at a slower pace (Molloy, 2006). The revival first became evident in the 1950s when many Scottish ring netters took part in this fishery with many of the Irish boats also using this gear. Then several boats changed to pelagic midwater trawls. The herring fleet continued to expand throughout the 1960s with many skippers becoming experts in pelagic pair trawling (Molloy, 2006).

In the 1970s and 1980s the autumn spawners became more significant and accounted for the majority of the landings. Galway and Rossaveal gained increasing importance as herring ports in the 1970s. In the 1974/75 season landings decreased dramatically and it was the first indication that the stock might have started to decline. The North Sea stock was already in decline and many Dutch boats were fishing off the Irish west coast. TACs were reduced and the stock continued to decline. In 1978 it was advised that the fishery be closed (Molloy, 2006). This closure lasted until 1981 and was reopened with new management units. VIaS and VIIb, c were joined and were assessed separately from VIaN.

In recent years the northern grounds have regained importance with catch also coming from the west coast close to the VIa boundary line (ICES, 2005). Very little fishing now takes place on previously important grounds in Galway Bay and along the Mayo coast (Molloy and Kelly, 2000).

Since the late 1970s considerable changes have taken place in the type of pelagic fishing carried out by Irish boats off the North West Coast, with directed herring fishing having been largely replaced by mackerel fishing (Breslin, 1998).

Recent

The TAC is taken mainly by Ireland, which has over 90% of the quota. In recent years, only Ireland has exploited herring in this area. The fishery is concentrated in quarters one and four. Landings have decreased markedly from about 44,000 t in 1990 to around 13,800t in 2004. Working group catches in the last two years have decreased over 17,000 t in 2007 to over 13,000 in 2008. Total catch over the complete time series are shown in the Figure 3. The number of boats participating in this fishery remained constant for a number of years at around 30 vessels. Increases were seen in the last two years with 62 vessels landing northwest herring in 2008. The number of vessels engaged in fishing for herring depends very much on the availability of mackerel or horse mackerel. Many of the larger vessels target these species primarily.

The majority of the landings in recent years are taken in quarters one and four with small quantities landed in quarter three. The main age groups are 2, 3, 4 and 5 with older age groups accounting for small proportions of the catch. The proportions of older age groups have been decreasing over the last number of years.

A.3. Ecosystem aspects

Divisions VIaS and VIIb, c are located to the North West and west of Ireland respectively. This area is limited to the southwest by the Rockall Trough, where the transition between the Porcupine Bank and the trough is a steep and rocky slope with reefs of deepwater corals; further north, the slope of the Rockall Trough is closer to the coast line; west of the shelf break is the Rockall Plateau with depths of less than 200m. The shelf area consists of mixed substrates, with soft sediments (sand and mud) in the west and more rocky, pinnacle areas to the east. The area has several seamounts: the Rosemary Bank, the Anton Dohrn sea mount and the Hebrides, which have soft sediments on top and rocky slopes (ICES, 2007b).

The shelf circulation is influenced by the poleward flowing ‘slope current’, which persists throughout the year north of the Porcupine Bank, but is stronger in the summer. A schematic representation of the oceanographic conditions in this area is presented in Figure A.2. Over the Rockall plateau, domes of cold water are associated with retentive circulation. Thermal stratification and tidal mixing generate a northwards running coastal current known as the Irish coastal current which runs northwards along the west coast (ICES, 2007). The main oceanographic features in these areas are the Islay and the Irish Shelf fronts. The waters to the west of Ireland are separated by the Irish shelf front. This front causes turbulence and this may bring nutrients from deep waters to the surface. This promotes the growth of phytoplankton and dinoflagellates where there is increased stratification. Associated with this is increased growth of zooplankton and aggregations of fish. The Islay front persists throughout the winter due to the stratification of water masses of different salinities

(ICES, 2006). The ability to quantify any variability in frontal location and strength is an important element in understanding fisheries recruitment (Nolan and Lyons, 2006).

In the North, most of the continental shelf is exposed to prevailing sothwesterly winds and saline oceanic waters cross the shelf edge between Malin head off the north coast of Ireland and Barra head in the Outer Hebrides. The Irish shelf current flows northwards and then eastwards along the north coast of Ireland (Reid *et al*, 2003). Freshwater discharges from rivers such as the Shannon and Corrib interact with the Eastern North Atlantic water on the Irish shelf front to produce the observed circulation pattern (ICES, 2006).

Sea surface temperature data have been collected from Malin head on the North coast of Ireland since 1958. During periods of low winter temperatures, there is less pronounced heating during the summer. This can be seen in 1963, 1978 and 1985-1986. During these years there were also stormy conditions. This is concurrent with the lower winter temperatures (ICES, 2007). There is considerable variability over the complete time series. A definite trend can be identified from the early 1990s. Since 1990 sea surface temperatures measured at stations along the northwest coast of Ireland have displayed a sustained increasing trend, with winter temperatures >6° and higher summer temperatures during the same period (Figure A.4), (Nolan and Lyons, 2006).

Environmental conditions can cause significant fluctuations in abundance in a variety of marine species including fish. A study conducted in 1980 found that west coast herring catches showed strong correlations with temperature and salinity at a constant lag of three or four years. Oceanographic variation associated with temperature and salinity fluctuations appears to affect herring in the first year of life, probably during the winter larval drift (Grainger 1980a).

Productivity in this region is reasonably high on the shelf but drops rapidly west of the shelf break. This area is important for many pelagic fish species. The shelf edge is a spawning area for mackerel *Scomber scombrus* and blue whiting *Micromesistius potassou*. Historically, there were important commercial fisheries for many demersals species also. On the shelf, the main resident pelagic species is herring *Clupea harengus* (ICES, 2007b). Preliminary examination of productivity shows that overall productivity in this area is currently lower than it was in the 1980s. Further information on this can be found in the HAWG report 2007 (ICES CM 2007).

Larvae that were spawned on the west and northwest coast follow a northwards drift. Larvae spawned further north off the Donegal coast were found to drift towards the Scottish west coast (Grainger and McArdle, 1985; Molloy and Barnwall, 1988) Studies have shown that the maximum larval depth is below the surface between 5-15m and there has been no evidence of diel migration, or variation in the distribution of different larval size categories (Grainger 1980b). Galway Bay and Donegal Bay, several inshore lochs and also Stanton Bank, an offshore area northwest of the Irish north coast are important nursery areas (ICES, 1994; Anon., 2000).

The spawning grounds for herring along the northwest coast are located in inshore areas close to the coast. These spawning grounds may contain one or more spawning beds on which herring deposit their eggs. The timing of spawning is not the same on each spawning ground. Spawning grounds tend to be vulnerable to anthropogenic influences such as dredging and sand and gravel extraction.

Discards

The main market for Irish herring in the late 1980s and early 1990s was the Japanese roe market. The development of this market coincided with a decline in a number of other herring markets. It was therefore only favourable to catch roe herring, whose ovaries are just at the point of spawning. This led to discarding of non roe herring due to the lack of a suitable market. The roe market is no longer the main market for Irish herring. It is not known what the level of discarding is in this stock area and if it is a problem in this fishery.

By Catch

Overall there is a paucity of data relating to by catch and discarding in this area. Interactions between cetaceans and fishing vessels have not been well documented and therefore no information is available. It is not possible therefore to make assumptions regarding implications for the marine ecosystem in area VIaS and VIIb, c.

B. Data

B.1. Commercial Catch

The commercial catch data are provided by national laboratories belonging to the nations that have quota for this stock. In recent years, only Ireland has been catching herring in this area, and the data are derived entirely from Irish sampling. Sampling is performed as part of commitments under the EU Council Regulation 1639/2001.

Commercial catch at age data are submitted in Exchange sheet v 1.6.4. These data are usually processed using SALLOCL (Patterson, 1998b). However, since only one country participates in this fishery this system is not required. Ireland acts as stock coordinator for this stock.

InterCatch

Since 2007, InterCatch, which is a web-based system for handling fish stock assessment data was used. National fish stock catches are imported into InterCatch. Stock coordinators then allocate sampled catches to unsampled catches, aggregate them to stock level and download the output. The InterCatch stock output can then be used as input for the assessment models. It is envisaged that this system will replace SALLOCL and other previously used systems.

Reallocation of Catches

Since 2007, landings data were revised with respect to reallocation of catches between area VIaS and VIaN, for the years 2000-2005. Before 2000, a comprehensive reallocation was used. For 2000-2005, various procedures were used. These attempted to deal with the increasing Irish catches along the 56° line and opportunistic Irish catches of herring in VIaN during the 4th and 1st quarter mackerel fishery. In some years some catches were reallocated, while in others no reallocations were made. In 2007, it was considered that the most correct procedure was that used before 2000. Therefore a retrospective reallocation has been conducted. It does not adequately consider the Irish herring catches in VIaN, nor does the reallocation consider fishing along the 56°line. However, in the absence of better information on Irish directed herring fishing in VIaN, this procedure provides the best possible method.

B.2. Biological

Sampling Protocol

Landings data are available for this area from 1970. Data on catch numbers at age, mean weights at age and mean lengths at age are derived from Irish data. Sampling is conducted by area and by quarter. Landings from this fishery, at present, are mainly into the port of Killybegs with lesser amounts landed into Rossaveal. Irish samples are collected from these commercial landings. Length frequency and age data is collected by ICES division by quarter. The length frequency data is added together for each division and quarter and raised to the landings for that area and quarter. The sample weight is divided into the catch weight to get the raising factor. The sum of the length frequencies per quarter is multiplied by the raising factor. An age length key is applied to this data and catch numbers at age calculated.

Age Reading Protocol

Northwest herring are currently aged using otoliths and are read using a stereoscopic microscope, with reflected light. The minimum level of magnification (15x) is used initially. It is then increased to resolve the features of the otolith. Herring otoliths are generally read in the magnification range of 20x – 25x. The patterns of opaque (summer) and translucent (winter) zones are viewed. The winter (translucent) ring at the otolith edge is counted only in otoliths from fish caught after the 1st January. The first winter ring that is counted is that which corresponds to the second "birth date" of the fish. Therefore a fish of 2 winter rings is a 3 year old. This convention applies to all ICES herring stocks with autumn spawning (Lynch, *in prep*).

Age composition in the catch

Scales were used in the past for ageing and on average 4 and 5 ringers counted for 46% of the total catch. In 1929 however strong year classes were evident with 4 and 5 ringers making up 85% of the total (Farran, 1928). Currently the catch is mainly composed of ages 2 ,3, 4 and 5 ringers. In recent years there have been decreasing proportions of older fish in the catch. This stock is different from the Celtic Sea in that there is no recruitment failure and the Northwest stock is less reliant on incoming recruitment. The decrease in the proportions of older ages can be seen in Figure B.1.

Precision Estimates

The precision estimates on 2006 ageing data were worked up using a bootstrap technique. The results of the method found that the relative error is below 20% over the age range 2-6wr. At older ages, estimates of NW herring show higher CVs which is likely to be due to the relative paucity in the catch.

Mean Weights

Mean weights in the stock (West) are calculated using samples taken from Q1 and Q4. A mean weight at age is then calculated. Mean weights in the catch (Weca) are calculated using samples from all quarters of the fishery and a mean weight per age derived.

Trends in mean weights over time

The mean weights in the catch display quite a stable pattern over the time series, although variable weights are only available from the early 1980s. Younger ages (1-6 ring) show an overall downward trend with more fluctuations evident in older ages (7-9 ring). The mean weights in the stock at spawning time have been calculated from Irish samples taken during the main spawning period and show similar patterns to the mean weight in the catch.

Maturity ogive

A maturity ogive has been produced from the 2007 acoustic survey shows that 58% are mature at 1-ring, 99% at 2-ring and 100% mature at 3-ring. The maturity ogive used in the assessment considers 1-ringers to be all immature and all subsequent age groups as fully mature.

Log Catch Ratios

The log catch ratios (ln $C_{a,y}$/ $C_{a+1,y+1}$) are presented below and are smoothed with a 4-year running average to show the main trends (Figure B.2). Data for 1-ringers are noisy because this group is not fully selected by the fishery. The data for older fish are also noisy, particularly in later years, reflecting their relative paucity in the catches and suggest high variability in the exploitation rates of these age groups. These show an upward trend for all fully recruited year classes since the mid nineties. Overall, the catch data show a diminishing range of ages in the catches and older fish are at their lowest levels in the time series.

Catch Curves

Cohort catch curves, were constructed for each year class in the catch at age data (Figure B.3). These catch curves show signals in total mortality over the time series. Low mortality seems evident on the very large 1981,985 and 1988 year classes. These represent three of the biggest year classes recruited to this fishery. Increasing mortality can be seen from 1990 on, whilst the 1970s cohorts show lower Z.

B.3. Surveys

Acoustic Surveys

Acoustic surveys have been carried out in this area since 1994. The timing of these surveys has changed over this period. Initially the surveys were undertaken in the summer in order to coincide with international herring surveys and with the summer feeding period of this stock. In 1997, a research vessel was not available and the survey was not carried out. From 1998 -2001 surveys were undertaken in October in order to survey the autumn spawning component. This was changed in 2002 with surveys carried out in January targeting the winter spawning components of this stock.

Since 2004 the surveys have been carried out on the *R.V. Celtic Explorer*. A parallel transect design was adopted with transects running perpendicular to the coastline and extending up to 54 nmi (nautical miles) offshore. Transect spacing was set at 2 nmi throughout the survey. In bays a single zigzag transect approach was used to optimise coverage. The survey area was divided into strata based on the timing of spawning in each area. The first strata to be covered was chosen in order to contain the earliest spawning components of the stock. The second strata is characterised as containing a mixture of early and mid spawning stock components. The third strata covered the area where the latest spawning is known to occur. Strata were subdivided in order to concentrate on known spawning grounds.

The acoustic data were collected using the Simrad ER60 scientific echosounder. The Simrad ES-38B (38 KHz) split-beam transducer is mounted within the vessels drop keel and lowered to the working depth of 3.3m below the vessels hull or 8.8m below the sea surface.

Acoustic data analysis was carried out using Sonar data's Echoview® (V 3.2) post processing software and was backed up every 24 hrs. Partitioning of data was viewed and agreed upon by 2 scientists experienced in viewing echograms. Where no directed trawling had taken place, biological data from the nearest neighbour was used to determine the size classification of the echotrace.

The following TS/length relationships were used to analyse the data.

Herring TS = 20logL – 71.2 dB per individual (L = length in cm)

Sprat TS = 20logL – 71.2 dB per individual (L = length in cm)

Mackerel TS = 20logL – 84.9 dB per individual (L = length in cm)

Horse mackerelTS = 20logL – 67.5 dB per individual (L = length in cm)

The winter acoustic survey time series was split and ran from 1999-2003 and 2004-2007 because of the timing. Earlier survey series were carried out in Q4 and the more recent surveys were in Q1. The acoustic survey time series is shown in the text table below. A problem with the winter acoustic survey series has been synchronising the survey with the peak spawning event to ensure containment of the stock. The winter surveys that were carried out from 2004 – 2007 varied sharply in age profile and biomass estimates, and was not considered reliable. Bad weather often affected the survey as it took place in January. Also it was recognised that synoptic coverage of a stock that spawns over a period from October to February in an area spanning all of Divisions VIaS and VIIb cannot be achieved with a winter survey. Thus the series was discontinued in 2007. The review group of the 2007 assessment highlighted that although there is an acoustic abundance estimate, the historical series is too short to consider it as a tuning survey in an analytical assessment.

Acoustic surveys have been conducted in this area since 1999. In the mid 1990s, surveys were undertaken in summer. The timing changed in 1999 with the surveys being carried out in the winter (Table 6.3.1). Table 6.3.2 shows acoustic abundance at age and biomass estimates from all surveys conducted in this area, since 1994. The WESTHER project recommended that the survey effort along the Malin shelf area (including VIaN, VIaS, VIIb,c, Clyde and Irish Sea) should be increased or diverted to a combined survey on non-spawning herring. In 2008 PGHERS (CM 2008/LRC:01) discussed the possibility of conducting synoptic summer surveys on the Malin shelf.

The WESTHER project recommended that the survey effort along the Malin shelf area (including VIaN, VIaS, VIIb,c, Clyde and Irish Sea) should be increased or diverted to a combined survey on non-spawning herring. In 2008 PGHERS (CM 2008/LRC:01) discussed the possibility of conducting synoptic summer surveys on the Malin shelf.

In 2008, the Irish survey of VIaS, VIIb, c was conducted in July with effort concentrating on summer feeding aggregations.

Larval Surveys

Assessment of this stock was largely based on the results of larval surveys in the 1980s. Herring Larval surveys were first carried out on this stock, by Ireland, in 1981 and continued until 1986. Prior to this the surveys were carried out by the Scottish but only had limited coverage of the assessment area. The survey grid consisted of sampling stations about 18km apart. A gulf III plankton sampler with 275 µm mesh was towed at each station. The samples collected were preserved in 4% formalin. Herring larvae were identified and measured. Only larvae of less than 10mm were used for the assessment. The number of larvae below each square meter was calculated and then multiplied by the area of the sea at each station (Grainger and McArdle, 1981). These surveys did not produce a satisfactory index of stock size because of two very low values in 1984 and 1985 (Molloy, 1989). However these surveys did provide valuable information on the distribution of very small larvae and on the location of the spawning grounds (Molloy and Kelly, 2000).

Ground Fish Survey

The IGFS is part of the western IBTS survey and has been carried out on the *RV Celtic Explorer* since 2003. The gear used on the survey is a GOV 36/47 demersal trawl with a 20mm cod end liner to retain juvenile and small fish, including small herring. This survey has been conducted since the early 1990s but is of little utility as a herring recruit index, because the gear, timing and survey vessel changed throughout. Once a sufficient time series becomes available it will be investigated as a possible tuning fleet. The Scottish groundfish survey, which has some coverage of VIaS will also be investigated as an additional tuning fleet.

B.4. Commercial CPUE

Research surveys were not started in Ireland until the mid 1960s and in the absence of this information commercial catch per unit effort (CPUE) data was used as an index of stock size. It is known that CPUE data may not give an accurate index of stock size due to the shoaling nature of pelagic stocks. Fish can aggregate in dense shoals in a small area and CPUE may remain high even though the stock size is low. However the CPUE data collected in the 1960s and 1970s did provide an index of changes that were occurring in the fisheries around Ireland. F was calculated for the Northwest herring stock using this data during this time and showed an increasing trend in F. This CPUE data was used to show the dramatic decline that took place in this stock in the 1970s (Molloy, 2006).

C. Historical Stock Development

Time periods in the fishery

This fishery peaked in the late 1980s, largely as a result of two strong year classes in 1981 and 1985. This corresponded to the highest SSB and a medium level of F. In the late 1980s changes also took place with regard to the location and timing of the fishery. The North and West coast fisheries in December and January were now the most important with smaller amounts taken during the autumn fishery (Molloy, 2006). Since then there has been a downward trend in SSB and recruitment with no evidence of strong year classes entering the fishery. Mean F has been fluctuating but is though to be at a high level.

Spawning stock size peaked in 1988 and has followed a steady decline since then. Landings have drastically fallen since 1999 (ICES, 2004). Long term changes in the spawning component have occurred in the area and time of spawning. In 1920-1930s there was a north coast fishery that spawned in the North in spring and an autumn fishery that spawned in the west of Donegal. Sligo and Galway had no important fishery. In the '40-50 herring all over Ireland declined and the recovery in the 1960s occurred mainly in Mayo, Sligo and Galway as autumn spawners. Recently there has been a shift to the northern fishery, while little fishing occurs on the west coast of Ireland. The northwest herring fishery was based on hard (stage V) herring but towards the late 1980s the focus shifted to spawning herring.

Assessment

In 1930, Farran made his first attempt to quantify the abundance of the herring stock in this area. In the 1930s many of the previous herring markets disappeared and there was widescale discarding of herring along the Donegal coast. It is thought that during this time that the herring population was at a very low level (Molloy, 1995).

Recent Assessments

In recent years the model used for this stock was a separable VPA. This was used to screen over three terminal fishing mortalities, 0.2, 0.4 and 0.6. In 2009 terminal F of 0.5 was also examined. This was achieved using the Lowestoft VPA software (Darby and Flatman, 1994). Reference age for calculation of fishing mortality was 3-6 and terminal selection was fixed at 1, relative to age 3 winter rings. ICA was used in exploratory assessments with the acoustic surveys as a tuning fleet.

Model used: ICA and VPA

No final assessment has been accepted for this stock by the working group. However several scenarios are run, screening over a range of terminal F's (0.2, 0.4, 0.5 and 0.6). In 2006 and 2007 exploratory runs using the ICA model (Patterson, 1998) were performed. In the absence of a sufficient time series in this area the use of the ICA model has discontinued.

Software used: **VPA**

A separable VPA is used to track the historic development of this stock.

Software used: Lowestoft VPA Package (Darby and Flatman, 1994).

VPA SETTINGS

Reference Age = 3

Selection in the terminal year = 1.0

Terminal F = 0.2, 0.4, 0.5, 0.6

1 Ringers: downweighted to 0.1

Reference ages for calculation of Mean F= 3-6

Software used: ICA (exploratory runs in 2006 and 2007 only)

Model Options chosen:

Separable constraint over the last 6 years (weighting = 1.0 for each year)

Reference ages: 3

Constant selection pattern model

Selectivity on oldest age: 1.0

First age for calculation of mean F: 3

Last age for calculation of mean F: 6

Weighting on 1 ringers: 0.01   Other age classes: 1.0

Lowest feasible F: 0.05

Highest feasible F: 2.0

Ages for acoustic abundance estimates: 3-4

Plus group: 9

Input data types and characteristics:

TYPE	NAME	YEAR RANGE	AGE RANGE	VARIABLE FROM YEAR TO YEAR YES/NO
Caton	Catch in tonnes	1970-2008	1-9 +	Yes
Canum	Catch at age in numbers	1970-2008	1-9 +	Yes
Weca	Weight at age in the commercial catch	1970-2008	1-9 +	Yes
West	Weight at age of the spawning stock at spawning time.	1970-2008	1-9 +	Yes
Mprop	Proportion of natural mortality before spawning	1970-2008	1-9 +	No
Fprop	Proportion of fishing mortality before spawning	1970-2008	1-9 +	No
Matprop	Proportion mature at age	1970-2008	1-9 +	No
Natmor	Natural mortality	1970-2008	1-9 +	No

Tuning data:

TYPE	NAME	YEAR RANGE	AGE RANGE
Tuning fleet 1	NWHAS	1999-2003	3-4
Tuning fleet 2	NWHAS	2004-2007	3-4

D. Short-Term Projection

Due to the absence of information on recruitment and the uncertainty about the current stock size short term predictions have not been routinely carried out for this stock.

E. Medium-Term Projections

Model Used: Multi Fleet Yield Per Recruit

Software Used: MFYPR Software

Yield-per-recruit analysis was carried out using MFYPR to provide yield-per-recruit plots for the data produced in the assessment. The values for $\mathbf{F}_{0.1}$ and $\mathbf{F}_{med}$ are 0.17 and 0.31. F_{max} is undefined and this is consistent with many other pelagic species (ICES, 2006).

F. Long-Term Projections

Not performed

G. Biological Reference Points

In 2007 the technical basis for the selection of the precautionary reference points was examined based on methods used by SGPRP (ICES CM 2001). No alternative biomass and fishing mortality reference points are available. It is clear that recruitment does not show any clear dependence on the SSB and that apart from the very high year classes in the 1980s is showing a decline.

The SGPRP (ICES CM 2003) has reviewed the methodology for the calculation of biological reference points, and applying a segmented regression to the stock and recruit data from the 2002 HAWG assessments. This showed that the fit to the stock and recruit data for this stock was not significant. There was no well defined change point and there was no reason to refine the reference points at that time.

Current reference points

B_{pa} = 81,000 t = the lowest reliable estimate of SSB

B_{llim} = 110,000 t = 1.4 x B_{pa}

F_{pa} = 0.22 = F_{med} (1998)

F_{lim} = 0.33 = lowest observed F

H: Other Issues

H.1 Biology of the species in the distribution area

The herring (*Clupea harengus*) is a widely distributed pelagic species in this area. This stock is comprised of different spawning components. Off the west coast the majority of the stock, are autumn spawners. Off the northwest coast distinct spawning units have also been identified. Autumn spawners, that spawn in the Donegal Bay area and winter/spring spawners, that spawn further north off the Donegal coast (Breslin, 1998). Autumn and winter spawners were distinguished by vertebral counts and timing of maturity.

Herring are benthic spawners and deposit their eggs on the sea bed usually on gravel or course sediments. The yolk sac larvae hatch and adopt a pelagic mode of life.

When referring to spawning locations the following terminology is used (Molloy, 2006)

- A spawning bed is the area over which the eggs are deposited
- A spawning ground consists of one or more spawning beds located in a small area.
- A spawning area is comprised of a number of spawning grounds in a larger area

Spawning grounds are typically located in high energy environments such as the mouth of large rivers and areas where the tidal currents are strong. Herring shoals return to the same spawning grounds each year (Molloy, 2006).

The spawning grounds for northwest herring are located in shallow waters close to the coast and are well known and well defined. Spawning begins in October and can continue until February. Fecundity is the number of eggs produced by the female and is proportional to the length of the fish (Molloy, 2006). Several studies were carried out in the early 1980s to analyse the fecundity of winter and autumn spawning components of the North West herring stock and considerable differences were found.

Donegal winter spawners produce significantly fewer eggs than autumn spawners. When compared to the Celtic Sea herring stock, Donegal herring have a higher fecundity and begin to spawn earlier (McArdle, 1983). A study conducted in the 1920s found that the eggs produced by winter/spring spawners were 25% bigger than those autumn spawners but were less numerous (Farran, 1938).

Herring produce benthic eggs that are adhered to the bottom substrate where they remain until the larvae hatch. The larvae are carried by the currents and drift towards the west coast of Scotland (Grainger and McArdle, 1985). Several important nursery grounds for juveniles have been identified in this area.

The larval phase is an important period in the herring life cycle. Larvae use their oil globule for food and to provide buoyancy. Their movements and survival are determined by favourable environmental conditions. Larvae originating from spawning grounds off the west coast are carried by currents to the northwest coast of Donegal and may even travel as far as Scotland (Molloy, 2006). Figure A.1 shows a schematic presentation of the life cycle of Herring west and northwest of Ireland.

The juveniles tend to remain close inshore, in shallow waters for the first two years of their lives, in nursery areas. There are many of these nursery areas around the coast, for example St. Johns point in Donegal Bay. The minimum landing size for herring is 20cm and therefore these juvenile herring are not caught by the fishery in the early stages of their life cycle (Molloy, 2006).

Changes in the growth rate of this stock can be seen over time. In the late 1980s a sudden and unexplained drop in mean weights was observed. This had an impact on the estimate of SSB and the advised TAC. The growth rate of this stock has never recovered to the levels before this decline (Molloy, 2006).

Adult herring are found offshore until spawning time, when they move inshore. Occasionally very large herring are found off the Irish coast. Theses herring appear off the north coast and are usually in a spawning or pre spawning condition (Molloy, 2006).

H.2. Management and ACFM advice

Local Management

Various management measures have been introduced to control the exploitation of this stock. From 1972-1978 TACs were set by NEAFC and covered all of area VIa. The TAC decreased rapidly and the stock was thought to be in decline. This continued until the fishery was closed in 1979 and 1980. During the closure because there was no analytical assessment of VIIb fishing was allowed to continue on a precautionary basis (ICES, 1994). When the fishery was reopened it was decided to split the area into VIaS and VIaN. Landings from this area increased due to the increased efficiency of the Irish vessels and the participation in this fishery by Dutch vessels (Anon, 2000).

Management measures were slowly introduced into this fishery with by-laws restricting fishing in certain areas off the coast in the early 1900s. This type of management continued until the 1930s when fishing was prohibited during April and May, in order to improve the quality of the herring being landed. In the 1970s management measured became more defined. Direct fishing of herring for fishmeal was banned. A minimum landing size of 20cm was implemented and also minimum mesh sizes. TACs were introduced in order to control the amount of herring landing each year from each ICES area (Molloy, 1995).

The management of the fishery has improved in recent years and catches have been considerably reduced since 1999. In 2000 the Irish North West Pelagic Management Committee was established to deal with the management of this stock. The assessment period runs concurrently with the annual quota. Quotas are allocated on a fortnightly basis and there is some capacity to carry unused allocation into the following fortnight with overruns being deducted.

In 2000, the Irish North West Pelagic Management Committee was established to deal with the management of this stock. The committee has the following objectives:

- To rebuild this stock to above the B_{pa} level of 110 000 t.
- In the event of the stock remaining below this level, additional conservation measures will need to be implemented.
- In the longer term it is the policy of the committee to further rebuild the stock to the level at which it can sustain annual catches of around 25 000 t.
- Implement a closed season from March to October.
- Regulate effort further through boat quotas allocated on a weekly basis in the open season.

This committee manages the whole fishery for this stock at present, given that Ireland currently accounts for the entire catch.

The current state of the stock is uncertain. Preliminary assessments suggest that SSB may be stable at a low level. The current level of SSB is uncertain but likely to be below B_{lim}. There is no evidence that large year classes have recruited to the stock in recent years. F appears to have increased concomitantly with increases in the catch. F is likely to be above F_{pa} and also likely above F_{lim}.

There is no explicit management plan for this stock. The local Irish management committee developed the objective to rebuild the stock to above B_{pa} and to maintain catches of 25 000 t per year. The implementation of the closed season from March to October has been successful in ensuring that the fishery mainly concentrates on the spawning component in this area. ICES have recommended that a rebuilding plan be put in place that will reduce catches. If no rebuilding plan is established, there should be no fishing. The rebuilding plan should be evaluated with respect to the precautionary approach.

H.4 Terminology

The WG uses "rings" rather than "age" or "winter rings" throughout the report to denominate the age of herring, with the intention to avoid confusion. It should be observed that, for autumn spawning stocks, there is a difference of one year between "age" and "rings". HAWG in 1992 (ICES 1992/Assess:11) stated that

"The convention of defining herring age rings instead of years was introduced in various ICES working groups around 1970. The main argument to do so was the uncertainty about the racial identity of the herring in some areas. A herring with one winter ring is classified as 2-years-old if it is an autumn spawner, and one-year-old if it is a spring spawner. Recording the age of the herring in rings instead of in years allowed scientists to postpone the decision on year of birth until a later date when they might have obtained more information on the racial identity of the herring.

The use of winter rings in ICES working groups has introduced a certain amount of confusion and errors. In specifying the age of the herring, people always have to state explicitly whether they are talking about rings or years, and whether the herring are autumn or spring spawners. These details tend to get lost in working group reports, which can make these reports confusion for outsiders, and even for herring experts themselves. As the age of all other fish species (and of herring in other parts of the world) is expressed in years, one could question the justification of treating West-European herring in a special way. Especially with the present trend towards multispecies assessment and integration of ICES working groups, there might be a case for a uniform system of age definition throughout all ICES working groups.

However, the change from rings to years would create a number of practical problems. Data files in national laboratories and at ICES would have to be adapted, which would involve extra costs and manpower. People that had not been aware of the change might be confused when comparing new data with data from old working group reports. Finally, in some areas (notably Division IIIa), the distinction between spring and autumn spawners is still hard to make, and scientists preferred to continue using rings instead of years.

The Working Group discussed at length the various consequences of a change from rings to years. The majority of the Group felt that the advantages of such a change did not outweigh the disadvantages, and it was decided to stick to the present system for the time being.”

