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REPORT OF THE HERRING ASSESSMENT WORKING GROUP SOUTH OF 62°N (HAWG)

13 - 22 MARCH 2007

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Executive Summary

The ICES herring assessment working group (HAWG) met for 10 days in March 2007 to assess the state of 7 herring stocks and 3 sprat stocks. New data were only available for 6 herring stocks and 2 sprat stocks. HAWG carried out a benchmark assessment on Celtic Sea herring. The following issues were explored:

- catch data through catch curves
- simpler models using CSA
- standard catch at age assessment models (ICA and XSA)
- time inconsistencies, outliers and time trends in indices.
- retrospective performance of the different models.
- Recruitment and productivity changes

The exploration showed that there is uncertainty in SSB, F and recruitment for last 3 years in Celtic Sea herring. However information from the catch shows an increasing trend in the mortality of the fish and a contraction in age structure of the stock. Exploration with simpler models showed a decline in biomass over the whole last 10 years. A Bayesian analysis suggests that the selection of the fishery has changed over the last 10 years, and supported the perception that the current status of SSB is uncertain, but probably at a low level. Analysis of recruitment patterns suggested that no major regime shift has taken place in Celtic Sea herring productivity in the last 40 years.

The recent trends in North Sea autumn spawning herring show that after a peak in spawning biomass (SSB) of 1.8 million tonnes in 2004, the SSB in 2006 was 1.2 million tonnes. The current fishing mortality (F_{2-6}) is 0.35 and is well above the target F prescribed by the management agreement. It is likely that the stock will decline further in the next few years to close to B_{lim} by 2009. The decline in SSB is due to serial poor recruitment since 2001 and a failure to fish adult herring at target F (0.25, as described in the management agreement) in the last few years. The estimate for the most recent recruiting year class is the lowest since 1979 and the low recruitment is caused during the larvae phase of North Sea herring.

All herring stocks assessed by the working group appear to have average or below average recruitment in the last few years. The fishing mortality on herring in IIIa is now considered too high, especially in light of MSY targets. This is also the case for herring for the west of Scotland (VIaN). There is no sign of stock recovery in VIaS herring. Conflicts in the data, made it impossible to assess Irish Sea herring, although data exploration suggest that the age profile of the stock has contracted and the SSB is stable at a low level. It is likely that the abundance of North Sea sprat is now less than in the last two previous years.

HAWG answered one special request from the EU on the findings of the WESTHER project, particularly with reference to the proposed management plan for herring to the west of Scotland (VIaN). See section 1.3 for the full answer.

HAWG also commented on the quality and availability of data, the problems with estimating the amounts of discarded fish, the use of the new data system INTERCATCH, the relevance of ecosystem changes to the stocks considered by the group and recent meetings and reports of relevance to HAWG. An analysis of the surplus and net production of 5 herring stocks also found that fisheries-independent shifts in productivity had occurred since the 1960s in North Sea, west of Scotland and Irish Sea herring.

HAWG was concerned about the apparent increase in misreporting of catches in recent years and the growing relaxation of regulations designed to restrict the ability to misreport or catch herring as bycatch.

1 Introduction

1.1 Participants

Steven Beggs	UK/Northern Ireland
Hans Bogaards	The Netherlands
Massimiliano Cardinale	Sweden
Maurice Clarke	Ireland
Mikael van Deurs	Denmark
Mark Dickey-Collas (Chair)	The Netherlands
Afra Egan	Ireland
Tomas Gröhsler	Germany
Joachim Gröger	Germany
Emma Hatfield	UK/Scotland
Henrik Mosegaard	Denmark
Peter Munk	Denmark
Mark Payne	Denmark
Beatriz Roel	UK/England & Wales
Marine Pomarede	UK
Norbert Rohlf	Germany
John Simmonds	UK/Scotland
Jorn Schmidt	Germany
Dankert Skagen	Norway
Else Torstensen	Norway
Christopher Zimmermann	Germany
Yves Verin	France

Contact details for each participant are given in Annex 1.

1.2 Terms of Reference

2006/2/ACFM04

The Herring Assessment Working Group for the Area South of 62ºN (HAWG) (Chair: Mark Dickey-Collas, The Netherlands) will meet in Copenhagen, Denmark from 13 – 22 March 2007 to:

a) assess the status of and provide management options (by fleet where possible) for 2008 for:

- the North Sea autumn-spawning herring stock in Division IIIa, Subarea IV, and Division VIId (separately, if possible, for Divisions IVc and VIId). Forecasts should be provided by fleet if possible and taking into account the management plan agreed between the EU and Norway;
- the herring stocks in Division VIa and Sub-area VII;
- the stock of spring-spawning herring in Division IIIa and Subdivisions 22–24 (Western Baltic); Management options for Division IIIa shall be given by fleets taking into account that North Sea herring and Western Baltic herring are taken together in this Division;

b) assess the status of the sprat stocks in Subarea IV and Divisions IIIa and VIId,e;

c) consider implications of SGRECVAP for the assessment and outlook of North Sea herring stock, as well as for PA reference points;

d) for the stocks mentioned in a) and b) perform the tasks described in C.Res. 2006/2/ACFM01.

HAWG will report by 2 April to the attention of ACFM.

1.3 Working Group's response to ad hoc requests

1.3.1 Request by European Commission (22/02/2007 D02012) on WESTHER and management of VIaN herring.

ICES received one special request from the European Commission to be considered by HAWG 2007.

Background

The WESTHER project proposed, tested and reported on one null hypothesis, and three alternative hypotheses, on the structure of herring populations to the west of the British Isles. Their report presents detailed reasoning and conclusions for each hypothesis. To provide the background required for our response, we present here the hypotheses and the WESTHER conclusions. For those who are interested in the supporting arguments we would refer you to the WESTHER report.

The **Null hypothesis** is that there is only one herring population to the west of the British Isles, with no detectable differences between any of the geographically and temporally separated spawning components. Examination of the null hypothesis involved the consideration of three alternative hypotheses relating to the spawning components, juveniles and feeding aggregations and lead to the following conclusions:

Alternative hypothesis 1: the different spawning aggregations sampled are discrete at spawning time and are, therefore, separate components.

WESTHER found that classification success of spawners was generally high suggesting that there is strong evidence to reject the null hypothesis and accept alternative hypothesis 1 because the different spawning aggregations sampled are discrete at spawning time.

Alternative hypothesis 2: there is clear distinction of juveniles sampled on different nursery grounds.

WESTHER found that parasites and otolith microchemistry act as tags for the juvenile stages of herring. There was a clear distinction between many of the different juvenile samples. There was also strong evidence that juveniles from separate spawning areas mix in some of the nursery areas sampled. WESTHER could ***distinguish the origin*** of juveniles even in mixtures, and thus accepted the alternative hypothesis 2.

Alternative hypothesis 3: fish from each spawning aggregation remain discrete on their feeding grounds.

WESTHER rejected alternative hypothesis 3 because there was evidence of mixing of adults from separate spawning components, especially in VIa North. The evidence also suggested that the Celtic Sea and VIIj adults do not mix as much as the more northerly herring. The science, therefore, suggests links between the areas, with fish spawning in different areas mixing, to varying extents, on feeding grounds. However, it was difficult to assess the level of mixing of non-spawning adults.

The HAWG supports these results and conclusions.

WESTHER briefly examined some of the assessment and management issues that derive from these results and presented the following conclusions:

"

1. ***Assess the herring to the west of the British Isles as two stock****s - Malin Shelf (including the current ICES stocks VIa North, VIaS and VIIb, c, Clyde and Irish Sea (VIIaN)) and Celtic Sea (the current Celtic Sea and VIIj stock). In the area studied in WESTHER we can hypothesise that there are two stocks within which data can be pooled for assessment. However, the boundary at the northern edge is unclear and there is no evidence presented in the report which separates autumn spawners in the north of Scotland west of $4^{o}W$ from autumn spawning fish east of $4^{o}W$ (the North Sea stock).*

2. *Survey effort should be increased or diverted to a combined survey on non-spawner distributions mixing on the Malin Shelf.*

3. *The current monitoring of the spawning components should be maintained, but not to the detriment of a wider scale Malin Shelf survey. Spawning ground surveys might provide data on the dynamics of individual stock components, which are thought to be useful for the development of a fleet-based advice*

However,

4. ***Management plans should be fleet/area based****, aiming at preventing the local depletion of any population unit in the area, and should make adaptive changes if current fishing practices change, specifically the introduction of a new 1^{st} or 2^{nd} quarter fishery in the southern part of VIa North and/or northern part of VIaS and VIIb,c.*

5. *Management plans should recognise the importance of the populations in the north of area VIa as a potential source of herring to spawning grounds to the south.*

6. *Management plans should recognise that there are potentially two separate stocks on the west coast of the British Isles, these constitute a population in the Celtic Sea and VIIj and a metapopulation centred on area VIa."*

HAWG recognizes the need to provide sound management advice for these areas, and in particular the importance of ensuring as far as possible that there is no depletion of local components. However, HAWG noted that WESTHER was not funded to evaluate the extent of mixing in the fisheries or to evaluate alternate management strategies for the area. 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.

HAWG considers that it is necessary to move towards an integrated management plan for this area through a series of iterations involving the following steps :-

- 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 two stock units of herring to the west of the British Isles.
- Replacement of existing or development of new cost effective assessment and data collection schemes which will be required to support this management.
- Movement to coordinated management for the region.

In this context HAWG proposes a study group with ToR given below.

Response to Commission

HAWG was requested to "*examine the WESTHER report and its recommendations to provide information on necessary changes to ICES long-term management advice concerning the herring stock to the West of Scotland (herring in VIa(N))*".

HAWG response: ICES considers that in the absence of any evaluated and coordinated management strategy for the herring to the west of the British Isles, the current separation of management units (VIa(N), VIa(S), Irish Sea and Celtic Sea) affords the best possible protection for local spawning stocks. However it does not afford protection to the fish of one stock distributed in another management area at feeding time.

Provided both the spawning fisheries (VIa(S), Irish Sea and Celtic Sea) and the fishery in the mixing area (predominantly VIa(N)) are maintained at an F that would be sustainable for each component, this should afford protection for these units, in the short term. ICES considers that further work is required on examining the issues surrounding surveys, assessment and management of each of the current three management units to the north of the area. This can be initiated, partly through a new study group or study contract. 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 previously endorsed plans for VIa(N) should be continued, until or unless some alternative strategy is found to be more useful.

TOR for study group: SGHERWAY

1) Consider the results of WESTHER in relation to VIaN, VIaS and VIIaN stocks.
2) Comprehensively evaluate the utility of a synoptic acoustic survey in the summer for the Hebrides, Malin and Irish shelves, in conjunction with PGHERS surveys of VIaN and the North Sea.
3) Investigate a alternative assessment methods of the three stocks that take into account WESTHER findings.Investigate their utility for advisory purposes.
4) Evaluate, through simulation alternative management strategies for the metapopulation of VIaN, VIaS and VIIaN.
5) Comment on what means is best to maintain each spawning component in a healthy state, whilst managing the fish of that component when they are in a neighbouring area.

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 The Annual Meeting of Assessment Working Group Chairs [AMAWGC]

The working group was addressed by the chair of ACFM (Martin Pastoors). Both he and Mark Dickey-Collas informed the group about the AMAWGC meeting in 2007. They described the construction of a roadmap for the working group for the next 3 years. The HAWG road map can be summarised as:

- 2007- Benchmark assessment Celtic Sea herring, evaluation of Irish management agreements
- 2008- Benchmark assessment of herring in IIIa (western Baltic spring spawning herring), comprehensive descriptions of the fleets
- 2009- Benchmark North Sea sprat

The new developments in mixed fisheries, INTERCATCH, the proposed new ICES advisory structure, evaluation of management strategies and ecosystem descriptions were also discussed at AMAWGC, and were taken into account when the HAWG 2007 report was put together.

1.4.2 The Planning Group for Herring Surveys [PGHERS]

The **Planning Group for Herring** Surveys [PGHERS] (Chair: Norbert Rohlf, Germany) met at the Danish Institute for Fisheries Research, Charlottenlund, Denmark, from 22–26 January 2007 to:

a. combine the 2006 survey data to provide indices of abundance for the population within the area, by means of the FishFrameAcoustics database;
b. coordinate the timing, area and effort allocation and methodologies for acoustic and larvae surveys for herring and sprat in the North Sea, around Ireland, Division VIa and IIIa and the Western Baltic in 2007;
c. intensively test the in-year developments of the FishFrame Acoustics database, specifically verify the ability of the new system to calculate global survey estimates from raw acoustic and trawl data using 2005 and – if possible – 2006 survey data;
d. further harmonise the maturity readings of North Sea and Western Baltic herring conducted by different labs, specifically the definition of mature and immature fish;
e. report on the possible bias introduced by a change in gear in the Dutch herring larvae survey.

Review of larvae surveys in 2006/2007: In total seven units and time periods out of ten were covered in the North Sea. The herring larvae sampling period was finished just prior to the PGHERS meeting, thus sample examination and larvae measurements have not yet been completed. The information necessary for the larvae abundance index calculation will be ready for and presented at the Herring Assessment Working Group (HAWG) meeting in March 2007.

Coordination of larvae surveys for 2007/2008: In the 2007/2008 period, the Netherlands and Germany will undertake seven larvae surveys in the North Sea. Outside the larval sampling programme some additional stations shall be sampled in the area of the Doggerbank to test anecdotal information of a recolonisation of the area and to obtain information about ongoing spawning activity. The Baltic Sea Fisheries Institute will continue with the larvae survey in the Greifswalder Bodden area in 2007, but the survey design will be altered and the N30 time series has to be recalculated to be assessable for the next benchmark assessment of the WBSS.

North Sea acoustic surveys in 2006: Six acoustic surveys were carried out during late June and July 2006 covering the North Sea and west of Scotland. The total combined estimate of North Sea spawning stock biomass (SSB) is 2.1 million t. This estimate is comparable to the 1.9 million t SSB in 2005 and the 2004 estimate of 2.6 million t. The stock is dominated by the 2000 year class. Growth of the 2000 year class seems still to be slower than average, individuals of this year class having almost the same size and weights than the one year younger fish of the 2001 year class. The West of Scotland estimate of SSB is 472,000 tonnes (190,000 in 2005). This is a substantial increase compared to last years estimate, and the SSB has more than doubled. The SSB is in the same order of magnitude that it had during the last ten years. The surveys are reported individually in Annex 2A-2F.

Western Baltic acoustic surveys in 2006: A joint German-Danish acoustic survey was carried out with RV “Solea” from 05 to 24 October in the Western Baltic. The estimate of Western Baltic spring spawning herring is 214,000 t (compared to 198,000 in 2005). The sprat year class 2006 was overall exceptional strong. In the Kattegat and the northern part of Subdivision 22 anchovy was observed in larger quantities. A full survey report is given in Annex 3.

Manuals for acoustic and herring larvae surveys: Several updates and improvements of the *manual for herring acoustic surveys in ICES Divisions III, IV, and VI*A have been suggested. The bibliography has been updated accordingly and the list of gears used by the different nations has been updated. The suggested changes are both very relevant and highly needed.

However, the suggested text will need some reviewing which will be done by correspondence in cooperation between Germany, Denmark and Scotland. The revised text will be sent to all members of PGHERS before the next meeting by the Chairman. No modifications were made in the *manual for the International Herring Larvae Surveys south of 62° north*.

Status and future of the FishFrame database: All countries have uploaded survey data from 2006 for herring and sprat. The stage 3 dataset for 2003, 2004 and 2005 is completed as well. Testing of the data browser, reports, upload, data checking and interpolation for both in stage 1 and 3 was done during the meeting. Two bugs were found, corrected and testing was redone. FishFrame performed satisfactory and was therefore used to combine the national data into the integrated survey result. FishFrame will be used again for the 2007 survey period.

Sprat: Sprat data were available from RV *Walther Herwig III*, RV *Tridens* and RV *Dana*. The total sprat biomass was estimated as 452,000 t in the North Sea (down from 563,000 t in 2005). The biomass is dominated by mature sprat (98 %). The total sprat in the Kattegat was estimated as 33,600 t, including 63 % immature sprat (down from 59,800 t in 2005). There is no clear indication that the southern distribution has been reached. However, the highest concentration of sprat was observed off the coast of Scarborough, on the east coast of England.

Coordination of acoustic surveys in 2007: Six acoustic surveys will be carried out in the North Sea and west of Scotland in 2007 between 21 June and 25 July. Participants are referred to Figure 4.3.1.1 for indications of survey boundaries. “Tridens” and “Walther Herwig” will cover the area between 52º and 57º together with interlaced transects. A survey of the western Baltic and southern part of Kattegat will be carried out by a German research vessel in October.

Investigation of bias introduced by change in gear in the larvae surveys: In 2004, the Netherlands changed from a Gulf III plankton torpedo to a Gulf VII. However, nothing was known about differences in catchability between these two devices. To investigate the possible bias introduced by the change of gear, real-time fishing comparison trials were conducted in 2006, deploying both samplers in a single frame. Volume filtered by the Gulf VII was found to be significantly higher than in the Gulf III, but catchability was less. However, due to technical problems, no accurate calibration of flow meters could be performed and therefore numbers of larvae caught can not be converted by the volume filtered. During the 2007 mackerel and horse mackerel egg survey, ichthyoplankton hauls with both samplers are planned to compare the catchability of mackerel eggs.

Recent studies on herring fat content and the accuracy of maturity staging: Deborah Davidson from the Aberdeen University gave a presentation of her ongoing PhD study dealing with modern methods of measurements on herring fat content. Data obtained from the 2006 herring acoustic surveys indicate that, as herring length and weight increases, so too does fat content. When comparing fat and weight, fish of a heavier weight did not tend to have very low fat contents. A FATMAP (a visual representation of spatial variation in fat content of North Sea herring) was constructed for the immature herring in the *Scotia*, *Solea* and *Tridens* data. Initial analysis showed that there was a strong linear relationship between length and fat content of immature fish. Plotting the raw fat data showed a clear southeast to northwest trend in fat content.

In a second talk Lindsay McPherson from Aberdeen University presented her findings concerning the accuracy of macroscopic staging of North Sea herring. As the macroscopic maturity scale is based on a histological scale, histology is the most accurate means of assessing maturity stage in fish. New, unambiguous histology keys were formed in order to calculate the accuracy of macroscopic staging. Macroscopic staging on *FRV Scotia* in 2006 was 78.6 % accurate for females and 83 % accurate for males. Much of the error in female staging was due to maturing repeat spawners (stage 3) being assessed as recovering (stage 8). While marked inaccuracies were found they are unlikely to impact upon the SSB as the number of fish assessed as immature (1-2) or mature (stages 3-8) were correct.

Recommendations:

PGHERS recommended HAWG to comment what proportion of the total survey effort should be directed to the different survey indices (adult herring / sprat / young herring). HAWG stated that it does no recommend any changes in survey effort.

HAWG does not recommend PGHERS to calculate the proportion of skipped spawners (see below).

HAWG recommends PGHERS considering a change in the name for the herring acoustic surveys. Not only herring, but all pelagic fish, especially clupeids like herring, sprat, anchovies and sardines, are monitored in the surveys. The latter ones become more and more abundant in the North Sea. This should be reflected in the labelling of the surveys.

HAWG response to PGHERS request on Skipped spawners.

A relatively high percentage of herring in the maturity stage 8 (Recovering) was seen in the biological samples from North Sea in the 2006 summer acoustic survey (ICES 2007/LRC:01). PGHERS raised the issue of "Skipped spawners" in the North Sea autumn spawners and has requested HAWG on their needs for data on the proportion of skipped spawners in an assessment context: "*HAWG should comment on their needs to calculate a proportion of skipped spawners (Stage 8) for the assessment*".

Skipped spawning is considered an important phenomenon in herring (Norwegian Spring spanners) and cod (http://www.ices.dk/iceswork/asc/2004/Theme%20Session.pdf) affecting particularly second time spawners. However, it is unclear how to properly classify skipped spawners. Knowledge of effective fecundity and its annual variations are of great importance in understanding the reproductive potential in a stock. In the assessment of North Sea autumn spawners maturity information (immature and mature) is used in the estimation of the Spawning Stock Biomass.

Differentiating between recruit and repeat spawners is often very difficult in macroscopic determination of the gonads, which is the method currently in use for the North Sea autumn Spawners. In the Norwegian spring spawning herring, there are indication that the spawners are recovering for about three months before they are back in the maturation cycle. It is thus a question if the high proportion of skipped spawners in June-July is related to autumn spawners spawned the previous year. There is little information on mixture of autumn and spring spawners in the different areas of the North Sea.

To include the "skipped spawners" in the current assessment context seems premature at present as available knowledge will most probably not improve the variability in the estimates of SSB. However, the WG recommends that the phenomenon be further studied to improve the methods for maturity determination and the understanding of the relation between recruitment and spawning biomass.

1.4.3 Study Group on Recruitment Variability in North Sea Planktivorous Fish [SGRECVAP].

SGRECVAP is due to meet in May 2007 in Plymouth, UK. It will consider the possible causes of the poor herring recruitment in the North Sea, in light of its previous report from 2006, which was discussed in last year's herring working group report. The findings of SGRECVAP have impacted on the choice of recruitment scenarios used for North Sea herring short and medium term projections. As SGRECVAP is yet to meet, HAWG cannot fulfil TOR c.

1.4.4 Workshop on Testing the Entrainment Hypothesis [WKTEST]

This workshop will take place in June 2007 in Nantes, France. It will document diagnostic case studies of pelagic fish for the evidence of the entrainment hypothesis and look for understanding of the mechanisms by which life cycles patterns are maintained or changed. It is hoped to used the finding to improve understanding for spatial fisheries management and recovery plans.

1.4.5 WESTHER [EU project]

WESTHER: A multidisciplinary approach to the identification of herring (*Clupea harengus* L.) stock components west of the British Isles using biological tags and genetic markers. Q5RS-2002-01056 (2003-2006).

WESTHER's overall goal was to describe the population structure of herring stocks distributed from the south-west of Ireland and the Celtic Sea to the northwest of Scotland. To achieve its goal WESTHER had four research objectives: (i) estimation of genetic and phenotypic differentiation between spawning aggregations; (ii) determination of stock origins and life history of juveniles; (iii) determination of composition of feeding aggregations and (iv) improved guidelines for the conservation and management of biodiversity and stock preservation. The Project started officially on January 1st, 2003 and was extended, in 2005, by six months to finish at the end of June 2006.

A meeting took place in April 2006, of the participants from the different fishery institutes within the project consortium, to discuss the outcomes of each method and their comparisons and to produce a report to fulfil Objective 4: improved guidelines for the conservation and management of biodiversity and stock preservation. At this meeting, four hypotheses were tested and used to inform the deliberations. The null hypothesis was that there is only one herring population to the west of the British Isles, with no detectable differences between any of the geographically and temporally separated spawning components. The following three alternative hypotheses were then tested and discussed. Alternative hypothesis 1: the different spawning aggregations sampled are discrete at spawning time and are, therefore, separate components. Alternative hypothesis 2: there is clear distinction of juveniles sampled on different nursery grounds. Alternative hypothesis 3: fish from each spawning aggregation remain discrete on their feeding grounds. This report was presented to HAWG in 2007 with the recommendations arising from the project's synthesis. The recommendations of WESTHER are given in section 1.3 of this report.

1.4.6 The Study Group on Management Strategies [SGMAS]

The Study Group on Management Strategies (SGMAS) met for the third time in January 2007. In previous meetings guidelines have been provided for evaluation of management plans. At this meeting, some plans at various stages of development were revisited, to learn from experience. Furthermore, indicator based management in data poor situations was considered. Finally, the process of developing management strategies, and the role of ICES in such processes was discussed.

The only example stock covered by the HAWG was the Celtic Sea herring. The HCR was a target yield with penalty when SSB<Btrig, but yield allowed to increase when SSB>Btrig, both subject to an annual +-15% TAC change limit. The experience from that development was that it was not successful. Reasons for that include poor communication between science and stakeholders, problems with the recruitment model (reduced recruitment at the adopted Bpa), and the lack of reliable assessments. Due to the uncertainty in the assessment the approach of using it in the proposed type of HCR will give very conservative yields as the trigger point needs to be well above the point of recruitment impairment.

On indicator based management, the SGMAS considered this to be a promising approach, in particular in data poor situations, but also pointed out that the understanding of the properties and performance of such regimes so far is limited.

The SGMAS emphasized the need for communication and mutual understanding between all interesting parties in the development of management strategies, not the least in the early phase of development. In this phase, the role of science should be to outline opportunities and limitations rather than coming up with specific detailed designs of harvest rules. Later, when evaluating proposed plans, the importance of identifying ambiguities was highlighted, with the recommendation to ask rather than assume.

Several study and working groups have matters relating to the SGMAS work on their agenda. At some stage, there is a need to merge the insight into a unified process for developing and evaluation of management strategies, but so far it is considered more rational to handle different specialized aspects separately. It is clear that the process will have to continue, but at present has not been decided how it will be organized in the future.

1.4.7 Workshop on the Integration of Environmental information into fisheries management Strategies WKEFA

Workshop on the Integration of Environmental information into fisheries management Strategies and advice will meet at ICES Copenhagen 18–22 June 2007.

The objective is to identify methodology to operationalize the use of environmental information for the improvement of fisheries management advice. The main thrust of the approach is to take case studies which have consequences for medium term and short term influence in management.

The approach to the workshop has been selected to be compatible with the current annual advice, and the use of management plans as detailed in the report of SGMAS[1]. The aspects of management advice are considered primarily under single species short term catch options, which follow from medium term management plans based on harvest rates and biomass objectives. Some consideration should also be given to long term implications. This implies evaluation of strategies using criteria of yield, year on year change in yield and the level of risk to the stock under situations of linear or nonlinear environmental change that can influence both the productivity of the stock and the quality of the assessment. For each case study the objective is to identify important life history aspects that change due to environment, including the following

- Recruitment
- Natural mortality
- Growth, Maturation fecundity, including year and cohort effects
- Distribution (habitat and availability)

While it is intended that the main thrust of the meeting will be through the selected case studies, the organisers would welcome detailed proposals for additional case studies, these should be proposed to the organisers as an extended abstract indicating the application of management to be considered and the extent of the effects. The abstract should be submitted no later than 18 May 2007, however, individuals are encouraged to contact the organisers with their intentions as soon as possible,

For each case study the authors need to comment on knowledge and importance, of each of the identified environmental aspects and show how this should influence management and advice.

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1 http://www.ices.dk/iceswork/wgdetailacfm.asp?wg=SGMAS

The Workshop will consider the influence of single or multiple factors on the management of single stocks, where the effects on management are demonstrated, as well as more complex interactions. Authors should select and prioritise the topic areas based on potential influence and available knowledge and should evaluate the impact of change / variability considering;

- Different conditions that influence medium term plans and changes to risk / precautionary limits
- Implications for short term advice and catch options.
- The potential changes in the long term advice and how this might we included in management plans.
- Possibility of extreme events on provision of short term advice.

Where the issues are medium or long term authors should illustrate how this will feed through to both management plans and short-term catch options. Consideration should be given both to management options robust to change as well as reactive management options based on estimation and adaptation.

Specifically the workshop will use the case studies to provide a basis for a synthesis of the needs and roles for management and will provide a report indicating how management advice should be considered, along the lines of environmental influence on:

Short term forecasts

Medium Term management plans

Long term prognosis

The workshop will result in a synthesis report and potentially a paper or collection of papers in a leading journal.

Participants should provide a detailed abstract by 18 May and bring a completed working paper and presentation to the workshop.

NS herring has been selected as a case study we hope to address the

- the influence of spawning stock biomass on recruitment at different environmental conditions and how to determine the contribution?
- the definition of Blim, how to determine it and adjust to different regimes?
- inclusion of recruitment indicators in short-term predictions
- Interannual variability in predation mortality may modify recruiting year classes.
- Appropriate use of year effect and cohort effect growth and maturation
- Inclusion of environmental variables in SRR or adjusting SRR and reference points to productivity regimes,
- Detection and advice during transition phases

1.4.8 Workshop on Limit and Target Reference Points [WKREF]

Workshop on Limit and Target Reference Points [WKREF] 29 January to 2 February 2007 in Gdynia, Poland. The TORs were: 1) to review and update the biological basis of limit reference points for fish stocks in the ICES area, taking into account the possible effects of species interactions and regime shifts; 2) to review the scientific and management literature on the implementation of maximum sustainable yield reference points in line with the Johannesburg agreement 2002; and 3) to comment on potential target references points for fish stocks in the ICES area as suggested by SGMAS, taking into account the possible effects of species interactions and regime shifts and the framework on the evaluation of management strategies.

WGREF explored limit reference points for North Sea autumn spawning (NSAS) herring.

In exercises using the segmented regression method (hockey stick) with Norwegian spring spawning herring this approach was found to be quite sensitive to both low S and R values as well as to recruitment values beyond the break point. Due to these theoretical deficiencies alternative methods were explored for NSAS herring.

A simple probabilistic approach to setting B_{lim} with the objective to be much less sensitive to recruitment at high biomass than the prevailing SR-methods was presented to the workshop. The method was scrutinised and further developed at the WKREF as a generic approach to stocks that typically have data on low recruitment at low spawning stock size.

The approach focused on low – stock low recruitment where the concept is that below some level of SSB there is an increased probability of a below average recruitment. P_{LRi} is defined as the probability of recruitment R_y (for a number of years y in an ascending sequence of B_y) falling below some level R_{bar} when spawning biomass B_y for these years is below some level B_i.

$$P_{LRi} = [\ \sum y : \{ R_y < R_{bar} \ \wedge \ B_y < B_i\}] / [\sum y : \{B_y < B_i\}].$$

This function is expected to be high at low biomass and be asymptotic to the probability of the level of R_{bar} for the population. The biomass point B_{break} at which P_{LRi} reaches the asymptote is the point where the probability of low recruitment increases.

WKREF considered the probabilistic approach to the entire time series of NSAS herring SRR from 1947 -2005. The breakpoint was evaluated in relation to the probability (P_{LRi}) of being below the 50% percentile of recruitment (R_{bar}). The breakpoint in logistic version was set at 10% above the estimated asymptotic value. The two model versions gave similar break points (B_{break}) of $0.89\times10^{\wedge 6}$ t and $0.84\times10^{\wedge 6}$ t for the linear and the logistic versions respectively. Model fit to data was slightly higher for the linear version than for the logistic version R^2 = 0.982 and R^2 = 0.975 respectively. Residual scatter was approximately normally distributed however some autocorrelation was indicated.

WKREF scrutinised the approach theoretically and concluded that the probability aspect of the method has interesting possibilities because it can specify the probability of obtaining low recruitment. However, the method appears to have some theoretical weaknesses because it does not allow a strict definition of a breakpoint because of the inherent curvature of the probabilistic approach. Further the curvature of probability for low recruitment is dependent on variation in SSR. The method needs further exploration on different types of SRR relationships before it can be applied in an advisory context.

WKREF concluded that there is no basis for changing B_{lim} based on current analysis. SGRECVAP results could be basis for revisiting reference point. The distance between a management reference point (trigger or B_{pa}) and B_{lim} defines a risk and should be evaluated in the context of harvest control rules in consultation with stakeholders and managers.

In general WKREF concluded:

that moving to a target F based management would probably remove the importance of B_{lim} in a management context.

WKREF has identified three approaches that could be followed in developing long term targets:

1. EC (B_{lim} not required; $F_{0.1}$-F_{max} from yield per recruit analysis as a proxy for F_{msy}) .
2. ICES (B_{lim} required, HCR risk analysis: probability of SSB falling below B_{lim})

3. Process/sustainability (NSRAC) (risk analysis also considering socio-economic implications)

For a discussion on advantages and drawbacks of each approach see the WKREF report (ICES CM 2007/ACFM:05).

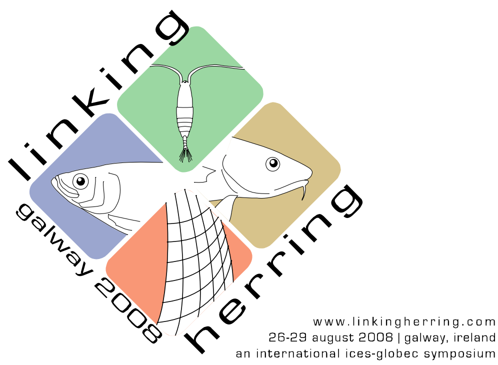
As indicated above, the question on the role of regime shifts in determining limit reference points was not resolved by WKREF. One approach could be to define different SRR curves for different environmental regimes and to evaluate the breakpoints in these two curves. In general, WKREF recommended looking for biomass limits that would be applicable in both environmental regimes. The distance between B_{pa} and B_{lim} could take into account the uncertainty due to different regimes.

As HAWG followed this workshop, no extra work was carried out on TOR c other than develop ideas for WKEFA and SGRECVAP.

1.4.9 Linking Herring 2008 [ICES/GLOBEC sponsored symposium]

The ICES/Globec sponsored symposium "Herring: Linking biology, ecology and status of populations in the context of changing environments", with the shortened title "Linking Herring" is planned to take place 26-29th August 2008 in Galway, Ireland. The conveners are Maurice Clarke, Mark Dickey-Collas and Aril Slotte. A science organising committee has been set up with Maurice Clarke, Mark Dickey-Collas, Aril Slotte, Emma Hatfield, Doug Hay, Richard Nash, Deirdre Brophy, Øyvind Fiksen as members. The symposium web site is www.linkingherring.com.

The proceedings will be published in the ICES Journal of Marine Science. Niels Daan will act as guest editor on the symposium proceedings.



The Theme Sessions will include:

i) *Herring in the middle*- the trophic and ecological interactions and impacts of herring

ii) *Managing Change*- management and exploitation of herring in a dynamic environment, within the context of long term change

iii) *Variable Production*- particularly the role of reproduction, recruitment and life history strategies.

iv) *Population Integrity*- the integrity of stocks and the drivers of migration

v) *Counting herring*- qualitative and quantitative estimation of herring and its application.

1.4.10 Improved advice for the mixed herring stocks in the Skagerrak and Kattegat [EU project IAMHERSKA]

An ecosystem approach to fisheries management should consider conservation of stock and stock sub-component diversity. Spatial variation in composition of stocks or stock sub-components in areas together with asynchronous population dynamics may lead to over-fishing of individual stocks or stock sub-components.

A descriptive analysis of the Danish fleet dynamics during the last decade, in terms of the distribution of herring catches in Division IIIa and Subdivision IVaE, together with an investigation of fleet/metier specific exploitation of the individual stocks in Division IIIa and Subdivision IVaE was performed in the IMHERSKA EU project (Clausen et al., 2006).

Fisheries identified in Ulrich and Andersen (2004) using multivariate analysis of landings profile (target species) and trips descriptors (mesh size, season, and area) were in the IMHERSKA projects modified, to get as much consistency with the previous HAWG work. This resulted in six herring targeting metiers.

The spatial and temporal distribution of the two main stocks (NSAS and WBSS respectively) and the individual life stages (juvenile versus mature) in the Subdivisions IVaE, Division IIIa and Subdivisions 22-24 appear to be following certain patterns in terms of seasonality, which in turn allow spatially and seasonally explicit predictions of the life stage- and stock-composition in catches. By using the above fleets/metiers and looking at the stock composition in their catches within different areas and seasons, stock selective metiers were identified (a stock selective metier was defined as: a metier with 80% or more of its landings constituting the same stock).

The ultimate last step of the IMHERSKA project was to bring this data and knowledge together in a metier based projection model, with the potential to predict stock specific Fs depending on how the total catch is distributed between metiers. This projection model is still under development.

1.4.11 Study Group on Risk Assessment and Management Advice [SGRAMA]

Whilst the concept of risk is not unfamiliar within ICES and whilst "risk" is commonly understood as the probability of some negative event or harm, most approaches to risk assessment, however, describe risk as consisting of two major components – a probability term and a term that addresses the magnitude of consequence. The need to clarify definitions and terminology as well as to setup a consistent risk assessment and management framework seems obvious. This was the initial intention of ICES to create a new study group in 2006 to deal with this complex topic. Consequently, a new ICES Study Group on Risk Assessment and Management Advice (SGRAMA) met the first time in Copenhagen 18-21 April 2006.

The SGRAMA was created as a first step "*in establishing guidelines for production of risk assessments and inclusion of considerations of risk management in the advice. Risk assessment and risk management is considered by ICES as an important field in several branches of science. The SGRAMA aims at drawing on the experience from other branches of science, and to include that experience in the development of risk assessment and risk management in fisheries science.*" Furthermore, the work of the SGRAMA is considered essential by ICES as "*such evaluations are necessary to fulfill the requirements stipulated in the MoUs between ICES and Commissions*". Such information is seen to help managers to manage risk in fisheries. As in particular the management component of SGRAMA (the other component is the assessment one) is closely related to the fields of SGMAS, risk management should be considered a part of all management strategies. The assessment part of the SGRAMA should relate to all working groups that are linked to specific stock assessments.

The SGRAMA began its work in 2006 by reviewing different approaches to risk assessment. This limited review discovered a multitude of different use of terminology and definitions. Also because of this, the SGRAMA recommended that the use of the term "risk" should be handled more carefully: "*Risk should mean something more than only the probability of some (potentially) harmful event*" and "*that at least the definition used and the context need to be specified*". To tackle this problem, the attempt of SGRAMA was

- to focus on differences in structural approaches and
- to start developing an ICES risk assessment framework
- by setting up definitions
- by concentrating on the clarification of terminology and
- by identifying relevant and important components for it.

This effort is in close compliance with the ICES terms of references a) and b) that are

1. *to review and report on available methodologies for risk assessment and frameworks for risk management within and outside the fisheries sector;*
2. *on the basis of the review, start development of a framework and operational guidelines, for risk assessment and advice which includes considerations on risk management. Risk assessments should inter alia relate to conservation limits and targets for exploitation of fish stocks taking into consideration the ecosystem effects of fisheries and environmental variability and management considerations should relate both to the production of such assessments and institutional aspects of risk management decisions and implementation. The framework should link to the framework for management strategies developed by SGMAS with the scope of ultimately being integrated with these;*

The SGRAMA met the second time in Cape Town, South Africa, 5-9 February 2007. This time the aim of the SGRAMA was to consider specific case studies of risk assessment coming from other parts of the world to learn from these. The specific focus this time was on qualitative approaches in risk assessment why the popular "Australian Approach" (Fletcher 2005) was reviewed and discussed. Apart from this, several other working documents were presented, mainly dealing with South African and Namibian experiences in qualitative risk assessment. The only European contribution was a presentation of a quantitative approach regarding risk assessment of North Sea Herring ("Risk assessment of North Sea Herring for stock rebuilding purposes using an optimization algorithm", Gröger 2007). As this approach is closely related to issues of the HAWG it can be considered a first attempt to introduce an integrative approach of risk assessment and an optimization procedure into North Sea herring stock assessments.

1.4.12 Workshop on recruitment process of Baltic Sea herring stocks [WKHRPB]

The Workshop on Recruitment Processes of Baltic Sea herring stocks [WKHRPB] was held in Hamburg from 27 February to 2 March 2007 to: conduct a review on recruitment processes of the different Baltic Sea herring stocks; evaluation of the effect of the abiotic and biotic environment of herring recruitment; construction of environmentally-sensitive stock-recruitment relationships; Outline of a scientific project addressing Baltic Sea herring recruitment. The first two tasks were fully addressed while the third was outlined as the possible main TOR in a next year Workshop. Preliminary results of the analysis are presented in section 1.8.

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 2006 catch data was v1.6.4. All but two nations provided commercial catch data on these spreadsheets, which were then further processed with the SALLOC-application (Patterson et al., 1997). 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 1.5.5), 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. Two nations failed to deliver their data on time. One of them failed also by the time of the meeting, and still required additional corrections during the meeting, which was rejected.

More information on data handling transparency, data archiving and the current methods for compiling fisheries assessment data are given in the stock annex 2. 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 in given in the table below for all herring stocks covered by HAWG. The table indicates that the sampling level (in terms of fraction of catch sampled and number of age readings per 1000 t catch) is very different for the various areas. Further details of the sampling quality can be found by stock in the respective sections (Sec. 2.2.4 for North Sea herring, 3.2.6 for Western Baltic Spring Spawners, 4.2.3 for Celtic Sea and VIIj herring, 5.2. for VIa(N) herring, 6.2.2 for VIa(S) and VIIb,c herring, 7.2.2 for Irish Sea herring).

Area	OFFICIAL catch (t)	SAMPLED catch (t)	AGED readings	AGE READINGS per 1000 t
IVa(E) Summe	102628	89299	2784	27
IVa(W) Summe	243561	203447	15564	64
IVb Summe	92996	59479	4305	46
IVc Summe	6755	2245	89	13
VIId Summe	44423	35195	839	19
VIIa(N)	4402	4230	1235	281
VIa(N)	27346	22135	1590	58
IIIa	53172	50125	12318	232
VIIj	6887	6887	6501	944
VIaS, VIIb,c	14840	14840	957	64

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. 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 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 has started 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.

HAWG reviewed the quality of the overall sampling of herring and sprat for the whole area. There is concern that the present sampling regime may lead to a deterioration of sampling quality, because it does not ensure an appropriate sampling of different metiers (each combination of fleet/nation/area and quarter). 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 EU data directive appears to not assure this. 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 Precision of catch sampling programmes

Port sampling programs aim to provide estimates of the biological composition of the landed catch. Typical characteristics that are collected are length, weight, sex, maturity and age. Of prime interest for stock assessment model input is the catch composition with regard to age. Because age reading is a labour intensive and thus costly method, various sampling schemes have been adopted to make optimal use of age data. Two examples are length-representative sub-sampling and length-stratified sub-sampling. Both methods rely on random selection of individual fish for length determination, but select a non-random subset for age reading. In the length-representative sub-sampling scheme, care is taken to ensure that the randomness at the level of the larger subset carries over to the smaller subset while reducing the probability of introducing bias. The length-stratified sub-sampling scheme makes use of an age-length key, preferably constructed from an independent subset, in order to translate the estimated length distribution into an age distribution. Both of these methods are used within HAWG. Estimates of numbers-at-age in the total landed catch are obtained via multiplication with a raising factor, which can be loosely defined as the inverse of the biomass fraction sampled.

In subsequent paragraphs, several aspects of precision are considered. First, the Swedish port sampling program is described with respect to the variability regarding weights at age. Next, the Dutch port sampling program is described with respect to the precision of numbers-at-age estimates. The Dutch program makes use of a length-representative sub-sampling scheme and its precision was estimated via an analytical approximation. Finally, precision estimates of the Irish port sampling program are presented. The Irish sampling scheme makes use of age-length keys and estimates were obtained through a bootstrapping procedure.

Analysis of weight-at-age of Swedish herring IIIa

Sweden has analysed precision levels of calculated CANUM and WECA for several stocks. The results from the analyses are used to establish the sampling plan for 2007.

Here we show the results of the analysis of weight at age (WECA) of Swedish herring IIIa sample in 2006. The replicate in our analysis was the sample vessel (50 random individuals). We estimated CV is plotted against the number of fish per age class (Figure 1). Age classes 1 – 4 are included in the graph, which constitute usually more than 90 % of the population in number of individuals. The result shows that CV decrease with increasing number of fish sampled down to a CV of 18- 20 %. To further decrease the CV, a sampling size much larger than 500 individuals per age class and quarter should be collected. This would increase the sampling costs dramatically (about 4-fold). Moreover, without a test that is based on such large sample size per age class, it is impossible to predict the number of individuals needed to reach the established CV (established in DCR). For example, based on the relationship in Figure 1, we predicted that with 2006 sample size (around 650 individuals in total per SD and Quarter, more than 150 in the age classes 1 – 4) we should have reached a CV under 12.5%. However, the observed CV was again around 18-20%. From these results, it was concluded that:

- Any sampling design that is aimed to reach the established CV should be based on experiments with very large and very small sample size to estimate the relationship between N and CV. This would be a very costly procedure but it would elucidate the sample size needed to reach established CV.
- The pattern observed here is likely to be related to the fact that there is an "inbuilt" CV (as it should be expected) in the WECA (as well as in CANUM) and much larger sample size would be necessary to reach the CV aimed by the DCR (i.e. 12.5% or lower).

It also worth to stress that WECA generates lower CVs than CV calculated for the number at age in catch (CANUM). This would imply that sample size would be even larger for CANUM if established CV should be reached. Thus, in the light of those results, we decided to keep the sampling at planned levels.

The Swedish sampling plan for herring in IIIa are to sample 650 per SD and quarter resulting in about 150 individuals in the age classes 1-4 and a CV around 20% (see Figure 1.5.3.1). About 50 individuals are sampled randomly from unsorted catches and a total of 10-12 boats are sampled in each quarter and area (Kattegat and Skagerrak), resulting in totally 1300 individuals per quarter in area IIIa.

Precision of numbers-at-age in the Dutch port sampling program

In the Netherlands, the herring catch is landed in frozen packages of approximately 21-23 kg, consisting of non-sorted fish. According to the Dutch port sampling program, a number of packages of a landing are randomly selected for biological determination. Per package, the number of fish is counted and all are measured for length. A subset of 25 individuals, representative of the length distribution of the package concerned, is selected for assessment of weight, sex, maturity and age. As a result of this length-representative sampling, the 25 individuals are as random a representation of the landing as the selected package is with regard to the length distribution. A schematic outline of the procedure is presented in Figure 1.5.3.2.

Observed numbers are raised to a total per month per area, taking into account the differences in biomass fraction sampled as well as possible spatiotemporal differences in population composition. Afterwards, the numbers-at-age are summed over areas and over months to arrive at estimates on a quarterly or yearly basis. Alternatively, observed numbers could be raised to quarterly or yearly estimates directly by ignoring spatiotemporal differences on the finer scale. Whether this would result in more precise estimates depends on the data. For the purpose of precision calculations, we have only considered raising procedures on a quarterly basis.

Precision calculations were based on the following basic formula:

$$[1] \qquad N_a = \sum\nolimits_s n_s \, F_s \, P_{a,s}$$

Here, N_a denotes the total number of fish per age a, n_s denotes the total number of fish sampled within a stratum s, F_s is a stratum-specific raising factor and $P_{a,s}$ denotes the stratum-specific age probability distribution. Because F_s is equal to the aggregate landing weight per stratum W_s divided by the product of n_s and the average fish weight per stratum w_s, the above formula can be rewritten as

$$[2] \qquad N_a = \sum\nolimits_s \frac{W_s \, P_{a,s}}{w_s}$$

This equation illustrates that uncertainty in the total numbers-at-age is governed by uncertainty in the aggregate landing weight and inaccuracy in the estimation of the average fish weight per sampled landing and the sample-specific probability that fish are of a particular age. As the uncertainty in the aggregate landing weight is not due to the sampling program, it will not be considered here.

An exact expression for propagation of estimation errors in w_s and $P_{a,s}$ can be obtained if the two stochastic variables can be considered independent. As we did not want to assume independence *a priori*, a linear approximation was applied to equation [2] by which covariance between w_s and $P_{a,s}$ can be taken into account. Estimates of covariance were obtained from variation on the sample level.

Figures 1.5.3.3, 1.5.3.4 and 1.5.3.5 illustrate the method pertaining to raising procedures on a quarterly basis for the years 2004, 2005 and 2006, respectively. Some general characteristics on input data are provided in Table 1.5.3.1. From the figures, it is immediately apparent that standard errors are related to point estimates. However, the relation is not strictly proportional as the relative error is not constant over the age range considered. Relative errors are generally the lowest for numbers-at-age in the third quarter. A striking cohort effect is apparent, in that the lowest relative error is associated with the strong 2000 year-class. Over the age range 2-6 wr, the relative error is generally below 20%. Exceptions are only apparent in the first and final quarter of the year.

Precision of numbers-at-age in the Irish port sampling program

Irish samples are collected from 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.

The precision estimates were worked up using a bootstrap technique. Bootstrapping involves the re-sampling and processing of the source data (measured and aged samples) many times in order to build up a series of results. Precision can then be calculated from the variance observed in the results. For measured data, a sample consisted of a length-frequency distribution. For aged data, a sample consisted of an age and length measurement of a single specimen.

The bootstrap re-sampled with substitution from the collection of measured samples and built up a composite length frequency distribution. For example, if there were five measured samples the algorithm would make five draws from the list with each sample having a 20% probability of being drawn each time. Re-sampling with substitution from the aged samples in a similar fashion gave an age-length key. Combined with the landings for the stock per quarter the numbers-at-age were derived. After 1000 repetitions, the precision of the numbers-at-age estimate was calculated from the spread of values at each realization. Specifically, the standard deviation of realized estimates was divided by the mean estimate to obtain a relative measure of estimation error.

The results of the method as applied to 2006 data are shown in Table 1.5.3.2 for CS herring and in Table 1.5.3.3 for NW herring. The relative error is below 20% over the age range 2-6 wr, irrespective of stock. In the third and the fourth quarter, estimates of 1 wr on CS herring were also remarkably precise. At older ages, estimates of NW herring were more precise than estimates of CS herring which is likely due to the higher catch of older fish derived from the NW stock.

1.5.4 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.

1.5.5 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 other legacy (previously used) systems were carried out and the maximum discrepancies between the systems are presented in the text table below.

HAWG is the first working group to use this system and some problems were encountered. Ease of use was dependent on the size of the stock and number of allocations required. Allocations can be tedious if dealing with large stocks such as North Sea herring.

The stock coordinators in general found that InterCatch provide a helpful tool at that it has the potential to reduce errors and reduce the work load of the stock coordinators. However several issues should be addressed.

List of suggestions for improvement of InterCatch, some of which are crucial and should be taken very serious:

1) Currently InterCatch does not allow the same full catch information as the Salloc output to be derived. For many stocks in HAWG there is often an issue of misreporting and unallocated catch. Salloc output lists official, working group and unallocated catches separately and, for full transparency, we need InterCatch to do the same.

2) The exchange formats used by pelagic working groups currently contain length frequency per quarter, and catch information by statistical rectangle. InterCatch does not include this information. It is recognised by HAWG stock coordinators that this information is not a requirement for assessment input, however, it is very useful in enabling the right allocation decisions to be made and for the

development of length based or spatial models. This information would be a valuable addition to the InterCatch system. It also is a quality control mechanism.

3) When uploading and allocating large amounts of information a cross checking procedure would be crucial. A suggestion would be a print version of a list containing all combinations of quarter, area, fleet and country uploaded together with the corresponding CATON. It would then be an easy task for the person responsible for uploading national data into InterCatch to cross-check that all data have been uploaded. Also a cross check list of the allocations made inside InterCatch would be convenient.

4) As it is now InterCatch will not catch the two following types of error: 1) Mismatch between age and CANUM and WECA in the InterCatch input file (e.g. if the data during the copying and pasting from one sheet to another is pasted into a wrong age group simply by mistake). 2) Problems concerning allocation of catches given by rectangle to the wrong areas.

5) InterCatch has a security service that prevents data with certain errors to be uploaded and provide easy comprehensible suggestions to where the error is to be found. However, this security system needs further improvement since several type errors in the input files were not discovered by the security system allowing the data to be uploaded but afterwards disappearing. These errors could alternatively be avoided if the check list print version suggested above was available.

6) Sprat is caught in vast abundances with numbers often in billions. It is likely this caused the problems encountered during the attempt to upload North Sea sprat data, and this should therefore be investigated.

7) Intercatch should be set up to generate some of the standard table (or at least the formatted input for the table) used in the report, otherwise data would in many cases still need to be handled in the ways the respective stock coordinators traditionally have been handling and processing the data.

8) As long as the split is not incorporated into InterCatch the stock coordinator of herring in IIIa and SD 22-24 will have to work both with the data in InterCatch and in the traditional way.

9) There is currently a lack of authority of stock coordinators to ensure reported data is uploaded to intercatch in the correct format. A formal agreement is needed for institute directors to consent that their staff will do this work.

Maximum discrepancies between InterCatch and other systems:

	HER - 3A 22	HER - 47 D3	HER - IRLS	HER - IRLW	HER - NIRS	HER - VIAN
Caton	0.01%	0.06%	0.02%	0.01%	0.00%	0.00%
Canum	0.01%	5.00%	0.01%	-0.01%	0.08%	2.17%
Weca	-7.43%	3.30%	-0.08%	0.13%	-0.02%	-0.35%

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 CPUE indices from commercial fisheries or research-vessel surveys, which may be age-structured or not as required. This model appears to behave well on the stocks considered by this WG.

The program ICAVIEW4 produces standard plots for the ICA output. However, ICAVIEW does not work on most computers, probably caused by the incompatibility of the program with windows XP and was not used this year. As a result, the standard ICA plots were not presented for all stocks.

1.6.2 CSA

“Catch Survey Analysis” (CSA: Mesnil, 2004) is an assessment method that aims to estimate absolute stock abundance, given a time series of catches and of relative abundance indices, typically from research surveys. It does this by filtering measurement error in the latter through a simple two-stage population dynamics model known in the literature as the Collie-Sissenwine (1983) model. The underlying aim is to reduce the dependence on age-structured data inherent in most VPA-type assessment methods. CSA can be used with only 2 life-history stages (recruits and adults, for example), although simplifying assumptions have to be made. CSA has been used for the exploratory analysis of Celtic Sea herring and North Sea sprat.

1.6.3 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 modeling integral 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. Currently, an effort is being made to incorporate stock assessment models that are used in some of the ICES working groups. Methods for reading in VPA suite files, for investigating the effect of different model input parameters on the stock estimates, and modeling different aspects of uncertainty are also being developed. Currently the assessment methods “Extended Survivors Analysis” (XSA: Darby & Flatman, 1994; Shepherd, 1999) and ICA have been incorporated in a package as FLXSA and FLICA, but the development of other stock assessment methods like ADAPT and SURBA is on-going.

During this 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, two plots were added to the diagnostic output: a Q-Q plot to show the distribution of the log residuals as compared to a normal distribution; and an autocorrelogram to show the autocorrelation function of the log- residuals. These two plots are shown because the catchability models fitted assume a normal distribution of the log residuals and no autocorrelation therein.

In this working group, FLR has been used for exploratory analyses of North Sea herring (FLICA for deterministic and retrospective analyses), herring in IIIa, Celtic Sea (exploratory analysis) and Via South.

1.6.4 SURBA

“Survey Based Assessment” (SURBA: Beare, 2005; Needle, 2003, 2004) is based on a simple survey-based separable model of mortality. At the moment SURBA is not yet available in FLR, but development towards this is ongoing. While SURBA was used in the past in this WG it was not implemented this year.

1.6.5 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.

1.6.6 STPR used for medium term projections NS 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.

1.6.7 Management simulations

In order to evaluate the impact of alternative scenarios of stock and recruitment for the North Sea herring stock population dynamics, an evaluation platform has been implemented, including four model components. In order to develop the platform, an age-structured population dynamics model has been developed (McAllister, Pikitch et al. 1994; Punt, Smith et al. 2002). The model allows a realistic representation of the population dynamics taking into account potential bias in observations through the observation error model (including all surveys available). The model also allows to evaluate the state of the stock using ICA as the assessment method and to utilise the actual management procedure to provide management advice using the harvest control rules model. The simulation-testing framework has been developed and implemented under FLR using several packages such as FLICA, already used last year by the WG. This platform was not used to evaluate the existing HCR yet, but the approach is being developed in the EU project FISBOAT (http://www.ifremer.fr/drvecohal/fisboat). During this year's meeting, substantial input was provided to the developer by HAWG.

1.6.8 Bayesian Statistical Catch-at-age

An exploratory analysis of the Celtic Sea herring data was performed by means of a statistical catch-at-age model. The model uses Bayesian estimation and was implemented in WINBUGS

(Spiegelhalter 2003). The statistical catch-at-age model was used for the period where survey data is available (1995 to 2006). The early part of the series is derived from a VPA with starting numbers from 1997. The fishery was fitted with a logistic selection function that can change from year to year. The example shown to the WG allowed only a slow change in selection.

The model exploration was considered preliminary, there was no evaluation of the influence of priors, though they were thought to be uninformative, and only a limited range of flexible selections were tested.

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 (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) or pumping unsorted catch overboard also results in discarding.

In the area considered by HAWG, only 3 nations reported discards from their fleets in 2006. From those, only two incorporated discards in the assessment data.. The discard figures were raised to national landings (based on the spatial and temporal distribution of the fleet), and used in the assessment of North Sea autumn spawning herring (UK/Scotland and Germany, see Section 2.3) and VIaN (UK/Scotland, see Section 5.1.3). For the Netherlands, the estimates of discards of approximately 4 thousands tonnes per year were not sampled at a high enough resolution to allocate the catch in individual stocks.

All other nations did not report notable amounts of 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 coverage is still not high enough.

Very few estimates of discarding of pelagic species from pelagic and demersal fisheries have been published. Discard percentages of pelagic species from demersal fisheries were estimated between 3% to 7% (Borges et al., 2005) of the total catch in weight, while from pelagic fisheries were estimated between 4% to 11% (Pierce et al., 2002; Hofstede and Dickey-Collas, 2006). Even less information exists on the discarding of non-commercial fish.

For the Dutch pelagic freezer-trawler fleet, a first ever estimation of discarding was carried out based on observers on-board vessels (Borges et al, working document). A total of 27 trips and 904 hauls were sampled between 2002 and 2005, covering the North Sea and western waters of the British Isles. This study intended to investigate suitable methods for estimating discarded fish by the Dutch pelagic freezer-trawler fleet. This fleet is viewed as fairly typical of similar vessels that operate under German, UK and French flags, which are mostly Dutch owned. Different methods to estimate the total discards were compared and raising observations by trip or by landing did not affect greatly the annual estimates of total discarding, except for 2003.

The results show that for this fleet which has high volumes of catches of a few species (mainly herring, mackerel, horse mackerel and blue whiting), approximately 10% of the total catch discarded is discarded, showing that it is a selective fishery for its targeted species. However the majority of discards are from not targeted. The percentage of catch discarded per species shows mackerel highly discarded (35% of the total catch) and this can be caused by either quota limitation or landings misreporting. For the horse mackerel and the herring, discards are respectively 7% and 5% of the total catch. Estimate discards par year for herring of approximately 5 500 tonnes (Figure 1.7.1) are low when compared to total landings of the Dutch pelagic freezer-trawler fleet (Figure 1.7.2). These estimates include slippages.

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 noise in the assessment because the sampling level for discards is usually lower than that for landings. 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 be based on a fleet based method, rather than on a national basis. Table 1.7.1. and 1.7.2 show the number of samples done in 2006 for the pelagic fleets by country.

1.8 Ecosystem considerations, sprat and herring- response to WGRED, SGRECVAP and SGRESP.

HAWG acknowledges the significance of the variability in the ecosystem as an important driver of the herring and sprat stock dynamic. This must be considered when giving advice. Despite the increasing pressure on working groups to consider their allocated stocks within the context of the ecosystem, the potential added value of having targeted ecosystem groups (such as NORSEPP, WGRED and REGSNS) is still minimal due to the lack of an interaction between these groups and the assessment groups. The provision of the data by the ecosystem groups and the summaries they provide are still largely unsuitable for consideration and adoption by assessment working groups. This is partly due to their acting in isolation. Although assessment working groups are generally populated by scientists with a “stock assessment” slant, HAWG has a history of using and investigating environmental drivers and changes in productivity, and such work has fed into and been used by groups such as SGPRISM, SGRESP, SPACC and other GLOBEC groups. Summaries of physical and environmental times series that reflect the dynamics of the NE Atlantic and environs of the North Sea are required by HAWG. These summaries must be cumulative and not “stand alone” quarterly reports, and they should document variability and fluctuations of inflow, transport, primary and secondary production, water column stability, turbulence, salinity and temperature.

Examples of the use and interest of HAWG in the dynamics of the ecosystem and its impact of the fish stocks include:

- the use of shifts in recruitment productivity in North Sea herring in short and medium term projections
- the accounting for productivity changes in the development of management scenarios for west of Scotland herring
- the analysis of surplus and net productivity in herring stocks in relation to fishing mortality
- by incorporating, whenever possible, empirically derived annually variable weights and maturity ogives in stock assessments

- by accounting for cohort specific dramatic changes in weight and maturity in short term projections
- investigations of the dynamics of the timing of spawning and the temporal origin of fish in both the catch and surveys
- the investigations of the between year larval mortality in North Sea herring
- investigations of fecundity in herring
- the search for more robust indices of recruitment in all stocks
- initiating work on the interactions of multispecies catches of the fleets that target small pelagics

HAWG welcomes that North Sea herring will be a case study in the work shop on Workshop on the Integration of Environmental Information into Fisheries Management Strategies and Advice (WKEFA).

1.8.1 North Sea

Salinity and temperature are known to have a large impact shaping the ecosystem structure in the North Sea and generally their variability reflects the influence of the North Atlantic Oscillation (NAO) on the movement of Atlantic water into the North Sea. The long-term temperature and salinity anomalies in the Atlantic waters flowing into the North Sea with the Faroe Isle current provide a broadly similar cyclical behaviour up to the late 1990s (ICES 2006/LRC:03). However, in more recent years the two signals appear to diverge, with relatively high temperatures persisting during years showing a marked decline in salinity (Hughes and Lavin 2005).

In 2005, SST (Sea Surface Temperature) was close to the long term mean for the first eight months of the year, but showed strong positive anomalies in September to December (source http://www.bsh.de/en/index.jsp). The last quarter of 2006 was characterised by much warmer condition (1-3 C° in the eastern part and about 1 C° in northern part of the North Sea) when compared to the average of the last 50 years (NORSEPP 2006).

A series of studies on the plankton ecosystem at the herring spawning grounds in the North Sea have shown a strong linkage between frontal hydrography and the prey availability, growth and drift of herring larvae which hatch in these areas (e.g. Richardson and Heath 1986, Kiørboe et al 1988) and other studies propose a strong connection between frontal hydrography and herring recruitment (Iles and Sinclair 1982, Sinclair 1988). Preliminary explorations of the hydrographic variability at the spawning grounds during the period 1975-2005 indicate that two periods of poor herring recruitment (1987-90 and 2001-05) coincide with periods of anomalous low water density in nearshore areas. This observed decline in water density is connected to both salinity and temperature fluctuations, and has most likely changed the performance of nearshore fronts. Hence, the preliminary comparisons indicate that the herring recruitment could be affected by oceanographic fluctuations, leading to changes in frontal hydrography at the herring spawning areas, and further investigations of this relationship are recommended.

In concomitance with an increased SST and decreased salinity, the plankton community in the North Sea has shifted to a dominance of more “southerly” species, as shown by CPR data (Reid et al., 2003) after the decline in the abundance of the copepod *Calanus finmarchicus*. Both *Calanus* species and juvenile sand eels are common prey of herring and recent evidence from the Baltic has shown that herring positively select *Pseudocalanus* and *Temora* and select less *Acartia* (Casini et al., 2004). *Acartia* is associated with summer blooms and warmer temperatures as shown by Gowen et al. (1998). These trends in zooplankton species abundance and species compositions appear to be continuing and those might have causal effect with herring growth and migration patterns (ICES 2006/ACE:03). The CPR data also show a reduction in euphausid availability. Although no changes have been recorded in the total zooplankton biomass and in total copepod abundance (e.g. northern North Sea; SAHFOS 2004, Heath 2005), the overall picture is one of a changing zooplankton community structure.

The production of herring has increased (ICES 2005/ACFM:18) since the collapse caused by overfishing in the 1970s (for methods details see Dutil and Brander, 2003). Surplus production has been of the order of 700 k tonnes for the last 25 years and the recent positive net production has lead to an increase in available herring biomass in the system. Also, the biomass of sprat is considered high and fairly stable compared to the last decade (ICES 2005/ACFM:18) (see also section 1.8.3).

In terms of the impact of a high biomass of herring and sprat on the North Sea ecosystem, some studies are ongoing, but more resources are required to obtain new estimates of stomach contents, prey selectivity, stomach evacuation rates and behavioural interactions by herring and sprat. With low sandeel and *Calanus* abundances, the herring may well be having a stronger impact on the ecosystem than in the previous last 2 decades. However, a high biomass of herring may also provide an alternative prey source to piscivores such as horse mackerel and Minke whales (Olsen and Holst, 2001) reducing the pressure on sandeel. Also, the impact of herring as predator of fish eggs varies with the prey spectra faced by the species (Segers et al., 2006). These last sentences are very speculative and if the quantitative trophic-complexities of the system are to be considered as a priority by ICES, more resources need to be spent on understanding the trophic interactions in the North Sea and developing spatial and temporal trophic dynamics models of the system.

Recent investigations of the decline in larval herring at age (empirical data from the ICES coordinated larval herring surveys, Dickey-Collas in prep.), which used a temperature dependent growth model to estimate larval age, suggest that the daily mortality rate of herring in the North Sea has recently increased to the highest in the time series (ICES 2006/LRC:03). There was evidence that high mortality of herring larvae can co-occur with high larval production (CM 2006/LRC:03). There was a strong negative trend in the residuals from stock-recruits relationship in the latest decade suggesting that the poor recruitment is not just related to high spawning stock biomass level (ICES 2006/LRC:03) but likely caused by an high mortality of herring larvae. The mechanisms for this were most likely poor larval feeding, predation, poor hatching condition and probably a combination of those with possible links to variable hydrographic conditions.

SGRECVAP (ICES 2006/LRC:03), using dynamic factor analysis, highlighted a positive correlation between the time series of SST and herring recruitment anomalies in the North Sea. In addition, a recent analysis (see Cardinale and Hjelm, 2006 for details on methods used) on the effect of spawning stock biomass (SSB) and sea surface temperature (SST) on clupeid recruitment in the North East Atlantic showed significantly more stocks with an SSB effect on recruitment compared to an SST effect on recruitment (Cardinale et al., 2006), although there was not significant difference on the strength of the SSB compared to the SST effect. Variability of recruitment anomalies of clupeid stocks (using all stocks assessed by ICES in the North East Atlantic) was positively strongly correlated with anomalies of SST in the area. A strong positive relationship was found between the first principal component, which explained around 29% of the recruitment anomalies variation, and average temperature deviations in the area. A similar relationship was found also with NAO, but its strength was lower than for SST. Interestingly, 70s and 80s are clearly separated from 90s and onwards, plausibly mimicking the different climate regimes (i.e cold against warm period) (Cardinale et al., 2006). This again highlights the link of temperature to recruitment strength of clupeids in the area but it does not provide any clear underlying mechanisms.

Recent analysis of the occurrence of sardine and anchovy as recorded in IBTS survey has increased rapidly in the last 10-15 years in the North Sea (Figure 1.8.1.1). Those are species adapted to warmer oceanic conditions and we could speculate that their increase is linked with warming of the North Sea. However, this investigation is preliminary and a spatial analysis of the occurrence of those species in the North Sea would add insight on the observed phenomenon.

The Kattegat and the Skagerrak is also considered an important area for herring by HAWG, it supports both local spawning populations and is the major nursery ground for North Sea herring. The impact of the higher saline inflows through this area into the Baltic Sea in recent years on the resident herring populations is at present unknown. Studies presented to HAWG in 2005 about the HERGEN (Bekkevold et al., 2005) project suggest that salinity may play a role in the genetic integrity of local spawning components. A preliminary analysis made at the WKHRPB (ICES 2007) was unable to find any climate signal on the recruitment of Western Baltic herring although the time series is rather short. For all other pelagic fish stocks in the Baltic area, a positive effect of a warm regime was evident although spawning stock biomass seems to play a more critical role for regulating recruitment in most of the stocks with the exception for stocks distributed in the gulfs (i.e. Gulf of Riga herring and Bothnian Bay herring) (ICES 2007).

In the neighbouring Baltic Sea, the interactions between herring and sprat have been shown to be very dynamic (Mollmann and Koster, 2002). A close association in food items predated upon by those species has been recently shown, together with a clear density-dependent (i.e. food limited) growth for both herring and sprat (Casini et al., 2006). Clupeid condition co-varied with the changes in the weight of zooplankton in the stomachs, which further suggest food competition being the main mechanism behind the changes in clupeid condition in the Baltic Sea during the last two decades. This is the first evidence of food resource mediated density-dependent fish growth in a large marine ecosystem (Casini et al., 2006). The individual fish from the strong 2000 year class of herring in the North Sea have been smaller in size and are less mature at age. This suggests that either slower-growing fish have survived in that year class or that the ecosystem has failed to provide enough food to allow the full potential growth for that cohort i.e. that food has been limiting for that cohort. This cohort grew well up to 1 winter ring of age. However, the less abundant 2001-2004 year classes show again average growth, tending to corroborate food limitation as the likely explaining factor for growth rates variability also in the North Sea herring (ICES 2006/LRC:03). With the decline in sandeel and other planktivorous fish, HAWG would support further studies into the feeding interaction and spatial and temporal associations of herring, sprat, anchovy and pilchard (sardine), especially in the light of the increase of the abundance of the latter southern species in the area during the latest decade (ICES 2006/ACE:03).

Most herring fisheries deploy gear that is deployed clear of the seabed. The impact of gravel extraction on the conservation and productivity of herring is still unclear, and there are virtually no studies to provide evidence at present (ICES 2005/ACFM:18). The limited evidence available at present records no incidences of cetacean mortality due to pelagic trawling (0 catches observed out of 218 pelagic hauls by commercial trawlers from 1999-2004). There are also very few other by-catches of fish, beyond the targeted fisheries of herring, mackerel, horse mackerel and blue whiting.

No specific environmental signals were identified specifically by WGRED (CM 2006/LRC:03) to be considered in assessment or management of herring and sprat in this area in 2006.

A possible link between ecosystem changes and the dynamic of North Sea herring might be the yearly variation of age specific natural mortality. HAWG (2007) has evaluated the effect of variable M (derived from MSVPA) on the historical dynamic of North Sea herring. Estimates of SSB made using variable M were similar to those using fixed M (used in the current assessment). However, and as expected, the use of variable M affected the perception of recruitment and F of the juveniles (age 0-1). Recruitment was smaller except for 1990 to

1995 year classes, while F (0-1) was slightly larger than with fixed M. The use of variable M also changed the relationship between stock and recruitment, making it more similar to a Beverton and Holt curve than previously believed. However, the largest changes appear for the segmented regression where the SSB Break point is largely reduced using fixed M, although the use of the segmented regression for estimating Blim has been recently questioned (WKREF 2007). (Figure 1.8.1.2).

1.8.2 Celtic Seas

The western herring stocks assessed by HAWG are found in the Celtic Seas (Celtic Sea, Irish Sea, Malin/Hebridean Shelf). There is less information on the hydrographic variability and ecosystem dynamics in the Celtic Seas. WGRED appeared to concentrate on the Celtic Sea.

Celtic Sea

In the Celtic Sea, in terms of hydrographic variability, the Irish Shelf Front, that occurs to the south and west of Ireland (at about 11°W) around the 150m isobath, and exists year-round, is an important feature for the structure of the marine ecosystem in the area. The turbulence caused by the front may bring nutrients from deeper water to the surface where it promotes the growth of phytoplankton, especially diatoms in spring, but also dinoflagellates where there is increased stratification. These may in-turn be fed on by swarms of zooplankton and associated with these, aggregations of fish, like herring and sprat (Reid et al. 2003).

The WGRED report (ICES 2006/ACE:03) suggests that are indications of steady warming in the area over recent years. Similar trends appear for salinity (ICES 2006/ACE:03). Considering that Celtic Sea herring is the second most southerly population of herring exploited in Europe, and this is an area of warming sea surface water, sea warming could affect the recruitment of this pelagic species.

Variation of zooplankton abundance and species composition might affect feeding conditions and mortality of juveniles and adults of both herring and sprat. Zooplankton monitoring data are available from one station in waters about 50 m deep in the English Channel. These data exhibited a decreasing trend from 1988 to 1995 but a recovery thereafter. This recovery was mainly due to two autumn developing small species of copepod, *Euterpina* sp. and *Oncaea* sp. In 1999 there was a decline in the zooplankton population, with the top ten species all below their typical average values (apart from *Temora* and *Corycaeus*, which exhibited very little variation) (ICES 2006/ACE:03). In 2000, 2001 and 2002 zooplankton population abundance experienced a recovery reaching values comparable to those after 1995 (reported in ICES Zooplankton Monitoring Status Summary 2001/2002). Data for 2004, 2005 and 2006 were not yet available.

WGRED considered that in the Celtic Sea a key pelagic species here is herring as well as sardine, in the southern area, and sprat, in the Celtic Sea proper. The area also accommodates considerable stocks of argentines (two species) and large numbers of small mesopelagic myctophids along the shelf break (ICES 2006/ACE:03).

Southward et al (1988) demonstrated that the abundance of herring *Clupea harengus* and pilchard *Sardina pilchardus* occurring off the south-west of England closely corresponded with fluctuations in water temperature. Sardine was generally more abundant and extended further to the east when climate was warmer whilst herring were generally more abundant in cooler times. This pattern has apparently been occurring for at least 400 years, and major changes were noted in the late 1960s as waters cooled and spawning of sardine was inhibited. In recent years herring populations have declined throughout the Celtic Seas ecoregion but are unclear whether sardine have increased in abundance.

Despite recent evidence from WESTHER and HERGEN that there is little genetic differentiation between herring stocks, their phenotypic characteristics and population dynamics are different. The Celtic Sea shows a very different pattern compared to both the west of Scotland and the Irish Sea stock (ICES 2006/ACE:03) (see section 1.8.3).

No obvious environmental signals were identified by WGRED that should be considered in assessment or management of herring and sprat in those areas. However, the major trends in the ecosystem noted above (i.e. the steady warming of the area and the reduction of copepod abundance) could play a major role to shape the dynamic of herring and sprat stocks in the near future (ICES 2006/ACE:03).

1.8.3 Investigating Productivity

The North Sea herring is a long and well documented species in terms of its exploitation and related collapses and recoveries (Cushing and Bridger 1966, Burd 1985, Nichols 2001, Simmonds 2005). The main impact on its productivity was generally expected to be fishing, although the environment may have a major impact as well. Each habitat or ecosystem is assumed to have a carrying capacity which varies in time (Jennings et al. 2003). To account for the influence of the ecosystem on the productivity of five different herring stocks (Tab. 1.8.3.1) two different methods were applied (Nash and Dickey-Collas 2005).

First the recruit per spawner ratio was calculated. High ratios were assumed to represent a high production and low ratios a low production. These calculations formed the basis for the detection of periods of high and low production of the stock.

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. The parameters used to fit the data from the different stocks are given in Table 1.8.3.2.

The data used in this analysis was derived from the assessment outputs from the HAWG in 2006 (Table 1.8.3.1). All stocks the HAWG dealt with are used, except the Western Baltic spring spawning herring (IIIa herring). The time series of the IIIa herring was assumed to be too short to meet the requirements of the analysis used.

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 impact of a varying F was tested using the North Sea herring time series as an example with both stock recruitment relationships adapted to the dataset.

All stocks showed highly variable production over time (Figures 1.8.3.1 and 1.8.3.2) that can be seen both in the recruit per spawner as well as in the net and surplus production estimates derived from the calculations that take the year effect into account. Except the Celtic Sea herring, all stocks showed markedly changes in the average productivity between different periods. However, these periods are not synchronized between the stocks. In the North Sea the productivity increased markedly after the collapse in the late 70's, supporting the recovery of the stock. In the middle of the 80's the productivity fell to the level before the collapse. In the last three years the productivity fell again (Figure 1.8.3.1). It is assumed, that without decreasing the fishing impact on this stock a collapse will happen again. If the recovery will be again supported by a high production due to good environmental conditions is doubtful.

The North Sea stock was also chosen to show the influence of different F on the outcome of the two fitted stock recruitment relationships. The overall trend is a decrease both in net and in surplus production with increasing F. Nevertheless the general pattern is still conserved. Therefore, for all other stocks only the figures derived with an F of 0.25 are chosen.

The Irish Sea herring stock showed a marked decline in productivity during the late 70’s and remained at a low level since then. This feature is represented in the recruit per spawner ratio as well as in the net and surplus production (Figure 1.8.3.2a). The Celtic Sea herring stock had a low productivity throughout the whole time series. However, the net and surplus production is very noisy displaying neither clear trend nor a general low productivity (Figure 1.8.3.2b). The VIa(N) herring stock showed a variable recruit to stock ratio without marked periods. However, the net and surplus production seemed to present a period of high productivity in average from the 60’s to the 90’s and a lower average in the recent decade (Figure 1.8.3.2c). The VIa(S) herring stock time series is shorter than the others. Therefore, general trends were not apparent. Nevertheless a high production in the 70’s and 80’s was followed by a sharp decline and a slow increase in the 90’s (Figure 1.8.3.2d).

1.9 Pelagic Regional Advisory Council [Pelagic RAC]

Members of HAWG have attended meetings of the pelagic RAC since its inauguration in 2005 and throughout 2006 and into 2007. HAWG considers the views of the Pelagic RAC as important, and welcomes the formation of the forum to give stakeholders a role in the advisory process. HAWG notes that the Pelagic RAC also has special members from outside the EU, 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 through the meeting.

1.10 Stock overview

Analytical assessment could be carried out for three of these eleven stocks. Results of the assessments are presented in the subsequent sections of the report and are summarized below and in Figures 1.10.1 - 1.10.3.

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. Following a period of good recruitment co-occurring with the new management measures, SSB and the proportion of older fish in the stock increased. This gave the opportunity to increase TACs and catch. The recent trends in SSB show that after a peak of 1.8 million tonnes in 2004, the SSB in 2006 was 1.2 million tonnes. The current fishing mortality ($F_{2\text{-}6}$) is 0.35 and is well above the target F prescribed the management agreement. It is likely that the stock will decline further close to B_{lim} by 2008. The decline in SSB is due to serial poor recruitment since 2001 and a failure to fish at target F for the adults in the last few years. The estimate for the most recent recruiting year class is the lowest since 1979 and the low recruitment is caused during the larvae phase of the North Sea herring.

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 SSB has been slightly increasing or stable over a number of years. When compared to possible MSY target fishing mortalities, it is likely that the current fishing mortality is too high. There is an indication of a declining recruitment in recent years in the WBSS herring stock.

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 2007, HAWG carried out a benchmark assessment on the Celtic Sea herring. The exploration showed that there is uncertainty in SSB, F and recruitment for last 3 years. However, information from the catch shows an increasing trend in the mortality of the fish and a contraction in age structure of the stock. Exploration with simpler models showed a decline in biomass over the whole last 10 years. A Bayesian analysis suggests that the selection of the fishery has changed over the last 10 years, and supported the perception that the current status of SSB is uncertain, but probably at a low level. Analysis of recruitment patterns suggested that no major regime shift has taken place in Celtic Sea herring productivity in the last 40 years.

West of Scotland herring was recently regarded as lightly exploited, but in 2006, the stock was more heavily exploited than it has been since 1999. Earlier data indicate the possibility of larger stock in the 1960s when the productivity of the stock was different from now. 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 2006, however, there was no misreporting from IVa into VIa (N). In 2006 the dominant year classes were 1999 and 2000. It appears that the 2001 year class is not strong as was originally supposed, but relatively weak. Recruitment seems to be low since 2001, but the level of recruitment at 1wr in 2006 and 2007 is uncertain.

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. 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 as 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 has declined. In the past decade there have been problems in assessing the stock. It seems likely that the stock has been relatively stable for the last 10 years, and that the fishing mortality does not appear to be increasing above the recent average. The catches have been low in recent years and the fishing activity has not varied considerably. There is evidence of a contraction in the age structure of this stock. Recruitment is approximately average for the period since the 1980s.

North Sea Sprat is the only sprat stock on which an assessment is carried out within this WG. Sprat in the North Sea 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. It is likely that the abundance of North Sea sprat is now less than in the last two previous years.

1.11 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 analysis 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, Celtic Sea and Irish Sea herring). Due to time constraints, not all the stock annexes were updated.

HAWG has adopted the ICES recommended procedure of benchmark and update assessments. In 2006 HAWG carried out one benchmark assessment: Celtic Sea herring. North Sea herring, VIaN herring, western Baltic spring spawning herring and North Sea sprat were all update assessments in 2007. VIaS and Irish Sea herring were all exploratory assessments. No exploration of IIIa herring was carried out in 2007. Two stocks, with very poor data (no catch at age sampling) and no current ongoing research are described in chapter 10. These are Clyde herring and sprat in the English Channel.

1.12 Recommendations

Please see Annex 2.

Table 1.5.1: Available disaggregated data for the HAWG per March 2007. X: Multiple spreadsheets (usually .xls); W: WG-data national input spreadsheets (xls); D: Disfad inputs and Alloc-outputs (ascii/txt)

Stock	Catchyear	Format X	Format W	Format D	Comments
Baltic Sea: IIIa and SD 22-24					
her_3a22	1991-2000	X			raw data, provided by Jørgen Dalskov, Mar. 2001, splitting revised
	1998	X			provided by Jørgen Dalskov, Mar. 2001, splitting revised
	1999	X			provided by Jørgen Dalskov, Mar. 2001, splitting revised, catch data revised
	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			provided by Lotte Worsøe Clausen, Mar. 2005
	2005	X			provided by Lotte Worsøe Clausen, Mar. 2006
	2006	X			provided by Mikael van Deurs, Mar. 2007
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	provided by Maurice Clarke, Mar. 2007
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			provided by Mark Dickey-Collas, Mar. 2002
	2002	X			provided by Richard Nash, Mar. 2003
	2003	X			provided by Richard Nash, Mar. 2004
	2004	X			provided by Beatriz Roel, Mar. 2005
	2005	X			provided by Steven Beggs, Mar. 2005
	2006	X			provided by Steven Beggs, Mar. 2006
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 by SG Rednose, Oct 2003
	1996	(X)	W	D	provided by Yves Verin, Feb. 2001, updated by SG Rednose, Oct 2003
	1997	(X)	W	D	provided by Yves Verin, Feb. 2001, updated by SG Rednose, Oct 2003
	1998	(X)	W	D	provided by Yves Verin, Mar. 2000, updated by SG Rednose, Oct 2003
	1999		W	D	provided by Christopher Zimmermann, Mar. 2000, updated by SG Rednose, Oct 2003
	2000		W	D	provided by Christopher Zimmermann, Mar. 2001, updated by SG Rednose, 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	provided by Norbert Rohlf, Mar. 2007
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, W included in North Sea
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	provided by Afra Egan, Mar. 2007
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)		provided by Lotte Askgaard Worsøe, Mar. 2002
	2002	X	(W)		provided by Lotte Worsøe Clausen, Mar. 2003
	2003	X	(W)		provided by Lotte Worsøe Clausen, Mar. 2004
	2004	X	(W)		provided by Lotte Worsøe Clausen, Mar. 2005
	2005	X	(W)		provided by Lotte Worsøe Clausen, Mar. 2006
	2006	X	(W)		provided by Mikael van Deurs, Mar. 2007
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)		provided by Lotte Askgaard Worsøe, Mar. 2002
	2002	X	(W)		provided by Lotte Worsøe Clausen, Mar. 2003
	2003	X	(W)		provided by Lotte Worsøe Clausen, Mar. 2004
	2004	X	(W)		provided by Lotte Worsøe Clausen, Mar. 2005
	2005	X	(W)		provided by Lotte Worsøe Clausen, Mar. 2006
	2006	X	(W)		provided by Mikael van Deurs, Mar. 2007
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)		provided by Lotte Askgaard Worsøe, Mar. 2002
	2002	X	(W)		provided by Lotte Worsøe Clausen, Mar. 2003
	2003	X	(W)		provided by Lotte Worsøe Clausen, Mar. 2004
	2004	X	(W)		provided by Lotte Worsøe Clausen, Mar. 2005
	2005	X	(W)		provided by Lotte Worsøe Clausen, Mar. 2006
	2006	X	(W)		provided by Mikael van Deurs, Mar. 2007
National Data					
Germany: Western Baltic	1991-2000	X			provided by Tomas Gröhsler, Mar. 2001 (with sampling)
Germany: North Sea	1995-1998		W		provided by Christopher Zimmermann, Mar 2001 (without sampling)
Norway: Sprat	1995-1998		W		provided by Else Torstensen, Mar 2001 (without sampling)
Sweden	1990-2000		W		provided by Johan Modin, Mar 2001 (without sampling)
UK/England & Wales	1985-2000	X			database output provided by Marinelle Basson, Mar. 2001 (without sampling)
UK/Scotland	1990-1998		W		provided by Sandy Robb/Emma Hatfield, Mar. 2002

Table 1.7.1: Sampling of the pelagic fleet by country, quarter and area for the North Sea (area IV) and area VIId. No. trip = number of trips. Total hauls = total number of hauls sampled. Herring hauls = total number of hauls sampled with herring catches (landings and/or discards) on a discard observer trip.

2006	Country	Quarter	Area	No. trips	Total hauls	Herring hauls
	Scotland	1	IVa	6	19	6
	Scotland	2	IVa	3	4	4
	Netherlands	3	Iva,IVb		38	
	Netherlands	3	IVa		54	
	Scotland	3	IVa	11	26	26
	Scotland	4	IVb	13	39	3
	Netherlands	4	VIId	-	33	

this table is based on the information available at the HAWG. It should not be regarded as a complete list of all biological samples taken in the pelagic fleet. The samples taken by The Netherlands are obtained from 11 trips.

Table 1.7.2 Sampling of the pelagic fleet by country, quarter and area for the remaining areas covered by the national sampling programmes within HAWG. No. trip = number of trips. Total hauls = total number of hauls sampled. Herring hauls = total number of hauls sampled with herring catches (landings and/or discards) on a discard observer trip.

2006	Country	Quarter	Area	No. trips	Total hauls	Herring hauls
	Scotland	1	VIa	7	19	2
	Scotland	3	VIa	3	8	8
	Germany	1	VIaN	1	1	1
	Netherlands	1	VIIj, VIIc		28	
	Netherlands	1	VIIj, VIIc,VIIb		32	
	Netherlands	1	VIIb, VIIh, VIIj, VIIIa		33	
	Netherlands	2	VIa		35	
	Netherlands	2	VIIIa		6	
	Netherlands	2	VIa, IVa,Vb1		53	
	Netherlands	3	Iva, Via, VIIb,VIIe,VIIj		39	
	Netherlands	4	VIId, VIIe, VIIh		40	

*** this table is based on the information available at the HAWG. It should not be regarded as a complete list of all biological samples taken in the pelagic fleet. The samples taken by The Netherlands are obtained from 11 trips.**

Table 1.5.3.1: General sampling characteristics of the Dutch port sampling program over the years 2004, 2005 and 2006, all quarters and divisions combined.

	2004	2005	2006
Number of samples	163	136	136
Number of fish aged	4050	3400	3400
Median age (IQR)	5 (4 – 6)	5 (5 – 7)	4 (4 – 6)
Average weight (SD) (grams)	187 (77)	213 (79)	190 (64)
Landing weight (tonnes)	159 038	152 488	110 404

Table 1.5.3.2: Results of the bootstrap algorithm to estimate precision in numbers-at-age as applied to CS herring landings in Ireland in 2006.

CS Herring 2006 Q1 (analysis id 36)

age	mean num	min num	max num	cv num
1	7099566	2633281	15020064	27.35
2	14430365	11276827	18117289	7.16
3	1431651	1122161	1657861	6.22
4	8929221	7082874	10602603	7.14
5	3426586	2117355	4527563	10.5
6	1161752	565975	1602919	14.71
7	186414	66192	308662	20.33

CS Herring 2006 Q3 (analysis id 52)

age	mean num	min num	max num	cv num
1	253766	120043	356106	14.42
2	9713009	5162143	12682446	11.38
3	4640709	3513891	5192945	5.35
4	1646663	1372748	1926113	5.32
5	3570583	2672145	4460396	7.56
6	1433178	939268	2352245	13.92
7	582711	294003	1481647	31.54
8	105343	22056	411620	60.45
9	43557	7993	157754	55.55
11	9238	1651	33908	52.81

CS Herring 2006 Q4 (analysis id 32)

age	mean num	min num	max num	cv num
0	13561	7113	52135	51.74
1	829905	633386	1038518	7.05
2	11601521	9088740	13499252	6.05
3	3004161	2500185	3341010	4.39
4	655337	410789	1005532	14.85
5	1548625	1037762	2230587	12.75
6	614223	319570	1062886	20.45
7	196611	87246	376347	25.53
8	27034	14942	52978	24.76
9	8099	572	25594	57.95

Table 1.5.3.3: Results of the bootstrap algorithm to estimate precision in numbers-at-age as applied to NW herring landings in Ireland in 2006.

NW Herring 2006 Q1 (analysis id 50)

age	mean num	min num	max num	cv num
2	905576	478885	1458279	17.8
3	20332250	12820605	29427317	10.66
4	19160703	18134865	20227194	1.68
5	14591315	13041387	16136608	2.92
6	6396043	4186431	7979064	7.61
7	1718249	778715	2380277	12.36
8	597265	179377	958553	17.75
9	190492	50673	363675	22.28
10	79568	16130	203110	37.71

NW Herring 2006 Q4 (analysis id 49)

age	mean num	min num	max num	cv num
1	599724	144769	1366649	32.06
2	21329275	13423887	30397002	13.61
3	17330775	13808288	19742328	4.29
4	10556765	8390400	12088730	5.66
5	7635251	5581843	10284265	10.34
6	2293685	1337493	3631527	16.07
7	668239	357452	1156314	18.77
8	175821	63514	390571	29.2
9	37275	6336	95029	37.45

Table 1.8.3.1 : Time series used in the analysis.

Stock	Length of the time series	Age of recruits	Source
North Sea	1947-2005	1	ICES 2006
Irish Sa	1962-2005	1	ICES 2006
Celtic Sea	1959-2005	1	ICES 2006
VIa(N)	1959-2005	1	ICES 2006
VIa(S)	1971-2004	1	ICES 2006

Table 1.8.3.2: Parameters for the hockey stick and the Ricker stock recruitment relationship used in the analysis.

Stock	Hockey stick		Ricker	
	α	β	α	β
North Sea	49.10506	0.879536	63.43208	0.49090
Irish Sa	34.28372	0.005509	15.81970	18.46749
Celtic Sea	7.36974	0.058526	10.25259	8.26308
VIa(N)	4.84980	0.622325	5.53721	0.49954
VIa(S)	6.22671	0.119607	9.33552	4.46681

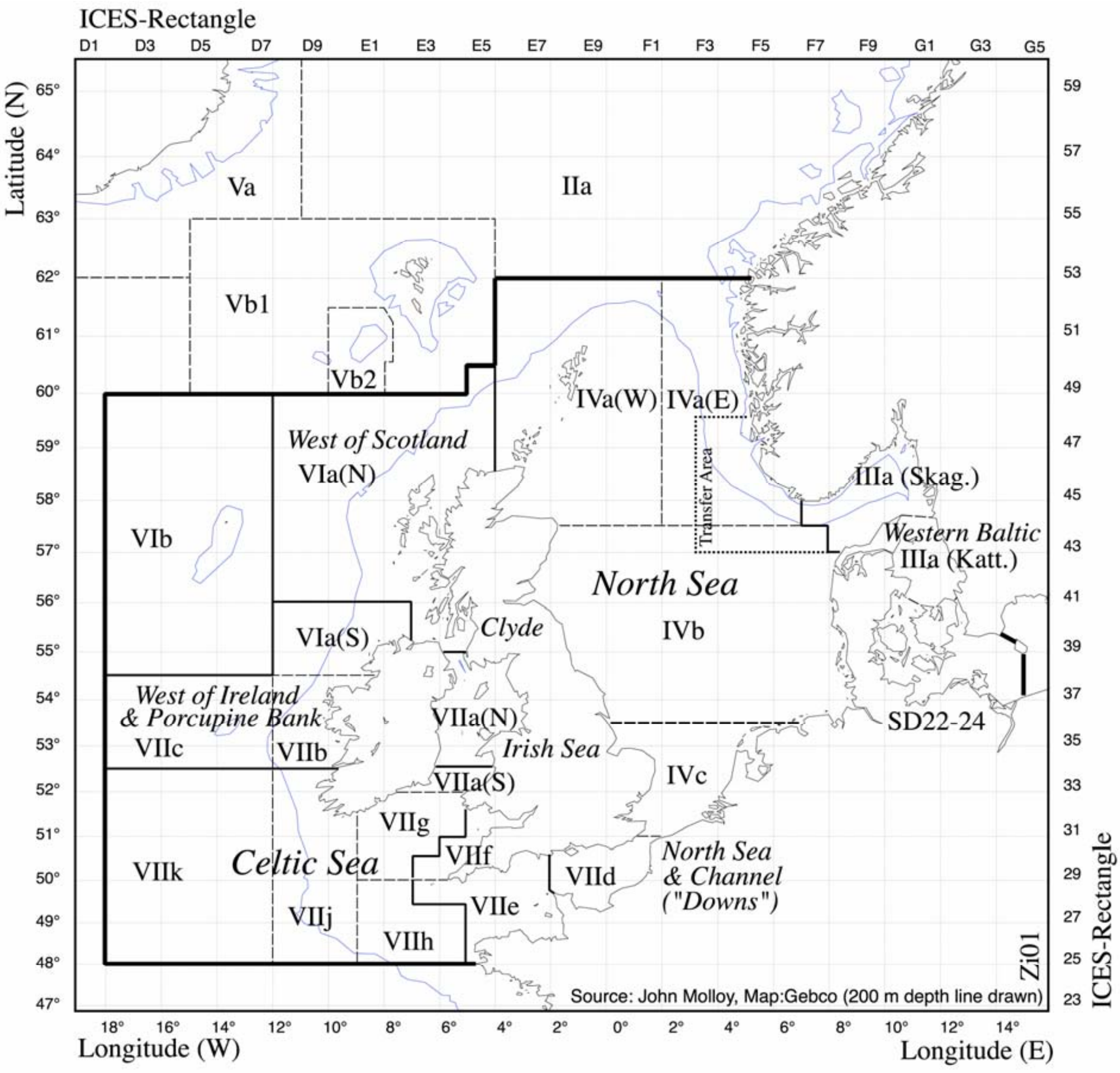


Figure 1.5.1: ICES areas as used for the assessment of herring stocks south of 62°N. Area names in italics indicate the area separation applied to the commercial catch and sampling data kept in long term storage. "Transfer area" refers to the transfer of Western Baltic Spring Spawners caught in the North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

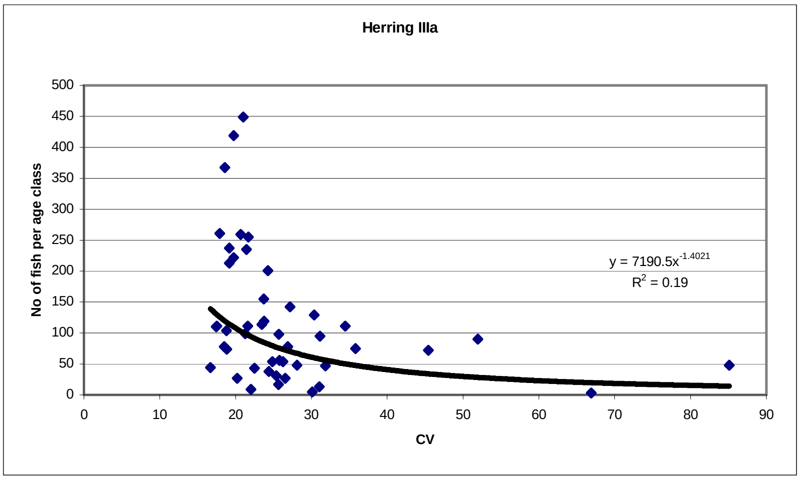


Fig 1.5.3.1. Observed CV of weight-at-age in relation to the number of fish sampled per age class as derived from the Swedish port sampling program in 2006.

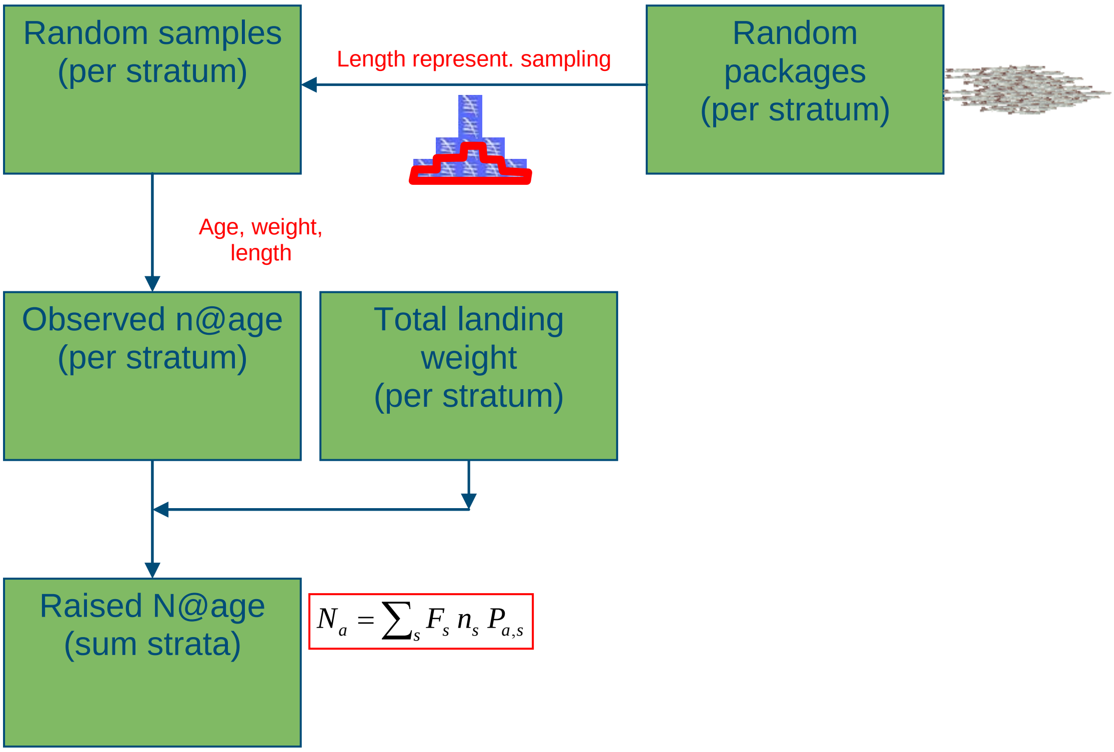


Fig 1.5.3.2. Schematic outline of the Dutch port sampling scheme for commercial herring landings.

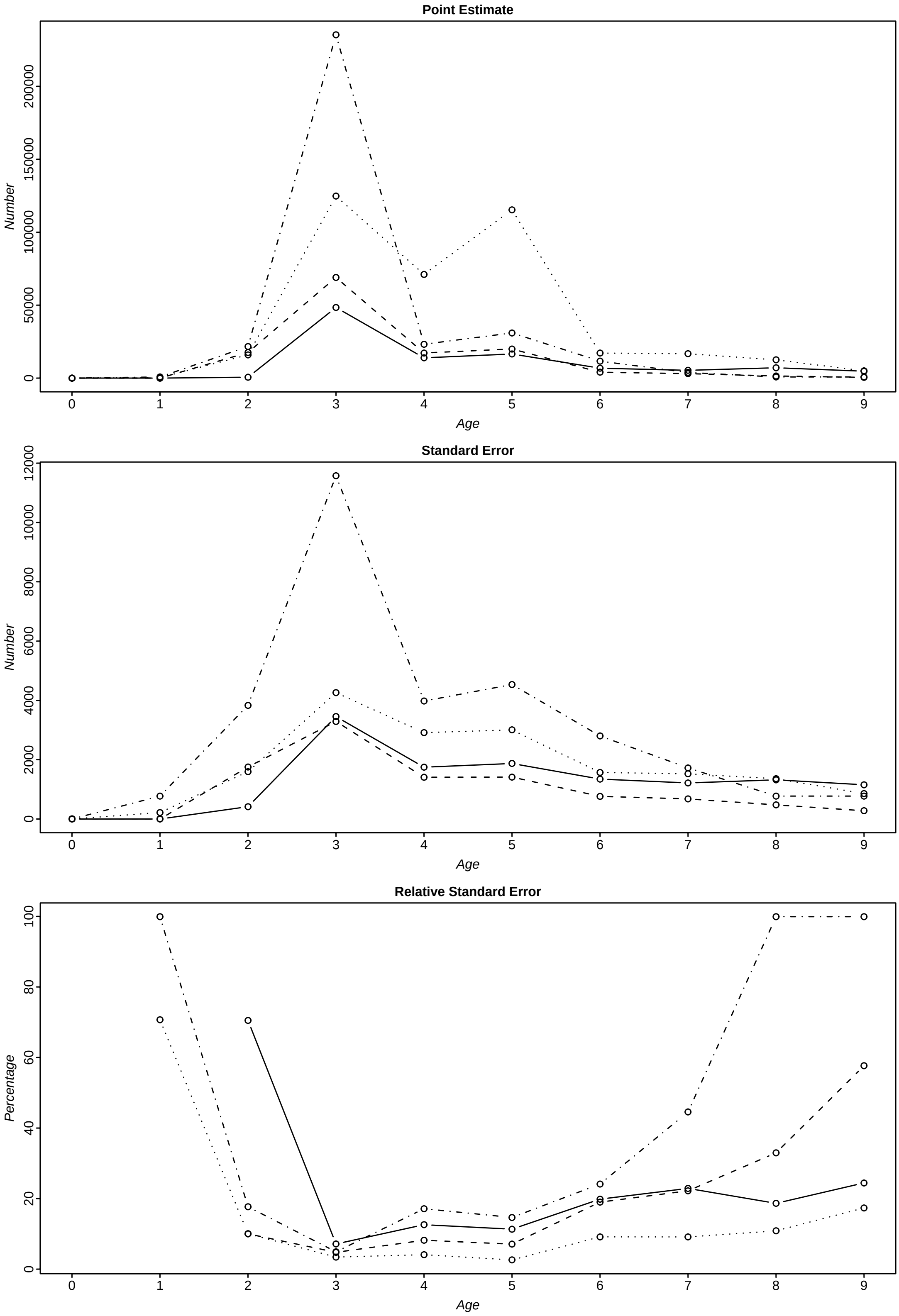


Figure 1.5.3.3. Estimates of numbers-at-age together with their (relative) standard error as derived from the Dutch port sampling program in 2004.

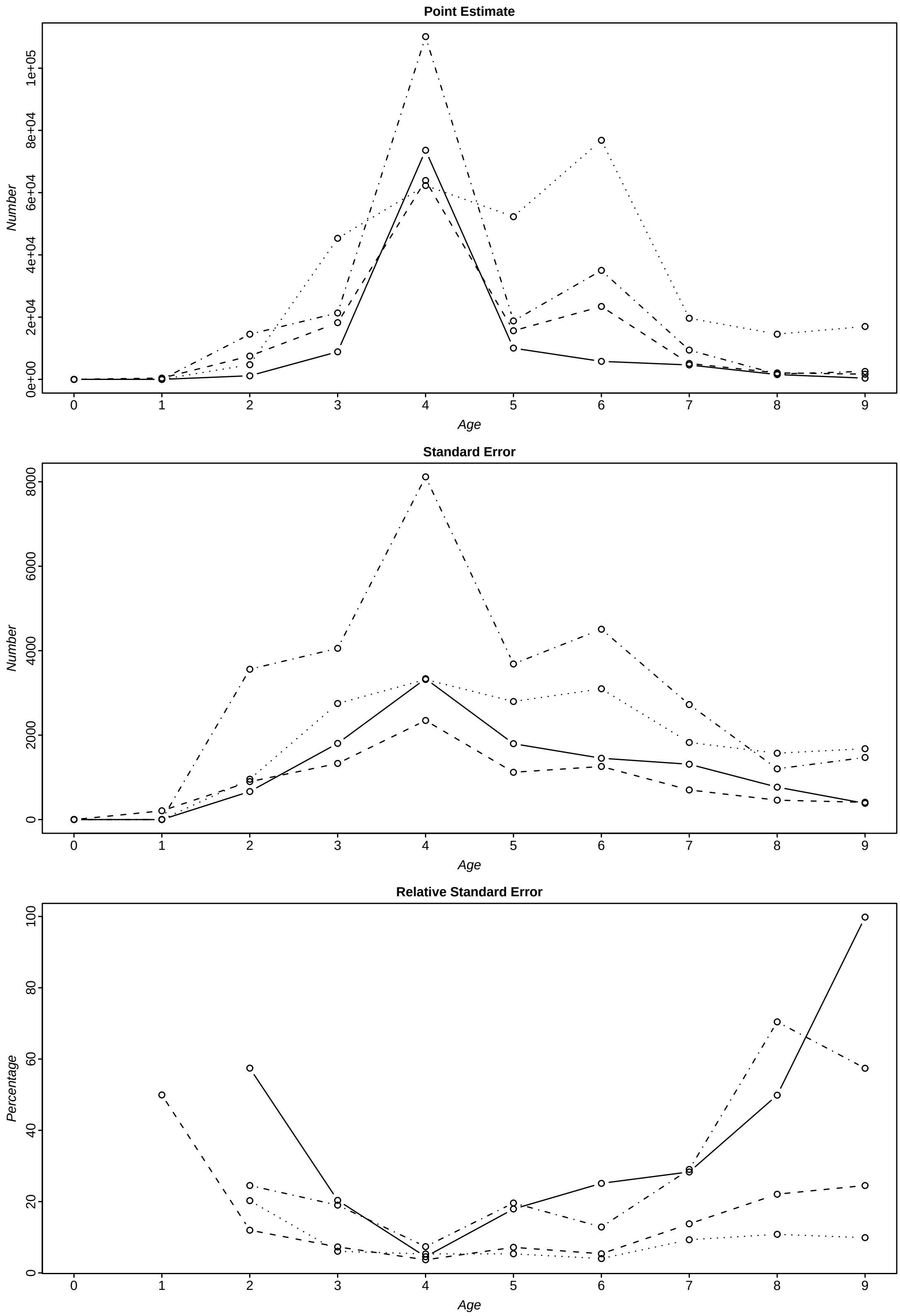


Figure 1.5.3.4. Estimates of numbers-at-age together with their (relative) standard error as derived from the Dutch port sampling program in 2005.

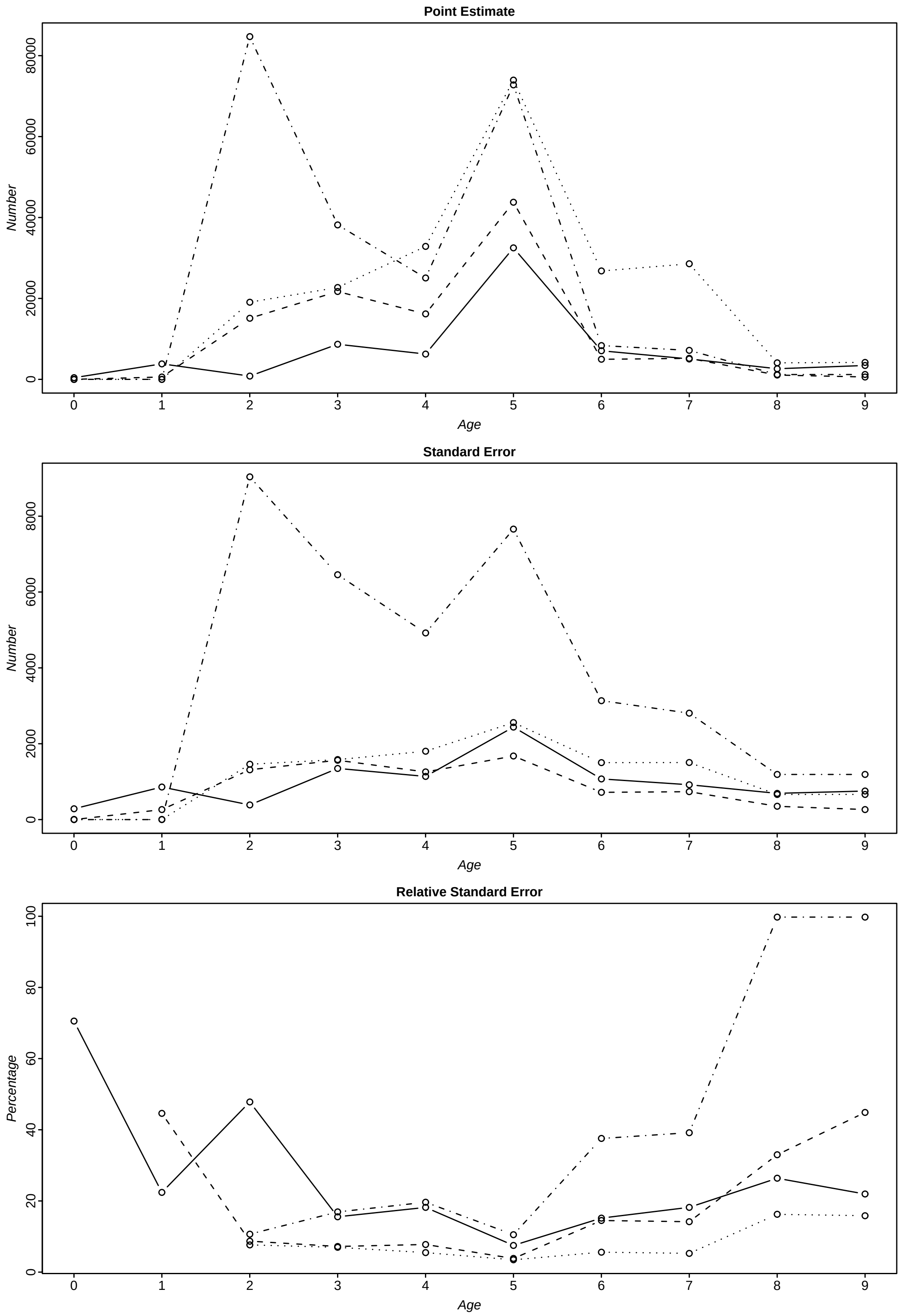


Figure 1.5.3.5. Estimates of numbers-at-age together with their (relative) standard error as derived from the Dutch port sampling program in 2006.

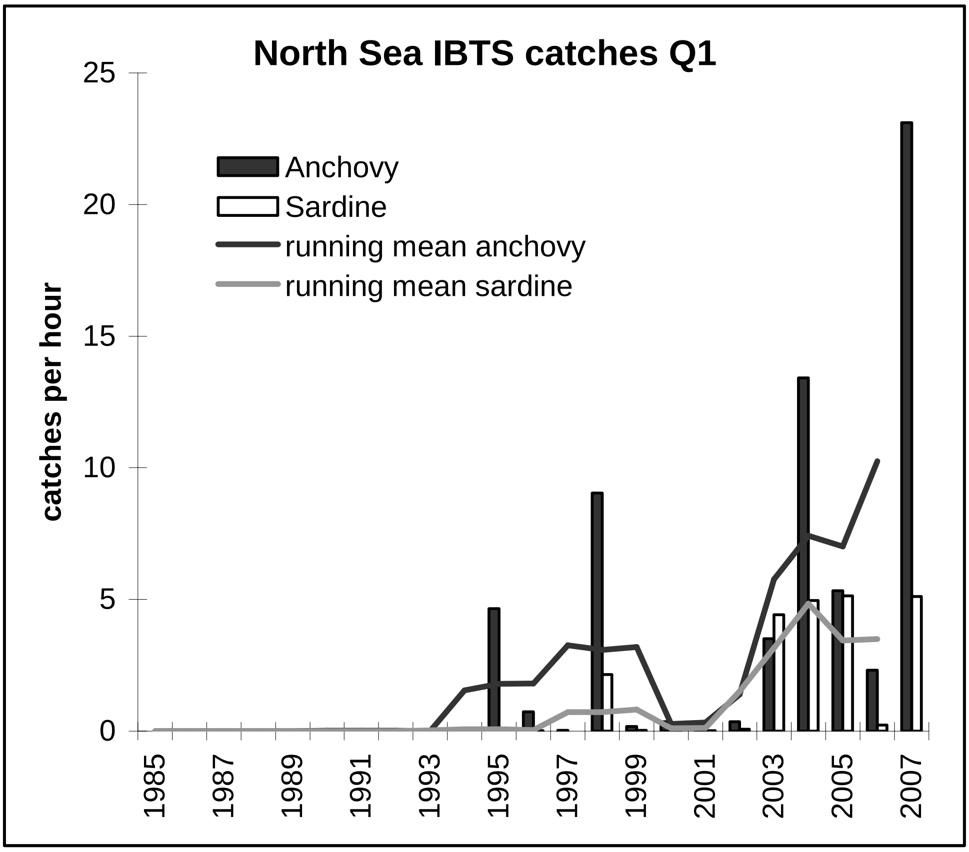


Figure 1.8.1.1. North Sea IBTS catches of anchovy and sardine.

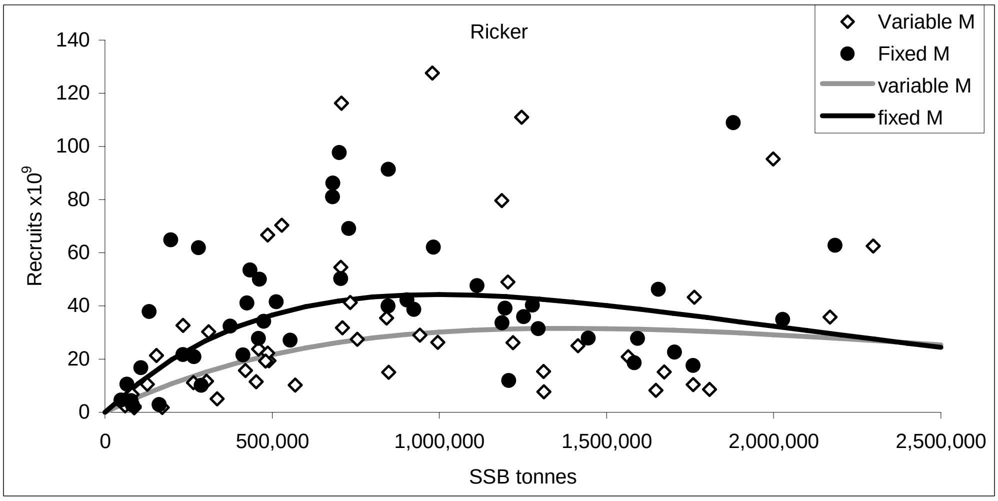


Figure 1.8.1.2. North Sea herring stock to recruit relationship (with Ricker curve) for the time series 1960-2006 from the standard assessment using a annual fixed M that varies by age and an annually varying M from the ICES multispecies working group.

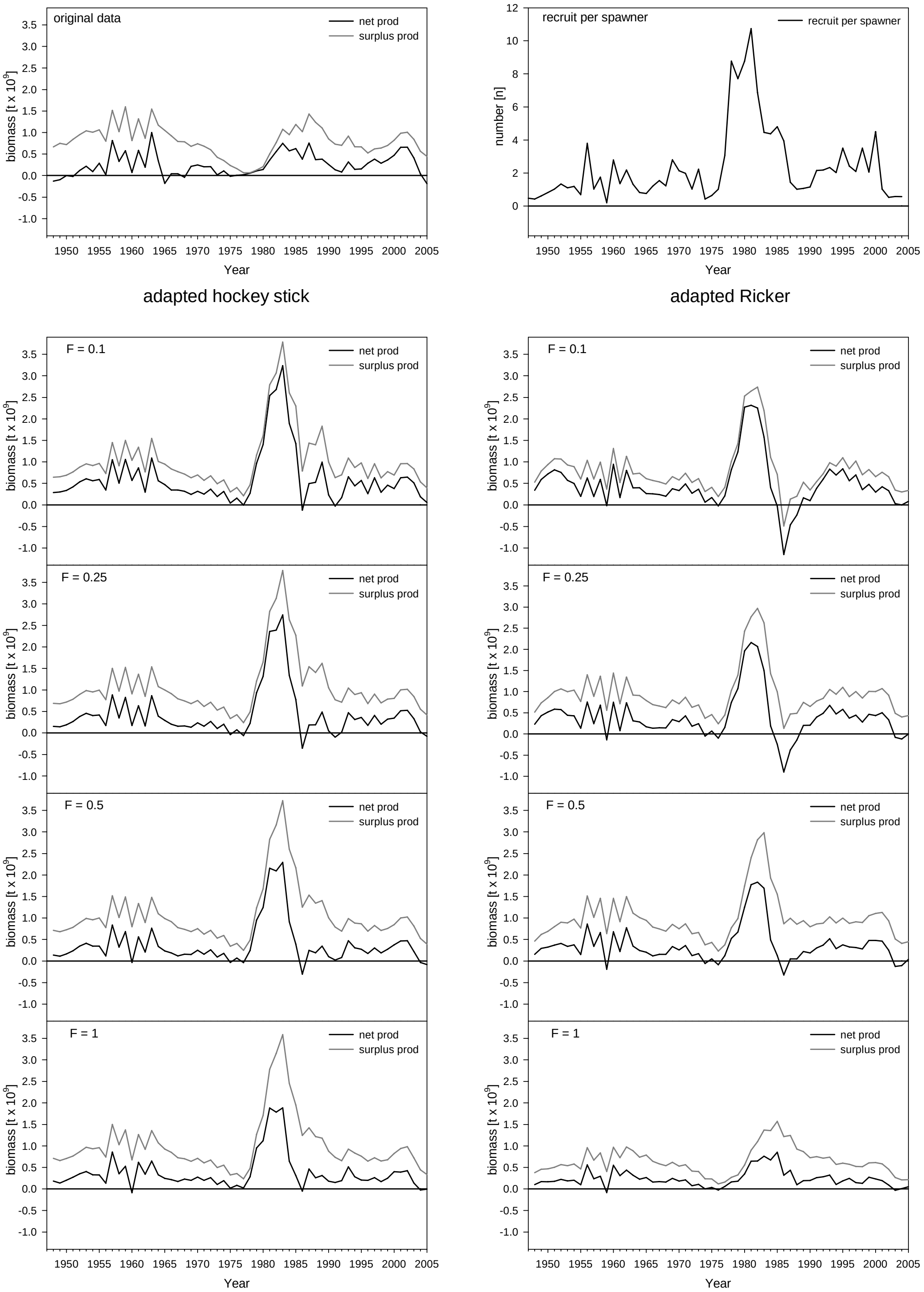


Figure 1.8.3.1: The net and surplus production of the original data output of ICA final run 2006 and the hockey stick and the Ricker stock recruitment relationship adjusted to calculate the residuals of the recruits of each year used as a weighing factor for the calculation of the net and surplus production assuming different F; The recruit per spawner ratio is shown for comparison.

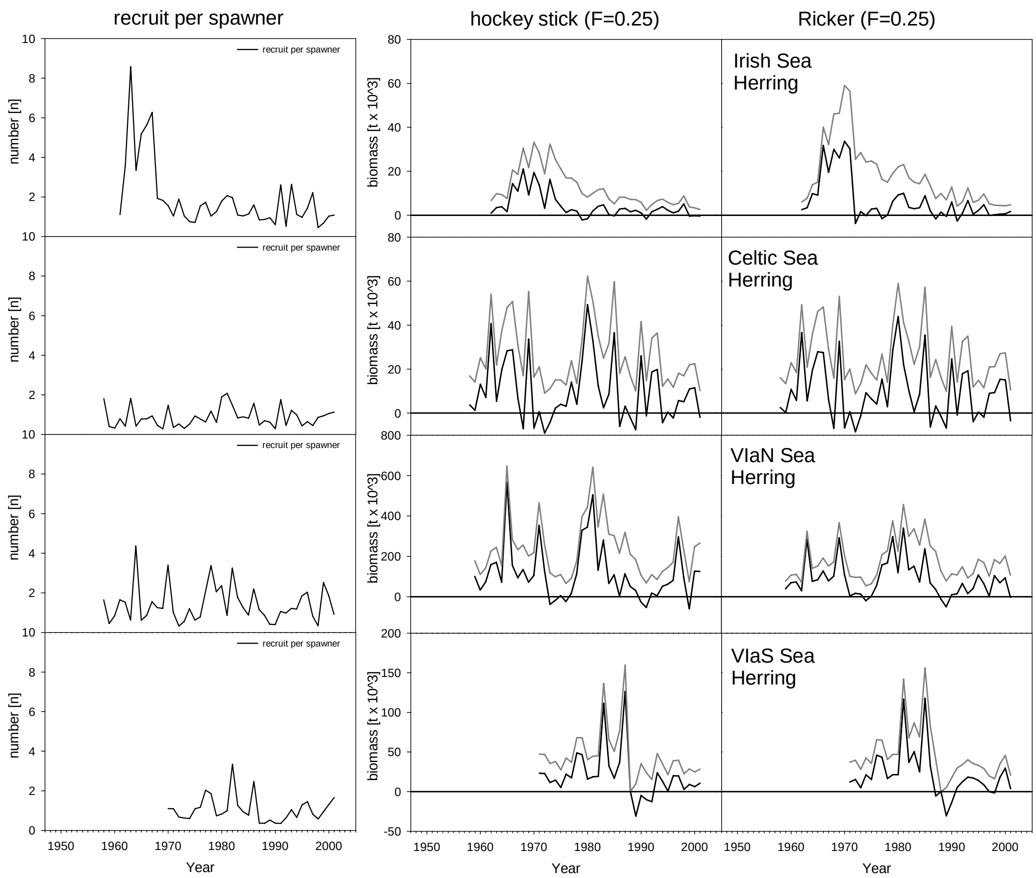


Figure 1.8.3.2: Recruit per spawner from the original ICA output 2006 and the hockey stick and the Ricker stock recruitment relationship adjusted to calculate the residuals of the recruits of each year used as a weighing factor for the calculation of the net and surplus production assuming a F of 0.25 for the Irish Sea, the Celtic Sea, the VIa(N) and the VIa(S) herring stock.

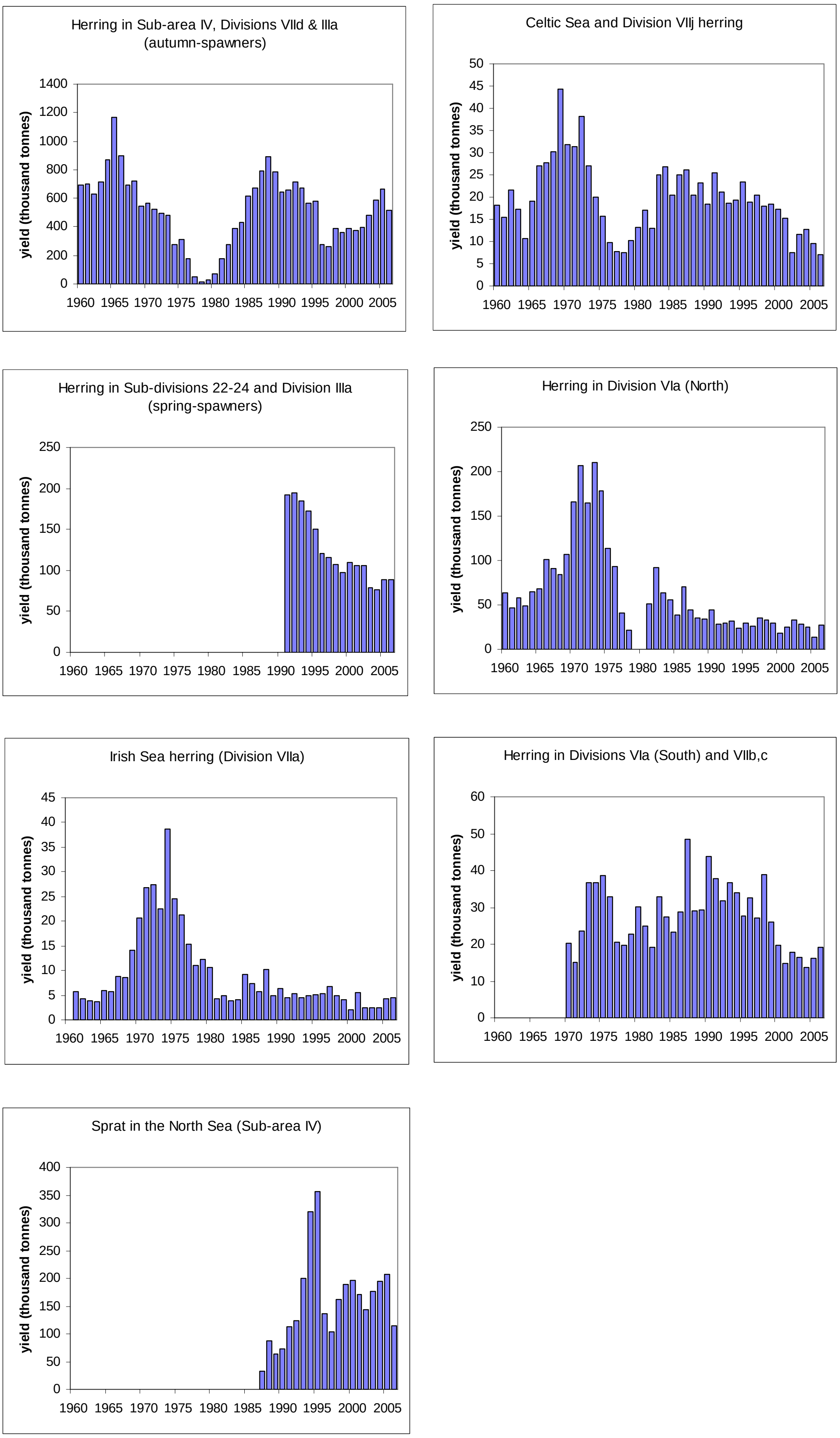


Figure 1.10.1 WG estimates of catch (yield) of the stocks presented in HAWG 2007.

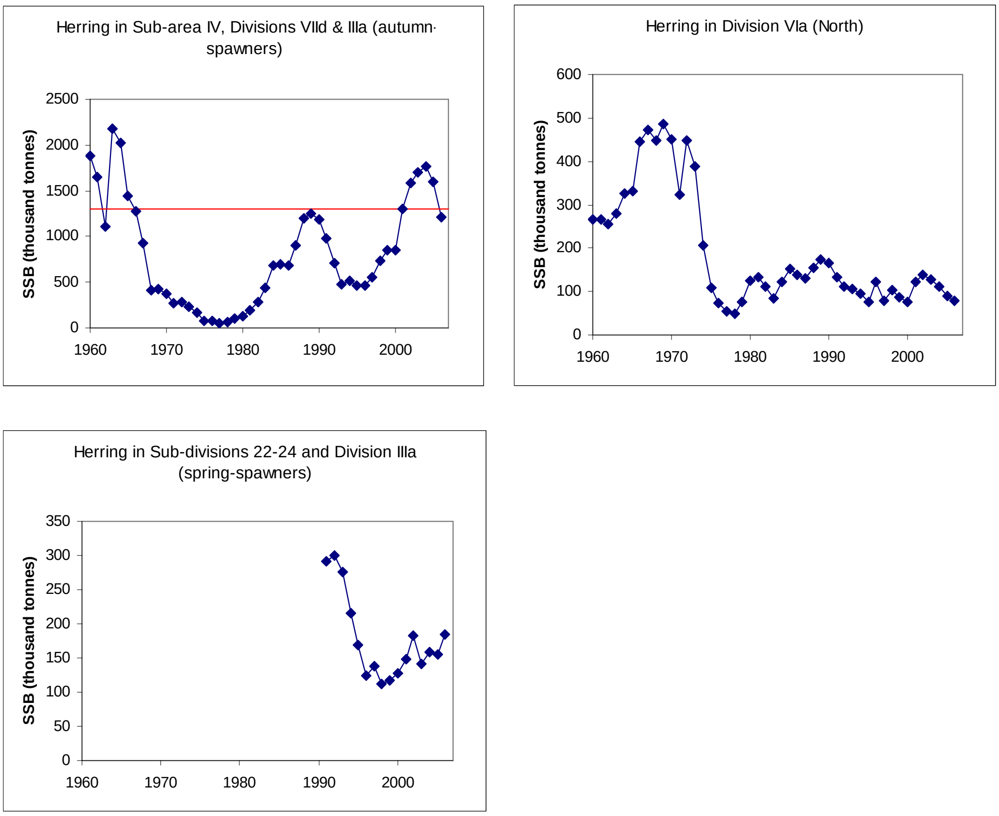


Figure 1.10.2: Spawning stock biomass estimates of the 3 stocks for which assessments were presented in HAWG 2007. The B_{pa} level (if defined) is indicated in the graphs.

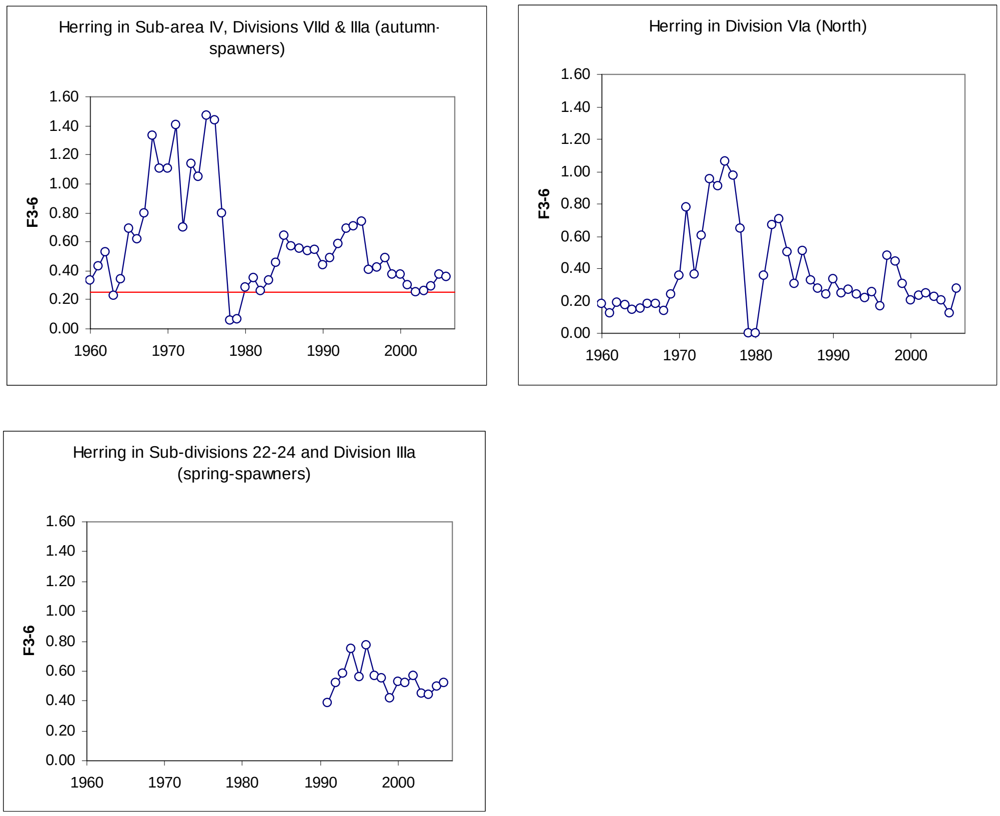


Figure 1.10.3 Estimates of mean F of the 3 stocks for which analytical assessments were presented in HAWG 2007. The F_{pa} level (if defined) is indicated in the graphs.

2 North Sea Herring

2.1 The Fishery

2.1.1 ACFM advice and management applicable to 2006 and 2007

According to the management scheme agreed between the EU and Norway, adopted in December 1997 and last amended in November 2004, efforts should be made to maintain the SSB of North Sea Autumn Spawning herring above 800 000 tonnes. An SSB reference point of 1.3 million has been set (=$\mathbf{B}_{pa}$) 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, the fishing mortality will have to be linearly reduced. A TAC deviation of more than 15% between two subsequent years should be avoided, however, the TAC might be reduced by more than 15% if the parties consider this appropriate.

Since 2002, the SSB is considered to have been above $\mathbf{B}_{pa}$. From then on, ACFM gave fleetwise catch option tables for fishing mortalities within the constraints of the EU-Norway management scheme. The advice for a sub-TAC on catches in IVc and VIId for 2004 was that it should not increase faster than the TAC for the North Sea as a whole. ACFM thought that a share of 11% on the total North Sea TAC (average share 1989-2002) would be an appropriate guide to distributing the harvesting of Downs herring.

It was expected at that time that fishing at the recommended level would lead to a further increase in the SSB in the short term, mainly due to large recruiting year classes entering the fishery. ACFM considered in 2006 that there were four recruiting year classes (2002, 2003, 2004 and 2005) that were all well below average. Last year ACFM offers options of 15 % to 25 % varying TACs to managers, taking into account an increased risk that the stock may fall below the 1.3 mill. tonnes in the medium-term if the rule of 15 % constraint on TAC variation is applied.

The final TAC adopted by the management bodies for 2006 was 454 800 t for Area IV and Division VIId, whereof not more than 50 000 t should be caught in Divisions IVc and VIId. For 2007, the TAC was reduced by 25 % to 341 100 t (37 517 t in Divisions IVc and VIId).

Catches of herring in the Thames estuary are not included in the TAC. The by-catch ceiling set for fleet B in the North Sea was 42 500 t for 2006 and was decreased by 25% to 31 900 t for 2007. 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). For a definition of the different fleets harvesting North Sea herring see the stock annex and Section 2.7.2.

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). Since 2005, for Division IIIa, Norway could only take half of its quota in the North Sea, and there is no flexibility for EU vessels. These amendments were kept for 2006. For 2007, Norway could take 40 % of the IIIa quota in the North Sea.

2.1.2 Catches in 2006

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 2.1.1e. 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. For corrections applied to and inconsistencies in previous year's data see Section 2.2.3. 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 catch in 2006 as used by the Working Group amounted to 510 600 t.

Total herring catches (including industrial catches as well) by area are stable in the most recent year in Division IVa (East) (+ 3 %) and IVb (almost no change). Catches decreased in IVa (West) by 31 % (after an increase of 40 % in 2005) and by 24 % in the southern North Sea (Division IVc and VIId).

Landings of herring taken as by-catch in the Danish small-meshed fishery in the North Sea have decreased by 45 % to 11 900 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 (42 500 t). In 2006, the Danish sprat fishery was carried out throughout the year with by-catches of herring of about 7 % (8 983 t; by-catch 2005: 9%). In the Norwegian industrial fishery, herring by-catch is almost the same in 2006 (961 t), compared to 998 t last year. The relative small proportion of herring by-catch could be influenced by the closure of the Norway pout fishery. The quarterly distribution of herring by-catches in the Norwegian industrial fishery and its relative share on the total industrial landings are given in the text table below. These figures are counted against the human consumption quota.

QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4	TOTAL
49 t	314 t	27 t	571 t	961 t
2.6 %	0.7 %	0.1 %	2.9 %	0.8 %

There is not much information on misreporting of landings taken in the North Sea but reported from other areas available. Misreporting within the North Sea accounts to 18 800 t.

Based on WG estimates of total catch, TACs for the human consumption fishery in Subarea IV and Division VIId have been greatly exceeded for several years. This appears to have continued in 2006, but on a somewhat lower level. Catches in the human consumption fishery have reduced to 498 000 t (decreased by 19 %) in 2006, so the excess over the TAC for the human consumption fishery amounted to 43 000 t (9 %) in the most recent year.

The total catch in the North Sea was 510 600 t, the TAC was set to 497 300 t (HC and industrial fishery). The over catch of total TAC in 2006 amounted to 13 300 t (< 3%). While the TAC in southern North Sea and the Eastern Channel was met well in 2004 and 2005, there is an over catch in 2006 of 6 600 t in this area (13 %). So misreporting is likely to be spread equally between the areas in the North Sea.

The total North Sea TAC excess for the years 1995 to 2006 is 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	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
TAC HC (‘000 t)	156	159	254	265	265	265	265	400	460	535	455
“Official” landings HC (‘000 t)[1]	170	162	253	275	267	275	282	414	484	547	478
Working Group catch HC (‘000 t)	196	226	324	318	328	303	331	438	537	617	498
Excess of landings over TAC HC (‘000 t)	40	67	70	53	63	38	66	38	77	83	43
By-catch ceiling (‘000 t) [3]	44	24	22	30	36	36	36	52	38	50	42
Reported by-catches (‘000 t) [4]	38	13	14	15	18	20	22	12	14	22	12
Working Group catch North Sea (‘000 t)	233	238	338	333	346	323	353	450	550	639	511

HC = human consumption fishery

[1] “Official” landings might be provided by WG members; they do not in all cases correspond to official catches and cannot be used for management purposes. Norwegian by-catches included in this figure.

[2] figure altered in 2000 on the basis of a re-evaluation of misreported catches from VIa North.

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

[4] provided by Denmark only.

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 1991-2006 (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 1996 – 2006.

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 and the total number of NSAS have decreased by 30 % (to 3.7 billion fish) and by 25 % (to 3.8 billion fish), respectively, as compared to last year. 0- and 1-ringers contributed 25 % of the total catch in numbers of NSAS in 2006 (Table 2.2.7). 0- and 1-ringer catch has decreased by 10 % and almost 80 %, respectively, as compared to 2005. Figure 2.2.1. shows the relative proportions of the total catch numbers for different periods. The catches contain more than 50 % of the age group 4+ winter ringers. This is consistent in all area in the North Sea. Catches are still dominated by the 2000 year class, but the catches also show larger quantities of 0 ringers. In area IVc and VIId, 0 and 1-winter ringers accumulate only to less than 10 % in the catch.

The following table summarises the total catch in tonnes of North Sea autumn spawners. To arrive at the total catch of NSAS, splitting of the catch into NSAS and Western Baltic Spring Spawners has to be done in Divisions IIIa and IVaE. WBSS from the North Sea are then subtracted and NSAS from IIIa added to the total NSAS catch figure. The final total catch used for the assessment of NSAS in 2006 was 515 000 tonnes:

AREA	ALLOCATED	UNALLOCATED	DISCARDS	TOTAL
IVa West	243 559	10 981	1 492	256 032
IVa East	102 628	-	-	102 628
IVb	92 996	2 364	-	95 360
IVc/VIId	51 178	5 419	-	56 597
	Total catch in the North Sea			510 617
	Autumn Spawners caught in Division IIIa (SOP)			15 015
	Baltic Spring Spawners caught in the North Sea (SOP)			-10 953
	Other Spring Spawners			-65
	Total Catch NSAS used for the assessment			**514 614**

"Other spring spawners" are 65 t of Blackwater herring caught under a separate quota and included in the catch figure for England & Wales. This year no spring spawners were reported from the commercial catch taken in other areas of the Western North Sea (see Sect. 2.2. below).

2.2.2 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. The amount of these catches varied significantly between less than 626 t in 2005 and 55 000 t in 1997. Coastal Spring Spawners in the southern North Sea (e.g. Thames estuary) are caught in small quantities (usually less than 100 t) regulated by a local TAC. The Netherlands reported increasing catches of spring spawners in the Western Part of the North Sea in some years, which were included in the national catch figures and subtracted from the total catch used for the assessment of NSAS, but in the last three years no spring spawners were reported from routine sampling of commercial catch taken in the west.

Western Baltic and local Division IIIa Spring-spawners (WBSS) are taken in the eastern North Sea during the summer feeding migration (see stock annex 2 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 1991-2006.

The method of separating these fish, using vertebral counts as described in former reports of this Working Group (ICES 1991/ACFM:15), is given in detail in Section 3.2.2.1 and in stock annex 2. The source for the splitting were samples taken from Danish and Norwegian catches, obtained in all quarters. The mean vertebral counts for herring 2-ringers, 3-ringers, and 4+-ringers caught in the 2nd and 3rd quarter in the transfer area are given in Figure 2.2.2. Details for the splitting procedure are given in section 3.2.2.1 The resulting proportion of spring spawners and the quarterly catches of these in the transfer area in 2006 were as follows:

Quarter	1-ringers (%)	2-ringers (%)	3-ringers (%)	4+-ringers (%)	Catch in the transfer area (t)	Catch of WBSS in the North Sea (t)
Q 1	50 %	23 %	25 %	2 %	4 951	249
Q 2	28 %	36 %	53 %	57 %	13 055	7 214
Q 3	14 %	3 %	74 %	62 %	3 687	2 203
Q 4	3 %	74 %	62 %	26 %	4 857	1 288
total					26 551	10 953

The quarterly age distribution and mean weight-at-age in sub-division IVa East was applied to the catches of the first, second, third, and fourth quarter in the transfer area. The numbers of spring spawners by age were obtained by applying the estimated proportion by age.

2.2.3 Data revisions

The result of the splitting procedure in 2006 for the transfer area is also known to contain a small bug in terms of tonnage. This was estimate to be below 0.5 %, therefore the table was not updated after this failure was recognized. This will be done in next years assessment.

There were two revisions to the historic catch data time series carried out this year. An incorrect allocation of fish to the plus group in the Dutch catches in 2004 and 2005 affected the age distribution in both years. In 2006, new sources of information on catch misreporting from the UK became available. This information was associated with a stricter enforcement regime that may be responsible for the lack of area misreporting between area IV and VIa(N) in 2006 (see also section 5.1.3). In light of this new information on misreporting a readjustment of catch figures was necessary from 2001 to 2004. The resulting changes to the catch in numbers, catch in tonnes and the mean weights at age in the catch are documented in Table 2.2.13.

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. Catches made in Division IVa were mainly misreported to Division VIa, IIIa and IIa, but misreporting also occurred from IIIa to IVa, within Area IV, and from Division VIId to IVb. The **Working Group catch**, which includes estimates of discards and misreported or unallocated catches (see Section 1.5), was estimated to exceed the official catch by 3 %. It is likely that this figure is an underestimate as it only includes information from a fraction of the fleets fishing herring in the North Sea, as an analysis conducted in 2002 indicated (ICES 2002/ACFM:12). This corroborates suggestions of the Study Group for Herring Assessment Procedures (ICES 2001/ACFM:22), that a important uncertainty of the total catch figure exists since the re-opening of the fishery in 1980.

Information on discards is rare in 2006. The final figure for discards as used in the assessment was 1 492 t, based on the raised discards for one fleets. As discards are likely to occur in all nation’s fisheries, this figure is certainly 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 in the order of 5 000 t per year, but cannot be split between area IV and VIaN. These are not included in the assessment.

The European Union implemented a new sampling regime in 2002, obliging member states to meet specified overall sampling levels. However, the **sampling of commercial landings** in 2006 for herring length and weight measured has decreased by 25 % when compared to 2005, while the number of age readings has increased by 50 % (Table 2.2.12). Only 79 % of the total catch was sampled in 2006 (2005: 95 %). 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.

However, more important than a sufficient overall sampling level is an appropriate spread of sampling effort over the different metiers (each combination of fleet/nation/area and quarter). Of 107 different *reported* metiers, only 39 were sampled in 2006. Some of them, however, yielded very little catch. The recommended sampling level of more than 1 sample per 1 000 t catch has been met only for 19 metiers (2005:14). For age readings (recommended level >25 fish aged per 1 000 t catch) this is also worse: only 21 metiers appear to be sampled sufficiently (2005: 17). The catch of France, UK/England and Wales, Sweden, UK/Northern Ireland, the Faroe Islands and Belgium from the North Sea has not been sampled. Information on catches landed abroad was again not available or could not be used. While it is known that by-catches of herring in other than the directed human consumption fisheries occur, most countries have not implemented a sampling scheme for monitoring these fisheries.

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 and information on these samples should be made available to the national laboratories (see Section 1.5).

2.3 Fishery Independent Information

2.3.1 Acoustic Surveys in VIa(N) and the North Sea in July 2006

Five surveys were carried out in the North Sea during late June and July 2006 covering most of the continental shelf north of 51° 30'N in the North Sea and 56°N to the west of Scotland to a northern limit of 62°N. The eastern edge of the survey area is bounded by the Norwegian, Danish, Swedish, German and Dutch coasts. The western edge is bounded by the UK coast and by the shelf edge at approximately 200 m depth. The individual surveys and the survey methods are given in the report of the Planning Group for Herring surveys (ICES 2007/LRC:04). 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 are 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.

Combined Acoustic Survey Results for the North Sea:

The estimate for North Sea autumn spawning herring is shown in Table 2.3.1.2. The estimates of SSB are reasonably consistent with previous years, at 2.1 million tonnes and 11,830 million herring (Table 2.3.1.2). The survey again shows two well-above average year classes of herring (1998 and 2000), followed by smaller year classes.

The abundance of the 2004 year class which is seen in this survey for the first time is similar in magnitude to the 2001-2003 year classes. Growth of the 2000 year class seems still to be slower than average; individuals of this year class have almost the same mean length and weight as those one year younger (2001 year class).

The spatial distribution of the abundance (numbers and biomass) of autumn spawning herring are shown in Figure 2.3.1.2. The distribution of numbers by age is shown in Figure 2.3.1.3 for 1 ring, 2 ring and 3+ ring autumn spawning herring. The survey provides estimates of maturity and weight at age: the mean weight at age for 1 and 2 ring herring along with the proportion mature for 2 and 3 ring herring are shown in Figure 2.3.1.4. The spatial distribution of mature and immature autumn spawning herring is shown in Figures 2.3.1.5 & 2.3.1.6 respectively.

The acoustic survey estimates for 2005 have been revised following checks in PGHERS (ICES 2007). The new values are given in Table 2.3.1.3, and the changes expressed as a percentage in Table 2.3.1.4. Changes to estimated SSB are about +3% in total.

The time series of abundance for North Sea autumn spawners, including changes to the 2005 estimate, are given in Table 2.3.1.5.

Reference

ICES 2007 Report of the planning group for herring surveys, ICES CM2007/LRC:04.

2.3.2 Larvae surveys

In 2006/07 the Netherlands and Germany carried out larvae surveys and managed to cover seven out of ten areas described in the protocol. The survey effort was comparable to previous years. The areas and time periods (including numbers of samples, vessel-days in sampling and area coverage) are given in Table 2.3.2.1 and Table 2.3.2.2. The spatial extent of the surveys is shown in Figures 2.3.2.1 – 2.3.2.7. The historical background of the larvae surveys and the methods used for abundance calculation are described in the handbook for quality control (Appendix 2). A more detailed description is available in the manual for the international herring larvae surveys in the North Sea (ICES CM 2005/LRC: 04).

In 2006 the **Orkney/Shetland** area was covered in both periods. In the first period a high number of larvae were observed west and northeast of the Orkney Islands (Figure 2.3.2.1). This is the first time that this period has been surveyed in the last 11 years. The total abundance therefore is not really comparable to previous years. Apart from 1989, the current estimate was similar to those in the late 1980's, when this period was last fully surveyed. In the second period the distribution was comparable to the years before with aggregations in the North and East of the Orkney Islands and South off the Scottish coast (Figure 2.3.2.2). Although the overall abundance showed large fluctuations during the last decades, the 2006 value followed the declining trend of the last two years and represented the lowest value since 1996 (Table 2.3.2.3).

In the **Buchan** area (Figure 2.3.2.3) the larvae were concentrated at only two stations resulting in a low abundance estimate at 20% of the previous year value (Table 2.3.2.3).

The abundance in the C**entral North Sea** decreased to 50% of the previous year estimate (Figure 2.3.2.4, Table 2.3.2.3).

Abundance estimates from the three surveys in the **Southern North Sea** resulted in a high index value, and in contrast to the downward trend in the previous year showed an increasing trend again (Tab. 2.3.2.3). The peak of the spawning activity appeared to shift towards the end of December, although the value was mainly driven through one station. Larvae were almost exclusively found in subdivision VIId (Figures 2.3.2.5-7).

The trends in the four survey areas are very different (Figure. 2.3.2.8) with an increase in the South and decline in the Central North Sea.

The model for the Multiplicative Larval Abundance Index (MLAI) was fitted to abundances of larvae less than 10 mm in length (11 mm for SNS). The analysis of variance and the parameter estimates are given in Table 2.3.2.4. The updated MLAI time-series is shown in Table 2.3.2.5. The estimated trend in spawning stock biomass from this model fit is plotted in Figure 2.3.2.9 along with the SSB values obtained from the ICA runs of the Herring Assessment Working Group.

Both the LAI per unit as well as the MLAI from the larvae surveys in period 2005/2006 indicate that the SSB has decreased considerably when compared to last years WG estimate (Table 2.3.2.5).

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. It has been carried out every year since, and presently the survey provides recruitment indices not only for herring, but for roundfish 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. During night-time on the IBTS 1st quarter, additional sampling of herring larvae (0-ringers) is carried out by small, fine-meshed nets. From 1977 to 1991 the gear was a small mid-water trawl (IKMT), but due to poor catchability of this gear, the standard gear was changed to a 2 metre ring net (MIK), used since the 1991 sampling. The total abundance of herring larvae in the survey area is used as an estimate of 0-ringer abundance of the stock. Hence, a series of herring abundance indices (0-5+ ringers) are available from the IBTS programme.

2.3.3.1 Indices of 2-5+ ringer herring abundances

Fishing gear and survey practices were standardised from 1983, and the series of 2-5+ ringer abundance estimates from 1983 onwards has shown the most consistent results in assessments of these age groups. This series is subsequently used in North Sea herring assessment. Note that the abundances in Division IIIa are not included in these 2-5+ ringer indices. The IBTS time series of indices has been revised and Table 2.3.3.1 shows the new time-series of abundance estimates of 2-5+ ringers from the 1st quarter IBTS for the period 1983-2007, while Table 2.3.3.2 contains area-disaggregated information on the IBTS indices for year 2007. This years indices are outstandingly low; the WG investigated this, but did not find any other reason than low abundances in the survey.

2.3.3.2 Index of 1-ringer recruitment

The 1-ringer index of recruitment is based on trawl catches in the entire survey area. The time series of indices has been revised and a new series are available for year classes 1977 to 2005 (Table 2.3.3.3). This year’s estimate of the 2005 year class strength (1336) indicates a low recruitment, however higher than the preceding three year classes

Figure 2.3.3.1 illustrates the spatial distribution of 1-ringers as estimated by the trawling in February 2005, 2006 and 2007. In 2007 the main concentrations of 1-ringers were found in the areas of Great Fisher Bank, northern Dogger Bank, and in coastal areas of Kattegat. The concentrations in the North Sea are more offshore than observed the preceding years. The mean length of 1-ringer herring in the areas of peak abundance is in the order of 15 cm (Figure 2.3.3.2).

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 (see discussion of procedures in earlier reports (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, based on a standard retrieval of the IBTS database, i.e. the standard index is in this case calculated 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 23% of this year's group of 1-ringers is smaller than 13 cm. These are almost exclusively found in the North Sea area (Table 2.3.3.3)

2.3.3.3 The MIK index of 0-ringer recruitment

This year's 0-ringer index is based on 636 depth-integrated hauls with a 2 metre ring-net (the 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 2.3.3.4, the new index value of 0-ringer abundance of the 2006 year class is estimated at 37.2.

The index is the lowest since the estimate of the 1989 year class strength, and it continues a now 5 year long series of low recruitment estimates (the average for these 5 years is about 50% of the all-year average). The 0-ringers were predominantly distributed in two concentrations, one off the Scottish coast (in the central-western area) and one in the Southern Bight. Compared to the preceding year classes, which are also shown in Figure 2.3.3.3, the distribution of 0-ringers from this year class is very restricted, without significant concentrations along the English coast. The long term trend in the distributional patterns of 0-ringers is illustrated by the changes in absolute and relative abundance of 0-ringers in the western part of the North Sea (Figure 2.3.3.4). In the Figure 2.3.3.4 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 86% for the present year class is in accordance with the long term trend.

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 (wr) in the North Sea stock during the 3rd quarter in Divisions IV and IIIa for the period 1996 to 2006. These values were obtained from the acoustic survey. The data for 2006 are taken from Table 2.3.1.2. In this quarter most fish are approaching their peak weights just prior to spawning. The spatial distribution of mean weight for 1 and 2-ringers is given in Figure 2.3.1.2. This spatial variability of mean weight is considerable but is not unusual. For comparison with the acoustic survey estimates, the mean weights-in-the-catch from the last ten years are also shown in Table 2.4.1.1 (from Section 2.2.1 for the 2006 values). For 4-ringers and older the mean weights for 2006 in the catch and acoustic survey are close to the long-term lows. For 5-ring herring, the acoustic survey shows mean weights that are the lowest for the last 10 years and are similar to one year younger herring, supporting the view that the exceptional 2000 year class is growing slowly. This year class, possibly the largest in recent years and the first large one competing with an already large herring stock biomass, has grown more slowly than earlier year classes.

2.4.2 Maturity ogive

The percentages of North Sea autumn-spawning herring (at age) that spawned in 2006 were estimated from the July acoustic survey (Table 2.4.2.2). The values were determined from samples of herring from the research vessel catches examined for maturity stage, and raised by the local abundance. All herring at maturity stage between 3 and 6 inclusive (using an 8-stage scale) in June or July were assumed to spawn in the autumn. The method and justification for the use of values derived from a single year's data was described fully in ICES (1996/ACFM:10). The values for 2- & 3-ringers are taken from the acoustic survey results which are presented in Table 2.3.1.2. For 2 and 3 ringers the proportion mature at 66% and 88% respectively is low for these age groups but not exceptional. The 2000 year class, which matured even more slowly, is now fully mature.

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 years prediction of the 2005 year class was confirmed by this year's IBTS 1-ringer index of the year class (black square in the figure). The good correlation between the indices is also evident when comparing the respective trends in indices during the period (Figure 2.5.2).

2.5.2 Trends in recruitment from the assessment

Recruitment is estimated in the ICA-assessment, and in Figure 2.5.3 the trends in 1-ringer recruitment based on 2007 assessment is illustrated. 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 strong year classes 1998-2001. However, the 1-ringer recruitments of the recent 2002-2005 year classes are low, and the MIK index of 0-ringer recruitment for the present year indicates a very small 2006 year class. The present ICA estimates of 1-ringer recruitment are 6.0 and 9.6 no10^9 for year classes 2004 and 2005 respectively, while the estimates for 0-ringers are 17.5, 27.8 and 11.9 no 10^9 for year classes 2004, 2005 and 2006 respectively.

2.6 Assessment of North Sea herring

2.6.1 Data exploration and preliminary results

A benchmark assessment for North Sea herring was carried out in 2006. North Sea herring is on the AFCM observation list, but was also classed as an update assessment in 2007 by ACFM. With this in mind limited exploration was carried out into the fit of the assessment. The full choice of assessment model, catch and survey weightings and the length of separable period were not explored in detail in 2007.

2.6.1.1 Revision of historic data

Since last year's WG, a number of sources of data have been revised

1) The ICES IBTS database for the full time series (section 2.3.3??)
2) The acoustic survey data for 2005 (Section 2.3.1)
3) The catch age structure from The Netherlands in 2004 and 2005, catch in tonnes from UK in 2001-2004.

The 2006 assessment was rerun with the same settings with original and revised historic data. The differences were all less than 2%, except for F in 2001-2004, which increased by an average of 5% and SSB in the terminal year (2005), which was reduced by 3.5%.

2.6.1.2 Selection of indices and weighting in the assessment of North Sea herring

The usual assessment tool for the assessment of North Sea herring is ICA. The settings were the same as last year. 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.

The WG in 2003 made an extensive review covering both inverse variance and structural errors, and it considered that the inverse variance weighting method provided the better method. In 2006 the WG updated the variance weights and showed that the revised weights produced only a small change in the results. Following this examination it was decided that the weighting of surveys and catch is fixed between benchmark assessments as the sensitivity of the assessment to yearly revision of weights is small and the work required to do the analysis extensive. The weights express the WG view that the young herring are best estimated with MIK and IBTS surveys, the older herring are best evaluated through the acoustic survey and the SSB should be estimated through the MLAI.

The influence of individual surveys in terminal F and SSB is shown in Figure 2.6.1 where the results of assessments based on catch data combined with each series one at a time are shown along with variance co-variance estimates of uncertainty in the terminal values. This shows that the MLAI alone would give a high value of SSB and low value of F, the other indices lie more within the cloud of points. Previous examination of the results of assessments using combinations of indices (ICES 2006) has shown that the best retrospective patterns are obtained when all the indices are used in the assessment.

2.6.1.3 Period of separable constraint

Changes in the regulations in 1996 have affected the various components of the fishery differently. During the period following these changes, meetings of this WG split the separable period into two different periods: 1992-1996 and 1997 onwards. In the WG 2001 it was considered that the number of years after the change in selection was long enough to use only a single separable period of four years. During 2002-2004 a separable period of five years was used. A retrospective study in 2002 found that year on year adaptation of the separable period did not improve the performance of the assessment model and that a fixed selection period gave more stable assessments, even with changing management. This year the WG noted that there was a small rise in selection at ages 5-7wr. Therefore the WG investigated the effect of increasing selection at ages 8 and 9+ to maintain a flat selection at old ages. No important differences in the model fit or outputs were detected. The estimation of F at reference age (4wr) was not significantly different and differences in estimates mean $F_{2\text{-}6}$ and SSB in 2006 were found to be negligible. So the 5 year separable period with F at age 8 and 9+ set equal to the reference age was maintained in the current assessment.

2.6.1.4 Model fit and residuals

The influence of the catch and the surveys was explored on the estimation of reference F and the model fit. ICA was run using all catch and survey data with the same procedure as last year. The patterns in catch residuals (Figure 2.6.2) are different to the assessments in 2006. The revision of data appears to have reduced the magnitude of the residuals overall by about 25% and particularly in the terminal year. There is no evidence of cohort effects across the full selection pattern but some residuals on cohorts are in a similar direction in adjacent years. Overall the catch residuals are small.

To explore the contribution of the catch and the survey data to the specific deviations in the data expressed in the residuals as large values, each data series was examined for large residuals in the recent past. The individual data values were then removed and the influence of these points on the assessment evaluated. The following points were considered:

i) Acoustic survey estimates of age 1wr in 2005 and 2006,
ii) IBTS estimates of 2wr in 2006 and 2007,
iii) MIK estimate of 0wr in 2004
iv) MLAI estimates of SSB in 2003 and 2004.

Table 2.6.2 shows the influence of these points on the main management parameters mean F ages 2-6, SSB, TSB and recruitment. The age based surveys influence F, SSB and TSB by less than 3%, the SSB index has a maximum influence of 6% on the same parameters. These changes are negligible both in the context of precision of the assessment and the management agreement. Changes to recruitment are similarly insignificant with the exception of the estimate of the 2004 year class. As this year class has only been included in catch figures at ages 0 and 1wr, and these are down-weighted in the assessment, the surveys dominate the estimation of this parameter. There is considerable and unusually large conflict between IBTS and Acoustic survey estimates of the value of this parameter, with the MIK estimate lying between the others. The source data from both time series were examined independently of the assessment: the Acoustic survey gives a high estimate and has a higher than usual CV; in contrast the IBTS index gives a low value with much higher mortality age 1 to 2wr than seen in any other pair of years. Thus both series appear potentially to have greater errors than would occur on average, so there is no obvious preference for one series over the other. The final estimate is somewhat in balance, the estimate being potentially pulled +19% by one survey and -33% by the other (Table 2.6.2). As it is impossible to assign preference, not further action is justified.

In previous assessments it has been noted that in recent years the MLAI has positive residuals, and the Acoustic survey has a block of negative residuals at older ages (Figure 2.6.2). The current assessment shows that this pattern has been maintained in history but the agreement in the terminal year appears to be better than that seen last year (Figure 2.6.2). In particular the 2006 residual in the MLAI is small. In the2006 benchmark assessment it was concluded that one of the reasons for the relatively stable assessment was the balance of three major sources of information, with each potentially delivering short periods with bias but in combination providing a balance of errors.

2.6.1.5 Analytical retrospective

Figure 2.6.3 shows retrospective estimates of mean F, SSB and recruitment, by removing one year of data at a time. The F shows considerable consistency over the last 6 years, with underestimation during the period immediately following the management changes of 1996-7. SSB is more variable in the last 6 years showing upward and downward revision. The SSB has the same period of bias following the 1996-7 management changes as F. This retrospective analysis, which shows improvements over the analytical retrospective presented in 2006 (ICES 2006). This improvement suggests that the revision of catch data back to 2001 may have improved the data series. Through the use of FLR the retrospective analysis has been further extended this year to evaluate the retrospective influence of individual indices of SSB or surveys that include adults. These are used one at a time along with the catch data and MIK recruit index. This gives three retrospective analyses using MLAI, Acoustic and IBTS surveys as the main tuning fleets (Figures 2.6.4, 2.6.5 and 2.6.6 respectively). In all cases these show poorer retrospective patterns than the combined data set (Figure 2.6.3).

2.6.1.6 Conclusions of exploration of the assessment.

In 2006 the formulation of the assessment was supported by an extensive benchmark and it was judged a credible tool for management advice. The patterns in the residuals seen in previous years is still present though is less in catch and the terminal year of this assessment compared with the terminal year last year. This indicates that catch and survey indices show different signals, and this is confirmed when indices are fitted individually to the assessment (Figure 2.6.1). However, the overall balance of index information appears useful and the retrospective analysis suggests that currently the assessment using the full data set performs the best.

2.6.2 Final Assessment for NS herring

The final assessment of North Sea herring was carried out by fitting the integrated catch-at-age model (ICA) with a separable constraint over a five-year period, tuned with the Acoustic survey (1989-2006), MLAI SSB index (1973-2006), IBTS (1984-2007) and the MIK survey (1992-2007) time series. The model settings are shown in Table 2.6.3, the ICA output is presented in Table 2.6.4, the stock summary in Table 2.6.5 and Figure 2.6.7 and model fit and parameter estimates in Table 2.6.8 and Figures 2.6.5 - 2.6.12.24

The spawning stock at spawning time in 2006 is estimated at approximately 1.2 million tonnes, declining from 1.6 million tonnes in 2005. The abundance of 0wr fish in 2006 (2005 year class) remains low for the fifth consecutive year and is currently estimated as the lowest since 1979. The strong 1998 and 2000 year classes are still evident in the population, with the 2000 year class at 5wr in 2006 and the 1998 year class at 7wr both being the highest in the time series since 1986/7. Mean fishing mortality on 2-6wr herring in 2006 is estimated at around 0.35, which is above the management agreement F of 0.25, while mean F on 0-1wr herring is 0.08, below the agreed F_{0-1} of 0.12. The value of mean F 2-6wr for 2005 in the current assessment is 0.37, which is slightly higher than the value of mean F 2-6wr from last year's assessment, which was 0.35. The SSB in 2005 has also been revised downwards by 6% from 1.7 to 1.6 million tonnes. The 2006 recruitment (0 group in 2007) is estimated at 12,000 million, which is 28% of geometric mean of recruitment since 1981.

2.7 Short term projection by fleets.

2.7.1 Method

The procedure and program 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.

2.7.2 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.

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 2007 the stock numbers at age were taken from ICA (ica.n – file)

Recruitment: For 2008 and 2009, the recruitment was set to 22963 million which is the geometric mean of the recruitments of the year classes 2001-2006, as estimated in this years assessment. This is less than half the mean recruitment used prior to 2006. The low recruitment was assumed because all the year classes from 2001 onwards have been poor. 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 from 2008 onwards. Consequently, the advice is adopted to the current recruitment regime.

Fishing Mortalities: Selection by fleet at age was calculated by splitting the total fishing mortality in 2006 at each age proportional to the catches by fleets at that age (Table 2.2.6). These fishing mortalities were used for all years in the prediction.

Mean weights in the catch by fleet: The mean weights by fleet for the years 2004 – 2006, excluding the 2000 year class, were used for all year. For the 2000 year class, the weights at age in the catches by the A-fleet have so far been in the order of 10% below the average of the adjacent year classes, and the difference appears to be increasing. Assuming that the 2000 year class will continue to have reduced weights at age, the weights at age for this year class were reduced in the prediction years. This was done by fitting a second order polynomial to the weights at age observed so far and extrapolating this function to the prediction years. The resulting weights for the 2000 year class in 2007 and 2008 are about 12% lower than the corresponding weights at age used for other year classes. For the fleets B, C and D, no adjustments were made. The lower weight at age of the 2000 year class has not been apparent in the catches of these fleets. For the C and D fleets, the reason may be that the samples for weight at age are likely to contain both autumn spawners and spring spawners. For the B-fleet, this year class is hardly represented in the catches any more.

Mean Weights at age in the stock: The smoothed weights at age in the stock for 2006 were used. However, the weights at age for the 2000 year class were reduced by 12%, which is the same reduction as for weights in the catch.

Maturity at age: The average maturity at age for 2004 to 2006, calculated without the 2000 year class, was used (Table 2.6.2.2). The 2000 year class is now fully mature.

Natural Mortality: Unchanged from last year, equal to those assumed in the assessment.

Proportion of M and F before spawning: Unchanged from last year at 0.67.

2.7.3 Prediction for 2006 and management option tables for 2007

2.7.3.1 Assumptions for 2007

After the TACs were increased in 2003, the TAC for the A-fleet has been over-fished by 9 – 16 percent, while the other fleets caught less than half their TAC or by-catch ceiling. Catches in 2007 may be predicted with some confidence. The retrospective error has been low in recent years. It therefore seems most reasonable to use assumed catches to account for the removal in 2007.

In previous years it has been assumed that the TAC for the A-fleet would be overshot as before. The overshoot has gone down in the most recent years (17% in 2004, 15% in 2005, 10% in 2006). Therefore, it is assumed that the TAC of 341 000 tonnes for 2007 for the A-fleet will be overshoot by 10%, which is the overshoot in 2006.

The utilisation of the by-catch quota by the B-fleet has fluctuated between 23% and 44% since 2003, and was 28% in 2006. For the prediction, it is assumed that 33% of the bycatch-quota will be taken, which is the average percentage since 2003. For the C and D fleet, it was assumed that their catch of North Sea autumn spawning herring would be the same as in 2006. The fishing mortalities resulting from these assumed catches were close to the fishing mortalities by fleet for 2006. Thus the difference between a catch constraint and F status quo constraint for 2007 therefore is small.

2.7.3.2 Management Option Tables for 2008

The EU-Norway agreement on management of North Sea herring was updated in 2004. The revised rule specifies fishing mortalities for juveniles (F_{0-1}) and for adults (F_{2-6}) not to be exceeded, at 0.12 and 0.25 respectively, for the situation where the SSB is above 1.3 million tonnes. In addition, it now has a rule specifying reduced fishing mortalities when the SSB is below 1.3 million tonnes. Moreover, the current agreement has a constraint on year-to-year change of 15% in TAC, but allows for a stronger reduction in TAC if necessary.

The rule for reducing F at SSB<1300 thousand tonnes derives the F from the SSB as

$F_{2-6} = 0.25-(0.15*(1300-SSB)/500)$

$F_{0-1} = 0.12-(0.08*(1300-SSB)/500)$

The interpretation by HAWG is that the SSB referred to should be the SSB in the prediction year, i.e. the Fs for 2008 should reflect its consequence for SSB in 2008.

Because of the recent poor recruitment, the management rule above leads to a strong reduction in quotas. The management agreement has a 15% limit on the change in TAC from one year to the next, and a clause to abandon this limit if needed. Short term predictions are presented for both alternatives.

With four fleets there are innumerable combinations of fleet-wise fishing mortalities and catches that satisfy the agreed rules.

Since the North Sea autumn spawning (NSAS) stock was rebuilt, the advice has been that the primary limiting factor for the fishery in IIIa should be the concern for the Western Baltic spring spawning (WBSS) stock. Due to the low recruitment og NSAS in particular, but also of WBSS, more restrictive quotas for the IIIa may be necessary. Using that as a guideline, options for catches by the fleets C and D were derived from two options for the outtake of WBSS:

1) Assuming a total WBSS catch of 76.3 thousand tonnes, representing a 15% reduction in TAC, gives NSAS catches for the C and D fleets of 14.4 and 7.6 thousand tonnes respectively

2) Assuming a total WBSS catch of 40.2 thousand tonnes, corresponding to a fishing mortality for WBSS at $F_{0.1}$ = 0.22, gives NSAS catches for the C and D fleets of 6.9 and 3.7 thousand tonnes respectively.

For 2007, Norway is allowed to transfer 40% of its quota in IIIa to IV. To show the effect on the stock of this transfer, which amounts to 3820 tonnes in 2007, an example was made where this catch was added to the A-fleet for 2007. The expected fraction of this catch that would be NSAS (720 tonnes) was subtracted from the C-fleet for 2007.

The following options for 2008 are tabulated:

1) Following the harvest rule without constraints on the year-to-year change in catch, assuming catches by the C and D fleets corresponding to a 15% reduction in TAC for WBSS.
2) Following the harvest rule without constraints on the year-to-year change in catch, assuming catches by the C and D fleets corresponding to $F_{0.1}$ for WBSS
3) As 1, but with a catch by the A-fleet of 289 800 tonnes, which is 85% of the TAC for 2007.
4) As 2, but with a catch by the A-fleet of 289 800 tonnes, which is 85% of the TAC for 2007.
5) As 1, but with a transfer of 3820 tonnes of catch from the C-fleet to the A-fleet.
6) No fishing

All predictions are for North Sea autumn spawning herring only.

The results are presented in Table 2.7.2.

2.7.4 Comments on the short-term projections

The outlook for this stock is poorer than in previous years, due to the recent reduction in the recruitment. This has been taken into account in the current prediction, both through the stock numbers at the start of 2007 as derived from the assessment, and by assuming a recruitment in line with what has been experienced the last 5 years.

As a result, even without fishing, the SSB will be well below 1.3 million tonnes in 2008. The present agreement includes a rule to reduce the fishing mortality below 0.25 if the SSB is below 1.3 million tonnes, but with the option to limit the reduction in TAC to15%. In the present situation, applying the 15% rule will lead to an F_{2-6} well above the agreed 0.25. Moreover, medium term predictions indicate a substantial risk to B_{lim} if the catches are reduced this slowly.

The effect of the assumed reduction in catches in IIIa is small in the short term, but will be more important in the medium term as the fishery in IIIa mostly exploits juveniles. Likewise, it is assumed that fishing mortality for the B-fleet follows the management rule, implying a continued low exploitation of juveniles in the North Sea,

The predictions presented here account for the slow growth of the large 2000 year class. There are no indications of reduced growth of the subsequent year classes.

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 advise, or if indeed such changes are taking place. However, some of the important predator stocks are currently in a poor condition.

2.8 Medium term predictions and HCR simulations

Medium term predictions have been made repeatedly for many years for this stock, to first develop and later evaluate the current management agreement. In all these simulations, a recruitment in line with what has been experienced in the 40 years in the past was assumed. This assumption may now be questioned, given the poor recruitment for 6 consecutive years. Such a prolonged sequence of poor recruitments is unusual for this stock, and would appear as very unlikely in the previous simulations. SGRECVAP has considered variability in the timeseries of recruitment and concluded that at least from a statistical point of view the current situation is different from the past. Although the cause of this poor recruitment is unclear and it is uncertain whether it will continue, management may have to adapt to a lower productivity of the North Sea herring stock.

To inform management under these circumstances medium term predictions assuming low recruitment in the future were presented in last years report. These studies are further extended here. This is done to give some guidance to management adaptation to a reduced productivity

The software used was STPR3, the same as used at the evaluation of HCRs for North Sea herring in June 2004. This is a program for performing 10 years stochastic simulations of the stock and fishery, applying some HCRs. A description can be found i.a. the SGMAS report (ICES CM 2005 /ACFM:09) and a manual in an EU Norway report on medium term management measures (EU 2004).

2.8.1 Input data

The program was run with 2 fleets, Fleet 1 corresponds to the A-fleet and Fleet 2 corresponds to fleets B, C and D combined.

Stock numbers in the initial year 2007 and their variances-covariances were taken from the current ICA output (ica.n and ica.vc). The stock-recruitment function was the same as used in previous simulations (‘Ockhams razor’), but with a reduced recruitment. It assumed recruitment of 22963 millions independent of SSB at SSB larger than 800 thousand tonnes, and a linear reduction of the recruitment at lower SSB. The recruitment was drawn from a log-normal distribution with $\sigma = 0.35$. These values are the mean and standard deviation (on a log scale) in the recent 6 years recruitment data series.

For weights and maturities historical data were used, by drawing years randomly and using data from that year.

Fleetwise selection at age were equal to those used in the short term prediction (Table 2.7.1)

For the intermediate year, catches by fleets were assumed as in the short term prediction.

Assessment was assumed to deviate from the true values by a random multiplier with mean 1.1 and CV = 0.1. For implementation error, a CV of 0.1 was assumed throughout.

To show the sensitivity to some of these assumptions, one run (run 4) was made with a CV on recruitment of 0.58 (as in the full historic series), and one (run 5) with a breakpoint in the stock-recruitment function at 500. Also, the risk to Blim in the last year (2017) for a range of levels of implementation error is shown, all assuming a CV on that error of 0.1.

2.8.2 Simulation options.

– Run 1 Standard HCR: The first set of simulations applied the basic harvest rule agreed by Norway and EU from 2004:

  At SSB > 1.3 million tonnes: F0-1 = 0.12 and F2-6 = 0.25

  At SSB < 1.3 million tonnes and SSB > 800 000 tonnes:

F0-1 = 0.12 – (0.08(1300 000 – SSB)/500 000)*

F2-6 = 0.25 – (0.15(1300 000 – SSB)/500 000) 800 000 tonnes:*

For SSB < 800 000 tonnes: F0-1 = 0.04 and F2-6 = 0.10

The agreement does not state the year which the SSB refers to. The SSB considered by STPR3 is the SSB in the quota year.

- Run 2 – 15% rule: The second set applied the rule to not change the TAC by more than 15% per year. The other parameters were as in the first set.
- Run 3 – Applying fishing mortalities F0-1 = 0.12 and F2-6 = 0.25: The other parameters were as in run 1, i.e. the rule constraining catch variation was not applied.
- Run 4 – as run 2 (i.e. with the 15% rule), but with a larger CV = 0.58 on recruitment
- Run 5 - as run 2 (i.e. with the 15% rule), but with a lower breakpoint (= 500 000 tonnes) in the stock-recruit relation.

2.8.3 Results

The main results for each run are shown in Figures 2.8.1-5. The risk associated with implementation error is shown in Figure 2.8.6

Run 1 shows that with the harvest rule implemented with no error, the risk to Blim is small. The SSB settles slightly above 1 million tonnes, and the catches in the order of 2-3 hundred thousand tonnes. With the 15% rule (Run 2), there is a considerable risk to Blim around 2010, with a fair chance of recovery once the fishing mortality has come down towards 0.2. Compared to Run 1, the catches will be higher in the first years, but lower thereafter. With the Fs of 0.12 and 0.25, the risk to Blim is substantial and stable. The assumptions about recruitment variation and breakpoint in the stock-recruit function do not appear to have a major impact on the results.

As shown in Figure 2.8.6, the current management rule is not robust to implementation error in terms of overfishing of the quotas beyond the level that is estimated at present. Hence, either the enforcement has to be stronger than in the past, or an even more conservative harvest rule has to be applied in order to safeguard against depleting the stock.

The present simulations have been done with weights and maturities representing the whole historic time series. The weights in recent years have tended to be lower that previously, which may explain why the predictions for 2007 give a somewhat larger biomass than the short term prediction. There is, however, no firm basis for assuming lower growth in the future.

2.9 Precautionary and Limit Reference Points

In 2003, SGPRP (ICES 2003 ACFM:04) suggested to reduce B_{lim} from the current 800 000 tonnes to about 560 000 tonnes, based on the results of the segmented regression analysis of the stock and recruitment data. Fitting a segmented regression stock-recruit function with non-linear minimisation of the SSQ of log residuals suggests a break point at 537 000 tonnes.

In 2007 WKREF explored limit reference points for NSAS herring among a number of other stocks. WKREF concluded that there is no basis for changing B_{lim} based on this analysis. SGRECVAP results could be basis for revisiting reference points. The distance between a management reference point (trigger or B_{pa}) and B_{lim} defines a risk and should be evaluated in the context of harvest control rules in consultation with stakeholders and managers.

HAWG decided not to propose any revision of the B_{lim} reference points at present for the following reasons:

- WKREF questioned the validity of the current calculation procedure for the segmented regression.
- Currently there is indications that the stock dynamics are changing
- The role of regime shifts in determining limit reference points should be integrated in the process
- HAWG would prefer to consider all reference points together, rather than revising just B_{lim}.

Most importantly, a downward revision of reference points now would not be helpful in precautionary management of the stock. When properly applied the harvest control rule in place for this stock has worked well in the recent past, and apart from B_{lim}, the current reference points are derived from this HCR. The target F in the HCR was adopted by ACFM as F_{pa}, while the trigger point at which F should be reduced below the target is adopted as B_{pa}.

2.10 Quality of the Assessment

2.10.1 Precision of historic timeseries

A bootstrap variance covariance evaluation of the precision of the assessment carried out using ICA is shown in Figure 2.10.1. The historic uncertainty supports the view that the stock has declined in recent years, and that recruitment is lower than since the late 1970s.

2.10.2 Comparison with earlier assessments

The 2007 assessment is in good agreement with last years assessment and the intermediate year in the short term projection, see table below.

ASSESSMENT YEAR	SSB IN 2005	F2-6 IN 2005	SSB IN 2006	F IN 2006
2007	**1.59 M t**	**0.37**	**Assessed 1.21 Mt**	**Assessed 0.35**
2006	**1.69 M t**	**0.35**	**Projected 1.33 Mt**	**Projected 0.35**

There has been a downward revision of SSB by about 6% of which about half is due to revision of catch (Section 2.1 and 2.6) but F is estimated to be very similar.

Cohort retrospectives are shown in Figure 2.10.2. The earliest cohorts shown have some revision over the early years. Latterly the cohort retrospective evaluations suggest the WG is providing a fairly consistent evaluation of most year classes. The exceptions are 2001 and 2004 year classes. In particular the dominant 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 in recent years, particularly since 2002. However, ACFM in 2005 expressed a range of 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 reduced from 74 000 tonnes in 2005 to 50 023 tonnes in 2006 (a reduction of 33% compared with 2005). For 2007, the same proportion (11%) was kept and the TAC was set at 37 517 tonnes. (Figure 2.11.1).

ACFM 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 (Figure 2.11.2), possibly because the TACs have been much higher. Landings in 2006 amounted to 56 597 tonnes, slightly higher than the TAC.

A further concern is that recent high catch levels in IVc and VIId have been driven largely by the strong 2000 year class. This year class accounted for 67% and 51% of the catch in numbers in 2004 and 2005 respectively but has reduced to 37 % in 2006. As has been noted previously these fish are smaller and less mature than the average for a given age therefore, if the fishery preferentially takes lighter fish the resulting F is comparatively higher.

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 this WG in 2006 (ICES CM 2006) based on population profiles suggested that total mortality (*Z*) was significantly higher for the 1998 and 1999 year classes of Downs herring compared to other classes caught in the Northern part.

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, but it has not been possible to quantify the Downs component in the catch. 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 (Dickey-Collas et al., 2005).

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 than those from the more northern, autumn spawning sites (<13 cm and >13 cm respectively). 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 (Figure 2.11.3, Table 2.3.3.3). These data suggest that around 35% of the strong 2000 year class came from Downs production and that approximately 70% of the 2002 year class originated from Downs production. The percentage contribution of the 2005 year class is about the same as the long-term average = 23% and appears to be stronger than the 2004 year class (Fig. 2.11.3).

2006 year class – The recruitment for the 2006 year class (Figure 2.11.4, MIK index) appears lower than the 2005 year class. With the extension of the IBTS area in the Eastern English Channel, the number of MIK samples, distributed in 4 statistical rectangles, increased during the last survey and therefore, results are considered more reliable.

Last year the EC set a proportion of TAC for herring in IVc and VIId in accordance with the ICES advice. 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 in 2008 at 11% of the total North Sea TAC (as recommended by ACFM). 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.

Extension of the IBTS area and acoustic survey in the Eastern Channel.

Winter spawning Downs herring stock is exploited off the eastern English Channel by different fleets, mainly at the end of the year. The rest of the year, this stock component is mixed with the overall population of North Sea herring in the feeding grounds. According to French fishermen this pattern seems to have changed as large herring shoals have been observed in the English Channel, mainly along French coasts, until April.

In March 2006, after the IBTS survey, the French RV “Thalassa” recorded acoustics data that confirmed the fishermen's observations. Shoals of significant size were observed in coastal waters in the ICES rectangle 30F1. Some trawl hauls were made and the catches consisted of herring with mean length of 25 cm.

During the last IBTS WG in March 2006, the extension of the IBTS 1st quarter survey area in the Eastern English Channel was considered: additional GOV hauls carried out in this area would provide more information on Downs herring and its distribution at this period of the year. The IBTS WG agreed that RV “Thalassa” could take some additional trawl hauls when it started its IBTS cruise at the end of January on its way through the English Channel before going to the North sea. The HAWG supported the idea and the extension of the IBTS area was implemented at the 1st quarter IBTS 2007.

During 4 days, (30 January – 2 February 2007) the RV "Thalassa" covered the Eastern part of the English Channel. 8 GOV hauls and 20 MIK stations were made in each ICES rectangle according to the IBTS protocol. In addition, acoustic data were recorded during day and night and 5 pelagic hauls made when fish marks were detected. Because of the vessel traffic in this area, the lack of time to do a full coverage and the impossibility to cross sandbanks, only two acoustic transects were done along the English and the French coasts and a third one in the middle of the English Channel (Figure 2.11.5).

The most important marks were recorded along French coasts and the catch composition of pelagics hauls consisted of mixed herring, sardine and other pelagic species in the south of the area and mainly herring in the northern part. For herring; the catch composition consisted of 26 cm mean length fish belonging to age-groups 3 – 6. (Figure 2.11.6).

According to fishermen's observations, very large and continuous shoals of herring were found at the same time as this survey in a local area, concentrated along sandbanks and observed again when IBTS was finishing at the end of February. Mean density could be estimated of between 500 and 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.

As it was the first year that the survey was carried out in this area at this time of the year, it must be considered preliminary. Further, the survey design needs to be improved and pelagic samples need to be increased. Though a reliable biomass estimation on herring during its migration through the English Channel is likely to be difficult, the survey could certainly give more information on herring shoals observed, their evolution and the possible change in behaviour in relation to herring spawning area.

In the 2006 HAWG report, some rules to set the percentage southern North Sea TAC allocation were proposed but no simulation testing of those was performed. The following pieces of information are required to develop the analysis further:

- catch at age by area,
- microincrement analysis of otoliths (to determine spawning type), expanded to other fleets in the North Sea, high resolution MIK coverage in Southern North Sea and the Channel area
- extension of IBTS in the Eastern Channel.

Hence, HAWG continues to recommend that existing surveys of herring in the southern North Sea and English Channel be maintained and that the microincrement analysis of otoliths currently undertaken are continued and expanded to other fleets in the North Sea. Further, extensive simulation testing of alternative HCRs needs to take place.

2.12 Management Considerations

Based on the most recent estimates of SSB and fishing mortality, the North Sea autumn spawning herring stock is considered to be at 1.2 million t in 2006 and is expected to decrease to 0.97 million tonnes in 2007. F in 2006 was 0.35 and expected to be similar at F=0.33 in 2007. Following currently estimated low recruitment, SSB is expected to remain at about this level of biomass for a while, declining further or rising slowly depending on the level of F.

SSB peaked after the rise from the low stock size in the mid-1990s, in response to reduced catches, strong recruitment and management measures that reduced exploitation both on juveniles and adults. However, in the last 5 years the recruitment has been at 40% average, and the stock is declining. Landings of adult herring in recent years have consistently exceeded the agreed TAC, mainly due to unallocated catches and catches misreported out of the North Sea (see section 2.1). The fishing mortality has increased, mainly due to the management rule that limits reduction to 15% per year, and at 0.35 is now above what was intended in the management agreement, and what was considered sustainable. If F is maintained at this level SSB will decline slowly over the next few years and may reach Blim in 2009 or 2010.