The text table below gives an example for the correlation between age, rings and year class for the different spawning types in late 2002:

YEAR CLASS (AUTUMN SPAWNERS)	2001/2002	2000/2001	1999/2000	1998/1999
Rings	0	1	2	3
Age (autumn spawners)	1	2	3	4
Year class (spring spawners)	2002	2001	2000	1999
Rings	0	1	2	3
Age (spring spawners)	0	1	2	3

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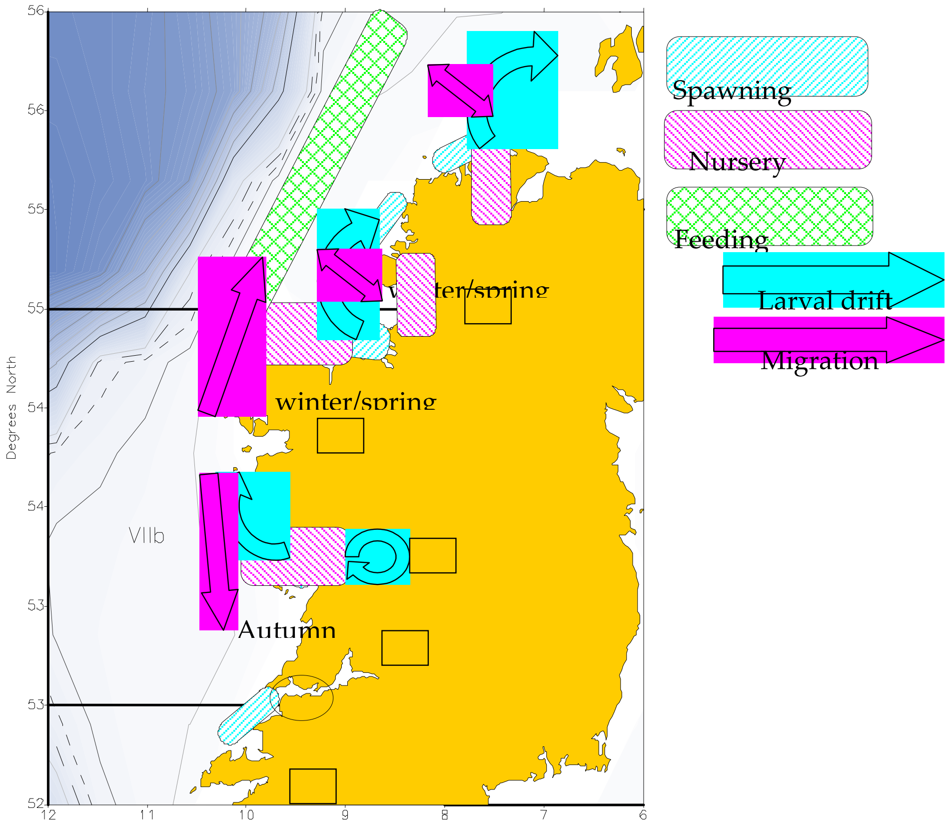


Figure A.1 Schematic presentation of the life cycle of Herring west and northwest of Ireland. Numbers represent locations mentioned in the text:1 – Dingle Peninsula, 2 – Shannon River, 3 – Galway Bay, 4 – Mayo, 5 – Donegal Bay (ICES, 2005b, SGRESP)

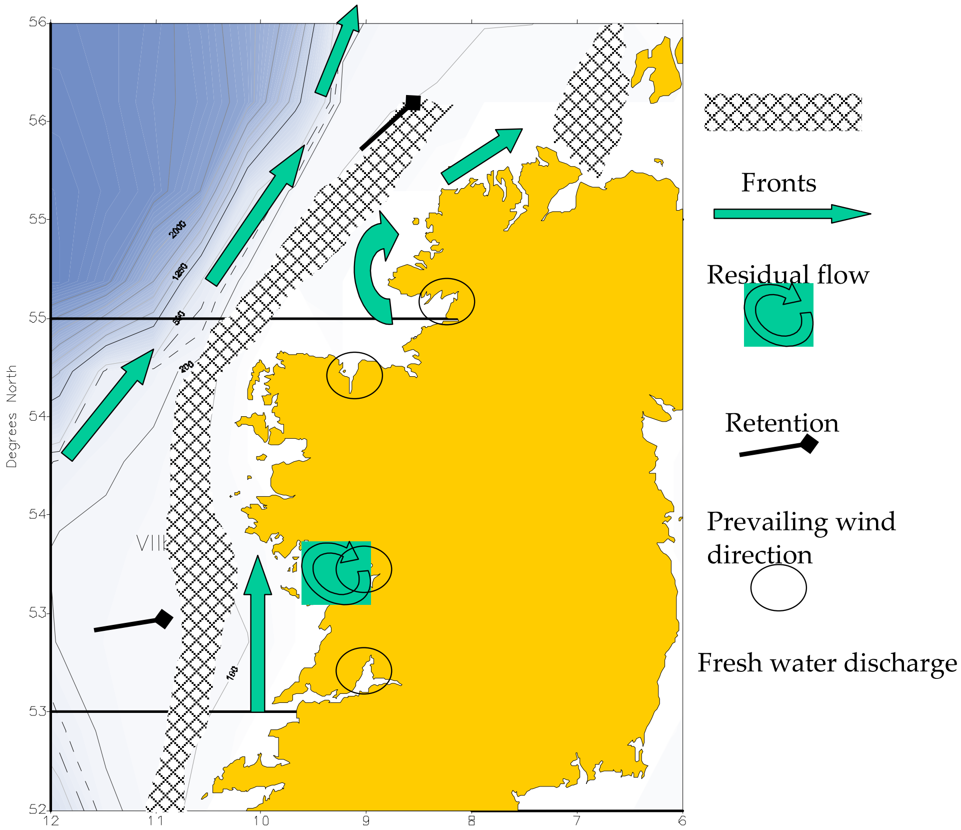


Figure A.2 Schematic presentation of prevailing oceanographic conditions in the west and northwest of Ireland. Fronts are 1.) the Islay front northeast of Ireland and 2.) the Irish shelf front to the west of the Celtic Sea, both fronts are a thermohaline fronts persisting throughout the year with an additional tidal mixing front developing near Islay during summer stratification. Residual currents are the Irish coastal current, a clockwise density current and the Atlantic shelf edge current. Circulation is mainly wind driven with prevailing south-easterly winds from October to May and density driven from May to October (ICES, 2005b, SGRESP).

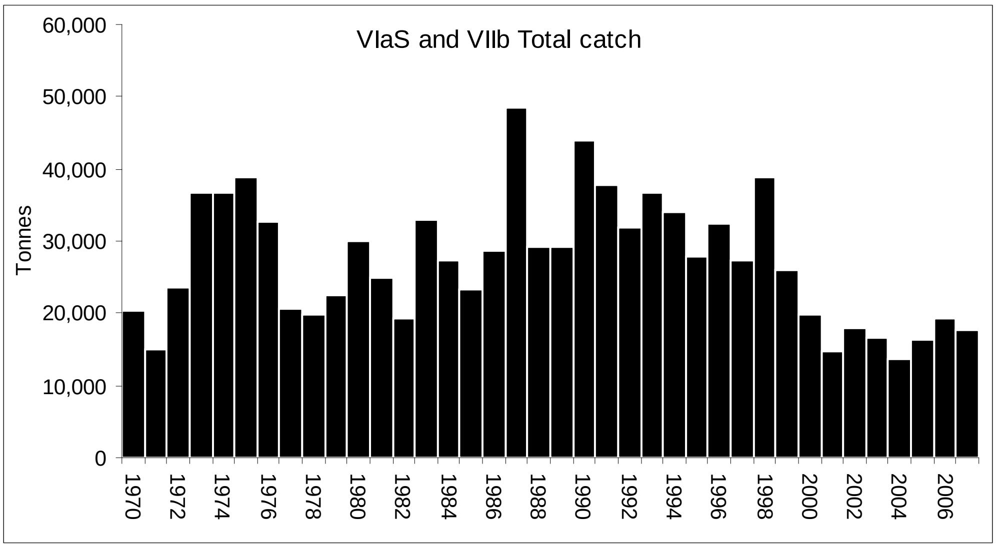


Figure A.3: Total landings from VIaS, VIIb,c

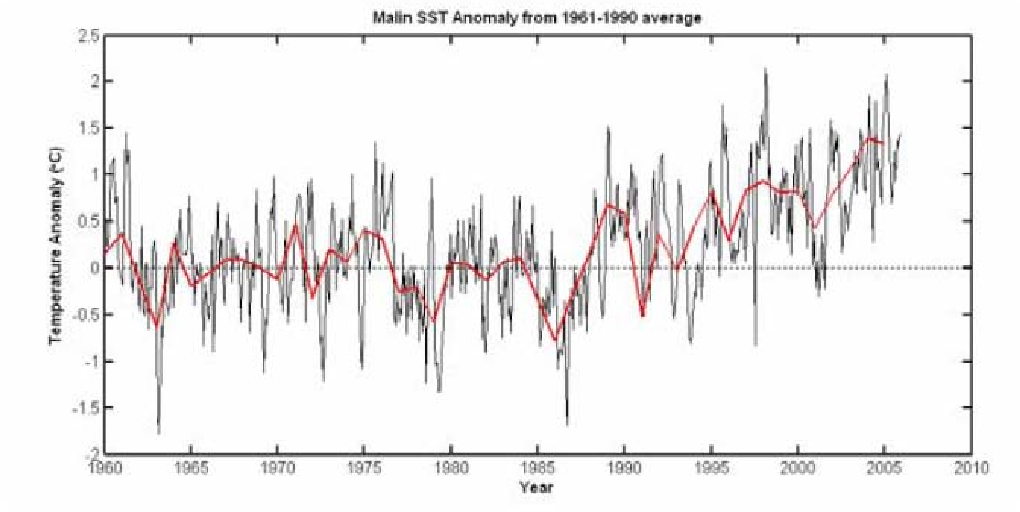


Figure A.4: Sea surface temperature anomaly at Malin Head (1960-2005) (Nolan and Lyons, 2006)

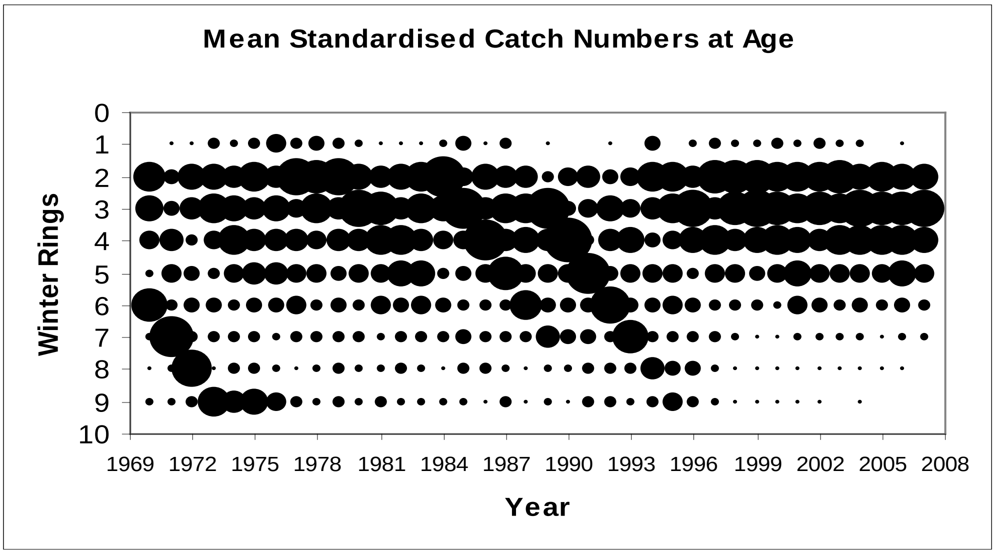
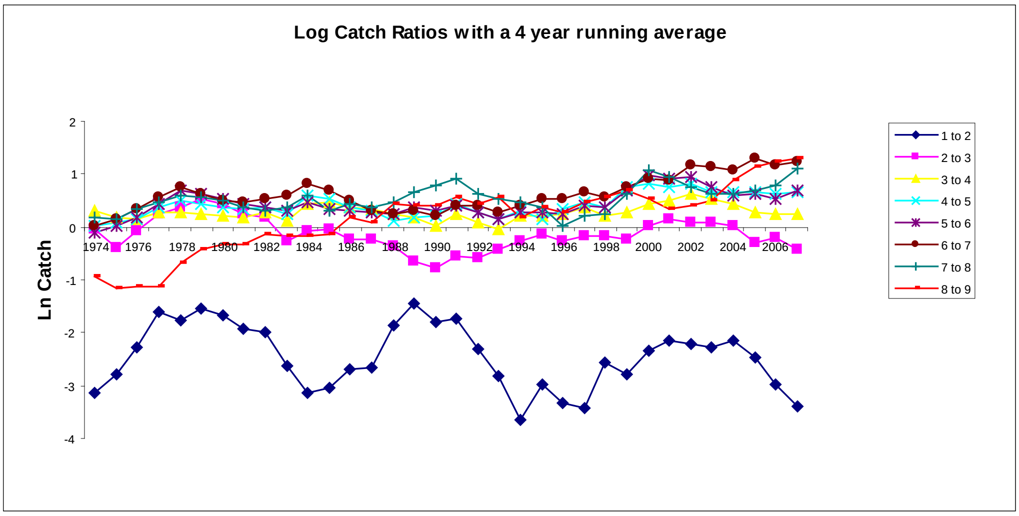


Figure B.1: Mean Standardised Catch Numbers at Age



B.2: Log Catch Ratios with a four year running average

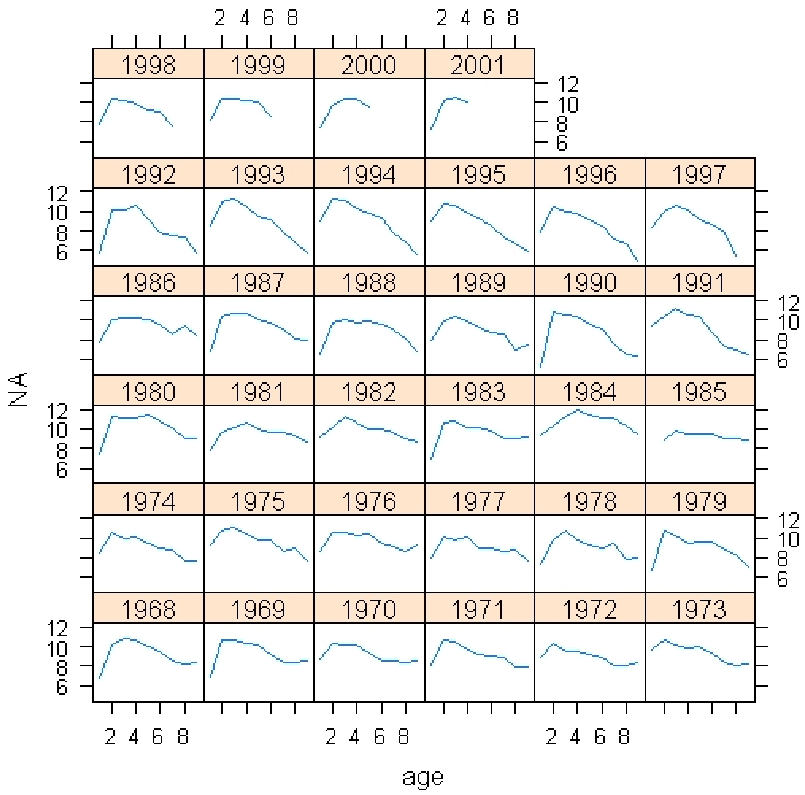


Figure B.3: Catch Curves by cohort

Annex 8 - Stock Annex Irish Sea Herring VIIa (N)

Quality Handbook	ANNEX:_hawg-nirs

Stock specific documentation of standard assessment procedures used by ICES.

Stock:	Irish Sea herring (VIIa(N)
Working Group	Herring Assessment Working Group (HAWG)
Date:	25 March 2009
Revised by	Steven Beggs

A. General

A.1. Stock definition

Herring spawning grounds in the Irish Sea are found in coastal waters to the west and north of the Isle of Man and on the Irish Coast at around 54°N (ICES, 1994; Dickey-Collas *et al.*, 2001). Spawning takes place from September to November in both areas, occurring slightly later on average on the Irish Coast than off the Isle of Man. ICES Herring Assessment Working Groups from 19XX to 1983 used vertebral counts to separate catches into Manx and Mourne stocks associated with these spawning grounds. However, taking account of inaccuracies in this method and the results of biochemical analyses, the 1984 WG combined the data from the two components to provide a "more meaningful and accurate estimate of the total stock biomass in the N. Irish Sea." All subsequent assessments have treated the VIIa(N) data as coming from a single stock. During the 1970s, catches from the Manx component were about three times larger than those from the Mourne component. By the early 1980s, following the collapse of the stock, the catches were of similar magnitude. The fishery off the Mourne coast declined substantially in the 1990s then ceased, whilst acoustic and larva surveys in this period indicate that the spawning population in this area has been very small compared to the biomass off the Isle of Man.

The occurrence in the Irish Sea of juvenile herring from a winter-spring spawning stock has been recognized since the 1960s based on vertebral counts (ICES, 1994). More recently, Brophy and Danilowicz (2002) used otolith microstructure to show that nursery grounds in the western Irish Sea were generally dominated by winter-spawned fish. Samples from the eastern Irish Sea were mainly autumn-spawned fish. Recaptures from 10,000 herring tagged off the SW of the Isle of Man in July 1991 occurred both on the Manx spawning grounds and along the Irish Coast with increasing proportions from the Celtic Sea in subsequent years (Molloy *et al.*, 1993). The pattern of recaptures indicated a movement towards spawning grounds in the Celtic Sea as the fish matured.

A proportion of the Irish Sea herring stocks may occur to the north of the Irish Sea outside of the spawning period. This was indicated by the recapture on the Manx spawning grounds of 3-6 ring herring tagged during summer in the Firth of Clyde (Morrison and Bruce, 1981). Aggregations of post-spawning adult herring were detected along the west coast of England during an acoustic survey in December 1996 (Department of Agriculture and Rural Development for Northern Ireland, unpublished data), showing that a component of the stock may remain within the Irish Sea.

The results of WESTHER, a recent EU-funded programme aiming to elucidate stock structures of herring throughout the western seaboard of the British Isles have recently been published. Using a combination of morphometric measurements, otolith structure, genetics and parasite loads the conductivity of stocks within and beyond the Irish Sea have been examined. The results of this programme and existing knowledge are currently being evaluated at SGHERWAY in light of the future assessment and management of stocks to the western British Isles.

A.2. Fishery

There have been three types of fishery on herring in the Irish Sea in the last 40 years:

i) Isle of Man- aimed at adult fish that spawn around the Isle of Man.

ii) Mourne- aimed at adult fish that spawn off the Northern Irish eastern coast.

iii) Mornington- a mixed industrial fishery that caught juveniles in the western Irish Sea.

The Mornington fishery started in 1969 and at its peak it caught 10,000 tonnes per year. It took place throughout the year. The fishery was closed due to management concerns in 1978 (ICES, 1994). In the 1970s the catch of fish from the Mourne fishery made up over a third of the total Irish Sea catch. The fishery was carried out by UK and Republic of Ireland vessels using trawls, seines and drift nets in the autumn. However the fishery declined and ceased in the early 1990s (ICES, 1994). The biomass of Mourne herring, determined from larval production estimates is now 2-4% of the total Irish Sea stock (Dickey-Collas *et al*., 2001).

The main herring fishery in the Irish Sea has been on the fish that spawn in the vicinity of the Isle of Man. The fish are caught as they enter the North Channel, down the Scottish coast, and around the Isle of Man. Traditionally this fishery supplied the Manx Kipper Industry, which requires fish in June and July. However the fish appeared to spawn slightly later in the year in the 1990s and this lead to problems of supply for the Manx Kipper Industry. In 1998 the Kipper companies decided to buy in fish from other areas. Generally the fishery has occurred from June to November, but is highly dependent on the migratory behaviour of the herring.

The fishery has been prosecuted mainly by UK and Irish vessels. TACs were first introduced in 1972, and vessels from France, Netherlands and the USSR also reported catches from the Irish Sea during the 1970s before the closure of the fisheries from 1978 to 1981. By the 1990s only the fishery on the Manx fish remained, and by the late 1990s this was dominated by Northern Irish boats. The number of Northern Irish vessels landing herring declined from 24 in 1995-96 to 6-10 in 1997-99 and to 4 in 2000. Only two vessels operated in 2002 and 2003. However, total landings have remained relatively stable since the 1980s whilst the mean amount of fish landed per fishing trip has increased, reflecting the increase in average vessel size

A.3. Ecosystem aspects

The main fish predators on herring in the Irish Sea include whiting (*Merlangius merlangus*), hake (*Merluccius merluccius*) and spurdog (*Squalus acanthias*). The size composition of herring in the stomach contents indicates that predation by whiting is mainly on 0-ring and 1-ring herring whilst adult hake and spurdogfish also eat older herring (Armstrong, 1979; Newton, 2000; Patterson, 1983). Sampling since the 1980s has shown cod (*Gadus morhua*), taken by both pelagic and demersal trawls in the Irish Sea, to be minor predators on herring. Small clupeids are an important source of food for piscivorous seabirds including gannets, guillemots and razorbills (ref…) which nest at several locations in and around the Irish Sea. Marine mammal predators include grey and harbour seals (ref.) and possibly pilot whales, which occur seasonally in areas where herring aggregate.

Whilst small juvenile herring occur throughout the coastal waters of the western and eastern Irish Sea, their distribution overlaps extensively with sprats (*Sprattus sprattus*). The biomass of small herring has typically been less than 5% of the combined biomass of small clupeids estimated by acoustics (ICES, 2008 ACOM:02). However in recent years the proportions have increased in favour of small herring (ICES, 2009 ACOM:??).

There are irregular cycles in the productivity of herring stocks (weights-at-age and recruitment). There are many hypotheses as to the cause of these changes in productivity, but in most cases it is thought that the environment plays an important role (through transport, prey, and predation). Coincident periods of high and low production have been seen in the herring in VIaN and Irish Sea herring. Exploitation and management strategies must account for the likelihood of productivity changing. The Irish Sea herring stock has shown a marked decline in productivity during the late 70's and remained on a low level since then.

Changes in Environment

There has been an increase in water temperatures in this area (ICES, 2006) which is likely to affect the distribution area of some fish species, and some changes of distribution have already been noted. Temperature increase is likely to affect stock recruitment of some species. In addition, the combined effects of over exploitation and environmental variability might lead to a higher risk of recruitment failure and decrease in productivity (ICES, 2007).

B. Data

B.1. Commercial catch

National landings estimates

The current ICES assessment of Irish Sea herring extends back to 1961, and is based on landings only. ICES WG reports (ICES 1981, 1986 and 1991) highlight the occurrence of discarding and slippage of catches, which can occur in areas where adult and juvenile herring co-occur. Discarding has been practised on an increasing scale since 1980 (ICES, 1986). This increase is primarily related to the onset of slippage of catches that coincided with the cessation of the industrial fishery in early 1979 (ICES, 1980). As a result of sorting practices, slippage has led to marked changes in the age composition of the catch since 1979 and considerable change in the mean weights at age in the catch of the three youngest age groups (ICES 1981). Estimates of discarding were sporadically performed in the 1980s (ICES, 1981, 1982, 1985 and 1986), but there are no estimates of discarding or slippage of herring in the Irish Sea fisheries since 1986. Highly variable annual discard rates are evident from the 1980s surveys. For example, discards estimates of juvenile herring (0-group) for the Mourne stock taken in the 1981 *Nephrops* fishery was estimated at $1.9x10^6$ of vessels landing in Northern Ireland, which amounts to approximately 20% of the Mourne fishery (ICES 1982). In 1982, at least 50% of 1-group herring caught were discarded at sea by vessels participating in the Isle of Man fishery (ICES, 1983). A more comprehensive survey programme to determine the rate of discarding in 1985 revealed discard estimates of 82% by numbers of 1-ring fish, 30% of 2-ring and 6% of 3-ring fish, with the dominant age group in the landed catch being 3 ring (ICES, 1986). A similar survey in 1986, however, found the discarding of young fish fell to a very low level (ICES, 1987). The 1991 WG discussed the discard problem in herring fisheries in general and suggested possible measures to reduce discarding. No quantitative estimates were given, but reports of fishermen suggesting discards of up to 50% of catch as a result of sorting practices by using sorting machines (ICES, 1991). The variation in discard rates since 1980, as a result of changes in discard practices, can probably be attributed to several changes in the management of the fishery. These include the availability of different fishing areas, the change to fortnightly catch quotas per boat (ICES, 1987) and level of TAC, where lower discard rates are observed with a higher TAC (ICES, 1989). The level of slippage is also related to the fishing season, since slippage is often at a high level in the early months (ICES, 1987). Due to the variable nature of discard estimates and the lack of a continuous data series, it has not been included in the annual catch at age estimates (with the exception of the 1983 assessment when the catch in numbers of 1-ringers was doubled based on a 50% discard estimate of this age group).

Landings data for herring in Division VIIa(N) are generally collated from all participating countries providing official statistics to ICES, namely UK (England & Wales, Northern Ireland, Scotland and the Isle of Man), Ireland, France, the Netherlands and what was formally the USSR. The data for the period 1971 to 2002 are reported in the various Herring Assessment Working Group Reports and are reproduced in Table 1. The official Statistics for Irish landings from VIIa have been processed to remove data from the Dunmore East fishery in area VIIa(S), and represent landings from VIIa(N) only.

Over the past three decades, the WG highlighted the under- or misreporting of catches as the major problem with regards to the accuracy of the landing data. Related to this are the problems of illegal landings during closed periods and paper landings. Area misreporting was also recognised (ICES, 1999), although a less prominent problem that is mostly corrected for.

The 1980 WG first identified the problem of misreporting of landings based on the results of a 3-year sampling programme, which was initiated after 1975 when herring were being landed in metric units at ports bordering the Irish Sea (1 unit = 100 kg nominal weight). The study showed the weight of a unit to be very variable, but was usually well in excess of 100 kg. An initial attempt to allow for misreporting using adjusted catches made very little difference to any of the values of fishing mortality (ICES, 1980). Subsequently, despite serious concerns about considerable under-reporting being raised (ICES 1990, 1994, 2000 and 2001), the WG made no attempts to examination the extent of the problem. This uncertainty signifies no estimates of under-reporting and consequently no allowance for under-reporting of landings has been made. Considerable doubt was raised as to the accuracy of landing data over the period 1981-87 (ICES, 1994). However, after apparent re-examination all WG landing statistics are assumed to be accurate up to 1997 (ICES, 2000), but with no reliable estimates of landings from 1998-2000 (ICES, 2001). The WG acknowledged that poor quality landing data bring the catch in numbers at age data into question and hence the accuracy of any assessment using data from such periods (ICES, 1994).

In 2002 the ICES assessment was extended back to include data for 1961-1970 with the intention of showing the stock development prior to the large expansion in fishing effort and stock size in the early 1970s. This has now been extended further back to 1955. Landings data for this period were extracted from the UK fisheries data bases (England & Wales, Scotland and Northern Ireland: Table 1, columns 8-10) and publications by Bowers and Brand (1973) for Isle of Man landings (column 11). Landings data for Ireland and France were not available.

To estimate the VIIa(N) herring landings for Ireland and France during 1955-1970, the NE Atlantic herring catches for each country were obtained from the FAO database (column 16). Using the ICES landings data for each country (column 17) the mean proportion of the VIIa(N) catch to the NE Atlantic catch during 1971 to 1981 was estimated (column 18). This was applied to the NE Atlantic catches from each country, for the period 1955 to 1970, to give an estimated landing for both France and Ireland (column 19). These landings were added to the known catches from the CEFAS database to give the total landings. The landings data (tonnes) used in the assessment are given in Table 1, column 14. It is anticipated that landings data for VIIa(N) for years prior to 1971 can be extracted from the Irish databases. However, the French landings will remain as estimates. As yet there has been no analysis of magnitude of errors in the old data. Need discussion on errors due to misreporting

Catch at age data

Age classes in the ICES Canum file refer to numbers of winter rings in otoliths. As the Irish Sea stock comprises autumn spawners, *i*-ring fish taken in year *y* will comprise fish in their i_{th} year of life if caught prior to the spawning season and $(i+1)_{th}$ year if caught after the spawning period. An *i*-ring fish will belong to year-class *y*-2. As spawning stock is estimated at spawning time (autumn), spawning stock and recruitment relationships require estimates of recruitment of *i*-ring fish in year *y* and estimates of SSB in year *i*-2. The current assessment estimates recruitment as numbers of 1-ring fish.

The most recent description of sampling and raising methods for estimating catch at age of herring stocks is in ICES (1996). This includes sampling by UK(E&W) and Ireland, but not UK(NI) and Isle of Man

UK(NI):A random sample of 10-20kg of herring is taken from each landing into the main landing port (Ardglass) by the NI Department of Agriculture and Rural Development. Samples are also collected from any catches landed into Londonderry. Prior to the 1990s, the samples were mostly processed fresh. During the 1990s, there was an increasing tendency for samples to be frozen for a period of weeks before processing. No corrections have been applied to weight measurements to allow for changes due to freezing and defrosting. The length frequency (total length) of each sample is recorded to the nearest 0.5cm below. A sample of herring is then taken for biological analysis as follows: one fish per 0.5 cm length class, followed by a random sample to make the sample up to 50 fish.

Otoliths are removed from each fish, mounted in resin on a black slide and read by reflected light. Ages are assigned according to number of winter rings.

Length frequencies (LFDs) for VIIa(N) catches are aggregated by quarter. The weight of the aggregate LFD is calculated using a length-weight relationship derived from the biological samples. The LFD is then raised to the total quarterly landings of herring by the NI fleets. A quarterly age-length key, derived from commercial catch samples only, is applied to the raised LFD to give numbers at age and mean weight at age.

IOM: IOM sampling covers the period 1923 – 1997. Samples are collected from any landings into Peel, by staff of the Port Erin Marine Laboratory (Liverpool University). The sampling and raising procedures are the same as described for UK(NI) with the following exceptions: i) the weight of the aggregate quarterly LFD is obtained from the original sample weights rather than using a length-weight relationship, and ii) the biological samples are random rather than stratified by length. The 1993 ICES herring assessment WGs noted a potential under-estimation by one ring, of herring sampled in the IOM. This was caused by a change in materials used for mounting otoliths and appears to have been a problem for ageing older herring in 1990-92. This was since rectified. However, the bias for the 1990-92 period has not yet been quantified and will be examined in the near future.

Ireland: Irish sampling of VIIa(N) herring covers the period 19xx – 2001. Some samples are from landings into NI but transported to factories in southern Ireland. Irish sampling schemes for herring in Div. VIa(S), VIIb, Celtic Sea and VIIj are described in ICES (1996). Methods for sampling catches in VIIa(N) are similar. The procedure is the same as described above for UK(NI) except that the biological samples are random rather than length stratified. ICES (1996) notes that a length-stratified scheme should be adopted to ensure proper coverage at the extremes of the LFDs.

Quality control of herring ageing has fallen under the remit of EU funded programmes EFAN and TACADAR, to which the laboratories sampling VIIa(N) herring contribute. An otolith exchange exercise was initiated in 2002 and is currently being completed.

B.2. Biological

Natural Mortality

Natural mortality (M) varies with age (expressed in number of winter rings) according to the following:

Rings	M
1	1
2	0.3
3	0.2
4+	0.1

Those values have been held constant from 1972 to date. Those values correspond to estimates for North Sea herring based on recommendations by the Multi-species WG (Anon. 1987a). which were applied to adjacent areas (Anon. 1987b).

Maturity at age

Combined, year-specific maturity ogives were used in the 2003 Assessment (ICES 2003). The way those values were derived is documented on Dickey-Collas *et al.* (2003). Prior to 2003 annually invariant estimates of the proportion of fish mature by age were used. Those were based on estimates from the 1970s (ICES, 1994). The use of the variable maturity ogive in 2003 did not change greatly the perception of the stock state (Dickey-Collas *et al., op cit*). Due to inconsistencies in the maturity data collected in 2003, the WG used a mean maturity ogive for the preceding nine years for 2003. The rationale for the 9 years was that there appeared to be a shift in the maturity ogive around 1993. After 2003 all weights and maturity-at-age data were based on corresponding annual biological samples.

SSB in September is estimated in the assessment. The survey larvae estimate is used as a relative index of SSB. The proportions of M and F before spawning are held constant over time in the assessment.

Stock weights

Stock weights at age have been derived from the age samples of the 3rd quarter landings since 1984 (R. Nash *pers comm.*). The stock mean weights for 1975-83 are time invariant and were re-examined in 1985 (Anon. 1985). They result from combining Manx and Mourne data sets. The weights at age of those stocks were considered relatively stable over time.

Mean weights

Mean weights-at-age in the catch (1985 to 2007) are given in Table 3. Mean weights-at-age of all ages remained low. There has been a change in mean weight over the time period 1961 to the present (ICES, 2003 ACFM:17). Mean weights-at-age increased between the early 1960s and the late 1970s whereupon there has been a steady decline to the early 1990s, where they remained low. In the assessment, mean weights-at-age for the period 1972 to 1984 are taken as unchanging. In extending the data series back from 1971 to 1961, mean weights-at-age in the catch were taken from samples recorded by the Port Erin Marine Laboratory (ICES, 2003 ACFM:17).

There was some uncertainty in the mean weights-at-age for 2003 presented to the WG, and consequently the WG replaced these with the average mean stock weights-at-age for the preceding five years (1998 to 2002).

Mean Lengths

Mean lengths-at-age are calculated using the catch data and are given for the years 1985 to 2006 in Table 4. In general, mean lengths have been relatively stable over the last few years and this trend has continued in 2006.

Catch at length

Catch at length are listed for the years 1990-2004 (Table 5)

B.3. Surveys

The following surveys have provided data for the VIIa(N) assessment:

Survey Acronym	Type	Abundance data	Area and Month	Period
AC(VIIaN)	Acoustic survey	Numbers at age (1-ring and older); SSB	VIIa(N) from 53^{0} 20’N – 55^{o}N; September	1994 – present
NINEL	Larva survey	Production of larvae at 6mm TL	VIIa(N) from 53^{o} 50’N – 54^{o} 50’N; November	1993 – present
DBL	Larva survey	Production of larvae at 6mm TL	East coast of Isle of Man; October	1989 – 1999 (1996 missing)
GFS-oct	Groundfis h survey	Mean nos. caught per 3 n.miles (1&2 ringers), by region	VIIa(N) from 53^{0} 20’N – 54^{o} 50’N (stratified); October	1993 - 1999
GFS-mar	Groundfis h survey	Mean nos. caught per 3 n.miles (1&2 ringers), by region	VIIa(N) from 53^{0} 20’N – 54^{o} 50’N (stratified); March	1993 - 1999

Data from a number of earlier surveys have been documented in the ICES WG reports. These include:

NW Irish Sea young herring surveys (Irish otter trawl survey using commercial trawler; 1980 – 1988)

Douglas Bank (East Isle of Man) larva surveys (ring net surveys; 1974 – 1988) (Port Erin Marine Lab)

Douglas Bank spawning aggregation acoustic surveys (1989, 1990, 1994, 1995) (Port Erin Marine Lab)

Western Irish Sea acoustic survey (July 1991, 1992) (UK(NI))

Eastern Irish Sea acoustic survey (December 1996)

Surveys used in recent assessments are described below.

AC(VIIaN) acoustic survey

This survey uses a stratified design with systematic transects, during the first two weeks of September. Vessel currently used is the R.V. Corystes (UK(NI)) replacing the R.V. *Lough Foyle* (UK(NI)). Starting positions are randomized each year (see recent HAWG reports for transect design and survey results). The survey is most intense around the Isle of Man (2 to 4 n.mile transect spacing) where highest densities of adult herring are expected based on previous surveys and fishery data. Transect spacing of 6 to 10 n.miles are used elsewhere. A sphere-calibrated EK-500 38kHz sounder is employed, and data are archived and analysed using Echoview (SonarData, Tasmania). Targets are identified by midwater trawling. Acoustic records are manually partitioned to species by scrutinising the echograms and using trawl compositions where appropriate. ICES-recommended target strengths are used for herring, sprat, mackerel, horse mackerel and gadoids. The survey design and implementation follows, where possible, the guidelines for ICES herring acoustic surveys in the North Sea and West of Scotland. The survey data are analysed in 15-minute elementary distance sampling units (approx. 2.5 n.miles). An estimate of density by age class, and spawning stock biomass, is obtained for each EDSU and a distance-weighted average calculated for each stratum. These are raised by stratum area to give population numbers and SSB by stratum.