The stock is managed according to the EU-Norway Management agreement which was updated on 26 November 2004, the relevant parts of the text are included here for reference:

1. *Every effort shall be made to maintain a level of Spawning Stock Biomass (SSB) greater than the 800,000 tonnes (Blim).*
2. *Where the SSB is estimated to be above 1.3 million tonnes the Parties agree to set quotas for the directed fishery and for by-catches in other fisheries , reflecting a fishing mortality rate of no more than 0.25 for 2 ringers and older and no more than 0.12 for 0-1 ringers.*
3. *Where the SSB is estimated to be below 1.3 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 equal to:*

   0.25 – (0.15(1,300,000-SSB)/500,000) for 2 ringers and older, and*

   0.12 – (0.08(1,300,000-SSB)/500,000) for 0-1 ringers.*
4. *Where the SSB is estimated to be below 800,000 tonnes the Parties agree to set quotas for the directed fishery and for by-catches in other fisheries, reflecting a fishing mortality rate of less than 0.1 for 2 ringers and older and less than 0.04 for 0-1ringers.*
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. *Not withstanding paragraph 5 the Parties may, where considered appropriate, reduce the TAC by more than 15% compared to theTAC of the preceding year.*
7. *By-catches of herring may only be landed in ports where adequate sampling schemes to effectively monitor the landings have been set up. All catches landed shall be deducted from the respective quotas set, and the fisheries shall be stopped immediately in the event that the quotas are exhausted*
8. *The allocation of TAC for the directed fishery for herring shall be 29% to Norway and 71% to the Community. The by-catch quota for herring shall be allocated to the Community*
9. *A review of this arrangement shall take place no later than 31 December 2007 .*
10. *This arrangement enters in to force on 1 January 2005.*

ACFM examined the performance of this revised harvest control rule in 2005, and considered "the agreement in terms of target F to be consistent with the Precautionary Approach. However, ACFM also considered that the strict application of the TAC change limit of 15% (rule number 5) is not consistent with the Precautionary Approach in a situation like the present when five consecutive weak year classes have recruited to the population. The harvest control rule is in accordance with the precautionary approach if paragraph 6 is consistently invoked sufficiently early to prevent or minimise the risk of SSB falling below B_{pa} even in the case of several consecutive weak year classes. Assuming that paragraph 6 would be invoked when TAC constraints would lead to SSB falling below B_{pa} it is considered that the revised HCR is in accordance with the Precautionary Approach."

The situation now is unusual, and had not been anticipated, with all the five year classes from 2002 onwards being poor. The SGRECVAP, which was set up to have a closer look at the recruitment failure in herring (as well as in Sandeel and Norway pout), concluded that the reduced recruitment is caused by an increased mortality in the first winter. Analysis of the time series of SSB and recruitment data clearly indicates a shift in the recruitment success in 2001. An analysis of stock production (Section 1.8) shows similar results. The underlying cause for the change in 2001 is not clear, but there is no evidence to justify an assumption of normal recruitment from 2008 onwards.

Given the current sustained low level of recruitment, considering the B_{trig} in the management plan as B_{pa} may be unrealistic and it is preferable to evaluate the precautionary nature of the management plan as a whole rather than referring to a biomass reference point that may not be achievable.

Following evaluation, the agreed plan is considered precautionary and the risk of SSB falling below B_{lim} in the medium term is less than 5%, when:

- current low levels of recruitment continue,
- implementation is constrained to give less than 10% over exploitation,
- there are no year on year restrictions on change in TAC

The continuation of the 15% year on year restriction in change in TAC increases the risk of SSB falling below B_{lim} to greater than 25% over the next 5 years. Alternatively an implementation error of 30% will have a similar effect. Implementation error is currently estimated at just under 10% for the human consumption fleet in 2006, though it has been higher in the past.

The failure to comply with precautionary management rule in setting the TAC in 2007 has given rise to a fishing mortality that is higher than was envisaged. This is a matter of concern in a situation of extreme low recruitment. The consequences of the maintaining the present fishing mortality at around 0.35, has not been examined in detail, but it is clear that if it is not reduced it will lead to a substantial reduction in SSB to a level below B_{lim} in the near future.

Consequently, the WG considers that the advice for 2008 should be adapted to the current recruitment. by allowing necessary year on year change in TAC and complying with the F reduction in the management plan and ensuring implementation of regulation is to better than 10%.

This stock complex also includes Downs herring (herring in Divisions IVc and VIId), which has shown independent trends in exploitation rate and recruitment, but cannot be assessed separately. This year the Working Group concludes that the current state of the component is unknown. The WG's understanding of the component's dynamics is unlikely to improve until further examination of catch and the existing time series of surveys takes place. Both, alternative assessment methods have to be explored, and a greater knowledge of the ecology of Downs herring is needed. The Downs fishery is concentrated on the spawning aggregations in a restricted area, which makes this stock component particularly vulnerable to excessive fishing pressure. Catches of the Downs component are taken both in the southern area and in the mixed fishery in the central and northern North Sea. The EU splits its share of the total North Sea herring TAC (Subarea IV and Division VIId) into TACs for Divisions IVa+IVb and for Divisions IVc+VIId. ICES has proposed that a share of 11% on the total North Sea TAC (average share 1989-2002) would be appropriate for distributing the harvesting among Downs Herring and other stock components. While the WG acknowledges that the basis for this exact 11% figure is weak there are strong indications that the total mortality on the Downs component, of which fishing is the major component, has recently been significantly higher than for the rest of the NS components.

For the last few years since the North Sea autumn spawning (NSAS) stock was rebuilt, the ICES advice has been that the primary limiting factor for the fishery in IIIa should be the concern for the Western Baltic spring spawning (WBSS) stock. With an expected decline of the NS herring below 1.0 million t in 2007 primacy of consideration must be given to protection of this stock. The provision of advice for the NS affects the C and D fleets operating in IIIa. Projections for the WBSS stock also indicate poor recruitment and an expected decline in SSB with present F levels, and an incremental reduction of fishing mortality towards F0.1 is therefore advisable for this stock. This issue is dealt with in detail in the discussion of short term predictions in Section 2.7. and in Section 3.10. In should be noted that in setting the catch of WBSS herring the corresponding catch of NSAS herring in the D fleet puts specific restraints on the catches of the B-fleet, and some options may be rather restrictive.

All of the relaxation of area and bycatch rules are now contributing to the increase in exploitation and current over exploitation of North Sea herring. Removal of these derogations and increased compliance would be beneficial, particularly in the current circumstance of a declining North Sea population.

Table 2.1.1: Herring caught in the North Sea (Sub-area IV and Division VIId). Catch in tonnes by country, 1997 – 2006. These figures do not in all cases correspond to the official statistics and cannot be used for legal purposes.

Country	1997 [9]	1998 [9]	1999 [9]	2000 [9]	2001 [9]
Belgium	1	-	2	-	-
Denmark	38324	58924	61268	64123	67096
Faroe Islands	1156	1246	1977	915	1082
France	14525	20784	26962	20952	24880 [14]
Germany, Fed.Rep	13380	22259	26764	26687	29779
Netherlands	35985	49933	54467	54341	51293
Norway [4]	41606	70981	74071	72072	75886
Poland					-
Sweden	2253	3221	3241	3046	3695
USSR/Russia	1619	452	-	-	-
UK (England)	3470	7635	11434	11179	14582
UK (Scotland)	22582	31313	29911	30033	26719
UK (N.Ireland)	-	1015	-	996	1018
Unallocated landings	63403 [6,12]	70329 [12]	43327 [12]	61673 [12]	27362 [12]
Total landings	238304	338092	333424	346017	323392 [14]
Discards	-	-	-	-	-
Total catch	**238304**	**338092**	**333424**	**346017**	**323392** [14]
Estimates of the parts of the catches which have been allocated to spring spawning stocks					
IIIa type (WBSS)	979	7833	4732	6649	6449
Thames estuary [5]	202	88	88	76	107
Others [11]	-	-	-	378	1097
Norw. Spring Spawners [13]	54728	29220	32106	25678	7108

Country	2002	2003	2004	2005	2006
Belgium	23	5	8	6	3
Denmark [7]	70825	78606	99037	128380	102322
Faroe Islands	1413	627	402	738	1785
France	25422	31544	34521	38829	49475
Germany	27213	43953	41858	46555	40414
Netherlands	55257	81108	96162	81531	76315
Norway [4]	74974	112481	137638	156802	135361
Poland	-	-	-	458	-
Sweden	3418	4781	5692	13464	10529
Russia	-	-	-	99	-
UK (England)	13757	18639	20855	25311	22198
UK (Scotland)	30926	40292	45331	73227	48428
UK (N.Ireland)	944	2010	2656	2912	3531
Unallocated landings	31552 [12]	31875 [12]	48898 [12]	57788	18764
Total landings	335724	445921	533058	626101	509125
Discards	17093	4125	17059	12824	1492
Total catch	**352817**	**450046**	**550117**	**638925**	**510617**
Estimates of the parts of the catches which have been allocated to spring spawning stocks					
IIIa type (WBSS)	6652	2821	7079	7039	10954
Thames estuary [5]	60	84	62	74	65
Others [11]	0	308	0	0	0
Norw. Spring Spawners [13]	4069	979	452	417	626

[4] Catches of Norwegian spring spawners removed (taken under a separate TAC)
[5] Landings from the Thames estuary area are included in the North Sea catch figure for the UK (England)
[7] Including any by-catches in the industrial fishery
[9] Figures verified and altered if needed in 2003 by SG Rednose (ICES 2003/ACFM:10)
[10] Figure altered in 2001
[11] Caught in the whole North Sea, partly included in the catch figure for The Netherlands
[12] may include misreported catch from IVaN and discards
[13] 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
[14] Figure altered in 2004

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	1997 [11]	1998 [11]	1999 [11]	2000 [11]	2001 [11]
Denmark	2657	4634	15359	25530	17770
Faroe Islands	1156	1246	1977	205	192
France	362	4758	6369	3210	8164
Germany	4576	7753	11206	5811	17753
Netherlands	6072	10917	21552	15117	17503 [10]
Norway	16869	27290	31395	33164	11653
Sweden	1617	315	859	1479	-
Poland					1418
Russia	1619	452	-	-	-
UK (England)	49	4306	7999	8859	12283
UK (Scotland)	17121	29462	28537	29055	25105
UK (N. Ireland)	-	1015	-	996	1018
Unallocated landings	40662 [6,8]	56058 [8]	25469 [8]	44334 [8]	24725 [8]
Misreporting from VIa North					
Total Landings	92760	148206	150722	167760	137584
Discards					
Total catch	**92760**	**148206**	**150722**	**167760**	**137584**

Country	2002	2003	2004	2005	2006
Denmark [7]	26422	48358	48128	80990	60462
Faroe Islands	-	95	-		580
France	10522	11237	10941	13474	18453
Germany	15189	25796	17559	22278	18605
Netherlands	18289	25045	43876	36619	39209
Norway	10836	34443	36119	66232	38363
Poland	-	-	-	458	-
Sweden	2397	2647	2178	8261	4957
Russia	-	-	-	99	-
UK (England)	10142	12030	13480	15523	12031
UK (Scotland)	30014	39970	43490	71941	47368
UK (N. Ireland)	944	2010	2656	2912	3531
Unallocated landings	14201 [8]	14115 [8]	28631 [8]	39324 [8]	10981 [8]
Misreporting from VIa North					
Total Landings	138956	215746	247058	358111	253048
Discards	17093	4125	15794	10861	1492
Total catch	**156049**	**219871**	**262852**	**368972**	**254540**

[4] Including IVa East
[5] Negative unallocated catches due to misreporting from other areas
[6] Altered in 2000 on the basis of a Bayesian assessment on m isreporting into IVa (North)
[7] Including any by-catches in the industrial fishery
[8] May include misreported catch from VIaN and discards
[9] Figure altered in 2001
[10] Including 1057 t of local spring spawners
[11] Figures verified and altered if needed in 2003 by SG Rednose (ICES 2003/ACFM:10)

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	1997 [7]	1998 [7]	1999 [7]	2000 [7]	2001 [7]
Denmark [5]	22862	25750	18259	11300	18466
Faroe Islands	-	-	-	710	890
France	3	-	115	-	-
Germany	-	-	-	29	-
Netherlands	756	301	-	38	-
Norway [2]	20975	43646	39977	38655	56904
Sweden	422	1189	772	1177	517
Unallocated landings	-756 [4]	-292 [4]	-	338	o
Total landings	44262	70594	59123	52247	76777
Discards	-	-	-	-	-
Total catch	**44262**	**70594**	**59123**	**52247**	**76777**
Norw. Spring Spawners [6]	54728	29220	32106	25678	7108

Country	2002	2003	2004	2005	2006
Denmark [5]	17846	7401	16278	5761	8614
Faroe Islands	1365	359	-	738	975
France	-	-	-		-
Germany	81	54	888		34
Netherlands	-	-	-		-
Norway [2]	63482	62306	100443	89925	90065
UK (Scotland)	-	-	-	-	83
Sweden	568	1529	1720	3510	2857
Unallocated landings	5961	11991	0	0	0
Total landings	89303	83640	119329	99934	102628
Discards	-	-	-	-	-
Total catch	**89303**	**83640**	**119329**	**99934**	**102628**
Norw. Spring Spawners [6]	4069	979	452	417	626

[2] Catches of Norwegian spring spawning herring removed (taken under a separate TAC)
[3] Included in IVa West
[4] Negative unallocated catches due to misreporting into other areas
[5] Including any by-catches in the industrial fishery
[6] 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 fir 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	1997 [6]	1998 [6]	1999 [6]	2000 [6]	2001 [6]
Belgium	-	-	1	-	-
Denmark [4]	11558	26667	26211	26825	30277
Faroe Islands	-	-	-	-	-
France	6069	8945	7634	10863	7796 [14]
Germany	7455	13590	13529	18818	8340
Netherlands	14976	27468	22343	26839	24160
Norway	3762	45	2699	253	7329
Sweden	214	1717	1610	390	1760
UK (England)	2033	1767	1641	669	814
UK (Scotland)	5461	1851	1374	978	1614
Unallocated landings	-3744 [5]	-12138 [5]	-3794 [5]	-9820 [5]	-22885 [5]
Total landings	47784	69912	73248	75815	59205
Discards [2]					
Total catch	**47784**	**69912**	**73248**	**75815**	**59205** [14]

Country	2002	2003	2004	2005	2006
Belgium	-	-	-	-	-
Denmark [4]	26387	22574	33857	41423	32277
Faroe Islands	48	173	402	-	200
France	4214	7918	10592	10205	17385
Germany	7577	12116	13823	14381	14222
Netherlands	13154	19115	23649	10038	13363
Norway	656	15732	1076	645	6933
Sweden	453	605	1794	1694	2715
UK (England)	317	2632	2864	3869	4924
UK (Scotland)	289	322	1841	1286	977
Unallocated landings	4052	-2401	8300	10233	2364
Total landings	57147	78786	98198	93774	95360
Discards [2]			1265	1963	
Total catch	**57147**	**78786**	**99463**	**95737**	**95360**

[2] **Discards partly included in unallocated landings**
[3] **Negative unallocated catches due to misreporting from other areas**
[4] **Including any by-catches in the industrial fishery**
[5] **May include discards. Negative unallocated due to misreporting into other areas**
[6] **Figures verified and altered if needed in 2003 by SG Rednose (ICES 2003/ACFM:10)**
[14] **Figure altered in 2004**

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	1997 [9]	1998 [9]	1999 [9]	2000 [9]	2001 [9]
Belgium	1	-	1	1	-
Denmark	1247	1873	1439	468	583
France	8091	7081	12844	6879	8750
Germany	1349	916	2029	2029	3686
Netherlands	14181	11247	10572	12348	9630
UK (England)	1388	1562	1794	1651	1485
UK (Scotland)	-	-	-	-	-
Unallocated landings	27241 [4]	26701 [4]	21652 [4]	26822 [4]	25522 [4]
Total landings	53498	49380	50331	50198	49656
Discards [3]					
Total catch	**53498**	**49380**	**50331**	**50198**	**49656**
Coastal spring spawners included above [2]	143	88	88	76	147 [11]

Country	2002	2003	2004	2005	2006
Belgium	23	5	8	6	3
Denmark	170	273	774	206	969
Faroe Islands	-	-	-	-	30
France	10686	12389	12988	15150	13637
Germany	4366	5987	9588	9896	7553
Netherlands	23814	36948	28637	34874	23743
UK (England)	3298	3977	4511	5919	5243
UK (Scotland)	623	-	-	-	-
Unallocated landings	7338	8170	11967	8231	5419
Total landings	50318	67749	68473	74282	56597
Discards [3]	-	-	-	-	-
Total catch	**50318**	**67749**	**68473**	**74282**	**56597**
Coastal spring spawners included above [2]	60	84	62	74	65

[2] Landings from the Thames estuary area are included in the North Sea catch figure for UK (England)
[3] Discards partly included in unallocated landings
[4] May include misreported catch and discards
[9] Figures verified and altered if needed in 2003 by SG Rednose (ICES 2003/ACFM:10)
[10] Figure altered in 2002 (was 7851 t higher before)
[11] Thames/Blackwater herring landings: 107 t, others included in the catch figure for The Netherlands
[14] Figure altered in 2004

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

Year	1989	1990	1991	1992	1993	1994	1995 [18]	1996 [18]	1997 [18]	1998 [18]	1999 [18]	2000 [18]	2001 [18]	2002	2003	2004	2005	2006
Sub-Area IV and Division VIId: TAC (IV and VIId)																		
Recommended Divisions IVa, b [1]	484	373, 332	363 [6]	352	290 [7]	296 [7]	389 [11]	156	159	254	265	265	- [22]	- [22]	- [22]	- [22]	- [22]	- [22]
Recommended Divisions IVc, VIId	30	30	50-60 [6]	54	50	50	50	- [14]	- [14]	- [14]	- [14]	- [14]	- [14]	- [14]	- [14]	- [14]	- [14]	- [14]
Expected catch of spring spawners				10	8													
Agreed Divisions IVa,b [2]	484	385	370 [6]	380	380	390	390	263;131 [13]	134	229	240	240	240	223	340.5	393.9	460.7	404.7
Agreed Div. IVc, VIId	30	30	50 [6]	50	50	50	50	50; 25 [13]	25	25	25	25	25	42.7	59.5	66.1	74.3	50.0
Bycatch ceiling in the small mesh fishery									24	22	30	36	36	36	52.0	38.0	50.0	42.5
CATCH (IV and VIId)																		
National landings Divisions IVa,b [3]	639	499	495	481	463	421	465	183	149	245	261	261	272	261	354.5	427.7	502.3	439.2
Unallocated landings Divisions IVa,b	-2	14	30	14	-1	6	-15	-5	36	44	22	35	2	24	23.7	36.9	49.6	13.3
Discard/slipping Divisions IVa,b [4]	3	4	2	3	1	1	-	-	-	-	-	-	-	17	4.1	17.1	12.8	1.5
Total catch Divisions IVa,b [5]	638	516	527	498	463	428	450	178	185	289	283	296	273	303	382.3	481.6	564.6	454.0
National landings Divisions IVc, VIId [3]	30	24	42	37	32 [21]	42	45	24	26	23	29	23	24	43	59.5	56.5	66.1	51.2
Unallocated landings Divisions IVc,VIId	48	32	16	35	43	30	22	31	27	27	22	27	26	7	8.2	12.0	8.2	5.4
Discard/slipping Divisions IVc, VIId [4]	1	5	3	2	2	2	-	-	-	-	-	-	-	0	-	-	-	-
Total catch Divisions IVc, VIId	79	61	61	74	77 [21]	74	67	55	53	49	50	50	50	50	67.7	68.5	74.3	56.6
Total catch IV and VIId as used by ACFM [5]	**717**	**578**	**588**	**572**	**540** [21]	**498**	**516**	**233**	**238**	**338**	**333**	**346**	**323**	**353**	**450.0**	**550.1**	**638.9**	**510.6**
CATCH BY FLEET/STOCK (IV and VIId) [10]																		
North Sea autumn spawners directed fisheries (Fleet A)	N.a.	N.a.	446	441	438	447	439	195	225	316	313	322	296	323	434.9	529.5	610.0	487.1
North Sea autumn spawners industrial (Fleet B)	N.a.	N.a.	134	124	101	38	67	38	13	14	15	18	20	22	12.3	13.6	21.8	11.9
North Sea autumn spawners in IV and VIId total	**696**	**569**	**580**	**564**	**539**	**485**	**506**	**233**	**237**	**330**	**329**	**339**	**317**	**346**	**447.2**	**543.0**	**631.9**	**499.0**
Baltic-IIIa-type spring spawners in IV	20	8	8	8	9	13	10	1	1	8	5	7	6	7	2.8	7.1	7.0	11.0
Coastal-type spring spawners	2.3	1.1	0.3	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
Norw. Spring Spawners caught under a separate quota in IV [20]	N.a.	4	5	5	9	6	10	30	55	29	32	26	7	4	1.0	0.5	0.4	0.6
Division IIIa: TAC (IIIa)																		
Predicted catch of autumn spawners			96	153	102	77	98	48	35	58	43	53	- [22]	- [22]	- [22]	- [22]	- [22]	- [22]
Recommended spring spawners	84	67	91	90	93–113	- [9]	- [12]	- [12]	- [15]	- [15]	- [15]	- [15]	- [15]	- [15]	- [15]	- [22]	- [22]	- [22]
Recommended mixed clupeoids	80	60	0	0	0	-	-	-	-	-	-	-	-	-	-	-	-	-
Agreed herring TAC	138	120	104.5	124	165	148	140	120	80	80	80	80	80	80	80.0	70.0	96.0	81.6
Agreed mixed clupeoid TAC	80	65	50	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
CATCH (IIIa)																		
National landings	192	202	188	227	214	168	157	115	83	120	86	108	90	79	76.0	61.1	90.8	88.9
Catch as used by ACFM	162	195	191	227	214	168	140	105	74	108	79	99	82	73	68.1	52.7	69.6	51.2
CATCH BY FLEET/STOCK (IIIa) [10]																		
Autumn spawners human consumption (Fleet C)	N.a.	N.a.	26	47	44	42	38	24	21	59	28 [17]	36	34	17	24.1	13.4	22.9	11.6
Autumn spawners mixed clupeoid (Fleet D) [19]	N.a.	N.a.	13	23	25	12	6	9	4	6	8 [17]	13	12	9	8.4	10.8	9.0	3.4
Autumn spawners other industrial landings (Fleet E)	N.a.	N.a.	38	82	63	32	29	8	2									
Autumn spawners in IIIa total	**91**	**77** [8]	**77**	**152**	**132**	**86**	**73**	**43**	**27**	**61**	**34** [17]	**49**	**46**	**26**	**32.5**	**24.2**	**31.9**	**15.0**
Spring spawners human consumption (Fleet C)	N.a.	N.a.	68	53	68	59	44	58	43	40	40 [17]	45	33	38	31.6	16.8	32.5	30.2
Spring spawners mixed clupeoid (Fleet D) [19]	N.a.	N.a.	5	2	1	1	2	4	3	3	3 [17]	5	3	9	4.0	11.2	5.1	5.9
Spring spawners other industrial landings (Fleet E)	N.a.	N.a.	40	20	12	24	21	2	1									
Spring spawners in IIIa total	**71**	**118**	**113**	**75**	**81**	**84**	**67**	**64**	**47**	**43**	**43** [17]	**50**	**36**	**47**	**35.6**	**28.0**	**37.6**	**36.1**
North Sea autumn spawners Total as used by ACFM	**787**	**646**	**657**	**716**	**671**	**571**	**579**	**275**	**264**	**392**	**363**	**388**	**363**	**372**	**479.7**	**567.2**	**663.8**	**514.6**

1 Includes catches in directed fishery and catches of 1-ringers in small mesh fishery up to 1992. 2 IVa,b and EC zone of IIa. 3 Provided by Working Group members. 4 Incomplete, only some countries providing discard information. Discards might also be included in un. 5 Includes spring spawners not included in assessment. 6 Revised during 1991. 7 Based on F=0.3 in directed fishery only; TAC advised for IVc, VIId subtracted. 8 Estimated. 9 130-180 for spring spawners in all areas. 10 Based on sum-of-products (number x mean weight at age). 11 Status quo F catch for fleet A. 12 The catch should not exceed recent catch levels. 13 During the middle of 1996 revised to 50% of its original agreed TAC. 14 Included in IVa,b. 15 Managed in accordance with autumn spawners. 17 Figure altered in 2001 and again in 2004. 18 Data for 1995-2001 were verified and amended where necessary by SG REDNOSE in 2003. 19 Fleet D and E are merged from 1999 onwards. 20 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. 21 figure altered in 2003 to account for earlier summarizing errors. 22 See catch option tables for different fleets.Shaded cells for the catch by fleet in Division IIIa indicate persisting inconsistencies which have to be resolved intersessionally.

Table 2.2.1: North Sea autumn spawning herring (NSAS), and western Baltic spring spawners (WBSS) caught in the North Sea in 2006. 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	**35.1**	**0.0**	**0.0**	**0.0**	**5.1**	**837.2**	**0.3**	**0.9**	**842.4**	**1.2**	**878.6**	**843.5**
1	**150.1**	**0.4**	**0.1**	**0.3**	**4.1**	**37.8**	**21.3**	**8.6**	**42.1**	**29.9**	**222.1**	**72.1**
2	**50.2**	**46.7**	**3.5**	**43.2**	**115.5**	**104.8**	**14.1**	**73.3**	**263.5**	**87.4**	**401.1**	**354.4**
3	**10.2**	**62.4**	**8.8**	**53.7**	**127.7**	**60.4**	**4.1**	**54.5**	**241.8**	**58.6**	**310.6**	**309.2**
4	**3.3**	**126.7**	**14.0**	**112.7**	**226.2**	**86.7**	**1.8**	**34.4**	**425.6**	**36.1**	**465.0**	**475.3**
5	**3.3**	**195.0**	**22.4**	**172.6**	**486.9**	**182.8**	**3.4**	**149.4**	**842.4**	**152.8**	**998.5**	**1016.8**
6	**0.6**	**51.9**	**5.1**	**46.8**	**150.0**	**38.8**	**0.4**	**16.4**	**235.6**	**16.9**	**253.1**	**256.7**
7	**0.4**	**63.6**	**5.3**	**58.3**	**139.0**	**35.6**	**0.1**	**15.1**	**232.9**	**15.2**	**248.5**	**251.9**
8	**0.2**	**19.7**	**2.1**	**17.6**	**30.4**	**9.5**	**0.1**	**5.5**	**57.5**	**5.5**	**63.2**	**65.0**
9+	**0.0**	**12.9**	**1.0**	**11.9**	**20.5**	**5.8**	**0.1**	**5.5**	**38.2**	**5.6**	**43.8**	**44.3**
Sum	**253.3**	**579.2**	**62.2**	**517.1**	**1305.5**	**1399.5**	**45.7**	**363.4**	**3222.1**	**409.1**	**3884.6**	**3689.3**
Quarter: 1												
0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.9	0.3	0.9	**1.2**	**1.2**
1	49.4	0.4	0.1	0.2	0.4	9.6	21.1	8.6	10.2	29.7	**89.2**	**40.0**
2	26.5	2.7	0.5	2.2	4.2	47.4	6.7	1.8	53.8	8.5	**88.7**	**62.7**
3	6.1	5.5	1.0	4.5	19.9	4.4	0.7	18.9	28.9	19.6	**54.6**	**49.5**
4	1.5	12.7	0.2	12.5	40.1	0.5	0.3	11.3	53.1	11.6	**66.2**	**64.8**
5	2.3	18.4	0.2	18.2	53.1	1.5	1.6	58.2	72.8	59.8	**134.9**	**132.8**
6	0.3	1.2	0.0	1.2	13.3	0.1	0.2	5.4	14.5	5.6	**20.3**	**20.1**
7	0.1	3.5	0.0	3.5	10.8	0.1	0.1	3.2	14.4	3.2	**17.7**	**17.6**
8	0.1	2.3	0.0	2.3	1.5	0.0	0.1	1.8	3.8	1.9	**5.8**	**5.7**
9+	0.0	0.1	0.0	0.1	0.8	0.0	0.1	2.7	1.0	2.8	**3.7**	**3.7**
Sum	**86.3**	**46.8**	**2.0**	**44.7**	**144.1**	**63.8**	**30.8**	**112.7**	**252.6**	**143.5**	**482.4**	**398.2**
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	10.0	0.0	0.0	0.0	0.0	5.9	0.2	0.0	5.9	0.2	**16.0**	**6.1**
2	11.3	38.9	3.0	35.9	25.3	8.1	0.0	0.0	69.2	0.0	**80.6**	**72.3**
3	0.0	47.0	5.2	41.7	32.1	12.5	0.0	0.0	86.3	0.0	**86.4**	**91.6**
4	0.0	98.4	12.0	86.4	47.3	10.1	0.0	0.0	143.9	0.0	**143.9**	**155.8**
5	0.0	136.1	16.5	119.6	119.0	23.5	0.0	0.0	262.0	0.0	**262.1**	**278.6**
6	0.0	24.5	3.0	21.5	21.8	3.4	0.0	0.0	46.7	0.0	**46.7**	**49.7**
7	0.0	19.3	2.3	16.9	22.3	4.3	0.0	0.0	43.5	0.0	**43.5**	**45.8**
8	0.0	10.3	1.3	9.1	5.9	2.3	0.0	0.0	17.3	0.0	**17.3**	**18.6**
9+	0.0	3.0	0.4	2.6	4.4	0.7	0.0	0.0	7.8	0.0	**7.8**	**8.1**
Sum	**21.4**	**377.5**	**43.6**	**333.8**	**278.1**	**70.7**	**0.3**	**0.0**	**682.7**	**0.3**	**704.4**	**726.7**
Quarter: 3												
0	27.0	0.0	0.0	0.0	5.1	651.7	0.0	0.0	656.8	0.0	**683.7**	**656.8**
1	40.8	0.0	0.0	0.0	1.9	17.3	0.0	0.0	19.2	0.0	**60.0**	**19.2**
2	10.2	4.9	0.1	4.9	72.0	28.3	0.0	0.0	105.2	0.0	**115.4**	**105.3**
3	2.5	8.7	2.4	6.3	67.8	25.8	0.0	0.0	99.8	0.0	**102.4**	**102.3**
4	0.8	5.7	1.3	4.4	111.6	63.0	0.0	0.0	179.0	0.0	**179.9**	**180.4**
5	0.3	19.3	4.5	14.8	274.7	88.6	0.0	0.0	378.1	0.0	**378.5**	**382.7**
6	0.2	4.1	0.9	3.1	104.0	20.3	0.0	0.0	127.4	0.0	**127.6**	**128.4**
7	0.1	4.1	1.0	3.1	98.5	22.5	0.0	0.0	124.1	0.0	**124.2**	**125.1**
8	0.0	2.5	0.6	1.9	20.0	3.4	0.0	0.0	25.3	0.0	**25.4**	**25.9**
9+	0.0	0.5	0.1	0.4	14.8	5.0	0.0	0.0	20.2	0.0	**20.2**	**20.3**
Sum	**82.0**	**49.8**	**10.9**	**38.9**	**770.4**	**925.9**	**0.0**	**0.1**	**1735.2**	**0.1**	**1817.4**	**1746.2**
Quarter: 4												
0	8.1	0.0	0.0	0.0	0.0	185.3	0.3	0.0	185.3	0.3	**193.7**	**185.6**
1	49.9	0.0	0.0	0.0	1.8	5.1	0.0	0.0	6.9	0.0	**56.8**	**6.9**
2	2.2	0.2	0.0	0.2	14.1	21.0	7.4	71.4	35.3	78.9	**116.3**	**114.2**
3	1.5	1.3	0.2	1.1	8.0	17.7	3.4	35.5	26.8	38.9	**67.3**	**65.9**
4	0.8	9.9	0.5	9.4	27.1	13.1	1.4	23.1	49.7	24.5	**75.0**	**74.3**
5	0.7	21.1	1.1	20.0	40.2	69.3	1.8	91.1	129.4	92.9	**223.0**	**222.7**
6	0.1	22.2	1.2	21.0	10.9	15.1	0.3	11.0	47.0	11.3	**58.3**	**58.5**
7	0.2	36.7	1.9	34.8	7.4	8.8	0.0	11.9	50.9	12.0	**63.1**	**63.3**
8	0.1	4.6	0.2	4.3	3.0	3.7	0.0	3.7	11.0	3.7	**14.7**	**14.7**
9+	0.0	9.2	0.5	8.8	0.6	0.0	0.0	2.8	9.3	2.8	**12.1**	**12.2**
Sum	**63.6**	**105.2**	**5.6**	**99.6**	**112.9**	**339.1**	**14.6**	**250.6**	**551.6**	**265.2**	**880.3**	**818.3**

Table 2.2.2: North Sea autumn spawning herring (NSAS), and western Baltic spring spawners (WBSS) caught in the North Sea in 2006. 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	**0.014**	**0.000**	**0.000**	**0.010**	**0.010**	**0.016**	**0.081**	**0.010**	**-**	**0.010**	**0.010**
1	**0.054**	**0.025**	**0.111**	**0.103**	**0.020**	**0.027**	**0.130**	**0.028**	**0.057**	**0.049**	**0.040**
2	**0.079**	**0.125**	**0.108**	**0.145**	**0.097**	**0.090**	**0.125**	**0.123**	**0.119**	**0.117**	**0.122**
3	**0.117**	**0.149**	**0.152**	**0.156**	**0.141**	**0.130**	**0.124**	**0.150**	**0.125**	**0.144**	**0.145**
4	**0.140**	**0.164**	**0.171**	**0.180**	**0.172**	**0.151**	**0.153**	**0.174**	**0.153**	**0.172**	**0.172**
5	**0.186**	**0.175**	**0.178**	**0.193**	**0.183**	**0.150**	**0.152**	**0.187**	**0.152**	**0.181**	**0.181**
6	**0.191**	**0.214**	**0.191**	**0.230**	**0.202**	**0.195**	**0.177**	**0.222**	**0.178**	**0.220**	**0.220**
7	**0.216**	**0.224**	**0.189**	**0.251**	**0.220**	**0.170**	**0.205**	**0.239**	**0.205**	**0.237**	**0.237**
8	**0.207**	**0.229**	**0.214**	**0.247**	**0.232**	**0.195**	**0.209**	**0.238**	**0.209**	**0.235**	**0.235**
9+	**0.000**	**0.254**	**0.201**	**0.286**	**0.239**	**0.216**	**0.220**	**0.269**	**0.219**	**0.262**	**0.262**
Quarter: 1											
0	0.000	0.020	0.020	0.020	0.020	0.081	0.081	-	-	**0.067**	**0.067**
1	0.020	0.024	0.024	0.024	0.024	0.027	0.130	0.024	0.057	**0.033**	**0.048**
2	0.070	0.107	0.107	0.097	0.070	0.048	0.117	0.074	0.062	**0.072**	**0.072**
3	0.107	0.127	0.127	0.126	0.107	0.095	0.092	0.123	0.092	**0.110**	**0.111**
4	0.129	0.140	0.140	0.133	0.141	0.109	0.109	0.134	0.109	**0.130**	**0.130**
5	0.187	0.151	0.151	0.147	0.145	0.124	0.124	0.148	0.124	**0.138**	**0.137**
6	0.195	0.193	0.193	0.165	0.171	0.153	0.153	0.167	0.153	**0.163**	**0.163**
7	0.220	0.164	0.164	0.172	0.177	0.166	0.166	0.170	0.166	**0.169**	**0.169**
8	0.209	0.189	0.189	0.186	0.192	0.194	0.194	0.188	0.194	**0.190**	**0.190**
9+	0.000	0.235	0.235	0.219	0.213	0.216	0.216	0.221	-	**0.217**	**0.217**
Quarter: 2											
0	0.000	0.000	0.000	0.000	0.000	0.081	0.081	-	-	**0.081**	**0.081**
1	0.045	0.000	0.000	0.000	0.031	0.029	0.130	0.031	0.030	**0.040**	**0.031**
2	0.075	0.126	0.126	0.134	0.100	0.057	0.117	0.126	0.057	**0.119**	**0.126**
3	0.103	0.141	0.141	0.147	0.122	0.113	0.092	0.140	0.112	**0.140**	**0.140**
4	0.135	0.160	0.160	0.181	0.144	0.124	0.109	0.165	0.121	**0.166**	**0.165**
5	0.144	0.168	0.168	0.190	0.152	0.133	0.124	0.176	0.131	**0.177**	**0.176**
6	0.000	0.191	0.191	0.211	0.178	0.157	0.153	0.199	0.156	**0.199**	**0.199**
7	0.000	0.206	0.206	0.241	0.188	0.161	0.166	0.222	0.162	**0.223**	**0.222**
8	0.171	0.218	0.218	0.224	0.199	0.178	0.194	0.218	0.182	**0.218**	**0.218**
9+	0.000	0.235	0.235	0.255	0.213	0.216	0.216	0.244	-	**0.244**	**0.244**
Quarter: 3											
0	0.013	0.000	0.000	0.010	0.010	0.000	0.000	0.010	-	**0.010**	**0.010**
1	0.078	0.111	0.111	0.100	0.016	0.000	0.000	0.024	#DIV/0!	**0.061**	**0.024**
2	0.103	0.149	0.149	0.152	0.118	0.000	0.125	0.143	0.125	**0.139**	**0.143**
3	0.129	0.174	0.174	0.169	0.150	0.000	0.142	0.164	0.142	**0.163**	**0.164**
4	0.146	0.191	0.191	0.201	0.177	0.000	0.170	0.192	0.170	**0.192**	**0.192**
5	0.163	0.193	0.193	0.205	0.205	0.000	0.167	0.205	0.167	**0.205**	**0.205**
6	0.175	0.259	0.259	0.246	0.222	0.000	0.188	0.242	0.188	**0.242**	**0.242**
7	0.188	0.246	0.246	0.263	0.236	0.000	0.214	0.257	0.214	**0.257**	**0.257**
8	0.204	0.244	0.244	0.262	0.255	0.000	0.219	0.259	0.219	**0.260**	**0.259**
9+	0.000	0.310	0.310	0.299	0.243	0.000	0.224	0.285	0.224	**0.285**	**0.285**
Quarter: 4											
0	0.018	0.000	0.000	0.000	0.010	0.010	0.000	0.010	-	**0.010**	**0.010**
1	0.069	0.141	0.141	0.122	0.017	0.015	0.000	0.045	0.015	**0.066**	**0.045**
2	0.098	0.165	0.165	0.141	0.130	0.129	0.125	0.135	0.125	**0.128**	**0.128**
3	0.139	0.182	0.182	0.154	0.149	0.137	0.142	0.152	0.141	**0.145**	**0.146**
4	0.155	0.203	0.203	0.166	0.172	0.160	0.175	0.175	0.174	**0.174**	**0.174**
5	0.192	0.210	0.210	0.183	0.165	0.175	0.169	0.178	0.169	**0.174**	**0.174**
6	0.213	0.236	0.236	0.200	0.181	0.217	0.189	0.210	0.190	**0.205**	**0.206**
7	0.232	0.237	0.237	0.227	0.197	0.214	0.216	0.229	0.216	**0.226**	**0.226**
8	0.207	0.252	0.252	0.220	0.232	0.219	0.217	0.237	0.217	**0.231**	**0.232**
9+	0.000	0.256	0.256	0.298	0.000	0.224	0.223	0.258	0.223	**0.250**	**0.250**

Table 2.2.3: North Sea autumn spawning herring (NSAS), and western Baltic spring spawners (WBSS) caught in the North Sea in 2006. 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.**		**n.d.**					**0.0**	**-**
1	**n.d.**		**n.d.**					**0.0**	**0.0**
2	**n.d.**		**n.d.**					**0.0**	**0.0**
3	**n.d.**		**n.d.**					**0.0**	**0.0**
4	**n.d.**		**n.d.**					**0.0**	**0.0**
5	**n.d.**		**n.d.**					**0.0**	**0.0**
6	**n.d.**		**n.d.**					**0.0**	**0.0**
7	**n.d.**		**n.d.**					**0.0**	**0.0**
8	**n.d.**		**n.d.**					**0.0**	**0.0**
9+	**n.d.**		**n.d.**					**0.0**	**0.0**
Quarter: 1									
0	n.d.		n.d.					-	-
1	n.d.		n.d.					0.0	0.0
2	n.d.		n.d.					0.0	0.0
3	n.d.		n.d.					0.0	0.0
4	n.d.		n.d.					0.0	0.0
5	n.d.		n.d.					0.0	0.0
6	n.d.		n.d.					0.0	0.0
7	n.d.		n.d.					0.0	0.0
8	n.d.		n.d.					0.0	0.0
9+	n.d.		n.d.					0.0	-
Quarter: 2									
0	n.d.		n.d.					-	-
1	n.d.		n.d.					0.0	0.0
2	n.d.		n.d.					0.0	0.0
3	n.d.		n.d.					0.0	0.0
4	n.d.		n.d.					0.0	0.0
5	n.d.		n.d.					0.0	0.0
6	n.d.		n.d.					0.0	0.0
7	n.d.		n.d.					0.0	0.0
8	n.d.		n.d.					0.0	0.0
9+	n.d.		n.d.					0.0	-
Quarter: 3									
0	n.d.		n.d.					0.0	-
1	n.d.		n.d.					0.0	#DIV/0!
2	n.d.		n.d.					0.0	0.0
3	n.d.		n.d.					0.0	0.0
4	n.d.		n.d.					0.0	0.0
5	n.d.		n.d.					0.0	0.0
6	n.d.		n.d.					0.0	0.0
7	n.d.		n.d.					0.0	0.0
8	n.d.		n.d.					0.0	0.0
9+	n.d.		n.d.					0.0	0.0
Quarter: 4									
0	n.d.		n.d.					0.0	-
1	n.d.		n.d.					0.0	0.0
2	n.d.		n.d.					0.0	0.0
3	n.d.		n.d.					0.0	0.0
4	n.d.		n.d.					0.0	0.0
5	n.d.		n.d.					0.0	0.0
6	n.d.		n.d.					0.0	0.0
7	n.d.		n.d.					0.0	0.0
8	n.d.		n.d.					0.0	0.0
9+	n.d.		n.d.					0.0	0.0

Table 2.2.4: North Sea autumn spawning herring (NSAS), and western Baltic spring spawners (WBSS) caught in the North Sea in 2006. Catches (tonnes) at-age (SOP figures), by quarter and division.

WR	IIIa NSAS	IVa(E) all	IVa(E) WBSS	IVa(E) NSAS only	IVa(W)	IVb	IVc	VIId	IVa & IVb NSAS	IVc & VIId	Total NSAS	Herring caught in the North Sea
Quarters: 1-4												
0	0.5	0.0	0.0	0.0	0.1	8.4	0.0	0.1	8.4	0.1	9.0	8.5
1	8.1	0.0	0.0	0.0	0.4	0.8	0.6	1.1	1.2	1.7	10.9	2.9
2	4.0	5.8	0.4	5.4	16.7	10.2	1.3	9.1	32.4	10.4	46.7	43.2
3	1.2	9.3	1.3	8.0	19.9	8.5	0.5	6.8	36.3	7.3	44.8	45.0
4	0.5	20.8	2.4	18.4	40.8	14.9	0.3	5.3	74.1	5.5	80.1	82.1
5	0.6	34.2	4.0	30.2	94.1	33.4	0.5	22.6	157.7	23.2	181.4	184.8
6	0.1	11.1	1.0	10.1	34.5	7.8	0.1	2.9	52.5	3.0	55.6	56.5
7	0.1	14.3	1.0	13.3	34.8	7.8	0.0	3.1	55.9	3.1	59.1	60.0
8	0.0	4.5	0.4	4.1	7.5	2.2	0.0	1.1	13.8	1.2	14.9	15.4
9+	0.0	3.3	0.2	3.1	5.9	1.4	0.0	1.2	10.3	1.2	11.6	11.7
Sum	15.0	103.2	10.7	92.5	254.6	95.4	3.3	53.4	442.6	56.7	514.3	510.0
Quarter: 1												
0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.1	0.1	0.1
1	1.0	0.0	0.0	0.0	0.0	0.2	0.6	1.1	0.2	1.7	2.9	1.9
2	1.9	0.3	0.0	0.2	0.4	3.3	0.3	0.2	4.0	0.5	6.3	4.5
3	0.7	0.7	0.1	0.6	2.5	0.5	0.1	1.7	3.6	1.8	6.0	5.5
4	0.2	1.8	0.0	1.7	5.3	0.1	0.0	1.2	7.1	1.3	8.6	8.4
5	0.4	2.8	0.0	2.8	7.8	0.2	0.2	7.2	10.8	7.4	18.6	18.2
6	0.1	0.2	0.0	0.2	2.2	0.0	0.0	0.8	2.4	0.9	3.3	3.3
7	0.0	0.6	0.0	0.6	1.9	0.0	0.0	0.5	2.4	0.5	3.0	3.0
8	0.0	0.4	0.0	0.4	0.3	0.0	0.0	0.3	0.7	0.4	1.1	1.1
9+	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.6	0.2	0.6	0.8	0.8
Sum	4.2	6.8	0.2	6.6	20.5	4.4	1.3	13.9	31.5	15.1	50.8	46.8
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	0.4	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.2	0.0	0.6	0.2
2	0.9	4.9	0.4	4.5	3.4	0.8	0.0	0.0	8.7	0.0	9.6	9.1
3	0.0	6.6	0.7	5.9	4.7	1.5	0.0	0.0	12.1	0.0	12.1	12.8
4	0.0	15.7	1.9	13.8	8.6	1.5	0.0	0.0	23.8	0.0	23.8	25.7
5	0.0	22.9	2.8	20.1	22.6	3.6	0.0	0.0	46.2	0.0	46.2	49.0
6	0.0	4.7	0.6	4.1	4.6	0.6	0.0	0.0	9.3	0.0	9.3	9.9
7	0.0	4.0	0.5	3.5	5.4	0.8	0.0	0.0	9.7	0.0	9.7	10.2
8	0.0	2.2	0.3	2.0	1.3	0.5	0.0	0.0	3.8	0.0	3.8	4.0
9+	0.0	0.7	0.1	0.6	1.1	0.2	0.0	0.0	1.9	0.0	1.9	2.0
Sum	1.3	61.8	7.2	54.5	51.6	9.5	0.0	0.0	115.7	0.0	117.1	123.0
Quarter: 3												
0	0.4	0.0	0.0	0.0	0.1	6.5	0.0	0.0	6.6	0.0	6.9	6.6
1	3.2	0.0	0.0	0.0	0.2	0.3	0.0	0.0	0.5	0.0	3.6	0.5
2	1.0	0.7	0.0	0.7	11.0	3.3	0.0	0.0	15.0	0.0	16.1	15.0
3	0.3	1.5	0.4	1.1	11.4	3.9	0.0	0.0	16.4	0.0	16.7	16.8
4	0.1	1.1	0.3	0.8	22.4	11.1	0.0	0.0	34.4	0.0	34.5	34.7
5	0.1	3.7	0.9	2.9	56.4	18.2	0.0	0.0	77.4	0.0	77.5	78.3
6	0.0	1.1	0.2	0.8	25.6	4.5	0.0	0.0	30.9	0.0	30.9	31.1
7	0.0	1.0	0.2	0.8	25.9	5.3	0.0	0.0	32.0	0.0	32.0	32.2
8	0.0	0.6	0.1	0.5	5.2	0.9	0.0	0.0	6.6	0.0	6.6	6.7
9+	0.0	0.1	0.0	0.1	4.4	1.2	0.0	0.0	5.7	0.0	5.7	5.8
Sum	5.2	9.9	2.2	7.7	162.5	55.2	0.0	0.0	225.4	0.0	230.6	227.7
Quarter: 4												
0	0.1	0.0	0.0	0.0	0.0	1.9	0.0	0.0	1.9	0.0	2.0	1.9
1	3.4	0.0	0.0	0.0	0.2	0.1	0.0	0.0	0.3	0.0	3.8	0.3
2	0.2	0.0	0.0	0.0	2.0	2.7	1.0	8.9	4.8	9.9	14.8	14.6
3	0.2	0.2	0.0	0.2	1.2	2.6	0.5	5.0	4.1	5.5	9.8	9.6
4	0.1	2.0	0.1	1.9	4.5	2.3	0.2	4.0	8.7	4.3	13.1	13.0
5	0.1	4.4	0.2	4.2	7.4	11.4	0.3	15.4	23.0	15.7	38.8	38.9
6	0.0	5.2	0.3	4.9	2.2	2.7	0.1	2.1	9.9	2.1	12.0	12.3
7	0.0	8.7	0.5	8.3	1.7	1.7	0.0	2.6	11.7	2.6	14.3	14.7
8	0.0	1.2	0.1	1.1	0.6	0.9	0.0	0.8	2.6	0.8	3.4	3.5
9+	0.0	2.4	0.1	2.2	0.2	0.0	0.0	0.6	2.4	0.6	3.0	3.2
Sum	4.4	24.2	1.3	22.9	19.9	26.3	2.0	39.5	69.1	41.5	115.0	111.9

Table 2.2.5: North Sea autumn spawning herring (NSAS), and western Baltic spring spawners (WBSS) caught in the North Sea in 2006. 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	13.9%	0.0%	0.0%	0.0%	0.4%	59.8%	0.6%	0.2%	26.1%	0.3%	22.6%	22.9%
1	59.3%	0.1%	0.2%	0.1%	0.3%	2.7%	46.6%	2.4%	1.3%	7.3%	5.7%	2.0%
2	19.8%	8.1%	5.7%	8.4%	8.9%	7.5%	30.9%	20.2%	8.2%	21.4%	10.3%	9.6%
3	4.0%	10.8%	14.1%	10.4%	9.8%	4.3%	9.0%	15.0%	7.5%	14.3%	8.0%	8.4%
4	1.3%	21.9%	22.5%	21.8%	17.3%	6.2%	3.8%	9.5%	13.2%	8.8%	12.0%	12.9%
5	1.3%	33.7%	36.0%	33.4%	37.3%	13.1%	7.5%	41.1%	26.1%	37.3%	25.7%	27.6%
6	0.2%	9.0%	8.2%	9.1%	11.5%	2.8%	1.0%	4.5%	7.3%	4.1%	6.5%	7.0%
7	0.1%	11.0%	8.5%	11.3%	10.6%	2.5%	0.2%	4.2%	7.2%	3.7%	6.4%	6.8%
8	0.1%	3.4%	3.4%	3.4%	2.3%	0.7%	0.1%	1.5%	1.8%	1.3%	1.6%	1.8%
9+	0.0%	2.2%	1.5%	2.3%	1.6%	0.4%	0.2%	1.5%	1.2%	1.4%	1.1%	1.2%
Sum 3+	7.1%	91.9%	94.1%	91.6%	90.4%	30.0%	21.8%	77.2%	64.4%	71.0%	61.3%	65.6%
Quarter: 1												
0	0.0%	0.0%	0.0%	0.0%	0.0%	0.4%	0.1%	0.8%	0.1%	0.6%	0.3%	0.3%
1	57.2%	0.8%	6.3%	0.5%	0.3%	15.0%	68.6%	7.6%	4.0%	20.7%	18.5%	10.0%
2	30.7%	5.7%	22.1%	4.9%	2.9%	74.2%	21.7%	1.6%	21.3%	5.9%	18.4%	15.7%
3	7.1%	11.7%	48.9%	10.0%	13.8%	6.9%	2.1%	16.8%	11.4%	13.7%	11.3%	12.4%
4	1.8%	27.1%	7.5%	28.0%	27.8%	0.7%	1.0%	10.0%	21.0%	8.1%	13.7%	16.3%
5	2.7%	39.4%	11.0%	40.7%	36.9%	2.3%	5.3%	51.6%	28.8%	41.7%	28.0%	33.4%
6	0.3%	2.5%	0.7%	2.6%	9.2%	0.2%	0.5%	4.8%	5.7%	3.9%	4.2%	5.0%
7	0.1%	7.5%	2.1%	7.8%	7.5%	0.2%	0.3%	2.8%	5.7%	2.3%	3.7%	4.4%
8	0.1%	4.9%	1.4%	5.1%	1.1%	0.1%	0.2%	1.6%	1.5%	1.3%	1.2%	1.4%
9+	0.0%	0.3%	0.1%	0.3%	0.6%	0.0%	0.2%	2.4%	0.4%	1.9%	0.8%	0.9%
Sum 3+	12.0%	93.5%	71.6%	94.5%	96.8%	10.4%	9.7%	90.0%	74.6%	72.8%	62.9%	73.9%
Quarter: 2												
0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.8%	0.0%	0.1%	0.0%	0.0%
1	46.7%	0.0%	0.0%	0.0%	0.0%	8.3%	58.2%	7.6%	0.9%	55.7%	2.3%	0.8%
2	53.0%	10.3%	6.8%	10.8%	9.1%	11.4%	14.7%	1.6%	10.1%	14.1%	11.4%	9.9%
3	0.2%	12.4%	12.0%	12.5%	11.5%	17.7%	11.0%	16.8%	12.6%	11.2%	12.3%	12.6%
4	0.1%	26.1%	27.4%	25.9%	17.0%	14.3%	2.8%	10.0%	21.1%	3.1%	20.4%	21.4%
5	0.0%	36.1%	37.9%	35.8%	42.8%	33.2%	11.3%	51.6%	38.4%	13.3%	37.2%	38.3%
6	0.0%	6.5%	6.8%	6.4%	7.9%	4.8%	0.9%	4.8%	6.8%	1.1%	6.6%	6.8%
7	0.0%	5.1%	5.4%	5.1%	8.0%	6.0%	0.6%	2.8%	6.4%	0.7%	6.2%	6.3%
8	0.0%	2.7%	2.9%	2.7%	2.1%	3.3%	0.2%	1.6%	2.5%	0.3%	2.5%	2.6%
9+	0.0%	0.8%	0.8%	0.8%	1.6%	1.0%	0.3%	2.4%	1.1%	0.4%	1.1%	1.1%
Sum 3+	0.3%	89.7%	93.2%	89.2%	90.9%	80.3%	27.0%	90.0%	89.0%	30.1%	86.3%	89.2%
Quarter: 3												
0	32.9%	0.0%	0.0%	0.0%	0.7%	70.4%	0.0%	0.0%	37.8%	0.0%	37.6%	37.6%
1	49.8%	0.0%	0.0%	0.0%	0.2%	1.9%	0.0%	0.0%	1.1%	0.0%	3.3%	1.1%
2	12.4%	9.9%	0.5%	12.5%	9.4%	3.1%	0.0%	28.0%	6.1%	28.0%	6.4%	6.0%
3	3.1%	17.5%	22.1%	16.2%	8.8%	2.8%	0.0%	14.5%	5.8%	14.5%	5.6%	5.9%
4	1.0%	11.5%	12.3%	11.3%	14.5%	6.8%	0.0%	8.7%	10.3%	8.7%	9.9%	10.3%
5	0.4%	38.8%	41.4%	38.1%	35.7%	9.6%	0.0%	36.3%	21.8%	36.3%	20.8%	21.9%
6	0.2%	8.2%	8.7%	8.0%	13.5%	2.2%	0.0%	4.5%	7.3%	4.5%	7.0%	7.4%
7	0.1%	8.2%	8.7%	8.0%	12.8%	2.4%	0.0%	5.0%	7.2%	5.0%	6.8%	7.2%
8	0.0%	5.0%	5.3%	4.9%	2.6%	0.4%	0.0%	1.8%	1.5%	1.8%	1.4%	1.5%
9+	0.0%	0.9%	1.0%	0.9%	1.9%	0.5%	0.0%	1.3%	1.2%	1.3%	1.1%	1.2%
Sum 3+	5.0%	90.1%	99.5%	87.5%	89.7%	24.7%	0.0%	72.0%	55.0%	72.0%	52.7%	55.3%
Quarter: 4												
0	12.8%	0.0%	0.0%	0.0%	0.0%	54.6%	1.8%	0.0%	33.6%	0.1%	22.0%	22.7%
1	78.5%	0.0%	0.0%	0.0%	1.6%	1.5%	0.0%	0.0%	1.3%	0.0%	6.5%	0.8%
2	3.4%	0.2%	0.7%	0.2%	12.4%	6.2%	50.7%	28.5%	6.4%	29.7%	13.2%	14.0%
3	2.4%	1.2%	2.9%	1.1%	7.0%	5.2%	23.4%	14.2%	4.9%	14.7%	7.6%	8.0%
4	1.3%	9.4%	9.2%	9.4%	24.0%	3.9%	9.8%	9.2%	9.0%	9.2%	8.5%	9.1%
5	1.1%	20.0%	19.7%	20.0%	35.6%	20.4%	12.1%	36.4%	23.5%	35.0%	25.3%	27.2%
6	0.1%	21.1%	20.6%	21.1%	9.6%	4.5%	2.0%	4.4%	8.5%	4.3%	6.6%	7.2%
7	0.3%	34.9%	34.1%	34.9%	6.5%	2.6%	0.1%	4.8%	9.2%	4.5%	7.2%	7.7%
8	0.1%	4.4%	4.3%	4.4%	2.6%	1.1%	0.0%	1.5%	2.0%	1.4%	1.7%	1.8%
9+	0.0%	8.8%	8.6%	8.8%	0.5%	0.0%	0.0%	1.1%	1.7%	1.1%	1.4%	1.5%
Sum 3+	5.4%	99.7%	99.3%	99.8%	85.9%	37.7%	47.4%	71.5%	58.8%	70.2%	58.3%	62.5%

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.

2003	**Fleet A**		**Fleet B**		**Fleet C**		**Fleet D**		**TOTAL**	
Total Winter rings	Numbers	Mean Weight	Numbers	Mean Weight	Numbers	Mean Weight	Numbers	Mean Weight	**Numbers**	**Mean Weight**
0	1.7	0.038	345.8	0.013	1.9	0.013	19.7	0.021	**369.1**	**0.014**
1	59.2	0.078	112.8	0.030	167.5	0.054	277.5	0.021	**617.0**	**0.037**
2	952.9	0.115	69.2	0.048	142.1	0.073	40.2	0.048	**1,204.5**	**0.104**
3	502.0	0.158	1.9	0.123	12.4	0.124	0.7	0.099	**516.9**	**0.157**
4	799.1	0.174	4.4	0.133	16.0	0.151	0.2	0.128	**819.7**	**0.173**
5	240.5	0.185	0.4	0.162	1.8	0.163	0.0	0.174	**242.7**	**0.184**
6	104.7	0.204	0.4	0.173	1.1	0.193	0.1	0.152	**106.2**	**0.204**
7	118.8	0.221	0.5	0.178	1.2	0.214	0.0	0.244	**120.5**	**0.221**
8	36.8	0.232	0.1	0.178	0.2	0.187	0.0	0.180	**37.1**	**0.232**
9+	8.3	0.253							**8.3**	**0.253**
TOTAL	2,824.0		535.5		344.1		338.4		**4,041.9**	
SOP catch	**434.8**		**12.3**		**24.1**		**8.4**		**479.6**	

Figures for A fleet include 3809 t unsampled bycatch in the industrial fishery

2004	**Fleet A**		**Fleet B**		**Fleet C**		**Fleet D**		**TOTAL**	
Total Winter rings	Numbers	Mean Weight	Numbers	Mean Weight	Numbers	Mean Weight	Numbers	Mean Weight	**Numbers**	**Mean Weight**
0			627.2	0.013	13.2	0.024	75.2	0.022	**715.6**	**0.014**
1	2.7	0.073	133.0	0.025	18.8	0.060	52.1	0.054	**206.7**	**0.036**
2	252.9	0.121	5.9	0.039	114.2	0.069	65.7	0.073	**438.8**	**0.099**
3	1298.6	0.138	6.8	0.096	12.0	0.120	8.7	0.121	**1,326.1**	**0.137**
4	510.6	0.183	2.9	0.137	4.4	0.138	1.6	0.147	**519.5**	**0.182**
5	714.6	0.206	1.9	0.175	8.7	0.149	1.0	0.171	**726.2**	**0.205**
6	168.6	0.221	0.8	0.168	1.6	0.169	0.2	0.185	**171.1**	**0.220**
7	99.1	0.229	0.2	0.217	1.9	0.187	0.1	0.183	**101.2**	**0.228**
8	69.7	0.241	0.5	0.232	0.8	0.178	0.0	0.213	**71.1**	**0.241**
9+	22.0	0.265							**22.0**	**0.265**
TOTAL	3,139.0		779.1		175.7		204.7		**4,298.4**	
SOP catch	**532.8**		**13.6**		**13.4**		**10.8**		**570.6**	

Figures for A fleet include 4984 t unsampled bycatch in the industrial fishery

2005	**Fleet A**		**Fleet B**		**Fleet C**		**Fleet D**		**TOTAL**	
Total Winter rings	Numbers	Mean Weight	Numbers	Mean Weight	Numbers	Mean Weight	Numbers	Mean Weight	**Numbers**	**Mean Weight**
0	0.4	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 Winter rings	Numbers	Mean Weight	Numbers	Mean Weight	Numbers	Mean Weight	Numbers	Mean Weight	**Numbers**	**Mean 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

Table 2.2.7: Catch at age (numbers in millions) of herring caught in the North Sea, 1992-2006.
SG Rednose's revisions for 1995-2001 are included (see Sect. 2.2.3).

Year/rings	0	1	2	3	4	5	6	7	8	9+	Total
1992	7874	705	995	424	344	351	370	149	39	24	11274
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

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, 1992-2006.

Year/rings	0	1	2	3	4	5	6	7	8	9+	Total
1992			0.3	9.9	11.1	8.4	8.6	2.5	0.7	0.6	42.1
1993			4.2	10.8	12.3	8.4	5.9	4.7	1.7	1.0	49.0
1994			8.8	28.2	16.3	11.0	8.6	3.4	3.2	0.7	80.2
1995			22.4	11.0	14.9	4.0	2.9	1.9	0.7	0.0	57.8
1996			0.0	2.8	0.8	0.4	0.1	0.1	0.3	0.0	4.5
1997			2.2	1.3	1.5	0.4	0.2	0.1	0.2	0.0	5.9
1998		5.1	9.5	12.0	10.1	6.0	3.0	0.4	0.9	0.0	47.0
1999			3.3	14.3	5.6	3.6	1.4	0.6	0.4	0.0	29.3
2000			8.2	9.8	10.2	5.7	2.5	0.6	0.7	0.1	37.6
2001			11.3	10.2	6.1	7.2	2.7	1.6	0.4	0.0	39.9
2002			7.6	14.8	10.6	3.3	2.9	1.0	0.5	0.1	40.8
2003			0.0	3.1	6.0	3.5	1.2	1.3	0.5	0.1	15.7
2004			15.1	27.9	3.5	4.1	1.0	0.5	0.1	0.0	52.3
2005			6.6	17.4	12.7	2.6	3.8	1.1	0.4	0.3	44.8
2006		0.1	3.5	8.8	14.0	22.4	5.1	5.3	2.1	1.0	62.2

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, 1992 - 2006. Figures for 1991-1999 were altered in 2001 and 2002, but for 1991-1995 not used n the assessment. SG Rednose's revisions and the revision of 2002 splitting are included (see Sect. 2.2.3).

Year/rings	0	1	2	3	4	5	6	7	8+	Total
1992	2298	1409	220	22	10	7	3	1	0	3971
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

Table 2.2.10: Catch at age (numbers in millions) of the total North Sea Autumn Spawning stock 1992 - 2006. Figures for 1991-1999 were altered in 2001 and 2002, but for 1991-1995 not used in the assessment.
SG Rednose's revisions and the revision of 2002 splitting are included (see Sect. 2.2.3).

Year/rings	0	1	2	3	4	5	6	7	8	9+	Total
1992	10390	2470	1342	445	376	368	383	156	40	23	15994
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

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 1996 – 2006. SG Rednose's revisions for 1995 – 2001 are included.

		Age (Rings)							
Div.	**Year**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9+**
IIIa	1996	0.078	0.110	0.160	0.182	0.215	0.215	0.244	-
	1997	0.066	0.122	0.155	0.176	0.175	0.179	0.185	-
	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	-
IVa(E)	1996	0.131	0.141	0.168	0.196	0.217	0.218	0.242	0.300
	1997	0.122	0.149	0.174	0.204	0.228	0.229	0.221	0.313
	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
IVa(W)	1996	0.131	0.167	0.215	0.218	0.237	0.275	0.301	0.278
	1997	0.127	0.166	0.218	0.248	0.246	0.262	0.294	0.289
	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
IVb	1996	0.111	0.184	0.209	0.230	0.249	0.297	0.282	0.287
	1997	0.124	0.170	0.210	0.230	0.259	0.263	0.286	0.286
	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
IVa & IVb	1996	0.124	0.162	0.199	0.215	0.236	0.267	0.282	0.288
	1997	0.125	0.161	0.202	0.233	0.245	0.254	0.264	0.291
	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
IVc & VIId	1996	0.121	0.143	0.159	0.185	0.194	0.203	0.155	-
	1997	0.101	0.133	0.156	0.168	0.166	0.190	0.163	-
	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
Total North Sea Catch	1996	0.123	0.157	0.189	0.205	0.212	0.262	0.280	0.288
	1997	0.118	0.149	0.195	0.227	0.227	0.235	0.245	0.291
	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

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 2006 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
Belgium	4	1	0	0%	3	0	0	0	n
total		**1**	**0**	**0%**	**3**	**0**	**0**	**0**	**n**
Denmark (A)	1	4	3	99%	25257	11	1661	1685	n
	2	3	2	96%	6419	8	1099	1109	y
	3	3	2	100%	40478	44	6195	6199	y
	4	3	3	100%	18267	13	1833	1834	n
total		**13**	**10**	**99%**	**90421**	**76**	**10788**	**10827**	**n**
Denmark (B)	1	4	2	96%	1425	8	210	210	y
	2	2	1	97%	282	4	9	11	y
	3	2	1	99%	6550	9	515	559	y
	4	3	2	100%	3644	8	24	29	y
total		**11**	**6**	**99%**	**11901**	**29**	**758**	**809**	**y**
England and W	1	3	0	0%	995	0	0	0	n
	2	4	0	0%	3294	0	0	0	n
	3	2	0	0%	10237	0	0	0	n
	4	3	0	0%	7672	0	0	0	n
total		**12**	**0**	**0%**	**22198**	**0**	**0**	**0**	**n**
Faroe Isl	1	1	0	0%	140	0	0	0	n
	3	1	0	0%	60	0	0	0	n
	4	3	0	0%	1585	0	0	0	n
total		**5**	**0**	**0%**	**1785**	**0**	**0**	**0**	**n**
France	1	2	0	0%	4308	0	0	0	n
	2	3	0	0%	4893	0	0	0	n
	3	3	0	0%	30964	0	0	0	n
	4	2	0	0%	9310	0	0	0	n
total		**10**	**0**	**0%**	**49476**	**0**	**0**	**0**	**n**
Germany	1	1	1	100%	401	9	487	1282	y
	2	2	0	0%	4431	0	0	0	n
	3	3	1	79%	12998	20	662	7049	y
	4	3	2	83%	22584	26	580	9716	y
total		**9**	**4**	**72%**	**40414**	**55**	**1729**	**18047**	**y**
Netherlands	1	4	2	100%	4811	14	350	2542	y
	2	4	2	100%	14250	37	925	5560	y
	3	2	2	100%	34004	72	1800	7904	y
	4	4	2	86%	23250	8	200	1310	n
total		**14**	**8**	**100%**	**76315**	**131**	**3275**	**17316**	**y**
Northern Irelan	1	1	0	0%	399	0	0	0	n
	3	1	0	0%	3127	0	0	0	n
	4	1	0	0%	5	0	0	0	n
total		**3**	**0**	**0%**	**3531**	**0**	**0**	**0**	**n**
Norway	1	3	1	91%	3213	1	50	80	n
	2	3	3	100%	80865	28	1829	3215	n
	3	3	1	61%	29563	3	150	295	n
	4	2	1	95%	21720	4	150	212	n
total		**11**	**6**	**90%**	**135361**	**36**	**2179**	**3802**	**n**
Scotland	1	2	1	25%	614	1	50	211	y
	2	4	3	100%	2794	17	932	4006	y
	3	2	1	98%	44455	59	3870	10518	y
	4	2	0	0%	566	0	0	0	n
total		**10**	**5**	**99%**	**48429**	**77**	**4852**	**14735**	**y**
Sweden	2	3	0	0%	3120	0	0	0	n
	3	3	0	0%	5836	0	0	0	n
	4	2	0	0%	1573	0	0	0	n
total		**8**	**0**	**0%**	**10529**	**0**	**0**	**0**	**n**
grand total		**107**	**78**	**79%**	**490362**	**404**	**23581**	**65536**	**n**
Period total	**1**	25	10	96%	41562	44	2808	6010	y
Period total	**2**	28	11	90%	120348	94	4794	13901	n
Period total	**3**	25	8	74%	218273	207	13192	32524	n
Period total	**4**	29	10	74%	110179	59	2787	13101	n
Total for stock 2006		**107**	**39**	**79%**	**490362**	**404**	**23581**	**65536**	**n**
Human Cons. only		96	33	79%	478461	375	22823	64727	n
Total for stock 2004		100	39	94%	484159	519	18643	93311	y
Total for stock 2005		102	39	95%	568312	438	15499	89011	n
Human Cons. only 2005		95	35	94%	546650	394	14888	87114	n

Table 2.2.13: Revision of historic catch numbers and mean weights at age in the catch due to incorrect allocation of fish to the plus group and new information on misreporting

Age	0	1	2	3	4	5	6	7	8	9	Total
2006 Assessment catch numbers at age											Tonnes
2001	1832691	614321	806490	477456	274048	311892	89298	37485	17218	2360	363343
2002	730279	835273	553042	903157	283997	133206	161196	46280	33355	7186	370941
2003	369074	616986	1204451	516945	819715	242669	106172	120497	37075	8313	472587
2004	715597	206658	438762	1326124	519503	726235	171149	101243	71100	22045	567252
2005	1015554	715547	355438	485676	1318373	479949	575851	115164	107986	39113	663813
Revised 2001-2004 data											
2001	1832691	614469	842635	485628	278884	321743	90918	38252	17910	2692	374065
2002	730279	837557	579592	970577	292205	140701	174570	48908	34620	8702	394709
2003	369074	617021	1221992	529386	835552	244780	107751	123291	37671	9044	482281
2004	715597	206648	447918	1366155	543376	753231	169324	104945	65341	31801	587698
2005	1015554	715547	355453	485746	1318647	479961	576154	115212	88311	58497	663813
2006 Assessment mean weights in catch											
2001	0.012	0.048	0.117	0.149	0.177	0.197	0.212	0.237	0.267	0.286	
2002	0.012	0.037	0.116	0.151	0.169	0.198	0.214	0.228	0.25	0.253	
2003	0.014	0.037	0.104	0.157	0.173	0.184	0.204	0.221	0.232	0.253	
2004	0.014	0.036	0.099	0.138	0.182	0.200	0.216	0.227	0.245	0.272	
2005	0.011	0.044	0.099	0.153	0.166	0.208	0.222	0.239	0.266	0.265	
Revised mean weights at age in the catch											
2001	0.012	0.048	0.118	0.149	0.177	0.198	0.213	0.238	0.267	0.288	
2002	0.012	0.037	0.118	0.153	0.170	0.199	0.214	0.228	0.250	0.252	
2003	0.014	0.037	0.104	0.158	0.174	0.184	0.205	0.222	0.232	0.256	
2004	0.014	0.036	0.100	0.138	0.183	0.201	0.216	0.228	0.246	0.272	
2005	0.011	0.044	0.099	0.153	0.166	0.208	0.223	0.24	0.257	0.278	
Percentage change in catch at age											
2001	0.00%	0.02%	4.48%	1.71%	1.76%	3.16%	1.81%	2.04%	4.02%	14.07%	2.95%
2002	0.00%	0.27%	4.80%	7.46%	2.89%	5.63%	8.30%	5.68%	3.79%	21.10%	6.41%
2003	0.00%	0.01%	1.46%	2.41%	1.93%	0.87%	1.49%	2.32%	1.61%	8.79%	2.05%
2004	0.00%	0.00%	2.09%	3.02%	4.60%	3.72%	-1.07%	3.66%	-8.10%	44.25%	3.60%
2005	0.00%	0.00%	0.00%	0.01%	0.02%	0.00%	0.05%	0.04%	-18.22%	49.56%	0.00%
Percentage change in mean weights at age in the catch											
2001	0.00%	0.01%	0.96%	0.33%	0.26%	0.42%	0.25%	0.30%	0.04%	0.55%	
2002	0.00%	0.39%	1.56%	1.27%	0.47%	0.31%	0.12%	0.16%	-0.16%	-0.56%	
2003	0.00%	0.02%	0.43%	0.33%	0.29%	0.18%	0.32%	0.31%	0.20%	1.17%	
2004	0.00%	0.00%	0.76%	0.57%	0.49%	0.37%	0.17%	0.36%	0.27%	0.24%	
2005	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.45%	0.42%	-3.38%	4.91%	

Table .2.3.1.1: Vessels, areas and cruise dates during the 2006 herring acoustic surveys.

VESSEL	PERIOD	AREA	RECTANGLES
FV Enterprise (SCO)	1 July – 21 July	56°- 60°30' N, 3° - 10° W	41E0-E3, 42E0-E3, 43E0-E3, 44E0-E3, 45E0-E4, 46E2-E5, 47E2-E6, 48E3-E6, 49E5
Johan Hjort (NOR)	19 June – 16 July	56°30' N - 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, plus overlap area A
Scotia (SCO)	1 July – 21 July	57° - 62° N, 2/4°W - 2°E	43E8-F1, 44E6-F1, 45F0-F1, 46E6-F1, 47E6-F1, 48E6-F1, 49E6-F1, 50E7-F1, 51E8-F1, 52E9-F1
Tridens (NED)	26 June – 21 July	53°30' – 58°30' N, Eng/Sco to Den/Ger coasts	38F2-F7, 40E8-F7, 41E7-F7, 42E7- F1, 45E6-E9
Solea (GER)	29 June – 18 July	52° - 56°30' N, Eng to Den/Ger coasts	33F1-F4, 34F2-F4, 35F2-F4, 36F0-F7, 37E9- F8, 38E9-F1, 39E8-F7
Dana (DEN)	25 June – 6 July	Kattegat north of 56° + Skagerrak and North Sea north of 56°30' N, east of 6° E	41G1-G2, 42F6-F7, 42G0-G3, 43F6-G2, 44F6-G1, 45F6, 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 acoustic surveys July 2006, with mean weights and mean lengths by age ring.

AGE (RING)	NUMBERS (MILLIONS)	BIOMASS ('000 T)	MATURITY	WEIGHT (G)	LENGTH (CM)
0	4621.8	42.1	0.00	9.1	10.65
1	6822.8	305.2	0.00	44.7	17.92
2	3772.3	477.8	0.66	126.7	24.22
3	1997.2	315.2	0.88	157.9	25.96
4	2097.5	394.3	0.98	188.0	27.19
5	4175.1	784.4	1.00	187.9	27.23
6	618.2	139.2	1.00	225.2	28.68
7	562.1	136.5	1.00	242.8	29.33
8	84.3	20.5	1.00	243.9	29.50
9+	70.4	18.6	1.00	265.0	30.19
Immature	12994.4	503.9		38.8	15.92
Mature	11827.3	2129.9		180.1	26.83
Total	24821.7	2633.8		106.1	21.12

Table 2.3.1.3. Revised numbers (millions) and biomass (thousands of tonnes) breakdown by age (winter rings) and maturity obtained for the 2005 International North Sea Herring Acoustic Survey.

NORTH SEA	NUMBERS (MILLIONS)	BIOMASS ('000 T)	MATURITY	WEIGHT (G)	LENGTH (CM)
0	5015.9	16.0	0.00	3.2	7.9
1	3114.1	134.8	0.01	43.3	17.5
2	2055.1	276.0	0.76	134.3	24.4
3	3648.5	617.8	0.96	169.3	26.1
4	5789.6	1040.2	0.96	179.7	26.5
5	1212.9	277.1	1.00	228.5	28.5
6	1174.9	290.7	1.00	247.5	29.2
7	139.9	35.3	1.00	252.6	29.5
8	126.5	34.7	1.00	274.4	30.2
9+	106.7	31.5	1.00	295.1	30.7
Immature	8994.7	243.5			
Mature	9890.7	1911.1			
Total	22384.3	2754.2			
1+ group	17368.4				

Table 2.3.1.4. Difference in number at age between original and revised estimates for the 2005 International North Sea Herring Acoustic Survey.

AGE	% CHANGE	CHANGE IN NUMBER (MILLIONS
0	0.00%	0.0
1	0.05%	1.6
2	8.73%	164.9
3	6.17%	212.1
4	3.21%	180.3
5	0.13%	1.6
6	0.23%	2.7
7	0.00%	0.0
8	0.00%	0.0
9+	0.00%	0.0
Immature	0.83%	74.2
Mature	3.27%	312.9
Total	2.58%	563.2
1+ group	3.35%	563.2

Table 2.3.1.5: Estimates of North Sea autumn spawners (millions) at age from acoustic surveys, 1984-2006. For 1984-1986 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 2006 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.

AGE (RINGS)	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
1	551	726	1,639	13,736	6,431	6,333	6,249	3,182	6,351	10,399	3,646	4,202
2	3,194	2,789	3,206	4,303	4,202	3,726	2,971	2,834	4,179	3,710	3,280	3,799
3	1,005	1,433	1,637	955	1,732	3,751	3,530	1,501	1,633	1,855	957	2,056
4	394	323	833	657	528	1,612	3,370	2,102	1,397	909	429	656
5	158	113	135	368	349	488	1,349	1,984	1,510	795	363	272
6	44	41	36	77	174	281	395	748	1,311	788	321	175
7	52	17	24	38	43	120	211	262	474	546	238	135
8	39	23	6	11	23	44	134	112	155	178	220	110
9+	41	19	8	20	14	22	43	56	163	116	132	84
Total	5,478	5,484	7,542	20,165	13,496	16,377	18,262	12,781	17,173	19,326	13,003	11,220
SSB (‘000t)	807	697	942	817	897	1,637	2,174	1,874	1,545	1,216	1,035	1,082

AGE (RINGS)	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
1	6,198	9,416	4,449	5,087	24,735	6,837	23,055	9,829	5,183	3,114	6,823
2	4,557	6,363	5,747	3,078	2,922	12,290	4,875	18,949	3,415	2,055	3,772
3	2,824	3,287	2,520	4,725	2,156	3,083	8,220	3,081	9,191	3,649	1,997
4	1,087	1,696	1,625	1,116	3,139	1,462	1,390	4,189	2,167	5,790	2,098
5	311	692	982	506	1,006	1,676	795	675	2,590	1,213	4,175
6	99	259	445	314	483	450	1,031	495	317	1,175	618
7	83	79	170	139	266	170	244	568	328	140	562
8	133	78	45	54	120	98	121	146	342	127	84
9+	206	158	121	87	97	59	150	178	186	107	70
Total	18,786	22,028	16,104	15,107	34,928	26,124	39,881	38,110	23,722	16,805	20,199
SSB(‘000t)	1,446	1,780	1,792	1,534	1,833	2,622	2,948	2,999	2,584	1,868	2,130

Table 2.3.2.1: North Sea autumn spawners. Fortnightly time periods sampled and survey effort in 2006/2007.

NL – Netherlands, FRG – Federal Republic of Germany

Area	Time period	Samples available	Vessel days	Nation	Coverage
Orkney/Shetland	01-15 Sep.	87	5	GER	Total
	16-30 Sep.	78	5	GER	Total
Buchan	01-15 Sep.	None			
	16-30 Sep.	78	5	NL	Total
Central North	01-15 Sep.	None			
Sea	16-30 Sep.	62	4	NL	Total
	01-15 Oct.	None			
Southern North	16-31 Dec.	77	4	NL	Total
Sea	01-15 Jan.	104	7	GER	Total
	16-31 Jan.	82	5	NL	Total

Table 2.3.2.2: North Sea autumn spawners. Number of samples taken and sampling effort for the herring larvae surveys 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

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		
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
1974	758	421	101	284	81		1184		10	
1975	371	50	312			90	77	1	2	
1976	545	81		1	64	108			3	
1977	1133	221	124	32	520	262	89	1		
1978	3047	50		162	1406	81	269	33	3	
1979	2882	2362	197	10	662	131	507		111	89
1980	3534	720	21	1	317	188	9	247	129	40
1981	3667	277	3	12	903	235	119	1456		70
1982	2353	1116	340	257	86	64	1077	710	275	54
1983	2579	812	3647	768	1459	281	63	71	243	58
1984	1795	1912	2327	1853	688	2404	824	523	185	39
1985	5632	3432	2521	1812	130	13039	1794	1851	407	38
1986	3529	1842	3278	341	1611	6112	188	780	123	18
1987	7409	1848	2551	670	799	4927	1992	934	297	146
1988	7538	8832	6812	5248	5533	3808	1960	1679	162	112
1989	11477	5725	5879	692	1442	5010	2364	1514	2120	512
1990		10144	4590	2045	19955	1239	975	2552	1204	
1991	1021	2397		2032	4823	2110	1249	4400	873	
1992	189	4917		822	10	165	163	176	1616	
1993		66		174		685	85	1358	1103	
1994	26	1179				1464	44	537	595	
1995		8688					43	74	230	164
1996		809		184		564		337	675	691
1997		3611		23				9374	918	355
1998		8528		1490	205	66		1522	953	170
1999		4064		185		134	181	804	1260	344
2000		3352	28	83		376		7346	338	106
2001		11918		164		1604		971	5531	909
2002		6669		1038			3291	2008	260	925
2003		3199		2263		12018	3277	12048	3109	1116
2004		7055		3884		5545		7055	2052	4175
2005		3380		1364		5614		498	3999	4822
2006	6311	2312		280		2259		10858	2700	2106

Table 2.3.2.4: North Sea autumn spawners. Parameter estimates obtained on fitting the MLAI model to the estimates of larval abundance by area and time-period. Model fitted to abundances of larvae < 10 mm in length (11 mm for the southern North Sea).

a) Analysis of variance of the model fit

	DF	Sum of Squares	Mean Square	F Value	P
Model	44	169.97	3.863	8.37	<0.0001
Error	240	110.81	0.462		
C Total	284	280.79			

b) Estimates of parameters

Reference Mean

Estimate	Standard Error	
6.81331	0.5502	Reference: 1972, Orkney/Shetland 09/01 – 09/15

Year Effects

Year	Estimate	Standard Error	Year	Estimate	Standard Error
1973	0.36421	0.68652	1990	2.93112	0.62998
1974	-0.13565	0.73565	1991	2.28800	0.68255
1975	-1.20382	0.74756	1992	1.52678	0.72159
1976	-1.30869	0.73370	1993	1.18798	0.69815
1977	-0.39908	0.70308	1994	0.81965	0.73606
1978	-0.21089	0.71378	1995	0.91582	0.72536
1979	0.46102	0.68699	1996	1.59260	0.76399
1980	0.08025	0.68409	1997	1.83934	0.71657
1981	0.46853	0.68072	1998	2.10117	0.67352
1982	0.83775	0.61811	1999	1.91752	0.67715
1983	1.08677	0.63376	2000	1.50754	0.69242
1984	1.67991	0.61516	2001	2.66180	0.70501
1985	2.10061	0.59342	2002	2.50106	0.68429
1986	1.44595	0.61315	2003	3.39638	0.69663
1987	2.01122	0.60506	2004	3.56639	0.73851
1988	2.69650	0.59323	2005	3.05304	0.68755
1989	2.67140	0.60716	2006	2.56592	0.70976

Sampling Unit Effects

Sampling Unit	Estimate	Standard Error
Or/Shet 16-30 Sep	-0.76580	0.31575
Buchan 01-15 Sep	-1.79146	0.41538
Buchan 16-30 Sep	-2.53508	0.34628
CNS 01-15 Sep	-1.62701	0.40196
CNS 16-30 Sep	-1.44483	0.34858
CNS 01-15 Oct	-2.05251	0.37851
CNS 16-31 Oct	-4.13775	0.52425
SNS 12-31 Dec	-1.79694	0.37487
SNS 01-15 Jan	-2.46444	0.32487
SNS 16-31 Jan	-3.43855	0.36116

Table 2.3.2.5: North Sea autumn spawners. Time-series of the Multiplicative Larval Abundance Index (MLAI). The original MLAI is given in the second column. $MLAI_{plus}$ is the sum of the MLAI and the value of the reference area (Orkney/Shetlands, 1^{st}-15^{th} September 1972). This estimate is then unlogged (eMLAI) and divided by 100 ($MLAI_{assess}$). The $MLAI_{assess}$ describes the time-series that is used in the assessment.

Reference Value:	6.81331

Year	MLAI	$MLAI_{plus}$	eMLAI	$MLAI_{assess}$
1973	0.36421	7.1775	1309.66	**13.097**
1974	-0.13565	6.6777	794.46	**7.945**
1975	-1.20382	5.6095	273	**2.73**
1976	-1.30869	5.5046	245.82	**2.458**
1977	-0.39908	6.4142	610.47	**6.105**
1978	-0.21089	6.6024	736.88	**7.369**
1979	0.46102	7.2743	1442.78	**14.428**
1980	0.08025	6.8936	985.91	**9.859**
1981	0.46853	7.2818	1453.66	**14.537**
1982	0.83775	7.6511	2102.88	**21.029**
1983	1.08677	7.9001	2697.49	**26.975**
1984	1.67991	8.4932	4881.58	**48.816**
1985	2.10061	8.9139	7434.74	**74.347**
1986	1.44595	8.2593	3863.25	**38.632**
1987	2.01122	8.8245	6799.02	**67.99**
1988	2.6965	9.5098	13491.46	**134.915**
1989	2.6714	9.4847	13157.08	**131.571**
1990	2.93112	9.7444	17058.94	**170.589**
1991	2.288	9.1013	8967.01	**89.67**
1992	1.52678	8.3401	4188.46	**41.885**
1993	1.18798	8.0013	2984.82	**29.848**
1994	0.81965	7.633	2065.17	**20.652**
1995	0.91582	7.7291	2273.63	**22.736**
1996	1.5926	8.4059	4473.42	**44.734**
1997	1.83934	8.6527	5725.33	**57.253**
1998	2.10117	8.9145	7438.89	**74.389**
1999	1.91752	8.7308	6190.9	**61.909**
2000	1.50754	8.3208	4108.65	**41.087**
2001	2.6618	9.4751	13031.31	**130.313**
2002	2.50106	9.3144	11096.36	**110.964**
2003	3.39638	10.2097	27165.27	**271.653**
2004	3.56639	10.3797	32199.47	**321.995**
2005	3.05304	9.8663	19270.81	**192.708**
2006	2.56592	9.3792	11839.94	**118.399**

Table 2.3.3.1. North Sea herring. Indices of 2-5+ ringers from the 1st quarter IBTS

YEAR OF SAMPLING	2-RINGER	3-RINGER	4-RINGER	5+ RINGER
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

Table 2.3.3.2. North Sea herring. Estimates of mean number per hour per statistical rectangle from 1st quarter IBTS 2007. Means for age groups in "Roundfish areas" (*) and in all areas. In the index 2-5+ for all areas, the findings in RF8 and RF9 are not included.

AREA	TOTAL	MEAN PER STATISTICAL RECTANGLE				
		AGE GROUP (WR)				
		1	2	3	4	5+
All areas		1336	41	18	8	41
RF1	294.9	0.0	33.4	64.0	28.2	169.3
RF2	158.8	149.5	8.3	0.8	0.0	0.2
RF3	95.8	84.9	9.8	0.8	0.0	0.4
RF4	83.1	36.9	23.6	7.4	14.9	0.3
RF5	645.7	601.5	24.2	13.4	3.8	2.7
RF6	2957.9	2912.5	44.7	0.4	0.0	0.2
RF7	4755.0	4566.0	186.8	1.9	0.0	0.3
RF8	1005.2	764.7	213.5	10.6	6.9	9.5
RF9	13332.9	10385.5	2636.4	266.3	44.7	0.0

***) "Roundfish areas" are shown in the IBTS Manual (Add. ICES CM 2002/D:03)**

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

Table 2.3.3.4 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**

Table 2.4.1.1: North Sea Herring: Mean weight-at-age (wr) in the third quarter, in Divisions IVa, IVb and IIIa

RING	THIRD QUARTER MEAN WTS IN CATCH (DIVISIONS IVA, IVB & IIIA)											JULY ACOUSTIC SURVEY										
	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
1	75	43	54	62	54	69	50	65	45	53	61	45	45	52	52	46	50	45	46	35	43	45
2	135.1	129	131	128	123	136	140	119	125	124	139	119	120	109	118	118	127	138	104	116	135	127
3	186.3	175	172	163	172	167	177	177	159	177	163	196	168	198	171	180	162	172	185	139	171	158
4	224.3	220	209	193	201	199	200	198	203	201	192	253	233	238	207	218	204	194	209	206	181	188
5	229.3	247	237	228	228	218	224	210	234	234	205	262	256	275	236	232	228	224	214	231	229	188
6	252.6	255	263	252	241	237	244	236	250	249	242	299	245	307	267	261	237	247	243	253	248	225
7	291.6	278	269	263	266	262	252	247	264	261	257	306	265	289	272	295	255	261	281	262	253	243
8	300.3	295	313	275	286	288	281	272	262	287	260	325	269	308	230	300	286	280	290	279	274	244
9+	302.3	295	298	306	271	298	298	282	299	270	285	335	329	363	260	280	294	249	307	270	295	265

Weights-at-age in the catch for 1996 to 2001 were revised by SG Rednose for details of the revision see last years report (ICES ACFM).

Table 2.4.2.1 North Sea herring. Percentage maturity at 2-, 3- and 4+ ring for Autumn Spawning herring in the North Sea. The values are derived from the acoustic survey for 1988 to 2006.

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

Table 2.6.1 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	1972-2006	1973-2006
IBTS 1st Quarter (Trawl survey)	1-5wr	1971-2007	1984-2007
Acoustic (+trawl)	1wr	1995-2006	1997-2006
	2-9+wr	1984-2006	1989-2006
MIK net	0wr	1977-2007	1992-2007

Table 2.6.2 North Sea herring. Percentage change in estimated mean F2-6, SSB, TSB and Recruitment in years 2001 to 2006 produced by removing points values in the surveys that show high residuals in the assessment.