NINEL larva survey

The DARD herring larva survey has been carried out in November each year since 1993. Sampling is carried out on a systematic grid of stations covering the spawning grounds and surrounding regions in the NE and NW Irish Sea (Figure 1). Larvae are sampled using a Gulf-VII high-speed plankton sampler with 280 μm net. Double-oblique tows are made to within 2m of the seabed at each station. Internal and external flow rates, and temperature and salinity profiles, were recorded during each tow. Lengths of all herring larva captured are recorded.

Mean catch-rates (nos.m^{-2}) are calculated over stations to give separate indices of abundance for the NE and NW Irish Sea. Larval production rates (standardised to a larva of 6mm), and birth-date distributions, are computed based on the mean density of larvae by length class. A growth rate of 0.35mm day^{-1} and instantaneous mortality of 0.14 day^{-1} are assumed based on estimates made in 1993 - 1997. More recent studies have indicated a mortality rate of 0.09, and this value is also applied to examine the effect on trends in estimates of larval production

DBL larva survey

Herring larvae were sampled on the east side of the Isle of Man in September or October each year. Double oblique tows with a 60 cm Gulf VII/PRO-NET high-speed plankton sampler with a 40cm aperture nose cone were undertaken on a 5 Nm square grid. The tow profile was followed with a FURUNO net sonde attached to the top of the equipment. The volume of water filtered was calculated from the nose cone mouth flow meter. The samples were preserved in 4% seawater buffered formalin and stored in 70% alcohol.

All herring larvae were sorted from the samples. The numbers of larvae per m^3 were calculated from the volume of water filtered and the number of larvae per tow. Up to 100 larvae from each tow were measured with an ocular graticule in a stereo microscope. Each sample was assigned to a sampling square and the total number of larvae per 0.5mm size class calculated from the average depth of the square and the surface area.

The total production and time of larvae hatch was calculated using an instantaneous mortality coefficient (k) of 0.14 and a growth rate of 0.35 mm d^{-1} in the formula:

$$N_t = N_o e^{-(kt)}$$

Production was calculated as the sum of all size classes/hatching dates. Spawning dates were taken as 10 days prior to the hatching date (Bowers 1952).

The Douglas Bank Larva survey has not been updated since 1999. Examination of the sum of squares surface from SPALY in 2005 indicated that the Douglas Bank larvae index (DBL) was having no influence in the assessment estimates for the current year. Therefore, the WG agreed on removing DBL from the analysis (ICES, 2005). The DBL time series is listed in Table 6

GFS-oct and –mar groundfish surveys

The DARD groundfish survey of ICES Division VIIaN are carried out in March and October at standard stations between 53° 20'N and 54° 45'N (Figure 2). Data from additional stations fished in the St George's Channel since October 2001 have not been used in calculating herring indices of abundance. As in previous surveys, the area was divided into strata according to depth contour and sediment type, with fixed station positions (note that the strata in Fig. 2 differ from those in the September acoustic survey shown in Fig. 1). The sampling gear was a Rockhopper otter trawl fitted with non-rotating rubber discs of approximately 15 cm diameter on the footrope. The trawl fishes with an average headline height of 3.0 m and door spread of 30 - 40 m depending on depth and tide. A 20mm stretched-mesh codend liner was fitted. During March, trawling was carried out at an average speed of 3 knots across the ground, over a standard distance of 3 nautical miles at standard stations and 1 nautical mile in the St. George's Channel. Since 2002, all survey stations in the October survey have been of 1-mile distance. Comparative trawling exercises during the October surveys and during an independent exercise in February 2003 indicate roughly similar catch-rates per mile between 1-mile and 3-mile tows. It is planned to continue with some comparative trawling experiments during future surveys to improve the statistical power of significance tests between the 1-mile and 3-mile tows.

As the surveys are targeted at gadoids, ages were not recorded for herring. The length frequencies in each survey were sliced into length ranges corresponding to 0-ring and 1-ring herring according to the appearance of modes in the overall weighted mean length frequency for each survey. Some imprecision will have resulted because of the overlap in length-at-age distributions of 1-ring and 2-ring herring. The error is considered to be comparatively small for most of the surveys where clear modes are apparent. There was no clear division between 1-ring and 2-ring herring in the March 2003 groundfish survey, and the estimate for 1-ringers may include a significant component of small 2-ringers. The arithmetic mean catch-rate and approximate variance of the mean was computed for each age-class in each survey stratum, and averaged over strata using the areas of the strata as weighting factors.

Groundfish surveys were used by the 1996 to 1999 HAWG to obtain indices for 0- and 1-ring herring in the Irish Sea. These indices have performed poorly in the assessment and have not been used since 1999. The time-series is listed in Table 7.

B.4. Commercial CPUE

Commercial CPUE's are not used for this stock.

B.5. Other relevant data

C. Historical Stock Development

Model used: ICA

Software used: ICA (Patterson 1998)

Model Options chosen:

Separable constraint over last 6 years (weighting = 1.0 for each year)

Reference age = 4

Constant selection pattern model

Selectivity on oldest age = 1.0

First age for calculation of mean F = 2

Last age for calculation of mean F = 6

Weighting on 1-rings = 0.1; all other age classes = 1.0

Weighting for all years = 1.0

All indices treated as linear

No S/R relationship fitted

Lowest and highest feasible F = 0.05 and 2.0

All survey weights fitted by hand i.e., 1.0 with the 1 ringers in the acoustic survey weighted to 0.1.

Correlated errors assumed i.e., = 1.0

No shrinkage applied

Input data types and characteristics:

Type	Name	Year range	Age range	Variable from year to year Yes/No
Caton	Catch in tonnes	1961-last data year	NA	Yes
Canum	Catch at age in numbers	1961-last data year	1-8+	Yes
Weca	Weight at age in the commercial catch	1961-1971 1972-1983 1984-last data year	1-8+ 1-8+ 1-8+	Yes No Yes
West	Weight at age of the spawning stock at spawning time.	1961-1971 1972-1983 1984-last data year	1-8+ 1-8+ 1-8+	Yes No Yes
Mprop	Proportion of natural mortality before spawning	1961-last data year	NA	No
Fprop	Proportion of fishing mortality before spawning	11961-last data year	NA	No
Matprop	Proportion mature at age	1961-last data year	1-8+	Yes
Natmor	Natural mortality	1961-last data year	1-8+	No

Tuning data:

Type	Name	Year range	Age range
Tuning fleet 1	NINEL	1993-2003	SSB
Tuning fleet 2	DBL	1989-1999	SSB
Tuning fleet 3	GFS-octtot	1993-2005	1 & 2
Tuning fleet 4	GFS-martot	1992-2003	1
Tuning fleet 5	ACAGE	1994-2003	1-8+
Tuning fleet 6	AC_VIIa(N)	1994-2003	SSB
Tuning fleet 7	AC_1+	1994-2003	SSB/Total biomass

Two-stage biomass model

In 2005 a Two-Stage Biomass model for the assessment of Irish Sea VIIa(N) herring given additional variance in the recruitment index was presented by Roel and De Oliveira (ICES 2005 WD10).

The model addresses the problem of the high uncertainty in the assessment of Irish Sea herring, which to some extent may be related to the presence of juvenile Celtic Sea herring in both the fishery and the survey area. In the absence of a Celtic Sea herring recruitment index, the biomass model presented addressed the problem by limiting recruitment variability in Irish Sea herring on the basis of information available for other herring stocks. The total variability in the recruitment data was divided into two components: the one related to Irish Sea herring recruitment variability and the rest which was likely to represent variability related to the presence of Celtic Sea juveniles.

The model is fitted to biomass indices of 1-ringer fish and to aggregated biomass indices for the 2-rings+ from Northern Ireland acoustic surveys. The survey age composition data and the weights-at-age from the catch are used to calculate the proportion of 1-ring fish in the survey. The proportion is then applied to the total acoustic biomass to compute the 1-ring biomass index while the 2-ring+ index is obtained by subtraction. The catch in weight was split in a similar manner but based on commercial catch samples.

The model

The dynamics take into account only two stages in the population: the recruits, 1-ringer fish, and the fully recruited that comprise 2-ringer and older fish. The biomass dynamics is represented by the following:

$$B_{y+1} = B_{1,y+1} + \left[(B_{2+,y} + B_{1,y}) e^{-3g/4} - C_y \right] e^{-g/4} \quad [1]$$

where

$B_{1,y}$ is the biomass of recruitment (tons) at the start of year y;

$B_{2+,y}$ is the biomass of 2+ aged fish (tons) at the start of year y;

C_y is the biomass of fish caught (tons) during year y, assumed to be taken in a pulse fishery 3/4 of the way into year y; and

g is a composite parameter, treated as an annual rate, which accounts for natural mortality and growth.

Maximum likelihood estimation is used, assuming survey indices are log-normally distributed about their expected values. Standard errors of the log-distributions are approximated by the sampling CVs of the untransformed distributions.

The estimable parameters are g, $B_{2+,1994}$, $B_{1,1994}$,...,$B_{1,2004}$, λ^2 and q

where q corresponds to the catchability associated with the survey indices $I_{1,y}$ and $I_{2+,y}$ and λ^2 is the additional variance.

The data were explored for values of recruitment variability (σ_R) = 0.4 and 0.8. The value 0.4 corresponds to the variability in recruitment age 1 as estimated by ICA for the period used in this analysis, but excluding the most recent estimate (1994 – 2006). The two parameters, g and q, may be confounded in the model indicating that fixing g was appropriate. This parameter was fixed to 0.2 following a similar approach as in Roel and De Oliveira (ICES 2005 WD10).

D. Short-Term Projection

NOT USED IN 2004
Model used: Age structured

Software used: MFDP ver 1a

Initial stock size: Taken from the last year of the assessment. 1-ring recruits taken from a geometric mean for the years 1983 to two years prior to the current year. Where 1-ringers are absurdly estimated in the assessment 2-ringers are estimated as a geometric mean of the previous 10 year period.

Maturity: Mean of the previous three years of the maturity ogive used in the assessment.

F and M before spawning: Set to 0.9 and 0.75 respectively for all years.

Weight at age in the stock: Mean of the previous three years in the assessment.

Weight at age in the catch: Mean of the previous three years in the assessment.

Exploitation pattern: Mean of the previous three years, scaled by the Fbar (2-6) to the level of the last year.

Intermediate year assumptions: TAC constraint.

Stock recruitment model used: None used

Procedures used for splitting projected catches: Not relevant

E. Medium-Term Projections

F. Long-Term Projections

Not done

G. Biological Reference Points

Until there is confidence in the assessment the Working Group decided not to revisit the estimation of $\mathbf{B}_{pa}$ (9,500 t) and $\mathbf{B}_{lim}$ (6,000 t). There were no new points to add to the discussions and deliberations presented in 2000 (ICES 2000/ACFM:10).

H. Other Issues

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Table 1. Biological sampling of Irish Sea (VIIa(N)) landings. Country denotes sampling nation.

	Coverage	% of landings sampled	No of samples	Total landings	landings by Q?	IRELAND				NORTHERN IRELAND				ISLE OF MAN				OTHERr UK/UK OFFSHORE				TOTAL			
Year						Landings	Samples	Lengths	Ages	Landings	Samples	Lengths	Ages	Landings	Samples	Lengths	Ages	Landings	Samples	Lengths	Ages	Landings	Samples	Lengths	Ages
1988	(4)					**2579																	0	0	0
1989	(3) temp spread good		88	4962	NO	1430	21	1843	555		45	11464	2249		21	5173	1057		1	96	0	4962	88	18576	3861
1990	p(1,2)	68%	100	6312	YES	1699	44	5176	1022	2322	38	9310	1900	542	18	5276	897	179/1570	0	0	0	6312	100	19762	3819
1991	g	90%	138	4398	YES	80	5	1255	247	3298	105	16724	2484	629	28	8280	1392	0/391	0	0	0	4398	138	26259	4123
1992	g	98%	32	5270	YES	406	3	593	99	4120	16	1588	770	741	13	3488	680	3	0	0	0	5270	32	5669	1549
1993	p (1)	65%	48	4408	YES	0	5	1378	245	3632	34	3744	832	776	9	1560	448	0	0	0	0	4408	48	6682	1525
1994	v.g	95%	59	4828	YES	0	21	569	100	3956	43	3691	1175	716	14	3724	614	156	0	0	0	4828	59	7984	1889
1995	g (1)	87%	85	5076	YES	0	21	569	100	3860	75	8282	2545	615	8	2182	400	601	0	0	0	5076	85	11033	3045
1996	g (1,5)	70%	51	5301	YES	100	1	537	55	4335	45	4813	1050	537	5	997	228	329	0	0	0	5301	51	6347	1333
1997	g (1,2)	91%	34	6649	YES	0	2	473	50	5679	25	2900	1199	765	7	2246	340	205	0	234	76	6649	34	5853	1665
1998	g (2)	84%	31	4904	YES	0	2	150	50	4131	29	2979	1450	0	0	0	0	7732	0	0	0	4904	31	3129	1500
1999	g (2)	72%	32	4127	YES	0	4	0	200	2967	28	2518	1400	0	0	0	0	11602	0	0	0	4127	32	2518	1600
2000	v.g	97%	28	2002	YES	0	5	932	0	2002	23	1915	1150	0	0	0	0	0	0	0	0	2002	28	2847	1150
2001	p (2)	70%	31	5461	YES	862	8	1031	222	3786	23	2915	1149	86	0	0	0	7272	0	0	0	5461	31	3946	1371
2002	p (1)	62%	9	2392	YES	286	0	0	0	2051	9	949	450	4	0	0	0	51	0	0	0	2392	9	949	450
2003			9	2399	YES	0				2399	9	1132	445												
2004			9	2531	YES	749	2	190	133	1782	7	991	350												
2005			26	4387	YES	1153	5	1312	372	3234	21	4135	1018												
2006			22	4402	YES	581	8	2248	549	3821	14	1982	686												
2007			29	4629	YES	0				4629	29														
2008			19	4895	YES	0				4895	19														

COVERAGE: Sum of the landings (by Q and Nation(UK disaggregated))/total landings. From 1993 (possibly from 1990) to date landings and sampling levels are presented by quarter so coverage is related to this level of detail:

VERY GOOD (v.g) : all landings which individually are >10% of the total were sampled, all Q for which there were landings were sampled

GOOD (g) : landings that constitute the majority of the catch (adding to approx 70% or more of total) were sampled

POOR (p) : some of the large landings not sampled

(1): unsampled quarters

(2): large landings with few samples or unsampled. High level of sampling corresponds to 1 sample per 100t landed (WG rep 1997)

(3): Comment from WG rep. From 1990 going back, Report landings and sampling levels are shown aggregated for the whole year. UK landings lumped in one figure.

(4): no information in the WGrep of level of sampling prior to 1988. Sampling levels believed to be good. Actual figures to be provided by R. Nash, M Armstrong and CEFAS after going back to their labs.

(5): NO samples for NI landings in 4th Q, there is a suspicion that the figures correspond to 'paper landings'.

[1]Samples applied to NI landings: [2]Large unsampled landings.

Table 2: Data and method used to estimate landings from Division VIIa(N) herring.

																Estimates of maximum likely catch for VIIa(N) incl. of French and ROI catches							
Column No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16		17		18		19	
	ICES table							British Isles catches						CATCH IN ASSESS-MENT		NE Atlantic catch		ICES 7a catch		% of NE atlantic		max likely catch	
	Ireland	UK	France	Netherlands	USSR/ Russia	Unallocated	Total	England	Northern Ireland	Wales	Manx	Irish	Total			France	Ireland	France	Ireland	France	Ireland	France	Ireland
1955								0	0	72	3815		3887	**8056**		60500	4900					3630	539
1956								5	0	20	4762		4787	**8743**		52000	7600					3120	836
1957								21	0	1638	2832		4491	**7966**		36100	11900					2166	1309
1958								31	0	12	2482		2525	**6261**		38800	12800					2328	1408
1959								20	0	96	3577		3693	**7833**		40400	15600					2424	1716
1960								1	0	9	2093		2103	**6607**		36200	21200					2172	2332
1961								32	0	144	1941		2117	**5710**		36600	12700					2196	1397
1962								4	0	21	1528		1552	**4343**		29100	9500					1746	1045
1963								5	0	34	974		1013	**3947**		33500	8400					2010	924
1964								2	0	0	556		558	**3593**		35000	8500					2100	935
1965								1629	0	398	1135		3162	**5923**		26400	10700					1584	1177
1966								2041	0	46	596		2683	**5666**		22400	14900					1344	1639
1967								2911	0	8	1959		4878	**8721**		20600	23700					1236	2607
1968								1504	0	5	3253		4762	**8660**		22800	23000					1368	2530
1969								3591	0	63	5044		8698	**14141**		27100	34700					1626	3817
1970								4662	0	16	9782		14461	**20622**		24400	42700					1464	4697
1971	3131	21861	1815				26807							**26807**		23500	31200	1815	3131	0.08	0.10		
1972	2529	23337	1224	260			27350							**27350**		29900	47800	1224	2529	0.04	0.05		
1973	3614	18587	254	143			22598							**22598**		30800	38900	254	3614	0.01	0.09		
1974	5894	27489	3194	1116	945		38638							**38638**		21199	39608	3194	5894	0.15	0.15		
1975	4790	18244	813	630	26		24503							**24503**		25645	29752	813	4790	0.03	0.16		
1976	3205	16401	651	989			21246							**21246**		20466	22227	651	3205	0.03	0.14		

1977	3331	11498	85	500			15414							**15414**		4164	23436	85	3331	0.02	0.14		
1978	2371	8432	174	98			11075							**11075**		4201	27717	174	2371	0.04	0.09		
1979	1805	10078	455				12338							**12338**		3596	27454	455	1805	0.13	0.07		
1980	1340	9272	1				10613							**10613**		6126	36917	1	1340	0.00	0.04		
1981	283	4094					4377							**4377**		6952	29926			0.00	0.00		
1982	300	3375				1180	4855							**4855**									
1983	860	3025	48				3933							**3933**						0.06	0.11		
1984	1084	2982					4066							**4066**									
1985	1000	4077				4110	9187							**9187**									
1986	1640	4376				1424	7440							**7440**									
1987	1200	3290				1333	5823							**5823**									
1988	2579	7593					10172							**10172**									
1989	1430	3532					4962							**4962**									
1990	1699	4613					6312							**6312**									
1991	80	4318					4398							**4398**									
1992	406	4864					5270							**5270**									
1993	0	4408					4408							**4408**									
1994	0	4828					4828							**4828**									
1995	0	5076					5076							**5076**									
1996	100	5180				22	5302							**5302**									
1997	0	6651					6651							**6651**									
1998	0	4905					4905							**4905**									
1999	0	4127					4127							**4127**									
2000	0	2002					2002							**2002**									
2001	862	4599					5461							**5461**									
2002	286	2107					2393							**2393**									
2003	0	2399					2399							**2399**									
2004	749	1782					2531							**2531**									
2005	1153	3234					4387							**4387**									
2006	581	3821					4402							**4402**									
2007	0	4629					4629							**4629**									
2008	0	4895					4895							**4895**									

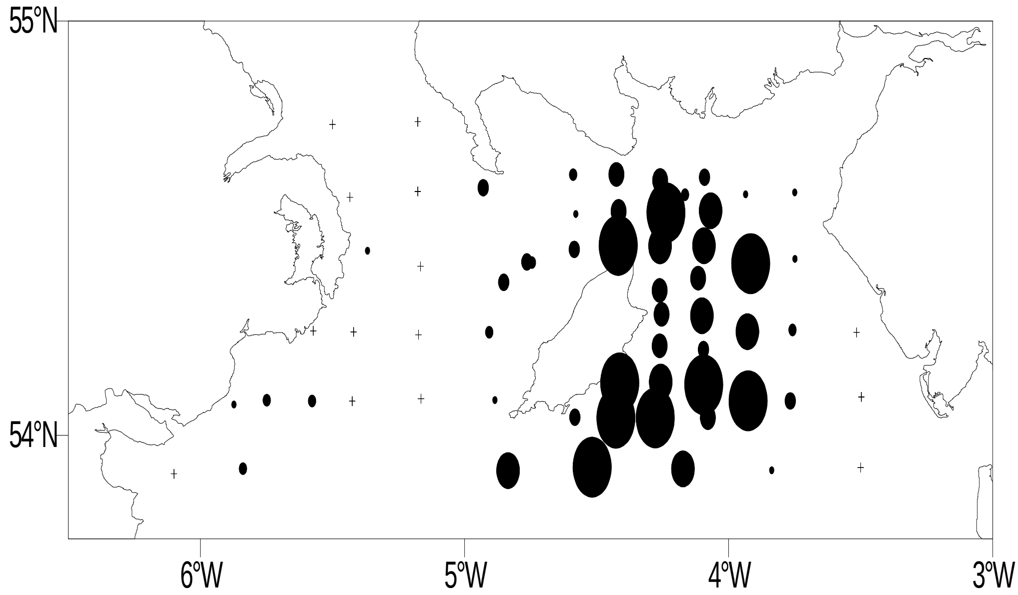
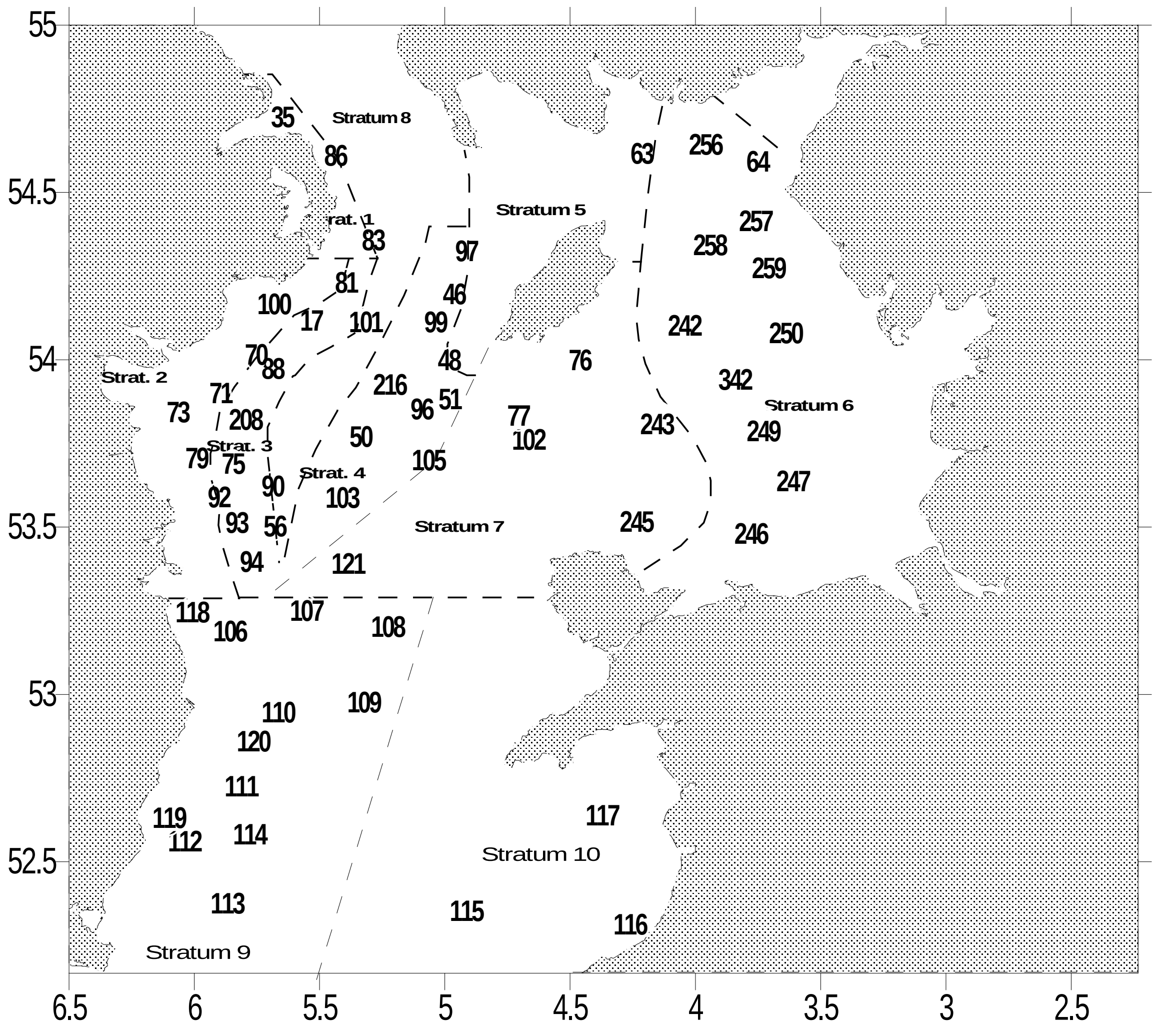


Figure 1. Sampling stations for larvae in the North Irish Sea (NINEL). Sampling is undertaken in November each year.



Key to strata:
1. Irish Coast (N), <100m, Mixed sediments
2. Irish Coast, < 50m, sand and finer sediments
3. Irish Coast, 50 - 100m, Muddy sediments
4. W and SW Isle of Man, 50 - 100m, mud and muddy sand
5. N Isle of Man, <50m, gravel sediments
6. Eastern Irish Sea, <50m, sand and finer sediments
7. S. Isle of Man, <100m, gravel sediments
8. Deep western channel and North Channel >100m
9. St George's Channel west; sandy/mixed sediments; <100m
10. St George's Channel east; sandy/mixed sediments; <100m

Figure 2. Standard station positions for DARD groundfish survey of the Irish Sea in March and October. Boundaries of survey strata are shown. Indices for the "Western Irish Sea" use data from strata 2 - 4. Indices for the "Eastern Irish Sea" use data from stratum 6 only (few juvenile herring are found in stratum 7). (Note different stratification to Fig. 1.). New stations fished in the St Georges Channel (strata 9 and 10) since October 2001 are not included in the survey indices. Stratum 5 (1 station only in recent years) is also excluded from the index. There are no stations in stratum 8 due to difficult trawling conditions for the gear used in the survey. Station 121 in stratum 7 has been fished only once and is excluded from the index.

Table 3. Irish Sea Herring Division VIIa(N). Mean weights-at-age in the catch.

Year	Weights-at-age (g) Age (rings)							
	1	2	3	4	5	6	7	8+
1985	87	125	157	186	202	209	222	258
1986	68	143	167	188	215	229	239	254
1987	58	130	160	175	194	210	218	229
1988	70	124	160	170	180	198	212	232
1989	81	128	155	174	184	195	205	218
1990	77	135	163	175	188	196	207	217
1991	70	121	153	167	180	189	195	214
1992	61	111	136	151	159	171	179	191
1993	88	126	157	171	183	191	198	214
1994	73	126	154	174	181	190	203	214
1995	72	120	147	168	180	185	197	212
1996	67	116	148	162	177	199	200	214
1997	64	118	146	165	176	188	204	216
1998	80	123	148	163	181	177	188	222
1999	69	120	145	167	176	188	190	210
2000	64	120	148	168	188	204	200	213
2001	67	106	139	156	168	185	198	205
2002	85	113	144	167	180	184	191	217
2003*	81	116	136	160	167	172	186	199
2004	73	107	130	157	165	187	200	205
2005	67	103	136	156	166	180	191	209
2006	64	105	131	149	164	177	184	211
2007	67	112	135	158	173	183	199	227
2008	71	110	135	153	156	182	196	206

*** Average for the preceding five years**

Table 4. Irish Sea Herring Division VIIa(N). Mean length-at-age in the catch.

Year	Lengths-at-age (cm) Age (rings)							
	1	2	3	4	5	6	7	8+
1985	22.1	24.3	26.1	27.6	28.3	28.6	29.5	30.1
1986	19.7	24.3	25.8	26.9	28.0	28.8	28.8	29.8
1987	20.0	24.1	26.3	27.3	28.0	29.2	29.4	30.1
1988	20.2	23.5	25.7	26.3	27.2	27.7	28.7	29.6
1989	20.9	23.8	25.8	26.8	27.8	28.2	28.0	29.5
1990	20.1	24.2	25.6	26.2	27.7	28.3	28.3	29.0
1991	20.5	23.8	25.4	26.1	26.8	27.3	27.7	28.7
1992	19.0	23.7	25.3	26.2	26.7	27.2	27.9	29.4
1993	21.6	24.1	25.9	26.7	27.2	27.6	28.0	28.7
1994	20.1	23.9	25.5	26.5	27.0	27.4	27.9	28.4
1995	20.4	23.6	25.2	26.3	26.8	27.0	27.6	28.3
1996	19.8	23.5	25.3	26.0	26.6	27.6	27.6	28.2
1997	19.6	23.6	25.1	26.0	26.5	27.1	27.7	28.2
1998	20.8	23.8	25.2	26.1	27.0	26.8	27.2	28.7
1999	19.8	23.6	25.0	26.1	26.5	27.1	27.2	28.0
2000	19.7	23.8	25.3	26.3	27.1	27.7	27.7	28.1
2001	20.0	22.9	24.8	25.7	26.2	26.9	27.5	27.8
2002	21.1	23.1	24.8	26.0	26.6	26.7	27.0	28.1
2003	21.1	23.7	25.0	26.5	26.9	27.1	27.8	28.5
2004	20.7	23.1	24.6	25.8	26.1	27.1	27.6	28.3
2005	20.0	22.6	24.5	25.5	26.0	26.6	27.1	27.8
2006	19.5	22.7	24.3	25.3	26.0	26.6	26.9	28.0
2007	20.1	23.0	24.1	25.1	25.8	26.2	26.7	27.8
2008	20.0	22.7	24.1	25.0	25.2	26.3	26.9	27.4

Table 5. Irish Sea Herring Division VIIa (N). Catch-at-length for 1990-2004. Numbers of fish in thousands.

Length	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
14															
14.5															
15			95												
15.5			169							10					
16	6		343			21	21	17		19	12	9			
16.5	6	2	275			55	51	94		53	49	27			13
17	50	1	779		84	139	127	281	26	97	67	53			25
17.5	7	4	1106		59	148	200	525	30	82	97	105			84
18	224	31	1263		69	300	173	1022	123	145	115	229			102
18.5	165	56	1662		89	280	415	1066	206	135	134	240	36		114
19	656	168	1767	39	226	310	554	1720	317	234	164	385	18		203
19.5	318	174	1189	75	241	305	652	1263	277	82	97	439	0	29	269
20	791	454	1268	75	253	326	749	1366	427	218	109	523	0	73	368
20.5	472	341	705	57	270	404	867	1029	297	242	85	608	18	215	444
21	735	469	705	130	400	468	886	1510	522	449	115	1086	307	272	862
21.5	447	296	597	263	308	782	1258	1192	549	362	138	1201	433	290	1007
22	935	438	664	610	700	1509	1530	2607	1354	1261	289	1748	1750	463	1495
22.5	581	782	927	1224	785	2541	2190	2482	1099	2305	418	1763	1949	600	2140
23	2400	1790	1653	2016	1035	4198	2362	3508	2493	4784	607	2670	2490	1158	2089
23.5	1908	1974	1156	2368	1473	4547	2917	3902	2041	4183	951	2254	1552	1380	2214
24	3474	2842	1575	2895	2126	4416	3649	4714	3695	4165	1436	3489	1029	1273	2054
24.5	2818	2311	2412	2616	2564	3391	4077	4138	2769	3397	1783	4098	758	1249	2269
25	4803	2734	2792	2207	3315	3100	4015	5031	2625	2620	2144	5566	776	1163	1749
25.5	3688	2596	3268	2198	3382	2358	3668	3971	2797	1817	1791	4785	1335	1211	1206
26	4845	3278	3865	2216	3480	2334	2480	3871	3115	1694	1349	3814	1570	1140	823
26.5	3015	2862	3908	2176	2617	1807	2177	2455	2641	1547	840	2243	1552	1573	587
27	3014	2412	3389	2299	2391	1622	1949	1711	2992	1475	616	1489	776	1607	510
27.5	1134	1449	2203	2047	1777	990	1267	1131	1747	867	479	644	433	1189	383
28	993	922	1440	1538	1294	834	906	638	1235	276	212	496	162	726	198
28.5	582	423	569	944	900	123	564	440	170	169	58	179	108	569	51
29	302	293	278	473	417	248	210	280	111	61	42	10	36	163	
29.5	144	129	96	160	165	56	79	59	92		12	0	36	129	
30	146	82	70	83	9	40	32	8	84		6	9		43	
30.5	57	36	36	15	27	5	0	5	3					43	
31	54	12	2	4		1	2							43	
31.5	31	3													
32	29														
32.5															
33															
33.5															
34															

Table 5 (continued). **Irish Sea Herring Division VIIa (N). Catch-at-length for 1990-2004. Numbers of fish in thousands.**

LENGTH	2005	2006	2007	2008
14				
14.5				
15				
15.5			16	
16		2		
16.5	1	44	33	1
17	39	140	69	3
17.5	117	211	286	11
18	291	586	852	34
18.5	521	726	2088	64
19	758	895	2979	85
19.5	933	1246	3527	108
20	943	984	3516	100
20.5	923	1443	2852	133
21	1256	1521	3451	192
21.5	1380	1621	2929	217
22	1361	2748	3821	271
22.5	1448	3629	3503	229
23	1035	4358	4196	322
23.5	1256	2920	3697	264
24	1276	3679	3178	259
24.5	1083	2431	2136	204
25	1086	3438	1503	148
25.5	584	2198	952	114
26	438	1714	643	78
26.5	203	605	330	42
27	165	445	147	23
27.5	60	155	72	10
28	45	104	33	12
28.5	18	9	26	1
29	12	46		
29.5			7	
30				
30.5				
31				
31.5				
32				
32.5				
33				
33.5				
34				

Table 6. Irish Sea herring Division VIIa(N). Northern Ireland groundfish survey indices for herring (Nos. per 3 miles).

(a) 0-ring herring: October survey

	Western Irish Sea			Eastern Irish Sea			Total Irish Sea		
Survey	Mean	N.obs	SE	Mean	N.obs.	SE	Mean	N. obs	SE
1991	54	34	22						
1992	210	31	99	240	8	149	177	46	68
1993	633	26	331	498	10	270	412	44	155
1994	548	26	159	8	7	5	194	41	55
1995	67	22	23	35	9	18	37	35	11
1996	90	26	58	131	9	79	117	42	50
1997	281	26	192	68	9	42	138	43	70
1998	980	26	417	12	9	10	347	43	144
1999	389	26	271	90	9	29	186	43	96
2000	202	24	144	367	9	190	212	38	89
2001	553	26	244	236	11	104	284	45	93
2002	132	26	84	18	11	10	63	45	31
2003	1203	26	855	75	11	47	446	45	296
2004	838	26	292	447	11	191	469	45	125
2005	1516	26	1036	256	11	152	627	45	363
2006	4677	26	2190	2140	11	829	2468	45	822

(b) 1-ring herring: March Surveys.