Year	Acoust ic 1 wr in 2005 and 20066	IBTS 2 wr in 2006 and 2007	Mik est 0 wr in 2004	MLAI est of SSB 2003 and 2004
			F 2-6	
2001	0%	0%	0%	2%
2002	0%	0%	0%	3%
2003	0%	0%	0%	4%
2004	-1%	1%	-1%	4%
2005	-1%	1%	-1%	4%
2006	-3%	2%	-3%	5%
			SSB	
2001	0%	0%	0%	-3%
2002	0%	0%	0%	-3%
2003	1%	0%	1%	-4%
2004	1%	-1%	1%	-5%
2005	1%	-1%	1%	-5%
2006	3%	-2%	3%	-6%
			TSB	
2001	0%	0%	0%	-2%
2002	1%	-1%	1%	-3%
2003	1%	0%	1%	-3%
2004	1%	-1%	1%	-4%
2005	1%	0%	2%	-4%
2006	0%	2%	2%	-4%
			Recruitment (yearclass)	
2000	1%	-1%	1%	-3%
2001	1%	-1%	1%	-2%
2002	2%	-1%	1%	-2%
2003	8%	-7%	7%	-2%
2004	-19%	33%	0%	-1%
2005	-1%	1%	-1%	-1%

Table 2.6.3 North Sea herring. Final assessment ICA log file . Note age=ringer.

```
                         Integrated Catch at Age Analysis
                       --------------------------------
                                 Version 1.4 w

                                 K.R.Patterson
                          Fisheries Research Services
                               Marine Laboratory
                                   Aberdeen

                                  24 August 1999

 Type * to change language
 Enter the name of the index file -->index.txt
canum.txt
weca.txt
 Stock weights in 2007  used for the year 2006
west.txt
 Natural mortality in 2007  used for the year 2006
natmor.txt
 Maturity ogive in 2007  used for the year 2006
matprop.txt
 Name of age-structured index file (Enter if none) : -->fleet.txt
 Name of the SSB index file (Enter if none) -->SSB
File not found: SSB
 Name of the SSB index file (Enter if none) -->SSB.txt
 No of years for separable constraint ?--> 5
 Reference age for separable constraint ?--> 4
 Constant selection pattern model (Y/N) ?-->y
 S to be fixed on last age ?-->    1.000000000000000
 First age for calculation of reference F ?--> 2
 Last age for calculation of reference F ?--> 6
 Use default weighting (Y/N) ?-->n

Enter relative weights at age
 Weight for age 0-->    0.100000000000000
 Weight for age 1-->    0.100000000000000
 Weight for age 2-->    3.670000000000000
 Weight for age 3-->    2.870000000000000
 Weight for age 4-->    2.230000000000000
 Weight for age 5-->    1.740000000000000
 Weight for age 6-->    1.370000000000000
 Weight for age 7-->    1.040000000000000
 Weight for age 8-->    0.940000000000000
 Weight for age 9-->    0.910000000000000

Enter relative weights by year
 Weight for year 2002-->    1.000000000000000
 Weight for year 2003-->    1.000000000000000
 Weight for year 2004-->    1.000000000000000
 Weight for year 2005-->    1.000000000000000
 Weight for year 2006-->    1.000000000000000

Enter new weights for specified years and ages if needed
 Enter year, age, new weight or -1,-1,-1 to end.  -1 -1   -1.000000000000000
 Is the last age of Acoustic survey 1-9+ wr a plus-group (Y/N) ?-->y
 Is the last age of IBTS1: 1-5+ wr a plus-group (Y/N) ?-->y
 Is the last age of MIK 0-wr a plus-group (Y/N) ?-->n
```

Table 2.6.3(cont) North Sea herring. Final assessment ICA log file . Note age=ringer.

```
You must choose a catchability model for each index.

Models:   A  Absolute:  Index = Abundance . e
          L  Linear:    Index = Q. Abundance . e
          P  Power:     Index = Q. Abundance^ K .e

   where Q and K are parameters to be estimated, and
   e is a lognormally-distributed error.

 Model for   MLAI  is to be A/L/P ?-->p
 Model for Acoustic survey 1-9+ wr  is to be A/L/P ?-->L
 Model for IBTS1: 1-5+ wr  is to be A/L/P ?-->L
 Model for MIK 0-wr  is to be A/L/P ?-->L
 Fit a stock-recruit relationship (Y/N) ?-->y
Enter the time lag in years between spawning and the stock size
 of fish aged 0  years on 1 January.
This will probably be 0 unless the stock is an autumn-spawning herring
 in which case it will probably be 1  years.
 Enter the lag in years (rounded up)--> 1
 Enter lowest feasible F-->   2.0000000000000000E-02
 Enter highest feasible F-->    0.500000000000000
Mapping the F-dimension of the SSQ surface

    F                  SSQ
+--------+------------------
    0.02       123.3974328218
    0.05        81.0648173194
    0.07        60.9889192791
    0.10        48.6616599867
    0.12        40.4041715837
    0.15        34.6450957408
    0.17        30.5385725459
    0.20        27.5729749766
    0.22        25.4183334268
    0.25        23.8529324093
    0.27        22.7235141854
    0.30        21.9217861351
    0.32        21.3698238771
    0.35        21.0106665969
    0.37        20.8020895893
    0.40        20.7123931302
    0.42        20.7175014351
    0.45        20.7989339979
    0.47        20.9423659141
    0.50        21.1365925135
Lowest SSQ is for F =     0.409
-----------------------------------------------------------------
No of years for separable analysis : 5
Age range in the analysis : 0  . . . 9
Year range in the analysis : 1960  . . . 2006
Number of indices of SSB : 1
Number of age-structured indices : 3
Stock-recruit relationship to be fitted.
Parameters to estimate : 45
Number of observations : 415
```

Table 2.6.3(cont) North Sea herring. Final assessment ICA log file . Note age=ringer.

```
Conventional single selection vector model to be fitted.
-----------------------------------------------------------------
 Survey weighting to be Manual (recommended) or Iterative (M/I) ?-->m
 Enter weight for   MLAI-->    0.600000000000000
 Enter weight for Acoustic survey 1-9+ wr  at age 1-->    0.630000000000000
 Enter weight for Acoustic survey 1-9+ wr  at age 2-->    0.620000000000000
 Enter weight for Acoustic survey 1-9+ wr  at age 3-->    0.170000000000000
 Enter weight for Acoustic survey 1-9+ wr  at age 4-->    0.100000000000000
 Enter weight for Acoustic survey 1-9+ wr  at age 5-->   8.9999999999999997E-02
 Enter weight for Acoustic survey 1-9+ wr  at age 6-->   8.0000000000000002E-02
 Enter weight for Acoustic survey 1-9+ wr  at age 7-->   7.0000000000000007E-02
 Enter weight for Acoustic survey 1-9+ wr  at age 8-->   7.0000000000000007E-02
 Enter weight for Acoustic survey 1-9+ wr  at age 9-->   5.0000000000000003E-02
 Enter weight for IBTS1: 1-5+ wr  at age 1-->    0.470000000000000
 Enter weight for IBTS1: 1-5+ wr  at age 2-->    0.280000000000000
 Enter weight for IBTS1: 1-5+ wr  at age 3-->   1.0000000000000000E-02
 Enter weight for IBTS1: 1-5+ wr  at age 4-->   1.0000000000000000E-02
 Enter weight for IBTS1: 1-5+ wr  at age 5-->   1.0000000000000000E-02
 Enter weight for MIK 0-wr  at age 0-->    0.630000000000000
 Enter weight for stock-recruit model-->    0.100000000000000
Enter estimates of the extent to which errors
in the age-structured indices are correlated
across ages. This can be in the range 0 (independence)
to 1 (correlated errors).
  Enter value for Acoustic survey 1-9+ wr-->  0.0000000000000000E+000
  Enter value for IBTS1: 1-5+ wr-->  0.0000000000000000E+000
  Enter value for MIK 0-wr-->  0.0000000000000000E+000
 Do you want to shrink the final fishing mortality (Y/N) ?-->n
Seeking solution. Please wait.
SSB index weights
  0.600
Aged index weights
Acoustic survey 1-9+ wr
 Age   :      1     2     3     4     5     6     7     8     9
 Wts :     0.630 0.620 0.170 0.100 0.090 0.080 0.070 0.070 0.050
IBTS1: 1-5+ wr
 Age   :      1     2     3     4     5
 Wts :     0.470 0.280 0.010 0.010 0.010
MIK 0-wr
 Age   :      0
 Wts :     0.630
 Stock-recruit weight           0.100
F in 2006  at age 4  is 0.403166  in iteration 1
 Detailed, Normal or Summary output (D/N/S)-->D
 Output page width in characters (e.g. 80..132) ?--> 80
 Estimate historical assessment uncertainty ?-->y
 Sample from Covariances or Bayes MCMC (C/B) ?-->c
 Use default percentiles (Y/N)  ?-->n
 Enter the number of percentiles required--> 5
 Enter a percentile-->    5.000000000000000
 Enter a percentile-->   25.000000000000000
 Enter a percentile-->   50.000000000000000
 Enter a percentile-->   75.000000000000000
 Enter a percentile-->   95.000000000000000
```

Table 2.6.4 North Sea herring. Final model fit ICA output. Note age=ringer

Catch in Number

AGE	1960	1961	1962	1963	1964	1965	1966	1967
0	195.	1269.	142.	443.	497.	157.	375.	645.
1	2393.	336.	2147.	1262.	2972.	3209.	1383.	1674.
2	1142.	1889.	270.	2961.	1548.	2218.	2570.	1172.
3	1967.	480.	797.	177.	2243.	1325.	741.	1365.
4	166.	1456.	335.	158.	148.	2039.	450.	372.
5	168.	124.	1082.	81.	149.	145.	890.	298.
6	113.	158.	127.	230.	95.	152.	45.	393.
7	126.	61.	145.	22.	256.	118.	65.	68.
8	129.	56.	86.	42.	26.	413.	96.	82.
9	142.	88.	87.	51.	58.	78.	236.	173.

x 10 ^ 6

Catch in Number

AGE	1968	1969	1970	1971	1972	1973	1974	1975
0	839.	112.	898.	684.	750.	289.	996.	264.
1	2425.	2503.	1196.	4379.	3341.	2368.	846.	2461.
2	1795.	1883.	2003.	1147.	1441.	1344.	773.	542.
3	1494.	296.	884.	663.	344.	659.	362.	260.
4	621.	133.	125.	208.	131.	150.	126.	141.
5	157.	191.	50.	27.	33.	59.	56.	57.
6	145.	50.	61.	31.	5.	31.	22.	16.
7	163.	43.	8.	27.	0.	4.	5.	9.
8	14.	27.	12.	0.	1.	1.	2.	3.
9	92.	25.	12.	12.	0.	1.	1.	1.

x 10 ^ 6

Catch in Number

AGE	1976	1977	1978	1979	1980	1981	1982	1983
0	238.	257.	130.	542.	1263.	9520.	11957.	13297.
1	127.	144.	169.	159.	245.	872.	1116.	2449.
2	902.	45.	5.	34.	134.	284.	299.	574.
3	117.	186.	6.	10.	92.	57.	230.	216.
4	52.	11.	5.	10.	32.	40.	34.	105.
5	35.	7.	0.	2.	22.	29.	14.	26.
6	6.	4.	0.	0.	2.	23.	7.	23.
7	4.	2.	0.	1.	1.	19.	8.	13.
8	1.	1.	0.	1.	0.	6.	4.	11.
9	0.	0.	0.	0.	0.	1.	1.	12.

x 10 ^ 6

Catch in Number

AGE	1984	1985	1986	1987	1988	1989	1990	1991
0	6973.	4211.	3725.	8229.	3165.	3058.	1303.	2387.
1	1818.	3253.	4801.	6836.	7867.	3146.	3020.	2139.
2	1146.	1326.	1267.	2137.	2233.	1594.	899.	1133.
3	441.	1182.	841.	668.	1091.	1364.	779.	557.
4	202.	369.	466.	467.	384.	809.	861.	549.
5	81.	125.	130.	246.	256.	212.	388.	501.
6	23.	44.	62.	75.	128.	124.	80.	205.
7	25.	20.	21.	24.	38.	61.	54.	39.
8	11.	13.	14.	8.	15.	20.	29.	26.
9	19.	16.	15.	8.	9.	9.	12.	13.

x 10 ^ 6

Table 2.6.4 (Cont) North Sea herring. Final model fit ICA output. Note age=ringer

Catch in Number

AGE	1992	1993	1994	1995	1996	1997	1998	1999
0	10331.	10265.	4499.	7438.	2311.	431.	260.	1566.
1	2303.	3827.	1785.	1665.	1606.	480.	978.	304.
2	1285.	1176.	1783.	1444.	642.	688.	1220.	616.
3	443.	609.	489.	817.	526.	447.	538.	1059.
4	362.	306.	348.	232.	172.	285.	276.	294.
5	361.	216.	109.	119.	58.	109.	176.	136.
6	376.	226.	92.	55.	23.	31.	89.	69.
7	152.	188.	76.	41.	9.	12.	15.	28.
8	39.	87.	70.	69.	17.	19.	17.	10.
9	23.	42.	47.	29.	4.	6.	4.	2.

x 10 ^ 6

Catch in Number

AGE	2000	2001	2002	2003	2004	2005	2006
0	1105.	1833.	730.	369.	716.	1016.	879.
1	1172.	614.	838.	617.	207.	716.	222.
2	623.	843.	580.	1222.	448.	355.	401.
3	463.	486.	971.	529.	1366.	486.	311.
4	647.	279.	292.	836.	543.	1319.	465.
5	213.	322.	141.	245.	753.	480.	998.
6	82.	91.	175.	108.	169.	576.	252.
7	36.	38.	49.	123.	105.	115.	247.
8	15.	18.	35.	38.	65.	88.	63.
9	2.	3.	9.	9.	32.	58.	4.

x 10 ^ 6

Predicted Catch in Number

AGE	2002	2003	2004	2005	2006
0	844.9	508.3	699.6	684.5	1034.3
1	1310.1	453.0	302.6	459.9	335.5
2	535.3	1268.2	484.4	352.6	398.9
3	906.2	524.4	1365.7	560.5	301.1
4	291.4	888.5	561.7	1545.3	464.3
5	174.9	217.5	722.7	477.7	948.9
6	170.4	118.0	159.8	553.5	262.8
7	52.9	111.0	83.7	118.4	294.3
8	33.0	33.1	75.8	59.9	60.8

x 10 ^ 6

Weights at age in the catches (Kg)

AGE	1960	1961	1962	1963	1964	1965	1966	1967
0	0.01500	0.01500	0.01500	0.01500	0.01500	0.01500	0.01500	0.01500
1	0.05000	0.05000	0.05000	0.05000	0.05000	0.05000	0.05000	0.05000
2	0.12600	0.12600	0.12600	0.12600	0.12600	0.12600	0.12600	0.12600
3	0.17600	0.17600	0.17600	0.17600	0.17600	0.17600	0.17600	0.17600
4	0.21100	0.21100	0.21100	0.21100	0.21100	0.21100	0.21100	0.21100
5	0.24300	0.24300	0.24300	0.24300	0.24300	0.24300	0.24300	0.24300
6	0.25100	0.25100	0.25100	0.25100	0.25100	0.25100	0.25100	0.25100
7	0.26700	0.26700	0.26700	0.26700	0.26700	0.26700	0.26700	0.26700
8	0.27100	0.27100	0.27100	0.27100	0.27100	0.27100	0.27100	0.27100
9	0.27100	0.27100	0.27100	0.27100	0.27100	0.27100	0.27100	0.27100

Table 2.6.4 (Cont) North Sea herring. Final model fit ICA output. Note age=ringer

Weights at age in the catches (Kg)

AGE	1968	1969	1970	1971	1972	1973	1974	1975
0	0.01500	0.01500	0.01500	0.01500	0.01500	0.01500	0.01500	0.01500
1	0.05000	0.05000	0.05000	0.05000	0.05000	0.05000	0.05000	0.05000
2	0.12600	0.12600	0.12600	0.12600	0.12600	0.12600	0.12600	0.12600
3	0.17600	0.17600	0.17600	0.17600	0.17600	0.17600	0.17600	0.17600
4	0.21100	0.21100	0.21100	0.21100	0.21100	0.21100	0.21100	0.21100
5	0.24300	0.24300	0.24300	0.24300	0.24300	0.24300	0.24300	0.24300
6	0.25100	0.25100	0.25100	0.25100	0.25100	0.25100	0.25100	0.25100
7	0.26700	0.26700	0.26700	0.26700	0.26700	0.26700	0.26700	0.26700
8	0.27100	0.27100	0.27100	0.27100	0.27100	0.27100	0.27100	0.27100
9	0.27100	0.27100	0.27100	0.27100	0.27100	0.27100	0.27100	0.27100

Weights at age in the catches (Kg)

AGE	1976	1977	1978	1979	1980	1981	1982	1983
0	0.01500	0.01500	0.01500	0.01500	0.01500	0.00700	0.01000	0.01000
1	0.05000	0.05000	0.05000	0.05000	0.05000	0.04900	0.05900	0.05900
2	0.12600	0.12600	0.12600	0.12600	0.12600	0.11800	0.11800	0.11800
3	0.17600	0.17600	0.17600	0.17600	0.17600	0.14200	0.14900	0.14900
4	0.21100	0.21100	0.21100	0.21100	0.21100	0.18900	0.17900	0.17900
5	0.24300	0.24300	0.24300	0.24300	0.24300	0.21100	0.21700	0.21700
6	0.25100	0.25100	0.25100	0.25100	0.25100	0.22200	0.23800	0.23800
7	0.26700	0.26700	0.26700	0.26700	0.26700	0.26700	0.26500	0.26500
8	0.27100	0.27100	0.27100	0.27100	0.27100	0.27100	0.27400	0.27400
9	0.27100	0.27100	0.27100	0.27100	0.27100	0.27100	0.27500	0.27500

Weights at age in the catches (Kg)

AGE	1984	1985	1986	1987	1988	1989	1990	1991
0	0.01000	0.00900	0.00600	0.01100	0.01100	0.01700	0.01900	0.01700
1	0.05900	0.03600	0.06700	0.03500	0.05500	0.04300	0.05500	0.05800
2	0.11800	0.12800	0.12100	0.09900	0.11100	0.11500	0.11400	0.13000
3	0.14900	0.16400	0.15300	0.15000	0.14500	0.15300	0.14900	0.16600
4	0.17900	0.19400	0.18200	0.18000	0.17400	0.17300	0.17700	0.18400
5	0.21700	0.21100	0.20800	0.21100	0.19700	0.20800	0.19300	0.20300
6	0.23800	0.22000	0.22100	0.23400	0.21600	0.23100	0.22900	0.21700
7	0.26500	0.25800	0.23800	0.25800	0.23700	0.24700	0.23600	0.23500
8	0.27400	0.27000	0.25200	0.27700	0.25300	0.26500	0.25000	0.25900
9	0.27500	0.29200	0.26200	0.29900	0.26300	0.25900	0.28700	0.27100

Weights at age in the catches (Kg)

AGE	1992	1993	1994	1995	1996	1997	1998	1999
0	0.01000	0.01000	0.00600	0.00900	0.01500	0.01500	0.02100	0.00900
1	0.05300	0.03300	0.05600	0.04200	0.01800	0.04400	0.05100	0.04500
2	0.10200	0.11500	0.13000	0.13000	0.11200	0.10800	0.11400	0.11500
3	0.17500	0.14500	0.15900	0.16900	0.15600	0.14800	0.14500	0.15100
4	0.18900	0.18900	0.18100	0.19800	0.18800	0.19500	0.18300	0.17100
5	0.20700	0.20400	0.21400	0.20700	0.20400	0.22700	0.21900	0.20700
6	0.22300	0.22800	0.24000	0.24300	0.21200	0.22600	0.23800	0.23300
7	0.23700	0.24400	0.25500	0.24700	0.26100	0.23500	0.24700	0.24500
8	0.24900	0.25600	0.27300	0.28300	0.28000	0.24400	0.28900	0.26100
9	0.28700	0.31000	0.28100	0.27600	0.28800	0.29100	0.28300	0.30100

Table 2.6.4 (Cont) North Sea herring. Final model fit ICA output. Note age=ringer

Weights at age in the catches (Kg)

AGE	2000	2001	2002	2003	2004	2005	2006
0	0.01500	0.01200	0.01200	0.01400	0.01400	0.01100	0.01000
1	0.03300	0.04800	0.03700	0.03700	0.03600	0.04400	0.04900
2	0.11300	0.11800	0.11800	0.10400	0.10000	0.09900	0.11700
3	0.15700	0.14900	0.15300	0.15800	0.13800	0.15300	0.14400
4	0.17900	0.17700	0.17000	0.17400	0.18300	0.16600	0.17200
5	0.20100	0.19800	0.19900	0.18400	0.20100	0.20800	0.18100
6	0.21600	0.21300	0.21400	0.20500	0.21600	0.22300	0.22000
7	0.24600	0.23800	0.22800	0.22200	0.22800	0.24000	0.23700
8	0.27500	0.26700	0.25000	0.23200	0.24600	0.25700	0.23500
9	0.26200	0.28800	0.25200	0.25600	0.27200	0.27800	0.26200

Weights at age in the stock (Kg)

AGE	1960	1961	1962	1963	1964	1965	1966	1967
0	0.01500	0.01500	0.01500	0.01500	0.01500	0.01500	0.01500	0.01500
1	0.05000	0.05000	0.05000	0.05000	0.05000	0.05000	0.05000	0.05000
2	0.15500	0.15500	0.15500	0.15500	0.15500	0.15500	0.15500	0.15500
3	0.18700	0.18700	0.18700	0.18700	0.18700	0.18700	0.18700	0.18700
4	0.22300	0.22300	0.22300	0.22300	0.22300	0.22300	0.22300	0.22300
5	0.23900	0.23900	0.23900	0.23900	0.23900	0.23900	0.23900	0.23900
6	0.27600	0.27600	0.27600	0.27600	0.27600	0.27600	0.27600	0.27600
7	0.29900	0.29900	0.29900	0.29900	0.29900	0.29900	0.29900	0.29900
8	0.30600	0.30600	0.30600	0.30600	0.30600	0.30600	0.30600	0.30600
9	0.31200	0.31200	0.31200	0.31200	0.31200	0.31200	0.31200	0.31200

Weights at age in the stock (Kg)

AGE	1968	1969	1970	1971	1972	1973	1974	1975
0	0.01500	0.01500	0.01500	0.01500	0.01500	0.01500	0.01500	0.01500
1	0.05000	0.05000	0.05000	0.05000	0.05000	0.05000	0.05000	0.05000
2	0.15500	0.15500	0.15500	0.15500	0.15500	0.15500	0.15500	0.15500
3	0.18700	0.18700	0.18700	0.18700	0.18700	0.18700	0.18700	0.18700
4	0.22300	0.22300	0.22300	0.22300	0.22300	0.22300	0.22300	0.22300
5	0.23900	0.23900	0.23900	0.23900	0.23900	0.23900	0.23900	0.23900
6	0.27600	0.27600	0.27600	0.27600	0.27600	0.27600	0.27600	0.27600
7	0.29900	0.29900	0.29900	0.29900	0.29900	0.29900	0.29900	0.29900
8	0.30600	0.30600	0.30600	0.30600	0.30600	0.30600	0.30600	0.30600
9	0.31200	0.31200	0.31200	0.31200	0.31200	0.31200	0.31200	0.31200

Weights at age in the stock (Kg)

AGE	1976	1977	1978	1979	1980	1981	1982	1983
0	0.01500	0.01500	0.01500	0.01500	0.01500	0.01500	0.01500	0.01700
1	0.05000	0.05000	0.05000	0.05000	0.05000	0.05000	0.05000	0.05700
2	0.15500	0.15500	0.15500	0.15500	0.15500	0.15500	0.15500	0.15000
3	0.18700	0.18700	0.18700	0.18700	0.18700	0.18700	0.18700	0.19000
4	0.22300	0.22300	0.22300	0.22300	0.22300	0.22300	0.22300	0.23000
5	0.23900	0.23900	0.23900	0.23900	0.23900	0.23900	0.23900	0.24300
6	0.27600	0.27600	0.27600	0.27600	0.27600	0.27600	0.27600	0.28200
7	0.29900	0.29900	0.29900	0.29900	0.29900	0.29900	0.29900	0.31100
8	0.30600	0.30600	0.30600	0.30600	0.30600	0.30600	0.30600	0.33800
9	0.31200	0.31200	0.31200	0.31200	0.31200	0.31200	0.31200	0.34700

Table 2.6.4 (Cont) North Sea herring. Final model fit ICA output. Note age=ringer

Weights at age in the stock (Kg)

AGE	1984	1985	1986	1987	1988	1989	1990	1991
0	0.01600	0.01400	0.00900	0.00800	0.00800	0.01200	0.01100	0.01000
1	0.05600	0.06100	0.05000	0.04800	0.04400	0.05200	0.05900	0.06400
2	0.13800	0.13000	0.12200	0.12300	0.12200	0.12600	0.13900	0.13700
3	0.18700	0.18300	0.17000	0.16600	0.16500	0.17400	0.18400	0.19400
4	0.23200	0.23200	0.21200	0.20800	0.20500	0.21200	0.21200	0.21400
5	0.24700	0.25200	0.23000	0.22900	0.22800	0.24400	0.23900	0.23400
6	0.27500	0.27300	0.24200	0.24800	0.25200	0.27000	0.26500	0.25300
7	0.32100	0.31500	0.27500	0.25900	0.26100	0.28400	0.28000	0.27100
8	0.34100	0.33200	0.26800	0.26300	0.27700	0.29800	0.30000	0.29100
9	0.36500	0.39200	0.34300	0.32500	0.31500	0.33100	0.32800	0.31200

Weights at age in the stock (Kg)

AGE	1992	1993	1994	1995	1996	1997	1998	1999
0	0.00600	0.00700	0.00600	0.00600	0.00500	0.00600	0.00600	0.00600
1	0.06100	0.06000	0.05700	0.05400	0.04900	0.04700	0.05100	0.05100
2	0.13400	0.12700	0.13000	0.13000	0.12300	0.11600	0.11600	0.11600
3	0.18400	0.19200	0.18600	0.19900	0.18300	0.18700	0.17900	0.18400
4	0.21300	0.21400	0.21100	0.22800	0.23000	0.24100	0.22600	0.22100
5	0.23500	0.24000	0.22400	0.23400	0.23700	0.26400	0.25600	0.24800
6	0.26200	0.27500	0.26800	0.27400	0.25700	0.28400	0.27300	0.27900
7	0.27300	0.29100	0.29300	0.30100	0.28000	0.28700	0.27600	0.28600
8	0.30200	0.30900	0.31800	0.32400	0.30300	0.30100	0.27000	0.28100
9	0.32000	0.33800	0.34600	0.34400	0.33400	0.34200	0.31800	0.30300

Weights at age in the stock (Kg)

AGE	2000	2001	2002	2003	2004	2005	2006
0	0.00600	0.00600	0.00700	0.00700	0.00600	0.00700	0.00600
1	0.05100	0.04700	0.04700	0.04200	0.04100	0.04100	0.04400
2	0.12200	0.12800	0.12300	0.11900	0.11800	0.12600	0.13100
3	0.17200	0.17200	0.17300	0.16500	0.16500	0.15500	0.16400
4	0.21000	0.20500	0.20200	0.20300	0.19800	0.19100	0.18400
5	0.23300	0.22800	0.22200	0.22300	0.22500	0.21600	0.20800
6	0.25500	0.24800	0.24200	0.24800	0.24800	0.24200	0.23600
7	0.27500	0.27000	0.26600	0.26800	0.26500	0.25200	0.24800
8	0.27400	0.28900	0.28500	0.28300	0.28100	0.26600	0.25900
9	0.28000	0.27500	0.28300	0.27500	0.29100	0.27700	0.28000

Natural Mortality (per year)

AGE	1960	1961	1962	1963	1964	1965	1966	1967
0	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
2	0.3000	0.3000	0.3000	0.3000	0.3000	0.3000	0.3000	0.3000
3	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000
4	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000
5	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000
6	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000
7	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000
8	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000
9	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000

Table 2.6.4 (Cont) North Sea herring. Final model fit ICA output. Note age=ringer

Natural Mortality (per year)

AGE	1968	1969	1970	1971	1972	1973	1974	1975
0	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
2	0.3000	0.3000	0.3000	0.3000	0.3000	0.3000	0.3000	0.3000
3	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000
4	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000
5	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000
6	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000
7	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000
8	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000
9	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000

Natural Mortality (per year)

AGE	1976	1977	1978	1979	1980	1981	1982	1983
0	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
2	0.3000	0.3000	0.3000	0.3000	0.3000	0.3000	0.3000	0.3000
3	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000
4	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000
5	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000
6	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000
7	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000
8	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000
9	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000

Natural Mortality (per year)

AGE	1984	1985	1986	1987	1988	1989	1990	1991
0	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
2	0.3000	0.3000	0.3000	0.3000	0.3000	0.3000	0.3000	0.3000
3	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000
4	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000
5	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000
6	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000
7	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000
8	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000
9	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000

Natural Mortality (per year)

AGE	1992	1993	1994	1995	1996	1997	1998	1999
0	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
2	0.3000	0.3000	0.3000	0.3000	0.3000	0.3000	0.3000	0.3000
3	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000
4	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000
5	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000
6	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000
7	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000
8	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000
9	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000

Table 2.6.4 (Cont) North Sea herring. Final model fit ICA output. Note age=ringer

Natural Mortality (per year)

AGE	2000	2001	2002	2003	2004	2005	2006
0	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
2	0.3000	0.3000	0.3000	0.3000	0.3000	0.3000	0.3000
3	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000
4	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000
5	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000
6	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000
7	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000
8	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000
9	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000

Proportion of fish spawning

AGE	1960	1961	1962	1963	1964	1965	1966	1967
0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
3	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
4	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
5	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
6	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
7	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
8	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
9	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

Proportion of fish spawning

AGE	1968	1969	1970	1971	1972	1973	1974	1975
0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2	1.0000	1.0000	1.0000	1.0000	0.8200	0.8200	0.8200	0.8200
3	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
4	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
5	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
6	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
7	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
8	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
9	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

Proportion of fish spawning

AGE	1976	1977	1978	1979	1980	1981	1982	1983
0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2	0.8200	0.8200	0.8200	0.8200	0.8200	0.8200	0.8200	0.8200
3	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
4	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
5	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
6	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
7	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
8	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
9	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

Table 2.6.4 (Cont) North Sea herring. Final model fit ICA output. Note age=ringer

Proportion of fish spawning

AGE	1984	1985	1986	1987	1988	1989	1990	1991
0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2	0.8200	0.7000	0.7500	0.8000	0.8500	0.8200	0.9100	0.8600
3	1.0000	1.0000	1.0000	1.0000	0.9300	0.9400	0.9700	0.9900
4	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
5	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
6	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
7	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
8	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
9	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

Proportion of fish spawning

AGE	1992	1993	1994	1995	1996	1997	1998	1999
0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2	0.5000	0.4700	0.7300	0.6700	0.6100	0.6400	0.6400	0.6900
3	0.9900	0.6100	0.9300	0.9500	0.9800	0.9400	0.8900	0.9100
4	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
5	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
6	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
7	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
8	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
9	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

Proportion of fish spawning

AGE	2000	2001	2002	2003	2004	2005	2006
0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2	0.6700	0.7700	0.8700	0.4300	0.7000	0.7600	0.6600
3	0.9600	0.9200	0.9700	0.9300	0.6500	0.9600	0.8800
4	1.0000	1.0000	1.0000	1.0000	1.0000	0.9600	0.9800
5	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
6	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
7	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
8	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
9	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

INDICES OF SPAWNING BIOMASS

MLAI

	1973	1974	1975	1976	1977	1978	1979	1980
1	13.10	7.94	2.73	2.46	6.11	7.37	14.43	9.86

MLAI

	1981	1982	1983	1984	1985	1986	1987	1988
1	14.54	21.03	26.97	48.82	74.35	38.63	67.99	134.91

Table 2.6.4 (Cont) North Sea herring. Final model fit ICA output. Note age=ringer

MLAI

	1989	1990	1991	1992	1993	1994	1995	1996
1	131.57	170.59	89.67	41.88	29.85	20.65	22.74	44.73

MLAI

	1997	1998	1999	2000	2001	2002	2003	2004
1	57.25	74.39	61.91	41.09	130.31	110.96	271.65	321.99

MLAI

	2005	2006
1	192.71	118.40

AGE-STRUCTURED INDICES

Acoustic survey 1-9+ wr

AGE	1989	1990	1991	1992	1993	1994	1995	1996
1	999990.	999990.	999990.	999990.	999990.	999990.	999990.	999990.
2	4090.	3306.	2634.	3734.	2984.	3185.	3849.	4497.
3	3903.	3521.	1700.	1378.	1637.	839.	2041.	2824.
4	1633.	3414.	1959.	1147.	902.	399.	672.	1087.
5	492.	1366.	1849.	1134.	741.	381.	299.	311.
6	283.	392.	644.	1246.	777.	321.	203.	99.
7	120.	210.	228.	395.	551.	326.	138.	83.
8	44.	133.	94.	114.	180.	219.	119.	133.
9	22.	43.	51.	104.	116.	131.	93.	206.

x 10 ^ 3

Acoustic survey 1-9+ wr

AGE	1997	1998	1999	2000	2001	2002	2003	2004
1	9361.	4449.	5087.	24736.	6837.	23055.	9829.	5184.
2	5960.	5747.	3078.	2923.	12290.	4875.	18949.	3416.
3	2935.	2520.	4725.	2156.	3083.	8220.	3081.	9192.
4	1441.	1625.	1116.	3140.	1462.	1390.	4189.	2167.
5	601.	982.	506.	1007.	1676.	795.	675.	2591.
6	215.	445.	314.	483.	450.	1031.	495.	317.
7	46.	170.	139.	266.	170.	244.	568.	328.
8	78.	45.	54.	120.	98.	121.	146.	342.
9	159.	121.	87.	97.	59.	149.	178.	186.

x 10 ^ 3

Acoustic survey 1-9+ wr

AGE	2005	2006
1	3114.	6823.
2	2055.	3772.
3	3649.	1997.
4	5790.	2097.
5	1213.	4175.
6	1175.	618.
7	140.	562.
8	126.	84.
9	107.	70.

x 10 ^ 3

Table 2.6.4 (Cont) North Sea herring. Final model fit ICA output. Note age=ringer

IBTS1: 1-5+ wr

AGE	1984	1985	1986	1987	1988	1989	1990	1991
1	1515.6	2097.3	2662.8	3693.0	4394.2	2331.6	1061.6	1286.7
2	161.5	721.6	782.1	917.5	4163.4	875.3	462.1	693.0
3	61.4	282.0	276.0	116.3	791.5	338.5	279.8	258.6
4	26.9	42.1	79.0	59.4	58.0	89.4	269.1	221.5
5	10.2	27.9	28.1	48.8	25.1	8.5	71.3	146.1

IBTS1: 1-5+ wr

AGE	1992	1993	1994	1995	1996	1997	1998	1999
1	1268.1	2794.0	1752.1	1345.8	1890.9	4404.6	2275.8	752.9
2	436.6	787.4	1167.2	1392.9	197.5	506.5	791.6	450.6
3	193.1	222.6	213.1	278.5	32.9	162.7	95.7	501.3
4	54.8	45.0	69.0	36.7	10.2	30.5	20.8	98.2
5	92.3	65.5	42.5	6.6	8.1	19.9	17.8	35.6

IBTS1: 1-5+ wr

AGE	2000	2001	2002	2003	2004	2005	2006	2007
1	3725.1	2499.4	4064.8	2765.1	979.0	1001.6	922.0	1336.3
2	199.4	1129.3	658.2	1556.1	451.0	214.2	1464.3	40.7
3	154.7	317.1	338.2	611.9	777.3	356.0	330.0	18.2
4	58.8	93.9	25.0	360.0	112.4	388.9	251.7	8.4
5	9.0	68.3	19.9	53.2	171.2	131.5	338.8	40.9

MIK 0-wr

AGE	1992	1993	1994	1995	1996	1997	1998	1999
0	200.70	190.10	101.70	127.00	106.50	148.10	53.10	244.00

MIK 0-wr

AGE	2000	2001	2002	2003	2004	2005	2006	2007
0	137.10	214.80	161.80	54.40	47.30	61.30	83.10	37.20

Fishing Mortality (per year)

AGE	1960	1961	1962	1963	1964	1965	1966	1967
0	0.0257	0.0186	0.0049	0.0148	0.0126	0.0071	0.0215	0.0256
1	0.2557	0.1294	0.0897	0.1241	0.3084	0.2461	0.1852	0.2980
2	0.4364	0.6166	0.2502	0.2975	0.3889	0.7753	0.5921	0.4222
3	0.3285	0.3527	0.6260	0.2755	0.4123	0.7387	0.7082	0.8046
4	0.3375	0.4088	0.4220	0.2264	0.3702	0.7766	0.5716	0.9244
5	0.2666	0.4025	0.5348	0.1507	0.3068	0.6598	0.8343	0.8271
6	0.3130	0.3821	0.8179	0.1820	0.2379	0.5172	0.3903	1.0090
7	0.6088	0.2498	0.6379	0.2850	0.2824	0.4569	0.3852	1.5312
8	0.5634	0.5322	0.5790	0.3372	0.5568	0.8634	0.7312	1.0509
9	0.5634	0.5322	0.5790	0.3372	0.5568	0.8634	0.7312	1.0509

Table 2.6.4 (Cont) North Sea herring. Final model fit ICA output. Note age=ringer

Fishing Mortality (per year)

AGE	1968	1969	1970	1971	1972	1973	1974	1975
0	0.0348	0.0082	0.0351	0.0340	0.0583	0.0462	0.0749	0.1570
1	0.3002	0.3291	0.2681	0.6021	0.5781	0.6739	0.4514	0.6880
2	1.3272	0.7844	0.9728	0.8826	0.8121	1.0219	1.0287	1.3100
3	1.8720	0.9124	1.2669	1.2147	0.8014	1.3335	0.9725	1.5045
4	1.0715	0.8741	1.3303	1.2263	0.7996	0.9877	0.9932	1.3707
5	1.2340	1.0541	0.8755	1.0843	0.5494	0.9514	1.1856	1.8787
6	1.1729	1.9008	1.0800	2.6145	0.5173	1.3770	1.0784	1.2742
7	1.5948	1.2928	4.1124	2.7132	0.0981	0.8048	0.7714	2.0312
8	1.6467	1.3070	1.7058	1.9039	1.0387	1.5539	1.3299	2.0080
9	1.6467	1.3070	1.7058	1.9039	1.0387	1.5539	1.3299	2.0080

Fishing Mortality (per year)

AGE	1976	1977	1978	1979	1980	1981	1982	1983
0	0.1465	0.0975	0.0455	0.0837	0.1257	0.4818	0.3343	0.3996
1	0.2486	0.2966	0.2000	0.1665	0.1132	0.2853	0.2250	0.2516
2	1.3390	0.2245	0.0242	0.0947	0.3634	0.3241	0.2605	0.3020
3	1.4294	1.4112	0.0424	0.0663	0.4191	0.2751	0.5083	0.3243
4	1.7396	0.4259	0.1041	0.0935	0.2965	0.3034	0.2468	0.4365
5	1.5898	1.2081	0.0165	0.0523	0.2645	0.4114	0.1543	0.2751
6	1.0714	0.7257	0.0777	0.0123	0.0672	0.4300	0.1444	0.3446
7	1.4994	0.7402	0.0595	0.4405	0.1008	0.9674	0.2286	0.3895
8	1.6429	0.9525	0.1771	0.2270	0.3653	0.6135	0.4286	0.5099
9	1.6429	0.9525	0.1771	0.2270	0.3653	0.6135	0.4286	0.5099

Fishing Mortality (per year)

AGE	1984	1985	1986	1987	1988	1989	1990	1991
0	0.2263	0.0852	0.0619	0.1614	0.1247	0.1303	0.0589	0.1179
1	0.2051	0.3827	0.3157	0.3723	0.5800	0.4308	0.4528	0.3082
2	0.3144	0.4043	0.4592	0.4061	0.3556	0.3983	0.3769	0.5743
3	0.4295	0.6708	0.5225	0.5053	0.4006	0.4100	0.3695	0.4546
4	0.5368	0.7371	0.5814	0.5890	0.5814	0.5553	0.4674	0.4576
5	0.6273	0.6630	0.5532	0.6156	0.6641	0.6555	0.4994	0.4833
6	0.3590	0.7298	0.7302	0.6341	0.6728	0.7005	0.4911	0.4769
7	0.6955	0.5551	0.8164	0.6088	0.6882	0.7031	0.6797	0.4210
8	0.6080	0.8591	0.8008	0.7866	0.9017	0.8230	0.7593	0.7055
9	0.6080	0.8591	0.8008	0.7866	0.9017	0.8230	0.7593	0.7055

Fishing Mortality (per year)

AGE	1992	1993	1994	1995	1996	1997	1998	1999
0	0.2968	0.3762	0.2285	0.3231	0.0754	0.0248	0.0152	0.0364
1	0.3873	0.4222	0.2462	0.2969	0.2551	0.0453	0.1663	0.0499
2	0.5726	0.6688	0.6838	0.6004	0.3140	0.2888	0.2661	0.2595
3	0.4983	0.6407	0.7167	0.8672	0.4909	0.4016	0.4111	0.4159
4	0.5727	0.7334	0.9111	0.8682	0.4186	0.5129	0.4409	0.3923
5	0.5463	0.7112	0.5574	0.8229	0.4794	0.4530	0.6099	0.3579
6	0.7208	0.6991	0.6693	0.5397	0.3139	0.4629	0.7231	0.4565
7	0.6940	0.8759	0.4760	0.6445	0.1431	0.2410	0.3797	0.4619
8	0.8558	1.0015	0.8593	0.9310	0.5374	0.4211	0.5544	0.4168
9	0.8558	1.0015	0.8593	0.9310	0.5374	0.4211	0.5544	0.4168

Table 2.6.4 (Cont) North Sea herring. Final model fit ICA output. Note age=ringer

Fishing Mortality (per year)

AGE	2000	2001	2002	2003	2004	2005	2006
0	0.0446	0.0322	0.0434	0.0441	0.0501	0.0635	0.0604
1	0.0781	0.0713	0.0655	0.0666	0.0756	0.0959	0.0912
2	0.2336	0.1240	0.1374	0.1398	0.1587	0.2012	0.1914
3	0.3378	0.3068	0.2017	0.2053	0.2330	0.2955	0.2810
4	0.4583	0.3317	0.2894	0.2946	0.3343	0.4240	0.4032
5	0.4863	0.3853	0.3184	0.3241	0.3678	0.4664	0.4436
6	0.3414	0.3497	0.3219	0.3277	0.3719	0.4716	0.4485
7	0.3998	0.2341	0.3139	0.3195	0.3626	0.4598	0.4373
8	0.4140	0.3184	0.2894	0.2946	0.3343	0.4240	0.4032
9	0.4140	0.3184	0.2894	0.2946	0.3343	0.4240	0.4032

Population Abundance (1 January)

AGE	1960	1961	1962	1963	1964	1965	1966	1967
0	12.09	108.86	46.28	47.66	62.79	34.90	27.86	40.26
1	16.43	4.33	39.31	16.94	17.27	22.81	12.75	10.03
2	3.70	4.68	1.40	13.22	5.51	4.67	6.56	3.90
3	7.71	1.77	1.87	0.81	7.27	2.76	1.59	2.69
4	0.61	4.54	1.02	0.82	0.50	3.94	1.08	0.64
5	0.75	0.39	2.73	0.60	0.59	0.31	1.64	0.55
6	0.44	0.52	0.24	1.45	0.47	0.39	0.15	0.64
7	0.29	0.29	0.32	0.09	1.09	0.34	0.21	0.09
8	0.31	0.14	0.21	0.15	0.06	0.75	0.19	0.13
9	0.34	0.22	0.21	0.19	0.14	0.14	0.48	0.28

x 10 ^ 9

Population Abundance (1 January)

AGE	1968	1969	1970	1971	1972	1973	1974	1975
0	38.70	21.58	41.08	32.31	20.86	10.11	21.70	2.84
1	14.43	13.75	7.87	14.59	11.49	7.24	3.55	7.41
2	2.74	3.93	3.64	2.22	2.94	2.37	1.36	0.83
3	1.89	0.54	1.33	1.02	0.68	0.97	0.63	0.36
4	0.98	0.24	0.18	0.31	0.25	0.25	0.21	0.20
5	0.23	0.31	0.09	0.04	0.08	0.10	0.08	0.07
6	0.22	0.06	0.10	0.03	0.01	0.04	0.04	0.02
7	0.21	0.06	0.01	0.03	0.00	0.01	0.01	0.01
8	0.02	0.04	0.02	0.00	0.00	0.00	0.00	0.00
9	0.12	0.04	0.02	0.02	0.00	0.00	0.00	0.00

x 10 ^ 9

Population Abundance (1 January)

AGE	1976	1977	1978	1979	1980	1981	1982	1983
0	2.73	4.34	4.61	10.61	16.74	37.88	64.78	61.83
1	0.89	0.87	1.45	1.62	3.59	5.43	8.61	17.06
2	1.37	0.26	0.24	0.44	0.50	1.18	1.50	2.53
3	0.17	0.27	0.15	0.17	0.29	0.26	0.63	0.86
4	0.07	0.03	0.05	0.12	0.13	0.16	0.16	0.31
5	0.04	0.01	0.02	0.04	0.10	0.09	0.11	0.11
6	0.01	0.01	0.00	0.02	0.04	0.07	0.05	0.08
7	0.01	0.00	0.00	0.00	0.02	0.03	0.04	0.04
8	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.03
9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03

x 10 ^ 9

Table 2.6.4 (Cont) North Sea herring. Final model fit ICA output. Note age=ringer

Population Abundance (1 January)

AGE	1984	1985	1986	1987	1988	1989	1990	1991
0	53.48	80.96	97.63	86.22	42.29	39.17	35.87	33.63
1	15.25	15.69	27.35	33.76	26.99	13.73	12.65	12.44
2	4.88	4.57	3.94	7.34	8.56	5.56	3.28	2.96
3	1.39	2.64	2.26	1.84	3.62	4.44	2.77	1.67
4	0.51	0.74	1.11	1.10	0.91	1.99	2.41	1.56
5	0.18	0.27	0.32	0.56	0.55	0.46	1.03	1.37
6	0.08	0.09	0.13	0.17	0.27	0.26	0.22	0.57
7	0.05	0.05	0.04	0.05	0.08	0.13	0.12	0.12
8	0.03	0.02	0.03	0.02	0.03	0.04	0.06	0.05
9	0.04	0.03	0.03	0.02	0.01	0.02	0.02	0.03

x 10 ^ 9

Population Abundance (1 January)

AGE	1992	1993	1994	1995	1996	1997	1998	1999
0	62.13	50.24	34.19	41.51	50.07	27.75	27.13	69.07
1	11.00	16.99	12.69	10.01	11.06	17.08	9.96	9.83
2	3.36	2.75	4.10	3.65	2.74	3.15	6.01	3.10
3	1.23	1.41	1.04	1.53	1.48	1.48	1.75	3.41
4	0.87	0.61	0.61	0.42	0.53	0.74	0.81	0.95
5	0.90	0.44	0.27	0.22	0.16	0.31	0.40	0.47
6	0.76	0.47	0.20	0.14	0.09	0.09	0.18	0.20
7	0.32	0.34	0.21	0.09	0.07	0.06	0.05	0.08
8	0.07	0.14	0.13	0.12	0.04	0.06	0.04	0.03
9	0.04	0.07	0.08	0.05	0.01	0.02	0.01	0.01

x 10 ^ 9

Population Abundance (1 January)

AGE	2000	2001	2002	2003	2004	2005	2006	2007
0	39.91	91.32	31.39	18.56	22.56	17.51	27.78	11.92
1	24.50	14.04	32.53	11.06	6.53	7.89	6.04	9.62
2	3.44	8.34	4.81	11.21	3.81	2.23	2.64	2.03
3	1.77	2.02	5.45	3.11	7.22	2.41	1.35	1.61
4	1.84	1.04	1.22	3.65	2.07	4.68	1.47	0.83
5	0.58	1.05	0.67	0.82	2.46	1.34	2.77	0.89
6	0.30	0.32	0.65	0.44	0.54	1.54	0.76	1.61
7	0.11	0.19	0.21	0.43	0.29	0.34	0.87	0.44
8	0.05	0.07	0.14	0.14	0.28	0.18	0.19	0.51
9	0.01	0.01	0.04	0.04	0.12	0.18	0.01	0.12

x 10 ^ 9

Weighting factors for the catches in number

AGE	2002	2003	2004	2005	2006
0	0.1000	0.1000	0.1000	0.1000	0.1000
1	0.1000	0.1000	0.1000	0.1000	0.1000
2	3.6700	3.6700	3.6700	3.6700	3.6700
3	2.8700	2.8700	2.8700	2.8700	2.8700
4	2.2300	2.2300	2.2300	2.2300	2.2300
5	1.7400	1.7400	1.7400	1.7400	1.7400
6	1.3700	1.3700	1.3700	1.3700	1.3700
7	1.0400	1.0400	1.0400	1.0400	1.0400
8	0.9400	0.9400	0.9400	0.9400	0.9400

Table 2.6.4 (Cont) North Sea herring. Final model fit ICA output. Note age=ringer

Predicted SSB Index Values

MLAI

	1973	1974	1975	1976	1977	1978	1979	1980
1	16.75	11.02	5.04	4.78	2.73	3.89	6.90	8.69

MLAI

	1981	1982	1983	1984	1985	1986	1987	1988
1	13.75	20.60	34.13	57.21	59.16	57.23	79.04	109.22

MLAI

	1989	1990	1991	1992	1993	1994	1995	1996
1	115.03	108.25	87.05	59.58	37.84	41.26	36.68	36.44

MLAI

	1997	1998	1999	2000	2001	2002	2003	2004
1	45.18	61.89	73.44	73.52	119.69	150.58	163.76	169.95

MLAI

	2005	2006
1	151.64	110.38

Predicted Age-Structured Index Values

Acoustic survey 1-9+ wr Predicted

AGE	1989	1990	1991	1992	1993	1994	1995	1996
1	999990.	999990.	999990.	999990.	999990.	999990.	999990.	999990.
2	5892.	3521.	2847.	3239.	2508.	3712.	3460.	3038.
3	5749.	3659.	2107.	1521.	1602.	1139.	1542.	1835.
4	2549.	3250.	2118.	1102.	714.	640.	450.	729.
5	579.	1414.	1893.	1197.	540.	354.	253.	219.
6	310.	293.	773.	912.	567.	241.	182.	131.
7	141.	130.	156.	357.	342.	267.	105.	111.
8	42.	68.	66.	81.	152.	145.	130.	59.
9	52.	77.	91.	132.	198.	263.	151.	37.

x 10 ^ 3

Table 2.6.4 (Cont) North Sea herring. Final model fit ICA output. Note age=ringer

Acoustic survey 1-9+ wr Predicted

AGE	1997	1998	1999	2000	2001	2002	2003	2004
1	11351.	6191.	6516.	15990.	9199.	21380.	7262.	4269.
2	3547.	6845.	3548.	3992.	10273.	5885.	13695.	4601.
3	1925.	2262.	4398.	2387.	2763.	7915.	4498.	10298.
4	976.	1108.	1332.	2492.	1502.	1805.	5405.	3000.
5	441.	519.	700.	801.	1538.	1018.	1243.	3625.
6	122.	215.	273.	439.	473.	964.	656.	779.
7	84.	67.	101.	150.	278.	285.	587.	389.
8	83.	56.	46.	66.	106.	215.	212.	426.
9	69.	34.	25.	30.	44.	155.	158.	489.

x 10 ^ 3

Acoustic survey 1-9+ wr Predicted

AGE	2005	2006
1	5102.	3916.
2	2632.	3133.
3	3315.	1875.
4	6457.	2044.
5	1872.	3919.
6	2109.	1056.
7	430.	1126.
8	264.	282.
9	704.	55.

x 10 ^ 3

IBTS1: 1-5+ wr Predicted

AGE	1984	1985	1986	1987	1988	1989	1990	1991
1	2140.2	2153.2	3785.0	4638.9	3613.9	1873.3	1720.8	1723.6
2	701.8	649.9	556.0	1043.3	1224.5	791.2	468.6	411.9
3	139.9	258.7	225.6	184.3	367.2	449.9	281.4	168.0
4	29.5	41.8	63.9	63.3	52.6	115.2	141.5	91.8
5	11.8	14.0	16.5	25.0	28.9	27.4	45.0	66.9

IBTS1: 1-5+ wr Predicted

AGE	1992	1993	1994	1995	1996	1997	1998	1999
1	1508.2	2320.0	1770.9	1388.4	1541.5	2445.1	1403.9	1406.4
2	468.3	377.8	562.7	506.3	393.5	454.6	868.9	449.1
3	123.6	138.3	101.6	146.5	148.6	150.1	177.0	345.0
4	50.2	34.8	33.6	23.2	31.1	43.3	47.7	56.2
5	64.2	44.1	27.3	18.7	11.8	16.9	21.1	25.0

IBTS1: 1-5+ wr Predicted

AGE	2000	2001	2002	2003	2004	2005	2006	2007
1	3492.8	2003.6	4645.1	1578.6	931.5	1122.9	860.2	1369.1
2	499.8	1227.6	707.3	1647.6	558.0	325.0	385.3	296.4
3	181.1	207.0	566.9	322.7	747.4	247.1	138.9	166.1
4	108.1	61.7	72.9	218.6	123.4	276.0	86.6	49.3
5	33.0	52.5	54.5	59.7	117.3	112.5	145.3	112.6

Table 2.6.4 (Cont) North Sea herring. Final model fit ICA output. Note age=ringer

MIK 0-wr Predicted

AGE	1992	1993	1994	1995	1996	1997	1998	1999
0	188.20	150.65	104.46	125.33	155.90	86.95	85.12	216.13

MIK 0-wr Predicted

AGE	2000	2001	2002	2003	2004	2005	2006	2007
0	124.77	285.91	98.13	58.01	70.47	54.59	86.66	37.20

Fitted Selection Pattern

AGE	1960	1961	1962	1963	1964	1965	1966	1967
0	0.0763	0.0455	0.0115	0.0653	0.0340	0.0092	0.0375	0.0277
1	0.7578	0.3165	0.2125	0.5479	0.8331	0.3169	0.3241	0.3224
2	1.2931	1.5084	0.5927	1.3138	1.0505	0.9984	1.0358	0.4567
3	0.9733	0.8628	1.4832	1.2165	1.1137	0.9513	1.2390	0.8703
4	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
5	0.7899	0.9848	1.2672	0.6655	0.8285	0.8497	1.4596	0.8947
6	0.9276	0.9347	1.9379	0.8039	0.6425	0.6660	0.6827	1.0915
7	1.8042	0.6111	1.5114	1.2587	0.7626	0.5884	0.6738	1.6563
8	1.6694	1.3019	1.3719	1.4890	1.5039	1.1118	1.2791	1.1368
9	1.6694	1.3019	1.3719	1.4890	1.5039	1.1118	1.2791	1.1368

Fitted Selection Pattern

AGE	1968	1969	1970	1971	1972	1973	1974	1975
0	0.0325	0.0094	0.0264	0.0277	0.0729	0.0467	0.0754	0.1145
1	0.2802	0.3765	0.2015	0.4910	0.7230	0.6823	0.4545	0.5019
2	1.2387	0.8973	0.7313	0.7197	1.0156	1.0347	1.0357	0.9557
3	1.7472	1.0438	0.9524	0.9906	1.0022	1.3501	0.9791	1.0976
4	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
5	1.1517	1.2059	0.6582	0.8842	0.6870	0.9633	1.1938	1.3706
6	1.0946	2.1745	0.8119	2.1321	0.6470	1.3942	1.0858	0.9296
7	1.4884	1.4790	3.0915	2.2126	0.1227	0.8149	0.7767	1.4819
8	1.5369	1.4952	1.2823	1.5527	1.2990	1.5733	1.3390	1.4650
9	1.5369	1.4952	1.2823	1.5527	1.2990	1.5733	1.3390	1.4650

Fitted Selection Pattern

AGE	1976	1977	1978	1979	1980	1981	1982	1983
0	0.0842	0.2289	0.4368	0.8949	0.4240	1.5881	1.3544	0.9155
1	0.1429	0.6963	1.9209	1.7810	0.3818	0.9404	0.9114	0.5765
2	0.7697	0.5272	0.2320	1.0125	1.2258	1.0681	1.0552	0.6920
3	0.8217	3.3132	0.4072	0.7095	1.4135	0.9067	2.0594	0.7431
4	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
5	0.9139	2.8363	0.1584	0.5594	0.8920	1.3558	0.6252	0.6302
6	0.6159	1.7037	0.7466	0.1319	0.2266	1.4173	0.5852	0.7896
7	0.8619	1.7379	0.5717	4.7115	0.3400	3.1885	0.9263	0.8923
8	0.9445	2.2363	1.7010	2.4279	1.2323	2.0221	1.7364	1.1682
9	0.9445	2.2363	1.7010	2.4279	1.2323	2.0221	1.7364	1.1682

Table 2.6.4 (Cont) North Sea herring. Final model fit ICA output. Note age=ringer

Fitted Selection Pattern

AGE	1984	1985	1986	1987	1988	1989	1990	1991
0	0.4215	0.1156	0.1065	0.2739	0.2144	0.2347	0.1260	0.2576
1	0.3822	0.5192	0.5429	0.6320	0.9975	0.7757	0.9687	0.6734
2	0.5856	0.5485	0.7899	0.6894	0.6116	0.7172	0.8065	1.2549
3	0.8000	0.9101	0.8986	0.8578	0.6889	0.7384	0.7906	0.9934
4	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
5	1.1686	0.8994	0.9515	1.0450	1.1421	1.1803	1.0685	1.0561
6	0.6688	0.9901	1.2559	1.0765	1.1572	1.2614	1.0508	1.0422
7	1.2956	0.7531	1.4042	1.0336	1.1835	1.2662	1.4544	0.9200
8	1.1327	1.1655	1.3774	1.3354	1.5509	1.4820	1.6246	1.5416
9	1.1327	1.1655	1.3774	1.3354	1.5509	1.4820	1.6246	1.5416

Fitted Selection Pattern

AGE	1992	1993	1994	1995	1996	1997	1998	1999
0	0.5182	0.5130	0.2508	0.3722	0.1800	0.0484	0.0345	0.0928
1	0.6762	0.5757	0.2702	0.3419	0.6094	0.0883	0.3772	0.1271
2	0.9999	0.9119	0.7505	0.6915	0.7502	0.5632	0.6034	0.6614
3	0.8701	0.8736	0.7866	0.9989	1.1728	0.7831	0.9323	1.0601
4	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
5	0.9539	0.9698	0.6118	0.9478	1.1453	0.8834	1.3832	0.9123
6	1.2586	0.9532	0.7346	0.6217	0.7500	0.9026	1.6398	1.1636
7	1.2119	1.1943	0.5224	0.7424	0.3419	0.4698	0.8611	1.1774
8	1.4943	1.3656	0.9432	1.0723	1.2840	0.8211	1.2574	1.0624
9	1.4943	1.3656	0.9432	1.0723	1.2840	0.8211	1.2574	1.0624

Fitted Selection Pattern

AGE	2000	2001	2002	2003	2004	2005	2006
0	0.0974	0.0970	0.1498	0.1498	0.1498	0.1498	0.1498
1	0.1705	0.2150	0.2262	0.2262	0.2262	0.2262	0.2262
2	0.5098	0.3739	0.4747	0.4747	0.4747	0.4747	0.4747
3	0.7371	0.9250	0.6970	0.6970	0.6970	0.6970	0.6970
4	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
5	1.0611	1.1617	1.1002	1.1002	1.1002	1.1002	1.1002
6	0.7450	1.0544	1.1124	1.1124	1.1124	1.1124	1.1124
7	0.8725	0.7059	1.0846	1.0846	1.0846	1.0846	1.0846
8	0.9034	0.9600	1.0000	1.0000	1.0000	1.0000	1.0000
9	0.9034	0.9600	1.0000	1.0000	1.0000	1.0000	1.0000

Table 2.6.5 North Sea herring. STOCK SUMMARY

YEAR	RECRUITS (0WR)	TSB	SSB	CATCH	F 0-1	F 2-6	SOP
1960	12090220	3743522	1879239	696200	0.141	0.3364	84
1961	1.09E+08	4356924	1655567	696700	0.074	0.4325	88
1962	46278300	4396065	1113211	627800	0.047	0.5302	85
1963	47657620	4623030	2183501	716000	0.069	0.2264	116
1964	62786110	4792818	2027173	871200	0.161	0.3432	93
1965	34895440	4339962	1445192	1168800	0.127	0.6935	86
1966	27859030	3314572	1278762	895500	0.103	0.6193	93
1967	40256750	2818497	923840	695500	0.162	0.7975	85
1968	38698710	2521399	412930	717800	0.168	1.3355	79
1969	21582030	1905697	424474	546700	0.169	1.1052	103
1970	41075180	1922113	374852	563100	0.152	1.1051	103
1971	32311340	1849636	266176	520100	0.318	1.4045	93
1972	20859510	1549643	288383	497500	0.318	0.6959	108
1973	10112390	1156261	233508	484000	0.360	1.1343	104
1974	21698680	912292	162128	275100	0.263	1.0517	103
1975	2835830	680823	81909	312800	0.423	1.4676	107
1976	2732610	359236	78190	174800	0.198	1.4338	104
1977	4337830	211261	47975	46000	0.197	0.7991	83
1978	4607740	225916	65437	11000	0.123	0.053	82
1979	10609250	383198	107786	25100	0.125	0.0638	99
1980	16736300	631767	131785	70764	0.119	0.2821	91
1981	37884260	1160336	196565	174879	0.384	0.3488	99
1982	64783950	1845289	279550	275079	0.280	0.2629	102
1983	61827260	2721807	434228	387202	0.326	0.3365	92
1984	53479090	2867668	681091	428631	0.216	0.4534	94
1985	80961730	3465627	701319	613780	0.234	0.641	95
1986	97627750	3475769	681317	671488	0.189	0.5693	87
1987	86218110	3939365	902754	792058	0.267	0.55	98
1988	42285210	3581728	1196701	887686	0.352	0.5349	85
1989	39169970	3312556	1252065	787899	0.281	0.5439	96
1990	35874850	2978778	1187444	645229	0.256	0.4409	95
1991	33629990	2716467	982049	658008	0.213	0.4893	98
1992	62134930	2438669	705612	716799	0.342	0.5822	100
1993	50235090	2521794	475030	671397	0.399	0.6906	97
1994	34193690	2026535	512227	568234	0.237	0.7077	95
1995	41513440	1836470	462284	579371	0.310	0.7397	99
1996	50065160	1618035	459664	275098	0.165	0.4034	100
1997	27747320	1938631	554416	264313	0.035	0.4239	99
1998	27131890	2044034	729386	391628	0.091	0.4902	99
1999	69069740	2318481	846758	363163	0.043	0.3764	100
2000	39913570	2857544	847507	388157	0.061	0.3715	99
2001	91323060	3229189	1296170	374065	0.052	0.2995	100
2002	31388390	3940158	1583275	394709	0.054	0.2538	100
2003	18557070	3637878	1703432	482281	0.055	0.2583	98
2004	22560060	3329996	1759399	587698	0.063	0.2932	100
2005	17505090	2838951	1593039	663813	0.080	0.3717	99
2006	27777000	2295022	1207822	514597	0.076	0.3535	102
2007	11900000						

```
No of years for separable analysis : 5   Age range in the analysis : 0  . . . 9
 Year range in the analysis : 1960  . . . 2006
 Number of indices of SSB : 1 Number of age-structured indices : 3
 Stock-recruit relationship to be fitted.
 Parameters to estimate : 45  Number of observations : 415
 Conventional single selection vector model to be fitted.
```

Table 2.6.6 North Sea herring. Model fit parameters, residuals and diagnostics.

PARAMETER ESTIMATES

Parm. No.		Maximum Likelh. Estimate	CV (%)	Lower 95% CL	Upper 95% CL	-s.e.	+s.e.	Mean of Param. Distrib.
Separable model : F by year								
1	2002	0.2894	9	0.2424	0.3455	0.2644	0.3168	0.2906
2	2003	0.2946	8	0.2471	0.3513	0.2693	0.3223	0.2958
3	2004	0.3343	9	0.2790	0.4006	0.3048	0.3667	0.3358
4	2005	0.4239	9	0.3495	0.5143	0.3842	0.4679	0.4260
5	2006	0.4032	11	0.3228	0.5036	0.3599	0.4516	0.4058
Separable Model: Selection (S) by age								
6	0	0.1498	29	0.0841	0.2668	0.1116	0.2011	0.1564
7	1	0.2262	28	0.1289	0.3970	0.1698	0.3014	0.2357
8	2	0.4747	8	0.3995	0.5640	0.4347	0.5183	0.4765
9	3	0.6970	8	0.5882	0.8260	0.6392	0.7601	0.6997
	4	1.0000	Fixed : Reference Age					
10	5	1.1002	9	0.9213	1.3137	1.0050	1.2044	1.1047
11	6	1.1124	9	0.9179	1.3482	1.0085	1.2271	1.1178
12	7	1.0846	11	0.8718	1.3493	0.9702	1.2124	1.0913
	8	1.0000	Fixed : Last true age					
Separable model: Populations in year 2006								
13	0	27777002	18	19358098	39857315	23103288	33396191	28252427
14	1	6043461	14	4588139	7960400	5250979	6955546	6103460
15	2	2638453	10	2156853	3227589	2380630	2924199	2652439
16	3	1349652	9	1122121	1623320	1228323	1482966	1355654
17	4	1465554	9	1227228	1750163	1338681	1604452	1471575
18	5	2773018	9	2303524	3338203	2522614	3048279	2785465
19	6	761340	10	617967	937977	684459	846857	765666
20	7	870024	12	678696	1115289	766483	987552	877036
21	8	192046	14	143216	257526	165348	223056	194210
Separable model: Populations at age								
22	2002	137602	21	90255	209787	110963	170636	140824
23	2003	136109	16	97759	189503	114962	161145	138063
24	2004	279640	14	209278	373660	241200	324207	282715
25	2005	181649	13	138182	238789	157990	208850	183426
Recruitment in year 2007								
26	2006	11923986	26	7092988	20045354	9147941	15542453	12350180

SSB Index catchabilities

MLAI

Power model fitted. Slopes (Q) and exponents (K) at age

27	1 Q	3.150	11	2.649	4.101	2.949	3.685	3.317
28	1 K	.1162E-04	11	.1693E-04	.2620E-04	.1884E-04	.2355E-04	.2227E-04

Age-structured index catchabilities

Acoustic survey 1-9+ wr

Linear model fitted. Slopes at age :

29	1 Q	1.181	8	1.088	1.520	1.181	1.401	1.291
30	2 Q	1.556	6	1.465	1.873	1.556	1.763	1.660
31	3 Q	1.810	11	1.618	2.559	1.810	2.287	2.048
32	4 Q	1.840	15	1.590	2.886	1.840	2.494	2.167
33	5 Q	1.906	16	1.633	3.066	1.906	2.628	2.267
34	6 Q	1.875	17	1.591	3.107	1.875	2.638	2.256
35	7 Q	1.738	18	1.458	2.990	1.738	2.508	2.123
36	8 Q	1.937	18	1.623	3.338	1.937	2.798	2.367
37	9 Q	5.295	21	4.307	10.01	5.295	8.144	6.721

Table 2.6.6 (cont) North Sea herring. Model fit parameters, residuals and diagnostics.

IBTS1: 1-5+ wr

Linear model fitted. Slopes at age :

38	1	Q	.1631E-03	6	.1537E-03	.1961E-03	.1631E-03	.1847E-03	.1739E-03
39	2	Q	.1553E-03	7	.1439E-03	.1964E-03	.1553E-03	.1820E-03	.1687E-03
40	3	Q	.1093E-03	41	.7339E-04	.3729E-03	.1093E-03	.2504E-03	.1803E-03
41	4	Q	.6292E-04	41	.4226E-04	.2147E-03	.6292E-04	.1442E-03	.1038E-03
42	5	Q	.3373E-04	41	.2265E-04	.1152E-03	.3373E-04	.7733E-04	.5566E-04

MIK 0-wr

Linear model fitted. Slopes at age :

43	0	Q	.3562E-05	6	.3333E-05	.4373E-05	.3562E-05	.4092E-05	.3827E-05

Parameters of the stock-recruit relationship

44	1	a	.6034E+08	21	.4900E+08	.1147E+09	.6034E+08	.9312E+08	.7675E+08
45	1	b	.4209E+06	44	.2736E+06	.1588E+07	.4209E+06	.1032E+07	.7289E+06

RESIDUALS ABOUT THE MODEL FIT

Separable Model Residuals

Age	2002	2003	2004	2005	2006
0	-0.1458	-0.3201	0.0227	0.3945	-0.1631
1	-0.4474	0.3089	-0.3814	0.4421	-0.4124
2	0.0796	-0.0371	-0.0782	0.0080	0.0054
3	0.0686	0.0095	0.0003	-0.1432	0.0311
4	0.0028	-0.0615	-0.0331	-0.1586	0.0007
5	-0.2178	0.1181	0.0414	0.0047	0.0503
6	0.0243	-0.0907	0.0581	0.0401	-0.0415
7	-0.0788	0.1050	0.2256	-0.0269	-0.1751
8	0.0484	0.1284	-0.1489	0.3875	0.0354

SPAWNING BIOMASS INDEX RESIDUALS

MLAI

	1973	1974	1975	1976	1977	1978	1979	1980
1	-0.2462	-0.3275	-0.6124	-0.6641	0.8061	0.6382	0.7375	0.1261

MLAI

	1981	1982	1983	1984	1985	1986	1987	1988
1	0.0557	0.0209	-0.2354	-0.1586	0.2285	-0.3930	-0.1506	0.2113

MLAI

	1989	1990	1991	1992	1993	1994	1995	1996
1	0.1343	0.4548	0.0296	-0.3523	-0.2372	-0.6920	-0.4782	0.2051

Table 2.6.6 (cont) North Sea herring. Model fit parameters, residuals and diagnostics.

MLAI

	1997	1998	1999	2000	2001	2002	2003	2004
1	0.2369	0.1840	-0.1708	-0.5818	0.0850	-0.3053	0.5061	0.6391

MLAI

	2005	2006
1	0.2397	0.0701

AGE-STRUCTURED INDEX RESIDUALS

Acoustic survey 1-9+ wr

Age	1989	1990	1991	1992	1993	1994	1995	1996
1	*******	*******	*******	*******	*******	*******	*******	*******
2	-0.365	-0.063	-0.078	0.142	0.174	-0.153	0.107	0.392
3	-0.387	-0.038	-0.215	-0.099	0.022	-0.306	0.281	0.431
4	-0.445	0.049	-0.078	0.040	0.233	-0.472	0.401	0.400
5	-0.163	-0.035	-0.023	-0.054	0.317	0.073	0.167	0.349
6	-0.090	0.291	-0.183	0.312	0.315	0.285	0.107	-0.279
7	-0.162	0.476	0.377	0.100	0.478	0.198	0.272	-0.290
8	0.039	0.667	0.358	0.336	0.169	0.414	-0.091	0.813
9	-0.853	-0.584	-0.582	-0.241	-0.537	-0.699	-0.486	1.716

Acoustic survey 1-9+ wr

Age	1997	1998	1999	2000	2001	2002	2003	2004
1	-0.193	-0.330	-0.248	0.436	-0.297	0.075	0.303	0.194
2	0.519	-0.175	-0.142	-0.312	0.179	-0.188	0.325	-0.298
3	0.422	0.108	0.072	-0.102	0.109	0.038	-0.378	-0.114
4	0.390	0.383	-0.177	0.231	-0.027	-0.261	-0.255	-0.325
5	0.309	0.637	-0.324	0.229	0.086	-0.248	-0.610	-0.336
6	0.567	0.727	0.139	0.095	-0.049	0.067	-0.281	-0.899
7	-0.596	0.925	0.318	0.574	-0.492	-0.154	-0.033	-0.171
8	-0.064	-0.213	0.170	0.599	-0.078	-0.575	-0.377	-0.221
9	0.835	1.259	1.241	1.161	0.304	-0.037	0.115	-0.969

Acoustic survey 1-9+ wr

Age	2005	2006
1	-0.494	0.555
2	-0.247	0.186
3	0.096	0.063
4	-0.109	0.026
5	-0.434	0.063
6	-0.585	-0.535
7	-1.122	-0.694
8	-0.735	-1.208
9	-1.886	0.247

Table 2.6.6 (cont) North Sea herring. Model fit parameters, residuals and diagnostics.

IBTS1: 1-5+ wr

Age	1984	1985	1986	1987	1988	1989	1990	1991
1	-0.345	-0.026	-0.352	-0.228	0.195	0.219	-0.483	-0.292
2	-1.469	0.105	0.341	-0.128	1.224	0.101	-0.014	0.520
3	-0.823	0.086	0.202	-0.460	0.768	-0.284	-0.006	0.431
4	-0.092	0.006	0.213	-0.065	0.097	-0.254	0.643	0.881
5	-0.143	0.689	0.531	0.669	-0.144	-1.168	0.460	0.781

IBTS1: 1-5+ wr

Age	1992	1993	1994	1995	1996	1997	1998	1999
1	-0.173	0.186	-0.011	-0.031	0.204	0.589	0.483	-0.625
2	-0.070	0.734	0.730	1.012	-0.689	0.108	-0.093	0.003
3	0.446	0.476	0.741	0.643	-1.509	0.080	-0.616	0.374
4	0.089	0.258	0.719	0.456	-1.115	-0.350	-0.830	0.559
5	0.362	0.396	0.444	-1.051	-0.380	0.166	-0.167	0.354

IBTS1: 1-5+ wr

Age	2000	2001	2002	2003	2004	2005	2006	2007
1	0.064	0.221	-0.133	0.561	0.050	-0.114	0.069	-0.024
2	-0.919	-0.083	-0.072	-0.057	-0.213	-0.417	1.335	-1.986
3	-0.158	0.427	-0.517	0.640	0.039	0.365	0.866	-2.209
4	-0.608	0.419	-1.068	0.499	-0.094	0.343	1.067	-1.771
5	-1.304	0.263	-1.005	-0.115	0.379	0.156	0.846	-1.013

MIK 0-wr

Age	1992	1993	1994	1995	1996	1997	1998	1999
0	0.0643	0.2326	-0.0268	0.0133	-0.3811	0.5325	-0.4719	0.1213

MIK 0-wr

Age	2000	2001	2002	2003	2004	2005	2006	2007
0	0.0943	-0.2860	0.5000	-0.0643	-0.3987	0.1159	-0.0419	0.0000

Table 2.6.6 (cont) North Sea herring. Model fit parameters, residuals and diagnostics.

```
 PARAMETERS OF THE DISTRIBUTION OF ln(CATCHES AT AGE)
 -----------------------------------------------------

 Separable model fitted from 2002  to 2006
 Variance                            0.0362
Skewness test stat.                  0.2836
Kurtosis test statistic              0.8048
Partial chi-square                   0.0592
Significance in fit                  0.0000
Degrees of freedom                       20


 PARAMETERS OF DISTRIBUTIONS OF THE SSB INDICES
 -----------------------------------------------


   DISTRIBUTION STATISTICS FOR   MLAI


 Power catchability relationship assumed
 Last age is a plus-group

 Variance                            0.1012
Skewness test stat.                  0.3945
Kurtosis test statistic             -0.8273
Partial chi-square                   1.4846
Significance in fit                  0.0000
Number of observations                   34
Degrees of freedom                       32
Weight in the analysis               0.6000

 PARAMETERS OF THE DISTRIBUTION OF THE AGE-STRUCTURED INDICES
 ------------------------------------------------------------


   DISTRIBUTION STATISTICS FOR Acoustic survey 1-9+ wr


 Linear catchability relationship assumed

 Age                         1         2         3         4         5
6         7         8         9
 Variance                0.0821    0.0422    0.0095    0.0085    0.0090
0.0136    0.0186    0.0186    0.0449
Skewness test stat.      0.2725    0.6861    0.2131   -0.0030   -0.0678   -
0.6720   -0.6167   -0.9256    0.2326
Kurtosis test statisti  -0.8796   -0.8160   -0.4212   -1.0087   -0.3933   -
0.2128   -0.3046   -0.0224   -0.5523
Partial chi-square       0.0471    0.0469    0.0110    0.0103    0.0112
0.0177    0.0258    0.0267    0.0671
Significance in fit      0.0000    0.0000    0.0000    0.0000    0.0000
0.0000    0.0000    0.0000    0.0000
Number of observations       10        18        18        18        18
18        18        18        18
Degrees of freedom            9        17        17        17        17
17        17        17        17
Weight in the analysis   0.6300    0.6200    0.1700    0.1000    0.0900
0.0800    0.0700    0.0700    0.0500


   DISTRIBUTION STATISTICS FOR IBTS1: 1-5+ wr


 Linear catchability relationship assumed

 Age                         1         2         3         4         5
 Variance                0.0446    0.1641    0.0055    0.0047    0.0044
Skewness test stat.      0.1515   -1.1821   -2.7863   -1.6362   -1.4818
Kurtosis test statisti  -0.3327    0.7375    1.7334    0.2593   -0.7119
Partial chi-square       0.1364    0.6158    0.0246    0.0269    0.0283
Significance in fit      0.0000    0.0000    0.0000    0.0000    0.0000
Number of observations       24        24        24        24        24
Degrees of freedom           23        23        23        23        23
Weight in the analysis   0.4700    0.2800    0.0100    0.0100    0.0100
```

Table 2.6.6 (cont) North Sea herring. Model fit parameters, residuals and diagnostics.

DISTRIBUTION STATISTICS FOR MIK 0-wr

Linear catchability relationship assumed

Age	0
Variance	0.0523
Skewness test stat.	0.2141
Kurtosis test statisti	-0.3484
Partial chi-square	0.1700
Significance in fit	0.0000
Number of observations	16
Degrees of freedom	15
Weight in the analysis	0.6300

ANALYSIS OF VARIANCE

Unweighted Statistics

Variance

	SSQ	Data	Parameters	d.f.	Variance
Total for model	109.2433	415	45	370	0.2953
Catches at age	1.5562	45	25	20	0.0778
SSB Indices					
MLAI	5.3996	34	2	32	0.1687
Aged Indices					
Acoustic survey 1-9+ wr	33.5959	154	9	145	0.2317
IBTS1: 1-5+ wr	49.1683	120	5	115	0.4276
MIK 0-wr	1.2444	16	1	15	0.0830
Stock-recruit model	18.2789	46	2	44	0.4154

Weighted Statistics

Variance

	SSQ	Data	Parameters	d.f.	Variance
Total for model	5.9548	415	45	370	0.0161
Catches at age	0.7246	45	25	20	0.0362
SSB Indices					
MLAI	1.9438	34	2	32	0.0607
Aged Indices					
Acoustic survey 1-9+ wr	1.0669	154	9	145	0.0074
IBTS1: 1-5+ wr	1.5428	120	5	115	0.0134
MIK 0-wr	0.4939	16	1	15	0.0329
Stock-recruit model	0.1828	46	2	44	0.0042

Table 2.7.1. Input to short term prediction.

```
North sea herring 2007
2007
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 2007
       0       11924
       1        9620
       2        2030
       3        1614
       4         834
       5         886
       6        1610
       7         440
       8         508
       9         124
recruitments
22966
22966
selection by age and fleet
               0           0.0005     0.0575     0.0004      0.0020
               1           0.0059     0.0237     0.0383      0.0233
               2           0.1580     0.0096     0.0199      0.0038
               3           0.2712     0.0009     0.0064      0.0025
               4           0.3972     0.0032     0.0020      0.0007
               5           0.4401     0.0021     0.0009      0.0005
               6           0.4475     0.0000     0.0007      0.0003
               7           0.4366     0.0000     0.0005      0.0002
               8           0.3991     0.0029     0.0008      0.0003
               9           0.4032     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 2007
               0           0.0922     0.0112     0.0238      0.0168
               1           0.0908     0.0269     0.0642      0.0384
               2           0.1234     0.0416     0.0741      0.0699
               3           0.1498     0.1073     0.1151      0.1131
               4           0.1775     0.1452     0.1446      0.1474
               5           0.2071     0.1673     0.1697      0.1718
               6           0.1956     0.1681     0.1817      0.1810
               7           0.2353     0.2168     0.2053      0.1951
               8           0.2476     0.2229     0.1977      0.1405
               9           0.2643     0.0000     0.0000      0.0000
        Weca 2008
               0           0.0922     0.0112     0.0238      0.0168
               1           0.0908     0.0269     0.0642      0.0384
               2           0.1234     0.0416     0.0741      0.0699
               3           0.1498     0.1073     0.1151      0.1131
               4           0.1775     0.1452     0.1446      0.1474
               5           0.2071     0.1673     0.1697      0.1718
               6           0.2210     0.1681     0.1817      0.1810
               7           0.2050     0.2168     0.2053      0.1951
               8           0.2476     0.2229     0.1977      0.1405
               9           0.2643     0.0000     0.0000      0.0000
```

west 2007		
	0	0.006
	1	0.044
	2	0.131
	3	0.164
	4	0.184
	5	0.208
	6	0.208
	7	0.248
	8	0.259
	9	0.280
west 2008		
	0	0.006
	1	0.044
	2	0.131
	3	0.164
	4	0.184
	5	0.208
	6	0.236
	7	0.218
	8	0.259
	9	0.280
west 2009		
	0	0.006
	1	0.044
	2	0.131
	3	0.164
	4	0.184
	5	0.208
	6	0.236
	7	0.248
	8	0.228
	9	0.280
maturity 2007		
	0	0.00
	1	0.00
	2	0.71
	3	0.83
	4	0.98
	5	1.00
	6	1.00
	7	1.00
	8	1.00
	9	1.00
maturity 2008		
	0	0.00
	1	0.00
	2	0.71
	3	0.83
	4	0.98
	5	1.00
	6	1.00
	7	1.00
	8	1.00
	9	1.00
maturity 2009		
	0	0.00
	1	0.00
	2	0.71
	3	0.83
	4	0.98
	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. Management options for North Sea herring.

Intermediate year (2007) with catch constraint.

F1	F2	F3	F4	F_{0-1}	F_{2-6}	C1	C2	C3	C4	SSB2007
0.328	0.042	0.012	0.007	0.064	0.336	374.9	10.5	11.6	3.4	968.7

Prediction year (2008)

F-values by fleet and total						Catches by fleet					
F1	F2	F3	F4	F_{0-1}	F_{2-6}	C1	C2	C3	C4	SSB2008	SSB2009
1. Following management rule, and with catches in IIIa according to a 15% reduction in WBSS catch											
0.156	0.028	0.024	0.022	0.076	0.168	171.9	8.7	14.4	6.9	1025.3	995.5
2. Following management rule, and with catches in IIIa according to F0.1 for WBSS											
0.158	0.050	0.013	0.012	0.076	0.167	174.1	15.5	7.6	3.7	1026.0	999.8
3. 15% reduction in TAC by fleet A, and with catches in IIIa according to a 15% reduction in WBSS catch											
0.280	0.028	0.024	0.022	0.078	0.292	289.9	8.7	14.4	6.9	944.2	821.9
4. 15% reduction in TAC by fleet A, and with catches in IIIa according to F0.1 for WBSS											
0.280	0.050	0.013	0.012	0.077	0.289	289.9	15.4	7.6	3.7	946.3	829.0
5. As 1, but with transfer of 3820 tonnes from C-fleet to A-fleet											
0.160	0.028	0.023	0.022	0.075	0.172	175.7	8.7	13.7	6.9	1022.9	990.4
6. No fishing											
0.0	0.0	0.00	0.0	0.0	0.0	0	0	0	0	1147.4	1309.9

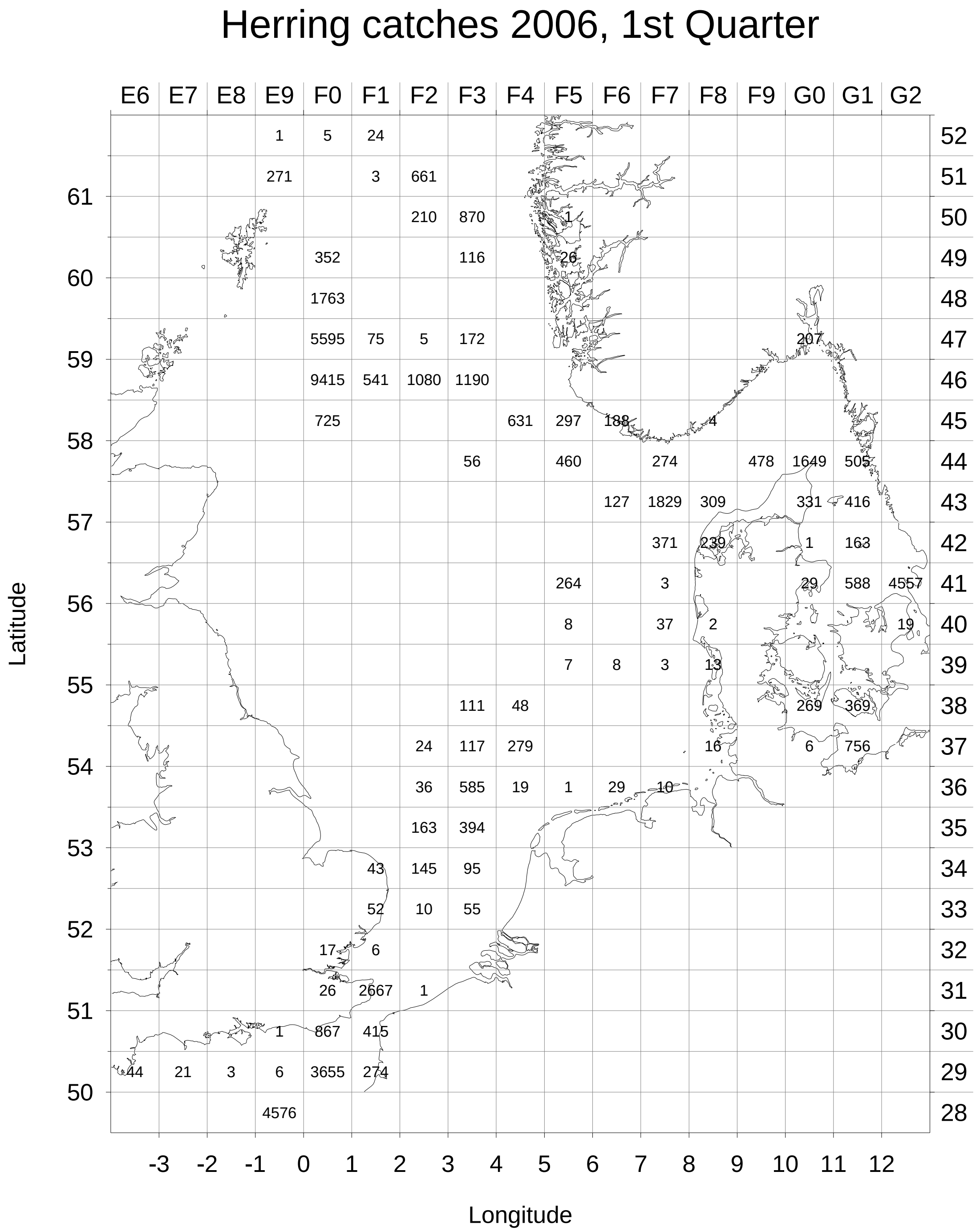


Figure 2.1.1: Herring catches (in tonnes)in the North Sea and Division IIIa in 2006 by statistical rectangle. Working group estimates (if available). a.: 1st quarter

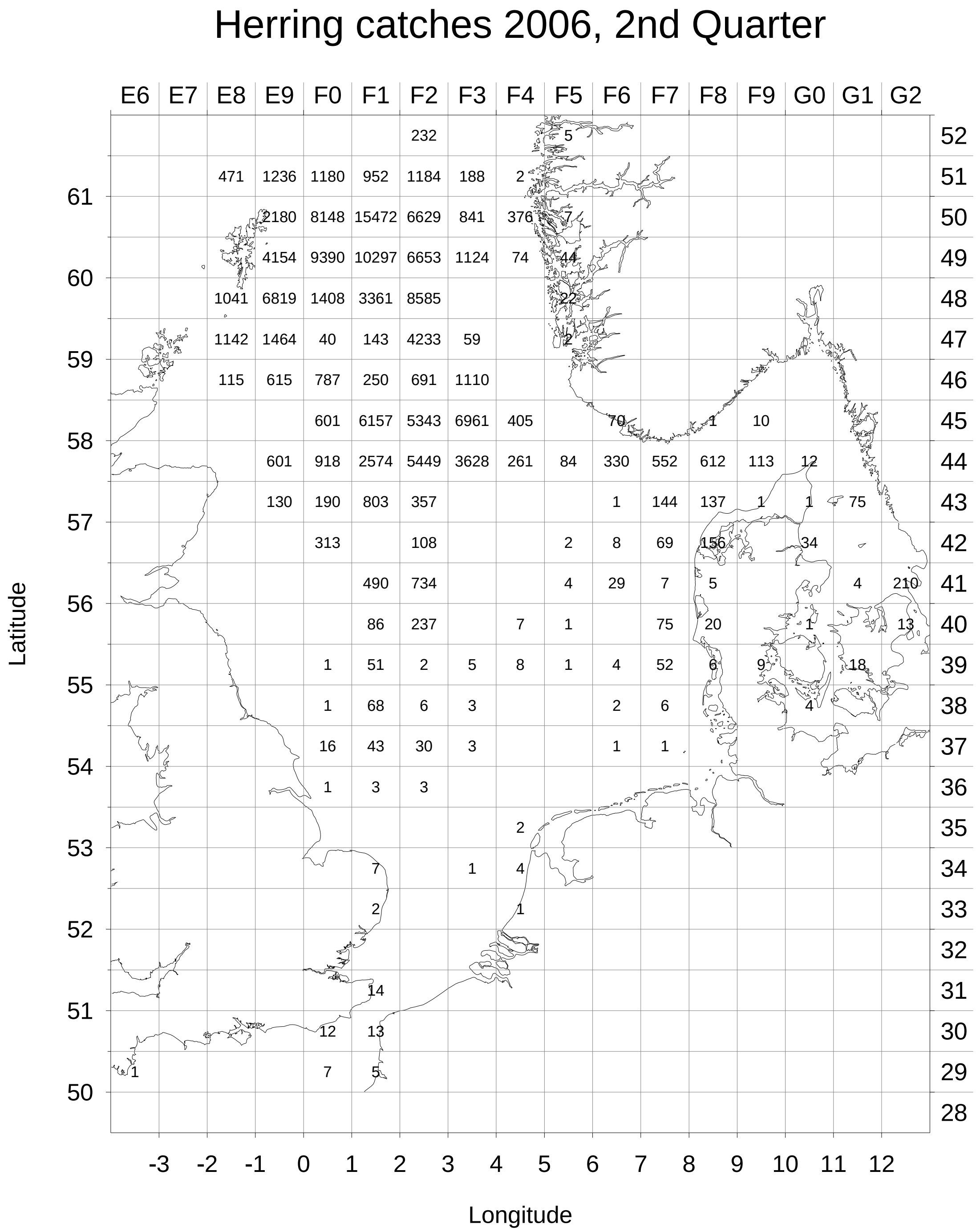


Figure 2.1.1: Herring catches (in tonnes) in the North and Division IIIa Sea in 2006 by statistical rectangle. Working group estimates (if available). b.: 2nd quarter

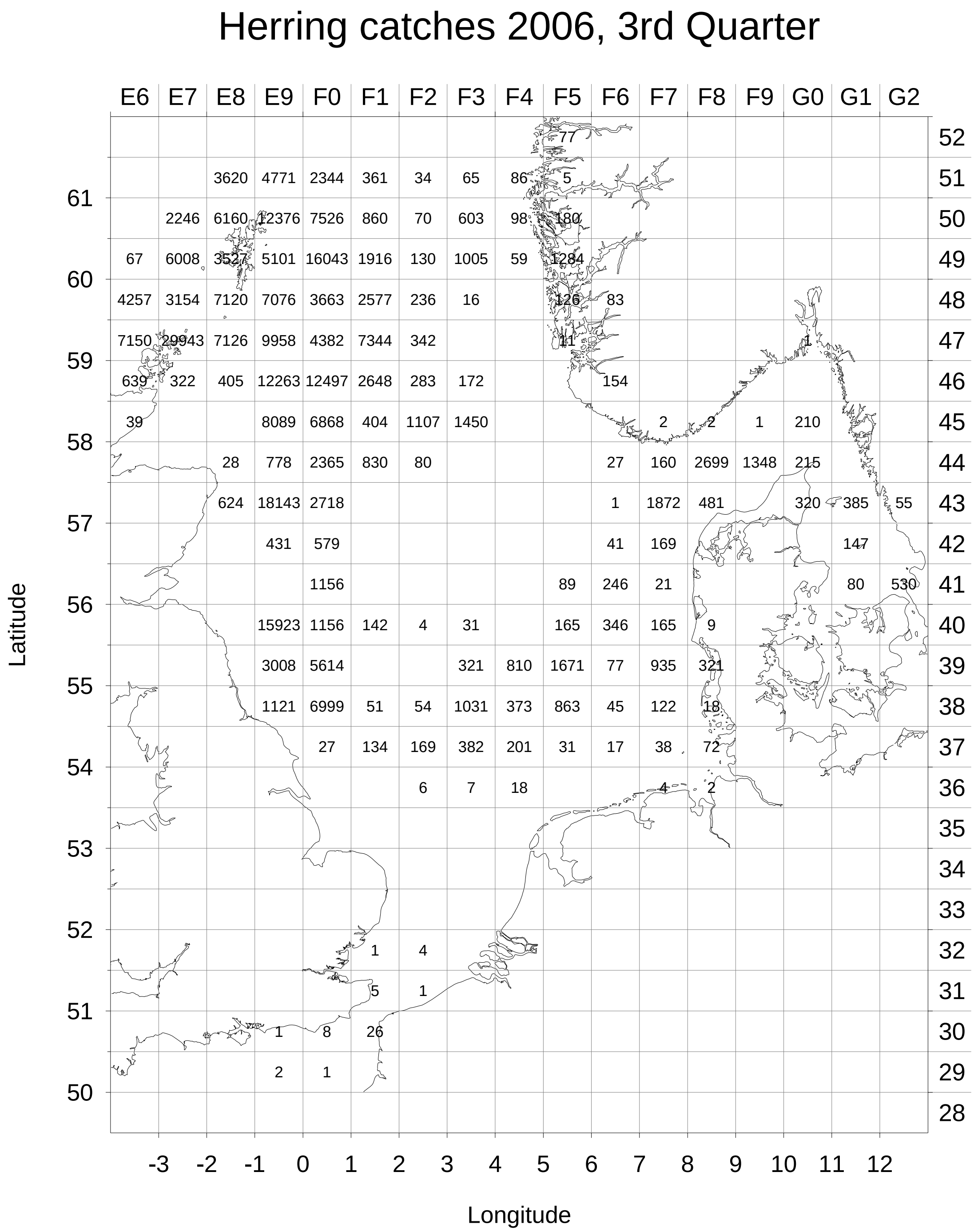


Figure 2.1.1: Herring catches (in tonnes)in the North Sea and Division IIIa in 2006 by statistical rectangle. Working group estimates (if available). c.: 3rd quarter

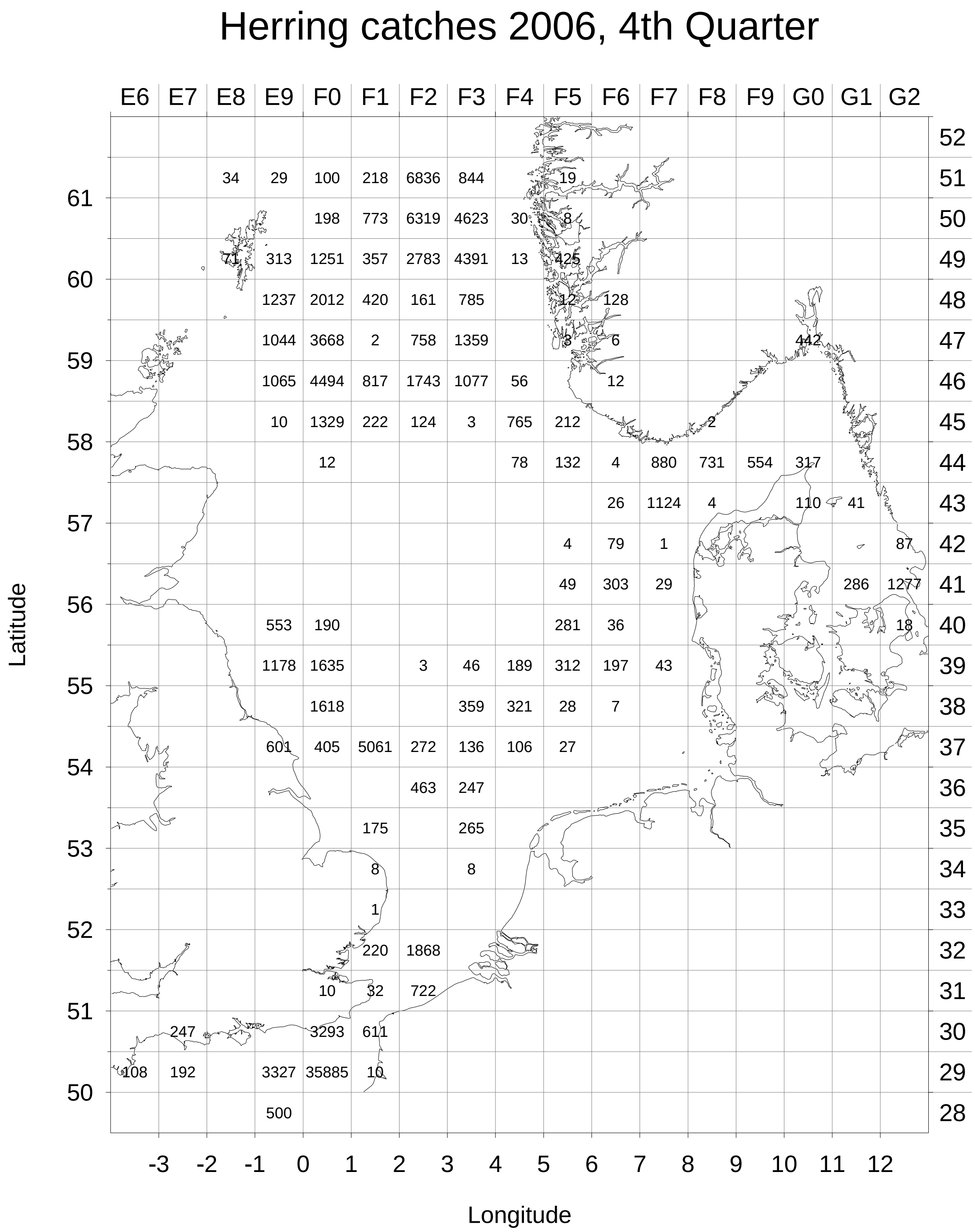


Figure 2.1.1.: Herring catches (in tonnes)in the North Sea and Division IIIa in 2006 by statistical rectangle. Working group estimates (if available). d.: 4th quarter

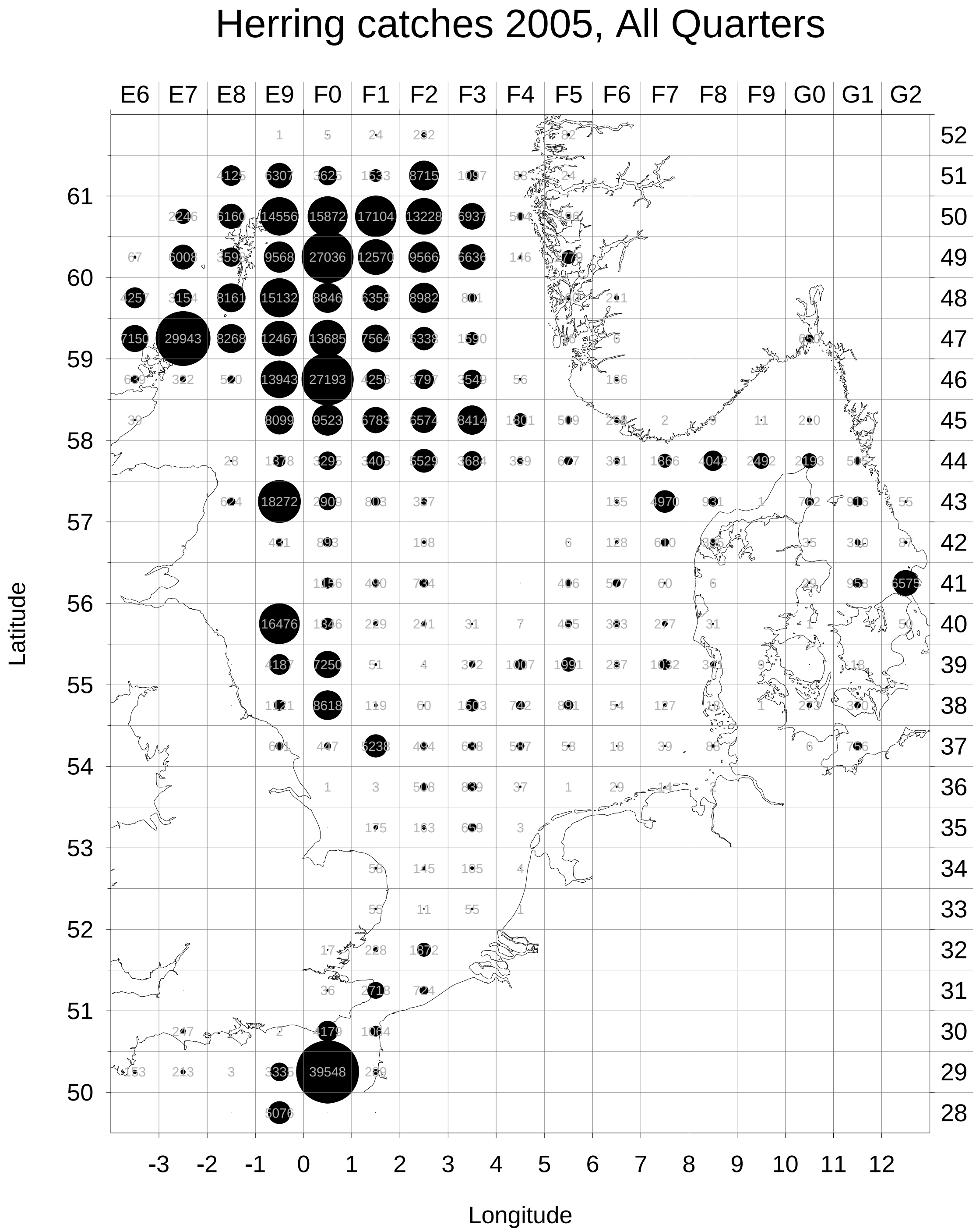


Figure 2.1.1: Herring catches (in tonnes) in the North and Division IIIa Sea in 2006 by statistical rectangle. Working group estimates (if available). e: all quarters. Note the wrong heading: figure show catches in 2006 and not 2005.