	Western Irish Sea			Eastern Irish Sea			Total Irish Sea		
Survey	Mean	N.obs	SE	Mean	N.obs.	SE	Mean	N.obs	SE
1992	392	20	198	115	10	73	190	34	77
1993	1755	27	620	175	10	66	681	45	216
1994	2472	25	1852	106	9	51	923	39	641
1995	1299	26	679	73	8	32	480	42	235
1996	1055	22	638	285	9	164	487	39	230
1997	1473	26	382	260	9	96	612	43	137
1998	3953	26	1331	250	9	184	1472	43	466
1999	5845	26	1860	736	9	321	2308	42	655
2000	2303	26	853	546	10	217	1009	44	306
2001	3518	26	916	1265	11	531	1763	45	381
2002[a]	2255	25	845	185	11	84	852	44	294
2002[b]	7870	26	5667	185	11	84	2794	45	1960
2003	2103	26	876	896	11	604	1079	45	382
2004	6611	25	2726	491	11	163	2486	44	945
2005	7274	26	3097	1240	8	375	3001	42	1121
2006	4249	26	1687	2630	11	813	2496	45	662

a. Unusually large catch removed, b. unusually large catch retained.

Table 6. (Continued) Irish Sea herring Division VIIa(N). Northern Ireland groundfish survey indices for herring (Nos. per 3 miles.).

(c) 1-ring herring: October Surveys

	Western Irish Sea			Eastern Irish Sea			Total Irish Sea		
Survey	Mean	N.obs	SE	Mean	N.obs.	SE	Mean	N.obs	SE
1991	102	34	34	n/a	n/a	n/a	n/a	n/a	n/a
1992	36	31	18	20	8	11	21	46	8
1993	122	26	66	4	10	2	44	44	23
1994	490	26	137	17	6	10	176	40	47
1995	153	22	61	3	9	1	55	35	21
1996	30	26	13	2	9	1	11	42	5
1997	612	26	369	0.2	9	0.2	302	43	156
1998	39	26	15	13	9	10	53	43	35
1999	81	26	41	104	9	95	74	43	40
2000	455	24	250	74	9	52	579	38	403
2001	1412	26	641	5	11	3	513	45	223
2002	370	26	111	4	11	2	291	45	158
2003	314	26	143	410	11	350	267	45	144
2004	710	26	298	103	11	74	299	45	108
2005	3217	25	1467	18	11	12	1121	44	507
2006	1458	26	669	40	11	18	523	45	231

Table 7. Irish Sea Herring Division VIIa (N). Larval production (10^{11}) indices for the Manx component.

Year	Douglas Bank		
	Date	Isle of Man Production	SE
1989	26 Oct	3.39	1.54
1990	19 Oct	1.92	0.78
1991	15 Oct	1.56	0.73
1992	16 Oct	15.64	2.32
1993	19 Oct	4.81	0.77
1994	13 Oct	7.26	2.26
1995	19 Oct	1.58	1.68
1996			
1997	15 Oct	5.59	1.25
1998	6 Nov	2.27	1.43
1999	25 Oct	3.87	0.88

Annex 9 Stock Annex Sprat in the North Sea

Quality Handbook	ANNEX: Sprat in the North Sea

Stock specific documentation of standard assessment procedures used by ICES.

Stock:	Sprat in the North Sea
Working Group	Herring Assessment Working Group (HAWG)
Date:	22TH March 2009
Authors	E. Torstensen, L. W. Clausen, C. Frisk, C. Kvamme.

A. General

A.1. Stock definition

Sprat in ICES area IV.

A.2. Fishery

The Danish small meshed fishery is responsible for the majority of the landings. A study undertaken in 2000 showed that the species composition in the Danish sprat fishery has changed towards a fishery with low by-catches of other species (ICES CM 2001/ACFM:12). The Norwegian sprat fishery is mainly carried out by purse-seiners. A closure of the Norwegian fishery was introduced for the second and third quarter in 1999 and this management regime is still in force. On top of this management regime, a maximum vessel quota is set for the Norwegian vessels; and they are not allowed to fish in the Norwegian Economic Zone until the Norwegian quota in EU waters has been taken.

A.3. Ecosystem aspects

Multispecies investigations have demonstrated that sprat is one of the important prey species in the North Sea ecosystem. Many of the plankton-feeding fish species have recruited poorly in recent years (e.g. herring, sandeel, Norway pout) possibly due to changing availability of prey. The influence of the sprat fishery for other fish species sea birds and sea mammals, are at present unknown.

Sprat is an important part of the pelagic ecosystem in the North Sea. As plankton feeders, sprat is an essential prey species for higher trophic levels. Both as juveniles and as adults they are an important source of food for other fish, sea birds and mammals.

The zooplankton community structure that is sustaining the sprat stock appears to be changing, and there has been a long-term decrease in total zooplankton abundance in the northern North Sea (Reid *et al.*, 2003; Beaugrand, 2003; ICES, 2006). However, sprat is mainly distributed in the southern North Sea where these trends have not been observed (ICES, 2006). The implications of the environmental change for sprat are unknown.

Sprat spawns in the upper water layers. In the North Sea sprat eggs and larvae are found more or less during the whole year. Spawning and nursery areas, being near the coast, are particularly sensitive and vulnerable to anthropogenic influences.

B. Data

B.1. Commercial catch

Commercial catch data is provided by the national laboratories of nations exploiting sprat in the North Sea. The labs have used a spreadsheet to provide landings and sampling data. The sampling intensity for biological samples, i.e., age and weight-at-age is mainly performed following the EU regulation 1639/2001 as the country landing most of the catches (Denmark) follows this regulation. This provision requires 1 sample per 2000 tonnes landed. This sampling level is lower than the guidelines (1 sample per 1000 tonnes) previously used by the HAWG. As the fishery is carried out in a limited area, the recommended sampling level can be regarded as adequate.

The majority of commercial catch and sampling data are submitted in the Exchange sheet v. 1.6.4. This method is now run in parallel with INTERCATCH, which is maintained by ICES. INTERCATCH is still in development and is not completely satisfactory in terms of flexibility and outputs. Thus HAWG uses both. The data in the exchange spreadsheets are samples allocated to catch using the SALLOCL-application (Patterson, 1998). This application gives the needed standard outputs on sampling status and biological parameters. It also clearly documents any decisions made by the stock co-ordinators for filling in missing data and raising the catch information of one nation/quarter/area with information from another data set. The stock co-ordinator allocates samples of catch numbers, mean length and mean weight-at-age to unsampled catches using appropriate samples by gear (fleet), area and quarter. If an exact match is not available then a neighbouring area in the same quarter is used.

B.2. Biological

Mean weights at age in the catch in the 1st quarter are used as stock weights.

Natural mortality: Results from the North Sea multi-species VPA (ICES CM 2002/D:04) can be used as an estimate of the predation mortality. To estimate total natural mortality a value of 0.2 to account for other sources of natural mortality should be added to the predation mortality.

B.3. Surveys

The acoustic surveys for the North Sea herring in June-July have estimated sprat abundance since 1996 (ICES 2009/LRC:02) (see table in section 8.3.2). In this period no sprat has been recorded in the northern part of the North Sea. The sprat has almost exclusively been found in the eastern and southern parts of the North Sea (Figure 8.3.2). The age-disaggregated time series of sprat abundance and biomass from the acoustic series (ICES areas IVa-c), have been re-calculated using FishFrame for the years 2003-2007 (ICES CM 2008/LRC:01). The surveyed area has increased over the years, thus only figures for the last 6 years are roughly comparable.

The acoustic recordings are carried out using a Simrad EK60 38 kHz sounder echo-integrator with transducers mounted on the hull, drop keel or towed bodies. Prior to 2006, Simrad EK500 and EY500 were also used. Further data analysis is carried out using either BI500, Echoview, Echoann software or LSSS. The survey track is selected to cover the area giving a basic sampling intensity over the whole area based on the limits of herring densities found in previous years. A transect spacing of 15 nautical miles is used in most parts of the area. The surveys are co-ordinated under ICES Planning Group for International Pelagic Surveys (PGIPS, former PGHERS).

The IBTS (February) sprat indices (no. per hour) in Div. IV were previously used as an index of abundance of sprat in the North Sea. The fishing gear used in the IBTS-survey was standardised in 1983. The complete time series of the IBTS Q1 index, from 1984 onwards, is calculated by the ICES DATARAS database (http://datras.ices.dk). The index is calculated as a weighted mean (over all squares sampled in a particular year) of the mean CPUE in a stat-square. Symbolically, this can be represented as:

$$I = \frac{\sum_{ss} \omega_{ss} \frac{\sum_{i}^{n_{ss}} CPUE_{ss,i}}{n_{ss}}}{\sum_{ss} \omega_{ss}}$$

where I is the index value, ω_{ss} is the weighting factor given to an individual stat square, n_{ss} is the number of hauls in a given stat square, and $CPUE_{ss,i}$ is the CPUE of haul i in a given stat-square. Only stat-squares that are sampled in the particular year are included the summations. The weighting factors for each stat-square are proportional to the volume of water in a square within a certain water depth. The limits of this water depth are uncertain and have been reported earlier as 10-150 m (ICES 1995/Assess: 13) and as 20-100 m (pers. comm. ICES staff, 2009). The weighting factors are given in the following table.

Area	Weight	Area	Weight	Area	Weight	Area	Weight	Area	Weight	Area	Weight	Area	Weight	Area	Weight
31F1	0.6	36F3	1	38F5	1	40F5	1	42F3	1	44F2	1	47E8	1	50E7	0.6
31F2	0.8	36F4	1	38F6	1	40F6	1	42F4	1	44F3	1	47E9	1	50E8	0.7
32F1	0.8	36F5	1	38F7	1	40F7	1	42F5	1	44F4	1	47F0	1	50E9	0.9
32F2	1	36F6	0.9	38F8	0.3	40F8	0.1	42F6	1	44F5	0.9	47F1	1	50F0	1
32F3	0.8	36F7	0.4	39E8	0.5	41E6	0.03	42F7	1	45E6	0.4	47F2	1	50F1	1
32F4	0.01	36F8	0.5	39E9	1	41E7	0.8	42F8	0.2	45E7	1	47F3	0.6	50F2	1
33F1	0.3	37E9	0.2	39F0	1	41E8	1	43E7	0.03	45E8	1	48E6	1	50F3	0.2
33F2	1	37F0	1	39F1	1	41E9	1	43E8	0.9	45E9	1	48E7	1	51E6	0
33F3	1	37F1	1	39F2	1	41F0	1	43E9	1	45F0	1	48E8	0.9	51E7	0
33F4	0.4	37F2	1	39F3	1	41F1	1	43F0	1	45F1	1	48E9	1	51E8	0.5
34F1	0.4	37F3	1	39F4	1	41F2	1	43F1	1	45F2	1	48F0	1	51E9	1
34F2	1	37F4	1	39F5	1	41F3	1	43F2	1	45F3	1	48F1	1	51F0	1
34F3	1	37F5	1	39F6	1	41F4	1	43F3	1	45F4	0.6	48F2	1	51F1	1
34F4	0.6	37F6	1	39F7	1	41F5	1	43F4	1	46E6	0.4	48F3	0.5	51F2	0.5
35F0	0.8	37F7	1	39F8	0.4	41F6	1	43F5	1	46E7	0.9	49E6	0.8	51F3	0
35F1	1	37F8	0.8	40E7	0.04	41F7	1	43F6	1	46E8	1	49E7	1	52E6	0
35F2	1	38E8	0.2	40E8	0.8	41F8	0.1	43F7	1	46E9	1	49E8	0.4	52E7	0
35F3	1	38E9	0.9	40E9	1	42E7	0.4	44E6	0.5	46F0	1	49E9	1	52E8	0
35F4	0.9	38F0	1	40F0	1	42E8	1	44E7	0.5	46F1	1	49F0	1	52E9	0.1
35F5	0.1	38F1	1	40F1	1	42E9	1	44E8	0.9	46F2	1	49F1	1	52F0	0.2
36F0	0.9	38F2	1	40F2	1	42F0	1	44E9	1	46F3	0.8	49F2	1	52F1	0.5
36F1	1	38F3	1	40F3	1	42F1	1	44F0	1	47E6	0.8	49F3	0.5	52F2	0.1
36F2	1	38F4	1	40F4	1	42F2	1	44F1	1	47E7	0.6	50E6	0.1	52F3	0

B.4. Commercial CPUE

Not used for this stock.

B.5. Other relevant data

None

C. Historical Stock Development

Sprat is a relatively short-lived species. The stock and the catches are consisting mostly of 1 and 2 year-olds. In addition, there are difficulties in age reading resulting in unreliable estimates of numbers at age both from the surveys and the commercial catch. Given those limitations a data exploration using Catch-Survey Analysis (CSA) was undertaken by the WG from 2003 to 2008 as an exploratory assessment (ICES CM 2008/ACOM:02). CSA is an assessment method designed for cases where full age-structured data are missing.

D. Short-Term Projection

Not performed.

E. Medium-Term Projections

Not performed

F. Long-Term Projections

Not performed

G. Biological Reference Points

Not set.

H. Other Issues

None

I. References

Beaugrand, G. 2003.Long-term changes in copepod abundance and diversity in the north-east Atlantic in relation to fluctuations in the hydrodynamic environment. Fisheries Oceanography 12: 270-283

.ICES 1995. Report of the Herring Assessment Working Group for the Area South of 62ºN. ICES 1995/Assess:13

ICES 2001. Report of Herring Assessment WG for the Area South of 62º N. CM 2001/ACFM:12.

ICES 2002. Report from the ICES Workshop on Multi-species VPA in the North Sea. ICES CM 2002/D:04.

ICES 2006. Herring Assessment Working Group for the Area South of 62ºN (HAWG). ICES CM 2006/ACFM:20.

ICES 2006. Report of the Study Group on Recruitment Variability in North Sea Planktivorous Fish (SGRECVAP). ICES CM 2006/LRC:03, 82 pp.

ICES 2008. Herring Assessment Working Group for the Area South of 62ºN (HAWG). ICES 2008/ACOM:02

ICES 2008. Report of the Planning Group for Herring Surveys. ICES CM 2008/LRC:01. 257 pp.

ICES 2009. Report of the Planning Group of International Pelagic Surveys (PGIPS). ICES CM 2009/LRC:02.

Patterson, K.R. 1998: A programme for calculating total international catch-at-age and weight-at-age. Working Document to Herring Assessment Working Group South of 62oN. ICES CM 1998/ACFM:14.

Reid, P.C., Edwards, M., Beaugrand, G., Skogen, M., Stevens, D. 2003. Periodic changes in the zooplankton of the North Sea during the twentieth century linked to oceanic inflow. Fish. Ocean. 12: 260-269.

Annex 10 – Stock Annex Sprat in Division IIIa

Quality Handbook	ANNEX: Sprat IIIa

Stock specific documentation of standard assessment procedures used by ICES.

Stock:	Sprat in Division IIIa
Working Group:	Herring Assessment Working Group (HAWG)
Date:	22th March 2009
Authors:	Torstensen, E.; Clausen, L.W., Frisk, C., Kvamme, C.

A. General

A.1. Stock definition

Sprat in ICES area IIIa

A.2. Fishery

Fleets from Denmark, Norway and Sweden carry out the sprat fishery in Division IIIa. The Danish sprat fishery consists of trawlers using a < 32 mm mesh size and the landings are used for fishmeal and oil production. Some of the sprat landings from Denmark and Sweden are by-catches in the herring fishery using 32 mm mesh-size cod ends. The Swedish fishery is directed at herring with by-catches of sprat. The Swedish fleet is mainly pelagic trawlers and also a few purse seiners. The Norwegian sprat fishery in Division IIIa is an inshore purse seine fishery (vessels <27.5 m) for human consumption.

The majority of the landings are made by the Danish fleet. In 1997 a mixed-clupeoid fishery management regime was changed to a new agreement between the EU and Norway that resulted in a TAC for sprat as well as a by-catch ceiling for herring. Catches are taken in all quarters, though with the bulk of catches in the first and fourth quarter. Denmark has a total ban on the sprat fishery in Division IIIa from May to September.

There was a considerable increase in landings from about 10,000 t in 1993 to a peak of 96,000 t in 1994. From 1996 the landings have varied between 9,000 t (2008) and 40,000t (2005).

A.3. Ecosystem aspects

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, as a prey species for both fish and seabirds. Many of the plankton feeding fish have recruited poorly in recent years (eg. herring, sandeel, Norway pout). The implications for sprat in IIIa are at present unknown.

B. Data

B.1. Commercial catch

Commercial catch data are submitted to ICES from the national laboratories belonging to nations exploiting the sprat in Division IIIa. The sampling intensity for biological samples, i.e., age and weight-at-age is mainly performed following the EU regulation 1639/2001 as Denmark, landing most of the catches, follows this regulation. This provision requires 1 sample per 2000 tonnes landed.

The majority of commercial catch and sampling data are submitted in the Exchange sheet v. 1.6.4. This method is now run in parallel with INTERCATCH, which is maintained by ICES. INTERCATCH is still in development and is not completely satisfactory in terms of flexibility and outputs. Thus HAWG uses both. The data in the exchange spreadsheets are samples allocated to catch using the SALLOCL-application (Patterson, 1998). This application gives the needed standard outputs on sampling status and biological parameters. It also clearly documents any decisions made by the stock co-ordinators for filling in missing data and raising the catch information of one nation/quarter/area with information from another data set.

The stock co-ordinator allocates samples of catch numbers, mean length and mean weight-at-age to unsampled catches using appropriate samples by gear (fleet), area and quarter. If an exact match is not available then a neighbouring area in the same quarter is used.

B.2. Biological

Mean-weight-at-age for all ages is in the same order as the previous years, except for 2007 where the mean weight-at-age were the largest in the period. Mean weights-at-age for 1996-2003 are presented in ICES CM 2005/ACFM:16.

No estimation of natural mortality is made for this stock.

B.3. Surveys

Acoustic estimates of sprat have been available from the ICES co-ordinated Herring Acoustic surveys since 1996. The estimated biomass of sprat has been very variable with low values in the period from 1997 to 2002, but recently the biomass has increased. In Division IIIa, sprat has mainly been observed in the Kattegat.

The IBTS (February) sprat indices (no per hour) in Division IIIa have been used as an index of abundance. In later years, the index has not been considered useful for management of sprat in Division IIIa. The indices are calculated as mean no./hr (CPUE) weighted by area where water depths are between 10 and 150 m (ICES 1995/Assess:13). The indices were revised in 2002 (ICES 2002/ACFM:12) based on an agreement in the IBTS WG in 1999, where it was decided to calculate the sprat index as an area weighted mean over means by rectangles for the IIIa (ICES 1999/D:2). The old time-series of IBTS indices (from 1984-2001) is shown in ICES 2001/ACFM:10.

B.4. Commercial CPUE

Not used for this stock.

B.5. Other relevant data

None

C. Historical Stock Development

Not performed

D. Short-Term Projection

Not performed

E. Medium-Term Projections

Not performed

F. Long-Term Projections

Not performed

G. Biological Reference Points

Not set

H. Other Issues

None

I. References

ICES 1995. Report of the Herring Assessment Working Group for the Area South of 62ºN. ICES 1995/Assess:13

ICES 1999. International Bottom Trawl Survey in the North Sea, Skagerrak and Kattegat in 1998. ICES 1999/D:2

ICES 2001. Report of the Study Group on the Herring Assessment Units in the Baltic Sea. ICES CM 2001/ACFM:10.

ICES 2002. Herring Assessment Working Group for the Area South of 62ºN (HAWG). ICES CM 2002/ACFM:12.

ICES 2005. Herring Assessment Working Group for the Area South of 62ºN (HAWG). ICES CM 2005/ACFM:16.

Patterson, K.R. 1998: A programme for calculating total international catch-at-age and weight-at-age. Working Document to Herring Assessment Working Group South of 62°N. ICES CM 1998/ACFM:14.

Annex 11 Stock Annex – Sprat in Division VIIde

Quality Handbook	ANNEX:_Sprat VIIde

Stock specific documentation of standard assessment procedures used by ICES.

Stock:	Sprat in Division VIId,e
Working Group:	Herring Assessment Working Group (HAWG)
Date:	25TH March 2009
Author:	Torstensen, E; Clausen, L.W., Kvamme, C.

A. General

A.1. Stock definition

Sprat in ICES area VIId, VIIe

A.2. Fishery

Vessels from UK (England and Wales) are currently responsible for the catches. The landings in this area are small and have never been above 6,000 t since 1985. Since 2000 the landings have been in the range of 840 t (2004) and 3 370 t (2008)

A.3. Ecosystem aspects

None

B. Data

B.1. Commercial catch

The commercial catch is provided by the national laboratories belonging to nations exploiting the sprat in the Division VIId and VIIe.

B.2. Biological

Sampling for biological samples, i.e. age and weight-at-age has not been performed since 1999, but as the fishery is so small, this is not considered to be a problem.

B.3. Surveys

There are no surveys targeting sprat in this area.

B.4. Commercial CPUE

Not used for this stock.

B.5. Other relevant data

None

C. Historical Stock Development

Not performed

D. Short-Term Projection

Not performed

E. Medium-Term Projections

Not performed

F. Long-Term Projections

Not performed

G. Biological Reference Points

Not set

H. Other Issues

None

I. References

Annex 12 - Celtic Sea Herring

Benchmark Review

6 May 2009 by correspondence

Reviewers:

Steve Cadrin, USA (chair)

Lionel Pawlowski, France

…with assistance from Daniel Goethel and Lisa Kerr, USA

"This annex describes the work done on Celtic Sea Herring immediately after the HAWG. The benchmark performed at the HAWG 2009 is reviewed (section 1). The management plan proposed for the stock has been evaluated (section 2) and consequently reviewed (section 3)."

Summary

Methodology of the Celtic Sea Herring stock assessment was reviewed according to the stock annex (Annex 05 Celtic Sea and Division VIIj_V1_09.doc), and the most recent application of the methodology was reviewed according to the 2009 stock assessment (04-Celtic Sea and Div. VIIj_Herring_2009.doc). Our review addresses the following questions from the ICES Secretariat (B. Schoute 22 April 2009):

1. Is the new assessment methodology correct, of high standard and does it make optimal use of the available data?
2. Are the settings of the forecast (only short term, medium and long term are not relevant here) chosen correctly and do the reference points still apply.
3. Is the methodology adequately described in the stock annex, meaning that the assessment can in principle be carried out by experienced outsiders on the basis of this text.

1) We conclude that the new assessment methodology is generally sound, but some inconsistencies between surveys remain, results are somewhat uncertain, and assumptions of the model should be further explored. The assessment results are relatively consistent, but calibration relationships are weak and based on a short survey time series. Among the alternative assessment models explored, the revised configuration of Integrated Catch Analysis (FLICA) appears to be most appropriate model of data from the fishery and resource. However, we encourage the assessment Working Group to continue to explore more advanced stock assessment models to make optimal use of the available data. The following sources of uncertainty should be addressed in subsequent assessments:

a) The ICA calibration is based on a short survey series, and the calibration relationships are weak, with some year effects. The resulting estimates of terminal SSB are imprecise, and much of the uncertainty in terminal SSB is not included in estimates of precision. For example, a large portion of the spawning stock is composed of 1-ringers, for which proportion mature is poorly understood, and geometric mean abundance is assumed in the terminal year.

b) A stock assessment model that relaxes the assumption of constant selectivity in recent years should be explored. The separability assumption (and the assumed selectivity at the oldest ages for the entire time series) may lead to misinterpretation of the apparent shifts in age selectivity by the fishery. According to the 2009 HAWG report (page 298), the 2007 benchmark concluded that changes in fishing pattern (and conflicting signals) prevented a final assessment from being conducted

c) The magnitude of discarded catch should be estimated and included in the stock assessment.

d) A stock assessment approach that accounts for the mixed-stock resource and connectivity with adjacent management units should be developed.

e) Fishing mortality reference points (F_{lim} and F_{pa}) should be proposed.

f) Consumption of Celtic Sea herring should be estimated and considered for stock assessment and fishery management.

2) The settings of the short-term forecast appear to be chosen correctly, and the B_{lim} and B_{pa} reference points (as revised for retrospective change) are still appropriate. However, we suggest that the same forecast approach be extended for long-term, stochastic projection to determine the fishing mortality rate associated with B_{lim} (as a candidate for F_{lim}) and its uncertainty (to derive F_{pa} and potentially a revised B_{pa}) as well as MSY reference points.

3) The methodology is generally well-described in the stock annex and allows repeatability. The various tables and information in the body of the report give the strong impression that all inputs are sufficiently documented to allow an outsider to do an assessment. However, some details of the most recent application of the stock assessment model (e.g., input and output tables, model diagnostics) should be provided to justify the modeling decisions.

<u>Detailed Comments (organized by Annex section)</u>

A. General

A.1. Stock definition – Several aspects of stock definition are described to justify the appropriateness of the management unit and identify aspects of population structure that may influence stock assessment and fishery management. Atlantic herring are 'population-rich' throughout their range, with complicated patterns of ontogenetic movement and mixing of spawning groups. These complex patterns present challenges to conventional stock assessment and fishery management.

1) Combined assessment of autumn and winter spawning groups appears to be the most appropriate use of available data, because of extensive mixing of spawning groups resulting in mixed-group fisheries and surveys. However, continued advancements in discrimination of seasonal spawning groups should be explored with the ultimate goal of stock composition analysis and consideration of spawning groups in assessment and management.

2) The inclusion of area VIIj in the Celtic Sea management unit appears to be appropriate because of similar demographic patterns in VIIj and g, larval mixing between the two areas, and a common nursery area in VIIj shared by herring spawned in VIIg. However, Figure 1 suggests that spawning in

VIIg is primarily in winter, while spawning in VIIj occurs in both autumn and winter. Similar to the comment above, the seasonal spawning pattern suggests that the development of stock composition analysis would facilitate the consideration of spawning groups in assessment and management.

3) The boundary between the Celtic Sea and Irish Sea herring management units is supported by the results of an extensive multidisciplinary program (WESTHER). Although the 52°30'N boundary is well-justified, advection of larvae from the Celtic Sea to the Irish Sea and subsequent return to spawn in the Celtic Sea has consequences to assessment and management of both resources. Loss of larvae from the Celtic Sea will add noise to the stock-recruit relationship. Depending on which age fish return to the Celtic Sea, the immigration may confound inferences of mortality from the catch-at-age analysis which assumes a closed population. Return migration at 1-ringers will have less influence on the perceived population dynamics than on immigration of older ages. The relationship between Celtic Sea and Irish Sea herring should be further investigated to better understand the sensitivity of the closed-population assumption in the assessment.

4) Similar to the comment above, the relationship between Celtic Sea herring and those in in VIIe-f and VIIIa should be investigated to understand the sensitivity of the closed-population assumption in the assessment.

5) Figures 1 and 2 are switched.

6) A Figure of the region should be provided that includes all of the areas described in the Annex (VIIe, VIIh, VIIk, VIIIa).

7) The species name *Clupea harengus* should be included in the Annex.

A.2. Fishery

1) The fishery description is informative and well-written.

2) The increased landings after World War II support the premise that fishing influences stock size – a principle that should not be taken for granted for small pelagic species.

3) Any information on historical landings (prior to 1958) would be informative.

4) The statement that "Further fluctuations in the landings were evident during this time with high quantities of herring landed from 1958 – 1960 and from 1966 – 1971 (Molloy, 1972)" is somewhat inconsistent with the data plotted in Figure 6, in which annual landings from 1959 to 1963 are similar (i.e., the 'high quantities from 1958-1960 persisted to 1963).

5) The 'polyvalent' category of vessels should be described as in the 2009 HAWG report ("The term 'Polyvalent' refers to a segment of the Irish fleet, entitled to fish for any species to catch a variety of species, under Irish law" page 296).

6) The catch of large, old fish appears to depend on what areas are seasonally open to the fleet (e.g., Labadie Bank being open in July 2003 led to older fish being caught as compared to openings later in the year). Therefore, two aspects of the assessment model (separability in the recent period and full selectivity of the oldest age in all years) may be inappropriate.

7) The last paragraph "the Irish Quota" is redundant almost word for word with the second paragraph of the "Fishery in recent years"

A.3. Ecosystem aspects

1) Given the important role of herring in the ecosystem, more information is needed on consumption of Celtic Sea herring and predation of other species by herring. Although estimates of herring consumption in the North Sea are used to derive the assumed natural mortality rates for Celtic Sea herring, consumption of herring in the North Sea should be estimated, and incorporation of consumption in stock assessment and management should be considered.

2) References should be provided for the statement that "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."

3) The recent reduction in size-at-age should be reported in this section as a possible response to ecosystem factors. The trend is critical for estimation of spawning biomass, and the cause of the trend is important for assessment decisions and modeling future expectations (e.g., forecasts and reference points).

4) Similarly, the increasing recent trend in total mortality estimates from catch curves or log catch ratios and the decreasing recent trend in fishing mortality from the stock assessment model suggest an increase in natural mortality, which may reflect ecosystem change.

5) The ecosystem description and the summary of spawning dynamics suggest that there is adequate information to develop a bio-physical model of larval transport that would provide a complementary perspective on connectivity among spawning groups.

6) Differences in survival between the Irish and Celtic Seas could have important consequences to population dynamics. The relative contribution of each habitat to the adult population in the Celtic Sea should be determined.

7) Given that the Celtic Sea is near the southern extent of the range of herring, and the increasing trend in temperature, the potential for a northward shift in distribution should be monitored.

Discards

1) The "discards" section of this part should probably be in the data section.

2) Although the discard rates are considered to be low and discards are not included in the assessment, discards occur. The report indicates that discarding is influenced by market situations, which suggests it may rise. While, it does not seem to have at the moment a potential impact on the assessment, it could be useful to evaluate the consequence of the inclusion of discards on an exploratory basis. The underestimate of total catch produces biased estimates of stock size and mortality. The discard rate estimated by Berrow, et al. (1998), 4.7%, should be used to derive an approximate magnitude of discards that would be more accurate than the implicit assumption of no discards.

3) An at-sea monitoring program should be developed to estimate discard rates (including slippage) and to sample size and age structure of discards.

4) The statement that Berrow, et al. (1998) "indicated that the Celtic Sea herring fishery is very selective and that discard rates are well within the figures estimated for fishery models" is not clear. Does the statement suggest

that a 4.7% discard rate is similar to that estimated for other fisheries, or similar to the rate assumed in fishery models? Celtic Sea herring stock assessment assumes no discards and is not consistent with the estimate of a 4.7% discard rate.

B. Data

B.1. Commercial catch

1) Sampling intensity of the series of catch-at-age should be provided to evaluate the reliability of catch-at-age estimates. For example, Table 4.2.2.1 in the 2009 HAWG report indicates that 45 samples were collected from the 2008 fishery, and all major area-quarter components of the catch were sampled. Is this typical of the sampling intensity since 1958 or are there any systematic gaps in historical sampling that should be considered in the interpretation of catch-at-age? Given the complex pattern of time-area closures and fishing patterns, 45 samples per year may not adequately characterize some of the fine-scale differences in catch-at-age.

2) The report mentions the landings statistics for this stock need correction for misreporting. Landings apparently include substantial amounts (>10%) of fish from other areas but while the correction is made (i.e. unallocated landings), no information is given on how this correction is done. This information is important to explain how to prepare the data from the raw landings statistics.

3) A requirement of logbook data for all vessels in the sentinel fishery could improve estimates of small boat landings.

B.2. Biological

1) The various biological parameters are well described and their quality appears to be reliable for the assessment.

2) Have the age determination methods been validated?

3) Including some typical age-length keys would be helpful to evaluate how well catch-at-age is being estimated, particularly at older ages.

4) Including the quality-control results for precision estimates would be informative, and potentially useful for the development of advanced statistical catch-at-age models that use the pattern of disagreements to model errors in the catch-at-age.

5) The use of age-specific natural mortality rates from multispecies VPA is appropriate for a small, pelagic forage species, but a development of a MSVPA for the Celtic Sea would be more appropriate than using the results from the North Sea. A reference should be provided for the MSVPA so that its details do not need to be included in the Annex.

6) The cause of the reduction in weight-at-age should be explored further. More specifically, determining if it results from ecosystem factors or fishing patterns is essential for making the correct selectivity assumptions in the stock assessment. It would be valuable to inspect weight-at-age data from surveys to see if fishery-independent data reflect the same recent reduction. The beginning of the decline is consistent with the development of the roe fishery.

7) The choice of the maturity ogive suggests that various sources of information provide similar results. However, the amount of available information

(number of individuals sampled) is not included. The rationale for assuming 50% maturity of 1-ringers, rather than the estimated 58%, is that the fishery probably samples precocious fish. However, the estimate of 58% is from a survey. The text does not report if the estimate of >50% by Lynch (in prep.) is from the fishery or a survey. Given the substantial contribution of 1-ringers to the spawning stock, a more precise estimate of proportion mature should be applied.

8) Recruitment from the Irish sea may affect maturity of the population (and consequently maturity ogives). The possible influence of individuals from the Irish Sea raises the question of the proportion of individuals from that area and the effects of possible changes in maturity from one area to another. For some other stocks, like the Celtic Sea cod, a similar situation is observed and the lack of samples makes any maturity ogive rather uncertain. This was one of the criticisms in the benchmark review of the Celtic Sea cod.

B.3. Surveys

1) The timing of the survey appears to be related to 'year effects' in calibration diagnostics (HAWG 2009 Figure 4.6.1.1), suggesting that the portion of the resource in the survey area is sensitive to the time of the survey. The 2002/2003 survey (conducted in September and October) has all positive residuals (i.e., more fish in the survey than predicted by the model), and the 2003/2004 survey (conducted in October and November) has all negative residuals (i.e., fewer fish in the survey than predicted by the model), suggesting that fewer fish are available to the survey later in the year. Is it possible that spawners are in the process of leaving the survey area during the survey?