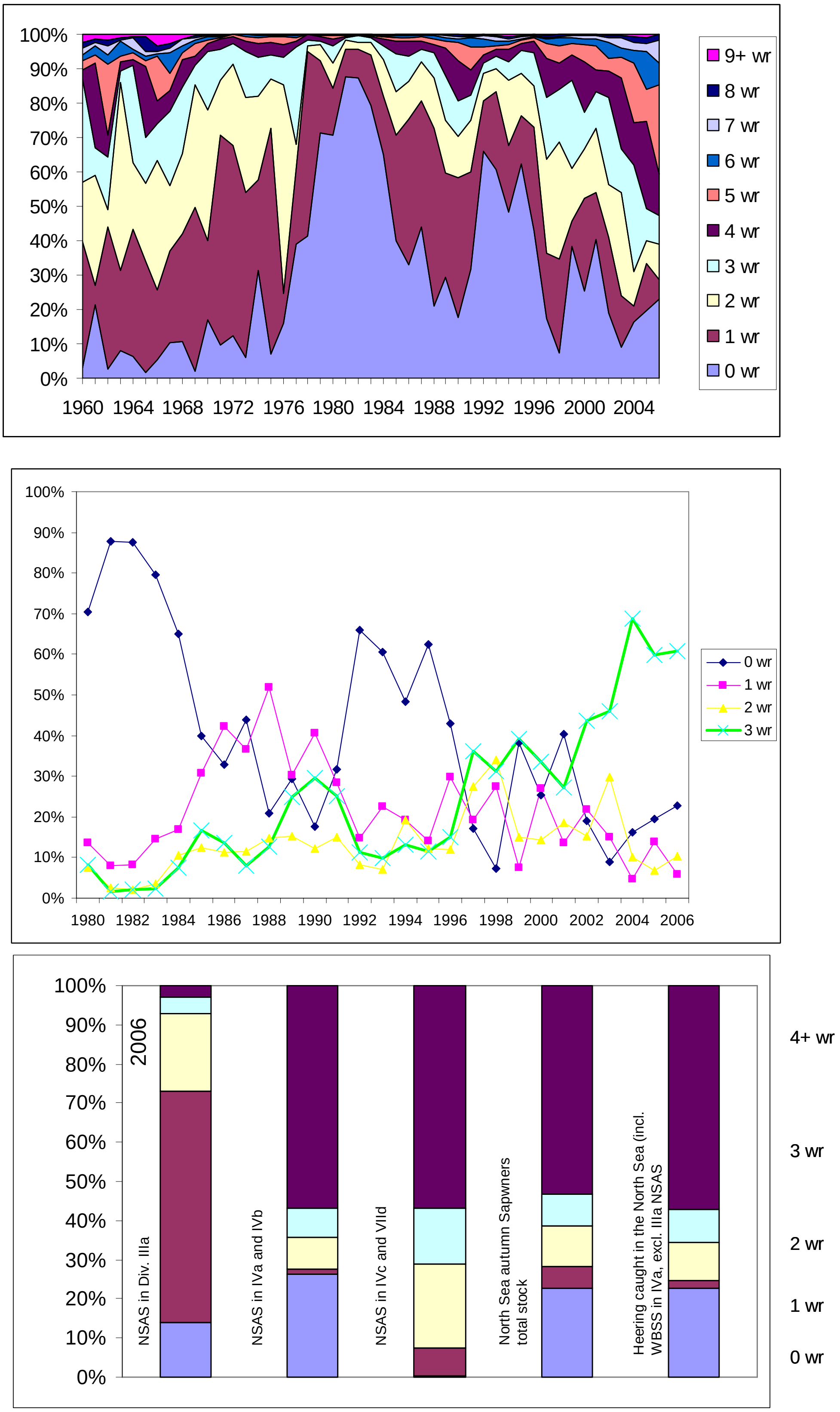
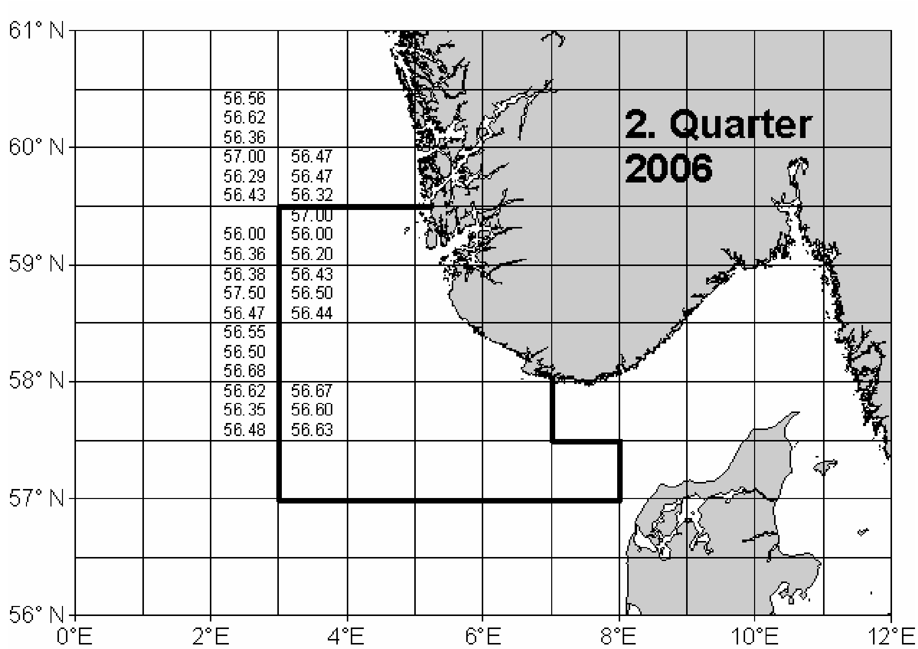


Figure 2.2.1: Proportions of age groups (numbers) in the total catch of herring in the North Sea (upper, 1960-2006, and middle panel, 1980-2006), and in the total catch of North Sea autumn spawners in 2006 (lower panel).



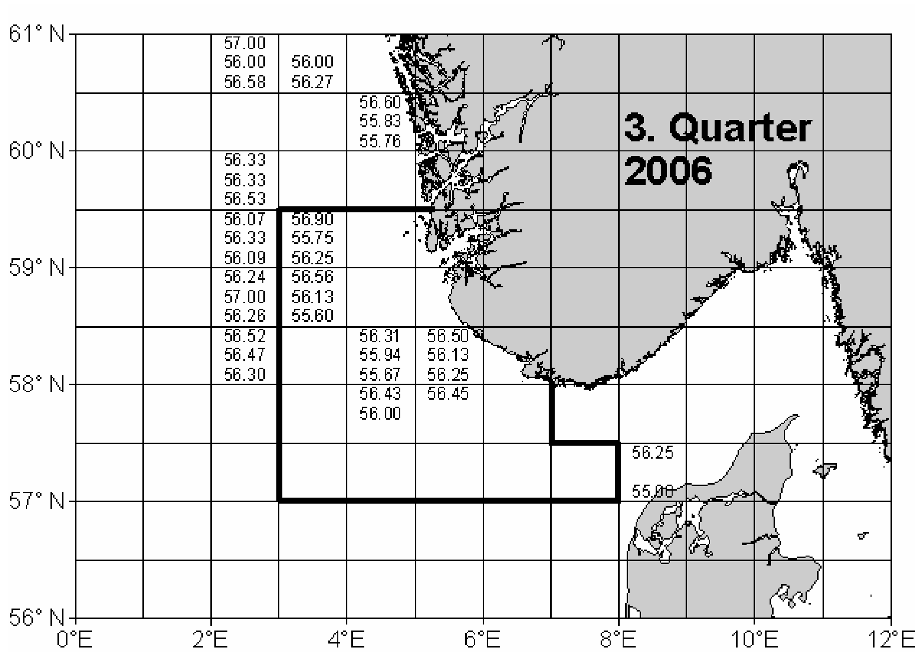


Figure 2.2.2: Mean vertebrae counts of 2 (upper number), 3 (middle) and 4+ herring (lower) in the North Sea and Div. IIIa as obtained by Norwegian sampling in the 2nd and 3rd quarter 2006. The transfer area (Western Baltic spring spawners transferred to the assessment of IIIa herring) is indicated.

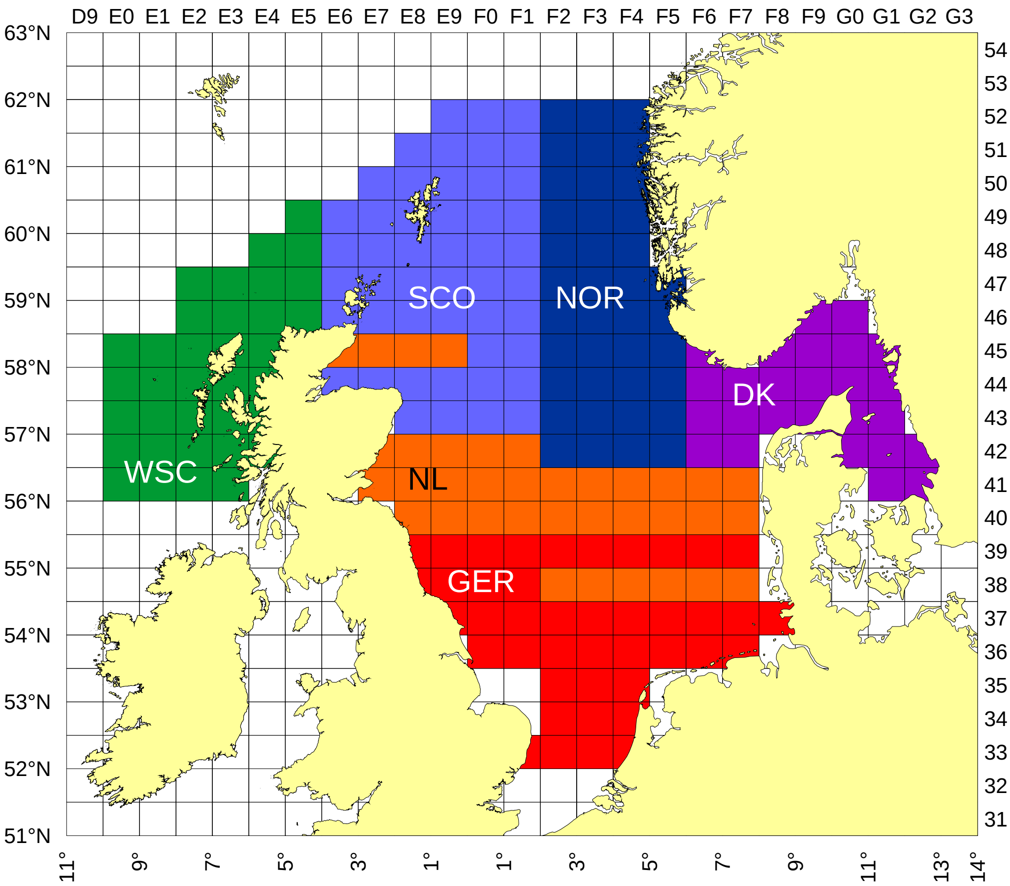


Figure 2.3.1.1: Survey area coverage in the ICES Coordinated herring acoustic surveys in June-July 2006, by rectangle and nation (WSC = West of Scotland charter vessel; SCO = Scotia; NOR = Johan Hjort; DK = Dana; NL = Tridens; GER = Solea).

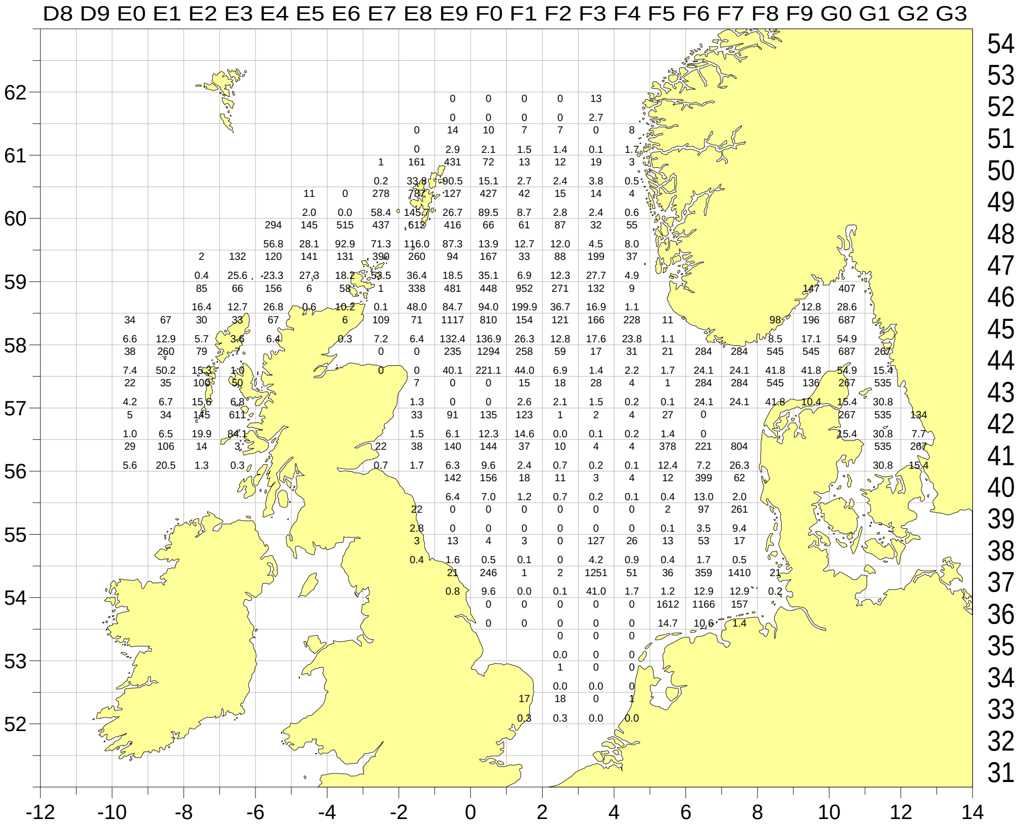


Figure 2.3.1.2: Abundance of Autumn spawning herring 1-9+ from combined acoustic survey June-July 2006. Numbers (millions) (upper figure) and biomass (thousands of tonnes) (lower figure).

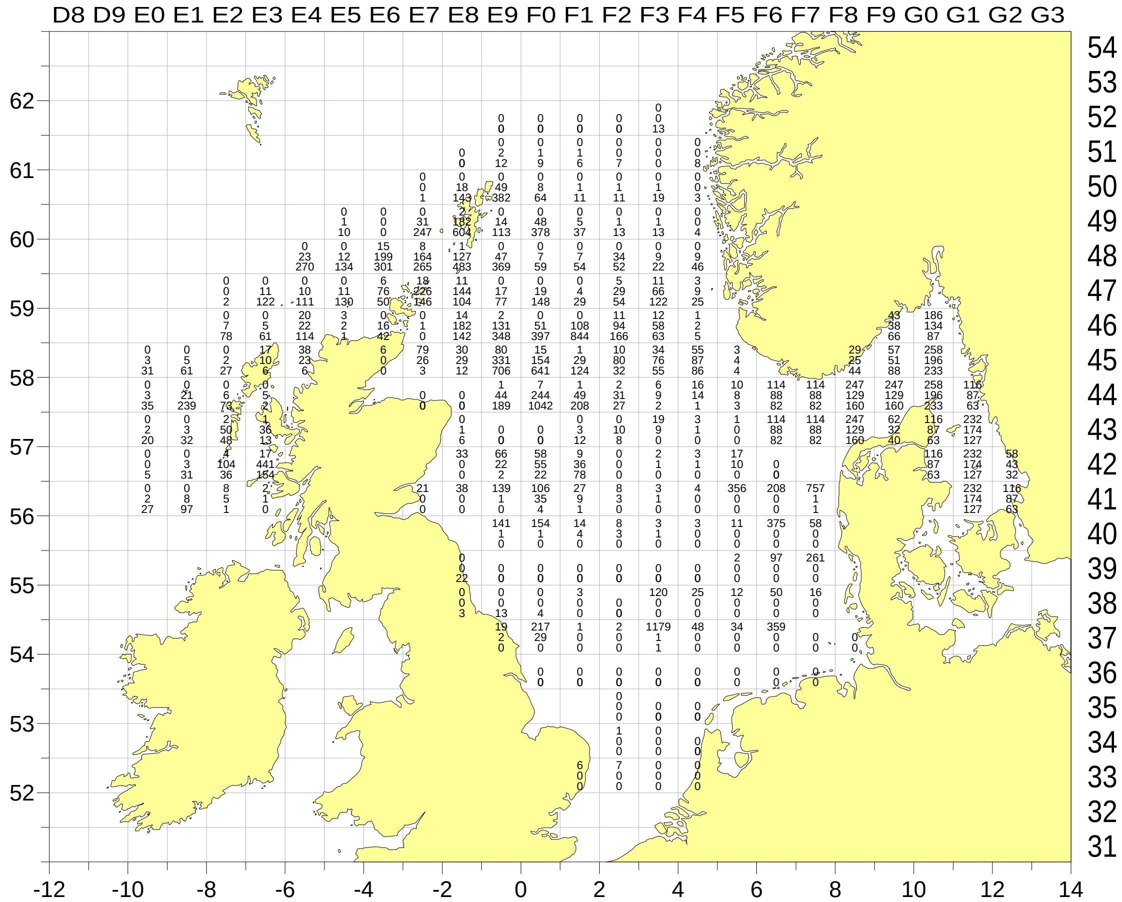


Figure 2.3.1.3: Numbers (millions) of Autumn spawning herring from combined acoustic survey June–July 2006. 1 ring (upper figure), 2 ring (centre figure), 3+ (lower figure).

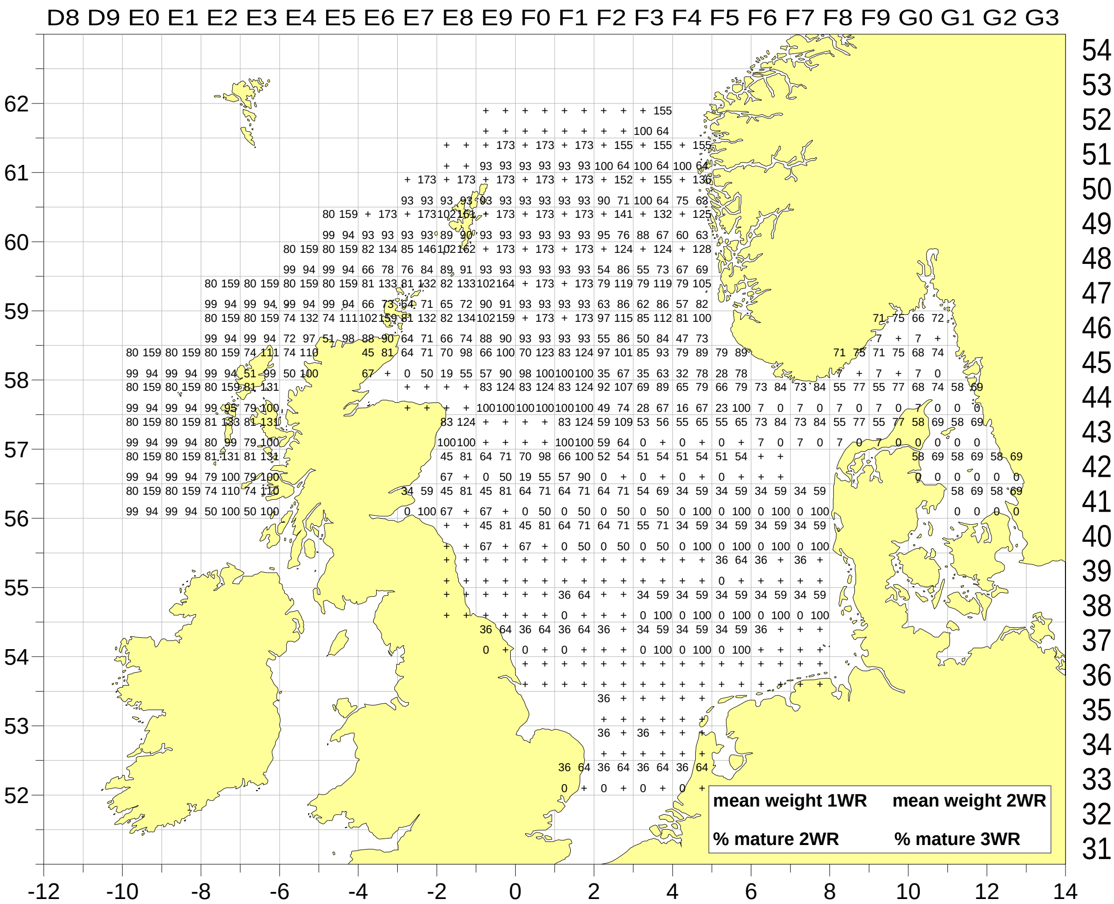


Figure 2.3.1.4: Mean weight and maturity of autumn spawning herring from combined acoustic survey June–July 2006. Four values per ICES rectangle, percentage mature of 2 ring (lower left) and 3 ring fish (lower right), mean weights gram of 1 ring (upper left) and 2 ring fish (upper right), 0 indicates measured percentage mature, + indicates surveyed with zero abundance, blank indicates an unsurveyed rectangle.

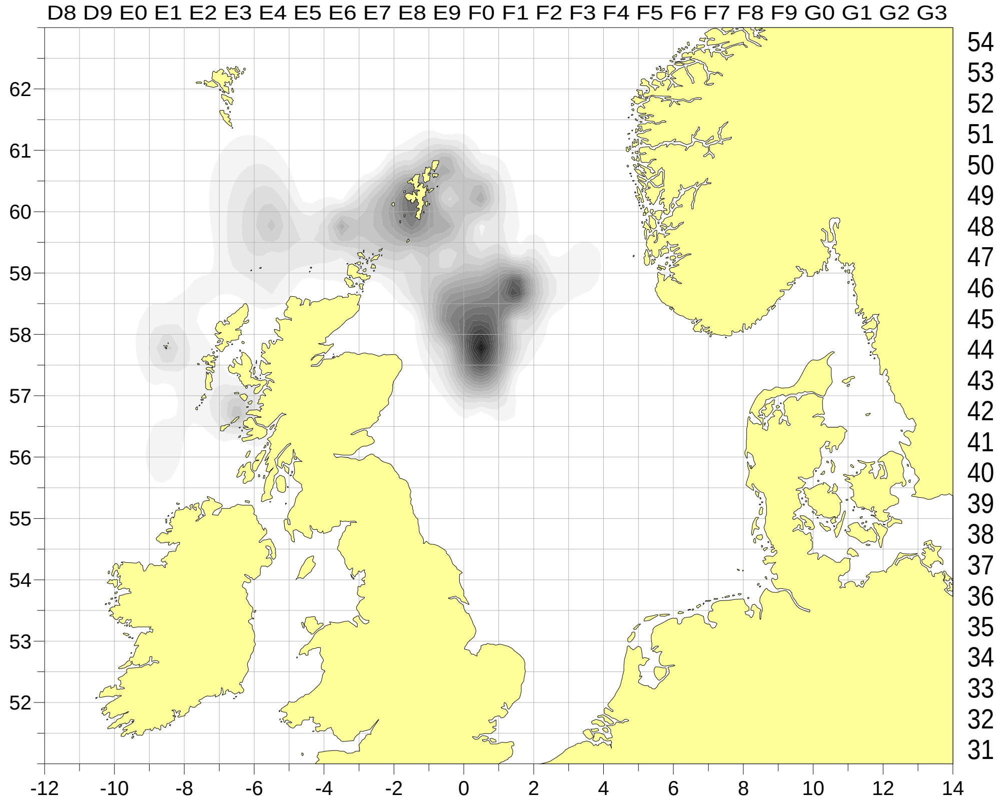


Figure 2.3.1.5: Biomass of mature autumn spawning herring from combined acoustic survey in June – July 2006.

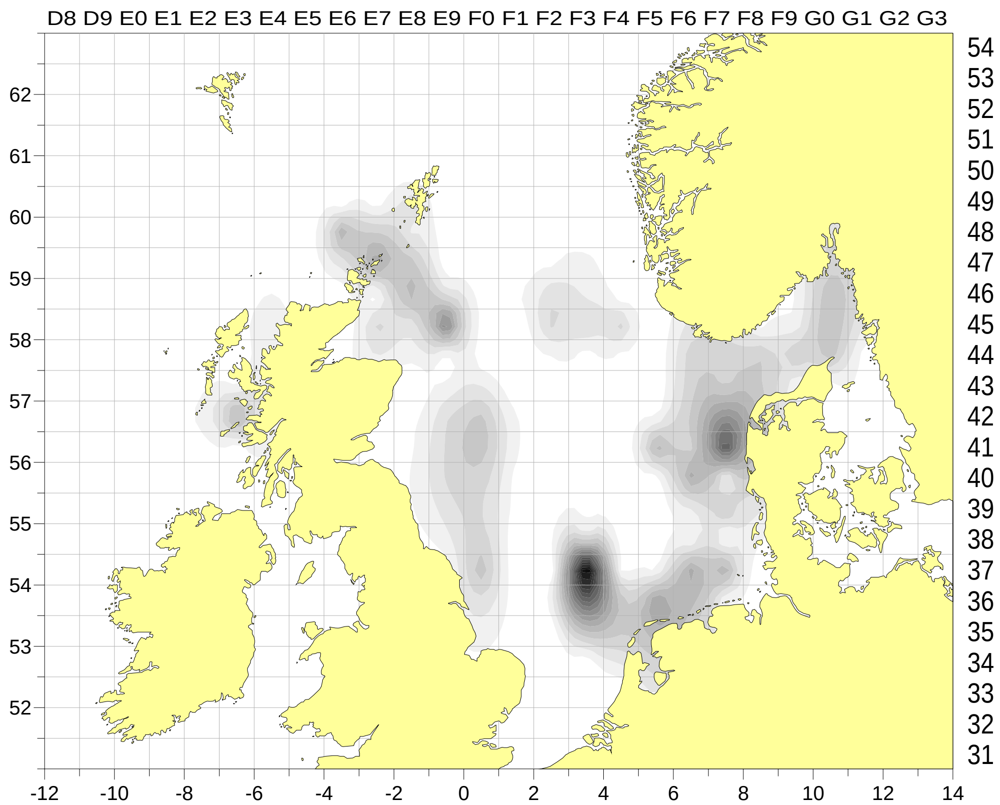


Figure 2.3.1.6: Biomass of immature autumn spawning herring from combined acoustic survey in June – July 2006.

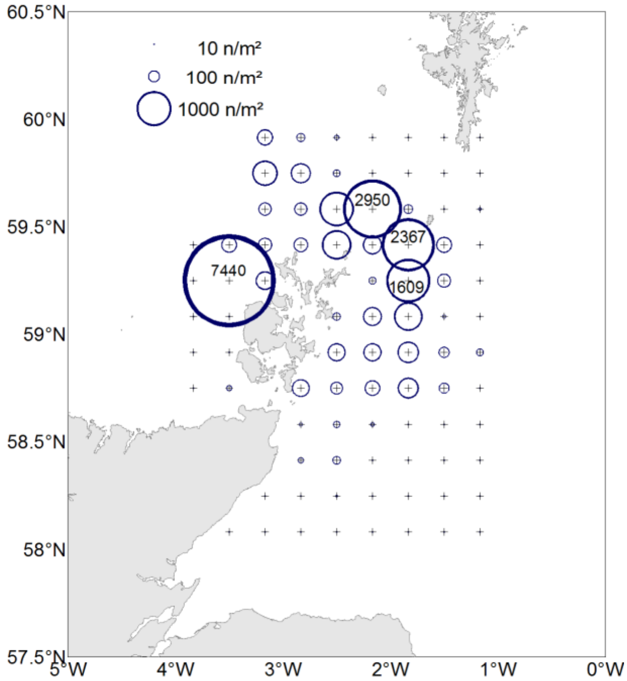


Figure 2.3.2.1: North Sea autumn spawners. Orkney/Shetlands 01–15 September 2006. Abundance of larvae < 10 mm (n/m²)

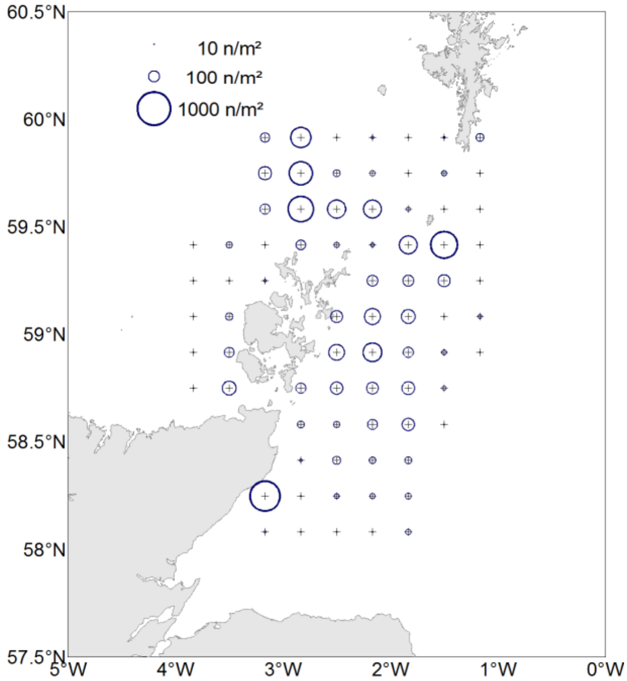


Figure 2.3.2.2: North Sea autumn spawners. Orkney/Shetlands 16–30 September 2006. Abundance of larvae < 10 mm (n/m²)

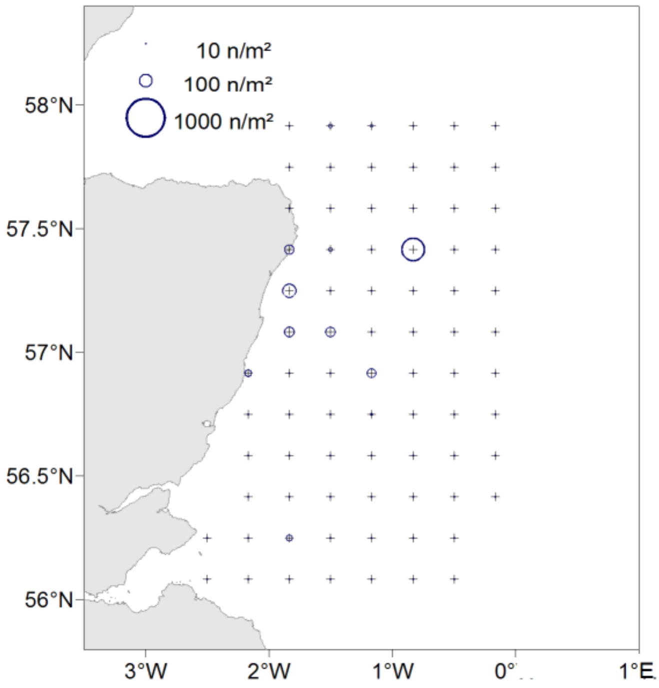


Figure 2.3.2.3: North Sea autumn spawners. Buchan 16–30 September 2006. Abundance of larvae < 10 mm (n/m²)

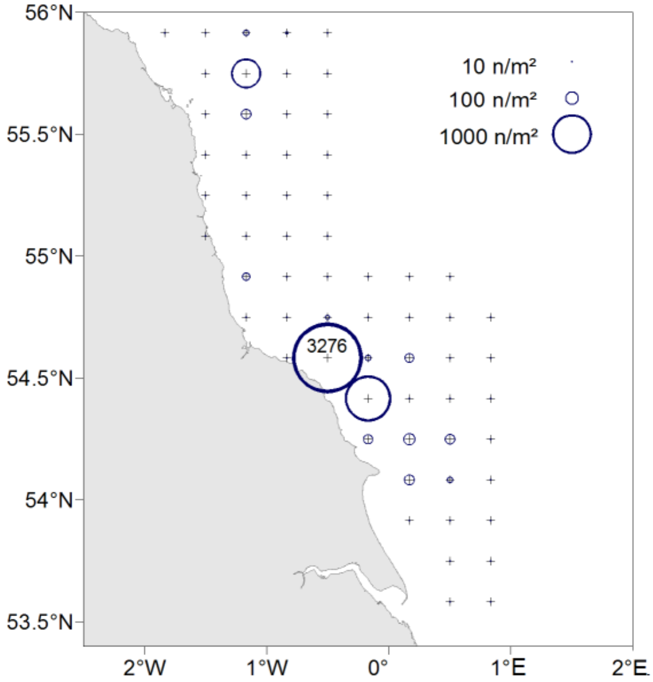


Figure 2.3.2.4: North Sea autumn spawners. Central North Sea 16–30 September 2006. Abundance of larvae < 10 mm (n/m²)

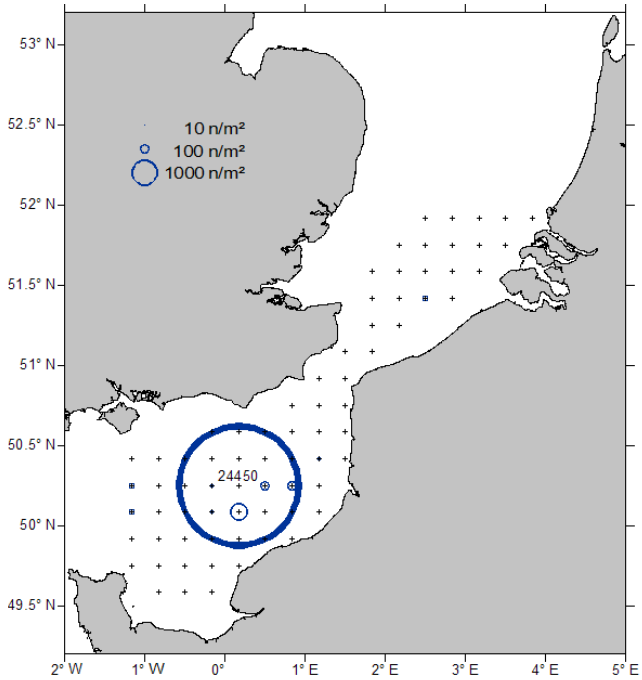


Figure 2.3.2.5: North Sea autumn spawners. Southern North Sea 16–31 December 2006. Abundance of larvae < 11 mm (n/m²)

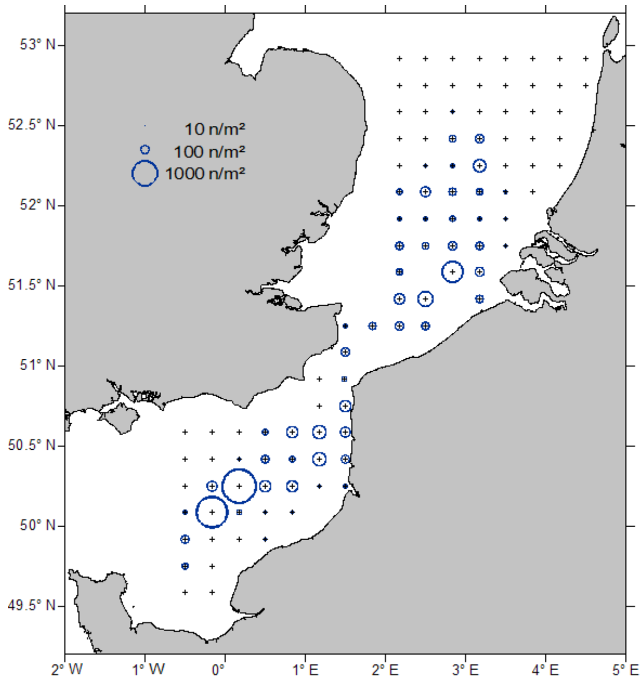


Figure 2.3.2.6: North Sea autumn spawners. Southern North Sea 1–15 January 2007. Abundance of larvae < 11 mm (n/m²)

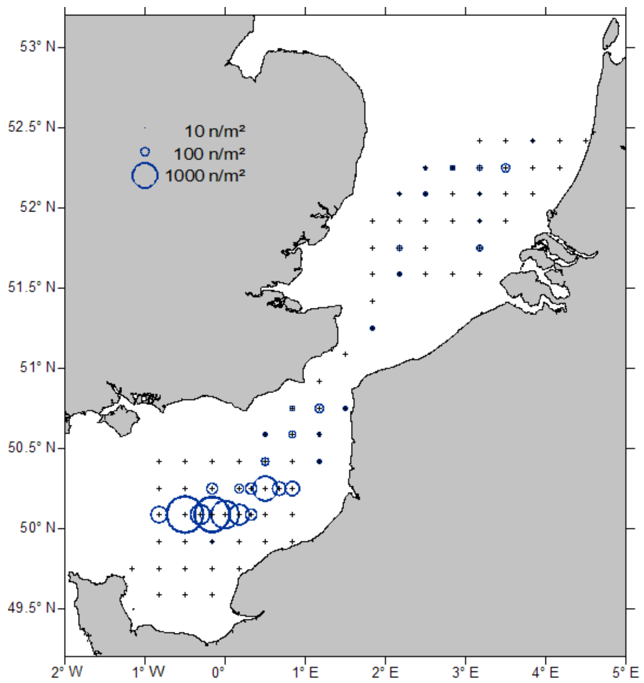


Figure 2.3.2.7: North Sea autumn spawners. Southern North Sea 16–31 January 2007. Abundance of larvae < 11 mm (n/m²)

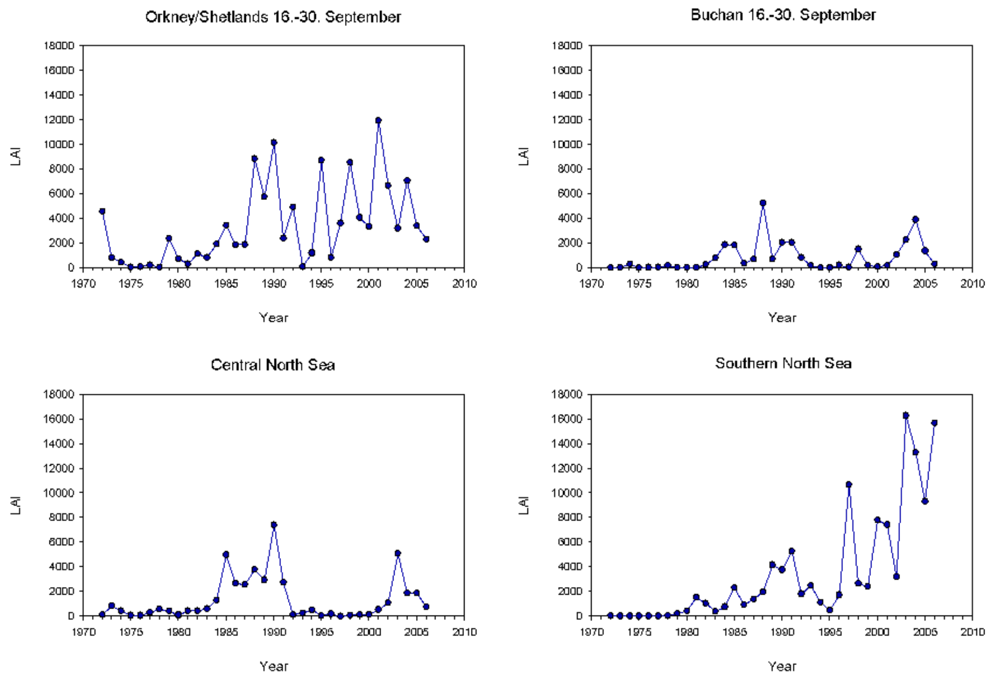


Figure 2.3.2.8: North Sea autumn spawners. Larval Abundance Index time-series for a collection of areas and sampling periods (Orkney/Shetlands 2nd half of September top left panel, Buchan 2nd half of September top right, central North Sea lower left, southern North Sea lower right. Due to historic reasons the abundance in the CNS is given as the mean of three surveys and in the SNS as the sum of three).

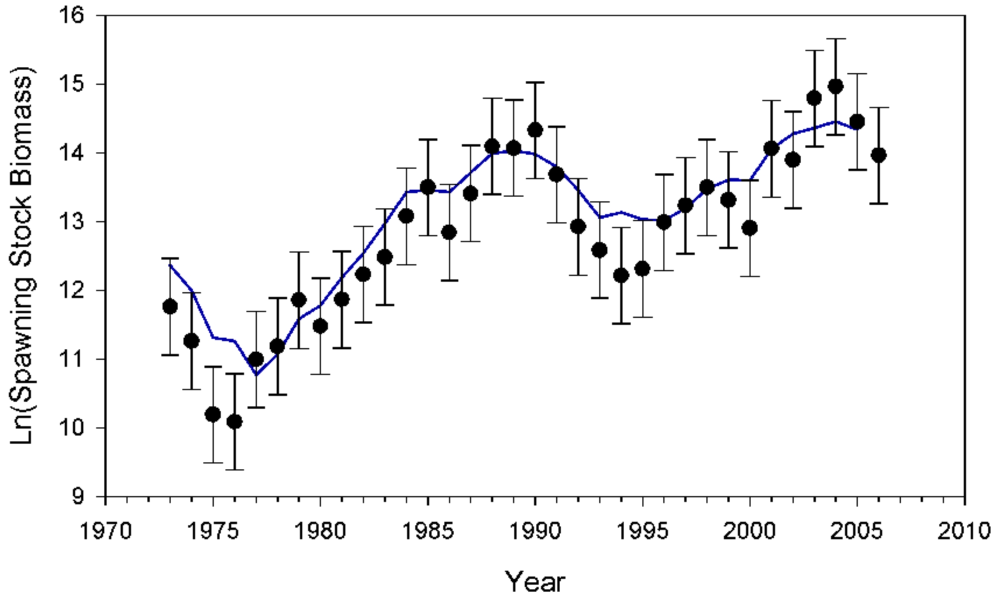


Figure 2.3.2.9: North Sea autumn spawners. Comparison of spawning stock size estimates from the Herring Assessment Working Group (ICES, 2006; bold line) and the year effects fitted to the larval abundances in the multiplicative model (symbols with error bars). The MLAI estimates have been rescaled to the mean of the WG estimates. Error bars indicate +/- one standard error of larval survey abundance estimates. Note the log y axis.

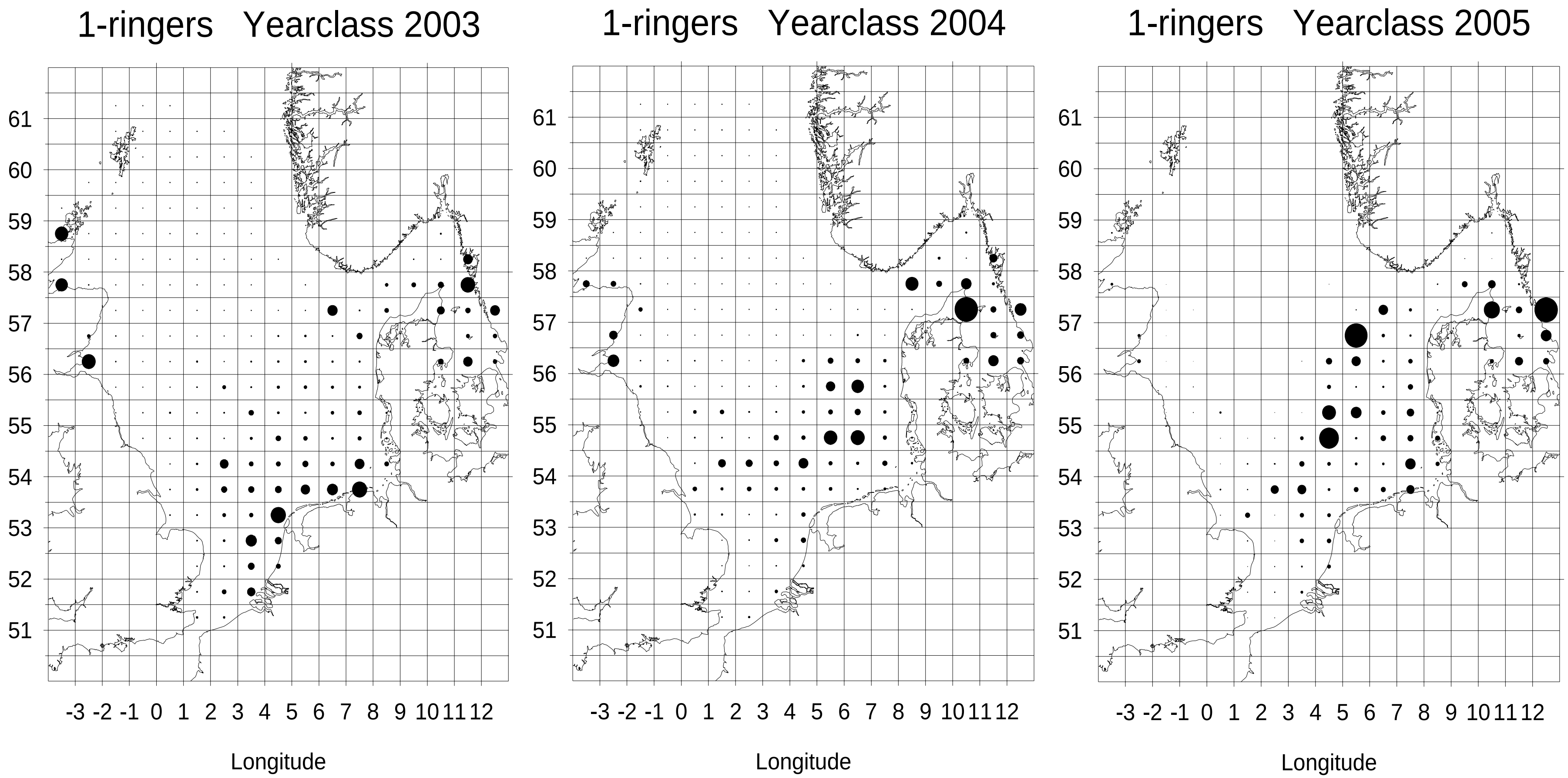


Figure 2.3.3.1. North Sea herring. Distribution of 1-ringer herring, year classes 2003-2005. Abundance estimates of 1-ringers within each statistical rectangle are based on GOV catches during IBTS in February 2005-2007. Areas of filled circles illustrate numbers per hour, the area of a circle extending to the border of a rectangle represents 45000 h^{-1}.

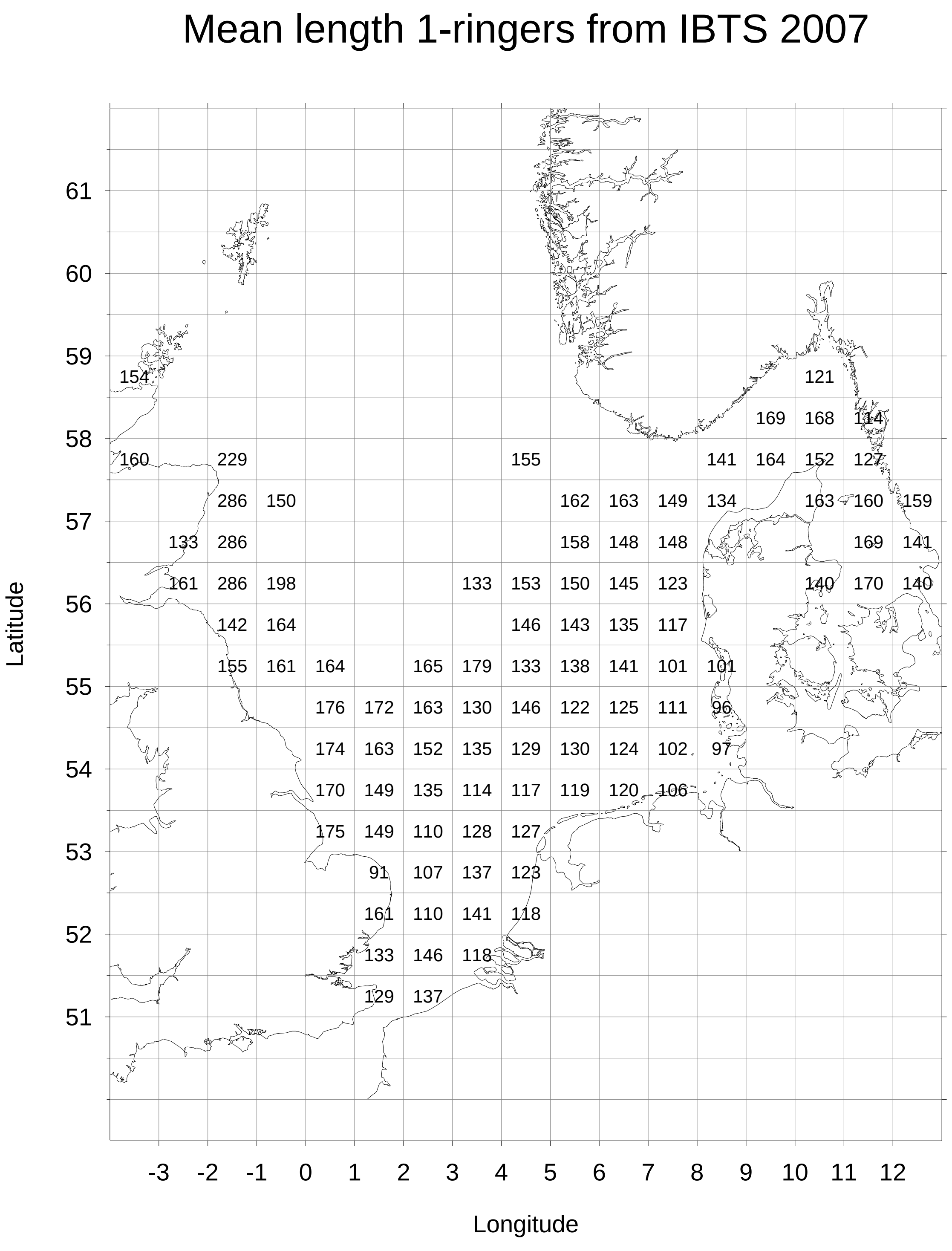


Figure 2.3.3.2. North Sea herring. Mean length (mm) of 1-ringer herring caught during IBTS 1st Quarter

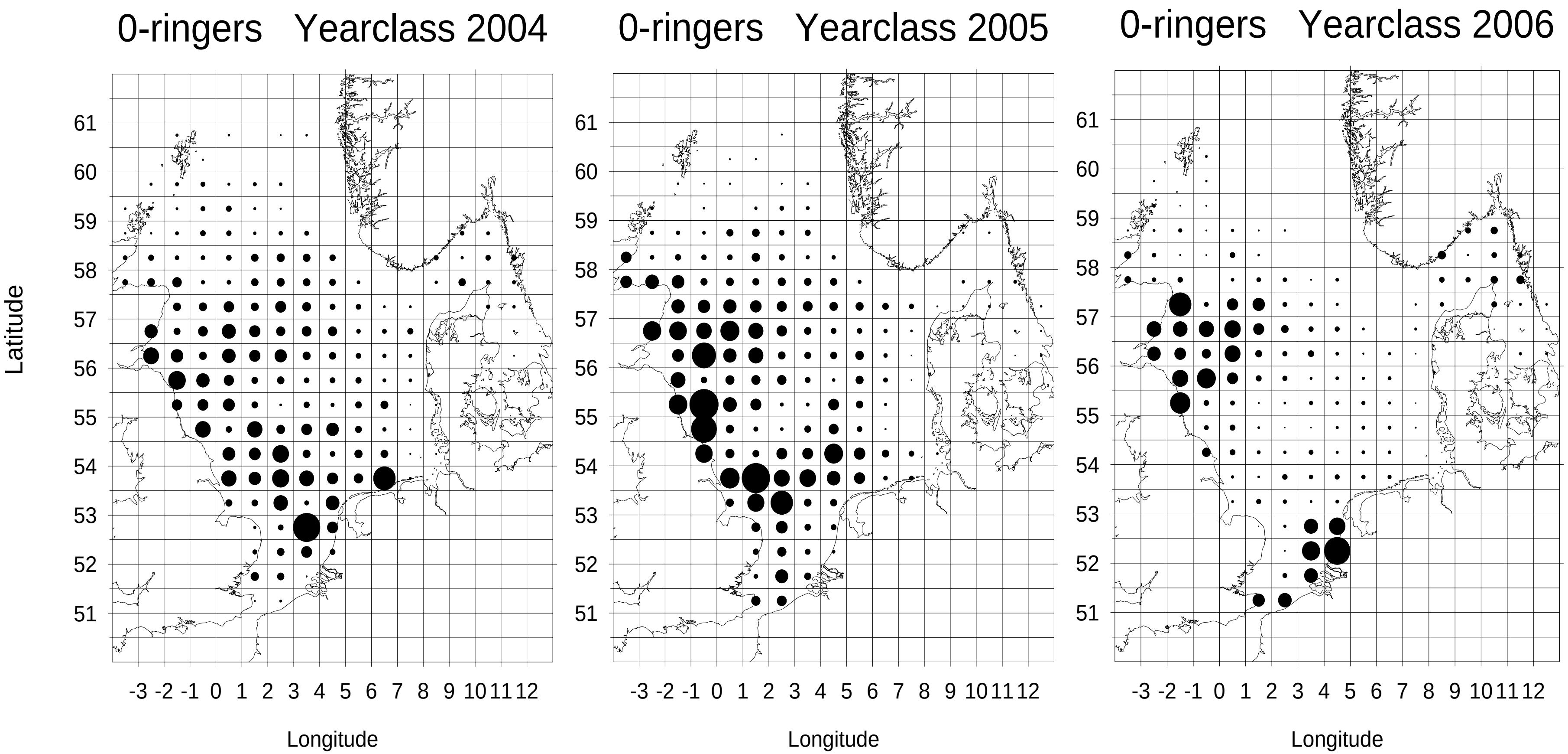


Figure 2.3.3.3. North Sea herring. Distribution of 0-ringer herring, year classes 2004-2006. Abundance estimates of 0-ringers within each statistical rectangle are based on MIK catches during IBTS in February 2005-2007 . Areas of filled circles illustrate densities in no m^{-2}, the area of a circle extending to the border of a rectangle represents 1 m^{-2}

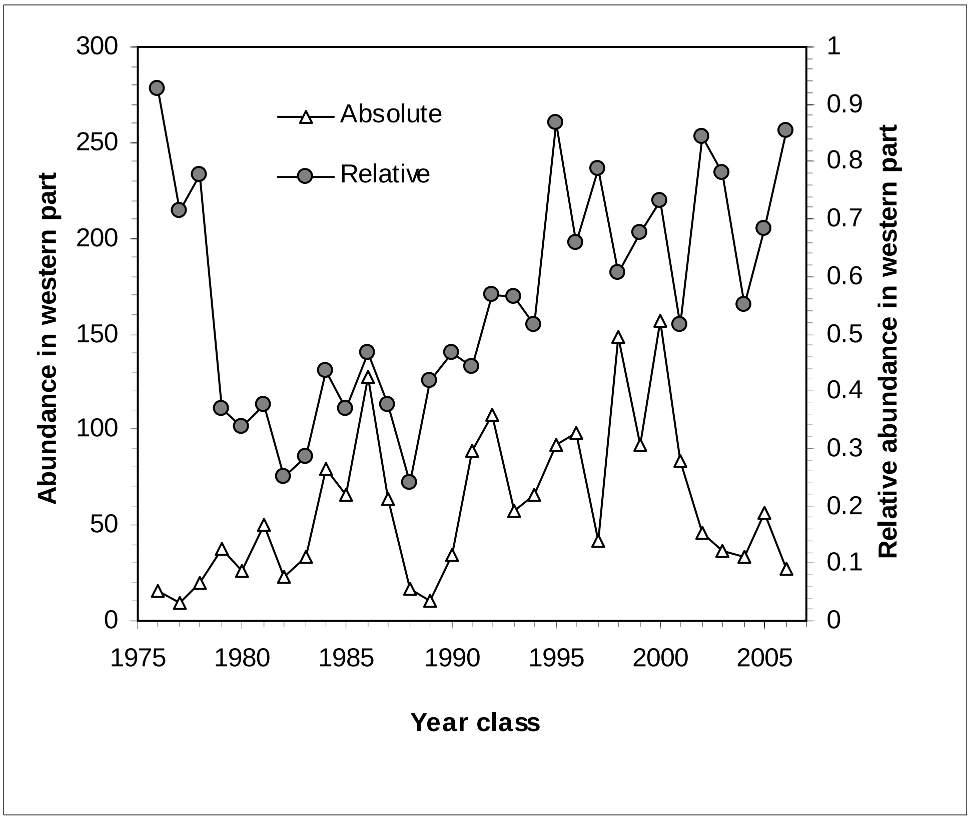


Figure 2.3.3.4 North Sea herring. Absolute (no * 10^9) and relative abundance of 0-ringers in the area west of 2°E in the North Sea. Abundances are based on MIK sampling during IBTS, the relative abundance in the western part is estimated as the number of 0-ringers west of 2°E relative to total number of 0-ringers.

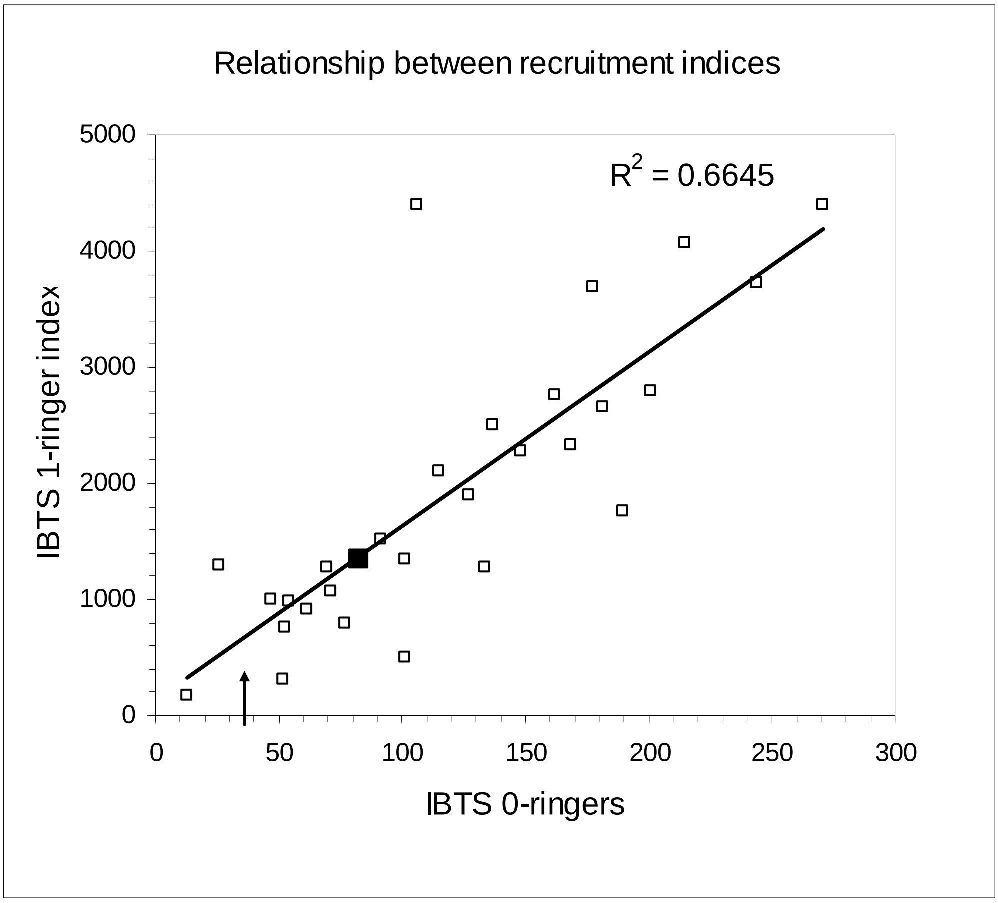


Figure 2.5.1 North Sea herring. Relationship between indices of 0-ringers and 1-ringers for year classes 1977 to 2005. The 2005 relation is shown as a filled square, the present 0-ringer index for year class 2006 is indicated by an arrow.

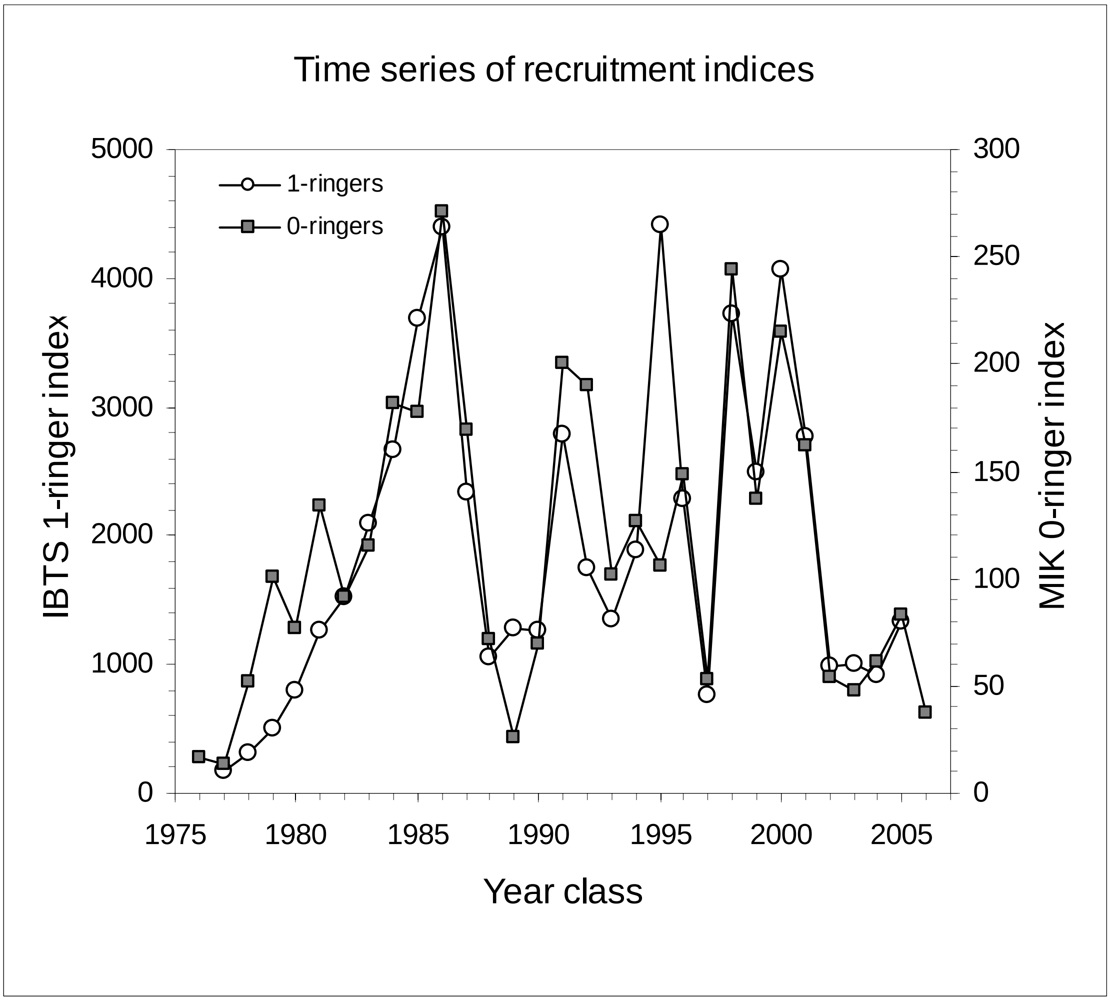


Figure 2.5.2 North Sea herring. Time series of 0-ringer and 1-ringer indices. Year classes 1976 to 2006 for 0-ringers, year classes 1977-2005 for 1-ringers.

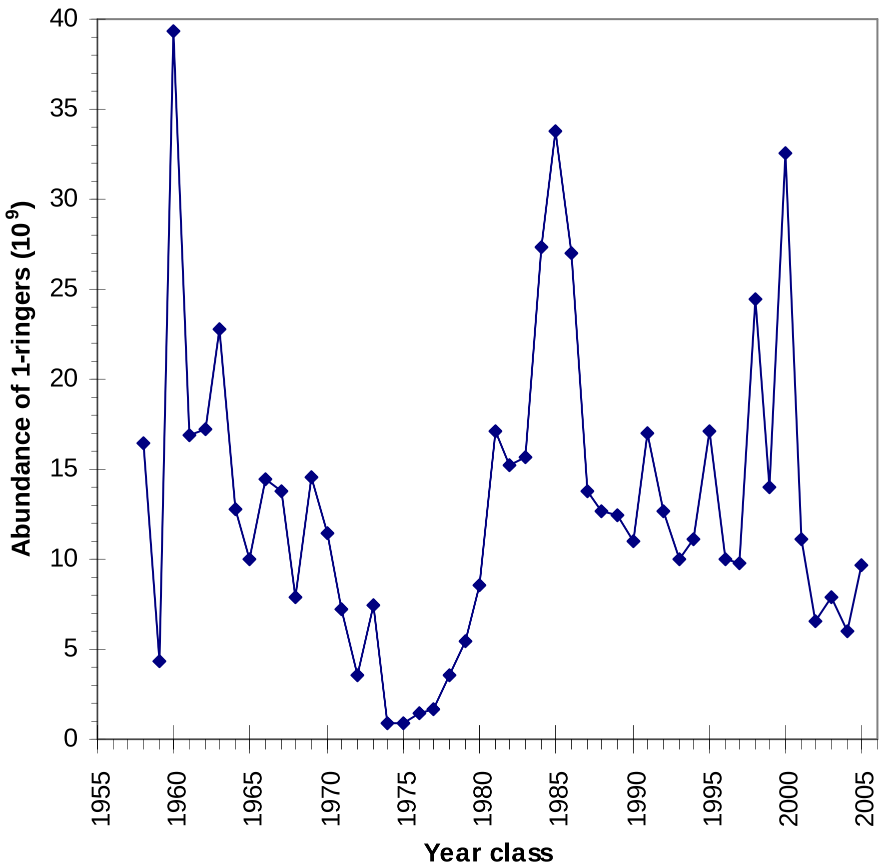


Figure 2.5.3. North Sea herring. Trend in recruitment of 1-ringers from year class 1958 to 2005. Data from the 2007 ICA assessment of the North Sea autumn spawned herring.

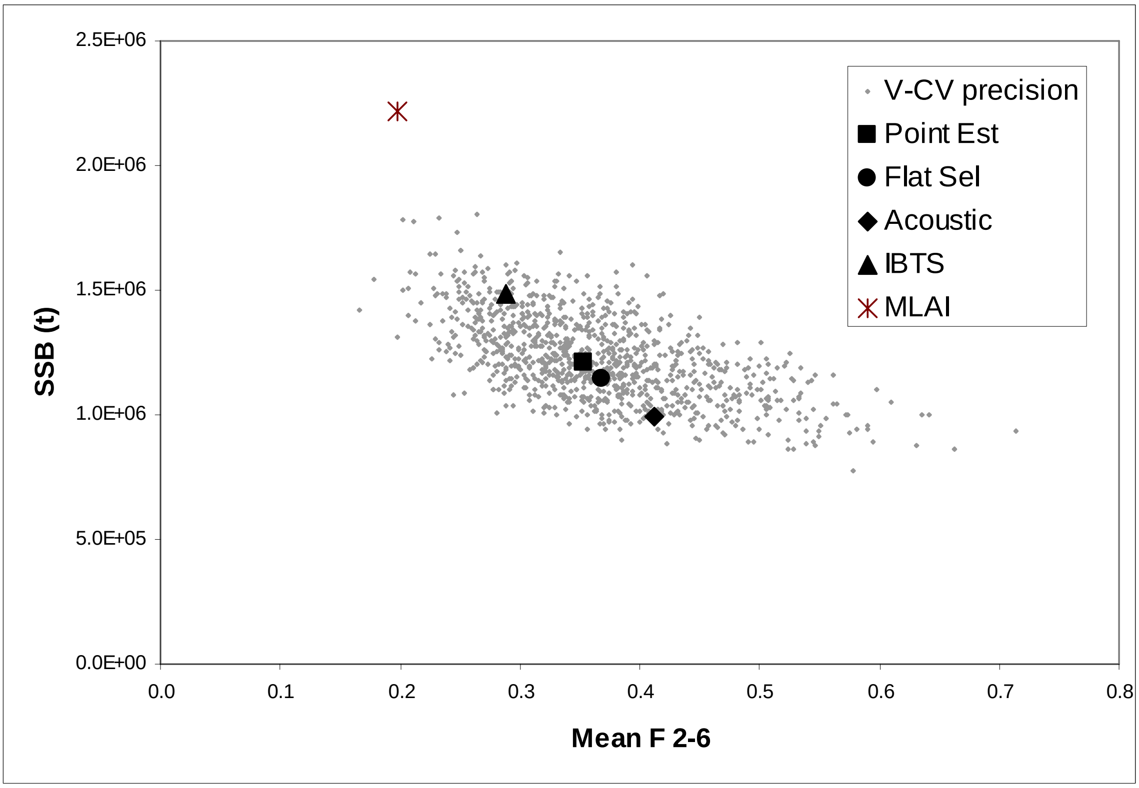


Figure 2.6.1. North Sea herring. Comparison of mean reference relationship between mean F and SSB for:

- **Assessment point estimate using catch and all indices using the benchmarked procedure from last year**
- **Variance – Covariance (V-CV) uncertainty of F and SSB using bootstrap estimates**
- **Flat selection of F at age 7,8,9+**
- **Each individual fleet as the only tuning indices (Acoustic 1-9+wr, IBTS 1-5+wr, MIK 0wr and MLAI SSB index)**

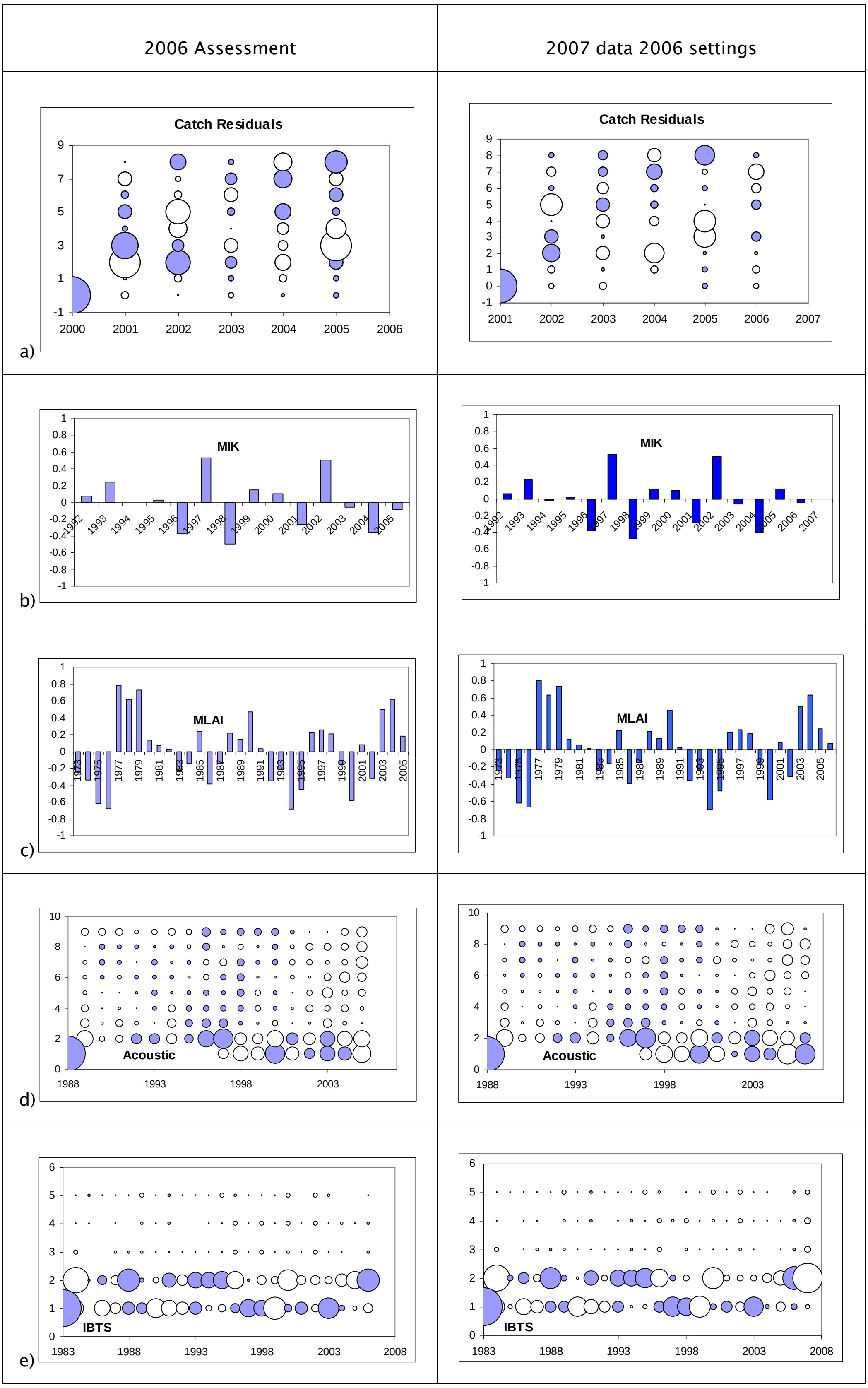


Figure 2.6.2 North Sea herring. Comparison of weighted residuals for assessment 2006 (left panels) and 2007 (right panels) using same procedure. Dark bubbles represent residual values greater than 0, white bubbles less then 0, left hand dark bubble represents a scaling value of 1.0. Plot of (a) catch residuals at age for the separable period; (b) MIK 0 group index; (c) MLAI SSB index; (d) Acoustic survey with age 1 only from 1997 onwards; (e) IBTS survey.

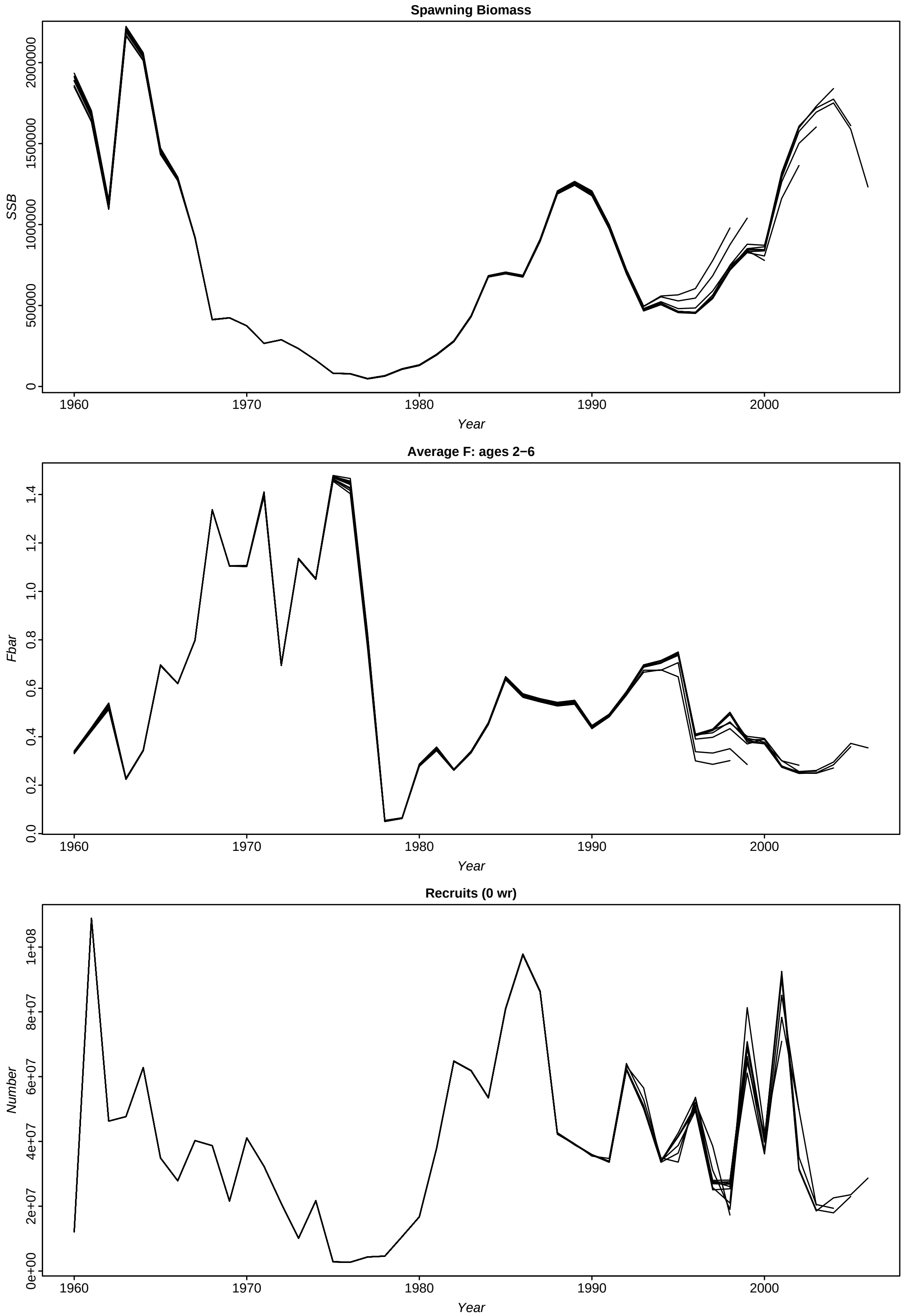


Figure 2.6.3. North Sea herring. Retrospective ICA plots for SSB, mean F on ages 2-6, and recruitment.

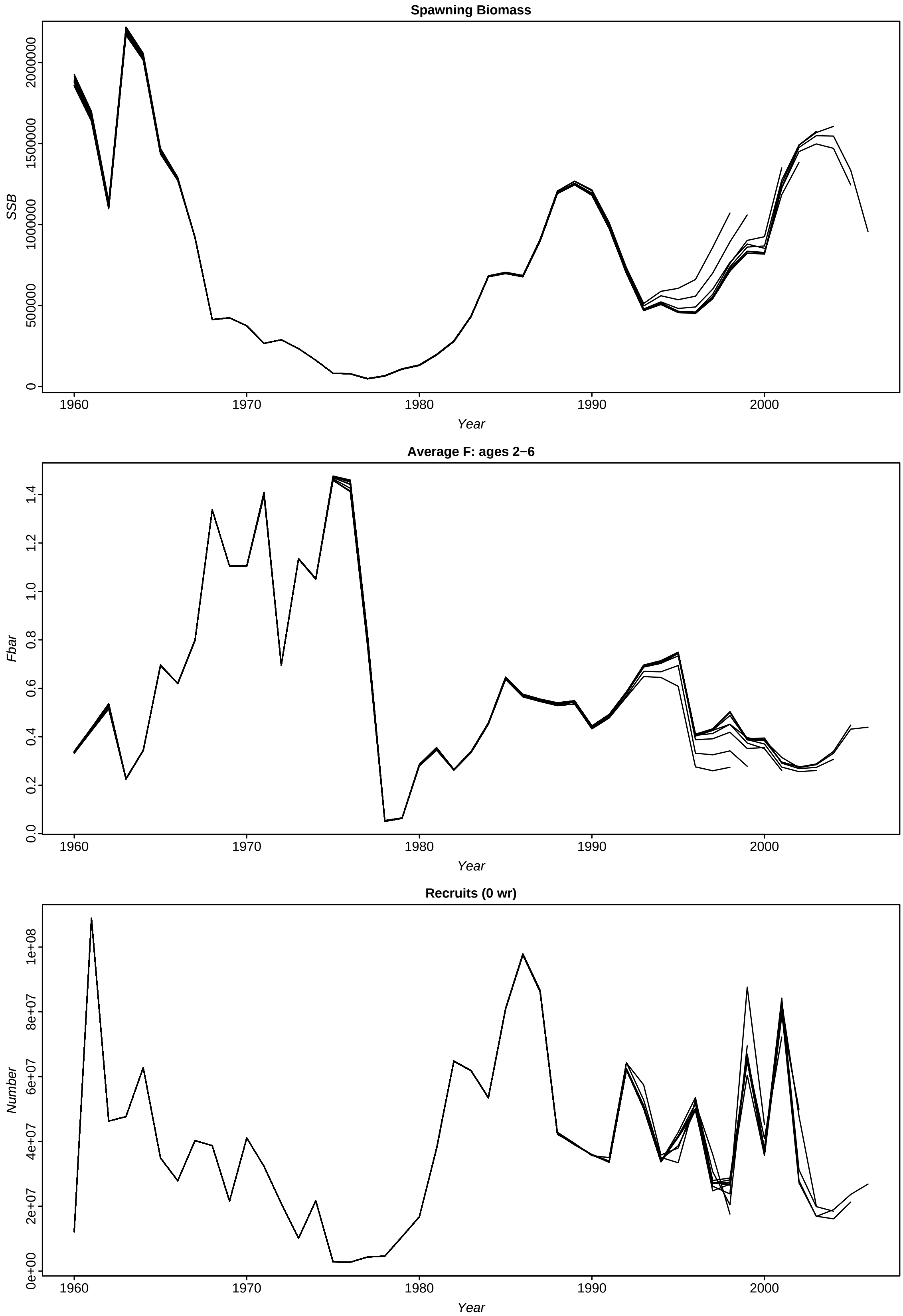


Figure 2.6.4. North Sea herring. Retrospective ICA plots for SSB, mean F on ages 2-6, and recruitment based on an assessment using only MIK and Acoustic survey data.