2) Imprecision of survey estimates is illustrated by the large difference between estimates of 2008 SSB from the survey (90kt) and the assessment model (56kt).

3) For the acoustic survey, the estimates of CV appear to be based on a simple function of the positive number of samples. Some explanations about that relationship would have been welcome. An apparent contradiction is in the text: "CV was obtained based on transect mean densities," but mean density is not included in the equation. There appears to be something missing from the equation.

4) The decision to use a shorter, standardized series for a tuning index is valid.

5) More information is needed to describe how indices of abundance at age are derived from the acoustic survey.

6) Tuning is based only on the acoustic survey which apparently provides the best indices. Data from other surveys are not used. Some other stocks, like the Celtic Sea cod, have the same issues of having surveys that are not specifically targeting those species sampling few and variable numbers of fish. Some work has been carried out during the WKROUND benchmark to combine survey indices and some others stocks (e.g. Sole in VIId) use combined survey indices. The report and stock annex do not mention any attempt to use or combine the available information. Some exploratory work on using those datasets would also be welcome. This could involve evaluating how the indices behave against each other, against fishing vessels

and how they could affect the assessment. Some analysis of the trends of all survey data would be helpful to support the choice of only using the acoustic survey for the assessment.

7) The analysis of productivity over time is sufficiently commented to naturally end with the conclusion that recent F has been detrimental to the stock productivity.

8) If the Irish Groundfish Survey is expected to provide qualitative information for the assessment, results should be included in the Annex.

9) Similarly, if the Northern Ireland GFS survey offers a potential recruitment index, more details are needed in the Annex so that it can be considered as more information becomes available on natal origin.

10) Similarly, data from larval surveys should be provided as a comparison to stock assessment results.

B.4. Commercial CPUE - The decision to exclude fishery CPUE as a tuning index in the stock assessment is valid, because of the nature of herring behavior, fishing patterns and management changes. However, it would be informative to compare the acoustic survey index to CPUE information from the fishing vessels. Some stocks (e.g. whiting in the North Sea) have conflicting patterns between surveys and fishing vessels. One reason could be some slight changes in the survey interfering with the results. Therefore, this type of comparison can be helpful to evaluate the consistency of the observation from the surveys in addition to the quality (i.e. level of noise) of the data which is another aspect to consider.

C. Historical Stock Development

1) This section shows some issues with noisy data but does not seem to explain the "conflicting signals in input data and changes in the fishing pattern" referenced in the HAWG report from the 2007 benchmark.

2) The description of 'time periods in the fishery' is informative and suggests that some of the selectivity assumptions in the stock assessment should be reconsidered. The roe fishery targeted older, mature fish, which would lead to greater selectivity of the oldest age during that period.

3) Tables 3 and 4 referenced in 'Time Periods in the Fishery' should be Tables 4 and 5.

4) Estimates of total mortality from log catch ratios and catch surveys are informative, but the age ranges selected for catch-curve analysis are inconsistent with results from the stock assessment model, because of the assumed pattern of natural mortality at age and estimated selectivity at age. According to the assessment model, herring are not fully selected until age-3, and natural mortality of ages 2 and 3 is greater than than for ages 4+, so catch curves should be revised from ages 2-7 to ages 4-7.

5) The increasing recent trend in total mortality estimates from catch curves or log catch ratios appear to contradict the decreasing recent trend in fishing mortality from the stock assessment model. The cause of the discrepancy (e.g., increasing natural mortality) should be explored.

6) In the assessment section, the HAWG report (4.6.1) mentions "conflicting signals in input data and changes in the fishing pattern" but no information is given on the "historic" choices made for exploratory assessments. The decisions about model configuration are well explained and the assessment well commented (changes in plus groups, shortening time series,

terminal selection and reducing the separable period) providing the rationale for the parameters used in the final assessment.

7) The concern raised by the 2007 benchmark assessment about violating the assumed constant separable pattern was not addressed. The assessment model still assumes separability in recent years. We reiterate the concern about assuming constant selectivity and repeat the recommendation to consider alternative modeling approaches that relax this assumption.

8) The revision of the catch-at-age used for the stock assessment model (truncation to ages 1-6+) produces a more realistic selectivity pattern than the previous analysis of ages 1-7+.

9) Diagnostic features of the stock assessment model are needed in the Annex to evaluate model performance. Standard diagnostics from the 2009 assessment should be included (e.g., HAWG 2009 Figures 4.6.1.2-3 model residuals, 4.6.1.4-5 confidence intervals, 4.6.1.6. historical comparisons, 4.6.2.1 calibration plots, 4.6.2.5-6 retrospective analysis). Inspection of diagnostics suggests that the ICA model is relatively consistent and has no strong patterns in catch residuals, but there are strong 'year effects' in the survey residuals (i.e., same direction of deviation at all ages) for the first three years of the six surveys used (Figure 4.6.1.1), and calibration relationships are relatively weak (Figure 4.6.2.1). A 'year effect' in the terminal year will present problems for estimating terminal abundance and determining stock status.

10) The advantage of ICA over other models is well explained as well as the reasons for adopting new parameters. Considering the few changes in the list of parameters, it can be confusing to have the parameters listed for the former and new assessment methods separately. Maybe combining both sets of parameters into a single table would be more useful (considering only 2 parameters of 8 changed) so no "quick reader" may switch to the wrong set of parameters.

11) The Annex reports that ICA was chosen because of its emphasis on young ages and greater consistency, but there is no information in the Annex or the 2009 HAWG report on the performance of alternative models. It is difficult to judge the validity of that conclusion without example results from all viable models. For example, did XSA also have year effects in survey residuals?

12) The ICA model appears to perform well for this application, but the method is somewhat dated (it is a re-codification of the CAGEAN model developed by Deriso et al. 1985). Catch-at-age models have evolved since the 1980s, and more advanced methods (e.g., statistical catch-at-age, SCAA) may be more appropriate for assessing the data available for Celtic Sea herring. SCAA would also be able to use all recent and historical information available (e.g., selectivity for each fishery and each period, calibration of historical abundance with discontinued surveys, discard rate estimates)

13) References for ICA (Patterson 1998) and FLICA (flr-project.org) are needed.

14) The analysis of productivity over time supports the conclusion that recent F has been detrimental to the stock productivity. However, the calculation of surplus production is either poorly described or inaccurate. The equa-

tion Ps=Br+Bg-M does not account for the different units of biomass (t) and natural mortality rate (y^{-1}). The inappropriate mix of instantaneous rates and biomass is continued in the subsequent statement that net production is calculated as Ps – F. Surplus production should be calculated as Ps=Br+Bg-Bm where Bm is biomass of fish that die of natural causes. Total Production should be calculated as P=Br+Bg-Bm+Y where Y is catch biomass.

D. Short-Term Projection

1) This section does not explain why the MFDP projection was not carried out from 2005 to 2008 and why this analysis is back in the assessment. It seems that the information available is of sufficient quality to allow this type of projection.

2) The projection methodology is appropriate, but stochastic projection, incorporating uncertainty in abundance at age estimates and recruitment estimates would help to evaluate alternative management actions by providing probability of achieving management objectives or risk of exceeding limits.

E. Medium-Term Projections – The text states that Fmsy is provided in Table 7, but it is not (nor can it be from a simple yield-per-recruit analysis).

F. Long-Term Projections and G. Biological Reference Points

1) The reference points have not been revised. However, considering the changes in the assessment methodology and some evidence Blim should be revised upwards. Some work to investigate a possible change of Blim should be encouraged (or an explanation is required to explain why these reference points should be kept as they are).

2) Long-term, stochastic projection should be used to determine the fishing mortality rate associated with B_{lim} (as a candidate for F_{lim}) and its uncertainty (to derive F_{pa} and potentially a revised B_{pa}) as well as MSY reference points.

H. Management and ICES Advice

1) The ICA model suggests a recent increase in spawning biomass (2008 SSB=55 800t) to greater than Bpa (44 000t), such that a rebuilding program is no longer necessary. However, important caveats should be communicated in the management advice. The ICA calibration is based on a short survey series, and the calibration relationships are weak, with some year effects. The resulting estimates of terminal SSB are imprecise, and much of the uncertainty in terminal SSB is not included in estimates of precision. For example, a large portion of the spawning stock is composed of 1-ringers, for which proportion mature is poorly understood, and geometric mean abundance is assumed in the terminal year.

2) Comparison of fishery yields and TACs indicates that the management system can effectively control the fishery (e.g., TAC was slightly exceeded in two years in the last 20 years).

3) Previous ICES advice that ‘catches of around 5 000 t would be associated with stock recovery’ appears to be unsubstantiated, because catches have not been that low in the observed catch series.

4) ‘ACFM Advice’ should be updated to ‘ICES Advice.’

Evaluation of proposed rebuilding plan for Celtic Sea herring

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Introduction

The herring to the south of Ireland in the Celtic Sea and in Division VIIj comprise both autumn and winter spawning components. For the purpose of stock assessment and management, these areas have been combined since 1982. The stock experienced a collapse in the 1970s, and again, in the mid 2000s.

The ICES advice for 2007, 2008 and 2009 has been that there should be no targeted fishing without a rebuilding plan. In 2008, the local Irish management committee presented a rebuilding plan to the European Commission and Council. The plan was not formally adopted, but the TAC for 2009 was consistent with the plan. Subsequently, in early 2009, the plan was endorsed by the Commission.

The plan (cited below) incorporated scientific advice with the main elements of the EU policy statement. A schematic representation of the plan is shown in Figure 1.

1) For 2009, the TAC shall be reduced by 25% relative to the current year (2008).
2) In 2010 and subsequent years, the TAC shall be set equal to a fishing mortality of $F_{0.1}$.
3) If, in the opinion of ICES and STECF, the catch should be reduced to the lowest possible level, the TAC for the following year will be reduced by 25%.
4) Division VIIaS will be closed to herring fishing for 2009, 2010 and 2011.
5) A small-scale sentinel fishery will be permitted in the closed area, Division VIIaS. This fishery shall be confined to vessels, of no more than 65 feet in length. A maximum catch limitation of 8% of the Irish quota shall be exclusively allocated to this sentinel fishery.
6) Every three years from the date of entry into force of this Regulation, the Commission shall request ICES and STECF to evaluate the progress of this rebuilding plan.
7) When the SSB is deemed to have recovered to a size equal to or greater than B_{pa} in three consecutive years, the rebuilding plan will be superseded by a long-term management plan.

In March 2009, the European Commission asked ICES (text of Commission interpretation below) to evaluate the plan. ICES was asked to evaluate if points 2 and 3 of the plan were precautionary:

- For 2010 and subsequent years the TAC will be set consistent with a fishing mortality rate of $F_{0.1}$ = 0.19.
- If, in the opinion of ICES and STECF the catch should be reduced to the lowest possible level, the TAC for the following year will be reduced by 25%.

This document presents a draft response to the questions posed by the Commission, on the proposed plan. Therefore this document is only concerned with points 2 and 3 of the proposed plan.

Materials and methods

Evaluation was performed using HCS-Celtic (Skagen, 2009). The program HCS-Celtic (Harvest Control rule Simulation-Celtic Sea herring) is a program for stochastic simulation of harvest control rules. The program is intended to imitate the normal advisory process where the stock is assessed one year before the TAC year. Because of that, a projection is made through the intermediate year to obtain the stock abundance at the start of the TAC year. HCS mimics that process without running actual assessments as part of the simulations. Instead, observation errors are specified as distributions and carried forward in predictions to get the numbers that are the basis for management decisions. Options for implementation error and bias are also available.

The program consists of a population model that generates yearly stock numbers at age, an observation model that transfers the stock numbers into noisy, 'observed' numbers, a decision rule through which a TAC is derived according to the observed stock (projected forward if relevant) and an implementation model that translates the TAC into actual removals. These removals are then input to the population model for the next time step. The outline is shown in Figure 2.

The program is run as a bootstrap, with the following stochastic elements:

- Initial numbers
- Recruitments
- Observation noise
- Implementation noise

This model was an adaptation of the original HCS model (Skagen, 2008). HCS –Celtic included an extra feature to test the effect of zero catch on SSB. If SSB < B_{lim}, then a reduction of 25 % applies. If not, the HCR applies as stated (Skagen, 2009). A subsequent modification was made which derives an SSB for input to the harvest control rule assuming a TAC in the fishing year corresponding to the target F (program available at http://groupnet.ices.dk). This modification showed slightly more conservative results. At low Fs this is not apparent as the HCR is not triggered due to the low exploitation on the stock. At higher Fs the modified version has slightly lower associated risks. Overall both versions produced very similar results. Since the proportion of F prior to spawning is only 0.2 the minor differences between the model versions is understandable. Further runs were carried using the modified version.

The program was used to screen over target F and $B_{trigger}$ levels. In addition, ranges of % TAC reductions if SSB < B_{lim} were also explored. Sensitivity analysis was conducted to evaluate observation and implementation error and bias.

Input Data

The HCS model used the following input data:

- Start Year
- Age range in the population
- Age range for the calculation of average fishing mortality
- For each age: population numbers, natural mortality, selection, catch weight, stock weight and proportion mature.
- TAC in the starting year.
- Parameters for the stock-recruit function.

For these simulations the start year was 2009 as this is the last year that an assessment was carried out. The age range used in the population model was 1-6, with mean fishing mortality calculated over ages 2-5. The 2009 population numbers were from the final assessment in 2009. Following the procedure of the assessment and forecast, 1 ringers were replaced with geometric mean recruitment from 1995-2006. Population numbers of 2 ringers in the intermediate season (2009) were calculated by the degradation of the geometric mean recruitment (1995-2006). Selection at age was taken from the final assessment run in 2009. Natural mortality was assumed to be constant every year. The mean weights in the catch and in the stock are calculated as averages over the last three years (2005-2008). The maturity ogive for this stock assumes that 50% of 1 ringers, and 100% of subsequent ringers are mature.

Three estimates of intermediate catch in 2009 were used. This was necessary because the catch in the intermediate year (2009/2010) includes the first quarter of the advice (TAC) year. Therefore the TAC set for 2010 influences the intermediate year catch. The interim year catches estimates were as follows:

6,809 15% increase based on EU TAC Decision Rule for stocks where SSB is increasing (ICES, 2009).

7,507 56% increase, based on $F_{0.1}$ (2009) = 0.17.

7,763 71 % increase, based on $F_{0.1}$ (2007) = 0.19.

Apart from the two alternative interim year catches, all of the inputs described above were used in the forecasts that were carried out at the 2009 working group (Table 1).

Table 1. Input data used in the simulations.

Age	Weight in the stock (kg)	Weight in the catch (kg)	Proportion Mature	F	Population Numbers 2009	Natural Mortality
1	0.078	0.086	0.5	0.008	360168	1
2	0.107	0.110	1	0.080	131499	0.3
3	0.126	0.131	1	0.137	145357	0.2
4	0.148	0.149	1	0.147	44017	0.1
5	0.157	0.164	1	0.137	84238	0.1
6	0.166	0.175	1	0.137	22269	0.1

Stock Recruit

In all simulations, the same stock-recruit relationship was used. The pattern in the stock-recruit pairs indicated that none of the classical models were appropriate. The segmented regression model was chosen, and applied to data for 1958-2006. Data from the most recent two years were excluded because they are less well estimated. Model fitting was conducted using R (http://www.r-project.org/) using Julios' algorithm (Julios, 2001), see Figure 3. The SSB changepoint was estimated at 41,000 t, and the plateau level of recruitment at 416 million individuals (Table 2). A log-normal distribution of the recruitments was assumed. The distribution was truncated at 0.1 and 3.0 to avoid drawing recruitments far outside the historical range. The modeled and expected distributions of recruitments are shown in the Figure 4. At cumulative probability 0.2 to 0.5 the model predicts higher recruitment than observed, though elsewhere there was excellent agreement. Diagnostics of the model fit are presented in Figure 5.

Table 2. Parameters of the segmented regression model fit for Celtic Sea herring, 1958-2006.

Slope	Mean recruitment (thousands)	Change point SSB (tonnes)	SSQ	p	S.E
10.17	416424	40,944	16.37	0.06	0.60

1.1 Results

A number of scenarios were tested, using several runs of the modified HCS-Celtic program. Initial runs investigated a broad range of target F levels (0.2-1.0), trigger biomass ($B_{trigger}$ 26,000 – 4,000), and % reductions (25% - 75%) when SSB<$B_{trigger}$. Contour plots were used to present the results of these simulations, showing target F on the horizontal, and $B_{trigger}$ on the vertical, with separate rows for the different % reductions, and columns for year combinations. The legend of probabilities (SSB<B_{lim}) is provided on the right, in terms of colours. According to ICES common practice, levels of less than 5% are considered to be in accordance with the precautionary approach.

Subsequent runs (Table 3) tested a narrower range of target Fs, in the range of $F_{0.1}$. $F_{0.1}$ has been estimated as 0.17 (ICES, 2009) and 0.19 (ICES, 2007). Therefore target F in the range 0.17 to 0.19 was evaluated. These runs were to simulate the rebuilding plan as is requested by the Commission. These runs also considered the sensitivities of various factors.

Initial runs

Results of initial runs are shown in Figures 6.1 (without bias), 6.2 (with bias). Summary plots are shown in Figure 6.3. The results of initial screening (Run 1) showed that target Fs above 0.4 have increased risk of SSB<$B_{trigger}$. These simulations suggest that target F in the range up to 0.4 is precautionary at any chosen trigger biomass to 45,000 t and any % reduction from 25% to 75%. Unacceptable risks are associated with target F above 0.6. At high target F, risk is lower when higher $B_{trigger}$ is chosen. The inclusion of implementation bias (10%) did not alter the risk profile appreciably (Figure 6.2). From Figure 6.3 it can be seen that risk to B_{lim} is predicted to increase to unacceptable levels by 2012 and that target F in the range 0.6 to 1.0 is predicted to lead to B_{lim} at some point in the simulation period. Figure 6.4 shows risk profiles for the first and second 10-year periods of the simulation. There was increased risk associated with higher target F, and lower $B_{trigger}$ in the second period.

Initial screening suggested that target F, in the range of recently proposed $F_{0.1}$ estimates, is precautionary. Subsequent simulations concentrated on a range of F in this region. The base case scenario that was tested considered three $F_{0.1}$ estimates, $B_{trigger}$ = B_{lim} from the proposed rebuilding plan and the proposed percentage reduction when SSB < B_{lim} (Run 3). A 10% implementation bias was considered appropriate and CV on the observation and implementation models was fixed at 20%. This was based on an interim year catch of 7,763 t (F=0.19).

Figure 7.1 shows trajectories of realised F and yield, SSB and risk to B_{lim} for this run, and Appendix 1 contains detailed outputs. This F range is associated with minimal risk (<1%) to B_{lim}, and a building of the stock to levels where yields of about 13,000 t are realised over the latter part of the simulation period. The highest target F (ICES, 2007; $F_{0.1}$) does not increase the risk to any appreciable degree and is associated with similar yields.

Table 3. Details of simulation runs conducted.

Run	Type	Int catch	F target	$B_{trigger}$	% TAC redn.	Notes
1	Broadscale	7763	0.2-1.0	24-44 K	25-75	
2	Broadscale	7763	0.2-1.0	24-44 K	25-75	
3	Base case	7763	0.17-0.19	26-44 K	25	
4	Sensitivity	7763	0.17-0.19	26-44 K	25	IAV 5-25%
5	Sensitivity	7763	0.17-0.19	26-44 K	25	Obs CV 0.2 - 0.4
6	Sensitivity	7763	0.17-0.19	26-44 K	25	Obs. Bias -0.1 to 0.5
7	Sensitivity	7763	0.17-0.19	26-44 K	25	Imp. CV 0.1 to 0.3
8	Sensitivity	7763	0.17-0.19	26-44 K	25	Imp. bias 0.1 to 0.3
9	Sensitivity	7507	0.17-0.19	26-44 K	25-75	
10	Sensitivity	6809	0.17-0.19	26-44 K	25-75	

The sensitivity of the base case run was tested against several factors, namely:

- Inter-annual TAC variation (Runs 4)
- Precision and bias on observation model (Runs 5 and 6 respectively)
- Precision and bias on implementation model (Runs 7 and 8 respectively)
- Interim year catch (Runs 9 and 10)

It was not appropriate to investigate the effect of changing the % reduction of TAC when SSB < B_{lim}. This was because the range of F's in the region of $F_{0.1,}$ which is specified in the proposed plan do not bring the SSB below B_{lim} or the other trigger points chosen.

The risk profiles for these sensitivity runs are presented in Figures 8.1 to 8.3. In the F and $B_{trigger}$ region of the proposed plan, no IAV was associated with a risk to $B_{lim,}$ that was appreciably lower than the base case (Figure 8.1). The proposed rebuilding plan appears robust to a plausible range of implementation errors and biases. Slightly higher risk was found to be associated with an observation CV of 40% (Figure 8.2). None of the likely interim year catches alter the risk profile to any extent (Figure 8.3).

Discussion

Results of simulations for conformity with the precautionary approach

The simulations conducted in this exercise predict that the proposed rebuilding plan is consistent with the precautionary approach to fisheries management. Target F in the range of recent estimates of $F_{0.1}$ is not associated with risk of SSB < B_{lim}.

The 25% TAC reduction when SSB < B_{lim} was shown to be precautionary, when target F < 0.4. At higher target F, acceptable risks were associated with a 75% TAC reduction, and $B_{trigger}$ in range of 40,000 t to 45,000 t. These simulations are based on the best estimate of current (2009) stock size, and low historic catch levels. However, if the stock was decreasing and catches were at levels observed historically, then it is not clear if a 25% reduction would be precautionary.

Point 3 may not be appropriate for a long term management plan for this stock. The current simulations are only relevant to the proposed rebuilding plan. However following this plan there will be minimal risk to $B_{lim.}$ Thus, the overall rule in the plan is precautionary, if the target F in point 2 is followed.

Interpretation of the rebuilding plan

The clause "the catch should be reduced to the lowest possible level, the TAC for the following year will be reduced by 25%", in point 3 of the plan may lead to confusion. This is a standard wording used in the EU policy statements on the fixing of catch opportunities. The stakeholder committee intended this text to represent the scenario, when the scientific advice is for a zero-catch. This would apply if the $SSB_{TAC\ year} \leq B_{lim}$. In this scenario, the plan provides for a 25% reduction in TAC, *not* TAC = 0 (Figure 3).

Stock dynamics and the population model

It is important that the stock dynamics are well understood and an adequate basis for simulating the plan. The underlying population model was that of the 2009 accepted ICES assessment (ICES, 2009b). This was considered an extension of the 2007 benchmark assessment of this stock. The independent reviewers endorsed the decisions made and concluded that the assessment was methodology was "generally sound", but with "some inconsistencies" (Cadrin et al. 2009). These inconsistencies were as follows:

a. Short survey series, with weak relationships to canum and some year effects.
b. A large portion of the spawning stock composed of 1-ringers, that are poorly estimated.
c. Assumption of constant selectivity.
d. Assumed selectivity at the oldest ages for the entire time series may lead to misinterpretation of the apparent shifts in age selectivity by the fishery.
e. No estimates of discards.
f. Consumption of herring as forage not estimated.
g. Mixed-stock resource and connectivity with adjacent management units assessment should be developed.

Points a, b, c, and d above represent structural aspects of the fisheries data that cannot be improved on at this time. The survey data used represents the longest time series of comparable surveys available. The poor estimation of 1-ringers can only be improved when a recruit series is available. The population model assumes 50% maturity at 1-ringer. This is a compromise. It is known that more than 50% of fish in Celtic Sea catches are mature at 1-ring (Lynch, 2009). However these are probably fast growing recruits. On the other hand, slower growing fish, present in the Irish Sea (Brophy and Danilowicz, 2002), may have a later maturity. The selection assumption seems valid for the separable period assumed in the model as the fishery pattern has been relatively constant over this period.

This evaluation is comparable with others conducted recently on West of Scotland herring, NEA mackerel and western horse mackerel, where discarding was either not accounted for at all, or else not fully accounted for in the observation model.

The consumption of herring as forage by predatory marine animals has not been evaluated in the population model. No good estimates of herring consumption exist in this area. Natural mortality in many herring stocks is poorly understood. Recent agreed management plans for west of Scotland herring and horse mackerel were based on data that did not explicitly consider the forage consumption. Though the approach taken for Celtic Sea herring is broadly comparable with other stock assessments, it is clear that more work needs to be done on the level of consumption of herring as forage.

Point f of the review group's comments is considered to add uncertainty to the stock dynamics. The current stock assessment model does not consider, the effect the mixing of juveniles, and indeed adults, of this stock with the neighbouring Irish Sea stock. One approach to this problem would be to employ an assessment model such as Roel et al. (2009). Another approach would be to use the framework developed by Kell et al. (2009). It was intended to use this framework to evaluate the proposed rebuilding plan. However, insufficient time was available to develop the program, which is currently not fully operational.

Stock recruitment relationship and recruitment variability

The stock recruitment data do not suggest that any of the classical models (Beverton and Holt, Ricker, Shepherd) are applicable. The data show low and high recruitments at low and high stock size. The segmented regression was chosen, and provided an independent estimate of the changepoint SSB, below which recruitment impairment is considered to occur. The estimate of change point (41,000 t) is close to recent estimates (45,000 t; STECF, 2006; 47,000 t; Clarke and Egan, 2008). Recent recruitment has fluctuated around a mean level of 360 million, lower than the long term mean estimated by the segmented regression model (416 million). The stock recruitment relationship may produce higher recruitments in the simulation period, than have been observed in the recent past. However, sensitivity analysis suggests that results are robust error and bias in the observation model.

Progress towards F_{msy} by 2015

According to the political commitment at the World Summit on Sustainable Development at Johannesburg, in September 2002, fish stocks should be maintained at or restored to levels that can produce maximum sustainable yield, not later than 2015. The current exercise did not seek to estimate F_{msy}. However, $F_{0.1}$ can be used as a proxy for F_{MSY}.

Conclusions

In answer to the specific questions posed by the Commission the following answers can be given:

1. Setting a TAC, consistent with a fishing mortality rate of $F_{0.1}$ = 0.19, for 2010 and subsequent years is not associated with an unacceptable risk of SSB < B_{lim}, in the simulation period 2009-2029.
2. If TACs consistent with F in the range 0.17 to 0.19 are set, then there is minimal risk that SSB < B_{lim} in the simulation period 2009-2029. However at fishing takes place at F > 0.4 the 25% TAC reduction in the proposed plan may not be precautionary.

The proposed rebuilding plan for Celtic Sea and Division VIIj herring is estimated to be in accordance with the precautionary approach, if the target fishing mortality of $F_{0.1}$ is adhered to.

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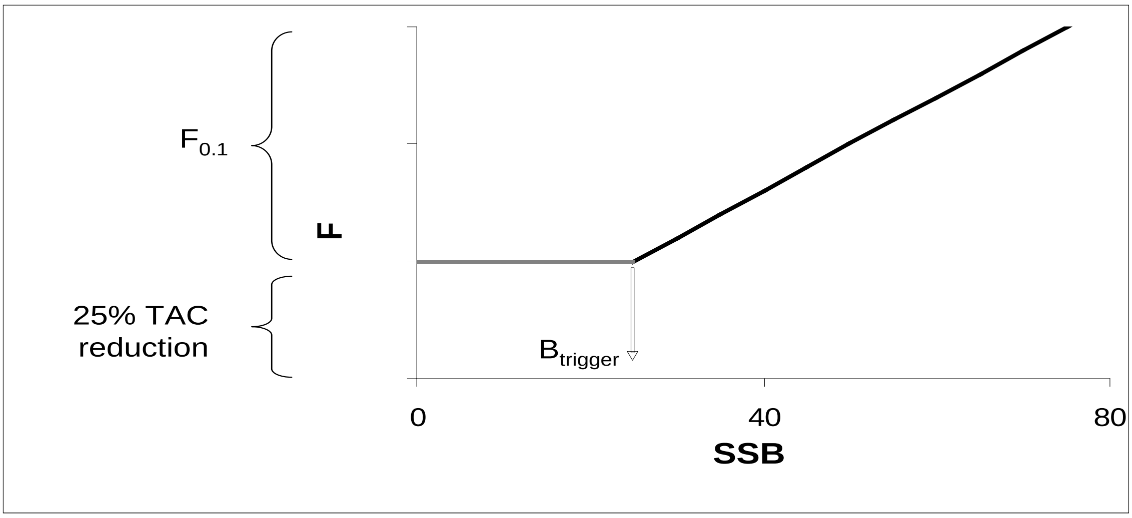


Figure 1. Schematic representation of the decision rule in the proposed rebuilding plan. $B_{trigger}$ = B_{lim} = 26,000 t.

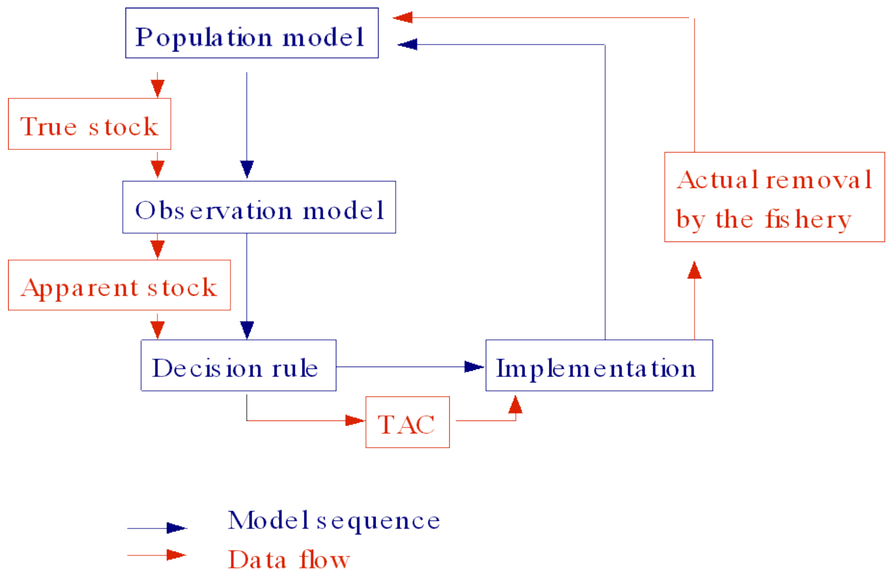


Figure 2. Outline of the simulation loop in the HCS-Celtic program.

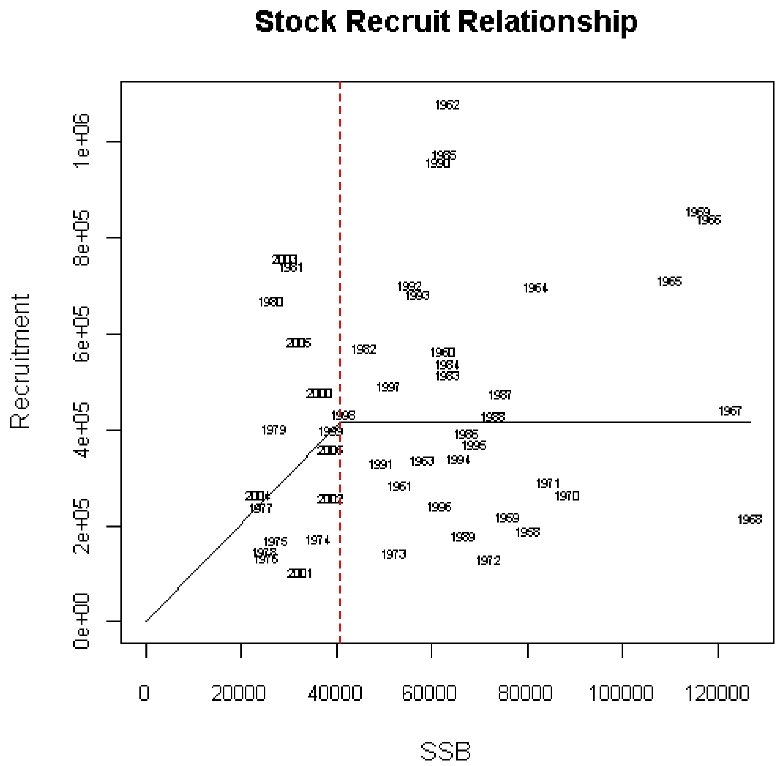


Figure 3. Stock recruit relationship using segmented regression and SSB changepoint indicated.

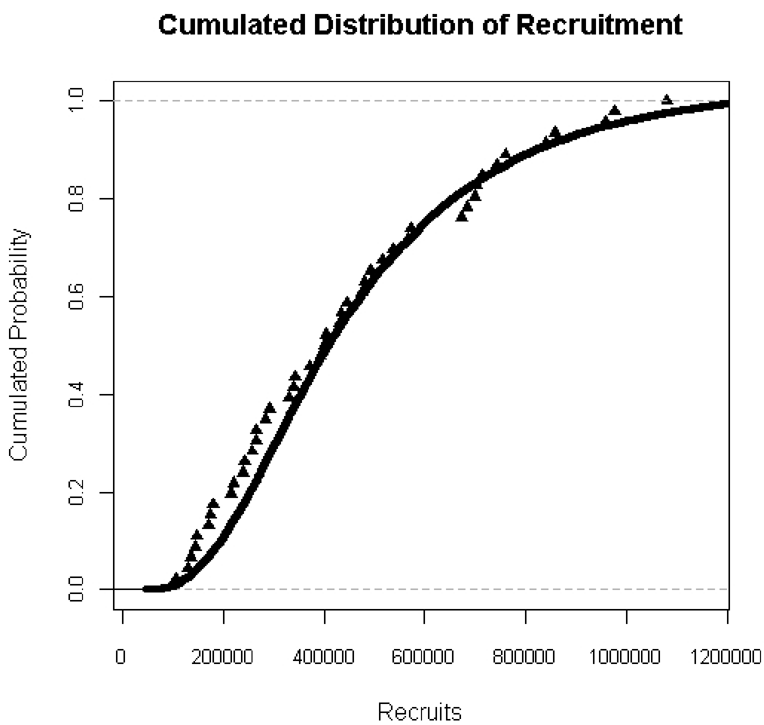


Figure 4. Stock recruit relationship cumulative distribution of observed and expected recruitments.