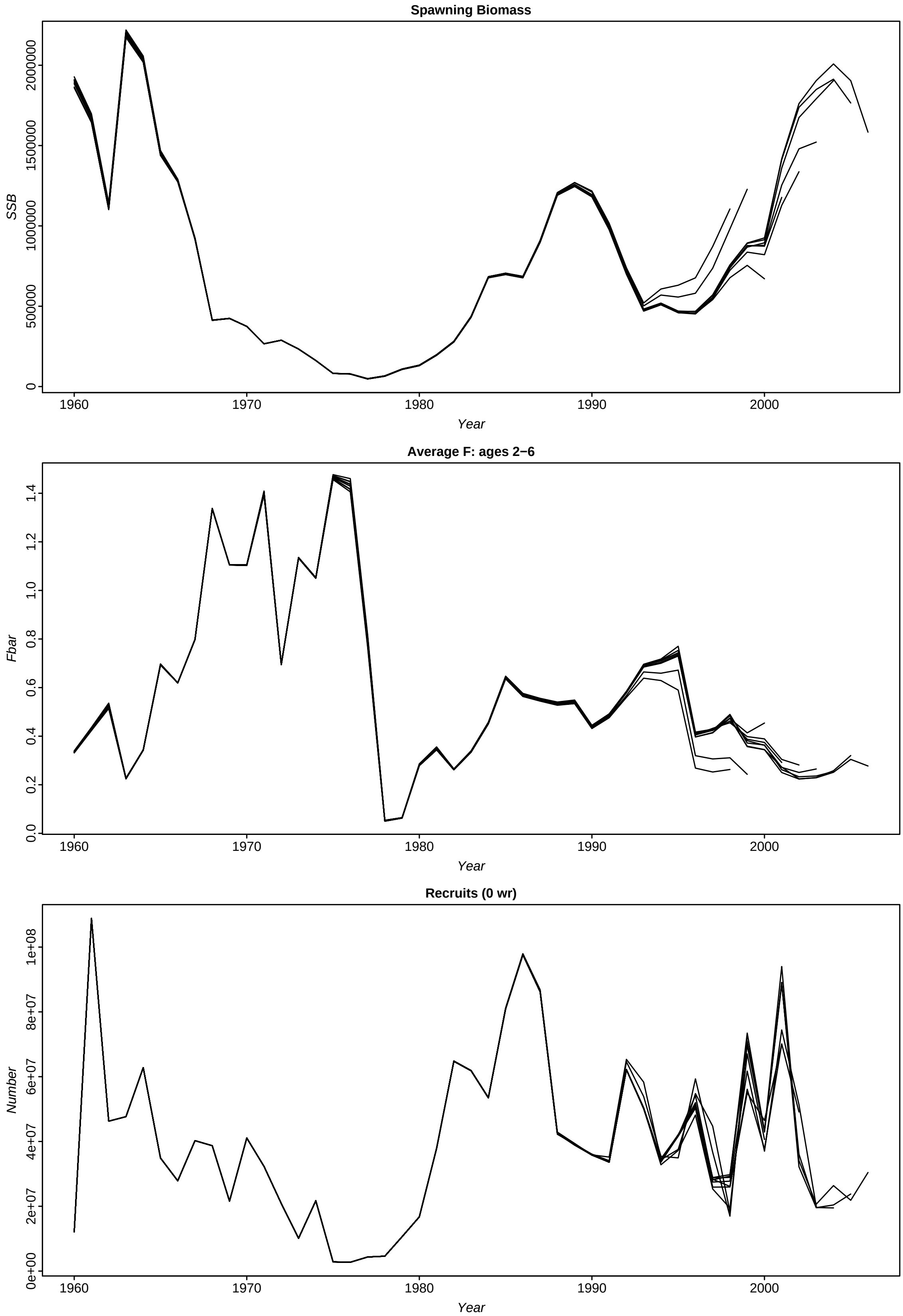


Figure 2.6.5. North Sea herring. Retrospective ICA plots for SSB, mean F on ages 2-6, and recruitment based on an assessment using only MIK and IBTS survey data.

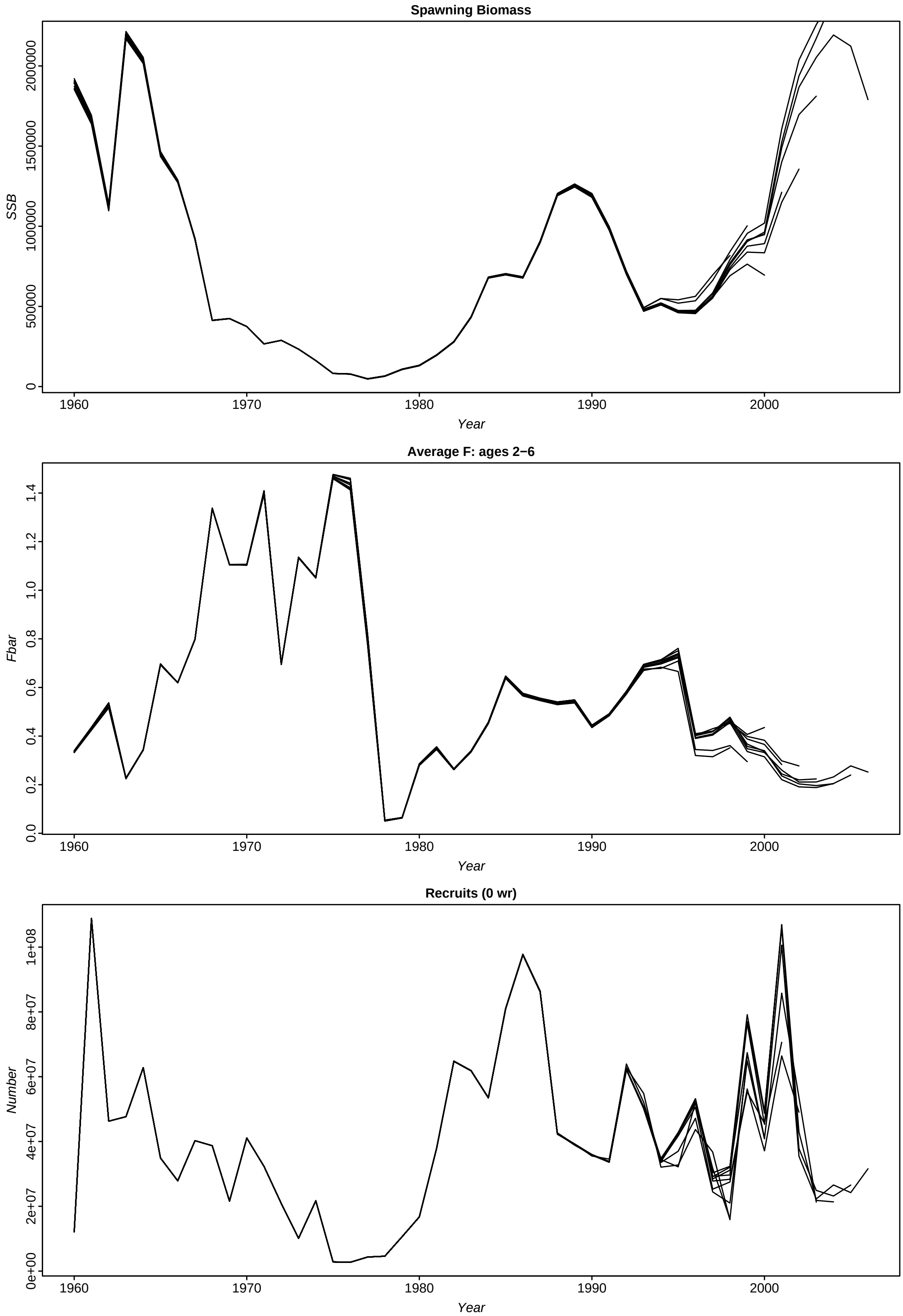


Figure 2.6.6. North Sea herring. Retrospective ICA plots for SSB, mean F on ages 2-6, and recruitment based on an assessment using only MIK and MLAI survey data.

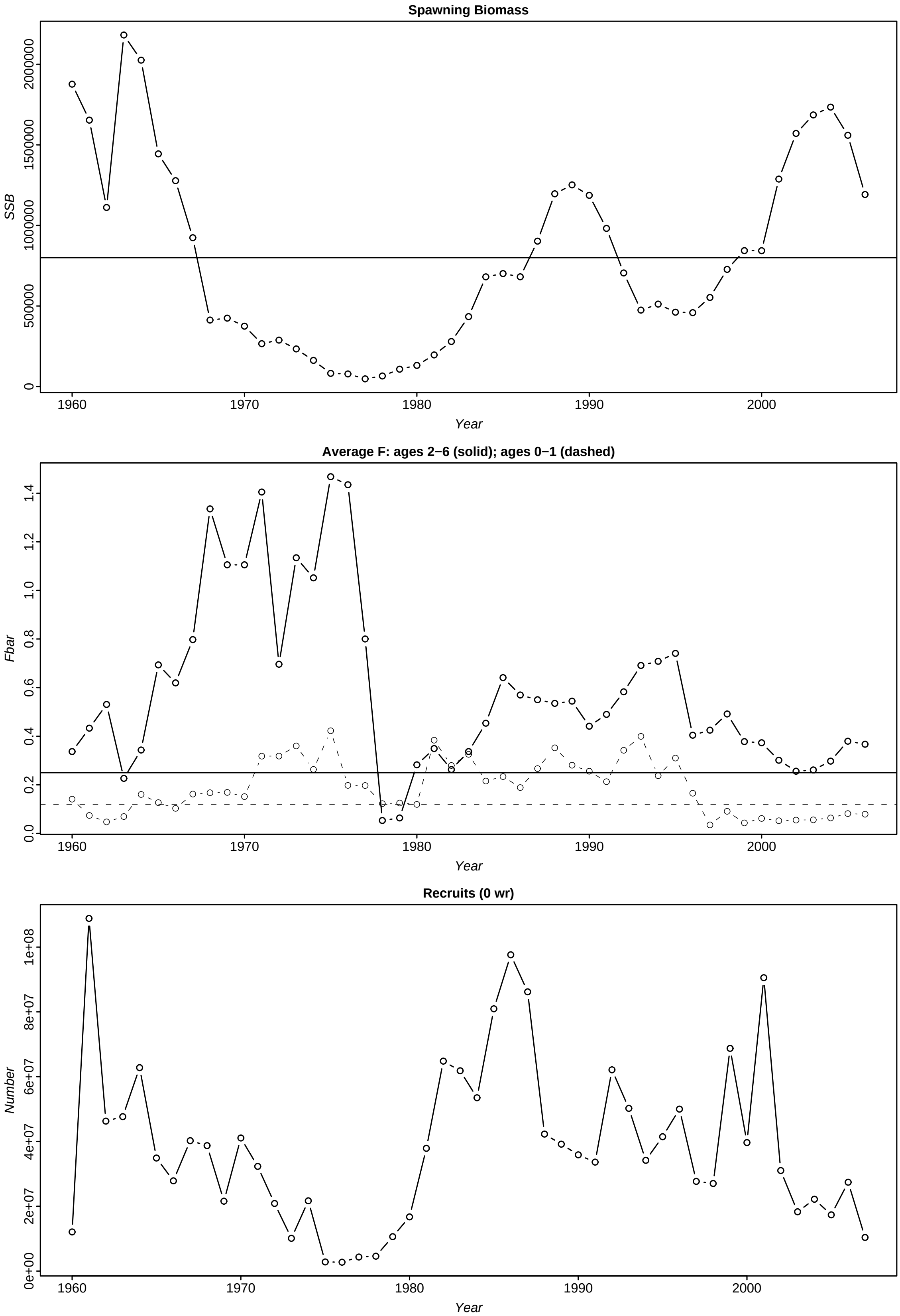


Figure 2.6.7. North Sea herring. Stock summary according to the final ICA assessment: SSB, mean F on ages 2-6 and ages 0-1, and recruitment. The reference line for SSB corresponds to 800 000 tonnes (Blim), while the reference lines for mean F correspond to 0.25 (solid line) and 0.12 (dashed line).

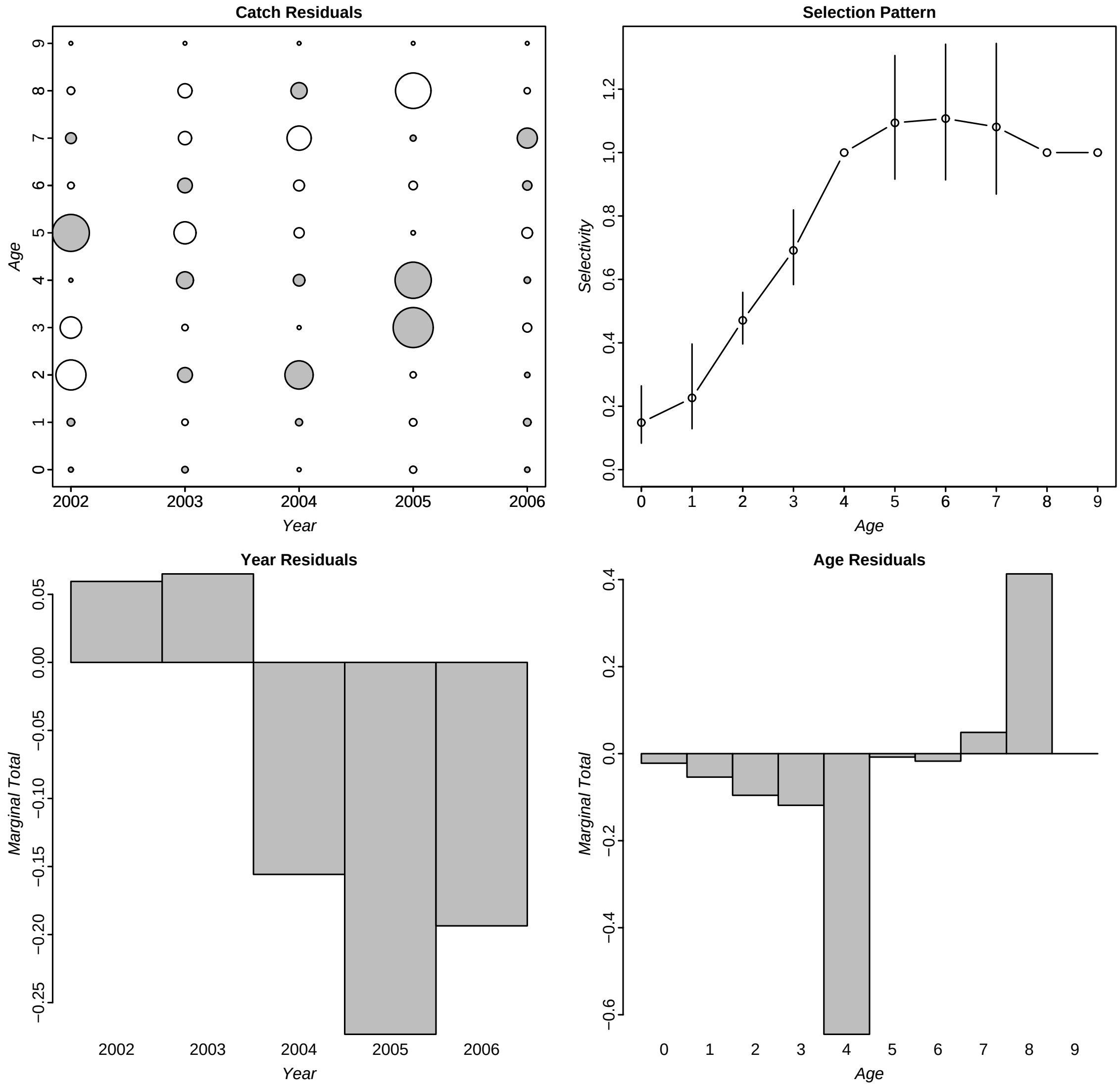


Figure 2.6.8. North Sea herring. Diagnostics of selection pattern from the final ICA assessment. Top left: bubbles plot of log catch residuals by age (weighting applied) and year (5 yr separable period). Top right: estimated selection parameters (relative to 4 wr) with 95% confidence intervals. Middle left: marginal totals of log residuals by year. Middle right: marginal totals of log residuals by age (wr).

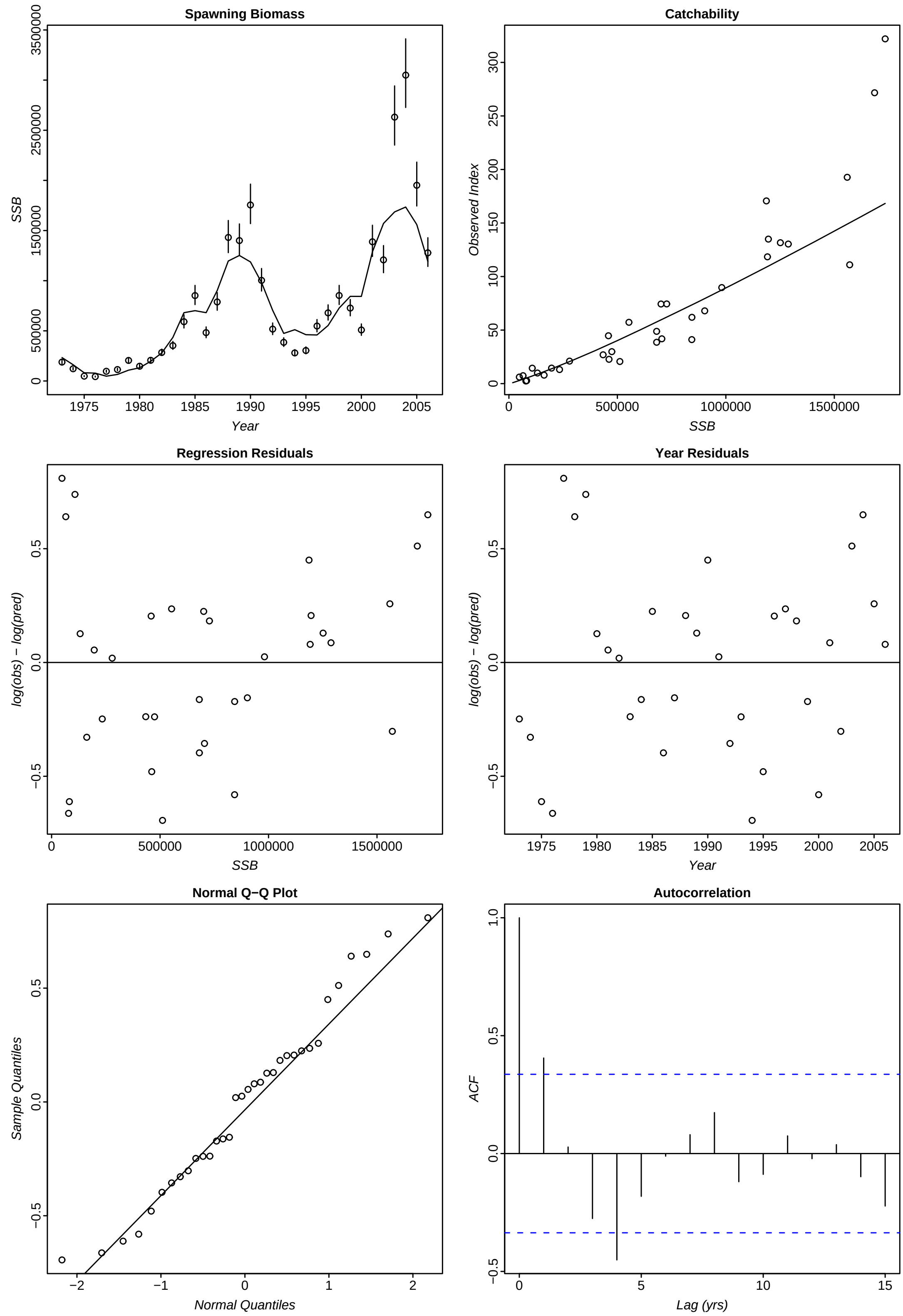


Figure 2.6.9. North Sea herring. Diagnostics of MLAI survey catchability from the final ICA assessment. Top left: VPA estimates of SSB (line) and SSB predictions made from index observations with 95% confidence intervals. Top right: scatterplot of index observations versus VPA estimates of SSB with the best-fit catchability model (power function). Middle left: log residuals of catchability model by VPA estimate of SSB. Middle right: log residuals of catchability model by year. Bottom left: normal Q-Q plot of log residuals. Bottom right: autocorrelogram of log residuals.

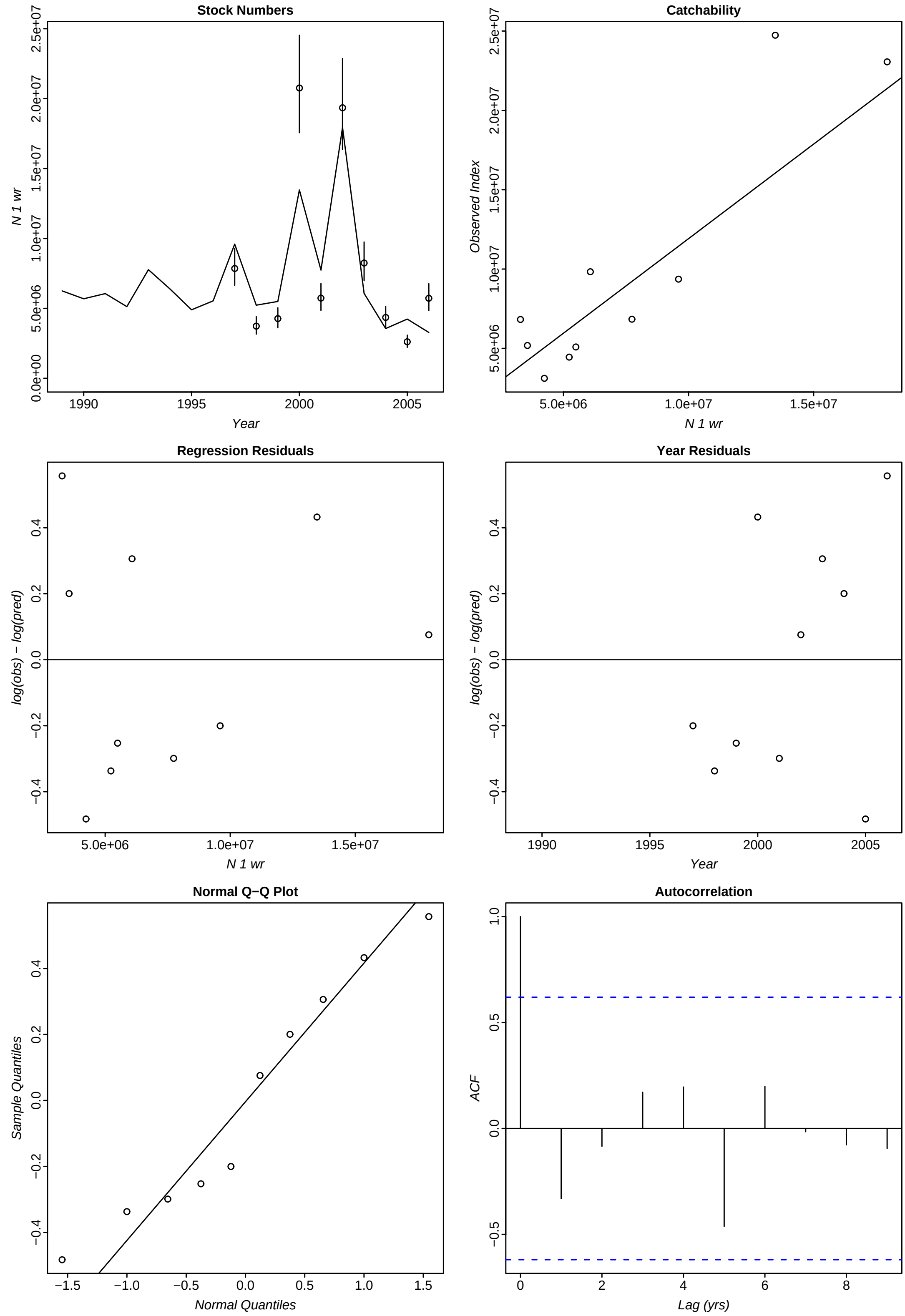


Figure 2.6.10. North Sea herring. Diagnostics of Acoustic survey catchability at 1 wr from the final ICA assessment. Top left: VPA estimates of numbers at 1 wr (line) and numbers predicted from index abundance at 1 wr with 95% confidence intervals. Top right: scatterplot of index observations versus VPA estimates of numbers at 1 wr with the best-fit catchability model (linear function). Middle left: log residuals of catchability model by VPA estimate of numbers at 1 wr. Middle right: log residuals of catchability model by year. Bottom left: normal Q-Q plot of log residuals. Bottom right: autocorrelogram of log residuals.

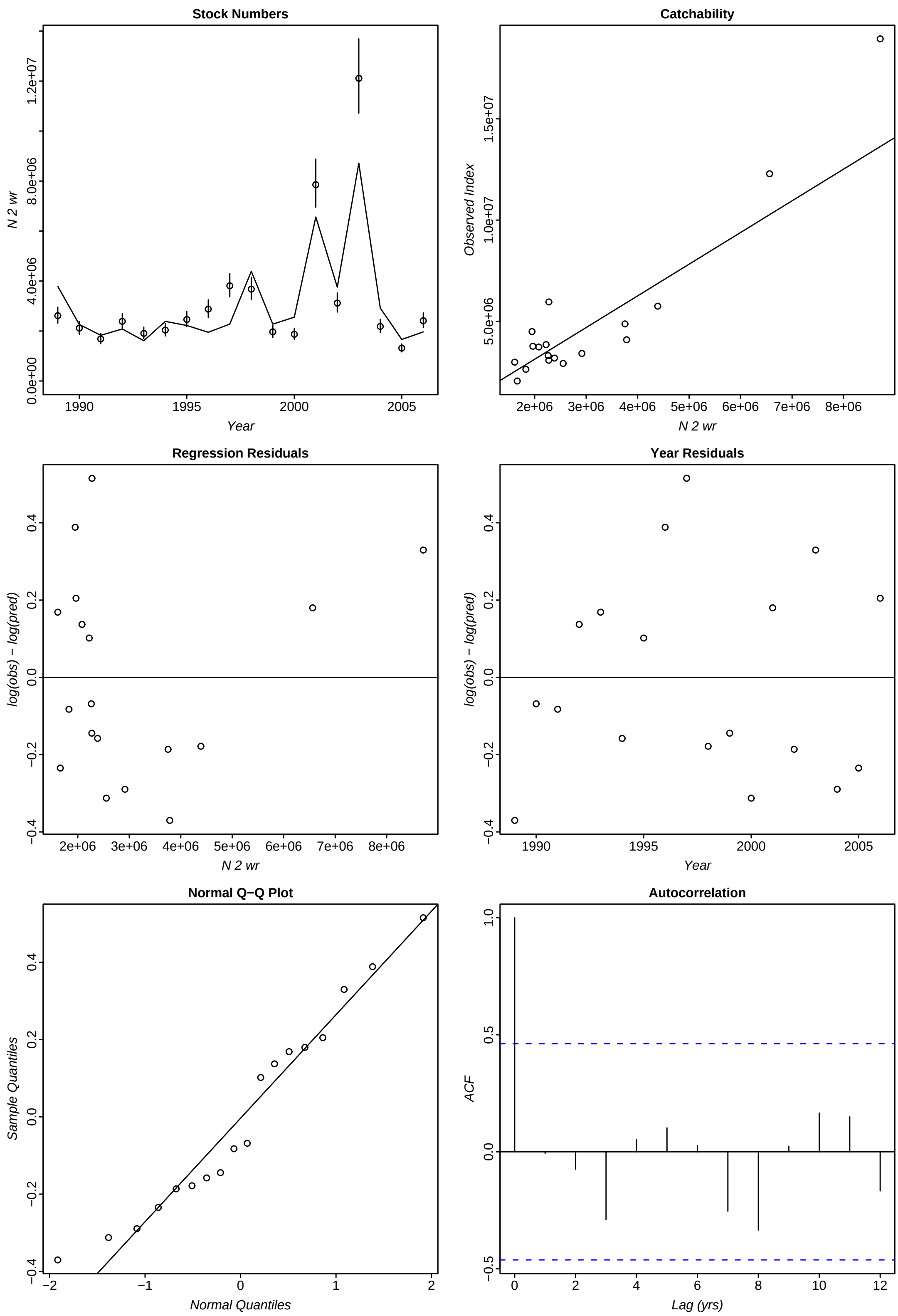


Figure 2.6.11. North Sea herring. Diagnostics of Acoustic survey catchability at 2 wr from the final ICA assessment. Top left: VPA estimates of numbers at 2 wr (line) and numbers predicted from index abundance at 2 wr with 95% confidence intervals. Top right: scatterplot of index observations versus VPA estimates of numbers at 2 wr with the best-fit catchability model (linear function). Middle left: log residuals of catchability model by VPA estimate of numbers at 2 wr. Middle right: log residuals of catchability model by year. Bottom left: normal Q-Q plot of log residuals. Bottom right: autocorrelogram of log residuals.

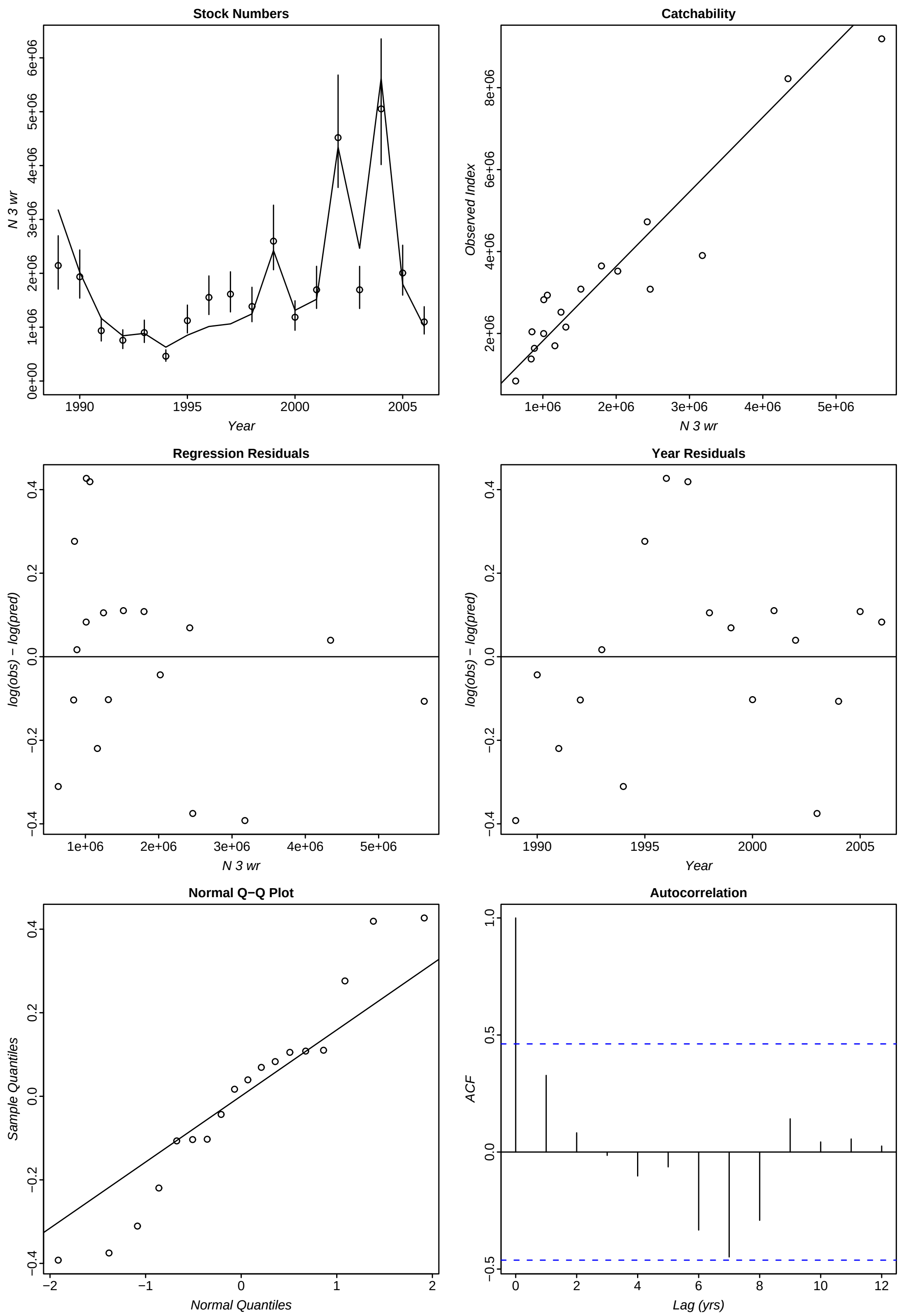


Figure 2.6.12. North Sea herring. Diagnostics of Acoustic survey catchability at 3 wr from the final ICA assessment. Top left: VPA estimates of numbers at 3 wr (line) and numbers predicted from index abundance at 3 wr with 95% confidence intervals. Top right: scatterplot of index observations versus VPA estimates of numbers at 3 wr with the best-fit catchability model (linear function). Middle left: log residuals of catchability model by VPA estimate of numbers at 3 wr. Middle right: log residuals of catchability model by year. Bottom left: normal Q-Q plot of log residuals. Bottom right: autocorrelogram of log residuals.

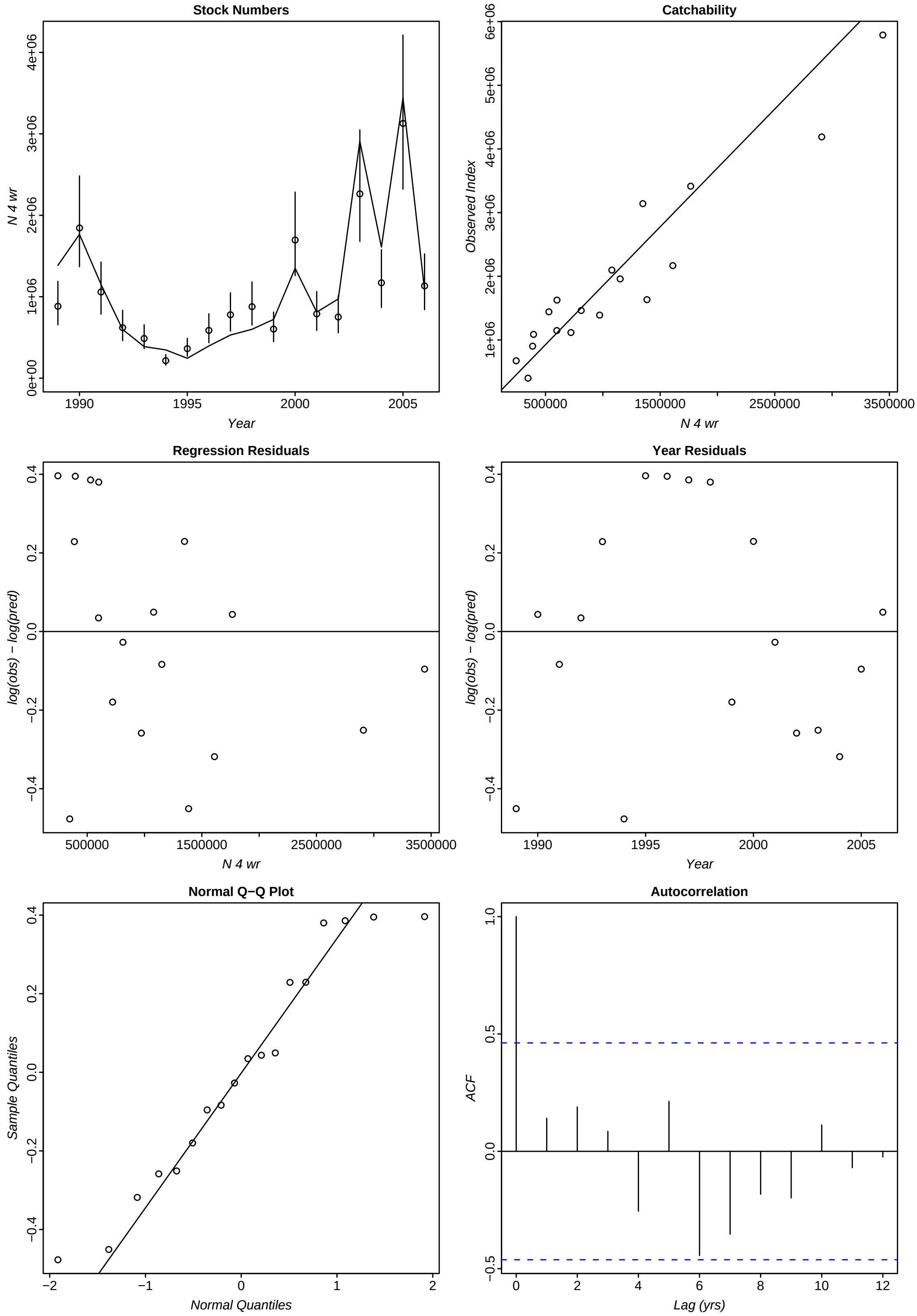


Figure 2.6.13. North Sea herring. Diagnostics of Acoustic survey catchability at 4 wr from the final ICA assessment. Top left: VPA estimates of numbers at 4 wr (line) and numbers predicted from index abundance at 4 wr with 95% confidence intervals. Top right: scatterplot of index observations versus VPA estimates of numbers at 4 wr with the best-fit catchability model (linear function). Middle left: log residuals of catchability model by VPA estimate of numbers at 4 wr. Middle right: log residuals of catchability model by year. Bottom left: normal Q-Q plot of log residuals. Bottom right: autocorrelogram of log residuals.

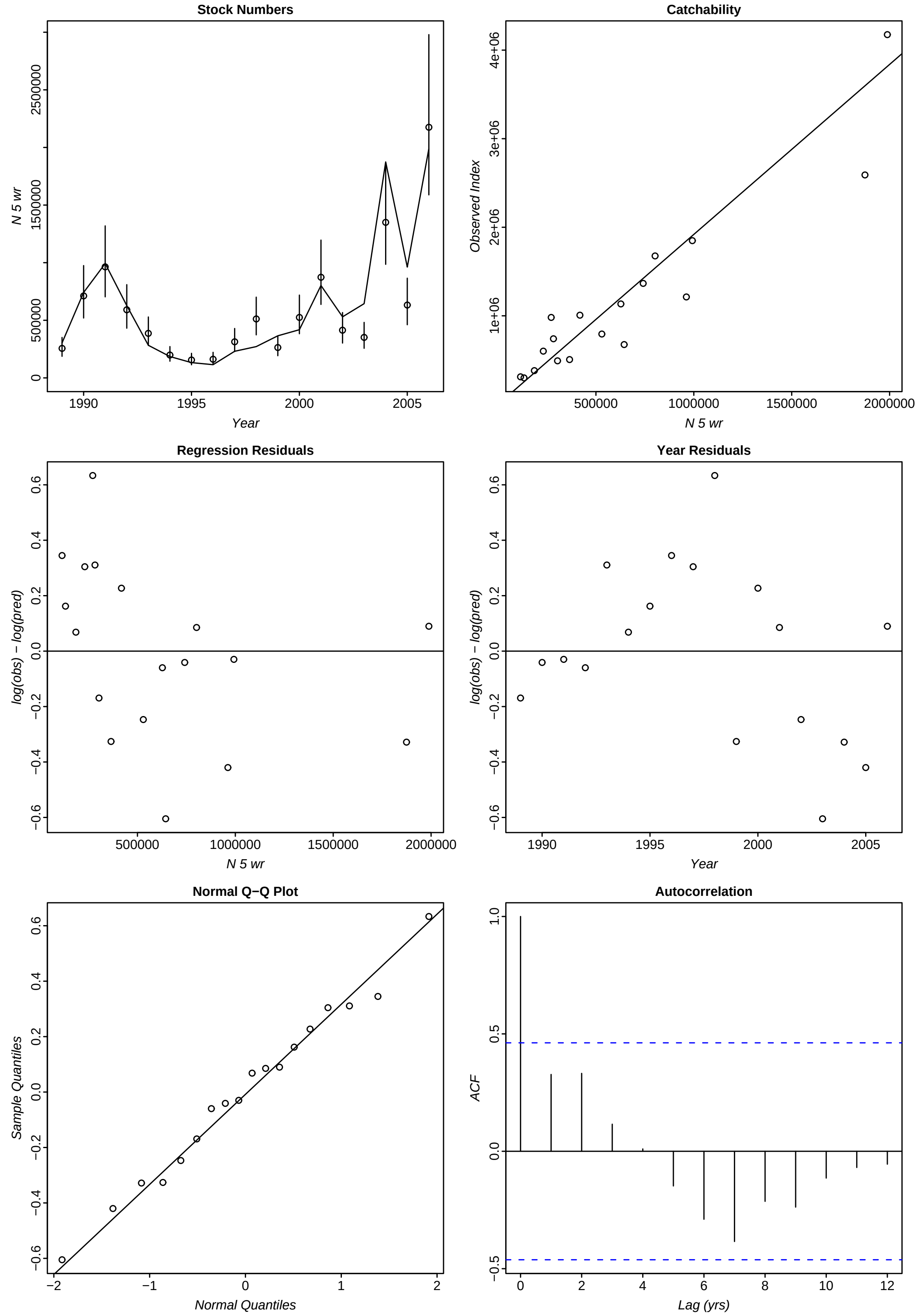


Figure 2.6.14. North Sea herring. Diagnostics of Acoustic survey catchability at 5 wr from the final ICA assessment. Top left: VPA estimates of numbers at 5 wr (line) and numbers predicted from index abundance at 5 wr with 95% confidence intervals. Top right: scatterplot of index observations versus VPA estimates of numbers at 5 wr with the best-fit catchability model (linear function). Middle left: log residuals of catchability model by VPA estimate of numbers at 5 wr. Middle right: log residuals of catchability model by year. Bottom left: normal Q-Q plot of log residuals. Bottom right: autocorrelogram of log residuals.

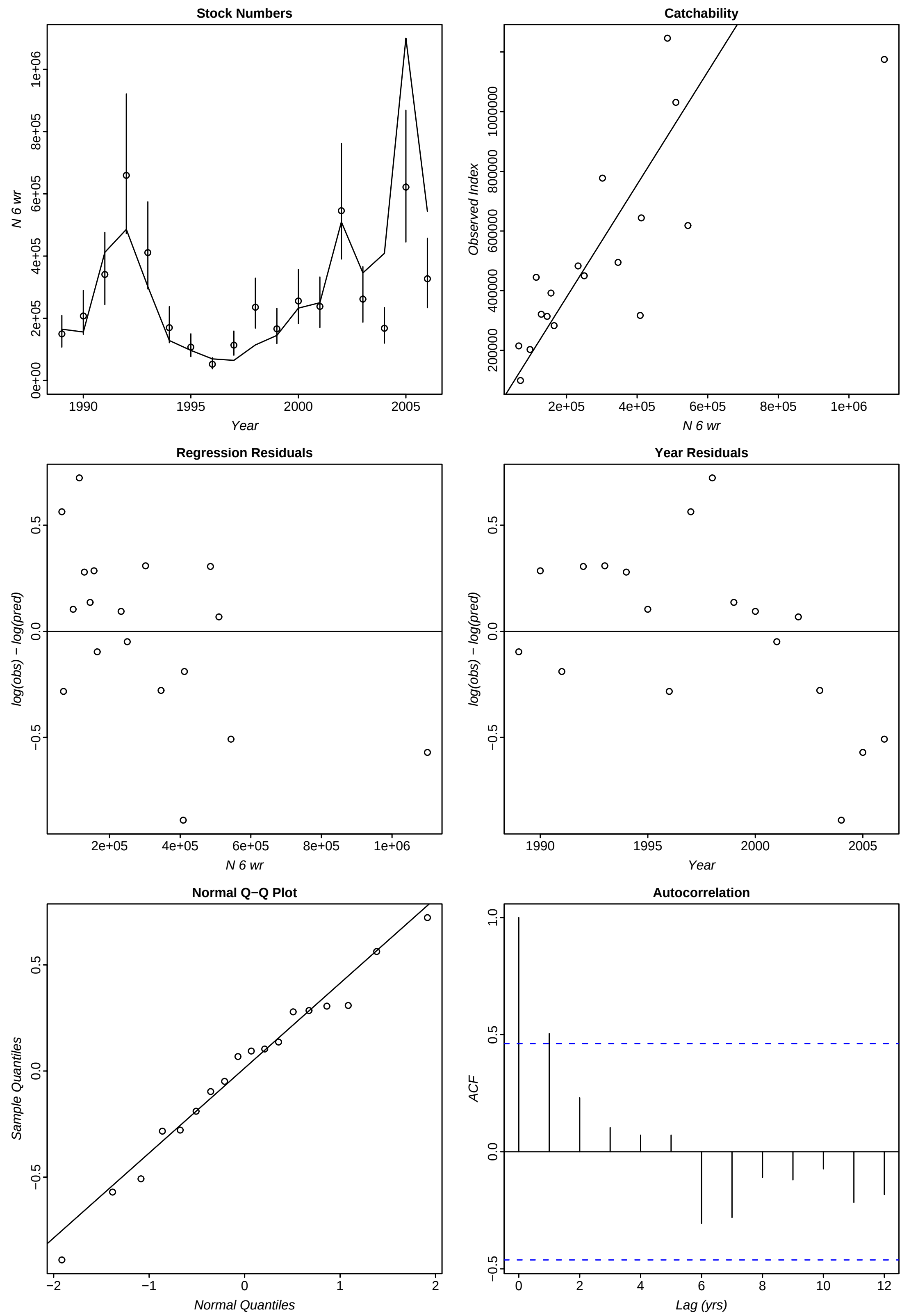


Figure 2.6.15. North Sea herring. Diagnostics of Acoustic survey catchability at 6 wr from the final ICA assessment. Top left: VPA estimates of numbers at 6 wr (line) and numbers predicted from index abundance at 6 wr with 95% confidence intervals. Top right: scatterplot of index observations versus VPA estimates of numbers at 6 wr with the best-fit catchability model (linear function). Middle left: log residuals of catchability model by VPA estimate of numbers at 6 wr. Middle right: log residuals of catchability model by year. Bottom left: normal Q-Q plot of log residuals. Bottom right: autocorrelogram of log residuals.

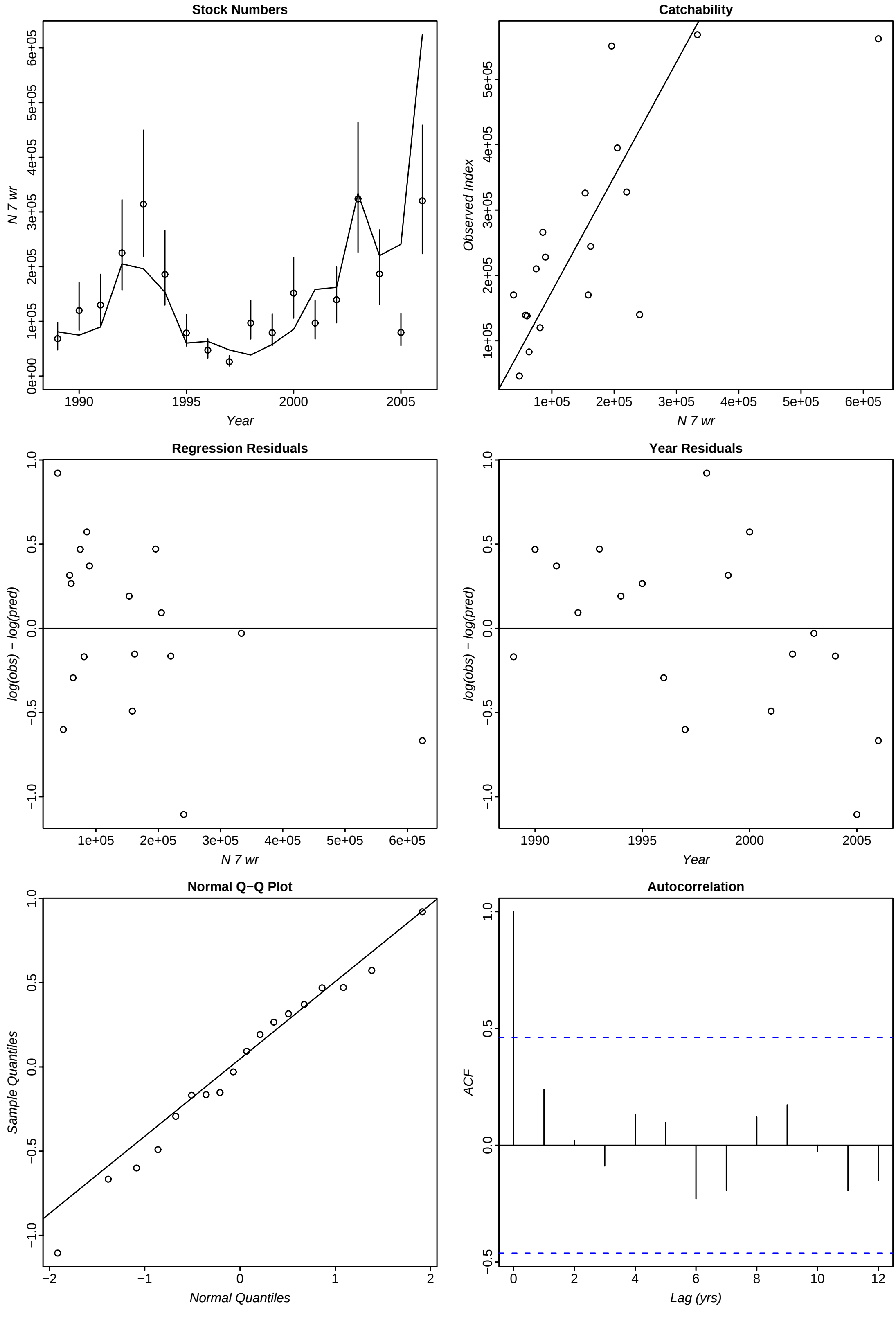


Figure 2.6.16. North Sea herring. Diagnostics of Acoustic survey catchability at 7 wr from the final ICA assessment. Top left: VPA estimates of numbers at 7 wr (line) and numbers predicted from index abundance at 7 wr with 95% confidence intervals. Top right: scatterplot of index observations versus VPA estimates of numbers at 7 wr with the best-fit catchability model (linear function). Middle left: log residuals of catchability model by VPA estimate of numbers at 7 wr. Middle right: log residuals of catchability model by year. Bottom left: normal Q-Q plot of log residuals. Bottom right: autocorrelogram of log residuals.

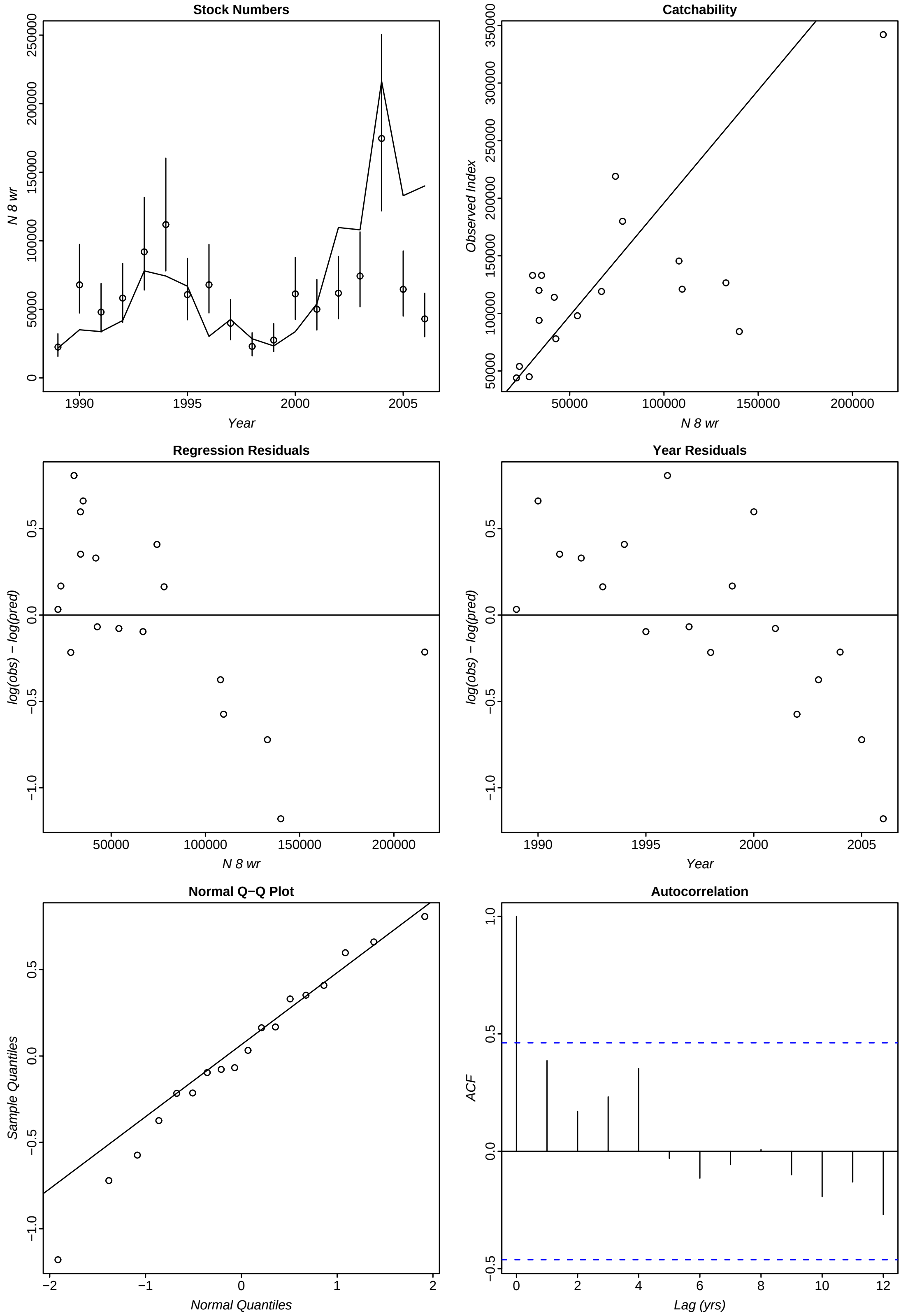


Figure 2.6.17. North Sea herring. Diagnostics of Acoustic survey catchability at 8 wr from the final ICA assessment. Top left: VPA estimates of numbers at 8 wr (line) and numbers predicted from index abundance at 8 wr with 95% confidence intervals. Top right: scatterplot of index observations versus VPA estimates of numbers at 8 wr with the best-fit catchability model (linear function). Middle left: log residuals of catchability model by VPA estimate of numbers at 8 wr. Middle right: log residuals of catchability model by year. Bottom left: normal Q-Q plot of log residuals. Bottom right: autocorrelogram of log residuals.

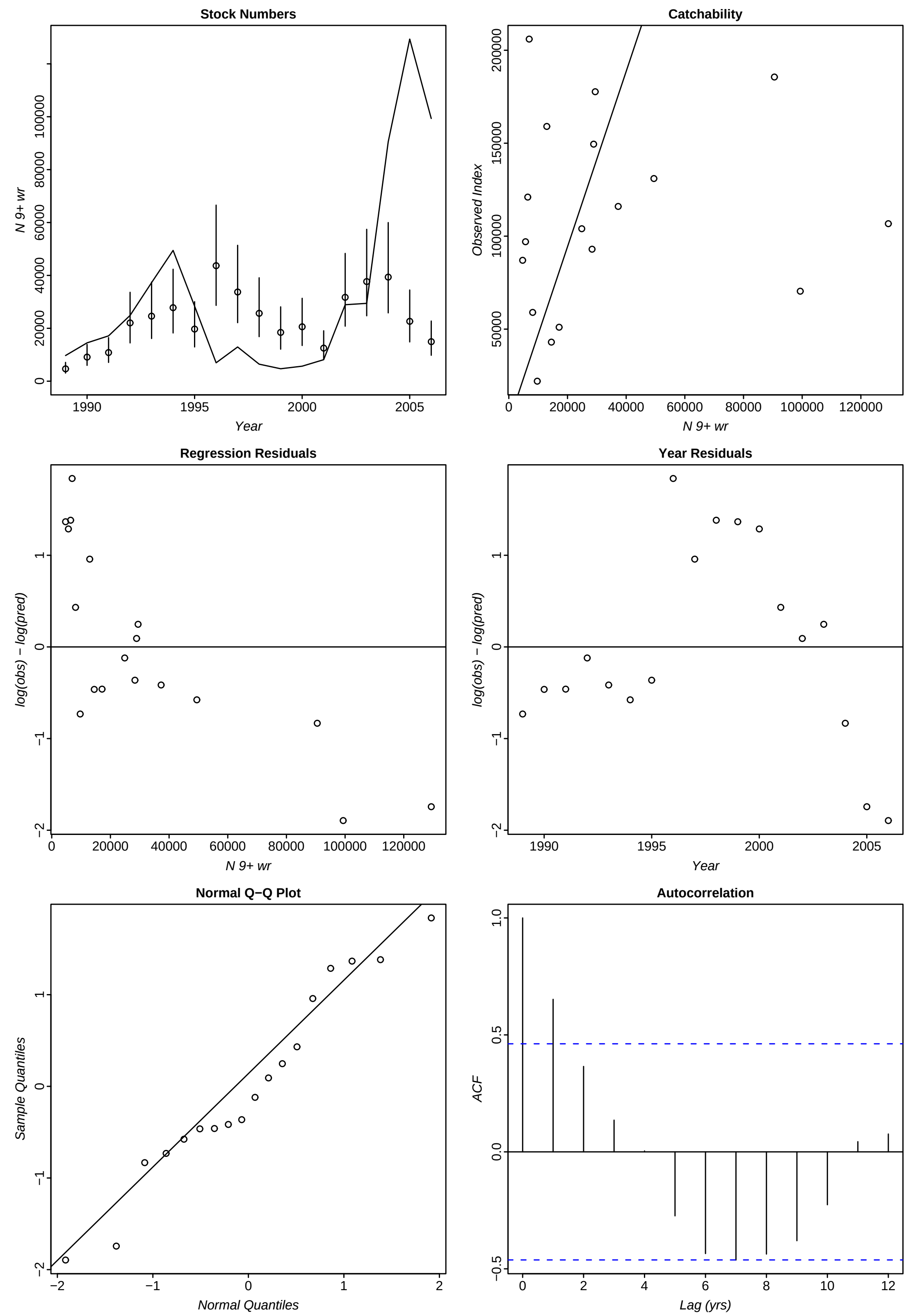


Figure 2.6.18. North Sea herring. Diagnostics of Acoustic survey catchability at 9+ wr from the final ICA assessment. Top left: VPA estimates of numbers at 9+ wr (line) and numbers predicted from index abundance at 9+ wr with 95% confidence intervals. Top right: scatterplot of index observations versus VPA estimates of numbers at 9+ wr with the best-fit catchability model (linear function). Middle left: log residuals of catchability model by VPA estimate of numbers at 9+ wr. Middle right: log residuals of catchability model by year. Bottom left: normal Q-Q plot of log residuals. Bottom right: autocorrelogram of log residuals.

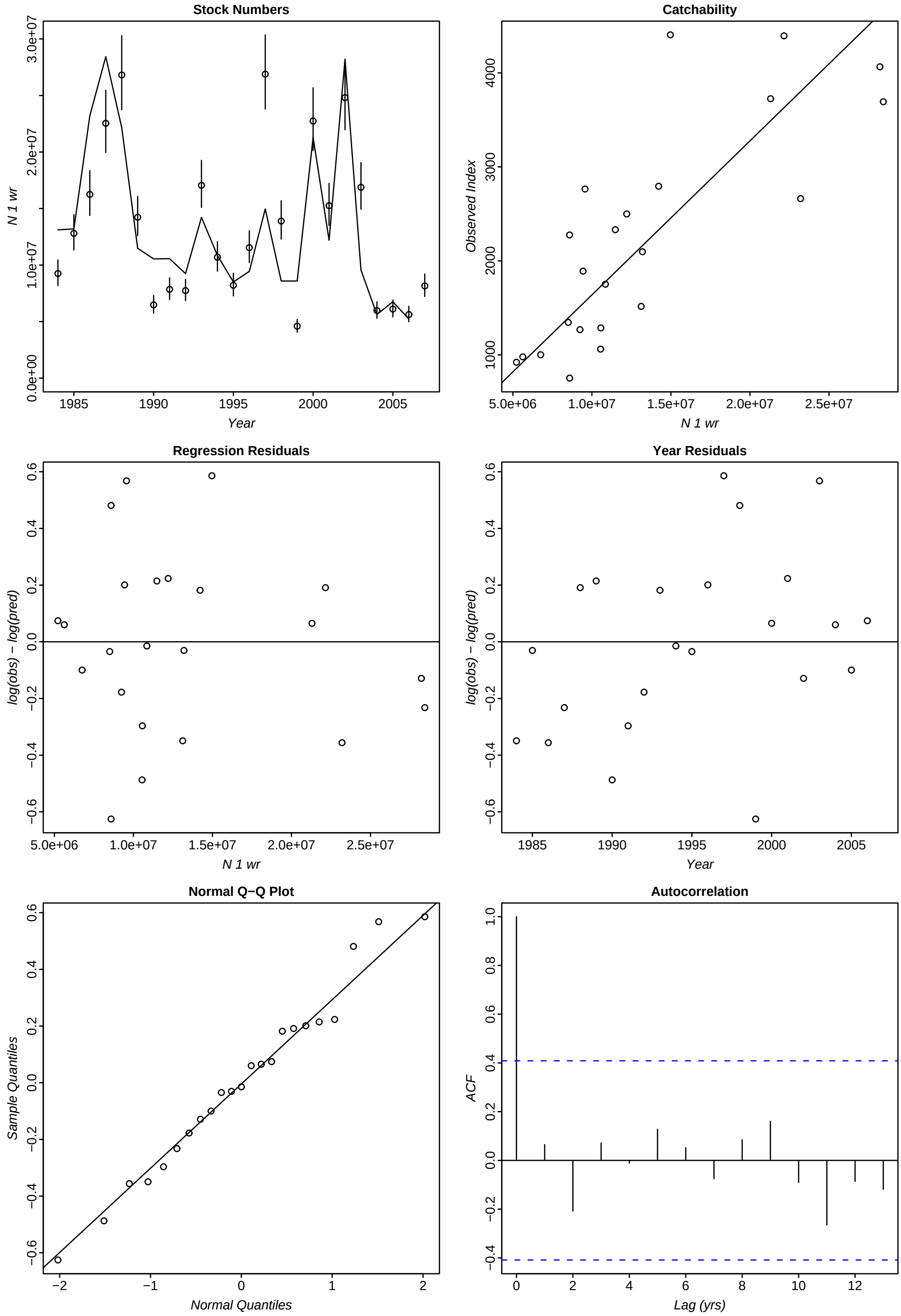


Figure 2.6.19. North Sea herring. Diagnostics of IBTS survey catchability at 1 wr from the final ICA assessment. Top left: VPA estimates of numbers at 1 wr (line) and numbers predicted from index abundance at 1 wr with 95% confidence intervals. Top right: scatterplot of index observations versus VPA estimates of numbers at 1 wr with the best-fit catchability model (linear function). Middle left: log residuals of catchability model by VPA estimate of numbers at 1 wr. Middle right: log residuals of catchability model by year. Bottom left: normal Q-Q plot of log residuals. Bottom right: autocorrelogram of log residuals.

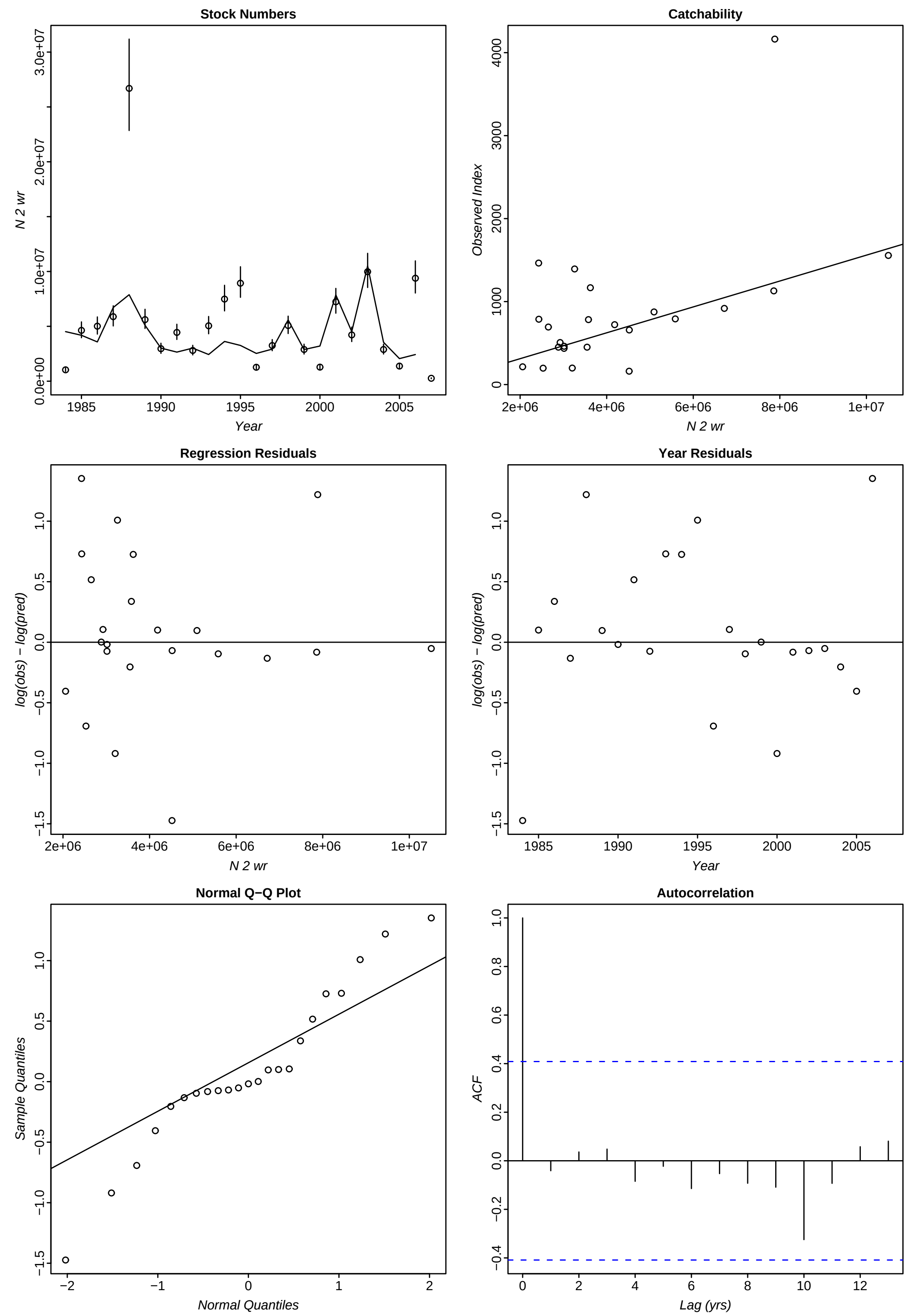


Figure 2.6.20. North Sea herring. Diagnostics of IBTS survey catchability at 2 wr from the final ICA assessment. Top left: VPA estimates of numbers at 2 wr (line) and numbers predicted from index abundance at 2 wr with 95% confidence intervals. Top right: scatterplot of index observations versus VPA estimates of numbers at 2 wr with the best-fit catchability model (linear function). Middle left: log residuals of catchability model by VPA estimate of numbers at 2 wr. Middle right: log residuals of catchability model by year. Bottom left: normal Q-Q plot of log residuals. Bottom right: autocorrelogram of log residuals.

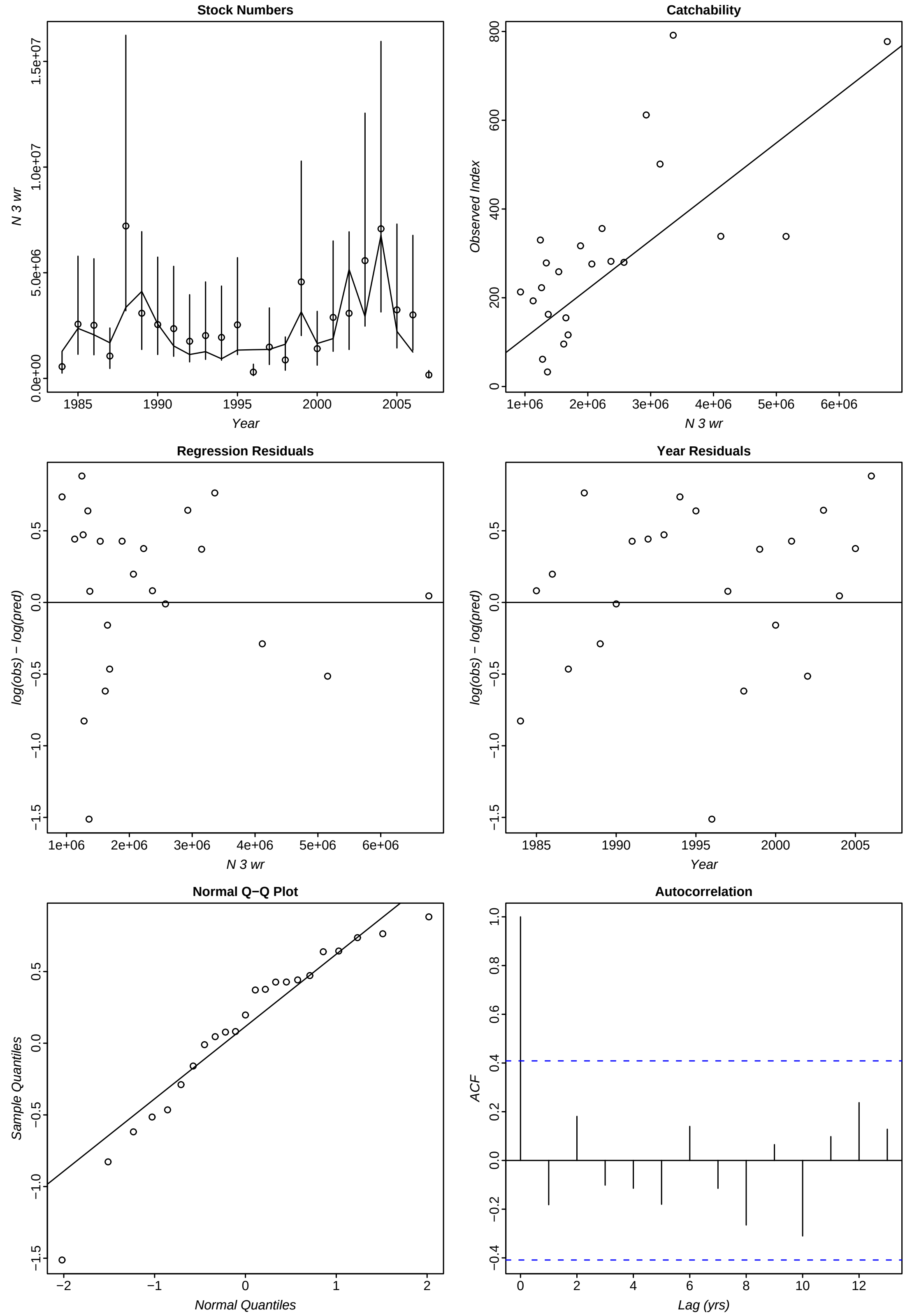


Figure 2.6.21. North Sea herring. Diagnostics of IBTS survey catchability at 3 wr from the final ICA assessment. Top left: VPA estimates of numbers at 3 wr (line) and numbers predicted from index abundance at 3 wr with 95% confidence intervals. Top right: scatterplot of index observations versus VPA estimates of numbers at 3 wr with the best-fit catchability model (linear function). Middle left: log residuals of catchability model by VPA estimate of numbers at 3 wr. Middle right: log residuals of catchability model by year. Bottom left: normal Q-Q plot of log residuals. Bottom right: autocorrelogram of log residuals.

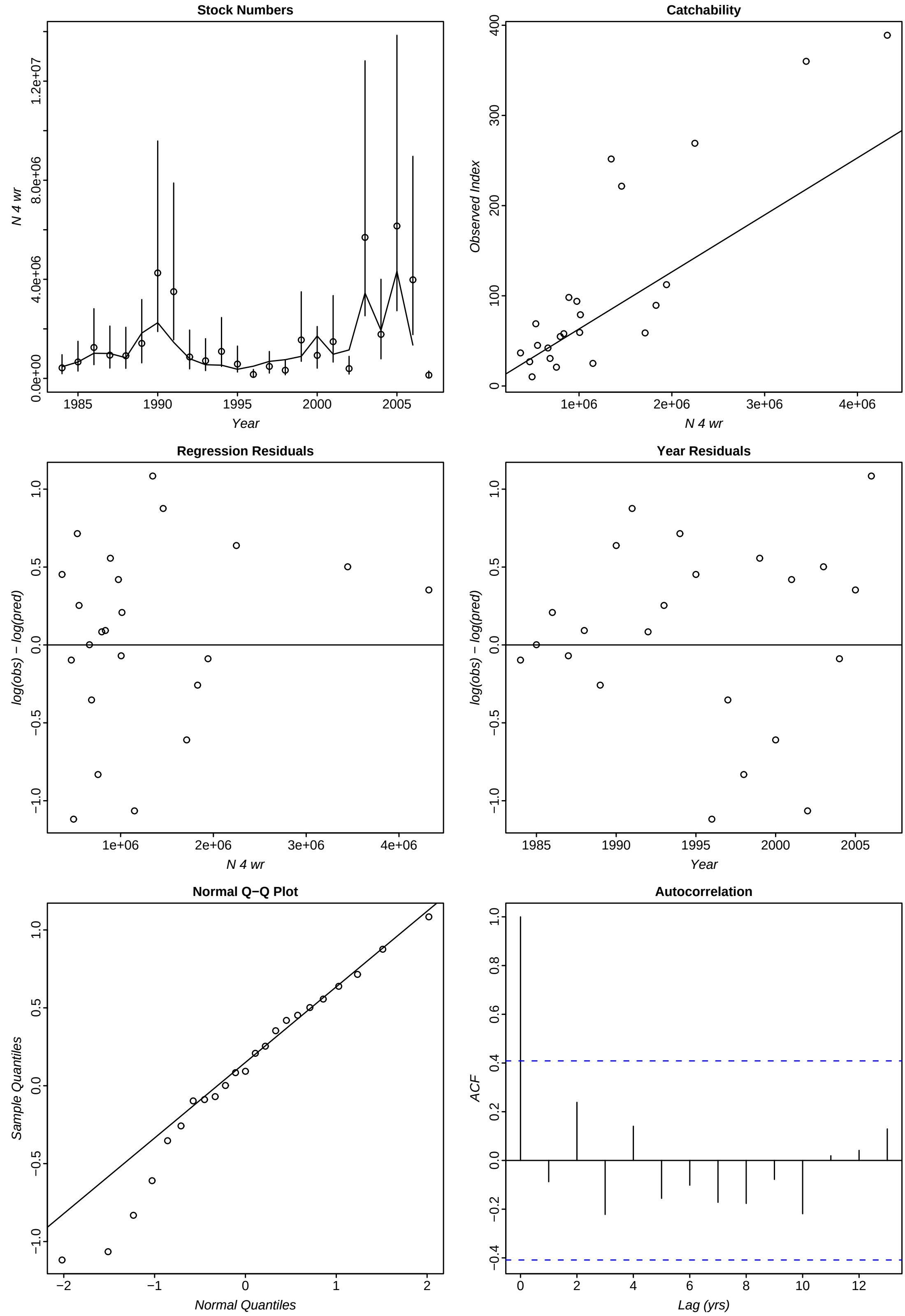


Figure 2.6.22. North Sea herring. Diagnostics of IBTS survey catchability at 4 wr from the final ICA assessment. Top left: VPA estimates of numbers at 4 wr (line) and numbers predicted from index abundance at 4 wr with 95% confidence intervals. Top right: scatterplot of index observations versus VPA estimates of numbers at 4 wr with the best-fit catchability model (linear function). Middle left: log residuals of catchability model by VPA estimate of numbers at 4 wr. Middle right: log residuals of catchability model by year. Bottom left: normal Q-Q plot of log residuals. Bottom right: autocorrelogram of log residuals.

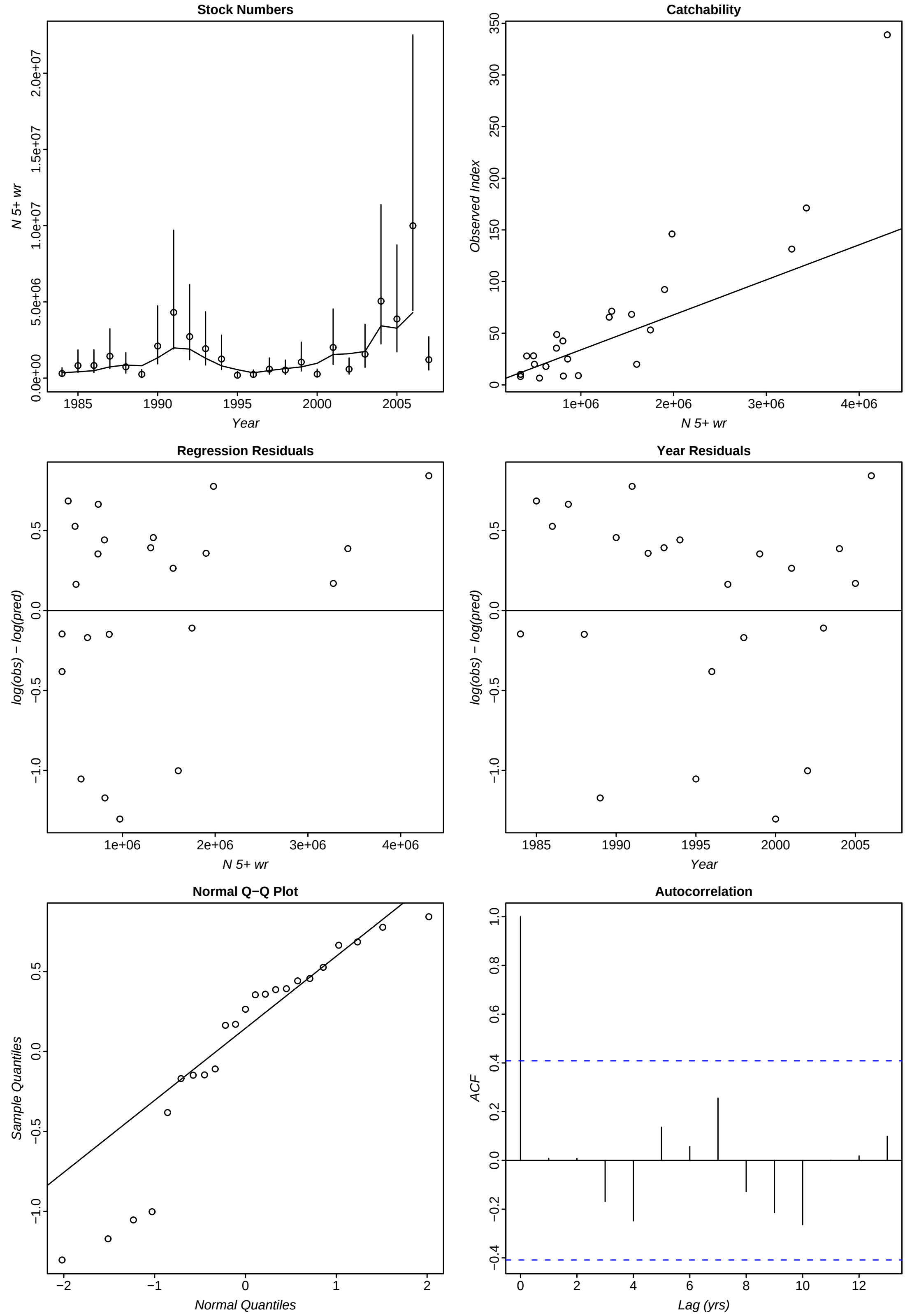


Figure 2.6.23. North Sea herring. Diagnostics of IBTS survey catchability at 5+ wr from the final ICA assessment. Top left: VPA estimates of numbers at 5+ wr (line) and numbers predicted from index abundance at 5+ wr with 95% confidence intervals. Top right: scatterplot of index observations versus VPA estimates of numbers at 5+ wr with the best-fit catchability model (linear function). Middle left: log residuals of catchability model by VPA estimate of numbers at 5+ wr. Middle right: log residuals of catchability model by year. Bottom left: normal Q-Q plot of log residuals. Bottom right: autocorrelogram of log residuals.

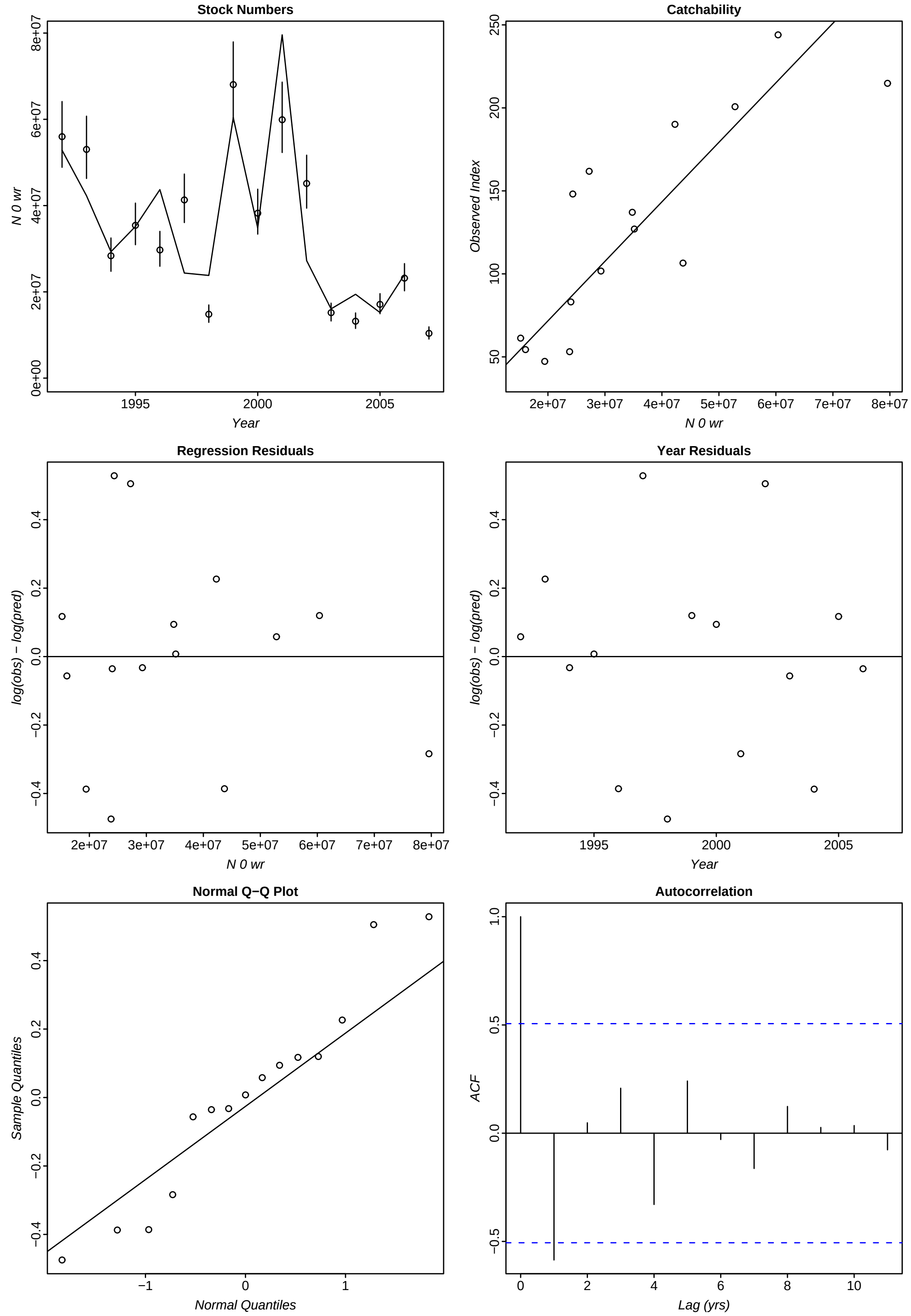


Figure 2.6.24. North Sea herring. Diagnostics of MIK survey catchability at 0 wr from the final ICA assessment. Top left: VPA estimates of numbers at 0 wr (line) and numbers predicted from index abundance at 0 wr with 95% confidence intervals. Top right: scatterplot of index observations versus VPA estimates of numbers at 0 wr with the best-fit catchability model (linear 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. Bottom right: autocorrelogram of log residuals.

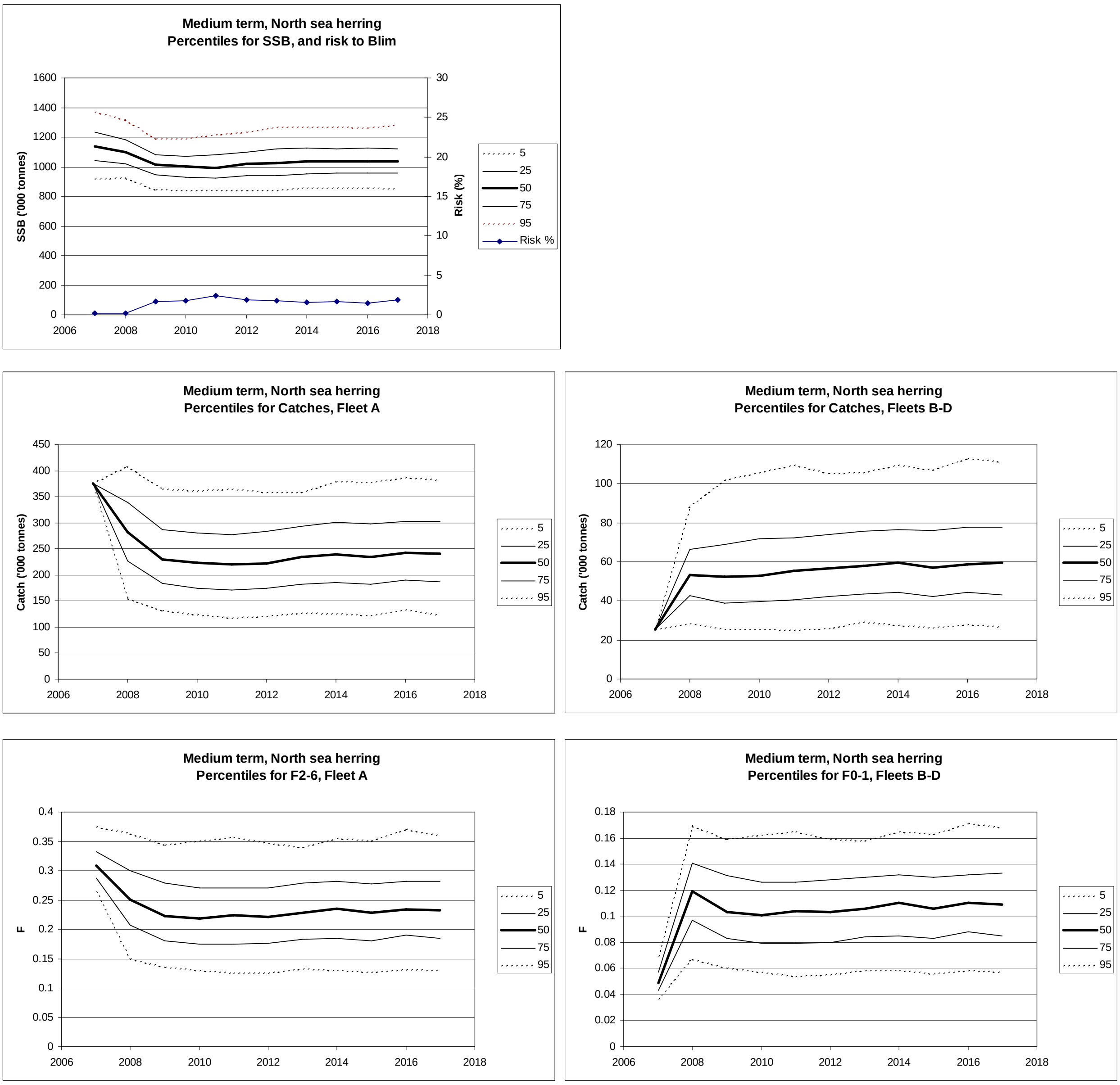


Figure 2.8.1

Results of medium term predictions for North Sea herring

Scenario 1: Harvest rule with not constraint on year-to-year change in TAC.

Upper panels: Percentiles for SSB, and risk to Blim

Middle panels: Percentiles for catch

Lower panels: Percentiles for fishing mortality

Left: Fleet A

Right: Fleets B-D

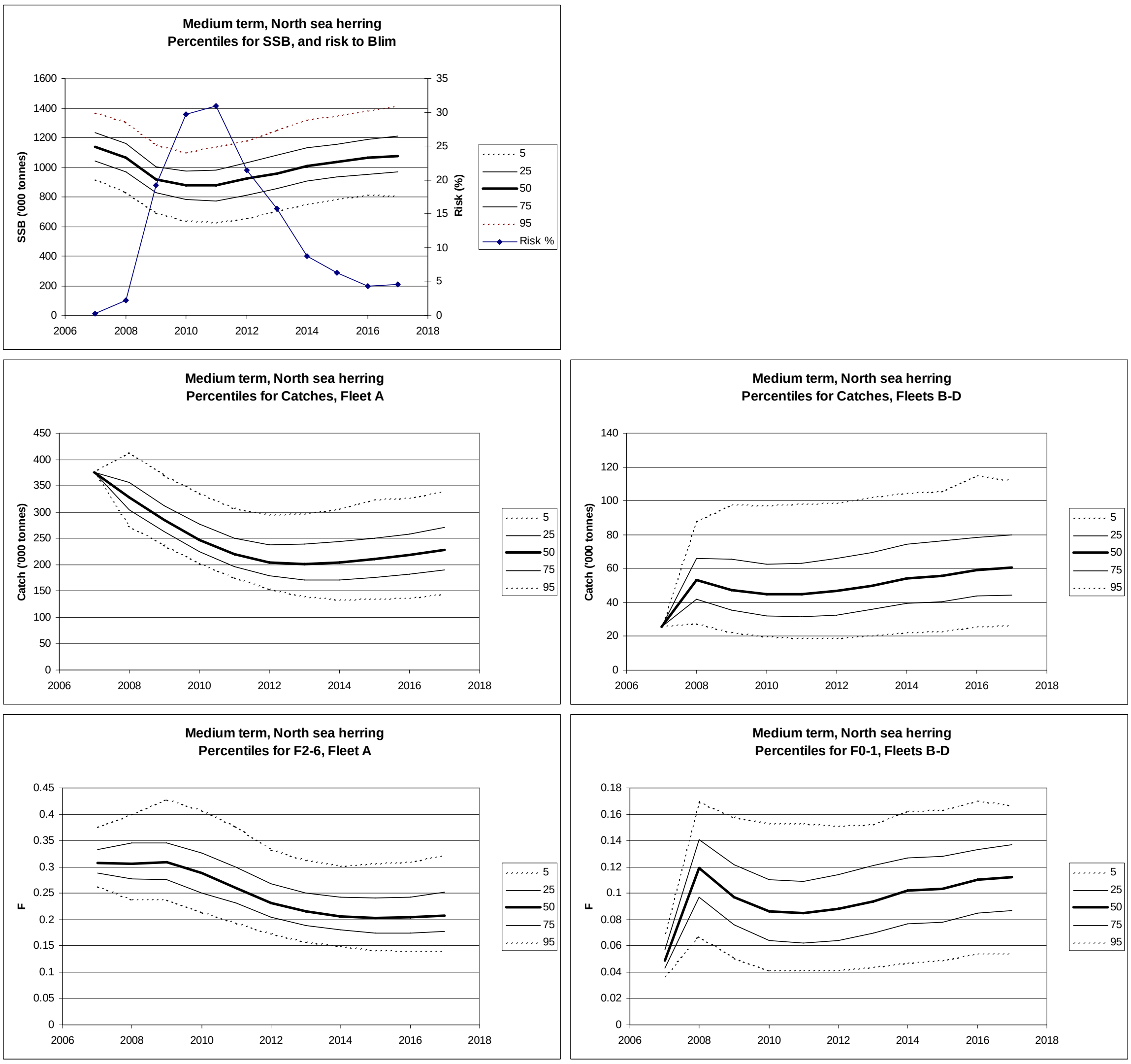


Figure 2.8.2

Results of medium term predictions for North Sea herring

Scenario 2: Harvest rule with 15% constraint on year-to-year change in TAC.

Upper panels: Percentiles for SSB, and risk to Blim

Middle panels: Percentiles for catch

Lower panels: Percentiles for fishing mortality

Left: Fleet A

Right: Fleets B-D

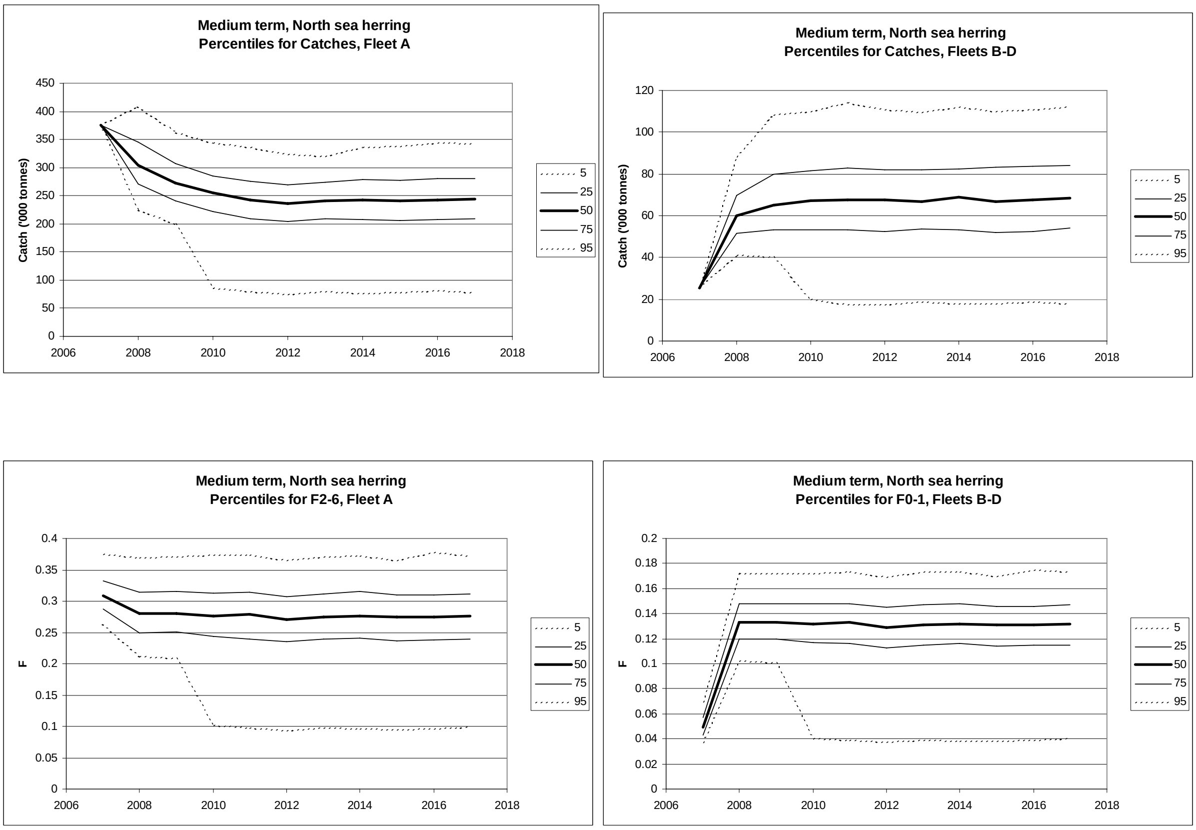


Figure 2.8.3

Results of medium term predictions for North Sea herring
Scenario 3: Fixed intended F0-1 = 0.12 and F2-6 = 0.25
Upper panels: Percentiles for SSB, and risk to Blim
Middle panels: Percentiles for catch
Lower panels: Percentiles for fishing mortality
Left: Fleet A
Right: Fleets B-D

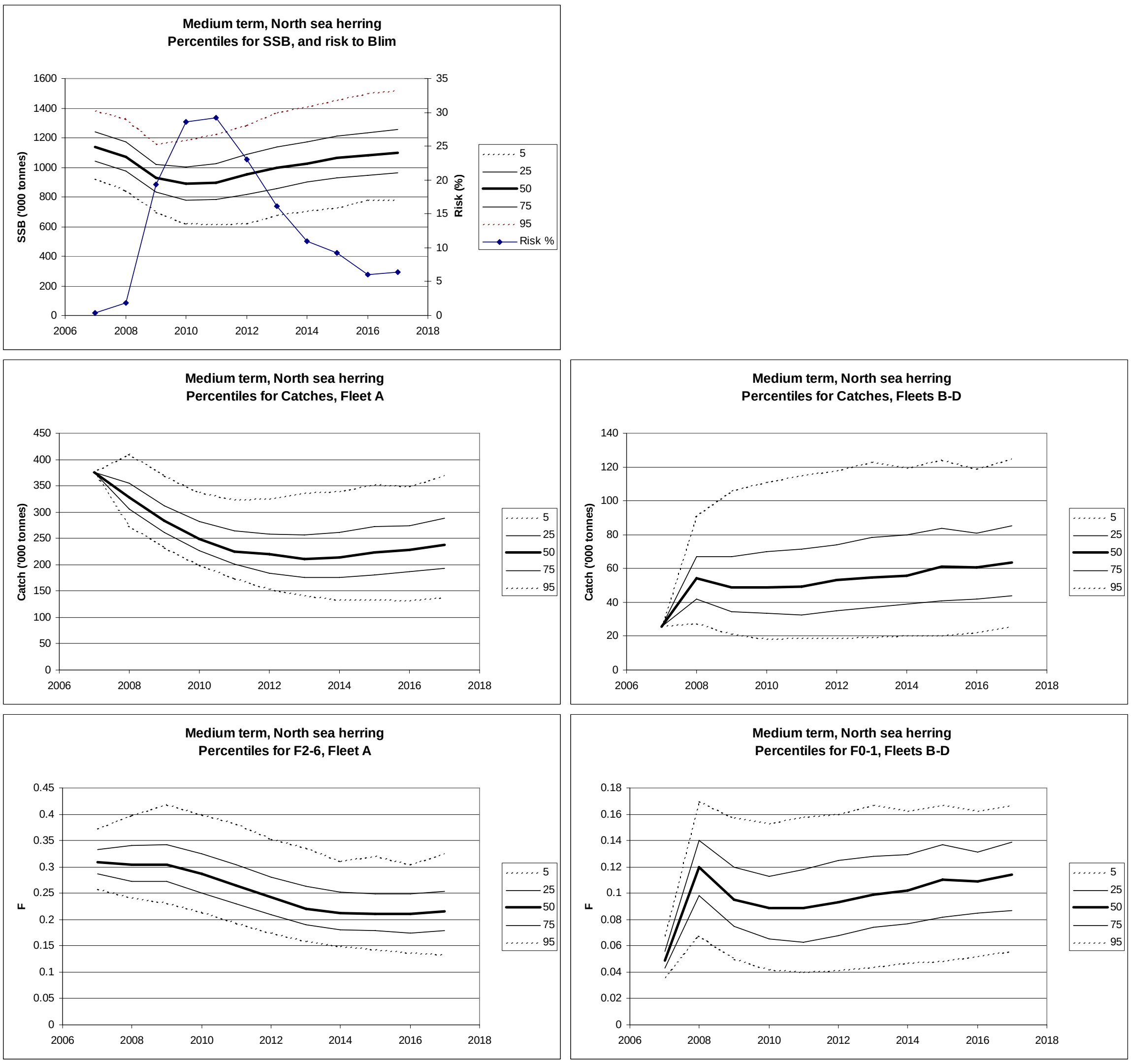


Figure 2.8.4

Results of medium term predictions for North Sea herring

Scenario 4: As scenario 1 (harvest rule with 15% constraint on year-to-year change in TAC), but with higher assumed CV on recruitment of 0.58.

Upper panels: Percentiles for SSB, and risk to Blim

Middle panels: Percentiles for catch

Lower panels: Percentiles for fishing mortality

Left: Fleet A

Right: Fleets B-D

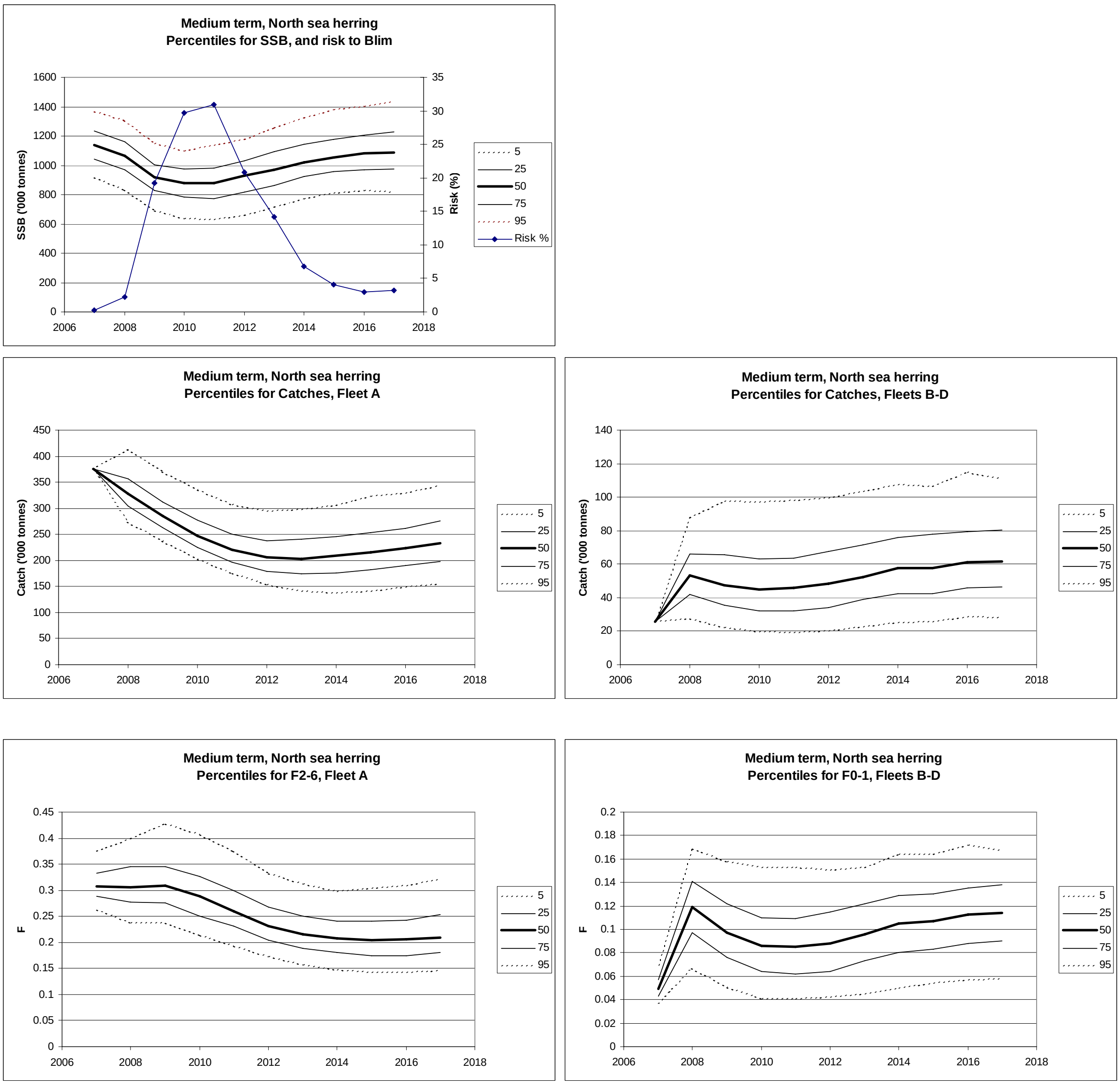


Figure 2.8.5

Results of medium term predictions for North Sea herring

Scenario 5: As scenario 1 (harvest rule with 15% constraint on year-to-year change in TAC), but with a lower breakpoint in the stock-recruit function at 500 000 tonnes

Upper panels: Percentiles for SSB, and risk to Blim

Middle panels: Percentiles for catch

Lower panels: Percentiles for fishing mortality

Left: Fleet A

Right: Fleets B-D

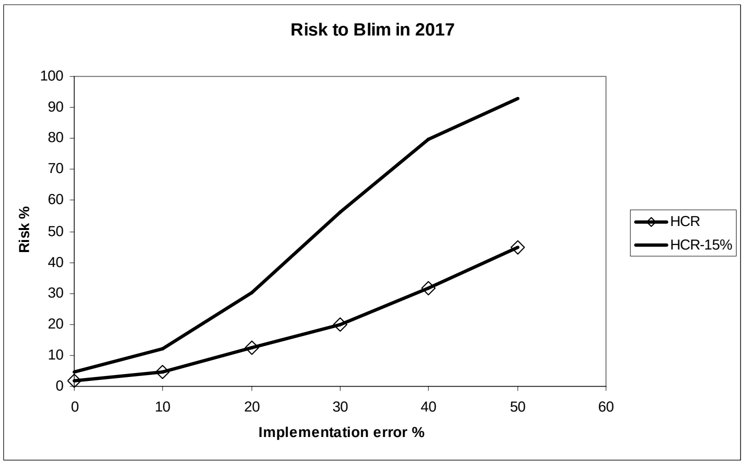


Figure 2.8.6 Results of medium term predictions for North Sea herring. Effect of implementation error. Risk to Blim in 2017 with and without 15% constraint on catch variation.

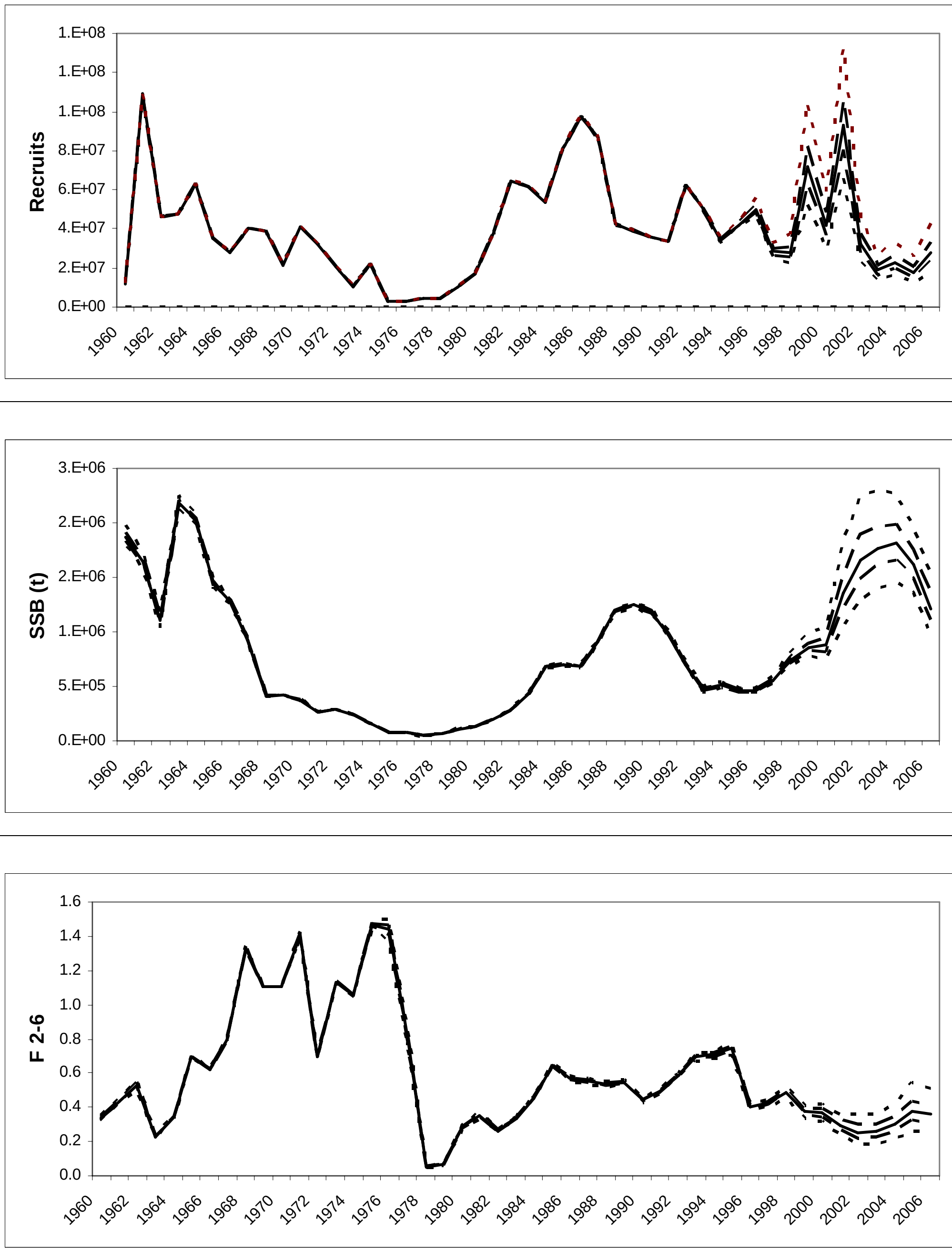


Figure 2.10.1 North Sea herring: historic uncertainty in recruitment, SSB and mean Fages 2-6 wr from 1960-2006 at 5, 25, 50, 75, 95 percentiles estimated by bootstrap of parameter residuals based on variance covariance method in ICA.

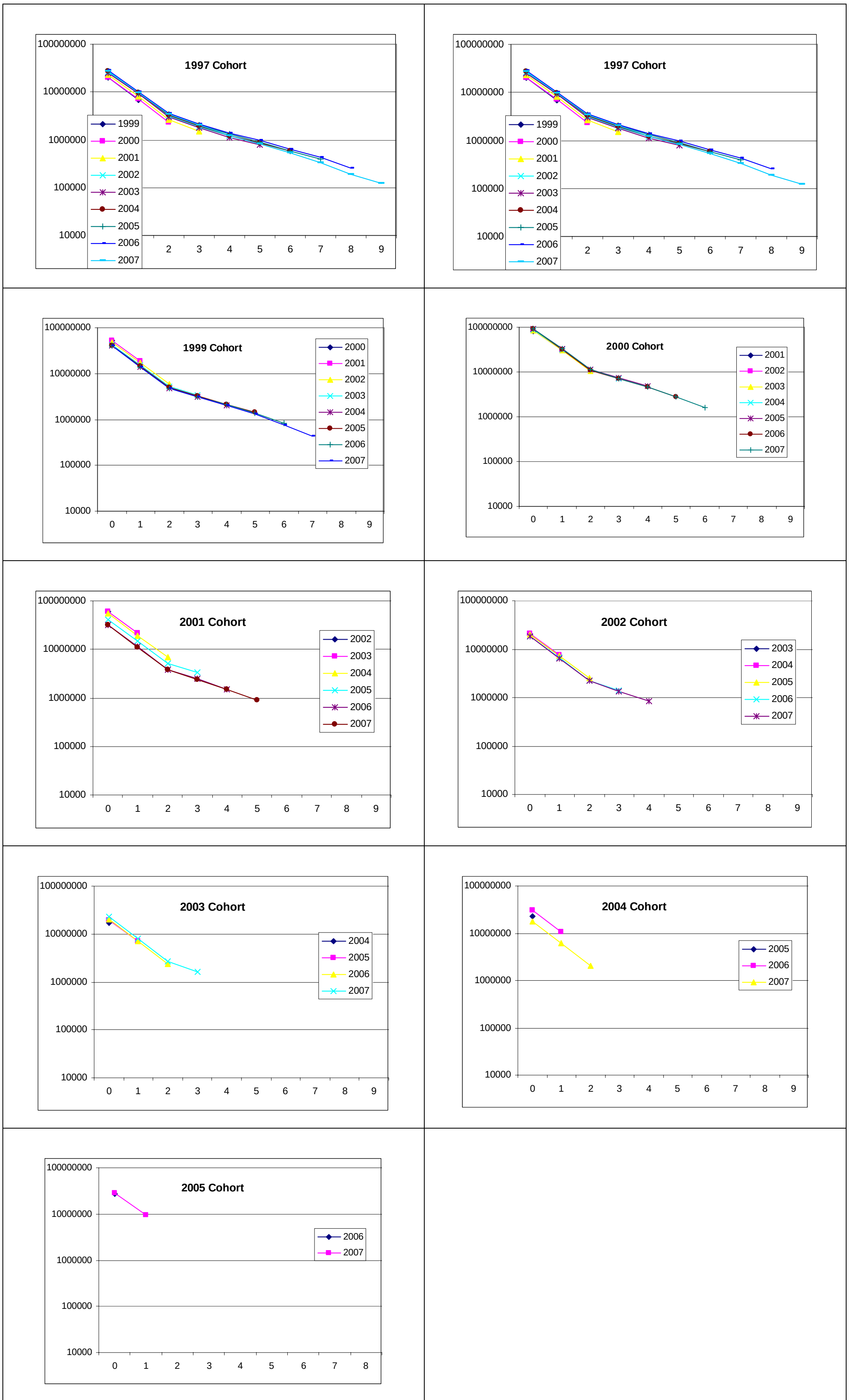


Figure 2.10.2 North Sea herring: cohort historic retrospectives for yearclasses currently in terminal year of the assessment , 1997 to 2005.

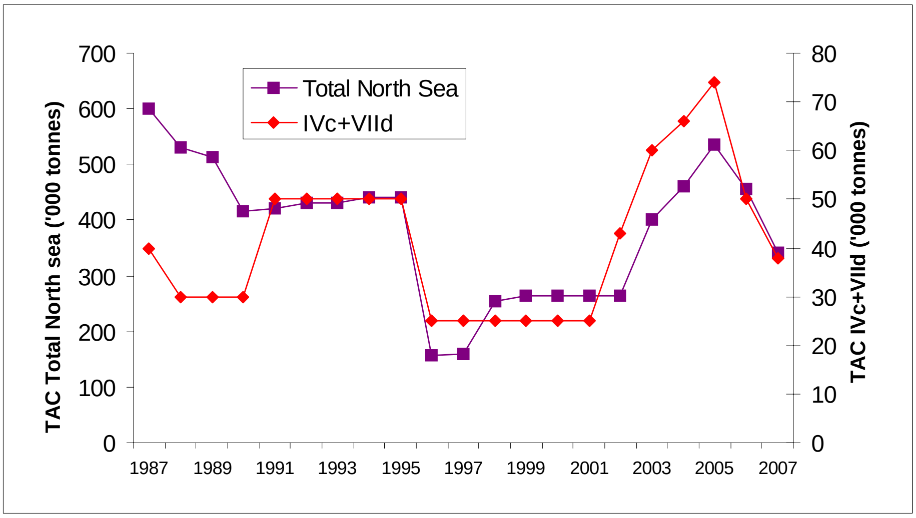


Figure 2.11.1. North Sea herring. Comparison of TACs for total North Sea and IVc and VIId

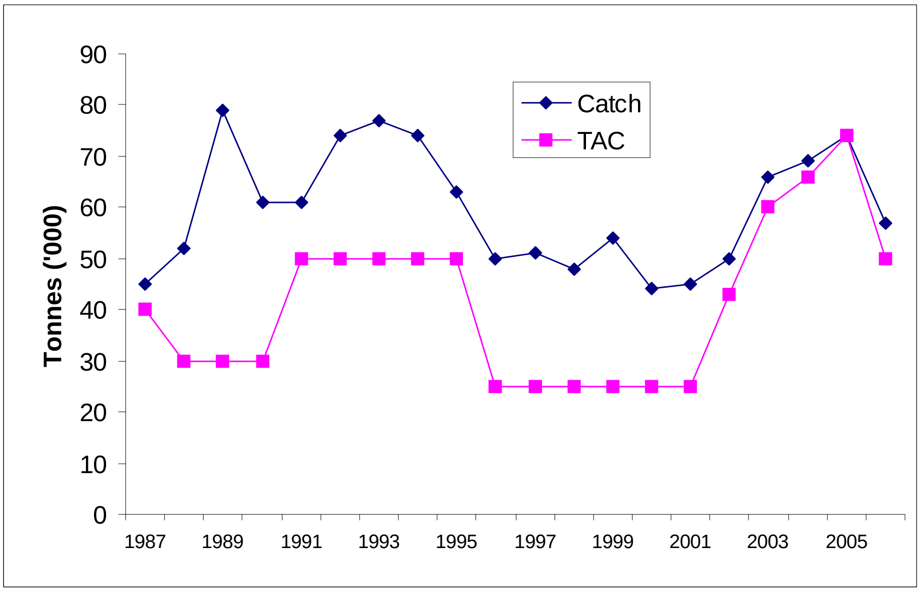


Figure 2.11.2. Herring in IVc and VIId. Comparison of historical catches and TACs

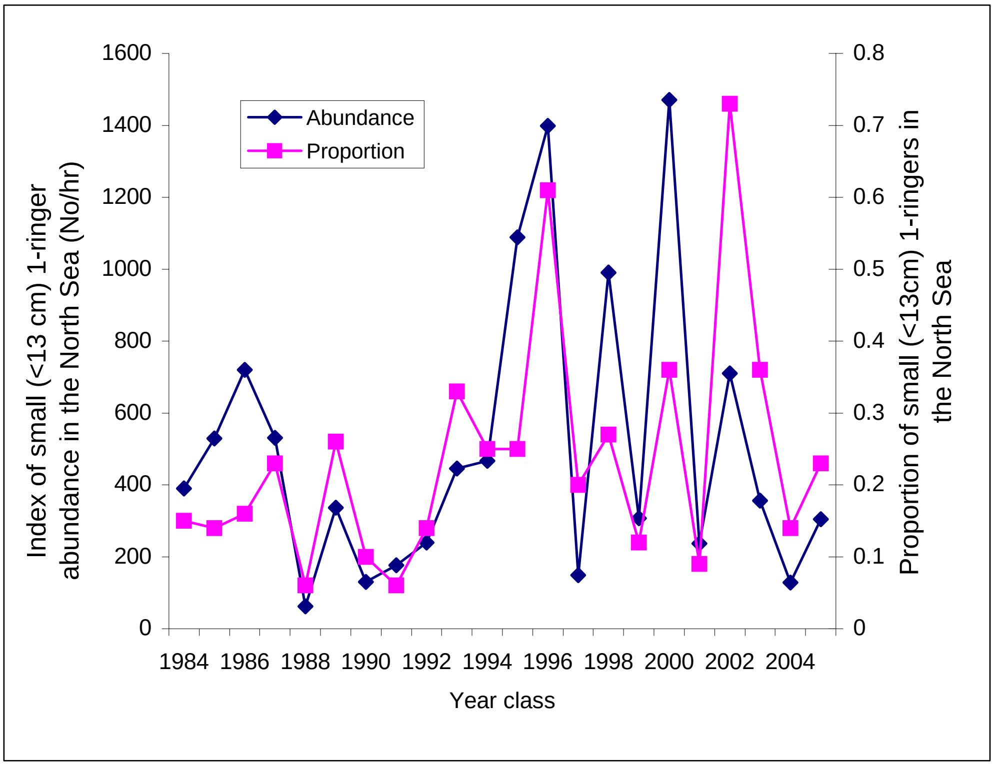


Figure 2.11.3 Downs herring. Index (nos per hr) of small (<13cm) 1-ringers in the North Sea and proportion of small 1-ringers versus all sizes in the North Sea (from table 2.3.3.3)

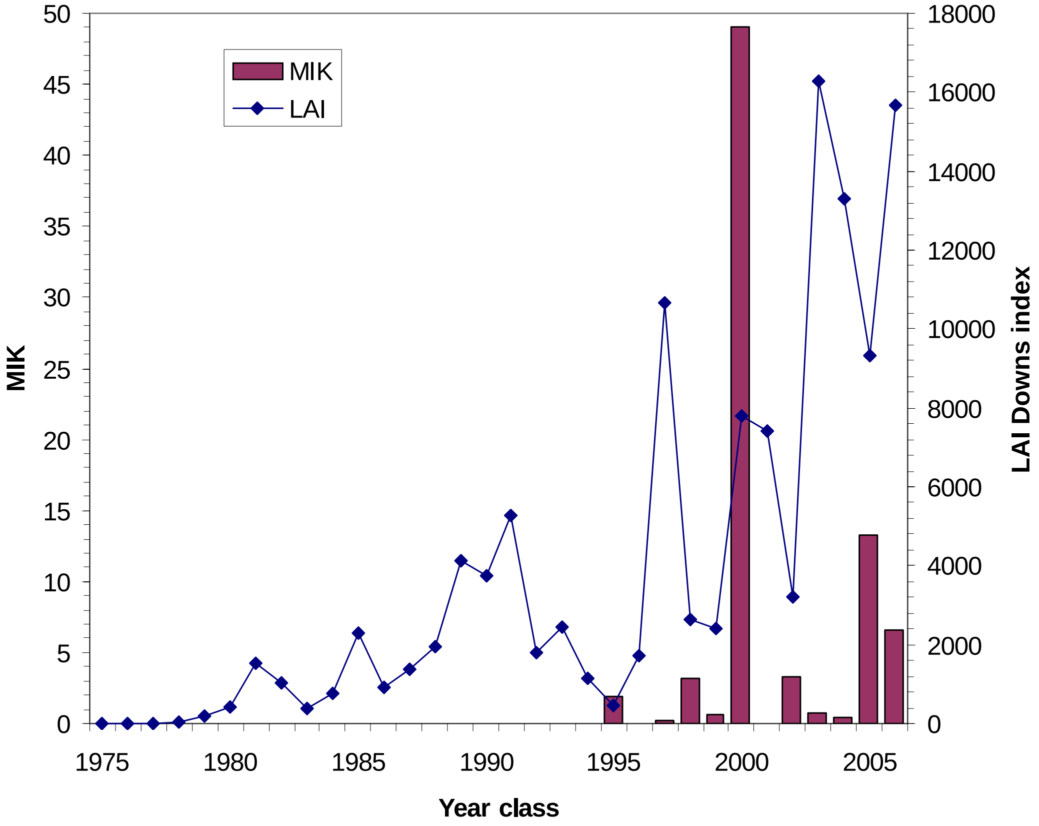


Figure 2.11.4. Downs herring. Larval Abundance Index (LAI) in the Channel area (line), calculated as the sum of surveys per year class 1975-2006, and preliminary MIK survey results in the Channel area (early spring 1995-2007, no data available in 1996 and 2001).

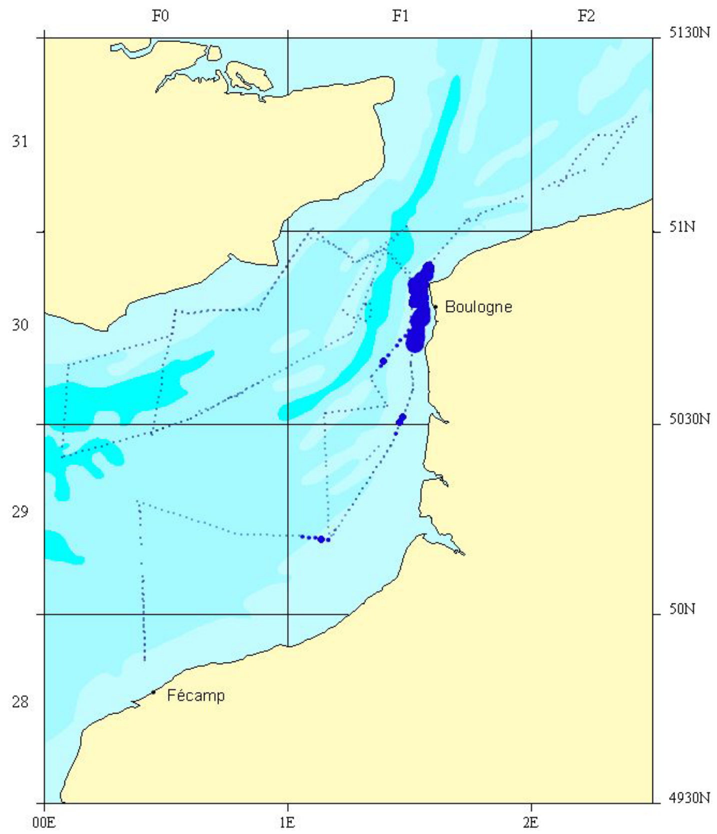


Figure 2.11.5 : Acoustic transects in the Eastern Channel. Herring detections are mainly concentrated in front of Boulogne and in less proportions (?) in the southern part of the area.

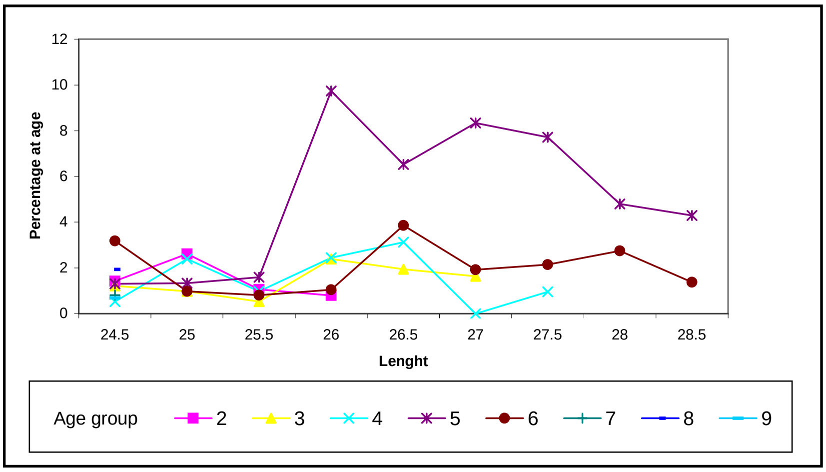


Figure 2.11.6 Catch composition by age from the pelagics hauls. Age groups 5, 6 and 7 represent respectively 11 %, 46% and 18 % of the total.

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

3.1 The Fishery

3.1.1 ACFM advice and management applicable to 2006 and 2007

At the ACFM (May) meeting in 2006, it was stated that the status of the stock is unknown relative to safe biological limits, because reference points have not been determined. SSB has been stable or has slightly increased over a number of years. Fishing mortality estimates for 2006 are 0.52 for adults and 0.18 for the juveniles (1-ringers).

ACFM recommended in 2006 that, since the current fishing mortality has lead to a stable or increased SSB, the fishing mortality should not be allowed to increase. This would correspond to catches in 2006 less than 95 000 t and less than 99 000 t in 2007. According to the recent geographic distribution of catches, approximately half of the total catches should be taken from Subdivisions 22-24.

The EU and Norway agreement on a herring TACs set for 2006 was 81 600 t in Division IIIa for the human consumption fleet and a by-catch ceiling of 20 528 t to be taken in the small mesh fishery. In 2006 the EU and Norway agreement on herring TACs for 2007 in Division IIIa was 118 860 t.

In previous years the International Baltic Sea Fishery Commission (IBSFC) set no special TAC for Subdivisions 22-24. In 2006, a TAC (47 500 t) was set for the first time on the Western Baltic stock component. The TAC for 2007 was set at 49 500 t.

3.1.2 Catches in 2006

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.

It is important to note that 2000 tonnes of Danish landings were, on a very early stage lost from the data due to a programming error. This error was not discovered in time and the catch in numbers in the present section therefore does not account for this. However, the error does not influence biological samples of size, age and proportions of spawning type. All relevant tables will be updated with the correct information in next year's report. The eventual effects of the missing catches on the assessment and short term projections for WBSS herring were found to be insignificant for estimates of SSB, F and recruitment.

Landings from 1985 to 2006 are given in Table 3.1.1. In 2006 the total landings in Division IIIa and Subdivisions 22–24 has decreased to 93 000 t, which is the second lowest value of the time series (1986-2006), only 2004 was slightly lower. The decrease in landings and their resemblance with 2004 is evident in the catches from the Kattegat and the Skagerrak. The German landings have increased slightly for the last three years in Subdivision 22-24, but are still diminutive in Division IIIa. The overall fishing pattern has changed in the last few years. As in previous years the 2006 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 2001 to 2006 in thousands of tonnes by fleet (as defined by HAWG) and quarter.

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 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 (Table 3.2.6 and see Section 3.2.2 for more details) catches were split between NSAS and WBSS.

The total numbers and mean weight-at-age of the WBSS and NSAS landed from Kattegat, Skagerrak, and Div. IIIa respectively was then estimated by quarter and fleet (Table 3.2.7 - 3.2.12).

The total catch (SOP) of the WBSS taken in the North Sea + Div. IIIa in 2006 were estimated to be 47 070 t, and has thereby increased in the last two years from the very low levels observed in 2004 and 2003 of 35 000 and 38 000 respectively (Table 3.2.13). However, they are still far below the values observed up to the mid nineties.

Total catches (SOP) of WBSS from the North Sea, Div. IIIa, and Subdivisions 22-24 respectively, by quarter, was estimated for 2006 (Table 3.2.14). Additionally, the total catches of WBSS in numbers and tonnes (SOP), divided between the North Sea + Div. IIIa and Subdivisions 22–24 respectively for 1991–2006, are presented in Tables 3.2.15 and 3.2.16.

Catches (SOP) of WBSS from Subdivisions 22-24 have remained rather stable for the last four years at levels just above 40 000 t, which also is the lowest level found in the time series (1991-2006) (Table 3.2.16).

The total catch (SOP) of NSAS in Div. IIIa amounted to 15 015 t in 2006, which is only 50 % of the 2005 value, and the lowest ever in the time series (1991-2006). The decrease relative to 2005 was mainly due to a proportionally large drop in representation of the 2004 year class in the catches (Table 3.2.17).

3.2.1 Quality of Catch Data and Biological Sampling Data

The amount of discards for 2006 is assumed to be insignificant as in previous years. However, no quantitative estimates of discards were available to the Working Group.

Table 3.2.4 shows the number of fish aged by country, area, fishery and quarter. The overall sampling in 2006 more than meets the recommended level of one sample per 1000 t landed per quarter. Coverage of areas, times of the year and gear (mesh size) was acceptable. One exception is a complete lack of samples to cover catches from Subdivision 23 comprising 2 477 t.

3.2.2 Stock composition in the catch

Catches of herring in the Kattegat, the Skagerrak and the Eastern part of the North Sea are taken from a mixture of two main spawning stocks. These are 1+ ringers of the Western Baltic Spring Spawners (WBSS) and 0-2-ringers from the North Sea Autumn Spawners (NSAS). The winter spawning Downs herring are included under NSAS (see stock annex 2). An uncertain amount of spring spawners belonging to local spawning populations in the Skagerrak/Kattegat area are likely to contribute to the catches. However due to lack of knowledge concerning these, they are included under WBSS (see also stock annex 2). As in recent years the WG uses the analysis of individual otolith microstructure for determination of spawning type in age-class stratified random sub-samples of herring in Division IIIa (see stock annex 2). The split between WBSS and NSAS in the eastern North Sea is limited to an area also referred to as the transfer area (ICES rectangles: 43F3 to 43F7, 44F3 to 44F6, 45F3 to 45F6, 46F3 to 46F6, and 47F3 to 47F6 (see also Figure 2.2.2)), under the assumption that the geographical distribution of WBSS into the North Sea is within the borders of the transfer area.

For the present year the otolith-based method has been exclusively applied for the Division IIIa split. For Subdivisions 22, 23 and 24 it was assumed that all individuals belong to the WBSS stock, even when otolith microstructure indicate occurrence of autumn spawners in the surveys or in samples of commercial catches (see stock annex 2).

Different area based TACs and by-catch ceilings are set for herring in Divisions IIIa and IV. However during summer feeding migrations components of WBSS and NSAS mix in both areas Divisions IIIa and IV East. A recently finalised research project has explored ways to regulate the fishing mortality of NSAS and WBSS individually within Divisions IV and IIIa (IMHERSKA). Results indicate that a set of proposed métiers for the Danish herring fisheries, to some degree, fished selectively with respect to stock (WBSS and NSAS) and fish size, in specific areas and quarters (IMHERSKA final report 2007 in prep.). It is also of note that the results agree with the existing knowledge on migration behaviors of the respective stocks.

3.2.2.1 Spring-spawning herring in the North Sea

Catches from the transfer area in the eastern North Sea in 2006 were split by analysis of Norwegian and Danish samples from landings (see Figure 2.2.2 for details about the transfer area). Mean vertebral counts from the Norwegian samples and otolith microstructure readings from the Danish samples were used to estimate the proportion of WBSS. Samples were missing in the 4th quarter for 1 to 3-ringers and were inferred from neighbouring quarters. The sources of data for splitting between NSAS and WBSS in the transfer area are:

	1-RINGERS	2-RINGERS	3-RINGERS	4+-RINGERS
1st quarter	DK samples (landings)	DK & NOR samples (landings)	DK samples (landings)	DK & NOR samples (landings)
2nd quarter	DK samples (acoustic + landings)	DK & NOR samples (acoustic + landings)	DK & NOR samples (acoustic + landings)	DK & NOR samples (acoustic + landings)
3rd quarter	DK & NOR samples (acoustic+ landings)	NOR samples (landings)	NOR samples (landings)	NOR samples (landings)
4th quarter	inferred from neighbouring quarters	inferred from neighbouring quarters	inferred from neighbouring quarters	DK samples (landings)

Resulting proportions of WBSS can be found in Section 2.2.2.

3.2.2.2 Autumn spawners in Division IIIa

The proportions and the analysed numbers are presented in Table 3.2.6.

For commercial landings in 2006 the split of the Swedish and Danish landings was conducted using the proportion by age in the combined samples of Swedish and Danish microstructure analyses. The estimation of the proportion of spring- and autumn-spawners in the landings from Division IIIa was performed on the basis of 4449 (2903 Danish and 1546 Swedish) otolith microstructure analyses in 2006. Data were disaggregated by area (Kattegat and Skagerrak), quarter (1–4) and age group (1-8+ wr in 1st quarter and 0-8+ wr in 2nd, 3rd and 4th quarter).

Generally, sampling for split in 2006 covered younger age classes (0-2-ringers). In cases where sampling of older age-classes had fewer than 12 individuals per cell (area, quarter, and wr) samples were supplemented with survey samples and/or the cells were pooled to combine age groups (for details see table 3.2.6).

All herring found in subdivisions 22-24 are treated as Western Baltic spring spawners (see stock annex 2).

3.2.2.3 Accuracy and precision in stock identification

The stock classification using visual inspection of otolith microstructure has been validated objective criteria as described in a recent publication (Clausen et al. 2007). The correspondence between results from visual inspection by experienced readers and back calculated hatch date from counted microstructures was high, with misclassification levels of 5% and 3% for autumn/winter and spring spawners respectively. All of the Danish routine samples for the stock identification are interpreted by experienced readers. However, in the case of spawning type infidelity this validation method would show false misclassification. Therefore, an objective method of hatch time estimation was also employed, counting daily increments in 0-group herring hatched during different seasons. Visual inspection and objective estimation agreed to 89%, and confusion between autumn and winter spawners was explained by overlapping hatch periods. Older herring have been classified using multiple linear regression of hatch time versus median increment width.

Issues of precision and further development of methods are dealt with in the stock annex.

3.3 Fishery Independent Information

3.3.1 International Bottom Trawl Survey in Division IIIa

The survey indices were split into spring and autumn spawning components by microstructure analysis of otoliths (section 3.2.2) except for 2001 3rd quarter and 2002 1st quarter when vertebrae counting methods were used. The estimates of the abundance by age of the spring spawning component in the Kattegat (SD21) are presented in Table 3.3.1 and Table 3.3.2. The estimated mean value for 1-ringers in 2007 1st quarter is lower than the average and similar to values observed in 2005 and 2006. The older age classes show a clear decrease with the lowest observed value for age 3 and age 5 and the second lowest for age 4. For 3rd quarter survey indices, the value for 1-ringers in 2006 is around the average of the time-series while the abundance of 3-ringers is the lowest on record.

3.3.2 Summer Acoustic Survey in Division IIIa

The acoustic survey from 23 June to 6 July 2006 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 2007/LRC:01). The estimated spawning biomass (3+) of Western Baltic

Spring Spawning herring (WBSS) in 2006 was about 244 000 tonnes, showing an increase compared to the previous year of about 105 %. The results from this survey are summarised in Table 3.3.3.

3.3.3 Autumn Acoustic Survey in Subdivisions 22-24

A joint German-Danish acoustic survey was carried out with R/V "SOLEA" between 5 and 24 October 2006 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 2007/LRC:01). The results for 2006 are presented in Table 3.3.4. The herring stock was estimated to be about 211 000 tonnes in Subdivisions 22-24 (Table 3.3.4). This is an increase of 11 % compared to the last year estimate.

3.3.4 Larvae Surveys

Herring larvae surveys in the western Baltic were conducted in weekly intervals during the 2006 spawning season. During the last decade, the Rügen herring larvae surveys in the Greifswalder Bodden aimed at delivering a fishery independent recruitment estimate for the WBSS assessment. The resulting N30 index (extrapolated abundance of larvae at 30 mm length) has shown to reliably predict very strong year classes, however it failed to predict year classes of intermediate strength.

The results for 2006 were not available at the meeting (Table 3.3.5).

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 was assumed constant between years. The same maturity ogive was used as in the HAWG 2006:

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 0-ringer abundance of the Western Baltic Spring Spawning herring (WBSS) in Subdivisions 22-24 for 2006 were available from the autumn acoustic survey in Subdivisions 22-24 (see also Table 3.3.5) while results for 2006 larval survey during spawning time were not available at the meeting. The index of the 0-ringer in 2006 from the autumn acoustic survey was similar compared to the latest years with a slight increase compared to 2005. The acoustic recruitment indices of the 0-ringer and 1-ringer were similar to previous years (Figure 3.5.1). The total number of individuals in the stock from the autumn acoustic survey was also similar to the last year estimates as well as the values for the older age classes.

3.6 Assessment of western Baltic spring spawners in Division IIIa and Subdivisions 22-24

3.6.1 Input data

Catch in numbers at age from 1991 to 2006 were available for Subdivision IVa (East), Division IIIa and Subdivisions 22-24 (Table 3.6.1) and as proportion at age (Figure 3.6.1). Years before 1991 have been 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.

Mean weights at age in the landings are found in Table 3.6.2 and in Figure 3.6.2. The proportions of F and M before spawning were 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 age 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).

Available survey indices (Tables 3.3.1-3.3.4) were:

FLT1: Hydroacoustic survey in Division IIIa & Sub-division IVa East, July 1991–2006, 0–8+ ringers

FLT2: Hydroacoustic survey in Subdivisions 22, 23 and 24, Oct. 1991–2006, 0–8+ ringers

FLT3: IBTS in Division IIIa, Quarter 1, 1991-2007, 1-5 ringers

FLT4: IBTS in Division IIIa, Quarter 3, 1991-2006, 1–5 ringers

All are age-structured indices. None of the indices covered the total spatial distribution of the WBSS stock and the indices covered the following quarters and areas:

SURVEY AREA	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4
Division IIIa	FLT3	-	FLT1 and FLT4	-
Subdivisions 22-24	-	-	-	FLT2

Subsets of these data series representing selected age groups were constructed to give a better representation of the stock (see section 3.6.3).

3.6.2 ICA settings

The following settings (Table 3.6.6) were used in 2007, similar to 2006:

- The period for the separable constraint: 5 years (2002-2006).
- 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.

3.6.3 Exploration by individual survey indices

Given that this is an update assessment only a limited exploration was carried out similar to last year. Exploratory runs of catch data with single indices were performed using the general ICA-setting mentioned above (Section 3.6.2). A summary of the results from these runs is presented in Figures 3.6.3 and 3.6.4.

No larval survey data was available for 2006. The IBTS in Kattegat Q1 (FLT3) indicate a high F of 2.4, somewhat higher than the hydro-acoustic survey indices in Division IIIa (FLT1a and FLT1b) being 1 and 1.5 respectively, whereas the Acoustic survey indices in Subdivisions 22-24 (FLT2a and FLT2b) and the IBTS index in Kattegat Q3 (FLT4) suggest low F of 0.3, 0.3 and 0.2 respectively.

With no larval index for 2006 only the only recruitment indices available were 0-ringer Acoustic in SD 22-24 and 1-ringer Acoustic in SD 22-24. Recent trends in log transformed values of the time series from 1991 show no exceptional development (Figure 3.5.1). The tuning fleet choice and the settings for the final ICA run for the 2006 assessment were therefore the same as in the last two years' assessments with fleets FLT1b, FLT2b, and FLT4. The biological reasoning behind the choice of indices with restricted numbers of age classes is that there is only a partial migration of age 0-1 ringers to the Division IIIa in the summer and that ages older than 5-ringers are poorly represented in the Subdivision 22-24 acoustic surveys and in the IBTS.

3.6.4 Final Assessment

This assessment conforms to an update assessment of WBSS herring, input data (years 1991-2006, Ages 0-8+ ringers) are given in the following tables:

- Catch in number (Table 3.6.1)
- Weight in catch (Table 3.6.2)
- Weight in stock (Table 3.6.3)
- Natural mortality (Table 3.6.4)
- Maturity (see text table in section 3.4)

The following surveys were included (Tables 3.6.5a-c):

- FLT 1b: DK Hydroacoustic survey in Division IIIa+ SD IVaE, July 1991–2006, excl. 1999, 2–8+ ringers
- FLT 2b: GER Hydroacoustic survey in Subdivisions 22, 23 and 24, Oct 1991–2006, 0–5 ringers
- FLT 4: IBTS in Kattegat, Quarter 3, 1991-2006, 1–5 ringers

The final model settings are shown in Table 3.6.6. The output data are given in Tables 3.6.7-3.6.16. The estimated SSB for 2006 is about 184 500 tonnes with a mean fishing mortality (ages 3-6) of 0.52 (Table 3.6.9, Figure 3.6.6). As the previous year, the model diagnostics show a rather well defined minimum SSQ response-curve for all age-indices except age-index 1 (Acoustic Survey in Division IIIa+IVaE) that is somewhat flat (Figure 3.6.5). The minimum SSQ for the Acoustic Survey in Subdivisions 22-24 (age-index 2) finds an intermediate compromise between the high F of age-index 1 (Acoustic Survey in Division IIIa+IVaE) and the low F of age-index 3 (IBTS Kattegat Q3).

The marginal totals of residuals between the catch and the separable model (scrutinised on screen in ICA-view) are overall small, as well as reasonably trend-free in the separable period (2002-2006) (see Figure 3.6.7). However, as already noted in last years assessment the largest residuals and most of the year effects are again caused by 0-ringers that are down-weighted in the analysis but still appears with full weight in the residual plot of the ICA diagnostics. For values see Table 3.6.12.

The diagnostics for the three surveys does not repeat the trend of low acoustic and high IBTS residuals seen in last year assessment, with values for IBTS in the last two years are now in the same order of magnitude when compared to Acoustic surveys. The Acoustic Survey in Division IIIa+IVaE and the Acoustic Survey in Subdivisions 22-24 showed a mix of negative and positive residuals for 2006 (Figure 3.6.8), with the Acoustic Survey in Subdivisions 22-24 resembling the pattern of IBTS Kattegat Q3 survey. All surveys had noisy fits to population estimates for the younger and older age-classes, and somewhat better for the intermediate ones.

The catch-at-age unweighted variance component is of the same magnitude as the individual acoustic survey variance components (Table 3.6.16), however in the unweighted statistics down-weighting of the 0-ringers is not accounted for, and this age contribute quite some variation with a C.V. of 57% compared to about 14-19% for the 2+ groups (Table 3.6.10). After a period of fluctuating high fishing mortality in the mid 1990s, the F3-6 values has slightly declined and stabilized around 0.4-0.5. After a marked decline in the mid 1990s and a slight increase after the late 1990s the SSB is now fluctuating at around 140 000-180 000 t (Table 3.6.9).

Overall trends in the age structured data for the ICA model

Exploring the cohort dynamics by log catch and log survey indices gives an indication of total mortality and catchability in successive cohorts from year classes 1991-2003 (Figures 3.6.9a-d). The slopes of log catches indicate a continuous decreasing trend in mortality (Figure 3.6.9a). Slopes from the three surveys; Division IIIa acoustic survey (Figure 3.6.9b), the Subdivisions 22-24 acoustic survey (Figure 3.6.9c), and the IBTS in quarter 3 in the Kattegat (Figure 3.6.9d) are more fluctuating, with a tendency in the latest years to a decreasing trend in mortality (Figures 3.6.9c-d). Although these cohorts are still based on few age-classes (3-4), all the slopes have R^2>0.9. There is therefore no indication of a long term increase in total mortality based on these indices.

3.7 Short term projections

The assessment was used to provide a yield-per-recruit plot for WBSS herring in Division IIIa and Subdivisions 22-24 (Figure 3.7.1). The values for $\mathbf{F}_{0.1}$ and $\mathbf{F}_{max}$ are 0.22 and 0.53 respectively, although $\mathbf{F}_{max}$ is not well defined.

Short-term predictions were carried out using MFDP v.1a software. ICA estimates of population numbers and fishing mortalities were used except for the numbers of 0-ringers in 2006-2009, where the geometric mean of the recruitment over the period 2000–2004 was taken, and for the numbers of 1-ringers in 2007, where the geometric mean over the period 2001-2005 was used. A shorter period compared to recent years was used in the short-term predictions. This choice reflects the decreasing trend in recruitment observed in the last years. A similar trend is observed for the North Sea herring.

Mean weights-at-age in the catch and in the stock were taken as a mean for the years 2004–2006. A *status quo* fishing mortality for 2007 onwards was assumed, with values rescaled to the last year estimate. Input data for catch predictions are presented in Table 3.7.1. It is worth of notice that *Status quo* F in 2006 is around $\mathbf{F}_{max..}$

Short-term predictions were carried out assuming a *status quo* fishing mortality for 2007. The single option table is available for 2007 to 2009 (Table 3.7.2) for the following scenarios: 1) *Status quo* F, 2) F_{01} and 3) F according to a 15% catch reduction in 2008 and *Status quo* F in 2009 (F_{2009}= F_{2008}).

SCENARIO	2007	2008	2009
1) *status quo* F	F_{2007}= F_{2006} = 0.522 *Status quo* F Catch = 89 800 t	F_{2008}= F_{2007} = 0.522 *Status quo* F Catch = 85 500 t	F_{2009}= F_{2008} = 0.522 *Status quo* F Catch = 86 300 t
2) F_{01}	F_{2007}= F_{2006} = 0.522 *Status quo* F Catch = 89 800 t	F_{2008} = 0.219 F_{01} Catch = 42 200 t	F_{2009}= F_{2008} = 0.219 F_{01} Catch = 48 800 t
2) F ≈ Catch reduction (-15%) in 2008 and *Status quo* F in 2009	F_{2007}= F_{2006} = 0.522 *Status quo* F Catch = 89 800 t	F_{2008}= 0.455 $F_{(-15\%)}$ Catch = 76 300 t	F_{2009}= F_{2008} = 0.455 *Status quo* F Catch = 81 300 t

The results of the short-term predictions are given in Tables 3.7.2 – 3.7.5. Table 3.7.2 shows single option predictions for 2007-2009. Table 3.7.3 shows multiple options for 2008 at *status quo* fishing mortality in 2007. The catches for 2008 and 2009 at *status quo* fishing mortality were predicted to be 85 500 t and 86 300 t, respectively, which is an overall slight decrease in relation to the current catch level of 88 900 t. The SSB is predicted to decrease to 135 300 t in 2008 and to 134 800 t in 2009, which are slightly larger than the lowest values observed during the middle of the 1990´s. Based on $F_{0.1}$ (0.22), SSB in 2008 and 2009 are predicted to be around 139 000 t and 176 000. This corresponds to landings of 42 200 t in 2008 and 48 800 t in 2009. Predictions based on catch reductions (-15%) scenario would result in SSB around 136 200 t and 143 000 t in 2008 and 2009. This would generate landings of about 76 300 t and 81 300 t in 2008 and 2009, respectively.

3.8 Precautionary and yield based reference points

The estimated SSB has not been below 111 615 t since 1991. However, reference points for F and SSB have neither been defined nor proposed for this stock as

- there is no obvious stock-recruitment relationship and
- the time series is quite short with revised catch data and reliable splitting factors for only 15 years.

To find appropriate reference points simulations have been performed this year. The method proposed and introduced performs IIIa herring management scenarios using a simulation and risk based non-linear optimization procedure. It allows estimating optimum F (or effort) values to be applied and optimum catch values to be taken. As such, it holds the potential to derive precautionary reference points.

The method uses past abundance values of the last assessment year as start values to initialize the optimization process (these start values, however, may also come from direct observations such as research surveys, commercial surveys, etc.). But the method differs from conventional scenario based medium-term projection models as it is not a prediction model evaluating the influence of measures taken as part of an impact study and using past F values that have been estimated from the stock history. However, in contrast to conventional scenarios the optimization tries to directly control a fishery by generating optimum F values. Along with these, optimum catches (optimum quotas or TAC values) will be generated as a result of the optimization process, given *a priori* specified upper F and lower SSB limits, respectively. I.e. based on this the outcome in terms of F and TAC values is expected to reflect the best management strategy under the given conditions. In case of IIIa herring it does this by maximizing the following objective function

$$\begin{aligned}\text{Objective Function} = \text{total herring catch} \\ - \lambda_1 \times \max(0, \text{SSB}_{\text{lower limit}} - \text{SSB}_{\text{estimated}}) \qquad (3.8.1) \\ - \lambda_2 \times (1 - 0.15) \times \max(0, (\text{catch} - \text{catch}_{\text{mean}})^2) .\end{aligned}$$

The equation consists of three components in which the latter two are penalizing either an undercut of the lower SSB limit or a change of resulting catches that fall outside a symmetrical ∀ 15% interval being the current catch variation allowance suggested by the EU commission. The two λ values are weight factors that can be used for strengthening or relaxing the penalties associated with them. Beyond this the other equations describing the underlying population dynamics are given in Gröger (2007). However, once the optimum F values are found, the catch calculated can be considered to be an optimum catch and thus may be used as TAC recommendation.

All values being input to the optimization procedure such as initial abundance values, weights, maturity observations, recruitment, etc. are prone to errors. Errors in general create uncertainty and uncertainty creates risk. The errors can be of systematic (bias) or of random nature (stochasticity). The errors address the fact that initial abundance values might have been overestimated, or that recruitment varies randomly with some variance around some function or expected value chosen. Investigating the underlying recruitment pattern of IIIa herring based on existing data for years 1991 to 2006 leads to the assumption that the IIIa herring recruitment is purely random. This allows the optimization process to be setup as being driven by a recruitment component that can be generated from a normal distribution with mean 3.94E9 and standard deviation 1.37E9 ($p_{H0:R\sim N} > 0.250$) without an assumption of 1st or 2nd order autocorrelation ($p_{DW} < 0.0001$) (see Figures 3.8.1, 3.8.2, and 3.8.3). Thus, to initiate the process of generating random recruitment values from a N[3.94E9,1.37E9] the seed values were taken in a way that the generated streams of random numbers will be annually independent of each other:

$$seed_2 = \text{int}\,(10000 \text{ x } CDF^{-1}_{uniform}\,(seed_1)) \qquad (3.8.2)$$

with $CDF^{-1}_{uniform}$ being the quantile function (inverse cumulative distribution function) of the uniform distribution. According to this setup of stochasticity, re-running the optimization procedure many times will result in different outcomes. Depending on the process specification, this may also lead to violations of the biological constraints as the SSB limit set may be undercut. In general, such undercuts can be interpreted as negative (hazardous, harmful) events and will happen with some frequency, in probabilistic terms with some likelihood. However, to get the optimization running, some other important points must be addressed from which specifications necessary for the optimization procedure need to be derived and setup. These issues are:

- As there are no reference points currently set for IIIa herring, what might be appropriate levels of F and SSB for specifying reference points? That includes
- a specification of a lower SSB limit not to be undercut during the optimization process
- a specification of an upper F limit below which the F value optimization can take place
- Is there an indication of changes in individual growth over time that may influence biomass production in time significantly?
- Is there an indication for a potential underreporting of catches (as part of an implementation error)?
- Is there an indication for potential changes (increases) in M?
- Is there an indication for potential hidden trends in F that may be induced by technological development and add to the implementation error?

To deal with these issues, we varied the assumptions relevant to the scenario and optimization based procedures by applying the following range of values:

- Candidates for SSB ref. points (lower limits): 111615 tons (Minimum), 156714 tons (P_{50}), 177609 tons (Mean)
- Candidates for F ref. points (upper limits): 0.22 ($F_{0.1}$), 0.27, 0.32, 0.41 (status quo) and 0.46 (F_{Max})
- Underreporting of catch (adding to the implementation error): by 0%, 20%, 40%
- Trends in mean weight: 0 and -0.00093112 (slope in mean catch weight, see Figures 3.8.4 and 3.8.5)
- Hidden trends of F (adding to the implementation error): 0 and 0.01 (increase of technological efficiency)
- Changes in M: by 0% and 20%

The simulations were generally based on a planning horizon of 10 years, starting with year 2007. Since our starting point is the year 2007, we based the optimization on input data from year 2006. The relevant stock data were hence taken from the most recent stock assessment of IIIa herring as reported by the Herring Assessment Working Group (HAWG) for year 2007. All data used are age disaggregated (ages 0-8) consisting of abundance estimates N_{2006}, weight W in kg, selectivity S, maturity observations and natural mortality M. The abundance estimates are based on final ICA estimates (Integrated Catch Analysis) derived from the 2007 HAWG assessment.

Firstly, simple but fast running scenario based simulations were performed, using 1000 runs each. Secondly, given their results, more complex optimization based simulations have been designed and performed, using 100 runs each. The scenario based simulation runs thus served only to find initial conditions for the optimization runs. The setup and initial conditions of the optimization type simulations can be summarized as follows:

1. Optimization A. (baseline scenario with SSB lower limit set to minimum SSB and F upper limit to status quo overall F)
   - SSB lower limit = 111615 tons (minimum SSB between 1991 and 2006)
   - F upper limit = 0.41 (for ages 0-8)
   - 40% underreported catch
   - Average hidden trend of F of 5% due to technological development
   - M 20% higher
2. Optimization B. (SSB lower limit set to mean SSB)
   - SSB lower limit = 177609 tons (mean SSB between 1991 and 2006)
   - F upper limit = 0.41 (for ages 0-8)
   - 40% underreported catch
   - Average hidden trend of F of 5% (due to technological development)
   - M 20% higher
3. Optimization C. (SSB lower limit set to mean SSB and F upper limit decreased from status quo overall F to 0.32)
   - SSB lower limit = 177609 tons (mean SSB between 1991 and 2006)
   - F upper limit = 0.32 (for ages 0-8)
   - 40% underreported catch
   - Average hidden trend of F of 5% (due to technological development)
   - M 20% higher
4. Optimization D. (F upper limit decreased from 0.32 to 0.27)
   - SSB lower limit = 177609 tons (mean SSB between 1991 and 2006)
   - F upper limit = 0.27(for ages 0-8)
   - 40% underreported catch
   - Average hidden trend of F of 5% (due to technological development)
   - M 20% higher
5. Optimization E. (F upper limit decreased from 0.27 to $F_{0.1}$ = 0.22)
   - SSB lower limit = 177609 tons (mean SSB between 1991 and 2006)
   - F upper limit = 0.22 (for ages 0-8)
   - 40% underreported catch
   - Average hidden trend of F of 5% (due to technological development)
   - M 20% higher

While the first optimization run was based on the lowest SSB ever observed during period 1991 to 2006, all other runs were based on the long term average SSB estimated from years 1991 to 2006 as being the lower SSB limit allowed. The hierarchical design of the optimization runs then reflect a gradual decrease in the upper F limit (beginning with status quo overall F = 0.41 and ending with $F_{0.1}$ = 0.22) below which the F values get optimized. This is to find that point below which the risk of undercutting the lower SSB limit can be ignored. The results are illustrated by Figures 3.8.6 to 3.8.10. All five figures similarly consist of 4 panels in which

- the upper left panel always shows the trajectories of R and SSB over time (plus their minimum and maximum values (vertical lines)),
- the upper right panel the trajectories of catch (TAC) and its changes (TAC change) over time (plus a ±15% interval as it was suggested by the EU commission as well as minimum and maximum values (vertical lines)),
- the lower left panel the trajectories of the optimized F values over time (plus their minimum and maximum values (vertical lines)), and
- the lower right panel the trajectories of the likelihood of undercutting the lower SSB limit, the mean loss in SSB and the combined risk over time.

The results thus indicate that an overall F value should be around F = 0.27 as the expected risk of SSB falling below the long term mean of SSB is negligibly small (around 1.5 on average, see Figure 3.8.9). This means a probability of occurrence of 1.1% and an average (future) loss of SSB of 137 tons per year. The loss addresses the fact that lost SSB will be missing in the next year's SSB budget which does affect the regeneration potential but also the future catches only marginally.

3.9 Quality of the Assessment

The assessment in 2007 is an update of last year's assessment. Therefore, the assessment has not been explored beyond examining the standard diagnostics.

Three data series (surveys) are used in addition to the catch numbers at age. None of these surveys cover the whole distribution area of the stock, but each of them covers areas where it is likely that certain ages are well represented at survey time. The acoustic survey in Division IIIa+IVaE covers fish age 2 and older while the two others largely cover the younger part of the population. Hence, these surveys can be regarded as complementary. All surveys are noisy. The acoustic survey in Division IIIa+IVaE indicates a higher mortality than the others, but its contribution to the total sum of squares does not have a distinct minimum (Figure 3.6.5). The selection pattern is smooth and no age (1+) or year effects (2001-2005) in model residuals are large (Figure 3.6.7).

Altogether, the current procedure for assessing the stock has given consistent results with respect to fishing mortality, spawning biomass and recruitment for several years (Figure 3.9.1).

The retrospective errors are small, except in the recruitment and even these are unbiased (Figure 3.9.2). Apparently, the strength of a year class is not firmly estimated before the year class has been followed for 2-3 years. The selection at age in the fishery changes in retrospective runs. This probably reflects a stronger exploitation of younger herring in earlier years, which in the present assessment is reflected in the VPA part. The selection at age in this year's assessment is similar to that in two last year's assessment (Figure 3.9.3), while the tendency to a decrease in exploitation for the younger ages is confirmed and the catch residuals are relatively small. Hence, the separable assumption does not seem to be generally violated.

Single fleet ICA runs show that SSB estimates from the final run for 2007 are lying between those obtained using IBTS Q3 and Q1, with Acoustic tuning fleets being closer to the SSB values of the final run (Figure 3.9.4) when compared to IBTS.

For prediction purposes, better indicators of recruitment would be useful. At present, geometric mean recruitment has to be assumed for age 0 in the intermediate year and for later years. HAWG suggests to investigate procedures that give a better predictive power of the recruitment by reducing the impact of outliers and to analyse within survey variances. The predictions are made for the Western Baltic Spring Spawning (WBSS) stock, while management is by areas. In Division IIIa, the fishery exploits both WBSS and North Sea autumn spawning herring. The Working Group has attempted to outline the consequences for both stocks in fishery in Division IIIa (Section 3.10). This requires insight to both how the catches of WBSS are distributed by areas, and the proportions of the catches in Division IIIa from each stock. Both these properties change over time, and are influenced both by managers' decisions and the abundance of the respective stocks in the area. So far, the only basis has been historical data of catches in biomass by area and species (cfr. Table 2.1.6). A better basis could be achieved by considering catches at age by different fleets, and investigations of how management decisions influence the fishery. Further a deeper understanding of relationships between stock characteristics and major migration patterns would help predictions of the seasonal stock composition in the mixed areas. These efforts require inter-sectional work; an attempt to resolve parts of the problem has been addressed through the IAMHERSKA project (see section 1.4.8).

Compared to last year's assessment, the change in the estimate is +15% and +21% for the fishing mortalities in 2004 and 2005 respectively; and –6% and -11% for the SSB in 2004 and 2005 respectively. The text table below gives an overview of the assumptions made in the 2006 and 2007 assessments and a comparison of the main results with 2004 and 2005 as baselines.

<table>
<tr><th>CATEGORY</th><th>PARAMETER</th><th>ASSESSMENT IN 2006</th><th>ASSESSMENT IN 2007</th><th>DIFF. 07-06 (+/-) %</th></tr>
<tr><td rowspan="8">ICA input</td><td>No. of years for separable constraints</td><td>5</td><td>5</td><td>No</td></tr>
<tr><td>Reference age for separable constraint</td><td>4</td><td>4</td><td>No</td></tr>
<tr><td>Selection to be fixed on last age</td><td>1</td><td>1</td><td>No</td></tr>
<tr><td>Weighting factor to all indices</td><td>1</td><td>1</td><td>No</td></tr>
<tr><td>Catch down-weighted to 0.1 for 0-ringer</td><td>Yes</td><td>Yes</td><td>No</td></tr>
<tr><td rowspan="3">Tuning data</td><td>Acoustic Surv. Div. IIIa 2-8+ ringers</td><td>Acoustic Surv. Div. IIIa 2-8+ ringers</td><td>No</td></tr>
<tr><td>Acoustic Surv. SDs 22-24 0-5 ringers</td><td>Acoustic Surv. SDs 22-24 0-5 ringers</td><td>No</td></tr>
<tr><td>IBTS Surv. Quarter 3 1-5 ringers</td><td>IBTS Surv. Quarter 3 1-5 ringers</td><td>No</td></tr>
<tr><td rowspan="4">ICA results</td><td rowspan="2">SSB 2004
F(3-6) 2004</td><td>168,700 t</td><td>158,200t</td><td>-6%</td></tr>
<tr><td>0.386</td><td>0.444</td><td>+15%</td></tr>
<tr><td rowspan="2">SSB 2005
F(3-6) 2005</td><td>164,600 t</td><td>155,300 t</td><td>-6%</td></tr>
<tr><td>0.408</td><td>0.494</td><td>+21%</td></tr>
</table>

3.10 Management Considerations

Catch options for mixed stocks in Division IIIa based on short term predictions for WBSS

There is an indication of a declining recruitment in recent years in the WBSS herring stock. The present state of a declining NSAS stock with poor recruitment in the last 5 years strongly suggest that advice given for the WBSS stock will not conflict with the present co-management of the two stocks in the mixed areas of Division IIIa and Division IVaE.

It should however also be noted that the scope for exploitation is not only dependent on the overall population dynamics of the two stocks. Management also has to consider age-class specific stock composition in the mixing zones brought about by unpredictable changes in distribution pattern triggered by environmental as well as population biological and behavioural cues.

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

Subdivision 22-24

Fleet F: All herring fisheries in Subdivisions 22-24

Quotas in Division IIIa

The quota for the C-fleet and the by-catch quota for the D-fleet are set for both stocks together. Therefore the implication of the quotas for the outtake of WBSS has to be considered. Furthermore the implication for the outtake of NSAS has to be taken into account when setting fleet wise quotas for that stock (see section 2.7).

For ***2006 the agreed TAC*** for the directed fishery in Division IIIa (C-fleet) was 81 600 t. The TAC was divided into quotas, 500 t for the Faeroes, 70 217 t for the EU of which all had to be taken in Division IIIa, and 10 883 t for Norway of which 50% could be taken in the North Sea. A by-catch quota for Division IIIa herring in the small meshed fishery (fleet-D) was set at 22 528 t.

For ***2007 the agreed TAC*** for the directed fishery in Division IIIa (C-fleet) is 69 360 t. The TAC is divided into quotas, 500 t for the Faeroes and 9 251 t for Norway of which 40% can be taken in the North Sea. For the EU a total quota of 59 609 t is agreed of which all has to be taken in Division IIIa; this is divided between Denmark 28 907 t, Germany 463 t and Sweden 30 239 t. A by-catch quota for Division IIIa herring in the small meshed fishery (fleet-D) is set at 15 396 t and divided between Denmark 13 160 t, Germany 117 t and Sweden 2 119 t.

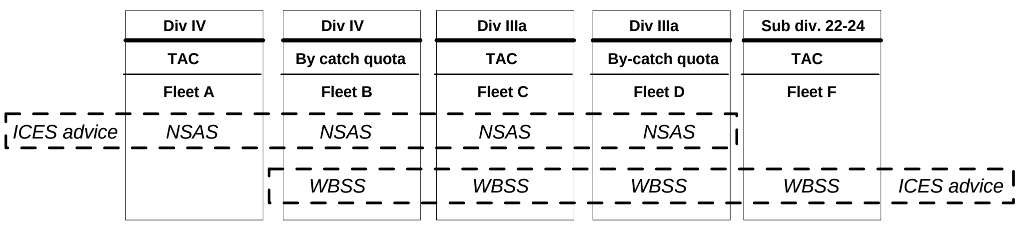
It must also be noted that a slightly variable and relatively small amount (around 8 000 t) of WBSS herring is taken in the fishery in Subarea IV (see Section 2.2.2 and Figure 2.2.2 for information about WBSS taken in Divisions IVa and IVb East). This component is accounted for in both the assessments on NSAS and WBSS. Adding to this there is misreporting by areas. 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. Regulations allowing quota transfers from Division IIIa to the North Sea were introduced with the incentive to decrease misreporting for the Norwegian part of the fishery. However, working group estimates suggest that out of the official landings for human consumption in the Skagerrak, 46%, 58%, 46% and 36% are misreported in 2003, 2004, 2005 and 2006 respectively. These figures are probably underestimating the problem since only a subset of countries supply this information to the HAWG. Misreported catches are moved to the appropriate stock for the assessment.

TAC in Subdivisions 22-24

For ***2007 the agreed TAC*** for the herring fishery in Subdivisions 22-24 (Fleet F) is 49 500 t. The TAC is divided into quotas, 6 939 t for Denmark, 27 311 t for Germany, 3 t for Finland, 6 441 t for Poland and 8 806 t for Sweden.

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 cross sectioning the geographical distribution of the stocks (see the following text diagram).



Data used for catch options in 2008

There is no firm basis for predicting the fraction of NSAS in the catches by the C- and D-fleets. The proportions of the two stocks as well as the distribution pattern of the fishery in the Eastern North Sea and the Division IIIa is dynamically changing year by year. This is probably influenced by year-class strength of the two stocks and their relative geographical distributions as well as fleet behaviour reacting on herring availability and management decisions.

Recent years' shares of the WBSS catches in IIIa and other areas is used to translate the total recommended TAC for WBSS into outtake of WBSS in Division IIIa and Subdivisions 22-24. The mix of the two stocks in the Division IIIa catches is used to derive the outtake of NSAS and total catches in Division IIIa. Predicted catches of WBSS and NSAS by fleet in IIIa is based on recent patterns of 1) ratio of WBSS catches taken by each fleet and 2) proportion of the two stocks in catches of the different fleets.

The catch option for 2008 is based on the share by fleet and stock composition in catches given as a mean for the years 2004 - 2006. The ratio by fleet and stock composition is given in the following text table A and B, respectively:

Text table **A** showing the 2004 - 2006 average **share** of the total catch in t of WBSS by each fleet.

WBSS	**Fleet C (IIIa)**	**Fleet D (IIIa)**	**Fleet F (SD22-24)** ***+ Fleet A (IV)****	**Total**
Mean (2004 - 2006) catch in t	26,500	7,400	54,800	88,700
Mean (2004 - 2006) share in %	30%	8%	62%	100%

*A constant catch of 8400 t of WBSS caught in Subarea IV is accounted for in the calculations.

Text table **B** showing the 2004 - 2006 average proportion of WBSS in catches by fleet (the split).

WBSS	**Fleet C**	**Fleet D**	**Fleet F (SD22-24)** ***+ Fleet A (IV)***
Mean (2004 - 2006) proportion	0.62	0.49	1.00

Exploring a range of total WBSS catches

The settings of F in the stock short term projections considered the indication of declining recruitment in the WBSS stock as well as the present level of a declining NSAS stock with very low recruitment in recent years. Catch options with focus on incremental change towards management for a maximum sustainable yield were explored for the two stocks in Division IIIa at total catches set for the WBSS stock.

The projected stock composition is assumed to equal the 2004 - 2006 average of the NSAS and WBSS in each of the C and D fleets (in Division IIIa). Further the 2004 -2006 average catch of 8 400 t of WBSS is assumed taken in Subarea IV.

The stock assessment indicates a recent increase in SSB to 185 000 t in 2006 likely driven by the quite large 2003 year-class coming through. Short-term projections calculate that the assumed catch in 2007 (in total 90 000 t with status quo fishing mortality) will lead to a decrease in SSB in 2007 to about 154 000 t (Table 3.7.2). Catch options for 2008 and 2009 with F_{sq} will further decrease SSB in 2008 and in 2009 (Table 3.7.2), whereas a fishing mortality based on a 15% catch reduction ($F_{C\text{-}15\%}$) will lead to a decrease in SSB in 2008 and a slight increase in 2009 (Table 3.7.4). The setting of the more restrictive F_{01} will lead to a decrease in SSB in 2008 and an increase in 2009 (Table 3.7.3).

The text table below gives catch options based on the F levels above and a series of other scenarios derived from the HAWG2007 short-term projections for the WBSS in Division IIIa, in SDs 22-24 and in Subarea IV.

In the text table below the options in bold corresponds to the three F – scenarios: Option 1 ≈ $F_{0.1}$, option 5 ≈ $F_{C\text{-}15\%}$, and option 7 ≈ F_{sq}, further a number of other options between 40 200 t and 88 700 t are given (values are rounded to the nearest 100 t).

MANAGEMENT CONSIDERATIONS FOR DIVISION IIIA + SD 22-24 BASED ON SHORT TERM PREDICTIONS (HAWG 2007)									
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*	FleetA*	Fleet C	Fleet D	Fleet F	Fleet C	FleetD	Fleet C	Fleet D	Fleet F
1 ($F_{0.1}$)	40,200	8,400	12,600	3,500	15,800	7,600	3,700	20,200	7,200	15,800
2	50,000	8,400	15,700	4,400	21,500	9,400	4,500	25,100	8,900	21,600
3	60,000	8,400	18,800	5,200	27,600	11,300	5,500	30,100	10,700	27,600
4	70,000	8,400	21,900	6,100	33,600	13,200	6,400	35,100	12,500	33,600
5($F_{C\text{-}15\%}$)	76,300	8,400	23,900	6,600	37,400	14,400	6,900	38,300	13,600	37,400
6	85,000	8,400	26,600	7,400	42,600	16,000	7,700	42,600	15,100	42,600
7 (F_{sq})	88,700	8,400	27,800	7,700	44,800	16,700	8,100	44,500	15,800	44,800
*A catch of 8400 t of WBSS herring taken in the Eastern North Sea is assumed.										

The short term projection with recent catch levels show a decline in SSB which indicates that fishing mortality should be reduced. Catches based on F_{01} quickly re-establish the SSB to above average values at the cost of high reductions in yield. Applying an incremental approach towards $F_{0.1}$ (as a proxy for maximum sustainable yield) may be achieved on a longer term basis by successive 15% catch reductions provided recruitment levels are not further reduced. However a catch reduction of 15% in 2008 followed by a status quo F in 2009 appears to be a rather slow progress in that direction.

For a TAC on catch of NSAS and total catch by the fleets in Division IIIa to be compatible with the advice for WBSS, the numbers derived as above, based on the largest advisable catch of WBSS, are upper bounds on the advisable catches of NSAS by the C- and D- fleets. Thus the resulting catch options were also used as constraints for short term predictions for the NSAS herring (section 2.7).

Table 3.1.1 WESTERN BALTIC HERRING.

Total landings in 1986-2006 in thousands of tonnes.

(Data provided by Working Group members 2006).

Year	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Skagerrak										
Denmark	94.0	105.0	144.4	47.4	62.3	58.7	64.7	87.8	44.9	43.7
Faroe Islands	0.5									
Germany										
Norway	1.6	1.2	5.7	1.6	5.6	8.1	13.9	24.2	17.7	16.7
Sweden	43.0	51.2	57.2	47.9	56.5	54.7	88.0	56.4	66.4	48.5
Total	139.1	157.4	207.3	96.9	124.4	121.5	166.6	168.4	129.0	108.9
Kattegat										
Denmark	37.4	46.6	76.2	57.1	32.2	29.7	33.5	28.7	23.6	16.9
Sweden	35.9	29.8	49.7	37.9	45.2	36.7	26.4	16.7	15.4	30.8
Total	73.3	76.4	125.9	95.0	77.4	66.4	59.9	45.4	39.0	47.7
Sub. Div. 22+24										
Denmark	14.0	32.5	33.1	21.7	13.6	25.2	26.9	38.0	39.5	36.8
Germany	60.0	53.1	54.7	56.4	45.5	15.8	15.6	11.1	11.4	13.4
Poland	12.3	8.0	6.6	8.5	9.7	5.6	15.5	11.8	6.3	7.3
Sweden	5.9	7.8	4.6	6.3	8.1	19.3	22.3	16.2	7.4	15.8
Total	92.2	101.4	99.0	92.9	76.9	65.9	80.3	77.1	64.6	73.3
Sub. Div. 23										
Denmark	1.5	0.8	0.1	1.5	1.1	1.7	2.9	3.3	1.5	0.9
Sweden	1.4	0.2	0.1	0.1	0.1	2.3	1.7	0.7	0.3	0.2
Total	2.9	1.0	0.2	1.6	1.2	4.0	4.6	4.0	1.8	1.1
Grand Total	307.5	336.2	432.4	286.4	279.9	257.8	311.4	294.9	234.4	231.0

Year	1996	1997	1998 [2]	1999 [2]	2000	2001 [5]	2002 [4]	2003	2004	2005	2006 [1,3]
Skagerrak											
Denmark	28.7	14.3	10.3	10.1	16.0	16.2	26.0	15.5	11.8	14.8	5.2
Faroe Islands										0.4	
Germany								0.7	0.5	0.8	*0.6*
Norway	9.4	8.8	8.0	7.4	9.7						
Sweden	32.7	32.9	46.9	36.4	45.8	30.8	26.4	25.8	21.8	32.5	26.0
Total	70.8	56.0	65.2	53.9	71.5	47.0	52.3	42.0	34.1	48.5	31.8
Kattegat											
Denmark	17.2	8.8	23.7	17.9	18.9	18.8	18.6	16.0	7.6	11.1	8.6
Sweden	27.0	18.0	29.9	14.6	17.3	16.2	7.2	10.2	9.6	10.0	10.8
Total	44.2	26.8	53.6	32.5	36.2	35.0	25.9	26.2	17.2	21.1	19.4
Sub. Div. 22+24											
Denmark	34.4	30.5	30.1	32.5	32.6	28.3	13.1	6.1	7.3	5.3	1.4
Germany	7.3	12.8	9.0	9.8	9.3	**11.4**	22.4	18.8	18.5	21.0	22.9
Poland	6.0	6.9	6.5	5.3	6.6	9.3	-	4.4	5.5	6.3	5.5
Sweden	9.0	14.5	4.3	2.6	4.8	13.9	10.7	9.4	9.9	9.2	9.6
Total	56.7	64.7	49.9	50.2	53.3	62.9	46.2	38.7	41.2	41.8	39.4
Sub. Div. 23											
Denmark	0.7	2.2	0.4	0.5	0.9	0.6	4.6	2.3	0.1	1.8	1.8
Sweden	0.3	0.1	0.3	0.1	0.1	0.2	-	0.2	0.3	0.4	0.7
Total	1.0	2.3	0.7	0.6	1.0	0.8	4.6	2.6	0.4	2.2	2.5
Grand Total	172.7	149.8	169.4	137.2	162.0	145.7	128.9	109.5	92.8	113.6	93.0

[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

Table 3.1.2 **WESTERN BALTIC HERRING.**
Landings (SOP) in 2001-2006 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
2001	1	19.6	3.8	20.8	44.2
	2	11.1	1.9	20.7	33.7
	3	24.7	7.9	7.5	40.1
	4	11.1	1.7	14.8	27.6
	Total	66.5	15.3	63.8	145.6
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

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

Division: Skagerrak Year: 2006 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	1.95	31	11.29	17	13.24	19
	2	24.37	77	14.25	74	38.62	76
	3	13.87	109	11.35	109	25.22	109
	4	3.50	131	2.87	131	6.37	131
	5	5.79	187	4.90	187	10.69	187
	6	0.69	195	0.58	195	1.28	195
	7	0.25	220	0.21	220	0.46	220
	8+	0.19	209	0.16	209	0.35	209
	Total	50.61		45.62		96.23	
	SOP		5,218		3,964		9,182
2	1	2.81	41	0.19	41	3.00	41
	2	11.87	75	0.81	75	12.68	75
	3	2.95	105	0.20	105	3.15	105
	4	0.77	135	0.05	135	0.82	135
	5	1.22	170	0.24	118	1.46	162
	6	0.03	179	0.00	179	0.03	179
	7	0.11	179	0.01	179	0.12	179
	8+	0.09	184	0.01	184	0.09	184
	Total	19.84		1.51		21.34	
	SOP		1,669		128		1,796
3	0	0.39	38	4.73	16	5.12	18
	1	36.56	83	2.87	47	39.43	81
	2	36.03	103	0.40	99	36.43	103
	3	24.54	131	0.18	129	24.72	131
	4	11.86	148	0.08	147	11.93	148
	5	5.81	162	0.12	177	5.93	163
	6	2.74	175	0.02	167	2.76	175
	7	2.62	188	0.02	187	2.64	188
	8+	0.98	204	0.01	219	0.98	204
	Total	121.52		8.43		129.95	
	SOP		13,842		317		14,158
4	0	4.25	15	1.40	15	5.64	15
	1	28.85	73	9.49	73	38.34	73
	2	5.82	104	1.91	104	7.73	104
	3	6.13	140	2.02	140	8.15	140
	4	3.38	155	1.11	155	4.49	155
	5	2.99	192	0.98	192	3.97	192
	6	0.31	216	0.10	216	0.42	216
	7	0.63	232	0.21	232	0.84	232
	8+	0.24	207	0.08	207	0.31	207
	Total	52.60		17.29		69.89	
	SOP		4,976		1,636		6,612
Total	0	4.63	17	6.13	16	10.76	16
	1	70.17	76	23.84	43	94.01	67
	2	78.10	91	17.37	78	95.46	88
	3	47.49	124	13.74	114	61.23	122
	4	19.50	146	4.11	138	23.62	144
	5	15.80	177	6.25	185	22.05	180
	6	3.78	182	0.71	197	4.48	185
	7	3.61	198	0.45	223	4.06	200
	8+	1.48	204	0.25	208	1.73	204
	Total	244.57		72.85		317.42	
	SOP		25,704		6,045		31,749

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

Division: Kattegat Year: 2006 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	15.27	31	67.22	17	82.49	20
	2	34.81	68	6.46	49	41.28	65
	3	37.73	97	2.54	102	40.27	97
	4	9.17	118	0.39	122	9.55	118
	5	11.81	174	0.63	170	12.45	174
	6	1.26	183	0.06	189	1.32	183
	7	0.90	171	0.02	147	0.92	171
	8+	0.37	171	0.02	167	0.39	171
	Total	111.32		77.34		188.66	
	SOP		10,081		1,892		11,973
2	1	6.82	48	0.42	17	7.24	47
	2	5.23	77	0.02	35	5.25	76
	3	1.06	102	0.00	144	1.06	102
	4	0.37	99			0.37	99
	5	0.12	144			0.12	144
	6						
	7						
	8+	0.06	171			0.06	171
	Total	13.66		0.44		14.10	
	SOP		903		8		911
3	0			22.12	12	22.12	12
	1	7.69	66	5.67	42	13.36	56
	2	7.59	78	0.15	77	7.75	78
	3	4.89	93	0.06	99	4.95	94
	4	1.81	107	0.02	112	1.83	107
	5	0.42	120	0.01	133	0.43	120
	6	0.13	163	0.00	163	0.13	163
	7	0.02	153	0.00	153	0.02	153
	8+						
	Total	22.55		28.03		50.58	
	SOP		1,828		531		2,359
4	0	3.50	29	2.36	15	5.86	23
	1	35.12	58	7.44	61	42.56	59
	2	7.33	86	1.66	89	8.99	86
	3	2.72	122	0.67	127	3.39	123
	4	0.91	145	0.24	147	1.15	145
	5	0.26	172	0.07	172	0.33	172
	6	0.10	191	0.03	191	0.13	191
	7	0.15	231	0.04	231	0.20	231
	8+	0.05	215	0.01	215	0.07	215
	Total	50.14		12.55		62.68	
	SOP		3,352		788		4,139
Total	0	3.50	29	24.48	12	27.98	14
	1	64.90	52	80.75	23	145.65	36
	2	54.96	73	8.31	58	63.27	71
	3	46.39	98	3.28	107	49.67	99
	4	12.25	117	0.65	131	12.90	118
	5	12.61	172	0.71	170	13.32	172
	6	1.49	182	0.09	188	1.58	182
	7	1.07	179	0.06	204	1.13	181
	8+	0.48	176	0.03	187	0.51	176
	Total	197.66		118.37		316.02	
	SOP		16,164		3,219		19,383

Table 3.2.3 WESTERN BALTIC HERRING. Division IIIa
Landings in numbers (mill.), mean weight (g.) and SOP (t) by age and quarter.

Division: 22-24 Year: 2006 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	10.39	14	0.20	16	4.44	18	15.04	15
	2	11.76	47	1.02	43	14.37	44	27.15	45
	3	10.67	84	2.12	80	33.83	89	46.63	87
	4	6.79	119	1.64	104	21.97	115	30.40	115
	5	3.11	147	0.64	136	9.75	146	13.50	146
	6	1.84	159	0.30	156	6.97	169	9.11	167
	7	1.02	163	0.34	170	7.35	190	8.71	186
	8+	0.60	195	0.22	176	4.17	187	4.99	187
	Total	46.18		6.50		102.85		155.53	
	SOP		3,436		621		11,004		15,061
		Sub-division 22		Sub-division 23		Sub-division 24		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
2	1	0.35	16	0.00	19	4.52	22	4.88	22
	2	0.82	42	0.03	47	13.83	48	14.68	48
	3	1.26	77	0.05	75	42.47	78	43.78	78
	4	1.21	114	0.04	101	43.66	106	44.91	106
	5	0.78	146	0.01	115	18.17	140	18.96	140
	6	0.59	166	0.01	141	15.04	160	15.64	160
	7	0.46	178	0.01	167	11.46	177	11.93	177
	8+	0.22	201	0.00	171	5.33	178	5.56	179
	Total	5.70		0.15		154.49		160.34	
	SOP		613		13		16,615		17,240
		Sub-division 22		Sub-division 23		Sub-division 24		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
3	0	0.00	22			0.00	22	0.00	22
	1	0.00	51	2.66	44	8.12	41	10.79	42
	2	0.00	79	1.68	66	8.51	59	10.20	60
	3	0.01	112	2.02	73	7.20	62	9.22	65
	4	0.00	130	1.61	65	11.20	52	12.81	54
	5	0.00	143	0.47	68	5.02	56	5.49	57
	6	0.00	171	0.25	57	3.93	59	4.17	59
	7	0.00	147	0.16	83	0.57	72	0.73	75
	8+	0.00	210			1.00	64	1.00	64
	Total	0.01		8.85		45.54		54.40	
	SOP		2		539		2,488		3,029
		Sub-division 22		Sub-division 23		Sub-division 24		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
4	0	0.01	22	0.17	21	0.47	21	0.65	21
	1	0.33	51	3.37	54	10.37	52	14.06	53
	2	1.11	79	4.44	78	14.50	76	20.04	77
	3	1.94	112	3.82	97	13.62	98	19.37	99
	4	1.07	130	2.51	111	10.03	102	13.61	106
	5	0.32	143	0.72	98	4.01	83	5.05	89
	6	0.16	171	0.28	115	2.01	95	2.44	102
	7	0.15	147	0.10	139	0.49	143	0.74	143
	8+	0.02	210	0.07	171	0.51	111	0.61	122
	Total	5.11		15.48		56.00		76.58	
	SOP		561		1,307		4,662		6,531
		Sub-division 22		Sub-division 23		Sub-division 24		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
Total	0	0.01	22	0.17	21	0.47	21	0.65	21
	1	11.07	15	6.24	48	27.45	38	44.76	34
	2	13.69	49	7.17	70	51.22	57	72.07	57
	3	13.87	87	8.01	87	97.12	83	119.00	84
	4	9.07	120	5.81	96	86.85	101	101.73	102
	5	4.22	147	1.84	104	36.94	124	43.00	125
	6	2.60	161	0.83	113	27.94	143	31.36	144
	7	1.63	166	0.61	142	19.87	178	22.11	176
	8+	0.85	197	0.30	175	11.01	168	12.16	170
	Total	57.00		30.97		358.87		446.84	
	SOP		4,612		2,479		34,770		41,861

Table 3.2.4 WESTERN BALTIC HERRING.
Samples of commercial landings by quarter and area for 2006 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	882.0	14	1635	1581
		2	14.0	1	1	0
		3	3815.0	14	1320	1318
		4	445.0	1	98	0
	Total		5156.0	30	3,054	2,899
	Germany	1	0.0			
		2	0.0			
		3	556.4		No data available	
		4	0.0			
	Total		556.4	0	0	0
	Faroe Islands	1				
		2				
		3				
		4				
	Total		0.0	0	0	0
	Sweden	1	8302.0	14	667	667
		2	1782.0	8	700	700
		3	9794.0	14	693	693
		4	6167.0	12	669	669
	Total		26045.0	48	2,729	2,729
Kattegat	**Denmark**	1	6058.0	27	3,061	3,010
		2	330.0	4	178	24
		3	1298.0	10	775	775
		4	931.0	6	709	706
	Total		8617.0	47.0	4723.0	4515.0
	Sweden	1	5916.0	14	684	684
		2	581.0	1	167	167
		3	1061.0	6	662	662
		4	3208.0	8	662	662
	Total		10766.0	29	2,175	2,175
Sub-Division 22	**Denmark**	1	1400.0	11	1,369	1,270
		2	5.0			
		3	0.2		No data available	
		4	0.0			
	Total		1405.2	11	1,369	1,270
	Germany	1	2036.5	3	1,330	358
		2	608.2	1	323	60
		3	1.6	0	0	0
		4	561.2	0	0	0
	Total		3207.5	4.0	1653.0	418.0
Sub-Division 23	**Denmark**	1	619.0			
		2	13.0		No data available	
		3	306.0			
		4	889.0			
	Total		1827.0			
	Sweden	1	232.0			
		2	418.0		No data available	
		3	0.0			
		4	0.0			
	Total		650.0	0	0	0
Sub-Division 24	**Denmark**	1	0.0			
		2	0.0		No data available	
		3	0.0			
		4	0.0			
	Total		0.0	0	0	0
	Germany	1	6409.7	10	4,158	992
		2	12420.5	22	9,805	1,486
		3	0	0	0	0
		4	832.0	1	426	113
	Total		19662.3	33	14,389	2,591
	Poland	1	936.3	1	472	89
		2	2586.9	6	2,033	477
		3	1545.4	2	643	215
		4	419.2	1	316	102
	Total		5487.8	10	3464	883
	Sweden	1	3658.0	7	434	434
		2	1606.0	5	288	288
		3	934.0	4	395	395
		4	3406.0	8	450	450
	Total		9604.0	24	1,567	1,567

Table 3.2.5 WESTERN BALTIC HERRING. 1/2
Samples of landings by quarter and area used to estimate catch in numbers and mean weight by age for 2006.