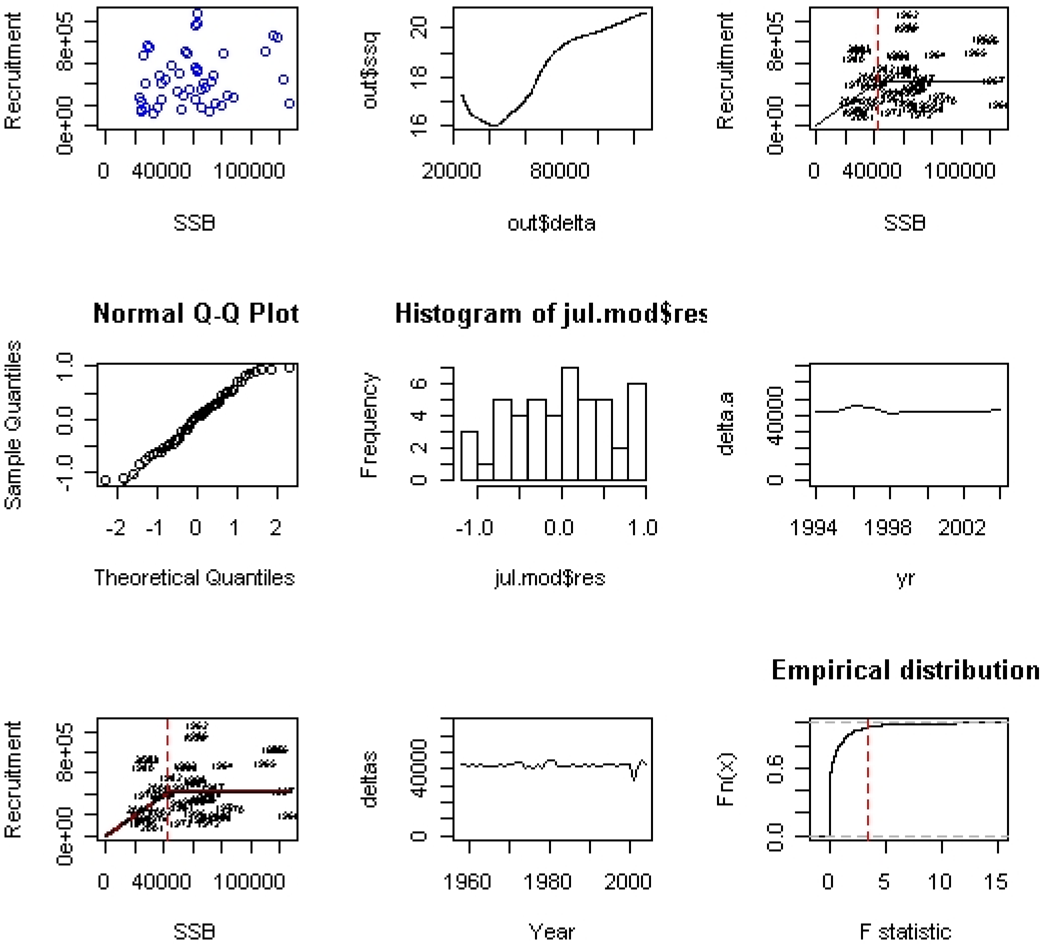


Figure 5. Stock recruit relationship diagnostics of the model fit.

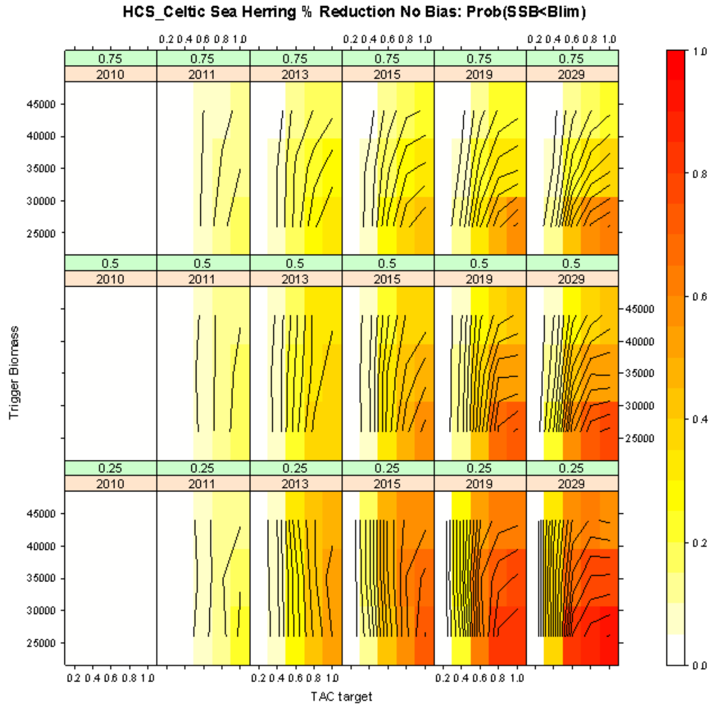


Figure 6.1. Contour plot showing the probability that SSB < B_{lim}. Run 1, broad scale screening without implementation bias. The x-axis shows potential target F over a broad range, and the y-axis the differing levels of trigger biomass. Each line represents a % TAC reduction, to be implemented if SSB <B_{lim} (25%, 50% and 75%).

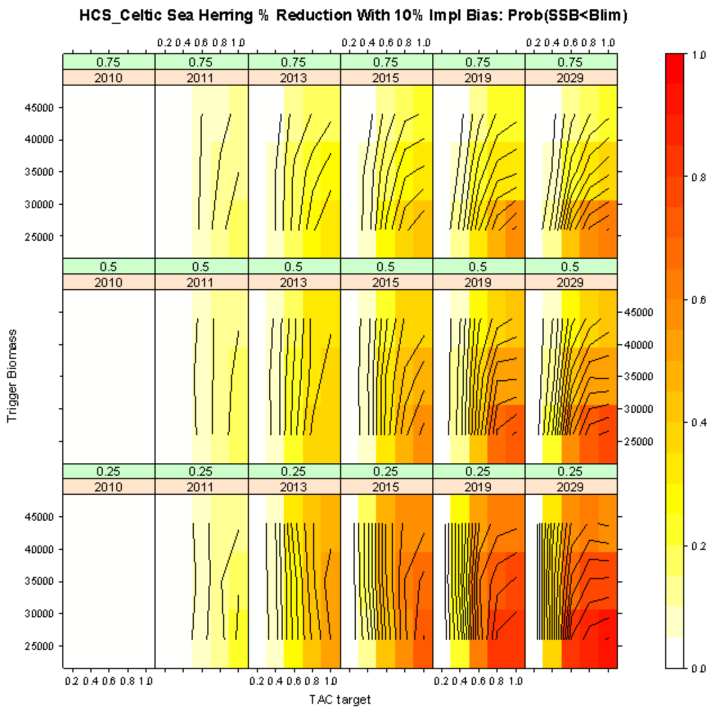


Figure 6.2. Contour plot showing the probability that SSB < B_{lim}. Run 2, broad scale screening with implementation bias. The x-axis shows potential target F over a broad range, and the y-axis the differing levels of trigger biomass. Each line represents a % TAC reduction, to be implemented if SSB <B_{lim} (25%, 50% and 75%).

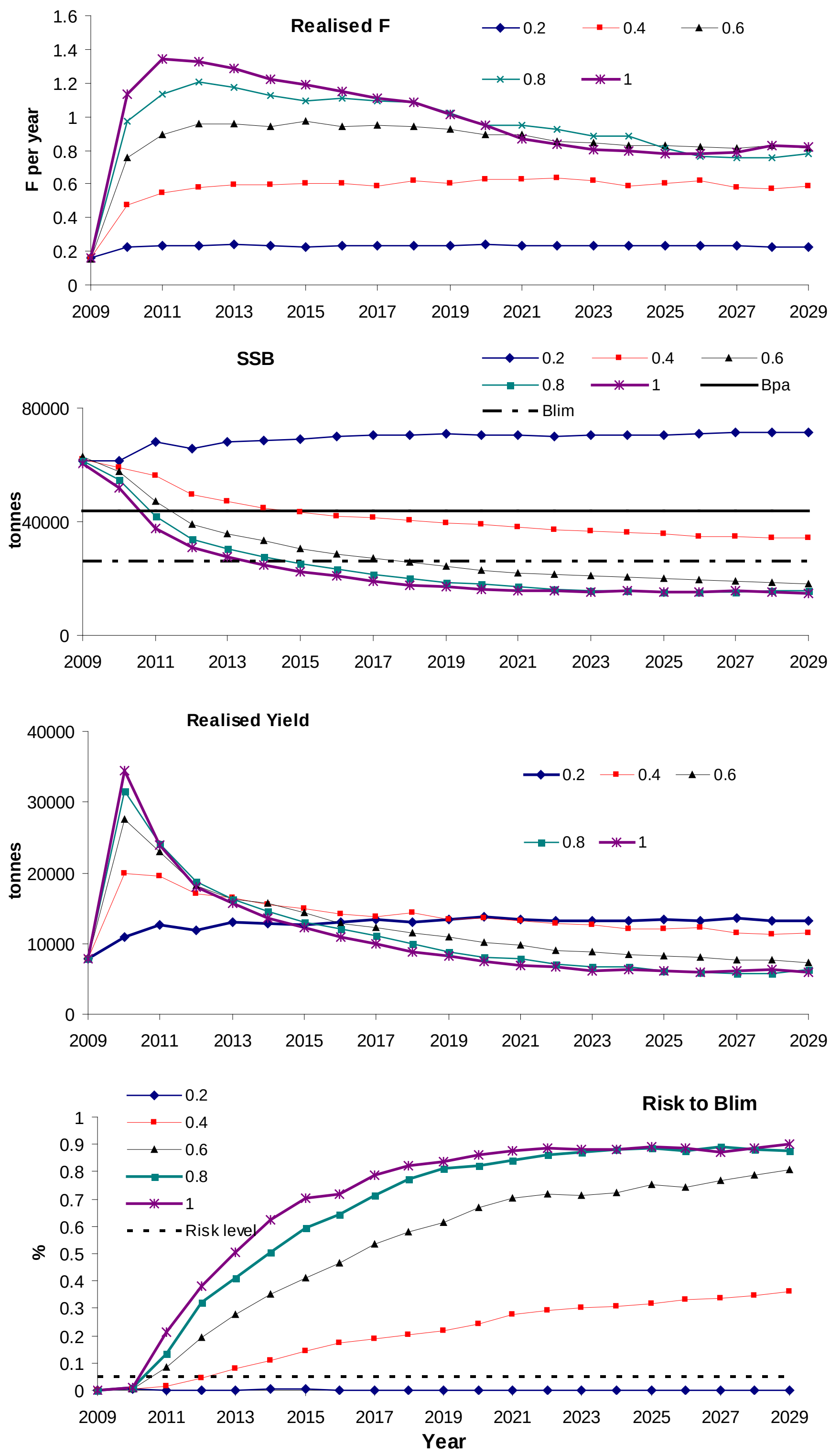
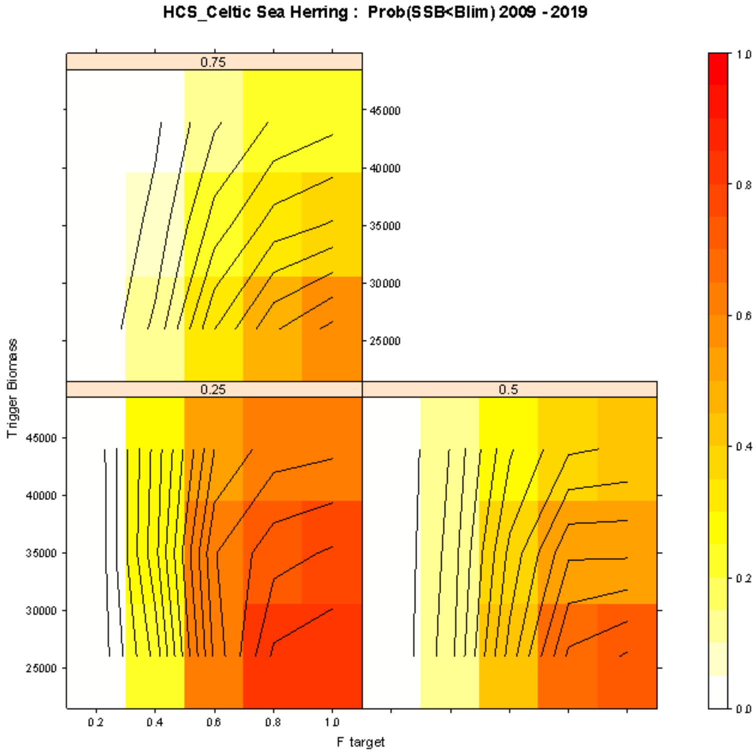


Figure 6.3. Trajectory plots for broad scale screening exercise (Run 2). Simulated trajectories for F, SSB, catch and risk to B_{lim}. Precautionary 5 % risk level indicated.



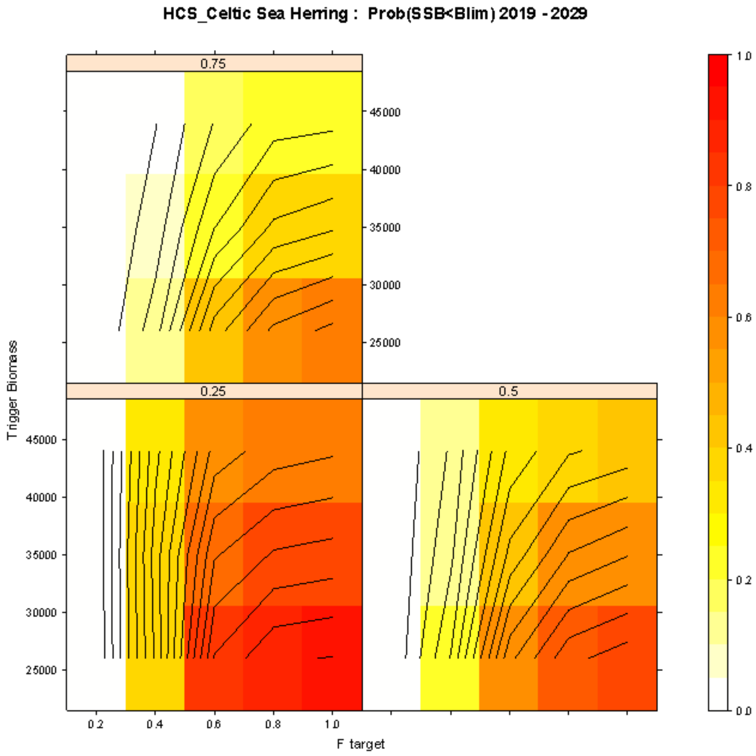


Figure 6.4. Plot showing the probability that SSB < B_{lim} (Run 2). Risk of being below B_{lim} in the first and second 10-year periods of the simulation. The x-axis shows potential target F over a broad range, and the y-axis the differing levels of trigger biomass. Each line represents a % TAC reduction, to be implemented if SSB <B_{lim} (25%, 50% and 75%).

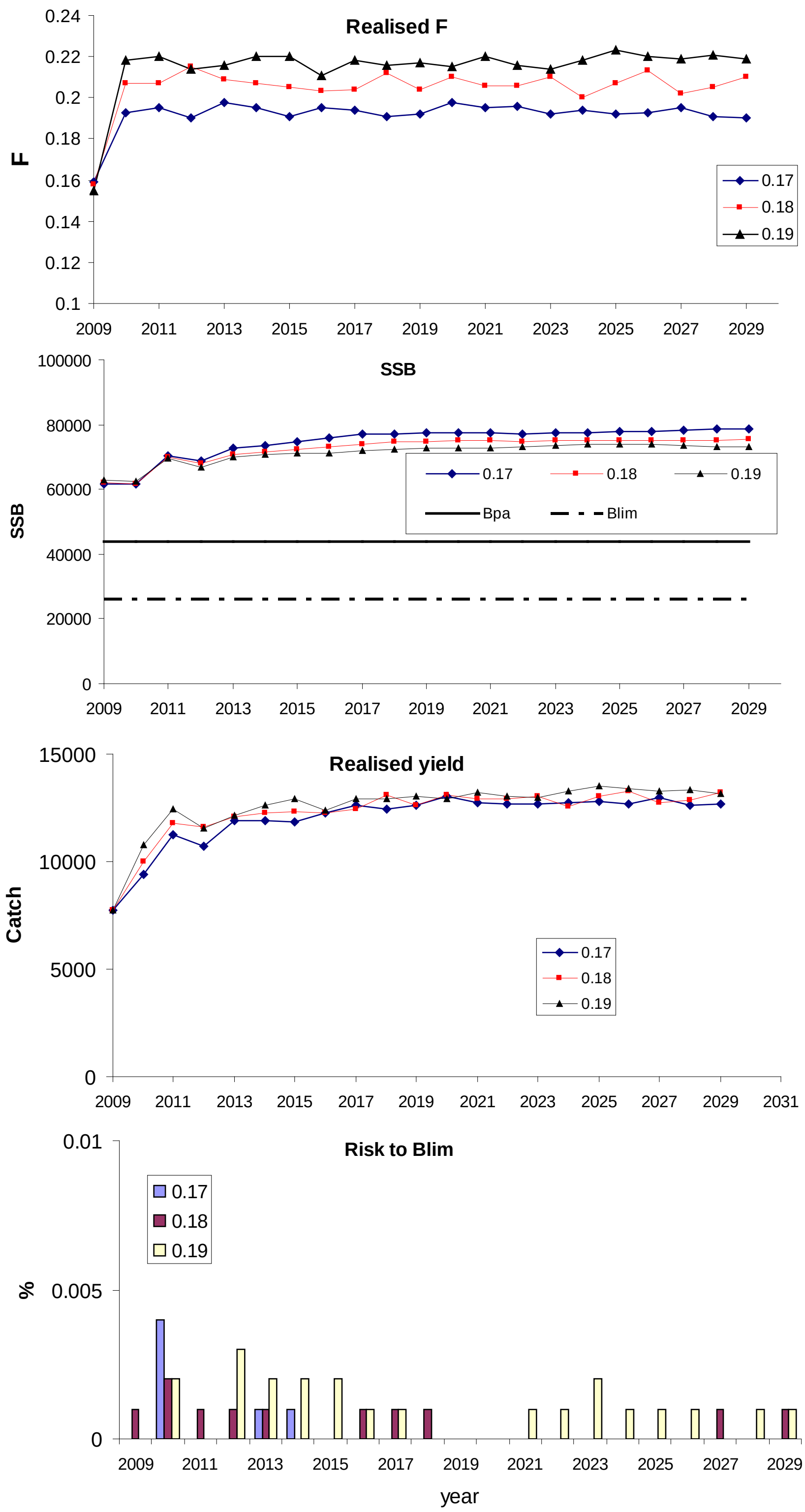


Figure 7.1. Trajectory plots for simulations of proposed rebuilding plan (Run 3). Simulated trajectories for F, SSB, catch and risk to B_{lim}. Risk to B_{lim} presented as a histogram because of very low levels.

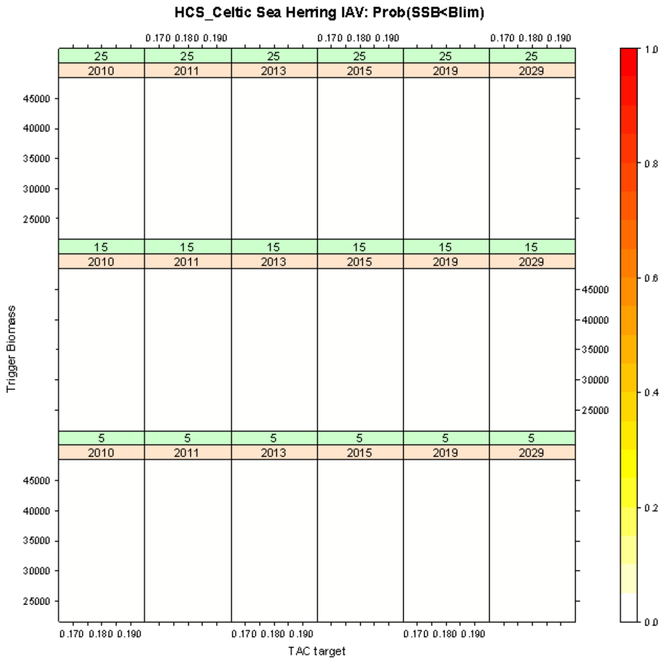


Figure 8.1. Plot showing the probability that SSB < B_{lim} for sensitivity analysis of the base case to differing inter-annual TAC variations. The x-axis shows potential target F, and the y-axis the differing levels of trigger biomass. Each line represents a % TAC reduction, to be implemented if SSB <B_{lim}.

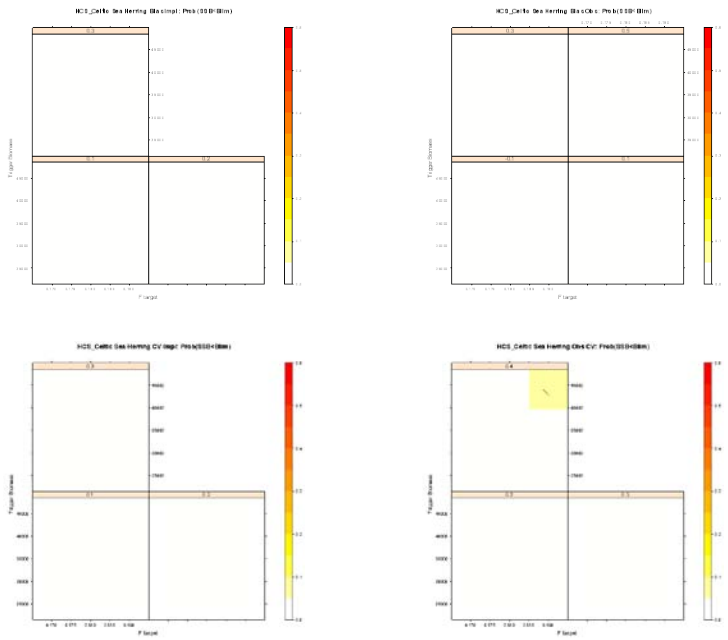
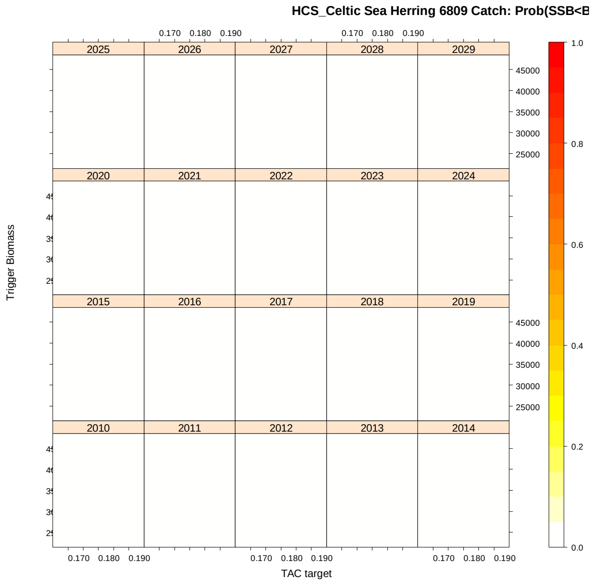
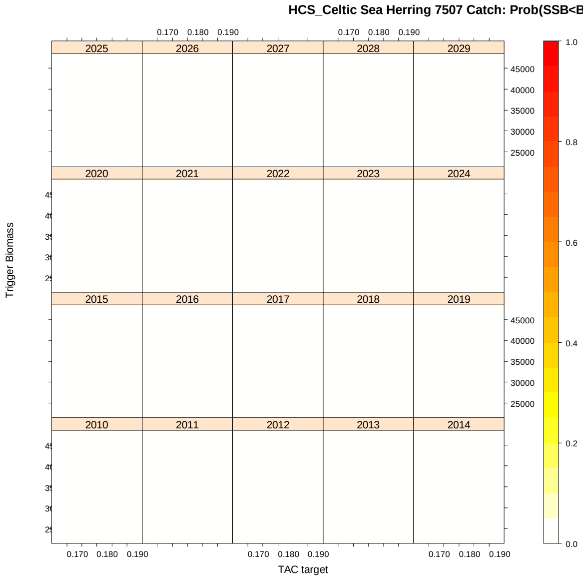


Figure 8.2. Plot showing the probability that SSB < B_{lim} for sensitivity analysis of the base case to observation and implementation model error (CV) and bias. The x-axis shows potential target F, and the y-axis the differing levels of trigger biomass. Top left to bottom right: Runs 8 (implementation bias), 6 (observation bias), 7 (implementation CV) and 5 (observation CV).





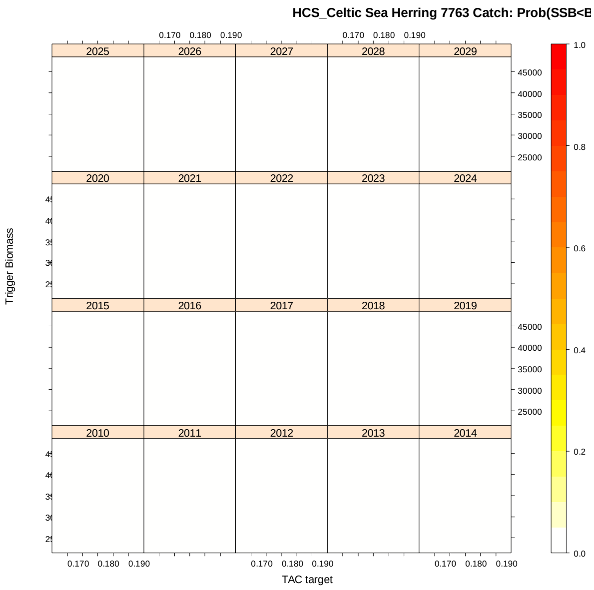


Figure 8.3. Plot showing the probability that SSB < B_{lim} for sensitivity analysis of the base case to the three most likely interim year catches. The x-axis shows potential target F, and the y-axis the differing levels of trigger biomass. Each plot represents a separate interim year catch.

Appendix 1. Detailed output of base case simulation run.

Target F	Btrig	Year	F	SSB	Catch	TAC	Change	Plim	Pcrash
0.17	26000	2009	0.159	61502	7763	7763	0	0	0
		2010	0.193	61689	9423	9244	8.6	0.004	0
		2011	0.195	70892	11237	11065	17.2	0	0
		2012	0.19	68904	10693	10692	-2.8	0	0
		2013	0.198	72535	11926	11606	7.1	0.001	0
		2014	0.195	73619	11920	11743	2.8	0.001	0
		2015	0.191	74682	11866	11823	0.7	0	0
		2016	0.195	75930	12249	12054	1.6	0	0
		2017	0.194	76897	12597	12246	2.5	0	0
		2018	0.191	77019	12442	12241	-0.6	0	0
		2019	0.192	77461	12632	12471	2.1	0	0
		2020	0.198	77431	13026	12698	2	0	0
		2021	0.195	77316	12759	12382	-2.1	0	0
		2022	0.196	77193	12674	12355	0.1	0	0
		2023	0.192	77547	12679	12467	0.4	0	0
		2024	0.194	77436	12719	12534	0.4	0	0
		2025	0.192	77832	12775	12503	-0.2	0	0
		2026	0.193	78015	12686	12444	0.5	0	0
		2027	0.195	78414	12977	12815	2.9	0	0
		2028	0.191	78531	12635	12417	-3.2	0	0
		2029	0.19	78626	12700	12459	0.2	0	0
0.17	35000	2009	0.158	62161	7763	7763	0	0	0
		2010	0.198	62176	9653	9553	10.9	0	0
		2011	0.195	71179	11336	11209	15.6	0.001	0
		2012	0.193	69654	10999	10824	-2.4	0	0
		2013	0.185	73415	11304	11276	3.9	0	0
		2014	0.195	74954	12227	11907	6	0	0
		2015	0.2	75970	12604	12331	3.4	0.001	0
		2016	0.201	75865	12541	12211	-0.6	0.001	0
		2017	0.197	76350	12633	12337	1.1	0.001	0
		2018	0.194	76575	12568	12237	-0.3	0.001	0
		2019	0.198	76705	12705	12449	1.2	0.001	0
		2020	0.191	77267	12354	12029	-2.3	0	0
		2021	0.195	78062	12773	12519	2.7	0.001	0
		2022	0.192	78410	12691	12391	0	0.001	0
		2023	0.195	78514	12910	12778	2.9	0.001	0
		2024	0.198	78436	13131	12679	-0.9	0.001	0
		2025	0.194	78079	12804	12485	-1.2	0	0
		2026	0.192	78053	12675	12344	-0.7	0	0
		2027	0.196	78357	12976	12697	2.3	0	0
		2028	0.2	77815	13160	12850	0.9	0	0
		2029	0.196	77217	12840	12524	-1.6	0	0
0.17	44000	2009	0.16	61166	7763	7763	0	0	0
		2010	0.206	61309	9806	9554	12.8	0.001	0
		2011	0.201	69457	11266	11098	13.2	0	0
		2012	0.201	68078	10891	10801	-1.6	0.003	0
		2013	0.201	71328	11722	11402	4.3	0.002	0
		2014	0.197	72793	11764	11597	3	0.002	0
		2015	0.208	73896	12520	12141	4.3	0.002	0
		2016	0.199	74811	12232	12049	-1	0.003	0
		2017	0.197	75515	12380	12139	1.3	0.002	0
		2018	0.199	76039	12588	12367	1.3	0.002	0
		2019	0.204	76230	12801	12266	-0.8	0.005	0
		2020	0.2	76422	12606	12488	0.8	0.003	0
		2021	0.199	76731	12673	12288	-0.9	0.003	0
		2022	0.196	76987	12444	12175	-0.2	0.002	0
		2023	0.197	77622	12714	12572	2.3	0.002	0
		2024	0.197	77580	12828	12577	0.4	0.002	0
		2025	0.2	77501	12865	12616	-0.1	0.001	0
		2026	0.196	77411	12800	12478	-1	0.001	0
		2027	0.195	77423	12626	12405	-0.2	0	0
		2028	0.196	77582	12729	12566	0.9	0.002	0
		2029	0.192	77572	12504	12313	-1.5	0.001	0

Appendix 1. (continued).

Target	Btrig	Year	F	SSB	Catch	TAC	Change	Plim	Pcrash
0.18	26000	2009	0.158	61961	7763	7763	0	0.001	0
		2010	0.207	61747	9984	9774	13.9	0.002	0
		2011	0.207	69857	11805	11651	16.4	0.001	0
		2012	0.215	67963	11609	11299	-2.8	0.001	0
		2013	0.209	70715	12062	11822	4.9	0.001	0
		2014	0.207	71432	12243	11995	2.2	0	0
		2015	0.205	72214	12300	12015	0.3	0	0
		2016	0.203	72940	12265	12157	2.2	0.001	0
		2017	0.204	73863	12432	12357	1.8	0.001	0
		2018	0.212	74594	13111	12682	1.5	0.001	0
		2019	0.204	74773	12634	12438	-0.8	0	0
		2020	0.21	75049	13081	12809	1.9	0	0
		2021	0.206	74991	12930	12739	0	0	0
		2022	0.206	74894	12903	12531	-1	0	0
		2023	0.21	75197	13047	12636	1.2	0	0
		2024	0.2	75018	12537	12392	-2.4	0	0
		2025	0.207	75175	13022	12715	2.1	0	0
		2026	0.213	75124	13279	12719	0.2	0	0
		2027	0.202	75163	12733	12565	-0.2	0.001	0
		2028	0.205	75291	12882	12664	0.6	0	0
		2029	0.21	75682	13223	12908	1.5	0.001	0
0.18	35000	2009	0.158	62319	7763	7763	0	0	0
		2010	0.209	62201	10182	9941	15.9	0.001	0
		2011	0.209	70065	11948	11742	13.9	0	0
		2012	0.212	68181	11628	11438	-0.9	0.001	0
		2013	0.211	70939	12111	11868	3.6	0.001	0
		2014	0.219	71455	12706	12380	5.2	0.003	0
		2015	0.214	72318	12603	12364	0.2	0.002	0
		2016	0.205	72791	12242	12042	-1.9	0.003	0
		2017	0.208	73357	12700	12351	2.2	0.002	0
		2018	0.209	73584	12887	12406	0.3	0.001	0
		2019	0.204	73590	12522	12298	-0.7	0.001	0
		2020	0.21	74294	12818	12696	3	0	0
		2021	0.213	74799	13126	12777	0.8	0.001	0
		2022	0.205	74549	12766	12606	-1.7	0.001	0
		2023	0.199	75385	12535	12437	-0.4	0	0
		2024	0.205	76199	13009	12631	2	0	0
		2025	0.208	75732	13195	12895	1.1	0	0
		2026	0.205	75359	12931	12720	-0.4	0	0
		2027	0.209	75084	13205	12842	0	0	0
		2028	0.204	74756	12792	12566	-1.8	0	0
		2029	0.208	74884	12984	12709	1.4	0	0
0.18	44000	2009	0.158	62136	7763	7763	0	0.001	0
		2010	0.206	62044	10058	9908	15.8	0.001	0
		2011	0.209	70258	11871	11712	15.8	0	0
		2012	0.216	68625	11841	11532	-0.9	0.002	0
		2013	0.212	71257	12209	12037	4	0.003	0
		2014	0.216	71702	12517	12186	1.6	0.004	0
		2015	0.217	72282	12601	12248	0.8	0.006	0
		2016	0.216	72974	12772	12330	0	0.006	0
		2017	0.219	73408	12857	12567	1.8	0.006	0
		2018	0.214	73806	12814	12604	0.3	0.005	0
		2019	0.212	74001	12793	12677	0.5	0.005	0
		2020	0.216	74563	12954	12656	0	0.005	0
		2021	0.213	74946	13016	12748	0.4	0.007	0
		2022	0.213	74829	12973	12706	-0.7	0.006	0
		2023	0.216	74868	13177	12773	0.7	0.005	0
		2024	0.212	74675	12878	12689	-0.3	0.005	0
		2025	0.208	74882	12907	12681	-1	0.005	0
		2026	0.214	74741	13116	12736	0.6	0.006	0
		2027	0.211	74515	13038	12857	0.4	0.003	0
		2028	0.214	74642	13190	12868	0	0.002	0
		2029	0.212	74829	12912	12710	-0.5	0.001	0

Appendix 1. (continued).

Target F	Btrig	Year	F	SSB	Catch	TAC	Change	Plim	Pcrash
0.19	**26000**	2009	0.155	62930	7763	7763	0	0	0
		2010	0.218	62427	10797	10621	21.8	0.002	0
		2011	0.22	69566	12448	12284	13.3	0	0
		2012	0.214	66959	11571	11491	-5	0.003	0
		2013	0.216	69767	12143	11928	3.1	0.002	0
		2014	0.22	70570	12618	12418	5.7	0.002	0
		2015	0.22	71204	12904	12485	-1.1	0.002	0
		2016	0.211	71328	12410	12252	-0.3	0.001	0
		2017	0.218	72048	12934	12674	3.1	0.001	0
		2018	0.216	72394	12927	12645	-0.2	0	0
		2019	0.217	72584	13012	12723	1.1	0	0
		2020	0.215	72824	12943	12788	0.4	0	0
		2021	0.22	72858	13222	12991	1.4	0.001	0
		2022	0.216	72998	13034	12861	-0.6	0.001	0
		2023	0.214	73454	12978	12754	-1	0.002	0
		2024	0.218	74060	13268	12946	1.8	0.001	0
		2025	0.223	73937	13500	13164	1.5	0.001	0
		2026	0.22	73794	13416	13108	-0.1	0.001	0
		2027	0.219	73582	13280	13027	-0.6	0	0
		2028	0.221	73266	13362	13066	-0.5	0.001	0
		2029	0.219	73091	13167	12907	-0.3	0.001	0
0.19	**35000**	2009	0.161	61051	7763	7763	0	0.001	0
		2010	0.22	61015	10540	10379	19	0.003	0
		2011	0.233	68491	12621	12308	16.6	0.001	0
		2012	0.229	66282	11850	11594	-4.5	0.004	0
		2013	0.228	69327	12488	12140	3.5	0.007	0
		2014	0.224	70431	12614	12424	2.8	0.006	0
		2015	0.227	70732	12916	12602	1.4	0.007	0
		2016	0.229	70821	13123	12767	1.3	0.005	0
		2017	0.232	70922	13238	12829	0.5	0.006	0
		2018	0.224	70706	12806	12624	-1	0.005	0
		2019	0.218	70840	12635	12419	-1.3	0.004	0
		2020	0.223	71334	12959	12793	2.4	0.002	0
		2021	0.22	71533	12854	12604	-0.6	0.001	0
		2022	0.222	71750	12919	12698	0.4	0.002	0
		2023	0.223	71954	13141	12742	1.1	0.004	0
		2024	0.224	72042	13040	12767	0.1	0.002	0
		2025	0.219	72501	12811	12712	0	0.002	0
		2026	0.22	72875	13143	12883	0.9	0.002	0
		2027	0.217	72736	13081	12898	0	0.001	0
		2028	0.218	72837	13124	13065	1.3	0.001	0
		2029	0.216	73021	12975	12823	-1.3	0.002	0
0.19	**44000**	2009	0.157	62139	7763	7763	0	0.001	0
		2010	0.222	61604	10720	10541	20.3	0.002	0
		2011	0.224	68915	12341	12128	14.2	0.002	0
		2012	0.236	66397	12333	12154	0.3	0.001	0
		2013	0.237	68375	12455	12227	0.1	0.003	0
		2014	0.234	68522	12481	12149	0.8	0.006	0
		2015	0.231	69238	12661	12516	2.5	0.005	0
		2016	0.226	69949	12465	12256	-1.4	0.004	0
		2017	0.222	70267	12612	12483	1.1	0.005	0
		2018	0.226	70671	12927	12757	1.9	0.004	0
		2019	0.225	71082	12910	12547	-1	0.003	0
		2020	0.224	71498	12898	12757	1.4	0.003	0
		2021	0.226	71389	13023	12789	-0.6	0.002	0
		2022	0.229	72163	13101	12746	0	0.002	0
		2023	0.235	72323	13562	13120	1.6	0.004	0
		2024	0.231	72388	13239	13095	0.2	0.003	0
		2025	0.233	72393	13390	13114	0.3	0.004	0
		2026	0.234	72414	13564	13198	0.7	0.005	0
		2027	0.228	72125	13235	13001	-2	0.005	0
		2028	0.233	72359	13399	13028	1	0.005	0
		2029	0.226	72192	12965	12737	-1.8	0.003	0

Review of Celtic Sea management plan

John Simmonds 9th June 2009

The proposed management plan for Celtic Sea (Zones VIIhjk):

1) For 2010 and subsequent years the TAC will be set consistent with a fishing mortality rate of F0.1 = 0.19.

2) If, in the opinion of ICES and STECF the catch should be reduced to the lowest possible level, the TAC for the following year will be reduced by 25%

(With additional restrictions not tested)

The EC requested the evaluation should address:

1) the consequences of implementing the above rule instead of implementing ICES' current advice for this stock according to the precautionary approach;

2) the extent to which the application of this rule would deliver management inconformity with the precautionary approach;

3) the extent to which the application of this rule would deliver maximum sustainable yield from the stock;

4) where possible, stochastic future time-streams of TACs and fishing effort

5) necessary to catch those TACs should be made available to STECF for economic analysis.

ICES has requested a review based on the 8 clauses

1) Is the study based on a correct interpretation of the management plan*?

2) Have the authors presented the correct information for evaluating the precautionary nature of the plan?

3) Are the assumed stock dynamics an adequate basis for simulating the plan?

4) Are the assumed fleet dynamics an adequate basis for predicting future catches and fishing mortality in the simulation?

5) Has an appropriate model formulation been used?

6) Have all sources of process and estimation error that could impact the conclusions been adequately represented?

7) Are the authors' conclusions valid?

8) Has the request been answered in full?

The review below is organised around these eight clauses and a brief look at the questions raised by the EC.

1. Correct interpretation

The plan appears to be correctly interpreted, though the diagram in Figure 1 is a poor representation of the process.

2. Correct information on the performance of the plan.

Figure 7.1 provides the basic information on the precautionary performance of the plan as simulated. Blim is specified at 26,000 t on the basis of lowest observed SSB, however, with a well established breakpoint at 41,600 t in the S/R relationship (see below) there are indications this may be miss specified. Nevertheless current specification is at 26,000 and ICES criteria of 5% are correctly dealt with.

3. Adequacy of the assumed stock dynamics

The fitted S/R relationship and input data are given in Figures 3 and 5. A example of the simulated data are given in Figure 4. The fitted model appears to be an adequate single model description of the historic stock and recruitment. The choice of model is plausible and well supported by the data, the fitting method is suitable to give a good fit between data and model. The SSB breakpoint is well described by the data and the value of SSB at the breakpoint and mean recruitment above the breakpoint are well established. The diagnostics indicate that the S/R data are stable over time and therefore the use of the fitted model to infer the future is reasonable. There are indications of slight deviation from the model below the breakpoint, but this does not substantively influence any aspect of the results.

The clipping of simulated values appears appropriate (Fig 4) but its unclear over which biomass values the comparison of simulated and predicted have been compared (normal practice would be to use only the observed SSBs hopefully this is what is presented). The report states that the model predicts higher recruitment from 0.2 to 0.5, but Fig 4 seems to show the reverse. No mention is made of a year on year correlation in recruitment, though this seems evident in the timeseries.

In conclusion the S/R model appears well founded with the exception of autocorrelation and thus may be classed as marginally adequate.

4. Adequacy of assumed fleet dynamics for predicting future catches and fishing mortality in the simulation?

No description is provided to describe fishery dynamics, though the use of implementation CV and bias of 20% and 10% seem reasonable (or too uncertain) given the recent history of fishing. The mismatch between TAC year and fishery and assessment implies some flexibility between years. Evaluations of between year flexibility (Methods 2008) suggest this is not a problem for low exploitation rates such as those proposed. Control through TAC would seem to be effective based on data in the ICES stock summary sheet (ICES 2008)

5. Appropriateness of model formulation

The software used was supplied from the ICES website and has been validated by use on other similar simulations.

Parameterisation of the model is rather superficial, ignoring any autocorrelation in either recruitment or measurement error, though both are available in the software. This simple approach does not include an evaluation of assessment error, or correlation in that error. Given that the evaluation was for one specific harvest rule with only one survey to tune the assessment and that assessment model used (FLICA) is available in FLR it would be feasible to carry out a fuller evaluation. At the least it would be helpful to check the characteristics of error in the assessment in a small number of runs of a single case.

6. Have all sources of process and estimation error that could impact the conclusions been adequately represented?

The basis for fishery dynamics and the implementation error is poorly described in the report. This base case assumes 20% CV on implementation and observation, and a 10% bias on implementation. While these figures are plausible, there is little presented in the document to back this up. Examination of the ICES ACOM advice sheet for Celtic Sea herring indicates that the catches recorded (and included in the data used for the S/R model) are below the TAC in the last 12 years. Suggesting that the values assumed for bias and CV on implementation may overestimate these errors.

The recent survey seems to perform well but the timeseries may be a bit short to determine errors well. Once the survey is compared with a converged VPA errors may be more reliably established, though this will not be possible for several more years. In this case choice of 20% CV may be over optimistic for a single vessel acoustic survey.

A sensitivity analysis to observation and implementation bias is provided, these vary from from -0.1 to 0.5 and .1 to 0.3 respectively. Similarly observation and implementation CV is varied from 0.2 to 0.4 and 0.1 to 0.3 respectively. These provide a fairly simple and effective approach to evaluating if the results are critical to the assumptions.

This sensitivity analysis shows risks are not significant except for observation CVs of 0.4 at Fs above 0.185. However, the investigation does not cover higher CVs and higher implementation bias combined.

Nevertheless the insensitivity of the conclusions to plausible if simplistic errors is such that this is an adequate approach in these circumstances. This would not be the case if the results were more marginal.

6. Validity of authors' conclusions

The authors conclude that from the current starting point fishing at F0.1 (0.17 to 0.19) is in accordance with the precautionary approach, this is supported by the analysis.

Some concern is expressed that previously observed catches may be too high to sustain a 25% restriction on TAC. However, if the target F of ~ 0.18 a 25% is complied with (within 10% bias and 20% CV) then the 25% should be acceptable unless a very long run of poor recruitment occurs. However, because autocorrelation has not been included in the simulated S/R relationship and SSB does not fall below Blim during simulations at F=0.17-0.19 the consequences of applying 25% with SSB below Blim are not tested and not know.

The conclusions are based on the current PA points which might benefit from reevaluation.

7. Has the request been answered in full?

In addition to the questions raised by ICES the EC asked the following:

1. the consequences of implementing the above rule instead of implementing ICES' current advice for this stock according to the precautionary approach;

The rebuilding plan proposed might result in slower recovery than that obtainable by following ICES precautionary advice of no directed fishery. However, currently this ICES advice does not seem to be being followed (see ICES stock summary sheets), so the plan may be lead to recovery more quickly than NOT following ICES precautionary advice.

2. the extent to which the application of this rule would deliver management in conformity with the precautionary approach;

The simulations show that the plan is precautionary within the ICES definition (risk <5% SSB below Blim). The evaluation was limited in scope ignoring some aspects that may be important but as a sensitivity analysis using more demanding conditions of bias and error was carried out and also show acceptable performance. Thus given the relatively low exploitation rate (F=~0.18) limitations are acceptable and the conclusion that the plan is precautionary is reasonable.

The inclusion of a 25% inter-annul restriction on reduction in TAC given SSB below Blim is not testable within the range of recruitment simulated, as the F target does not bring the stock to Blim to allow this to be tested. Any test if this would be artificial. Nevertheless it is expected that such a restriction is acceptable as the exploitation rate implied by F-0.18 is lower than the 25% restriction thus TACs should come down faster than the stock.

3. the extent to which the application of this rule would deliver maximum sustainable yield from the stock;

The plan is designed to give fishing at F0.1. Based on yield per recruit studies presented in HAWG (ICES 2009), Celtic Sea herring has no defined Fmax within a plausible range of F. In the absence of Fmax, F0.1 forms a good surrogate for Fmsy.

Review of the Celtic Sea Herring management plan evaluation

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1. Is the study based on a correct interpretation of the management plan*?

This study integrates mainly points 2 and 3 of the EU policy statements.

Point 2: "In 2010 and subsequent years, the TAC shall be set equal to a fishing mortality of F0.1." . F0.1 = 0.17 and 0.19 were integrated as input parameters for the simulations therefore this point is fully implemented into the modeling framework used for this study.

Point 3: The discussion section of this study clearly explains how point 3 "the catch should be reduced to the lowest possible level, the TAC for the following year will be reduced by 25%" has been interpreted in the study. The wording of the EU policy statement is misleading but the interpretation of this clause appears to be correct: if SSBtacyear<Blim , A 25% reduction in TAC is applied.

Points 4 and 5 deal with the closure of VIIaS. Considering the possible migrations between areas, it would have been interesting to make an attempt to consider how the closure of this area may or may not reflect on the short term scale on VIIj. That, however, could have added another factor of uncertainties.

Points 1, 6 and 7 were not points to be discussed/implemented in the management plan.

2. Have the authors presented the correct information for evaluating the precautionary nature of the plan?

The authors focused on the following criteria to evaluate the plan : the probability of SSB falling below Blim, Realized F, catch, SSB and risk to Blim. Those parameters are sufficient to understand what the plan may imply for the stock and its harvesting.

The presentation of the results however lacks of a sound temporal limit which also reflects the lack of temporal limit in implementation of the EU policy statements. From a modeler point of view, on figure 6.3, most runs tend towards some steady states situation past 2019 and until the end of the runs in 2029. The occurrence of steady-state situation in nature is itself a nearly philosophical debate among scientists. Here, considering the variation in recruitment on a short term species and all the potential factors that may affect the fishing efforts (adjustment in fleets due to gas price for example), estimating the state of the stock without too much errors is probably only possible for a few number generations (e.g. 3-4). In that sense, going past 2019 may be misleading as a quick reading of the plots may suggest people outside of the modeling world that things will be nicely steady after 2019 which is not realistic as this situation is more a signal from the model structure rather than the natural variations of its parameters (biology, harvesting, environmental factors…). This could be avoided by limiting all plots to 2019.

3. Are the assumed stock dynamics an adequate basis for simulating the plan?

The discussion section of this study mentions the problems identified in the assessment methodology (i.e. benchmark). The general impression is that the authors are aware of the problems and of some of the solutions to explore to solve them. However, no exploratory/sensitivity analyses were made to evaluate the impact of those factors. The reason was mainly the lack of knowledge/data of some aspects or the fact some of those points were usually not considered into the assessments. The stock dynamics does not include the effect of mixing from adjacent area as this point is considered to add some uncertainty. However, this discussion gives the overall impression that the stock dynamics is well relatively described considering the current knowledge on the fisheries.

Dealing with the stock recruitment relationship is a source of issues due to the variability of the recruitment between years. The authors mentioned any of the classical models were applicable but no indication of the quality of the fitting of those relationships was provided (such as r^2 or AIC). A similar S-R situation has been observed with the Bay of Biscay anchovy long term management plan (STECF, 2008) and none of the regular models were apparently applicable as well. In practice, all models for BoB anchovy had the same AIC which meant that none of the model was performing better than the others therefore the adjustment was quite poor. In that case, choosing the most convenient (i.e the least worst) model may be based on some criteria such as the shape or the number of parameters. Here, the segmented regression is simpler to use than any curvilinear approach and still provides more or less the same (poor) adjustment.

A closer look at figure 3 (S-R) shows the stock has been quite low in recent years but recruitment has been very variable. Data go back to 1958 and up to 2006. Considering the recent biomass of the stock, fitting the S-R relationships for the whole time series may put too much weight on past biomass situations. The authors explain however that the fitting on the whole time series provides some robust results.

Under the scrutiny of different neutral eyes, any attempt to fit a relationship on those points may result in different approaches/point of view. It would have been interesting to have a better explanation of this choice of segmented regression and maybe a sensitivity analysis using another descriptor/relationship for S-R.

4. Are the assumed fleet dynamics an adequate basis for predicting future catches and fishing mortality in the simulation?

The fleet dynamics is not explicitely mentioned in this study as the total catch is ruled by the Harvest Control Rules (HCR) through the automatic TAC set by the estimates of SSB. The activity of the fleet is not simulated. The closure of VIIaS and its possible effects on the redeployment of the local fleet are not integrated into this study as well. Considering the distances between areas, it is hard to tell if integrating that measure into this plan would have affected the biomass in VIIj.

5. Has an appropriate model formulation been used?

The general procedure used for this study is more or less standard and is described with details in the "Materials and Method" section. From an outsider point of view, the information is detailed enough to understand the approach taken. The procedure itself seems fine for the task (the same principles have been applied on some other MSE e.g. North Sea Cod).

6. Have all sources of process and estimation error that could impact the conclusions been adequately represented?

The major sources of uncertainties for this stock have been reviewed in this study in the discussion section (see answers #3 and #4).

One source of error apparently not accounted into this study remains using the most recent assessment as a starting point for the simulations. The Benchmark report (Cadrin et al., 2009) mentions that the assessment model lacks of performance diagnostics (e.g. the screening of possible retrospective pattern). Considering the various sources of uncertainties from the data and from the performance of the model, it would have been interesting to test the behavior of the Management plan for different starting years (for example, the assessments for the last 5 years). I suspect as the management plan converge towards steady-state on the long run that the plan, overall, is not strongly affected by some possible biases in the initial conditions of the simulation. However, as this plan is more oriented towards a short-term situation, there may be some significant changes in the first years simulated.

7. Are the authors' conclusions valid?

The modeling framework provides the usual responses one can expect from looking for the compromise between protecting and harvesting the stock: setting higher Btrigger is a protective measure and lowering F reduce the risk of collapse. The management plan is qualitatively sound on these mandatory aspects. Overall, the author's conclusions from the simulations appear to be valid. The sensitivity analysis which goes through various value of F and reductions of TAC is helpful to test how precautionary the 25% TAC reduction rule and F target (0.17-0.19) are in comparison to other values.

In the discussion, the paragraph "point 3 may not be…" is too concise to explain why the 25% TAC reduction should not be in a long term management plan.

Note: on figures 8.1, 8.2, 8.3, it would have been helpful to tell that probabilities are very low. For the quick reader, it seems like no plot has been correctly produced.

8. Has the request been answered in full?

The request has been answered in full for points 2 and 3 which were the only points ICES was asked to evaluate. The authors dealt with the consequence for catch and stock biomass of the implementation of the points 2 and 3, the limit of use of those rules to remain within the precautionary approach and to sustain maximum yield. The simulations also provide time series of the evolution of SSB, F, TAC and risk to be below Blim (although as I wrote earlier, the temporal extension after 2019 might be misleading). All those points were in the EU request letter*.

Through the sensitivity analysis, the authors went further than the initial request by exploring the risks associated with a wide range of target F (0.2-1) and higher reduction of TAC (50-75%). This kind of initiative is also within the EU request letter as ICES was "invited to propose alternative rules or modified rules on its own initiative or in consultation with RACs and to evaluate these"

*:(see
http://groupnet.ices.dk/HAWG2009/Celtic%20Sea%20Herring/Commision%20reply%20_Celtic%20Sea%20RebPlan.pdf)

References:

Anon. , 2008. Report of the STECF Meeting on long-term anchovy management. STECF. 77p + annex.

Cadrin, S., Pawlowski, L., Goethel, D. and Kerr, L. 2009. Benchmark review of Celtic Sea Herring. Unpublished report to ICES ACOM. 9 pp.

Annex 13 Technical Minutes of the Celtic Sea Review Group (RGCS) 2009

26 May – 4 June 2009, Fairhaven Massachusetts, USA

Reviewers: Steve Cadrin (chair), Adam Barkley, Greg DeCelles, Dan Goethel, Nikki Jacobson, Lisa Kerr, Dave Martins, Cate O'Keefe, Sally Roman, Tony Wood

Working Groups:

- Working Group on Celtic Seas Ecoregion (WGCSE, Colm Lordan chair)
- Herring Assessment Working Group (HAWG, Maurice Clarke chair)
- Working Group on the Assessment of Hake Monk and Megrim (WGHMM, Carmen Fernandez, chair)

Secretariat: Barbara Schoute

Process - The ICES advisory service quality assurance program requested that a team of graduate and post-doctoral students and their professor serve as a review group. The group initially met on 26 May to review the ICES advisory process, RG guidelines and to assign several WG report sections to each reviewer. A second meeting was held on 27 May to review standard ICES assessment models (XSA, ICA, SURBA, TSA and BADAPT). Members reviewed WG report sections independently, then presented their summaries and reviews to the group in a series of meetings during 1-3 June to discuss reviewers' proposals and form RG conclusions.

General - Stock assessment reports for 32 stocks were reviewed (Table1). The WG reports were generally informative, and WG decisions about data, model choice and specification and interpretations were clearly explained and justified. The RG concludes that the reports are technically correct, and the RG agrees with WG recommendations, with few exceptions. In nearly all cases, the assessments appropriately applied the procedures specified in the stock annexes. Some general issues were raised for many stocks related to discards, definition of assessment and management units and standardized methods. These general observations should be considered for the next benchmark reviews of these stocks.

Table 1. Stocks reviewed ordered by working group (WG), terms of reference (ToR), type of assessment and assessment method.

WG	Stock	Name	ToR	type	method
wgcse	cod-7e-k	Cod in Divisions VIIe-k (Celtic Sea Cod)	Update	no method	Benchmarked
wgcse	cod-iris	Cod in Division VIIa (Irish Sea)	Update	assess	BADAPT
wgcse	cod-rock	Cod in Division VIb (Rockall)	No assessment	no advice	
wgcse	cod-scow	Cod in Division VIa (West of Scotland)	Update	assess trends	TSA
wgcse	had-7b-k	Haddock in Divisions VIIb-k	Update	assess trends	XSA
wgcse	had-iris	Haddock in Division VIIa (Irish Sea)	Update	assess trends	SURBA
wgcse	had-rock	Haddock in Division VIb (Rockall)	Update	assess	XSA
wgcse	had-scow	Haddock in Division VIa (West of Scotland)	Update	assess	TSA
wgcse	whg-7e-k	Whiting in Divisions VIIe-k	Same Advice	assess trends	XSA
wgcse	whg-iris	Whiting in Division VIIa (Irish Sea)	Same Advice	assess trends	SURBA
wgcse	whg-scow	Whiting in Division VIa (West of Scotland)	Update	assess	SURBA
wgcse	ple-7h-k	Plaice in Divisions VIIh-k (Southwest of Ireland)	Same Advice	catch trends	-
wgcse	ple-celt	Plaice in Divisions VIIf,g (Celtic Sea)	Update	assess	XSA
wgcse	ple-echw	Plaice in Division VIIe (Western Channel)	Update	catch trends	XSA
wgcse	ple-iris	Plaice in Division VIIa (Irish Sea)	Update	assess	ICA
wgcse	sol-celt	Sole in Divisions VIIf, g (Celtic Sea)	Update	assess	XSA
wgcse	sol-echw	Sole in Division VIIe (Western Channel)	Update	survey trends	Benchmarked
wgcse	sol-iris	Sole in Division VIIa (Irish Sea)	Update	assess	XSA
wgcse	nep-11	Nephrops in Division VIa (North Minch, FU 11)	Update	assess trends	Benchmarked
wgcse	nep-12	Nephrops in Division VIa (South Minch, FU 12)	Update	assess trends	Benchmarked
wgcse	nep-13	Nephrops in Division VIa (Firth of Clyde, FU 13)	Update	assess trends	Benchmarked
wgcse	nep-14	Nephrops in Division VIIa (Irish Sea East, FU 14)	No assessment	assess trends	
wgcse	nep-15	Nephrops in Division VIIa (Irish Sea West, FU 15)	Update	assess trends	Benchmarked
wgcse	nep-17	Nephrops in Division VIIb (Aran Grounds, FU 17)	Update	assess trends	Benchmarked
wgcse	nep-19	Nephrops in Division VIIa,g,j (South East & West of IRL, FU 19)	No assessment	assess trends	
wgcse	nep-2022	Nephrops in Division VIIf,g,h (Celtic Sea, FU 20-22)	No assessment	assess trends	
wgcse	nep-7bcj	Nephrops in Division VIIb,c,j,k (Porcupine Bank, FU 16)	No assessment	assess	Status changed
wgcse	ang-ivvi	Anglerfish in Division IIa, IIIa, Subarea IV and VI	Update	assess trends	-
wgcse	meg-scrk	Megrim in Subarea VI (West of Scotland and Rockall)	Update	catch trends	-
wghmm	ang-78ab	Anglerfish in Divisions VIIb-k and VIIIa,b,d	Update	assess trends	-
wghmm	mgw-78	Megrim in Divisions VIIb-k and VIIIa,b,d	Update	survey & cpue trends	-
hawg	her-irls	Herring in Division VIIa South VIIg,h,j,k (Celtic Sea & S. Ireland)	Benchmark	assess trends	ICA
hawg	her-irlw	Herring in Divisions VIa (South) and VIIb,c	Same Advice	assess trends	ICA
hawg	her-nirs	Herring in Division VIIa North of 52° 30' N (Irish Sea)	Same Advice	assess trends	-
hawg	her-vian	Herring in Division VIa (North)	Update	assess	ICA

Most of the stocks that were reviewed are caught in mixed-stock fisheries. Many assessments include mixed-stock considerations, estimate discards, and include them in the stock assessment. However, the treatment of discards varies widely among assessments. The RG recommends that all information on discarded catch should be reported, the magnitude of discards should be estimated or approximated for all fleets, and if the proportion of discards is substantial, discards should be included as a component of catch for the entire assessment series for exploratory analyses and possibly as the basis for fishery management advice. The RG recognizes that estimates of discards for some fleets and in historical periods will be highly uncertain. However, many of the stocks in this group have substantial discards, and retrospective patterns suggest under-reported catch. The RG concludes that including discard approximations may improve the accuracy and consistency of assessments.

The definition of assessment units and management units do not correspond for many stocks in this group. Many management areas include multiple assessment units, such that catch of each assessment unit is not directly managed, because TACs can be taken from any component stock. Assessment and management unit definitions should be re-evaluated to improve the effectiveness of management. Furthermore, stock units should reflect biological stocks within the practical constraints of fishery monitoring and resource surveys for stocks that overlap. Many of the data-poor assessments in this group may benefit from aggregation of management units.

Stock: Herring in Divisions VIIa South VIIg,h,j,k (Celtic Sea)

(see May 2009 benchmark review, Appendix A)

Assessment Type: Benchmark

Assessment: Analytical

Forecast: short-term projections

Assessment method: ICA

Consistency the assessment is relatively consistent, but stock status has changed.

Stock Status: SSB recently increased (2008 SSB=55 800t) to greater than Bpa (44 000t), such that a rebuilding program is no longer necessary. However, there is considerable uncertainty in the stock assessment.

Management Plan: There is no explicit management plan

General and Technical Comments: see Appendix A

Conclusions:

The ICA calibration is based on a short survey series, and the calibration relationships are weak, with some year effects. The resulting estimates of terminal SSB are imprecise, and much of the uncertainty in terminal SSB is not included in estimates of precision. For example, a large portion of the spawning stock is composed of 1-ringers, for which proportion mature is poorly understood, and geometric mean abundance is assumed in the terminal year.

Stock: Herring in Divisions VIIa (South) and VIIb,c

Assessment Type: Same advice as last year.

Assessment: Trends

Forecast: None presented

Assessment method: No final assessment has been accepted for this stock. A separable VPA without a tuning index was used in an exploratory assessment of this stock (terminal F scenarios = 0.2, 0.4, 0.5, 0.6). An ICA with acoustic survey tuning index was used in 2006 and 2007, but subsequently discontinued.

Consistency: The stock status is considered to be the same as last year. Retrospective assessments were conducted for each terminal F scenario, terminal F of 0.4 to 0.5 produced more stable estimates of SSB and F.

Stock Status: The current SSB is uncertain, but thought to be below Blim. Current F is uncertain, but thought to be above Flim (Flim = 0.33). Estimates of SSB from an acoustic survey (in 2008 the survey took place in July designed to survey summer feeding aggregations) estimated abundance at 43,000 t. It is unclear whether the stock is contained in this area during this time of year.

Management Plan: The TAC for this stock in 2009 is 9,314 t (this represents a 20% decrease from 2008). ICES advises that a rebuilding plan should be put in place to reduce F and catch, however, there is no explicit management plan currently in place for this stock. .

General Comments:

- Results of the assessment indicate that SSB and recruitment have declined and F has increased since late 1980s.
- Log catch ratios confirm that mortality has been increasing in recent years.
- There are no recruitment indices for this stock; however, abundance of young age classes (1-ringers) in catches by the fishery has been at its lowest in recent years.
- Additionally, age composition of catch indicates an apparent truncation of the age structure in this stock.
- Because of the limited number of years of data collection and changes in the design of the acoustic survey it is not considered to be a useful tuning index for the assessment.
- Herring are caught in a targeted single-species fishery. There is a lack of information on discards for this stock and bycatch in the fishery. Since the fishery is predominantly (>90 % of TAC) taken by Ireland, a priority should be put on obtaining discard and bycatch data from the Irish fleet. Additionally, there is a large amount of misreporting of herring catch by area (~23 to 29% of total catch in recent years).
- Ecosystem information was not considered in examination of stock trends.

Technical Comments:

- An exploratory assessment was conducted using a separable VPA (Lowestoft VPA software) in which 4 choices for terminal fishing mortalities (0.2, 0.4, 0.5, 0.6) were examined. An assessment of retrospective bias indicated that recent F is most likely between 0.4 and 0.5. The current SSB is uncertain but most likely less than Bpa and Blim. No tuning indices were used, therefore, data from most recent, unconverged years is not considered informative. Yield per recruit analysis was conducted in 2006 (F0.1 = 0.17), it was not considered necessary to update this analysis.

- The current reference points are listed in the annex which states that Bpa is 81,000 t and Blim is 110,000, these numbers appear to be inverted and should be corrected.
- An effort should be made to ensure tables and figures are easily interpretable. The font should be increased in tables and figures. Figures should be revised to ensure that axes are readable. Figures 6.2.1.1, 6.4.1.1, 6.6.2.3 were unreadable.
- The current assessment does not give a strong basis for issuing advice. A tuning index is needed for this stock assessment to be useful in estimating SSB and F in recent years.

Conclusions:

The assessment has been performed as indicated in the annex. The lack of a tuning index for this stock makes recent information uninformative and estimates of recent SSB and F are uncertain. All indicators point to SSB being below critical levels (Blim). The RG agrees with the need for a rebuilding plan for this stock. Given the current uncertainty with respect to stock status a more precautionary approach in the management of this stock, specifically a more aggressive reduction in TAC (>20%), seems appropriate.

Stock: Herring in Division VIIa North (Irish Sea)]

Assessment Type: Same as last year

Assessment: None

Forecast: None

Assessment method: None

Consistency: a status quo TAC is proposed and is considered precautionary.

Stock Status: SSB > Bpa. There is no Fpa or Flim.

Management Plan: None

General Comments:

- No discard data is included, but in Annex 8 it is stated that slippage discarding has been increasing over the time series since 1980. It may be appropriate to develop a method for obtaining better estimates of discards especially if the majority of the catch is coming from two vessels in the third quarter of the fishing season. The reason discards were not included is because of the variability of discarding rates observed with rates ranging from 20 percent in 1982 to 50 percent in 1991.
- The fact that there is mixing between the Celtic Sea and the Irish Sea stocks may lead to inflated biomass estimates for younger age classes from the acoustic survey for the VIIa stock. The otolith work done seems like an appropriate method for determining the abundance of Celtic Sea juveniles in the Irish Sea, but does need to be done on a yearly basis as proposed by the WG. The divergence between the acoustic and catch-at-age data from landings may be diminished when stock separation is taken into account.
- Sampling of the smaller Mourne fishery may want to be included. The fishery's landings have increased over the last couple of years and in the document it is stated that this fishery may be fishing on a subpopulation of the stock.
- Ecosystem considerations were discussed in Annex 8, but not included in the report. The Annex stated that a rise in temperature may affect recruitment.
- No mixed fishery concerns were addressed, but do not need to be considered because the herring fishery is a relatively clean fishery in regards to other species.

Technical Comments:

- The use of weight-at-age data collected from landings data in the third quarter of each fishing year is appropriate because the method captures the weight of the herring in that fishing year which accounts for the decrease in weight-at-age observed over the time series.
- The TAC partitioned amounts of 3,500 t to the UK and 1,250 t to the Republic of Ireland do not add up to the total TAC of 4,800 t.
- The first sentence on page 362- "The TAC for VIIa (N) is partitioned as 3500 t to the UK and 1250 t to the Republic of Ireland." is a repeat of previous sentences in section 7.1.1 and seems out of place. It is not in a paragraph.

- In section 7.2.4 it may be appropriate to include the time series average because it is not stated in the table referenced. The CV of .98 could also be included in the paragraph because it is the highest CV in the time series.
- Figure 7.2.2 B is missing the label B in the upper left corner of the bottom image.
- In Figure 7.2.4 there are 28 trawl length class histograms, but in Figure 7.2.2 A and Section 7.2.3 there are 27 trawls completed that accompanied the acoustic survey. Axis labels could be better identified.
- In Figure 7.2.5 there is no legend to indicate what the changes in color mean.

Conclusions:

The RG agrees with the WG on the lack of an assessment and the precautionary TAC recommendation. The TAC allows for flexibility in biomass levels as juveniles from the Celtic Sea stock leave VIIa. Further work should be done to address the mixing of stocks and juvenile residence issues to allow for the models discussed in Annex 8 to be applied with better results.

Stock: Herring in Division VIa North (West of Scotland)

Assessment Type: Update

Assessment: Analytical

Forecast: Both short and medium term forecasts were presented in the assessment.

Assessment method: An integrated catch analysis (ICA) was used and calibrated with the herring acoustic survey.

Consistency: ICA settings have not changed since previous assessments, data was updated but with no significant changes, and the perception of the stock remains relatively unchanged. Retrospective analysis indicates no patternsand bias appears relatively low. The assessment appears relatively noisy, yet balanced.

Stock Status: SSB has been above Btrigger (75,000t) for most of the time series and F (.16) remains well below Ftarget (.25).

Management Plan: As of December 2008 the newly accepted management plan is:

F = 0.25 if SSB > 75 000 t	20% TAC constraint.
F = 0.20 if SSB < 75 000 t but > 62 500 t	20% constraint on TAC change.
F = 0.20 if SSB <62 500 t but > 50 000 t	25% constraint on TAC change
F = 0 if SSB < 50 000 t.	

In accordance with this plan, the proposed TAC for 2009 is 21,760t, which represents a slight increase from the 2008 TAC of 27,200t.

General Comments:

- Overall, the assessment is very well done and although it is noisy it appears to be relatively unbiased.
- The RG agrees with the WG that the issues of misreported catch and the high variability in abundance estimates from the acoustic survey that is used to tune the model are the main sources of uncertainty that must be addressed to improve assessment results.
- The issue of misreporting appears to be an enforcement problem that cannot be directly resolved from a modeling standpoint. Although catch estimates are adjusted in order to attempt to resolve this problem, it appears almost impossible to accurately judge misreporting rates. It is suggested that better documentation is made of how catch is adjusted and the reasoning behind such adjustments. Although the method maybe sound, little documentation is given, this makes it difficult for outside sources to determine how or why catch levels were adjusted. In addition, it is suggested that sensitivity runs are made for different levels of catch in order to determine how greatly model outputs differ according to varying degrees of misreporting.
- The variability seen in the acoustic survey is very disconcerting. Relatively little information is given about the general survey protocol. More details should be given either in the stock annex or the assessment document regarding how the acoustic survey is carried out and how it is included in the assessment. Work

should be done to attempt to standardize the acoustic survey in order to reduce the variability in biomass estimates. For instance, it is suggested that the same vessel is used each year, that the survey takes place while a majority of fish are in spawning aggregations, and general sampling design should be standardized. It is believed that such improvements will reduce variability and avoid extreme yearly changes in biomass estimates, such as the 165% increase in biomass from 2007 to 2008. The impact of such variability on model results is severe. Additionally, the RG agrees that the strong trends in the model fit to the survey over the last few years are quite troubling. Most survey residuals since 2004 have been strongly negative, yet in 2008 all residuals become positive. Possible reasons for these trends should be investigated.

- The use of an age-varying M is seen as appropriate due to the extreme differences in mortality seen in most herring species over their lifecycle, but data supporting the M values used should be given in the annex. Also, it is probably inappropriate to use time-invariant values of M as the ecosystem has changed drastically since 1957, both in terms of predator and prey levels, but also in regards to general environment and temperature regime, all of which affect natural mortality levels. It is suggested that a MSVPA model may be appropriate to update M estimates, as was used in Celtic Sea Herring assessments.
- The RG agrees that the biological sampling for this stock is very poor and should be increased immediately. Only 13 samples were taken in 2008, 11 of which were from the same fleet in the same quarter (Scotland, 3rd quarter). Sampling should be increased and diversified so that samples are taken throughout the year from all fleets.
- Although discards are generally very low and thus not included in the model, it appears that high-grading could be an important issue especially in the freezer trawler fleet. This should be investigated and high grading should be treated as discards and included in future assessments if deemed to be high enough to affect model results.
- In general, it seems that the herring fishery is a clean, directed fishery with little bycatch of other species. Also, a number of ecosystem considerations were discussed regarding the importance of herring as one of the key foundations of the marine food chain. As suggested earlier, it maybe worthwhile to look at MSVPA type models of herring in order to address their importance to the food web and how changes in the ecosystem can affect herring mortality.

Technical Comments:

Overall, this is an excellent document. Graphs and tables are well labeled and documented. In addition, they all have good descriptions of what is presented. The formatting is also well done with graphs being large enough to read and tables not being too crowded. The variety and types of diagnostic plots is an outstanding feature. The only criticism is that color coding may improve the readability of some graphs, especially the retrospective plots.

Conclusions:

- The RG agrees with the WG that the ICA assessment is an acceptable model for Herring west of Scotland in area VIa North. Although the assessment is noisy due to variability in the acoustic survey and relatively high levels of misreporting of catch, it appears to be relatively unbiased. It is suggested that future work be done to increase biological sampling and standardize the acoustic survey, which should help to reduce the noise in the model.

- The RG disagrees with the management plan and the suggestion that the TAC remain at status quo levels. The RG proposes that the precautionary reference points are not in fact precautionary. Bpa is set at 75,000t, which the stock has been above for its entire time series except for a handful of one year intervals in the early 1990s and a period in the late 1970s. At the same time, though, stock abundance has decreased compared to historical estimates and recruitment is at the lowest levels ever seen, while F remains at intermediate levels. It appears that productivity of this stock has declined, possibly due to environmental changes, which will hinder its ability to recover from high fishing levels. It is suggested that target reference points should be reevaluated, and that target SSB should be increased.
- As a foundation of the ecosystem it is important to avoid a stock collapse of herring and so it seems that a more precautionary approach should be undertaken. Also, the ecosystem relations between species and between herring recruitment and the environment should be investigated. In addition, stocks in neighboring areas are in poor conditions and since large proportions of catch in VIa north are from these areas it would make sense to decrease the VIa north TAC to avoid stock collapses in all areas.
- Although stock structure was recently re-evaluated by the WESTHER project, there could be high connectedness between adjacent populations. Mixing between populations could be one reason for the noise in the acoustic survey. It might be better to model these areas as one population with one TAC or to develop a movement model that models each unit as a separate population, but allows movement between areas. This would require data on movement such as a tagging study. Finally, it is suggested that modeling fleets within VIa north separately might be appropriate since each uses different techniques and fishes different geographic locations, and thus will have very different selectivity patterns. This would most likely be best addressed through a forward projecting statistical catch at age model.

Appendix A. Benchmark Review of Celtic Sea Herring

6 May 2009 by correspondence

Reviewers:

Steve Cadrin, USA (chair)

Lionel Pawlowski, France

…with assistance from Daniel Goethel and Lisa Kerr, USA

Summary

Methodology of the Celtic Sea Herring stock assessment was reviewed according to the stock annex (Annex 05 Celtic Sea and Division VIIj_V1_09.doc), and the most recent application of the methodology was reviewed according to the 2009 stock assessment (04-Celtic Sea and Div. VIIj_Herring_2009.doc). Our review addresses the following questions from the ICES Secretariat (B. Schoute 22 April 2009):

1. Is the new assessment methodology correct, of high standard and does it make optimal use of the available data?
2. Are the settings of the forecast (only short term, medium and long term are not relevant here) chosen correctly and do the reference points still apply.
3. Is the methodology adequately described in the stock annex, meaning that the assessment can in principle be carried out by experienced outsiders on the basis of this text.

1) We conclude that the new assessment methodology is generally sound, but some inconsistencies between surveys remain, results are somewhat uncertain, and assumptions of the model should be further explored. The assessment results are relatively consistent, but calibration relationships are weak and based on a short survey time series. Among the alternative assessment models explored, the revised configuration of Integrated Catch Analysis (FLICA) appears to be most appropriate model of data from the fishery and resource. However, we encourage the assessment Working Group to continue to explore more advanced stock assessment models to make optimal use of the available data. The following sources of uncertainty should be addressed in subsequent assessments:

   a) The ICA calibration is based on a short survey series, and the calibration relationships are weak, with some year effects. The resulting estimates of terminal SSB are imprecise, and much of the uncertainty in terminal SSB is not included in estimates of precision. For example, a large portion of the spawning stock is composed of 1-ringers, for which proportion mature is poorly understood, and geometric mean abundance is assumed in the terminal year.

   b) A stock assessment model that relaxes the assumption of constant selectivity in recent years should be explored. The separability assumption (and the assumed selectivity at the oldest ages for the entire time series) may lead to misinterpretation of the apparent shifts in age selectivity by the fishery. According to the 2009 HAWG report (page 298), the 2007 benchmark concluded that changes in fishing pattern (and conflicting signals) prevented a final assessment from being conducted

c) The magnitude of discarded catch should be estimated and included in the stock assessment.

d) A stock assessment approach that accounts for the mixed-stock resource and connectivity with adjacent management units should be developed.

e) Fishing mortality reference points (Flim and Fpa) should be proposed.

f) Consumption of Celtic Sea herring should be estimated and considered for stock assessment and fishery management.

2) The settings of the short-term forecast appear to be chosen correctly, and the B_{lim} and B_{pa} reference points (as revised for retrospective change) are still appropriate. However, we suggest that the same forecast approach be extended for long-term, stochastic projection to determine the fishing mortality rate associated with B_{lim} (as a candidate for F_{lim}) and its uncertainty (to derive F_{pa} and potentially a revised B_{pa}) as well as MSY reference points.

3) The methodology is generally well-described in the stock annex and allows repeatability. The various tables and information in the body of the report give the strong impression that all inputs are sufficiently documented to allow an outsider to do an assessment. However, some details of the most recent application of the stock assessment model (e.g., input and output tables, model diagnostics) should be provided to justify the modeling decisions.

Detailed Comments (organized by Annex section)

A. General

A.1. Stock definition – Several aspects of stock definition are described to justify the appropriateness of the management unit and identify aspects of population structure that may influence stock assessment and fishery management. Atlantic herring are ‘population-rich’ throughout their range, with complicated patterns of ontogenetic movement and mixing of spawning groups. These complex patterns present challenges to conventional stock assessment and fishery management.

1) Combined assessment of autumn and winter spawning groups appears to be the most appropriate use of available data, because of extensive mixing of spawning groups resulting in mixed-group fisheries and surveys. However, continued advancements in discrimination of seasonal spawning groups should be explored with the ultimate goal of stock composition analysis and consideration of spawning groups in assessment and management.

2) The inclusion of area VIIj in the Celtic Sea management unit appears to be appropriate because of similar demographic patterns in VIIj and g, larval mixing between the two areas, and a common nursery area in VIIj shared by herring spawned in VIIg. However, Figure 1 suggests that spawning in VIIg is primarily in winter, while spawning in VIIj occurs in both autumn and winter. Similar to the comment above, the seasonal spawning pattern

suggests that the development of stock composition analysis would facilitate the consideration of spawning groups in assessment and management.

3) The boundary between the Celtic Sea and Irish Sea herring management units is supported by the results of an extensive multidisciplinary program (WESTHER). Although the 52°30'N boundary is well-justified, advection of larvae from the Celtic Sea to the Irish Sea and subsequent return to spawn in the Celtic Sea has consequences to assessment and management of both resources. Loss of larvae from the Celtic Sea will add noise to the stock-recruit relationship. Depending on which age fish return to the Celtic Sea, the immigration may confound inferences of mortality from the catch-at-age analysis which assumes a closed population. Return migration at 1-ringers will have less influence on the perceived population dynamics than on immigration of older ages. The relationship between Celtic Sea and Irish Sea herring should be further investigated to better understand the sensitivity of the closed-population assumption in the assessment.

4) Similar to the comment above, the relationship between Celtic Sea herring and those in in VIIe-f and VIIIa should be investigated to understand the sensitivity of the closed-population assumption in the assessment.

5) Figures 1 and 2 are switched.

6) A Figure of the region should be provided that includes all of the areas described in the Annex (VIIe, VIIh, VIIk, VIIIa).

7) The species name *Clupea harengus* should be included in the Annex.

A.2. Fishery

1. The fishery description is informative and well-written.
2. The increased landings after World War II support the premise that fishing influences stock size – a principle that should not be taken for granted for small pelagic species.
3. Any information on historical landings (prior to 1958) would be informative.
4. The statement that "Further fluctuations in the landings were evident during this time with high quantities of herring landed from 1958 – 1960 and from 1966 – 1971 (Molloy, 1972)" is somewhat inconsistent with the data plotted in Figure 6, in which annual landings from 1959 to 1963 are similar (i.e., the 'high quantities from 1958-1960 persisted to 1963).
5. The 'polyvalent' category of vessels should be described as in the 2009 HAWG report ("The term 'Polyvalent' refers to a segment of the Irish fleet, entitled to fish for any species to catch a variety of species, under Irish law" page 296).
6. The catch of large, old fish appears to depend on what areas are seasonally open to the fleet (e.g., Labadie Bank being open in July 2003 led to older fish being caught as compared to openings later in the year). Therefore, two aspects of the assessment model (separability in the recent period and full selectivity of the oldest age in all years) may be inappropriate.
7. The last paragraph "the Irish Quota" is redundant almost word for word with the second paragraph of the "Fishery in recent years"

A.3. Ecosystem aspects

1. Given the important role of herring in the ecosystem, more information is needed on consumption of Celtic Sea herring and predation of other species by herring. Although estimates of herring consumption in the North Sea are used to derive the assumed natural mortality rates for Celtic Sea herring, consumption of herring in the North Sea should be estimated, and incorporation of consumption in stock assessment and management should be considered.
2. References should be provided for the statement that "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."
3. The recent reduction in size-at-age should be reported in this section as a possible response to ecosystem factors. The trend is critical for estimation of spawning biomass, and the cause of the trend is important for assessment decisions and modeling future expectations (e.g., forecasts and reference points).
4. Similarly, the increasing recent trend in total mortality estimates from catch curves or log catch ratios and the decreasing recent trend in fishing mortality from the stock assessment model suggest an increase in natural mortality, which may reflect ecosystem change.
5. The ecosystem description and the summary of spawning dynamics suggest that there is adequate information to develop a bio-physical model of larval transport that would provide a complementary perspective on connectivity among spawning groups.
6. Differences in survival between the Irish and Celtic Seas could have important consequences to population dynamics. The relative contribution of each habitat to the adult population in the Celtic Sea should be determined.
7. Given that the Celtic Sea is near the southern extent of the range of herring, and the increasing trend in temperature, the potential for a northward shift in distribution should be monitored.

Discards

1) The "discards" section of this part should probably be in the data section.

2) Although the discard rates are considered to be low and discards are not included in the assessment, discards occur. The report indicates that discarding is influenced by market situations, which suggests it may rise. While, it does not seem to have at the moment a potential impact on the assessment, it could be useful to evaluate the consequence of the inclusion of discards on an exploratory basis. The underestimate of total catch produces biased estimates of stock size and mortality. The discard rate estimated by Berrow, et al. (1998), 4.7%, should be used to derive an approximate magnitude of discards that would be more accurate than the implicit assumption of no discards.

3) An at-sea monitoring program should be developed to estimate discard rates (including slippage) and to sample size and age structure of discards.

4) The statement that Berrow, et al. (1998) "indicated that the Celtic Sea herring fishery is very selective and that discard rates are well within the figures estimated for fishery models" is not clear. Does the statement suggest that a 4.7% discard rate is similar to that estimated for other fisheries, or similar to the rate assumed in fishery models? Celtic Sea herring stock as-

sessment assumes no discards and is not consistent with the estimate of a 4.7% discard rate.

B. Data

B.1. Commercial catch

1) Sampling intensity of the series of catch-at-age should be provided to evaluate the reliability of catch-at-age estimates. For example, Table 4.2.2.1 in the 2009 HAWG report indicates that 45 samples were collected from the 2008 fishery, and all major area-quarter components of the catch were sampled. Is this typical of the sampling intensity since 1958 or are there any systematic gaps in historical sampling that should be considered in the interpretation of catch-at-age? Given the complex pattern of time-area closures and fishing patterns, 45 samples per year may not adequately characterize some of the fine-scale differences in catch-at-age.
2) The report mentions the landings statistics for this stock need correction for misreporting. Landings apparently include substantial amounts (>10%) of fish from other areas but while the correction is made (i.e. unallocated landings), no information is given on how this correction is done. This information is important to explain how to prepare the data from the raw landings statistics.
3) A requirement of logbook data for all vessels in the sentinel fishery could improve estimates of small boat landings.

B.2. Biological

1) The various biological parameters are well described and their quality appears to be reliable for the assessment.
2) Have the age determination methods been validated?
3) Including some typical age-length keys would be helpful to evaluate how well catch-at-age is being estimated, particularly at older ages.
4) Including the quality-control results for precision estimates would be informative, and potentially useful for the development of advanced statistical catch-at-age models that use the pattern of disagreements to model errors in the catch-at-age.
5) The use of age-specific natural mortality rates from multispecies VPA is appropriate for a small, pelagic forage species, but a development of a MSVPA for the Celtic Sea would be more appropriate than using the results from the North Sea. A reference should be provided for the MSVPA so that its details do not need to be included in the Annex.
6) The cause of the reduction in weight-at-age should be explored further. More specifically, determining if it results from ecosystem factors or fishing patterns is essential for making the correct selectivity assumptions in the stock assessment. It would be valuable to inspect weight-at-age data from surveys to see if fishery-independent data reflect the same recent reduction. The beginning of the decline is consistent with the development of the roe fishery.
7) The choice of the maturity ogive suggests that various sources of information provide similar results. However, the amount of available information

(number of individuals sampled) is not included. The rationale for assuming 50% maturity of 1-ringers, rather than the estimated 58%, is that the fishery probably samples precocious fish. However, the estimate of 58% is from a survey. The text does not report if the estimate of >50% by Lynch (in prep.) is from the fishery or a survey. Given the substantial contribution of 1-ringers to the spawning stock, a more precise estimate of proportion mature should be applied.

8) Recruitment from the Irish sea may affect maturity of the population (and consequently maturity ogives). The possible influence of individuals from the Irish Sea raises the question of the proportion of individuals from that area and the effects of possible changes in maturity from one area to another. For some other stocks, like the Celtic Sea cod, a similar situation is observed and the lack of samples makes any maturity ogive rather uncertain. This was one of the criticisms in the benchmark review of the Celtic Sea cod.

B.3. Surveys

1) The timing of the survey appears to be related to 'year effects' in calibration diagnostics (HAWG 2009 Figure 4.6.1.1), suggesting that the portion of the resource in the survey area is sensitive to the time of the survey. The 2002/2003 survey (conducted in September and October) has all positive residuals (i.e., more fish in the survey than predicted by the model), and the 2003/2004 survey (conducted in October and November) has all negative residuals (i.e., fewer fish in the survey than predicted by the model), suggesting that fewer fish are available to the survey later in the year. Is it possible that spawners are in the process of leaving the survey area during the survey?

2) Imprecision of survey estimates is illustrated by the large difference between estimates of 2008 SSB from the survey (90kt) and the assessment model (56kt).

3) For the acoustic survey, the estimates of CV appear to be based on a simple function of the positive number of samples. Some explanations about that relationship would have been welcome. An apparent contradiction is in the text: "CV was obtained based on transect mean densities," but mean density is not included in the equation. There appears to be something missing from the equation.

4) The decision to use a shorter, standardized series for a tuning index is valid.

5) More information is needed to describe how indices of abundance at age are derived from the acoustic survey.

6) Tuning is based only on the acoustic survey which apparently provides the best indices. Data from other surveys are not used. Some other stocks, like the Celtic Sea cod, have the same issues of having surveys that are not specifically targeting those species sampling few and variable numbers of fish. Some work has been carried out during the WKROUND benchmark to combine survey indices and some others stocks (e.g. Sole in VIId) use combined survey indices. The report and stock annex do not mention any attempt to use or combine the available information. Some exploratory work on using those datasets would also be welcome. This could involve evalu-

ating how the indices behave against each other, against fishing vessels and how they could affect the assessment. Some analysis of the trends of all survey data would be helpful to support the choice of only using the acoustic survey for the assessment.

7) The analysis of productivity over time is sufficiently commented to naturally end with the conclusion that recent F has been detrimental to the stock productivity.

8) If the Irish Groundfish Survey is expected to provide qualitative information for the assessment, results should be included in the Annex.

9) Similarly, if the Northern Ireland GFS survey offers a potential recruitment index, more details are needed in the Annex so that it can be considered as more information becomes available on natal origin.

10) Similarly, data from larval surveys should be provided as a comparison to stock assessment results.

B.4. Commercial CPUE

The decision to exclude fishery CPUE as a tuning index in the stock assessment is valid, because of the nature of herring behavior, fishing patterns and management changes. However, it would be informative to compare the acoustic survey index to CPUE information from the fishing vessels. Some stocks (e.g. whiting in the North Sea) have conflicting patterns between surveys and fishing vessels. One reason could be some slight changes in the survey interfering with the results. Therefore, this type of comparison can be helpful to evaluate the consistency of the observation from the surveys in addition to the quality (i.e. level of noise) of the data which is another aspect to consider.

C. Historical Stock Development

1) This section shows some issues with noisy data but does not seem to explain the “conflicting signals in input data and changes in the fishing pattern” referenced in the HAWG report from the 2007 benchmark.

2) The description of ‘time periods in the fishery’ is informative and suggests that some of the selectivity assumptions in the stock assessment should be reconsidered. The roe fishery targeted older, mature fish, which would lead to greater selectivity of the oldest age during that period.

3) Tables 3 and 4 referenced in ‘Time Periods in the Fishery’ should be Tables 4 and 5.

4) Estimates of total mortality from log catch ratios and catch surveys are informative, but the age ranges selected for catch-curve analysis are inconsistent with results from the stock assessment model, because of the assumed pattern of natural mortality at age and estimated selectivity at age. According to the assessment model, herring are not fully selected until age-3, and natural mortality of ages 2 and 3 is greater than than for ages 4+, so catch curves should be revised from ages 2-7 to ages 4-7.

5) The increasing recent trend in total mortality estimates from catch curves or log catch ratios appear to contradict the decreasing recent trend in fishing mortality from the stock assessment model. The cause of the discrepancy (e.g., increasing natural mortality) should be explored.

6) In the assessment section, the HAWG report (4.6.1) mentions "conflicting signals in input data and changes in the fishing pattern" but no information is given on the "historic" choices made for exploratory assessments. The decisions about model configuration are well explained and the assessment well commented (changes in plus groups, shortening time series, terminal selection and reducing the separable period) providing the rationale for the parameters used in the final assessment.

7) The concern raised by the 2007 benchmark assessment about violating the assumed constant separable pattern was not addressed. The assessment model still assumes separability in recent years. We reiterate the concern about assuming constant selectivity and repeat the recommendation to consider alternative modeling approaches that relax this assumption.

8) The revision of the catch-at-age used for the stock assessment model (truncation to ages 1-6+) produces a more realistic selectivity pattern than the previous analysis of ages 1-7+.

9) Diagnostic features of the stock assessment model are needed in the Annex to evaluate model performance. Standard diagnostics from the 2009 assessment should be included (e.g., HAWG 2009 Figures 4.6.1.2-3 model residuals, 4.6.1.4-5 confidence intervals, 4.6.1.6. historical comparisons, 4.6.2.1 calibration plots, 4.6.2.5-6 retrospective analysis). Inspection of diagnostics suggests that the ICA model is relatively consistent and has no strong patterns in catch residuals, but there are strong 'year effects' in the survey residuals (i.e., same direction of deviation at all ages) for the first three years of the six surveys used (Figure 4.6.1.1), and calibration relationships are relatively weak (Figure 4.6.2.1). A 'year effect' in the terminal year will present problems for estimating terminal abundance and determining stock status.

10) The advantage of ICA over other models is well explained as well as the reasons for adopting new parameters. Considering the few changes in the list of parameters, it can be confusing to have the parameters listed for the former and new assessment methods separately. Maybe combining both sets of parameters into a single table would be more useful (considering only 2 parameters of 8 changed) so no "quick reader" may switch to the wrong set of parameters.

11) The Annex reports that ICA was chosen because of its emphasis on young ages and greater consistency, but there is no information in the Annex or the 2009 HAWG report on the performance of alternative models. It is difficult to judge the validity of that conclusion without example results from all viable models. For example, did XSA also have year effects in survey residuals?

12) The ICA model appears to perform well for this application, but the method is somewhat dated (it is a re-codification of the CAGEAN model developed by Deriso et al. 1985). Catch-at-age models have evolved since the 1980s, and more advanced methods (e.g., statistical catch-at-age, SCAA) may be more appropriate for assessing the data available for Celtic Sea herring. SCAA would also be able to use all recent and historical information available (e.g., selectivity for each fishery and each period, calibration of historical abundance with discontinued surveys, discard rate estimates)

13) References for ICA (Patterson 1998) and FLICA (flr-project.org) are needed.

14) The analysis of productivity over time supports the conclusion that recent F has been detrimental to the stock productivity. However, the calculation of surplus production is either poorly described or inaccurate. The equation Ps=Br+Bg-M does not account for the different units of biomass (t) and natural mortality rate (y^{-1}). The inappropriate mix of instantaneous rates and biomass is continued in the subsequent statement that net production is calculated as Ps – F. Surplus production should be calculated as Ps=Br+Bg-Bm where Bm is biomass of fish that die of natural causes. Total Production should be calculated as P=Br+Bg-Bm+Y where Y is catch biomass.

D. Short-Term Projection

1) This section does not explain why the MFDP projection was not carried out from 2005 to 2008 and why this analysis is back in the assessment. It seems that the information available is of sufficient quality to allow this type of projection.

2) The projection methodology is appropriate, but stochastic projection, incorporating uncertainty in abundance at age estimates and recruitment estimates would help to evaluate alternative management actions by providing probability of achieving management objectives or risk of exceeding limits.

E. Medium-Term Projections

The text states that Fmsy is provided in Table 7, but it is not (nor can it be from a simple yield-per-recruit analysis).

F. Long-Term Projections and G. Biological Reference Points

1) The reference points have not been revised. However, considering the changes in the assessment methodology and some evidence Blim should be revised upwards. Some work to investigate a possible change of Blim should be encouraged (or an explanation is required to explain why these reference points should be kept as they are).

2) Long-term, stochastic projection should be used to determine the fishing mortality rate associated with B_{lim} (as a candidate for F_{lim}) and its uncertainty (to derive F_{pa} and potentially a revised B_{pa}) as well as MSY reference points.

H. Management and ICES Advice

1) The ICA model suggests a recent increase in spawning biomass (2008 SSB=55 800t) to greater than Bpa (44 000t), such that a rebuilding program is no longer necessary. However, important caveats should be communicated in the management advice. The ICA calibration is based on a short survey series, and the calibration relationships are weak, with some year effects. The resulting estimates of terminal SSB are imprecise, and much of the uncertainty in terminal SSB is not included in estimates of precision. For example, a large portion of the spawning stock is composed of 1-

ringers, for which proportion mature is poorly understood, and geometric mean abundance is assumed in the terminal year.

2) Comparison of fishery yields and TACs indicates that the management system can effectively control the fishery (e.g., TAC was slightly exceeded in two years in the last 20 years).

3) Previous ICES advice that 'catches of around 5 000 t would be associated with stock recovery' appears to be unsubstantiated, because catches have not been that low in the observed catch series.

Annex 14 Technical Minutes of the North Sea ecosystem Review Group

Review of ICES **HAWG Report 2009**

Reviewers:	Gary Melvin (Canada, chair)
	Outi Heikinheimo (Finland)
	Norman Graham (Ireland)
Chair WG:	Tomas Gröhsler
Secretariat:	Barbara Schoute

General

This HAWG was one of 3 working groups reviewed by the North Sea Technical group. The RG acknowledges the intense effort expended by the working group to produce the report and the work required to complete their documentation in a timely manner.

The Review Group considered the following stocks:

her-3a22	Herring in Division IIIa and Subdivisions 22 - 24 (Western Baltic spring spawners)
her-47d3	Herring in Subarea IV and Divisions IIIa and VIId (North Sea autumn spawners)
spr-nsea	Sprat in Subarea IV (North Sea)

Stocks which may need a benchmark in future are:

The North Sea Sprat in Subarea IV will be the subject of a benchmark assessment in September 2009

Herring in Division IIIa and Subdivisions 22 - 24 (Western Baltic spring spawners) her-3a22

1) **Assessment type**: update
2) **Assessment**: analytical
3) **Forecast**: Short term forecast presented
4) **Assessment model:** FLICA
5) **Consistency:** Retrospective analysis: Bias (20%) in SSB and F compared to previous assessment.
6) **Stock status**: SSB and F stable, decreasing trend in recruitment since 2003. Recruitment the lowest observed. F is larger than any proxy of $F_{msy.}$ SSB 2008=159,406, 2009=141,824, F3-6=0.37. 2008 recruitment estimated to be lowest in last 18 years
7) **Man. Plan.**: At an early stage. No defined reference points. However, exploratory management plan of Fmsy=0.25, Blim=110,00, TAC variation 15%, and Target F =0.25

General comments

The spring spawning stock is composed of several rather distinct spring spawning populations and probably different sub-stocks, and partly mix with the North Sea autumn spawners in IIIa and IVa(east). In addition, the stock is exploited by fleets from several countries. This makes the assessment and management planning extremely complicated. A substantial part of the catch reported as taken in Division IIIa by fleet C was actually has been taken in Subarea IV

Fleet C – Directed fishery by trawlers and purse seiners, Fleet D – all trawlers and small purse seiners (Danish and Swedish) fishing for sprat, Norway pout and blue whiting. And Fleet-F (SD 22-24) in Western Baltic

The 2003 year-class has been largest component of the SSB for last 3 years.

According to the WG, the overall sampling in 2008 more than meets the recommended level and the coverage of areas, times of the year and gear (mesh size) was acceptable. Only in Subdivision 23 is the temporal coverage not acceptable. Discards considered insignificant.

The maturity ogive of WBSS applied in HAWG has been assumed constant between years although large year-to-year variations in the percentage mature have been observed. A Workshop on Sexual Maturity Staging of Herring and Sprat is taking place during 2009 in order to establish correspondence between old and new scales to convert time series and propose optimal sampling strategy to estimate accurate maturity ogives.

Technical comments

3.6.1.2.: The estimates of natural mortality were derived as a mean for the years 1977–1995 from the Baltic MSVPA (ICES 1997/J:2). Would more recent estimates be available, and would there be any difference?

3.11: Recent recruitment has dropped appreciably and consistently, while stock size has remained constant. This indicates an environmental effect, which is not discussed in "Ecosystem considerations". (This issue is discussed in the report for NSAS). Are there attempts to examine this phenomenon and take it into account in the management planning? The target F =0.25 may be too high if the reproductive success is low and leads to a decrease of the spawning stock in coming years.

Conclusions

The assessment is correct but more profound ecosystem considerations would be necessary.

Herring in Subarea IV and Divisions IIIa and VIId (North Sea autumn spawners) her-47d3

1) **Assessment type**: update
2) **Assessment:** analytical
3) **Forecast:** Short-term forecast presented.
4) **Assessment model:** FLICA. 4 indices; Acoustic, Larval, IBTS, and MIL(0-ringer)
5) **Consistency:** Retrospective analysis: consistency good, exception recruitment, age 0 in 2008.
6) **Stock status:** SSB above Blim but increased risk (below Bpa), recruitment better than in recent years but still low, F appropriate but above target.
7) 2008 SSB= 1.0 million t, Bpa (1.3 million t), Blim (800,000) with trigger at B=1.5 million. $F_{2\text{-}6}$ in 2008 = 0.24, target $F_{2\text{-}6}$ =0.14. The 2008 year-class is higher than the previous 6 years but similar to the 2001 year class
8) **Man. Plan**.: Yes, adjusted in November 2008. Currently reduction of F advised. $F_{2\text{-}6}$ (0.24), in 2008 above the target $F_{2\text{-}6}$ of 0.14. SSB is not expected to reach Bpa in 2010 even without fishery, but it may reach Bpa in 2011 with a substantial reduction (well over 30%) in catches.

General comments

The sampling coverage has decreased from 2007 but the spread of the effort over the different métiers was a little better than 2007. Information on discards has improved but is still on a low level.

There was an increase in recruitment from last year's estimate, which was outstandingly low, but was one in a series of poor recruitments starting from the 2002 year class.

North Sea herring is nominally being managed by a precautionary management plan, although the SSB is now below the precautionary biomass reference point. HAWG considers that the parameters of the management plan should take primacy over the management against precautionary reference points Fpa or Bpa. Not following the management plan has resulted in the SSB being at greater risk of being below B_{lim} and lower catches

The low reproductive success is discussed in Environmental considerations (2.13). An ICES study group has reviewed the hypotheses for the serial poor recruitment in North Sea herring. Further investigation of the causes of the poor recruitment will require targeted research projects.

Technical comments

The report might be easier to read when the text would be in the beginning and all large tables and figures after the text (as in the WBSS assessment report).

All predictions are for North Sea autumn spawning herring only.

Conclusions

The SSB is expected to increase slightly both in 2010 and further in 2011.

The assessment has been performed correctly and the RG agrees with the conclusions

Sprat in Subarea IV (North Sea) spr-nsea

1) **Assessment type: update**
2) **Assessment**: not presented
3) **Forecast**: not presented
4) **Assessment model**: no assessment was performed this year, see below
5) **Consistency**:
6) **Stock status**: Abundance, recruitment and catches at a low level
7) **Man. Plan.**: No. Management by TAC, ITQ

General comments

Previous exploratory assessments of this stock have been performed using the CSA method, and catch prediction for the assessment year was provided on the basis of a linear regression of catch (as estimated by landings) versus the IBTS sprat index.

Boot strapping indicated the upper confidence limit ranges from 30% to 4600% greater than the index estimated by ICES, with a median value of 250%. The lower confidence limit ranges from 20% to 90% less than the value index, with a median value of 40% However, these methods were found clearly inappropriate for the task at hand, and the results meaningless in an advice context. The decision was therefore made by HAWG not to perform or report any such runs this year.

The 2005 index (2004 year class) was the highest for the time series prior to 2009. The incoming 1-group (2008 year class) is estimated to be the highest for the whole time series, both in absolute and relative terms but this estimate should be considered as preliminary

This stock will be the subject of a benchmark assessment in September 2009, as part of the WKSHORT workshop.

Technical comments

The IBTS results are presented in Table 8.3.1. and Figures 8.3.1. a-c. How reliable are these results? Uncertainty about these estimated used as reasoning for not presenting an assessment or a forecast. There could be a footnote to remind the reader that the indices for some years are highly uncertain.

Fig. 8.3.5. cannot be interpreted because of many overlapping curves. Some examples could be presented only.

Conclusions

The decision not to present any assessment or forecast because of large uncertainties was justified.