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

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

continued **2/2**

Table 3.2.5 WESTERN BALTIC HERRING.
Samples of landings by quarter and area used to estimate catch in numbers and mean weight by age for 2006

	Country	Quarter	Fleet	Sampling
Sub-Division 22	**Denmark**	1	F	Danish sampling in Q1
		2	F	Danish sampling in Q1
		3	F	No landings
		4	F	Swedish sampling in Q4 in Sub-division 24
	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
Sub-Division 23	**Denmark**	1	F	Swedish sampling in Q1 in Sub-division 24
		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
	Sweden	1	F	Danish sampling in Q1 in Sub-division 22
		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
Sub-Division 24	**Denmark**	1	F	No landings
		2	F	No landings
		3	F	No landings
		4	F	No landings
	Germany	1	F	German sampling in Q1
		2	F	German sampling in Q2
		3	F	Swedish sampling in Q3
		4	F	German sampling in Q4
	Poland	1	F	Polish sampling in Q1
		2	F	Polish sampling in Q2
		3	F	Polish sampling in Q3
		4	F	Polish sampling in Q4
	Sweden	1	F	Swedish sampling in Q1
		2	F	Swedish sampling in Q2
		3	F	Swedish sampling in Q3
		4	F	Swedish sampling in Q4

Fleet C= Human consumption, Fleet D= Industrial landings, Fleet E= All landings from sub.div.22-24.

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

Year: 2006

		Skagerrak				Kattegat			
Quarter	**W-rings**	North Sea autumn SP	W-Baltic Spring SP	**n**	**source**	North Sea autumn SP	W-Baltic Spring SP	**n**	**source**
1	1	44.7%	55.3%	244		52.7%	47.3%	296	
	2	33.8%	66.2%	204		32.6%	67.4%	270	
	3	**21.4%**	**78.6%**		(3-8+)	1.7%	98.3%	343	
	4	**21.4%**	**78.6%**			1.9%	98.1%	106	
	5	**21.4%**	**78.6%**			0.0%	100.0%	110	
	6	**21.4%**	**78.6%**			**0.0%**	**100.0%**		(6-8+)
	7	**21.4%**	**78.6%**			**0.0%**	**100.0%**		
	8+	**21.4%**	**78.6%**	**14**		**0.0%**	**100.0%**	**19**	
2	0	100.0%	0.0%	54	a	100.0%	0.0%	0	Sk
	1	92.0%	8.0%	25		100.0%	0.0%	75	
	2	72.7%	27.3%	33		40.3%	59.7%	77	
	3	0.4%	99.6%	223	a	1.9%	98.1%	53	
	4	2.1%	97.9%	94	a	0.0%	100.0%	17	
	5	0.0%	100.0%	34	a	**2.7%**	**97.3%**		(5-8+)
	6	0.0%	100.0%	21	a	**2.7%**	**97.3%**		
	7	**0.0%**	**100.0%**		a (7-8+)	**2.7%**	**97.3%**		
	8+	**0.0%**	**100.0%**	**15**	a	**2.7%**	**97.3%**	**37**	
3	0	100.0%	0.0%	37		98.8%	1.2%	255	
	1	93.1%	6.9%	58		30.8%	69.2%	201	
	2	27.6%	72.4%	116		1.5%	98.5%	67	
	3	9.9%	90.1%	181		1.7%	98.3%	60	
	4	6.7%	93.3%	90		2.6%	97.4%	38	
	5	5.6%	94.4%	36		0.0%	100.0%	12	a
	6	7.1%	92.9%	14		**5.9%**	**94.1%**		a (6-8+)
	7	**4.2%**	**95.8%**		(7-8+)	**5.9%**	**94.1%**		a
	8+	**4.2%**	**95.8%**	**24**	a	**5.9%**	**94.1%**	**17**	
4	0	91.3%	8.7%	23		50.5%	49.5%	214	
	1	93.5%	6.5%	31		33.0%	67.0%	291	
	2	**18.2%**	**81.8%**		(2-8+)	8.3%	91.7%	120	
	3	**18.2%**	**81.8%**			1.0%	99.0%	100	
	4	**18.2%**	**81.8%**			2.8%	97.2%	36	
	5	**18.2%**	**81.8%**			0.0%	100.0%	29	
	6	**18.2%**	**81.8%**			**7.7%**	**92.3%**		(6-8+)
	7	**18.2%**	**81.8%**			**7.7%**	**92.3%**		
	8+	**18.2%**	**81.8%**	**22**		**7.7%**	**92.3%**	**13**	

Age-classes with few otolith analyses were supplemented with analyses from acoustic survey sampling and/or pooled into plus-groups with more than 11 individuals as indicated by bold figures and in bracketts in the source column.
a = supplemented with acoustic samples, sk = assumed equal to Skagerrak

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

Division: Kattegat Year: 2006 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	8.05	31	35.42	17	43.47	20
	2	11.35	68	2.11	49	13.45	65
	3	0.66	97	0.04	102	0.70	97
	4	0.17	118	0.01	122	0.18	118
	5						
	6						
	7						
	8+						
	Total	20.23		37.58		57.81	
	SOP		1,109		711		1,821
2	1	6.82	48	0.42	17	7.24	47
	2	2.10	77	0.01	35	2.11	76
	3	0.02	102	0.00	144	0.02	102
	4						
	5	0.00	144			0.00	144
	6						
	7						
	8+	0.00	171			0.00	171
	Total	8.95		0.43		9.38	
	SOP		494		7		502
3	0			21.86	12	21.86	12
	1	2.37	66	1.75	42	4.12	56
	2	0.11	78	0.00	77	0.12	78
	3	0.08	93	0.00	99	0.08	94
	4	0.05	107	0.00	112	0.05	107
	5						
	6	0.01	163	0.00	163	0.01	163
	7	0.00	153	0.00	153	0.00	153
	8+						
	Total	2.62		23.61		26.23	
	SOP		180		341		521
4	0	1.77	29	1.19	15	2.96	23
	1	11.58	58	2.46	61	14.04	59
	2	0.61	86	0.14	89	0.75	86
	3	0.03	122	0.01	127	0.03	123
	4	0.03	145	0.01	147	0.03	145
	5						
	6	0.01	191	0.00	191	0.01	191
	7	0.01	231	0.00	231	0.02	231
	8+	0.00	215	0.00	215	0.01	215
	Total	14.04		3.81		17.85	
	SOP		791		182		973
Total	0	1.77	29	23.05	12	24.82	13
	1	28.83	49	40.05	21	68.87	33
	2	14.18	70	2.26	52	16.43	68
	3	0.79	97	0.05	105	0.84	98
	4	0.25	118	0.01	133	0.26	119
	5	0.00	144			0.00	144
	6	0.02	177	0.00	189	0.02	179
	7	0.01	225	0.00	231	0.02	226
	8+	0.01	202	0.00	215	0.01	204
	Total	45.84		65.43		111.27	
	SOP		2,575		1,242		3,817

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

Division: Skagerrak Year: 2006 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	0.87	31	5.04	17	5.92	19
	2	8.24	77	4.82	74	13.06	76
	3	2.97	109	2.43	109	5.40	109
	4	0.75	131	0.62	131	1.37	131
	5	1.24	187	1.05	187	2.29	187
	6	0.15	195	0.13	195	0.27	195
	7	0.05	220	0.05	220	0.10	220
	8+	0.04	209	0.03	209	0.07	209
	Total	14.32		14.17		28.49	
	SOP		1,365		1,024		2,389
2	1	2.58	41	0.18	41	2.76	41
	2	8.64	75	0.59	75	9.22	75
	3	0.01	105	0.00	105	0.01	105
	4	0.02	135	0.00	135	0.02	135
	5						
	6						
	7						
	8+						
	Total	11.25		0.77		12.01	
	SOP		757		52		809
3	0	0.39	38	4.73	16	5.12	18
	1	34.04	83	2.67	47	36.71	81
	2	9.94	103	0.11	99	10.05	103
	3	2.44	131	0.02	129	2.46	131
	4	0.79	148	0.01	147	0.80	148
	5	0.32	162	0.01	177	0.33	163
	6	0.20	175	0.00	167	0.20	175
	7	0.11	188	0.00	187	0.11	188
	8+	0.04	204	0.00	219	0.04	204
	Total	48.27		7.55		55.81	
	SOP		4,422		218		4,641
4	0	3.88	15	1.27	15	5.15	15
	1	26.99	73	8.88	73	35.87	73
	2	1.06	104	0.35	104	1.41	104
	3	1.12	140	0.37	140	1.48	140
	4	0.61	155	0.20	155	0.82	155
	5	0.54	192	0.18	192	0.72	192
	6	0.06	216	0.02	216	0.08	216
	7	0.11	232	0.04	232	0.15	232
	8+	0.04	207	0.01	207	0.06	207
	Total	34.41		11.32		45.73	
	SOP		2,528		831		3,360
Total	0	4.26	17	6.01	16	10.27	16
	1	64.49	76	16.77	51	81.25	71
	2	27.88	87	5.87	76	33.74	85
	3	6.54	122	2.82	113	9.36	119
	4	2.17	144	0.82	137	3.00	142
	5	2.11	184	1.24	188	3.34	186
	6	0.40	188	0.15	197	0.55	191
	7	0.28	212	0.08	225	0.36	215
	8+	0.12	206	0.05	208	0.17	207
	Total	108.25		33.79		142.04	
	SOP		9,073		2,125		11,198

Table 3.2.9 WESTERN BALTIC HERRING. Spring Spawners in Kattegat. Landings in numbers (mill.), mean weight (g.) and SOP (t) by age, quarter and fleet. ***Western Baltic Spring spawners***

Division: Kattegat Year: 2006 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	7.22	31	31.79	17	39.02	20
	2	23.47	68	4.36	49	27.82	65
	3	37.07	97	2.50	102	39.56	97
	4	8.99	118	0.38	122	9.37	118
	5	11.81	174	0.63	170	12.45	174
	6	1.26	183	0.06	189	1.32	183
	7	0.90	171	0.02	147	0.92	171
	8+	0.37	171	0.02	167	0.39	171
	Total	91.09		39.76		130.85	
	SOP		8,972		1,181		10,152
2	1						
	2	3.12	77	0.01	35	3.14	76
	3	1.04	102	0.00	144	1.04	102
	4	0.37	99			0.37	99
	5	0.12	144			0.12	144
	6						
	7						
	8+	0.06	171			0.06	171
	Total	4.71		0.02		4.72	
	SOP		409		1		409
3	0			0.26	12	0.26	12
	1	5.32	66	3.92	42	9.24	56
	2	7.48	78	0.15	77	7.63	78
	3	4.80	93	0.06	99	4.87	94
	4	1.76	107	0.02	112	1.78	107
	5	0.42	120	0.01	133	0.43	120
	6	0.12	163	0.00	163	0.12	163
	7	0.02	153	0.00	153	0.02	153
	8+						
	Total	19.93		4.42		24.35	
	SOP		1,648		190		1,838
4	0	1.74	29	1.17	15	2.90	23
	1	23.53	58	4.99	61	28.52	59
	2	6.72	86	1.52	89	8.24	86
	3	2.69	122	0.67	127	3.36	123
	4	0.88	145	0.24	147	1.12	145
	5	0.26	172	0.07	172	0.33	172
	6	0.09	191	0.03	191	0.12	191
	7	0.14	231	0.04	231	0.18	231
	8+	0.05	215	0.01	215	0.06	215
	Total	36.10		8.74		44.84	
	SOP		2,561		606		3,166
Total	0	1.74	29	1.43	14	3.17	22
	1	36.07	54	40.70	25	76.78	39
	2	40.79	73	6.05	60	46.84	72
	3	45.60	98	3.23	107	48.83	99
	4	12.00	117	0.64	131	12.64	118
	5	12.61	172	0.71	170	13.32	172
	6	1.47	182	0.09	188	1.57	182
	7	1.06	179	0.06	202	1.12	180
	8+	0.47	175	0.03	186	0.51	176
	Total	151.82		52.94		204.75	
	SOP		13,589		1,977		15,566

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

Division: Skagerrak Year: 2006 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	1.08	31	6.25	17	7.33	19
	2	16.13	77	9.43	74	25.56	76
	3	10.90	109	8.91	109	19.81	109
	4	2.75	131	2.26	131	5.01	131
	5	4.55	187	3.85	187	8.40	187
	6	0.54	195	0.46	195	1.00	195
	7	0.20	220	0.17	220	0.36	220
	8+	0.15	209	0.13	209	0.27	209
	Total	36.29		31.45		67.74	
	SOP		3,852		2,940		6,793
2	1	0.22	41	0.02	41	0.24	41
	2	3.24	75	0.22	75	3.46	75
	3	2.93	105	0.20	105	3.13	105
	4	0.75	135	0.05	135	0.80	135
	5	1.22	170	0.24	118	1.46	162
	6	0.03	179	0.00	179	0.03	179
	7	0.11	179	0.01	179	0.12	179
	8+	0.09	184	0.01	184	0.09	184
	Total	8.59		0.74		9.33	
	SOP		911		76		988
3	0						
	1	2.52	83	0.20	47	2.72	81
	2	26.09	103	0.29	99	26.38	103
	3	22.10	131	0.16	129	22.26	131
	4	11.06	148	0.07	147	11.14	148
	5	5.49	162	0.12	177	5.60	163
	6	2.54	175	0.02	167	2.56	175
	7	2.51	188	0.02	187	2.53	188
	8+	0.93	204	0.01	219	0.94	204
	Total	73.25		0.88		74.14	
	SOP		9,419		98		9,518
4	0	0.37	15	0.12	15	0.49	15
	1	1.86	73	0.61	73	2.47	73
	2	4.76	104	1.57	104	6.33	104
	3	5.02	140	1.65	140	6.67	140
	4	2.77	155	0.91	155	3.68	155
	5	2.44	192	0.80	192	3.25	192
	6	0.26	216	0.08	216	0.34	216
	7	0.51	232	0.17	232	0.68	232
	8+	0.19	207	0.06	207	0.26	207
	Total	18.18		5.98		24.16	
	SOP		2,448		805		3,252
Total	0	0.37	15	0.12	15	0.49	15
	1	5.69	68	7.07	23	12.76	43
	2	50.22	93	11.50	79	61.72	90
	3	40.95	124	10.93	114	51.88	122
	4	17.33	146	3.29	138	20.62	145
	5	13.70	176	5.01	184	18.71	178
	6	3.37	182	0.56	197	3.94	184
	7	3.34	196	0.37	222	3.70	199
	8+	1.36	203	0.20	208	1.56	204
	Total	136.32		39.05		175.38	
	SOP		16,631		3,920		20,551

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

Division: IIIa Year: 2006 Country: All

		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
1	1	8.92	31	40.47	17	49.39	20
	2	19.59	72	6.93	66	26.52	70
	3	3.63	106	2.48	109	6.11	107
	4	0.92	128	0.62	131	1.55	129
	5	1.24	187	1.05	187	2.29	187
	6	0.15	195	0.13	195	0.27	195
	7	0.05	220	0.05	220	0.10	220
	8+	0.04	209	0.03	209	0.07	209
	Total	34.55		51.75		86.30	
	SOP		2,475		1,735		4,210
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
2	1	9.40	46	0.59	24	9.99	45
	2	10.74	75	0.60	74	11.34	75
	3	0.03	103	0.00	106	0.03	103
	4	0.02	135	0.00	135	0.02	135
	5	0.00	144			0.00	144
	6						
	7						
	8+	0.00	171			0.00	171
	Total	20.20		1.19		21.39	
	SOP		1,252		59		1,311
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
3	0	0.39	38	26.59	13	26.98	13
	1	36.41	82	4.42	45	40.83	78
	2	10.05	103	0.11	99	10.16	103
	3	2.52	129	0.02	128	2.54	129
	4	0.84	146	0.01	143	0.84	146
	5	0.32	162	0.01	177	0.33	163
	6	0.20	175	0.00	167	0.20	175
	7	0.11	188	0.00	187	0.11	188
	8+	0.04	204	0.00	219	0.04	204
	Total	50.89		31.16		82.05	
	SOP		4,602		559		5,162
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
4	0	5.64	19	2.47	15	8.11	18
	1	38.58	68	11.33	70	49.91	69
	2	1.67	97	0.49	100	2.16	98
	3	1.14	139	0.37	139	1.52	139
	4	0.64	155	0.21	155	0.85	155
	5	0.54	192	0.18	192	0.72	192
	6	0.07	213	0.02	213	0.09	213
	7	0.13	232	0.04	232	0.17	232
	8+	0.05	207	0.02	207	0.06	207
	Total	48.45		15.12		63.58	
	SOP		3,319		1,014		4,333
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
Total	0	6.03	20	29.06	13	35.09	14
	1	93.31	68	56.82	30	150.13	54
	2	42.05	81	8.12	69	50.18	79
	3	7.33	119	2.87	113	10.20	118
	4	2.42	141	0.84	137	3.26	140
	5	2.11	184	1.24	188	3.34	186
	6	0.42	188	0.15	197	0.56	190
	7	0.29	213	0.09	225	0.38	216
	8+	0.13	206	0.05	209	0.18	207
	Total	154.09		99.22		253.31	
	SOP		11,648		3,367		15,015

Table 3.2.12 WESTERN BALTIC HERRING. Spring spawners in Division IIIa. Landings in numbers (mill.), mean weight (g.) and SOP (t) by age, quarter and fleet.

Western Baltic Spring spawners

Division: IIIa Year: 2006 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	8.30	31	38.04	17	46.34	20
	2	39.59	72	13.79	66	53.38	70
	3	47.97	99	11.41	107	59.38	101
	4	11.74	121	2.64	130	14.38	122
	5	16.36	178	4.48	185	20.84	179
	6	1.80	186	0.52	194	2.32	188
	7	1.09	180	0.19	212	1.28	185
	8+	0.52	182	0.15	203	0.66	187
	Total	127.38		71.21		198.59	
	SOP		12,824		4,121		16,945
2	1	0.22	41	0.02	41	0.24	41
	2	6.36	76	0.23	73	6.60	76
	3	3.98	105	0.20	106	4.18	105
	4	1.11	123	0.05	135	1.17	124
	5	1.33	168	0.24	118	1.57	161
	6	0.03	179	0.00	179	0.03	179
	7	0.11	179	0.01	179	0.12	179
	8+	0.14	179	0.01	184	0.15	179
	Total	13.30		0.76		14.05	
	SOP		1,320		77		1,397
3	0			0.26	12	0.26	12
	1	7.84	72	4.12	43	11.96	62
	2	33.57	97	0.44	91	34.01	97
	3	26.90	124	0.22	121	27.13	124
	4	12.83	142	0.09	139	12.92	142
	5	5.91	159	0.12	175	6.03	160
	6	2.67	175	0.02	166	2.68	175
	7	2.53	188	0.02	187	2.55	188
	8+	0.93	204	0.01	219	0.94	204
	Total	93.18		5.31		98.48	
	SOP		11,068		289		11,356
4	0	2.10	26	1.29	15	3.40	22
	1	25.39	59	5.60	62	30.99	60
	2	11.48	93	3.09	97	14.57	94
	3	7.71	134	2.32	136	10.02	134
	4	3.65	153	1.15	153	4.80	153
	5	2.70	190	0.88	190	3.58	190
	6	0.35	209	0.11	210	0.46	209
	7	0.66	232	0.21	232	0.86	232
	8+	0.24	208	0.08	208	0.32	208
	Total	54.28		14.72		69.00	
	SOP		5,008		1,410		6,419
Total	0	2.10	26	1.55	14	3.66	21
	1	41.76	56	47.78	24	89.54	39
	2	91.01	84	17.55	72	108.56	82
	3	86.55	110	14.15	112	100.71	111
	4	29.33	134	3.93	137	33.26	135
	5	26.31	174	5.72	182	32.03	176
	6	4.85	182	0.65	196	5.50	183
	7	4.39	192	0.43	219	4.82	195
	8+	1.83	196	0.23	205	2.07	197
	Total	288.14		91.99		380.13	
	SOP		30,220		5,897		36,116

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 1991-2006.

Year	W-rings	0	1	2	3	4	5	6	7	8+	Total
1991	Numbers	100.00	157.43	382.91	394.77	166.97	112.35	21.86	7.33	3.15	1,346.77
	Mean W.	33.0	48.6	69.5	99.9	135.7	146.2	166.9	179.7	193.2	
	SOP	3,300	7,656	26,614	39,455	22,657	16,430	3,648	1,318	609	121,687
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	25.7	209.3	96.0	94.0	18.2	16.8	4.5	1.5	0.6	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 [1]	Numbers	3.7	89.7	112.1	109.5	47.2	54.4	10.6	10.1	5.1	442.3
	Mean W.	21.1	39.2	83.6	113.7	143.3	175.6	198.1	210.1	220.7	
	SOP	77	3,512	9,369	12,446	6,766	9,550	2,100	2,118	1,131	47,070

Data for 1995 to 2001 was revised in 2003.

[1] 2000 tonnes of landings from IIIa are missing. See text section 3.1.2

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: 2006**

Quarter	W-rings	Division IV Numbers	Division IV Mean W.	Division IIIa Numbers	Division IIIa Mean W.	Sub-division 22-24 Numbers	Sub-division 22-24 Mean W.	Total Numbers	Total Mean W.
1	1	0.13	24	46.34	20	15.04	15	61.51	18
	2	0.45	107	53.38	70	27.15	45	80.99	62
	3	1.00	127	59.38	101	46.63	87	107.00	95
	4	0.15	140	14.38	122	30.40	115	44.93	117
	5	0.22	151	20.84	179	13.50	146	34.57	166
	6	0.01	193	2.32	188	9.11	167	11.44	171
	7	0.04	164	1.28	185	8.71	186	10.03	186
	8+	0.03	192	0.66	187	4.99	187	5.68	187
	Total	2.04		198.59		155.53		356.15	
	SOP		249		16,945		15,061		32,254
2	1	0.00	0.00	0.24	41	4.88	22	5.12	23
	2	2.97	126	6.60	76	14.68	48	24.25	65
	3	5.22	141	4.18	105	43.78	78	53.18	86
	4	11.95	160	1.17	124	44.91	106	58.03	118
	5	16.54	168	1.57	161	18.96	140	37.08	154
	6	2.98	191	0.03	179	15.64	160	18.65	165
	7	2.34	206	0.12	179	11.93	177	14.40	181
	8+	1.62	222	0.15	179	5.56	179	7.32	188
	Total	43.63		14.05		160.34		218.02	
	SOP		7,214		1,397		17,240		25,851
3	0	0.00	0.00	0.26	12	0.00	22	0.26	12
	1	0.00	110.50	11.96	62	10.79	42	22.75	52
	2	0.05	148.70	34.01	97	10.20	60	44.26	89
	3	2.40	174	27.13	124	9.22	65	38.75	113
	4	1.33	191	12.92	142	12.81	54	27.07	103
	5	4.50	193	6.03	160	5.49	57	16.02	134
	6	0.95	259	2.68	175	4.17	59	7.81	123
	7	0.95	246	2.55	188	0.73	75	4.23	181
	8+	0.68	255	0.94	204	1.00	64	2.63	164
	Total	10.87		98.48		54.40		163.76	
	SOP		2,203		11,356		3,029		16,587
4	0	0.00	0	3.40	22	0.65	21	4.05	22
	1	0.00	141	30.99	60	14.06	53	45.06	58
	2	0.04	165	14.57	94	20.04	77	34.65	84
	3	0.16	182	10.02	134	19.37	99	29.56	112
	4	0.52	203	4.80	153	13.61	106	18.92	120
	5	1.11	210	3.58	190	5.05	89	9.74	140
	6	1.16	236	0.46	209	2.44	102	4.07	152
	7	1.92	237	0.86	232	0.74	143	3.53	216
	8+	0.72	255	0.32	208	0.61	122	1.65	197
	Total	5.64		69.00		76.58		151.22	
	SOP		1,288		6,419		6,531		14,238
Total	0	0.00	0	3.66	21	0.65	21	4.31	21
	1	0.13	25	89.54	39	44.76	34	134.43	37
	2	3.51	125	108.56	82	72.07	57	184.14	73
	3	8.78	149	100.71	111	119.00	84	228.48	98
	4	13.96	164	33.26	135	101.73	102	148.95	115
	5	22.37	175	32.03	176	43.00	125	97.40	153
	6	5.10	214	5.50	183	31.36	144	41.97	158
	7	5.26	224	4.82	195	22.11	176	32.19	187
	8+	3.06	237	2.07	197	12.16	170	17.28	185
	Total	62.17		380.13		446.84		889.15	
	SOP		10,953		36,116		41,861		88,931

Table 3.2.15 **WESTERN BALTIC HERRING.**
Total catch in numbers (mill) of *Western Baltic Spring Spawners* in Division IIIa and the North Sea + in Sub-Divisions 22-24 in the years 1991-2006

	W-rings	0	1	2	3	4	5	6	7	8+	Total
Year	Area										
1991	Div. IV+Div. IIIa	100.0	157.4	382.9	394.8	167.0	112.4	21.9	7.3	3.2	1246.8
	Sub-div. 22-24	19.0	668.5	158.3	169.7	112.8	65.1	24.6	5.9	1.8	1206.8
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	41.34	190.29	155.67	122.26	43.16	22.21	4.42	3.02	2.40	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	114.8	318.2	302.1	99.9	50.8	18.8	8.2	1.3	1.4	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 [1]	Div. IV+Div. IIIa	3.7	89.7	112.1	109.5	47.2	54.4	10.6	10.1	5.1	442.3
	Sub-div. 22-24	0.6	44.8	72.1	119.0	101.7	43.0	31.4	22.1	12.2	446.8

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

[1] 2000 tonnes of landings from IIIa are missing, and a proportion of those are autumn spawners. See text section 3.1.2

Table 3.2.16 **WESTERN BALTIC HERRING.**

Mean weight (g) and SOP (tons) of *Western Baltic Spring Spawners* in Division IIIa and the North Sea + in Sub-Divisions 22-24 in the years 1991 - 2006

Year	Area / W-rings	0	1	2	3	4	5	6	7	8+	SOP
1991	Div. IV+Div. IIIa	33.0	48.6	69.5	99.9	135.7	146.2	166.9	179.7	193.2	121,687
	Sub-div. 22-24	11.5	31.5	60.4	83.2	105.2	126.6	145.6	160.0	163.7	69,886
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 [1]	Div. IV+Div. IIIa	21.1	39.2	83.6	113.7	143.3	175.6	198.1	210.1	220.7	47,070
	Sub-div. 22-24	21.2	34.0	56.7	84.0	102.2	125.3	143.9	175.8	170.0	41,861

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

[1] 2000 tonnes of landings from IIIa are missing, and a proportion of those are autumn spawners. See text section 3.1.2

Table 3.2.17 WESTERN BALTIC HERRING.
Transfers of *North Sea autumn spawners* from Div. IIIa to the North Sea
Numbers (mill) and mean weight, SOP in (tonnes) 1991-2006.

Year	W-Rings	0	1	2	3	4	5	6	7	8+	Total
1991	Number	677.1	748.3	298.3	52.4	7.7	5.1	1.1	0.4	0.1	1,790.6
	Mean W.	25.6	40.5	72.9	97.2	135.8	149.7	155.7	159.8	176.8	
	SOP	17,314	30,336	21,744	5,098	1,049	771	178	59	26	76,575
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 [1]	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

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

[1] 2000 tonnes of landings from IIIa are missing, and a proportion of those are autumn spawners. See text section 3.1.2

Table 3.3.1 WESTERN BALTIC HERRING.
International Bottom Trawl Survey (IBTS) in the Kattegat in quarter 1.
Mean catch of spring-spawning herring at age in number per hour.

Year	Winter rings				
	1	2	3	4	5
1990	416	681	65	43	11
1991	190	206	144	25	20
1992	588	82	33	21	13
1993	3140	554	81	35	50
1994	1380	256	112	22	31
1995	781	132	30	42	24
1996	1312	1405	160	42	22
1997	3267	229	119	15	18
1998	407	853	165	74	8
1999	309	66	43	21	14
2000	1933	219	28	10	7
2001*	-	-	-	-	-
2002	2335	178	222	23	7
2003	1364	1495	41	10	0
2004	147	144	37	6	2
2005	286	257	26	12	5
2006	361	163	48	19	17
2007	346	185	15	10	0

* = no data available

Table 3.3.2 WESTERN BALTIC HERRING.
International Bottom Trawl Survey (IBTS) in the Kattegat in quarter 3.
Mean catch of spring-spawning herring at age in number per hour.

Year	Winter rings				
	1	2	3	4	5
1991	141	83	101	41	24
1992	372	108	70	63	25
1993	404	159	42	36	25
1994	265	229	154	49	36
1995	687	192	113	99	29
1996	631	322	31	17	11
1997	52	122	33	8	13
1998	118	86	22	27	5
1999	292	116	71	34	14
2000*	-	-	-	-	-
2001	313	190	72	18	2
2002	1568	169	100	16	6
2003	969	550	170	53	29
2004	1225	215	144	30	23
2005	607	255	54	23	13
2006	509	79	64	40	32

* = no survey was carried out in 2000

Table 3.3.3 WESTERN BALTIC HERRING. Acoustic surveys on the Spring Spawning Herring in the North Sea/Division IIIa in 1991-2006 (July).

Year	1991	1992*	1993*	1994*	1995*	1996*	1997	1998	999**	2000	2001	2002	2003	2004	2005	2006
	Numbers in millions															
W-rings																
0		3,853	372	964												
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
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	1,927	1,799	1,274	935	1,022	247	787	901	523	674	452	1,393	395	726	464	1,780
4	866	1,593	598	501	1,270	141	166	282	135	364	153	524	323	307	201	490
5	350	556	434	239	255	119	67	111	28	186	96	88	103	184	103	180
6	88	197	154	186	174	37	69	51	3	56	38	40	25	72	84	27
7	72	122	63	62	39	20	80	31	2	7	23	18	12	22	37	10
8+	10	20	13	34	21	13	77	53	1	10	12	17	5	18	21	0.1
Total	**5,177**	**#####**	**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**
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**
	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
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
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
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
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
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
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
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
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
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
	Mean weight (g)															
W-rings																
0		8.9	4.0	9.0												
1		96.8	66.3	80.0	35.2	48.5	36.9	51.9	54.7	40.7	54.0	41.0	43.1	38.3	39.4	54.1
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
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
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
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
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
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
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
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

* 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 3.3.4 WESTERN BALTIC HERRING. Acoustic survey on the Spring Spawning Herring in Sub-divisions 22-24 in 1991-2006 (September/October).

Numbers in millions

Year	1991[3]	1992[3]	1993[1]	1994[1]	1995[1]	1996[1]	1997[1]	1998[1]	1999[1]	2000	2001[2]	2002	2003	2004	2005	2006
W-rings																
0	5,577	3,467	768	4,383	4,001	1,418	2,608	2,179	4,821	1,021	1,831	3,984	3,701	2,401	2,769	3,438
1	2,507	2,179	345	412	1,163	1,084	1,389	451	1,145	1,208	1,314	611	781	912	662	716
2	880	1,015	354	823	307	541	492	557	246	477	1,761	372	200	590	569	201
3	852	465	485	540	332	413	343	364	187	348	1,013	566	230	352	378	328
4	259	233	381	433	342	282	151	232	129	206	357	337	276	166	183	340
5	102	71	121	182	247	283	112	99	44	81	92	61	103	145	102	180
6	49	32	52	56	124	110	92	51	8	39	55	23	41	81	87	130
7	6	8	28	22	40	44	32	23	1	5	5	3	9	23	25	85
8+	27	9	13	2	27	18	46	9	2	4	0	13	11	12	16	30
Total	10,259	7,480	2,547	6,854	6,583	4,193	5,265	3,966	6,582	3,389	6,428	5,970	5,353	4,682	4,791	5,447
3+ group	1,295	818	1,080	1,235	1,112	1,151	775	778	370	682	1,522	1,002	671	780	791	1,092

Biomass ('000 tonnnes)

W-rings	1991[3]	1992[3]	1993[1]	1994[1]	1995[1]	1996[1]	1997[1]	1998[1]	1999[1]	2000	2001[2]	2002	2003	2004	2005	2006
0	62.0	48.9	11.1	49.3	41.1	12.3	25.6	20.4	54.2	12.8	21.4	33.9	31.5	20.5	28.6	34.6
1	97.8	77.8	12.3	14.3	39.6	32.9	49.4	18.2	42.3	47.5	59.1	23.9	24.7	34.2	26.0	26.5
2	60.0	57.5	15.7	38.1	19.8	26.8	29.2	41.4	18.8	29.7	118.7	27.1	14.9	34.9	43.6	14.3
3	76.9	39.5	29.7	39.2	28.5	29.2	31.9	32.9	22.0	29.0	93.4	56.1	23.3	28.4	34.3	31.7
4	29.4	28.5	23.5	41.3	39.1	20.0	21.0	27.5	13.1	24.1	34.2	39.8	36.3	18.9	21.8	36.2
5	13.5	10.6	12.3	22.9	26.7	33.9	16.0	11.2	5.6	9.2	11.6	8.6	15.6	17.8	14.0	26.9
6	6.4	5.1	6.7	11.5	14.7	14.7	13.2	6.1	0.8	5.6	7.6	3.3	6.2	12.6	14.0	19.8
7	0.8	1.6	2.2	4.9	8.8	5.7	5.1	3.7	0.2	1.1	0.9	0.5	1.5	3.5	5.0	14.6
8+	3.6	2.1	1.8	0.6	6.6	2.7	10.2	2.2	0.4	0.7	0.0	1.9	1.8	2.1	3.5	6.5
Total	350.3	271.6	115.3	222.1	224.8	178.4	201.6	163.5	157.4	159.7	346.9	195.2	155.8	172.8	190.8	211.2
3+ group	130.5	87.4	76.2	120.4	124.4	106.3	97.4	83.5	42.1	69.6	147.7	110.3	84.6	83.2	92.6	135.7

Mean weight (g)

W-rings	1991[3]	1992[3]	1993[1]	1994[1]	1995[1]	1996[1]	1997[1]	1998[1]	1999[1]	2000	2001[2]	2002	2003	2004	2005	2006
0	11.1	14.1	14.4	11.2	10.3	8.7	9.8	9.4	11.2	12.6	11.7	8.5	8.5	8.6	10.3	10.1
1	39.0	35.7	35.7	34.7	34.0	30.4	35.6	40.3	37.0	39.3	45.0	39.1	31.7	37.5	39.2	37.1
2	68.2	56.7	44.3	46.3	64.5	49.6	59.4	74.3	76.4	62.2	67.4	72.8	74.5	59.1	76.7	71.1
3	90.2	84.9	61.3	72.6	85.9	70.7	93.1	90.4	117.6	83.3	92.2	99.2	101.2	80.7	90.8	96.7
4	113.5	122.3	61.6	95.5	114.5	71.1	139.2	118.3	101.8	117.1	95.7	118.2	131.2	113.6	118.8	106.5
5	132.2	148.7	101.3	125.9	108.0	119.7	142.3	114.0	127.5	114.1	126.0	142.6	151.0	122.6	137.2	149.7
6	130.4	161.0	129.6	204.0	118.1	133.5	143.4	120.5	107.2	143.0	137.0	142.8	150.9	154.6	161.8	153.0
7	133.0	205.7	80.2	222.6	222.0	128.5	161.6	158.1	232.7	202.9	175.7	205.5	155.7	151.1	202.5	171.8
8+	132.5	224.4	137.5	269.1	241.1	154.7	222.2	232.9	219.1	180.9		143.5	165.6	169.0	215.3	214.1
Total	34.1	36.3	45.3	32.4	34.2	42.5	38.3	41.2	23.9	47.1	54.0	32.7	29.1	36.9	39.8	38.8

1) revised in 2001 due to new presented area of strata in the 'Manual for the Baltic International Acoustic Survey'. ICES CM 2000/H:2 Ref.: D: Annex 3 (Table 2.2)

2) incl. estimates for Sub-division 23, which was covered by RV ARGOS (Sweden) in November 2001

3) revised in 2003 due to revised Sa values

Table 3.3.4 WESTERN BALTIC HERRING. Acoustic survey on the Spring Spawning Herring in Sub-divisions 22-24 in 1991-2006 (September/October).

Year	1991[3]	1992[3]	1993[1]	1994[1]	1995[1]	1996[1]	1997[1]	1998[1]	1999[1]	2000	2001[2]	2002	2003	2004	2005	2006
Numbers in millions																
W-rings																
0	5,577	3,467	768	4,383	4,001	1,418	2,608	2,179	4,821	1,021	1,831	3,984	3,701	2,401	2,769	3,438
1	2,507	2,179	345	412	1,163	1,084	1,389	451	1,145	1,208	1,314	611	781	912	662	716
2	880	1,015	354	823	307	541	492	557	246	477	1,761	372	200	590	569	201
3	852	465	485	540	332	413	343	364	187	348	1,013	566	230	352	378	328
4	259	233	381	433	342	282	151	232	129	206	357	337	276	166	183	340
5	102	71	121	182	247	283	112	99	44	81	92	61	103	145	102	180
6	49	32	52	56	124	110	92	51	8	39	55	23	41	81	87	130
7	6	8	28	22	40	44	32	23	1	5	5	3	9	23	25	85
8+	27	9	13	2	27	18	46	9	2	4	0	13	11	12	16	30
Total	10,259	7,480	2,547	6,854	6,583	4,193	5,265	3,966	6,582	3,389	6,428	5,970	5,353	4,682	4,791	5,447
3+ group	1,295	818	1,080	1,235	1,112	1,151	775	778	370	682	1,522	1,002	671	780	791	1,092
Biomass ('000 tonnnes)																
W-rings																
0	62.0	48.9	11.1	49.3	41.1	12.3	25.6	20.4	54.2	12.8	21.4	33.9	31.5	20.5	28.6	34.6
1	97.8	77.8	12.3	14.3	39.6	32.9	49.4	18.2	42.3	47.5	59.1	23.9	24.7	34.2	26.0	26.5
2	60.0	57.5	15.7	38.1	19.8	26.8	29.2	41.4	18.8	29.7	118.7	27.1	14.9	34.9	43.6	14.3
3	76.9	39.5	29.7	39.2	28.5	29.2	31.9	32.9	22.0	29.0	93.4	56.1	23.3	28.4	34.3	31.7
4	29.4	28.5	23.5	41.3	39.1	20.0	21.0	27.5	13.1	24.1	34.2	39.8	36.3	18.9	21.8	36.2
5	13.5	10.6	12.3	22.9	26.7	33.9	16.0	11.2	5.6	9.2	11.6	8.6	15.6	17.8	14.0	26.9
6	6.4	5.1	6.7	11.5	14.7	14.7	13.2	6.1	0.8	5.6	7.6	3.3	6.2	12.6	14.0	19.8
7	0.8	1.6	2.2	4.9	8.8	5.7	5.1	3.7	0.2	1.1	0.9	0.5	1.5	3.5	5.0	14.6
8+	3.6	2.1	1.8	0.6	6.6	2.7	10.2	2.2	0.4	0.7	0.0	1.9	1.8	2.1	3.5	6.5
Total	350.3	271.6	115.3	222.1	224.8	178.4	201.6	163.5	157.4	159.7	346.9	195.2	155.8	172.8	190.8	211.2
3+ group	130.5	87.4	76.2	120.4	124.4	106.3	97.4	83.5	42.1	69.6	147.7	110.3	84.6	83.2	92.6	135.7
Mean weight (g)																
W-rings																
0	11.1	14.1	14.4	11.2	10.3	8.7	9.8	9.4	11.2	12.6	11.7	8.5	8.5	8.6	10.3	10.1
1	39.0	35.7	35.7	34.7	34.0	30.4	35.6	40.3	37.0	39.3	45.0	39.1	31.7	37.5	39.2	37.1
2	68.2	56.7	44.3	46.3	64.5	49.6	59.4	74.3	76.4	62.2	67.4	72.8	74.5	59.1	76.7	71.1
3	90.2	84.9	61.3	72.6	85.9	70.7	93.1	90.4	117.6	83.3	92.2	99.2	101.2	80.7	90.8	96.7
4	113.5	122.3	61.6	95.5	114.5	71.1	139.2	118.3	101.8	117.1	95.7	118.2	131.2	113.6	118.8	106.5
5	132.2	148.7	101.3	125.9	108.0	119.7	142.3	114.0	127.5	114.1	126.0	142.6	151.0	122.6	137.2	149.7
6	130.4	161.0	129.6	204.0	118.1	133.5	143.4	120.5	107.2	143.0	137.0	142.8	150.9	154.6	161.8	153.0
7	133.0	205.7	80.2	222.6	222.0	128.5	161.6	158.1	232.7	202.9	175.7	205.5	155.7	151.1	202.5	171.8
8+	132.5	224.4	137.5	269.1	241.1	154.7	222.2	232.9	219.1	180.9		143.5	165.6	169.0	215.3	214.1
Total	34.1	36.3	45.3	32.4	34.2	42.5	38.3	41.2	23.9	47.1	54.0	32.7	29.1	36.9	39.8	38.8

[1] revised in 2001 due to new presented area of strata in the 'Manual for the Baltic International Acoustic Survey'. ICES CM 2000/H:2 Ref.: D: Annex 3 (Table 2.2)

[2] incl. estimates for Sub-division 23, which was covered by RV ARGOS (Sweden) in November 2001

[3] revised in 2003 due to revised Sa values

Table 3.3.5 WESTERN BALTIC HERRING. Estimation of the herring 0-Group (TL >=30 mm) Greifswalder Bodden and adjacent waters (March/April to June).

Year	Number in Millions
1977	2000[1]
1978	100[1]
1979	2200[1]
1980	360[1]
1981	200[1]
1982	180[1]
1983	1760[1]
1984	290[1]
1985	1670[1]
1986	1500[1]
1987	1370[1]
1988	1223[2]
1989	63[2]
1990	57[2]
1991	236[3]
1992	18[4]
1993	199[4]
1994	788[4]
1995	171[4]
1996	31[4]
1997	54[4]
1998	2553[4]
1999	1945[4]
2000	151[4]
2001	421[4]
2002	2051[4]
2003	2005[4]
2004	860[4]
2005	162[5]
2006	not available

[1] Brielmann 1989
[2] Klenz 1999 Inf. Fischwirtsch. Fischereiforsch. 46(2), 1999: 15-17
[3] Müller & Klenz 1994
[4] Klenz 2005 Inf. Fischwirtsch. Fischereiforsch. 52, 2005: 21-22
[5] unpublished

Table 3.6.1 WESTERN BALTIC HERRING. Input to ICA.
Catch in number (millions)

Age	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
0	119.0	145.1	206.1	263.2	541.3	171.1	376.8	549.8	569.6	152.6	756.3
1	826.0	456.7	530.7	249.4	1660.7	638.9	668.6	623.1	616.1	934.5	523.2
2	541.2	602.6	495.9	365.0	438.1	400.6	289.3	430.9	334.3	496.4	488.8
3	564.4	364.9	415.1	382.6	226.8	199.7	276.9	182.9	246.2	186.6	257.8
4	279.8	334.0	260.9	267.0	194.9	144.2	75.3	146.7	90.3	128.6	108.1
5	177.5	183.2	210.5	168.1	84.1	130.1	43.1	45.3	55.9	71.7	68.4
6	46.5	139.8	102.8	118.4	60.1	65.3	39.9	23.8	15.5	38.3	39.1
7	13.2	52.7	63.9	49.5	32.9	30.7	21.2	15.4	9.5	13.8	18.3
8+	4.9	22.6	24.5	33.1	20.5	25.1	24.1	14.1	6.1	10.7	6.7

Age	2002	2003	2004	2005	2006
0	150.3	53.5	243.6	106.9	4.3
1	659.1	126.9	457.8	305.2	134.4
2	281.8	264.9	197.8	319.2	184.1
3	321.3	161.3	164.8	177.8	228.5
4	172.3	189.4	93.2	130.4	149.0
5	57.2	103.6	91.2	60.6	97.4
6	38.5	29.1	49.0	65.7	42.0
7	13.8	17.5	14.9	31.2	32.2
8+	8.3	8.8	11.0	12.6	17.3

Table 3.6.2 WESTERN BALTIC HERRING. Input to ICA.
Mean weight in catch (kg)

Age	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
0	0.02957	0.01519	0.01535	0.01458	0.01010	0.01056	0.02962	0.01426	0.01112	0.02113	0.01229
1	0.03476	0.03447	0.02545	0.03704	0.02092	0.02458	0.02748	0.03333	0.03433	0.02550	0.02432
2	0.06685	0.06732	0.06797	0.08328	0.06843	0.08090	0.06845	0.06634	0.06583	0.05775	0.05931
3	0.09490	0.09435	0.10204	0.10323	0.09841	0.09702	0.11807	0.09423	0.09814	0.09501	0.08618
4	0.12342	0.11630	0.11428	0.12213	0.12349	0.11254	0.13420	0.11779	0.11642	0.13013	0.10886
5	0.13901	0.14169	0.13615	0.14115	0.15196	0.13283	0.16198	0.13673	0.14713	0.14280	0.15673
6	0.15560	0.16511	0.16795	0.15648	0.17041	0.13687	0.18170	0.16628	0.15660	0.14633	0.15597
7	0.17091	0.17576	0.18228	0.17046	0.20626	0.15425	0.19671	0.16523	0.15382	0.15829	0.15560
8+	0.18256	0.19152	0.19890	0.18596	0.21696	0.19100	0.20872	0.18701	0.15756	0.15908	0.17132

Age	2002	2003	2004	2005	2006
0	0.01053	0.01325	0.00618	0.01401	0.02116
1	0.02127	0.03152	0.02754	0.02719	0.03744
2	0.06998	0.06711	0.06419	0.07208	0.07306
3	0.09678	0.09075	0.10017	0.09378	0.09820
4	0.11956	0.10792	0.10596	0.11057	0.11521
5	0.14003	0.12234	0.13139	0.12280	0.15337
6	0.18763	0.13188	0.15228	0.14933	0.15760
7	0.18141	0.16029	0.16768	0.16192	0.18658
8+	0.17170	0.16252	0.15295	0.17355	0.18501

Table 3.6.3 WESTERN BALTIC HERRING. Input to ICA. Mean weight in stock (kg)

Age	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
0	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010
1	0.03085	0.02029	0.01563	0.01855	0.01305	0.01815	0.01310	0.02209	0.02106	0.01398	0.01686
2	0.05277	0.04513	0.04020	0.05288	0.04590	0.05456	0.05147	0.05578	0.05668	0.04313	0.05088
3	0.07873	0.08176	0.09671	0.08357	0.07081	0.09051	0.10633	0.08293	0.08705	0.08370	0.07829
4	0.10412	0.10751	0.10793	0.10767	0.13269	0.11703	0.13334	0.11280	0.10813	0.12504	0.11594
5	0.12447	0.13127	0.14087	0.13921	0.16745	0.11974	0.16618	0.13378	0.14801	0.14365	0.16904
6	0.14492	0.15934	0.16715	0.15656	0.18923	0.15383	0.19429	0.16779	0.16015	0.16287	0.17627
7	0.15943	0.17102	0.18273	0.17676	0.20970	0.14667	0.20895	0.16832	0.14394	0.16503	0.16808
8+	0.16398	0.18693	0.18906	0.20275	0.23377	0.12803	0.22635	0.18432	0.15043	0.18311	0.18052

Age	2002	2003	2004	2005	2006
0	0.00010	0.00010	0.00010	0.00010	0.00010
1	0.01645	0.01444	0.01306	0.01260	0.01846
2	0.06368	0.04447	0.04561	0.05136	0.06210
3	0.09046	0.07926	0.08106	0.08000	0.09527
4	0.12388	0.10509	0.10925	0.10657	0.11740
5	0.17365	0.12681	0.14399	0.13221	0.16593
6	0.19830	0.15061	0.16285	0.15733	0.17102
7	0.19801	0.17287	0.19321	0.16766	0.18584
8+	0.20363	0.18471	0.20759	0.18205	0.18708

Table 3.6.4 WESTERN BALTIC HERRING. Input to ICA. Natural mortality

Years	Age 0	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8+
1991-2006	0.3	0.5	0.2	0.2	0.2	0.2	0.2	0.2	0.2

Table 3.6.5 a **WESTERN BALTIC HERRING. Input to ICA.**
AGE - STRUCTURED INDICES.
Fleet 1b: Acoustic Survey in Div. IIIa+IVaE, Ages 2-8+
Ages 2-8+ (Catch: Number in millions)

Age	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
2	1864.0	2092.0	2768.0	413.0	1887.0	1005.0	715.0	1682.0	-	1891.1	641.2
3	1927.0	1799.0	1274.0	935.0	1022.0	247.0	787.0	901.0	-	673.6	452.3
4	866.0	1593.0	598.0	501.0	1270.0	141.0	166.0	282.0	-	363.9	153.1
5	350.0	556.0	434.0	239.0	255.0	119.0	67.0	111.0	-	185.7	96.4
6	88.0	197.0	154.0	186.0	174.0	37.0	69.0	51.0	-	55.6	37.6
7	72.0	122.0	63.0	62.0	39.0	20.0	80.0	31.0	-	6.9	23.0
8+	10.0	20.0	13.0	34.0	21.0	13.0	77.0	53.0	-	9.6	11.9

Age	2002	2003	2004	2005	2006
2	1576.6	1110.0	929.6	1342.1	2217.0
3	1392.8	394.6	726.0	463.5	1780.4
4	524.3	323.4	306.9	201.3	490.0
5	87.5	103.4	183.7	102.5	180.4
6	39.5	25.2	72.1	83.6	27.0
7	17.8	12.0	21.5	37.2	9.5
8+	17.1	5.4	18.0	21.4	0.1

Table 3.6.5 b **WESTERN BALTIC HERRING. Input to ICA.**
AGE - STRUCTURED INDICES.
Fleet 2b: Acoustic Survey in SD 22-24
Ages 0-5 (Catch: Number in millions)

Age	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
0	5577.0	3467.0	768.0	4383.0	4001.0	1418.0	2608.0	2179.0	4821.0	1021.0	1831.0
1	2507.0	2179.0	345.0	412.0	1163.0	1084.0	1389.0	451.0	1145.0	1208.0	1314.0
2	880.0	1015.0	354.0	823.0	307.0	541.0	492.0	557.0	246.0	477.0	1761.0
3	852.0	465.0	485.0	540.0	332.0	413.0	343.0	364.0	187.0	348.0	1013.0
4	259.0	233.0	381.0	433.0	342.0	282.0	151.0	232.0	129.0	206.0	357.0
5	102.0	71.0	121.0	182.0	247.0	283.0	112.0	99.0	44.0	81.0	92.0

Age	2002	2003	2004	2005	2006
0	3984.0	3701.0	2401.0	2769.0	3437.7
1	611.0	781.0	912.0	662.0	716.3
2	372.0	200.0	590.0	569.0	201.1
3	566.0	230.0	352.0	378.0	327.5
4	337.0	276.0	166.0	183.0	339.9
5	61.0	103.0	145.0	102.0	179.8

Table 3.6.5 c **WESTERN BALTIC HERRING. Input to ICA.**
AGE - STRUCTURED INDICES.
Fleet 4: IBTS in Kattegat
Ages 1-5 (Catch: Number per hour)

Age	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1	141.2	371.5	404.0	264.5	687.3	631.3	52.4	117.5	292.0	-	313.0
2	83.2	107.6	158.7	229.4	191.5	321.8	122.2	85.8	116.3	-	190.0
3	100.9	69.9	41.9	154.2	113.2	30.8	33.2	22.4	71.2	-	72.0
4	41.2	63.0	36.0	49.0	99.1	17.5	8.4	27.3	33.6	-	18.0
5	23.8	24.7	25.1	35.7	29.4	11.3	13.2	5.0	14.3	-	2.0

Age	2002	2003	2004	2005	2006
1	1567.8	968.8	1225.2	607.2	508.6
2	169.0	550.2	215.0	255.4	78.8
3	100.2	170.2	143.6	53.7	63.6
4	15.5	52.7	30.0	23.3	40.1
5	5.8	29.4	23.0	12.5	31.9

Table 3.6.6 WESTERN BALTIC HERRING: Input parameters for ICA FINAL Run 2007

```
Integrated Catch at Age Analysis
                         --------------------------------

                                Version 1.4 w

                                K.R.Patterson
                          Fisheries Research Services
                               Marine Laboratory
                                   Aberdeen

                                 24 August 1999

 Type * to change language
 Enter the name of the index file -->index.dat
canum.low
weca.low
 Stock weights in 2007  used for the year 2006
west.low
 Natural mortality in 2007  used for the year 2006
natmor.low
 Maturity ogive in 2007  used for the year 2006
matprop.low
 Name of age-structured index file (Enter if none) : -->dagaiyfd.dat
 Name of the SSB index file (Enter if none) -->
No indices of spawning biomass to be used.
 No of years for separable constraint ?--> 5
 Reference age for separable constraint ?--> 4
 Constant selection pattern model (Y/N) ?-->y
 S to be fixed on last age ?-->    1.000000000000000
 First age for calculation of reference F ?--> 3
 Last age for calculation of reference F ?--> 6
 Use default weighting (Y/N) ?-->n
Enter relative weights at age
 Weight for age 0-->    0.100000000000000
 Weight for age 1-->    1.000000000000000
 Weight for age 2-->    1.000000000000000
 Weight for age 3-->    1.000000000000000
 Weight for age 4-->    1.000000000000000
 Weight for age 5-->    1.000000000000000
 Weight for age 6-->    1.000000000000000
 Weight for age 7-->    1.000000000000000
 Weight for age 8-->    1.000000000000000
Enter relative weights by year
 Weight for year 2002-->    1.000000000000000
 Weight for year 2003-->    1.000000000000000
 Weight for year 2004-->    1.000000000000000
 Weight for year 2005-->    1.000000000000000
 Weight for year 2006-->    1.000000000000000
Enter new weights for specified years and ages if needed
 Enter year, age, new weight or -1,-1,-1 to end.  -1 -1   -1.000000000000000
 Is the last age of Acoustic  Survey in  Div IIIa+IVaE Ages a plus-group (Y/--
>y
 Is the last age of Acoustic Survey in Sub div 22-24 Ages 0- a plus-group (Y--
>n
 Is the last age of IYFS Katt Quart3 Age groups 1-5 (Mean Ca a plus-group (Y--
>n
You must choose a catchability model for each index.

Models:   A  Absolute:  Index = Abundance . e
          L  Linear:    Index = Q. Abundance . e
          P  Power:     Index = Q. Abundance^ K .e

   where Q and K are parameters to be estimated, and
   e is a lognormally-distributed error.

 Model for Acoustic  Survey in  Div IIIa+IVaE Ages  is to be A/L/P ?-->L
 Model for Acoustic Survey in Sub div 22-24 Ages 0-  is to be A/L/P ?-->L
 Model for IYFS Katt Quart3 Age groups 1-5 (Mean Ca  is to be A/L/P ?-->L
 Fit a stock-recruit relationship (Y/N) ?-->n
 Enter lowest feasible F-->   5.0000000000000003E-02
 Enter highest feasible F-->    1.000000000000000
```

Table 3.6.6 continued

```
Mapping the F-dimension of the SSQ surface
    F                 SSQ
+--------+------------------
    0.05         50.2620266115
    0.10         32.9711999044
    0.15         26.9752864680
    0.20         24.5050556865
    0.25         23.4671220303
    0.30         23.1061293378
    0.35         23.1045226825
    0.40         23.3136212587
    0.45         23.6575109198
    0.50         24.0949511126
    0.55         24.6026016546
    0.60         25.1672969125
    0.65         25.7823178972
    0.70         26.4457799557
    0.75         27.1600932312
    0.80         27.9325319698
    0.85         28.7769982805
    0.90         29.7183202515
    0.95         30.8021318446
    1.00         32.1213085431
Lowest SSQ is for F =     0.324
-----------------------------------------------------------------
No of years for separable analysis : 5
Age range in the analysis : 0  . . . 8
Year range in the analysis : 1991  . . . 2006
Number of indices of SSB : 0
Number of age-structured indices : 3
Parameters to estimate : 41
Number of observations : 316
Conventional single selection vector model to be fitted.
-----------------------------------------------------------------
 Survey weighting to be Manual (recommended) or Iterative (M/I) ?-->M
 Enter weight for Acoustic  Survey in  Div IIIa+IVaE Ages  at age 2-->    1.000000000000000
 Enter weight for Acoustic  Survey in  Div IIIa+IVaE Ages  at age 3-->    1.000000000000000
 Enter weight for Acoustic  Survey in  Div IIIa+IVaE Ages  at age 4-->    1.000000000000000
 Enter weight for Acoustic  Survey in  Div IIIa+IVaE Ages  at age 5-->    1.000000000000000
 Enter weight for Acoustic  Survey in  Div IIIa+IVaE Ages  at age 6-->    1.000000000000000
 Enter weight for Acoustic  Survey in  Div IIIa+IVaE Ages  at age 7-->    1.000000000000000
 Enter weight for Acoustic  Survey in  Div IIIa+IVaE Ages  at age 8-->    1.000000000000000
 Enter weight for Acoustic Survey in Sub div 22-24 Ages 0-  at age 0-->    1.000000000000000
 Enter weight for Acoustic Survey in Sub div 22-24 Ages 0-  at age 1-->    1.000000000000000
 Enter weight for Acoustic Survey in Sub div 22-24 Ages 0-  at age 2-->    1.000000000000000
 Enter weight for Acoustic Survey in Sub div 22-24 Ages 0-  at age 3-->    1.000000000000000
 Enter weight for Acoustic Survey in Sub div 22-24 Ages 0-  at age 4-->    1.000000000000000
 Enter weight for Acoustic Survey in Sub div 22-24 Ages 0-  at age 5-->    1.000000000000000
 Enter weight for IYFS Katt Quart3 Age groups 1-5 (Mean Ca  at age 1-->    1.000000000000000
 Enter weight for IYFS Katt Quart3 Age groups 1-5 (Mean Ca  at age 2-->    1.000000000000000
 Enter weight for IYFS Katt Quart3 Age groups 1-5 (Mean Ca  at age 3-->    1.000000000000000
 Enter weight for IYFS Katt Quart3 Age groups 1-5 (Mean Ca  at age 4-->    1.000000000000000
 Enter weight for IYFS Katt Quart3 Age groups 1-5 (Mean Ca  at age 5-->    1.000000000000000
Enter estimates of the extent to which errors
in the age-structured indices are correlated
across ages. This can be in the range 0 (independence)
to 1 (correlated errors).
  Enter value for Acoustic  Survey in  Div IIIa+IVaE Ages-->    1.000000000000000
  Enter value for Acoustic Survey in Sub div 22-24 Ages 0--->    1.000000000000000
  Enter value for IYFS Katt Quart3 Age groups 1-5 (Mean Ca-->    1.000000000000000
 Do you want to shrink the final fishing mortality (Y/N) ?-->N
Seeking solution. Please wait.
Aged index weights
Acoustic  Survey in  Div IIIa+IVaE Ages
 Age   :       2     3     4     5     6     7     8
 Wts :     0.143 0.143 0.143 0.143 0.143 0.143 0.143
Acoustic Survey in Sub div 22-24 Ages 0-
 Age   :       0     1     2     3     4     5
 Wts :     0.167 0.167 0.167 0.167 0.167 0.167
IYFS Katt Quart3 Age groups 1-5 (Mean Ca
 Age   :       1     2     3     4     5
 Wts :     0.200 0.200 0.200 0.200 0.200
F in 2006  at age 4  is 0.597225  in iteration 1
 Detailed, Normal or Summary output (D/N/S)-->D
 Output page width in characters (e.g. 80..132) ?--> 132
 Estimate historical assessment uncertainty ?-->n
Succesful exit from ICA
```

Table 3.6.7 **WESTERN BALTIC HERRING. Output from ICA Final Run. FISHING MORTALITY (per year)**

Age	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
0	0.02820	0.04760	0.08110	0.05110	0.16960	0.04670	0.11940	0.12120	0.11100	0.05440	0.20920
1	0.26280	0.17630	0.30290	0.16340	0.65010	0.38500	0.31930	0.36680	0.23880	0.33180	0.32970
2	0.32570	0.37880	0.35690	0.43090	0.58900	0.38950	0.36730	0.42940	0.42020	0.37430	0.35230
3	0.43040	0.38080	0.48900	0.51600	0.52470	0.59160	0.51300	0.41900	0.46850	0.44000	0.34000
4	0.41900	0.49170	0.51730	0.68110	0.54460	0.76250	0.46570	0.56790	0.37690	0.48010	0.49540
5	0.40960	0.53690	0.66840	0.75740	0.47290	0.88420	0.54360	0.57150	0.44120	0.58480	0.51060
6	0.29090	0.66370	0.66540	1.04840	0.68340	0.84310	0.76280	0.66370	0.38950	0.62000	0.74970
7	0.56950	0.62460	0.74500	0.80950	0.99150	0.94030	0.74690	0.77450	0.61500	0.72330	0.69590
8+	0.56950	0.62460	0.74500	0.80950	0.99150	0.94030	0.74690	0.77450	0.61500	0.72330	0.69590

Age	2002	2003	2004	2005	2006
0	0.03390	0.02660	0.02640	0.02930	0.03100
1	0.20230	0.15900	0.15750	0.17530	0.18520
2	0.31320	0.24620	0.24390	0.27140	0.28680
3	0.39300	0.30890	0.30610	0.34050	0.35990
4	0.65220	0.51270	0.50800	0.56520	0.59720
5	0.55940	0.43980	0.43570	0.48480	0.51230
6	0.67570	0.53120	0.52630	0.58550	0.61870
7	0.65220	0.51270	0.50800	0.56520	0.59720
8+	0.65220	0.51270	0.50800	0.56520	0.59720

Table 3.6.8 **WESTERN BALTIC HERRING. Output from ICA Final Run. POPULATION ABUNDANCE (millions)- 1 January**

Age	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
0	4948.6	3608.4	3056.6	6107.6	3999.8	4339.1	3863.8	5560.2	6257.6	3328.2	4613.7
1	4493.3	3564.1	2548.9	2088.0	4299.2	2500.9	3067.9	2540.2	3649.1	4148.7	2334.9
2	2137.0	2095.6	1812.3	1142.0	1075.5	1361.2	1032.2	1352.2	1067.7	1743.1	1805.8
3	1767.8	1263.3	1174.7	1038.4	607.7	488.6	754.9	585.3	720.6	574.2	981.5
4	895.5	941.1	706.8	589.8	507.5	294.4	221.4	370.0	315.2	369.3	302.8
5	578.8	482.2	471.2	345.0	244.4	241.0	112.4	113.8	171.7	177.0	187.1
6	202.2	314.6	230.8	197.8	132.4	124.7	81.5	53.5	52.6	90.4	80.8
7	33.3	123.8	132.6	97.1	56.7	54.7	43.9	31.1	22.5	29.2	39.8
8+	12.4	53.1	50.9	64.9	35.3	44.8	50.0	28.5	14.5	22.6	14.5

Age	2002	2003	2004	2005	2006	2007
0	2812.7	4325.3	2900.0	2054.5	1313.5	1408.2
1	2772.8	2014.3	3120.1	2092.5	1478.0	943.3
2	1018.4	1373.8	1042.2	1616.6	1065.1	744.9
3	1039.5	609.6	879.3	668.6	1009.0	654.6
4	572.0	574.5	366.4	530.1	389.4	576.4
5	151.0	243.9	281.7	180.5	246.6	175.5
6	91.9	70.7	128.6	149.2	91.0	121.0
7	31.2	38.3	34.0	62.2	68.0	40.1
8+	19.0	24.1	30.3	32.0	42.0	49.6

Table 3.6.9 **WESTERN BALTIC HERRING. Output from ICA Final Run. STOCK SUMMARY**

Year	Recruits Age 0 (thousands)	Total Biomass (tonnes)	Spawning Biomass (tonnes)	Landings (tonnes)	Yield SBB ratio	Mean F Ages 3-6	SoP (%)
1991	4948600	592997	291885	191573	0.6563	0.3875	99
1992	3608410	516235	300193	194411	0.6476	0.5183	100
1993	3056560	441711	275864	185010	0.6707	0.5850	100
1994	6107580	359334	216065	172438	0.7981	0.7507	99
1995	3999770	302368	169325	150831	0.8908	0.5564	100
1996	4339120	260568	124469	121266	0.9743	0.7704	100
1997	3863760	258511	137152	115588	0.8428	0.5713	100
1998	5560200	257062	111615	107032	0.9589	0.5555	99
1999	6257570	274058	117525	97240	0.8274	0.4190	100
2000	3328150	276864	128178	109914	0.8575	0.5312	100
2001	4613680	298829	147878	105803	0.7155	0.5239	99
2002	2812740	330136	182038	106191	0.5833	0.5701	99
2003	4325300	251938	141617	78309	0.5530	0.4482	99
2004	2900010	274243	158180	76815	0.4856	0.4440	100
2005	2054450	283160	155248	88406	0.5694	0.4940	100
2006	1313450	312382	184516	88931	0.4820	0.5220	100

Table 3.6.10 **WESTERN BALTIC HERRING. Output from ICA Final Run. PARAMETER ESTIMATES**

Parm. No.		Max. Likelh. Estim.	Cv	Lower 95% CL	Upper 95% CL	-s.e.	+s.e.	Mean of param. Estim.
Separable model : F by year								
1	2002	0.6522	14	0.4929	0.8632	0.5654	0.7525	0.6589
2	2003	0.5127	14	0.3852	0.6825	0.4431	0.5933	0.5182
3	2004	0.5080	14	0.3807	0.6778	0.4385	0.5885	0.5135
4	2005	0.5652	15	0.4166	0.7667	0.4837	0.6603	0.572
5	2006	0.5972	18	0.4162	0.857	0.4967	0.7181	0.6074
Separable Model: Selection (S) by age								
6	0	0.0519	42	0.0224	0.1203	0.0338	0.0797	0.0569
7	1	0.3101	18	0.2175	0.4422	0.2588	0.3716	0.3152
8	2	0.4802	17	0.3417	0.6747	0.4037	0.5712	0.4875
9	3	0.6026	17	0.4309	0.8425	0.5078	0.715	0.6114
4	1	Fixed: Reference Age						
10	5	0.8577	15	0.6361	1.1566	0.7364	0.9991	0.8678
11	6	1.0360	14	0.7765	1.3822	0.8943	1.2002	1.0473
7	1	Fixed: Last true age						
Separable Model: Populations in year 2007								
12	0	1313454	57	424063	4068172	737756	2338391	2E+06
13	1	1477962	25	894493	2442023	1143918	1909554	2E+06
14	2	1065115	18	735017	1543460	881461	1287033	1E+06
15	3	1008998	16	734936	1385259	858352	1186083	1E+06
16	4	389393	14	292578	518244	336549	450534	393556
17	5	246630	14	184403	329857	212627	286071	249359
18	6	91023	16	66220	125115	77386	107063	92230
19	7	67998	19	46641	99133	56100	82419	69267
Separable Model: Populations at age								
20	2002	31242	27	18191	53654	23708	41168	32454
21	2003	38287	22	24705	59334	30618	47876	39255
22	2004	34019	19	23352	49559	28078	41219	34652
23	2005	62225	18	43132	89770	51613	75019	63322

Table 3.6.11 **WESTERN BALTIC HERRING. Output from ICA Final Run.**
AGE STRUCTURED INDEX OF CATCHABILITIES

Fleet 1b: Acoustic Survey in Div. IIIa+IVaE, Ages 2-8+

Linear model fitted. Slopes at age :

24	2 Q	1332.0	19	1108.0	2355.0	1332.0	1957.0	1645.0
25	3 Q	1474.0	19	1226.0	2604.0	1474.0	2165.0	1820.0
26	4 Q	1354.0	19	1126.0	2393.0	1354.0	1989.0	1672.0
27	5 Q	1125.0	19	934.5	1992.0	1125.0	1655.0	1390.0
28	6 Q	977.4	19	810.4	1741.0	977.4	1444.0	1211.0
29	7 Q	1036.0	19	856.1	1863.0	1036.0	1540.0	1288.0
30	8 Q	710.8	19	589.3	1267.0	710.8	1051.0	880.9

Fleet 2b: Acoustic Survey in SD 22-24

Linear model fitted. Slopes at age :

31	0 Q	975.6	17	823.0	1648.0	975.6	1391.0	1183.0
32	1 Q	607.6	17	514.4	1016.0	607.6	859.7	733.7
33	2 Q	562.7	17	476.7	938.5	562.7	795.0	678.9
34	3 Q	813.7	17	689.5	1356.0	813.7	1149.0	981.5
35	4 Q	1003.0	17	849.8	1674.0	1003.0	1418.0	1211.0
36	5 Q	872.3	17	738.3	1459.0	872.3	1235.0	1054.0

Fleet 4: IBTS in Kattegat

Linear model fitted. Slopes at age :

37	1 Q	0.00023	16	0.00020	0.00038	0.00023	0.00032	0.00028
38	2 Q	0.00017	16	0.00015	0.00028	0.00017	0.00024	0.00021
39	3 Q	0.00012	16	0.00010	0.00020	0.00012	0.00017	0.00015
40	4 Q	0.00011	16	0.00009	0.00017	0.00011	0.00015	0.00013
41	5 Q	0.00010	16	0.00009	0.00016	0.00010	0.00014	0.00012

Table 3.6.12 **WESTERN BALTIC HERRING. Output from ICA Final Run.**
RESIDUALS ABOUT THE MODEL FIT Separable Model Residuals
(log(Observed Catch) log(Expected Catch))

Age	2002	2003	2004	2005	2006
0	0.618	-0.608	1.317	0.733	-2.086
1	0.492	-0.615	0.240	0.135	-0.388
2	0.122	-0.030	-0.037	-0.091	-0.273
3	0.042	0.088	-0.248	0.011	-0.196
4	-0.377	-0.106	-0.358	-0.474	-0.073
5	-0.035	0.269	0.005	-0.044	0.075
6	-0.071	0.089	0.017	0.082	0.087
7	0.009	0.218	0.183	0.240	0.140

Table 3.6.13 **WESTERN BALTIC HERRING. Output from ICA Final Run. AGED INDEX RESIDUALS: LOG(OBSERVED INDEX) LOG(EXPECTED INDEX**

Fleet 1b: Acoustic Survey in Div. IIIa+IVaE, Ages 2- 8+

Age	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
2	-0.095	0.073	0.485	-0.910	0.769	-0.222	-0.299	0.325	*******	0.154	-0.977
3	0.092	0.328	0.123	-0.046	0.585	-0.576	0.099	0.430	*******	0.171	-0.825
4	0.050	0.656	-0.022	0.084	1.080	-0.438	-0.175	-0.095	*******	0.107	-0.550
5	-0.240	0.485	0.343	0.114	0.345	-0.146	-0.171	0.340	*******	0.421	-0.337
6	-0.502	0.095	0.159	0.742	0.848	-0.540	0.458	0.516	*******	0.049	-0.148
7	1.216	0.466	-0.189	0.147	0.335	-0.329	1.156	0.570	*******	-0.900	-0.024
8+	0.606	-0.119	-0.433	0.325	0.566	-0.183	1.365	1.570	*******	0.061	0.700

Age	2002	2003	2004	2005	2006
2	0.471	-0.221	-0.124	-0.178	0.750
3	0.275	-0.505	-0.264	-0.417	0.530
4	0.143	-0.432	-0.038	-0.793	0.425
5	-0.189	-0.576	-0.148	-0.256	0.015
6	-0.274	-0.551	-0.102	-0.065	-0.681
7	-0.065	-0.750	-0.052	-0.071	-1.505
8+	0.770	-0.707	0.265	0.419	-5.200

Fleet 2b: Acoustic Survey in SD 22-24

Age	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
0	0.407	0.263	-1.052	-0.026	0.401	-0.816	-0.033	-0.575	0.093	-0.873	-0.492
1	0.525	0.547	-0.859	-0.594	0.111	0.37	0.361	-0.537	-0.07	-0.07	0.587
2	0.108	0.313	-0.612	0.752	-0.047	0.124	0.288	0.192	-0.397	-0.261	0.992
3	-0.019	-0.329	-0.127	0.125	0.181	0.671	-0.012	0.226	-0.608	0.217	0.67
4	-0.749	-0.846	-0.047	0.392	0.198	0.724	0.147	0.144	-0.435	-0.043	0.718
5	-1.112	-1.19	-0.528	0.263	0.686	1.165	0.728	0.615	-0.712	-0.017	-0.005

Age	2002	2003	2004	2005	2006
0	0.64	0.13	0.097	0.587	1.252
1	-0.452	0.078	-0.206	-0.112	0.322
2	-0.022	-0.995	0.361	-0.092	-0.703
3	0.073	-0.361	-0.304	0.068	-0.470
4	0.15	-0.166	-0.229	-0.455	0.499
5	-0.163	-0.214	-0.019	0.114	0.391

Fleet 4: IBTS in Kattegat

Age	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1	-1.528	-0.383	0.115	-0.196	0.340	0.632	-2.103	-1.077	-0.609	*******	-0.036
2	-1.166	-0.856	-0.336	0.541	0.519	0.678	-0.028	-0.612	-0.078	*******	-0.155
3	-0.362	-0.424	-0.795	0.648	0.880	-0.163	-0.571	-0.771	0.210	*******	-0.167
4	-0.455	-0.034	-0.290	0.300	1.070	0.017	-0.622	0.112	0.361	*******	-0.150
5	-0.514	-0.217	-0.094	0.623	0.596	-0.090	0.616	-0.356	0.210	*******	-1.800

Age	2002	2003	2004	2005	2006
1	1.324	1.135	0.931	0.640	0.816
2	0.276	1.115	0.451	0.201	-0.548
3	0.139	1.150	0.612	-0.077	-0.307
4	-0.835	0.295	0.178	-0.408	0.462
5	-0.486	0.579	0.186	0.055	0.694

Table 3.6.14 **WESTERN BALTIC HERRING. Output from ICA Final Run. PARAMETERS OF THE DISTRIBUTION OF ln CATCHES AT AGE**

Separable model fitted from 2002 to 2006

Variance	0.1512
Skewness test stat.	-2.1845
Kurtosis test statistic	0.5288
Partial chi-square	0.2212
Significance in fit	0.0000
Degrees of freedom	17

Table 3.6.15 WESTERN BALTIC HERRING. Output from ICA Final Run. PARAMETERS OF THE DISTRIBUTION OF THE AGE-STRUCTURED INDICES

DISTRIBUTION STATISTICS FOR Acoustic Survey in Div IIIa+IVaE WR 2-8+

Linear catchability relationship assumed

Age	2	3	4	5	6	7	8+
Variance	0.0385	0.0262	0.0323	0.0148	0.0327	0.0743	0.3493
Skewness test stat.	-0.5093	-0.7157	0.852	0.1159	0.4952	-0.2902	-4.0764
Kurtosis test statisti	-0.3768	-0.7109	0.1507	-0.9021	-0.7584	-0.0801	5.1371
Partial chi-square	0.0258	0.0179	0.0228	0.0109	0.0255	0.0607	0.2942
Significance in fit	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Number of observations	15	15	15	15	15	15	15
Degrees of freedom	14	14	14	14	14	14	14
Weight in the analysis	0.1429	0.1429	0.1429	0.1429	0.1429	0.1429	0.1429

DISTRIBUTION STATISTICS FOR Acoustic Survey in Subdiv 22-24 WR 0-5

Linear catchability relationship assumed

Age	0	1	2	3	4	5
Variance	0.0651	0.0329	0.0447	0.0222	0.0367	0.0720
Skewness test stat.	-0.0479	-0.5885	-0.1057	0.4452	-0.2911	-0.3886
Kurtosis test statisti	-0.4652	-0.7655	-0.2537	-0.3694	-0.6080	-0.4639
Partial chi-square	0.0457	0.0239	0.0334	0.0169	0.0283	0.0576
Significance in fit	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Number of observations	16	16	16	16	16	16
Degrees of freedom	15	15	15	15	15	15
Weight in the analysis	0.1667	0.1667	0.1667	0.1667	0.1667	0.1667

DISTRIBUTION STATISTICS FOR IYFS Kattegat Quarter 3 WR 1-5

Linear catchability relationship assumed

Age	1	2	3	4	5
Variance	0.1998	0.0785	0.071	0.0468	0.085
Skewness test stat.	-1.0212	-0.2526	0.7759	0.4319	-2.0693
Kurtosis test statisti	-0.3838	-0.5678	-0.6522	-0.0456	1.4464
Partial chi-square	0.4633	0.2096	0.2407	0.1913	0.4675
Significance in fit	0.0000	0.0000	0.0000	0.0000	0.0000
Number of observations	15	15	15	15	15
Degrees of freedom	14	14	14	14	14
Weight in the analysis	0.2000	0.2000	0.2000	0.2000	0.2000

Table 3.6.16 WESTERN BALTIC HERRING. Output from ICA Final Run. ANALYSIS OF VARIANCE TABLE

Unweighted Statistics	SSQ	Data	Param.	d.f.	Variance
Variance					
Total for model	123.1888	316	41	275	0.4480
Catches at age	9.2091	40	23	17	0.5417
Aged Indices					
Acoustic Survey Div IIIa+IVaE WR 2-8+	55.6831	105	7	98	0.5682
Acoustic Survey Subdiv 22-24 WR 0-5	24.6146	96	6	90	0.2735
IYFS Kattegat Quarter 3 WR 1-5	33.6821	75	5	70	0.4812

Weighted Statistics	SSQ	Data	Param.	d.f.	Variance
Variance					
Total for model	5.7385	316	41	275	0.0209
Catches at age	2.5711	40	23	17	0.1512
Aged Indices					
Acoustic Survey Div IIIa+IVaE WR 2-8+	1.1364	105	7	98	0.0116
Acoustic Survey Subdiv 22-24 WR 0-5	0.6837	96	6	90	0.0076
IYFS Kattegat Quarter 3 WR 1-5	1.3473	75	5	70	0.0192

Table 3.7.1 WESTERN BALTIC HERRING. Input table for short term predictions

MFDP version 1a
Run: WBSS GeoMean 5 years
Time and date: 14:54 18/03/2007
Fbar age range: 3-6

2007

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
0	3521756	0.3	0.00	0.1	0.25	0.000	0.031	0.014
1	2432366	0.5	0.00	0.1	0.25	0.015	0.185	0.031
2	744900	0.2	0.20	0.1	0.25	0.053	0.287	0.070
3	654600	0.2	0.75	0.1	0.25	0.085	0.360	0.097
4	576400	0.2	0.90	0.1	0.25	0.111	0.597	0.111
5	175500	0.2	1.00	0.1	0.25	0.147	0.512	0.136
6	121000	0.2	1.00	0.1	0.25	0.164	0.619	0.153
7	40100	0.2	1.00	0.1	0.25	0.182	0.597	0.172
8	49600	0.2	1.00	0.1	0.25	0.192	0.597	0.171

2008

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
0	3521756	0.3	0.00	0.1	0.25	0.000	0.031	0.014
1		0.5	0.00	0.1	0.25	0.015	0.185	0.031
2		0.2	0.20	0.1	0.25	0.053	0.287	0.070
3		0.2	0.75	0.1	0.25	0.085	0.360	0.097
4		0.2	0.90	0.1	0.25	0.111	0.597	0.111
5		0.2	1.00	0.1	0.25	0.147	0.512	0.136
6		0.2	1.00	0.1	0.25	0.164	0.619	0.153
7		0.2	1.00	0.1	0.25	0.182	0.597	0.172
8		0.2	1.00	0.1	0.25	0.192	0.597	0.171

2009

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
0	3521756	0.3	0.00	0.1	0.25	0.000	0.031	0.014
1		0.5	0.00	0.1	0.25	0.015	0.185	0.031
2		0.2	0.20	0.1	0.25	0.053	0.287	0.070
3		0.2	0.75	0.1	0.25	0.085	0.360	0.097
4		0.2	0.90	0.1	0.25	0.111	0.597	0.111
5		0.2	1.00	0.1	0.25	0.147	0.512	0.136
6		0.2	1.00	0.1	0.25	0.164	0.619	0.153
7		0.2	1.00	0.1	0.25	0.182	0.597	0.172
8		0.2	1.00	0.1	0.25	0.192	0.597	0.171

Input units are thousands and kg - output in tonnes

M =	Natural mortality
MAT =	Maturity ogive
PF =	Proportion of F before spawning
PM =	Proportion of M before spawning
SWT =	Weight in stock (kg)
Sel =	Exploit. Pattern
CWT =	Weight in catch (kg)

N_{2007} Age 1:	Geometric Mean from ICA of age 1 (Table 3.6.8) for the years 2001-2005
N_{2007} Age 2-8+:	Output from ICA (Table 3.6.8)
$N_{2006/2007/2008/2009}$ Age 0:	Geometric Mean from ICA of age 0 (Table 3.6.8) for the years 2000-2004
Natural Mortality (M):	Average for 2004-2006
Weight in the Catch/Stock (CWt/SWt):	Average for 2004-2006
Expoitation pattern (Sel):	Average for 2004-2006 rescaled to the last year

Table 3.7.2 WESTERN BALTIC HERRING.
Short term prediction single option table, status quo F.

MFDP version 1a
Run: WBSS GeoMean 5 years
Time and date: 14:54 18/03/2007
Fbar age range: 3-6

Year:	2007	F multiplie 1		Fbar:	0.522				
Age	F	CatchNos	Yield	StockNos	Biomass	SSNos(Jan)	SSB(Jan)	SSNos(ST)	SSB(ST)
0	0.031	92941	1281	3521756	352	0	0	0	0
1	0.1852	326103	10019	2432366	35772	0	0	0	0
2	0.2868	169132	11801	744900	39497	148980	7899	137708	7302
3	0.3599	180384	17566	654600	55931	490950	41948	450499	38492
4	0.5972	237242	26234	576400	64023	518760	57620	464852	51633
5	0.5123	64307	8736	175500	25865	175500	25865	158604	23375
6	0.6187	51116	7824	121000	19812	121000	19812	108193	17715
7	0.5972	16505	2840	40100	7308	40100	7308	35933	6548
8	0.5972	20415	3481	49600	9535	49600	9535	44446	8544
Total		1158146	89783	8316222	258094	1544890	169987	1400234	153608

Year:	2008	F multiplie 1		Fbar:	0.522				
Age	F	CatchNos	Yield	StockNos	Biomass	SSNos(Jan)	SSB(Jan)	SSNos(ST)	SSB(ST)
0	0.031	92941	1281	3521756	352	0	0	0	0
1	0.1852	339105	10418	2529347	37198	0	0	0	0
2	0.2868	278340	19422	1225880	65000	245176	13000	226625	12016
3	0.3599	126157	12286	457816	39117	343362	29338	315071	26921
4	0.5972	153921	17021	373965	41537	336568	37384	301593	33499
5	0.5123	95164	12928	259711	38275	259711	38275	234708	34590
6	0.6187	36367	5567	86087	14095	86087	14095	76975	12603
7	0.5972	21963	3779	53360	9724	53360	9724	47815	8714
8	0.5972	16635	2836	40416	7770	40416	7770	36216	6962
Total		1160594	85538	8548338	253070	1364681	149586	1239004	135306

Year:	2009	F multiplie 1		Fbar:	0.522				
Age	F	CatchNos	Yield	StockNos	Biomass	SSNos(Jan)	SSB(Jan)	SSNos(ST)	SSB(ST)
0	0.031	92941	1281	3521756	352	0	0	0	0
1	0.1852	339105	10418	2529347	37198	0	0	0	0
2	0.2868	289438	20196	1274757	67592	254951	13518	235661	12496
3	0.3599	207617	20218	753427	64375	565070	48281	518512	44303
4	0.5972	107650	11904	261545	29051	235390	26146	210929	23429
5	0.5123	61742	8388	168499	24833	168499	24833	152277	22442
6	0.6187	53818	8238	127394	20859	127394	20859	113911	18651
7	0.5972	15626	2689	37964	6918	37964	6918	34019	6199
8	0.5972	17391	2965	42253	8123	42253	8123	37863	7279
Total		1185327	86297	8716942	259301	1431522	148678	1303171	134799

Input units are thousands and kg - output in tonnes

Table 3.7.3 WESTERN BALTIC HERRING. Short term prediction single option table 2007: Status quo F and 2008/2009: $F_{0.1}$

MFDP version 1a
Run: WBSS F0-1
Time and date: 16:36 19/03/2007
Fbar age range: 3-6

Year:	**2007**	**F multiplie**	**1**	**Fbar:**	**0.522**				
Age	F	CatchNos	Yield	StockNos	Biomass	SSNos(Jan)	SSB(Jan)	SSNos(ST)	SSB(ST)
0	0.0310	92941	1281	3521756	352	0	0	0	0
1	0.1852	326103	10019	2432366	35772	0	0	0	0
2	0.2868	169132	11801	744900	39497	148980	7899	137708	7302
3	0.3599	180384	17566	654600	55931	490950	41948	450499	38492
4	0.5972	237242	26234	576400	64023	518760	57620	464852	51633
5	0.5123	64307	8736	175500	25865	175500	25865	158604	23375
6	0.6187	51116	7824	121000	19812	121000	19812	108193	17715
7	0.5972	16505	2840	40100	7308	40100	7308	35933	6548
8	0.5972	20415	3481	49600	9535	49600	9535	44446	8544
Total		1158146	89783	8316222	258094	1544890	169987	1400234	153608

Year:	**2008**	**F multiplie**	**0.4203**	**Fbar:**	**0.2194**				
Age	F	CatchNos	Yield	StockNos	Biomass	SSNos(Jan)	SSB(Jan)	SSNos(ST)	SSB(ST)
0	0.0130	39398	543	3521756	352	0	0	0	0
1	0.0778	149548	4595	2529347	37198	0	0	0	0
2	0.1205	126422	8821	1225880	65000	245176	13000	230424	12218
3	0.1513	58392	5686	457816	39117	343362	29338	321713	27488
4	0.2510	75558	8355	373965	41537	336568	37384	312217	34679
5	0.2153	45762	6217	259711	38275	259711	38275	241782	35633
6	0.2601	17944	2747	86087	14095	86087	14095	79786	13064
7	0.2510	10781	1855	53360	9724	53360	9724	49500	9021
8	0.2510	8166	1392	40416	7770	40416	7770	37492	7208
Total		531971	40212	8548338	253070	1364681	149586	1272915	139310

Year:	**2009**	**F multiplie**	**0.4203**	**Fbar:**	**0.2194**				
Age	F	CatchNos	Yield	StockNos	Biomass	SSNos(Jan)	SSB(Jan)	SSNos(ST)	SSB(ST)
0	0.0130	39398	543	3521756	352	0	0	0	0
1	0.0778	152259	4678	2575209	37873	0	0	0	0
2	0.1205	146362	10213	1419234	75253	283847	15051	266768	14145
3	0.1513	113476	11051	889694	76018	667270	57014	625199	53419
4	0.2510	65102	7199	322213	35789	289992	32210	269011	29880
5	0.2153	41972	5702	238207	35106	238207	35106	221762	32683
6	0.2601	35736	5470	171443	28071	171443	28071	158895	26016
7	0.2510	10980	1889	54342	9903	54342	9903	50411	9187
8	0.2510	12069	2058	59734	11483	59734	11483	55412	10652
Total		617355	48802	9251832	309849	1764834	188838	1647458	175982

Input units are thousands and kg - output in tonnes

Table 3.7.4 WESTERN BALTIC HERRING.
Short term prediction single option table
2007: Status quo F; 2008: Catch reduction of 15%; 2009: Status quo F

MFDP version 1a
Run: WBSS -15%
Time and date: 17:50 19/03/2007
Fbar age range: 3-6

Year:	**2007**	**F multiplie**	**1**	**Fbar:**	**0.522**				
Age	F	CatchNos	Yield	StockNos	Biomass	SSNos(Jan)	SSB(Jan)	SSNos(ST)	SSB(ST)
0	0.0310	92941	1281	3521756	352	0	0	0	0
1	0.1852	326103	10019	2432366	35772	0	0	0	0
2	0.2868	169132	11801	744900	39497	148980	7899	137708	7302
3	0.3599	180384	17566	654600	55931	490950	41948	450499	38492
4	0.5972	237242	26234	576400	64023	518760	57620	464852	51633
5	0.5123	64307	8736	175500	25865	175500	25865	158604	23375
6	0.6187	51116	7824	121000	19812	121000	19812	108193	17715
7	0.5972	16505	2840	40100	7308	40100	7308	35933	6548
8	0.5972	20415	3481	49600	9535	49600	9535	44446	8544
Total		1158146	89783	8316222	258094	1544890	169987	1400234	153608

Year:	**2008**	**F multiplie**	**0.8707**	**Fbar:**	**0.4545**				
Age	F	CatchNos	Yield	StockNos	Biomass	SSNos(Jan)	SSB(Jan)	SSNos(ST)	SSB(ST)
0	0.0270	81077	1118	3521756	352	0	0	0	0
1	0.1613	298417	9168	2529347	37198	0	0	0	0
2	0.2497	246531	17202	1225880	65000	245176	13000	227467	12061
3	0.3133	112198	10926	457816	39117	343362	29338	316541	27046
4	0.5200	138623	15329	373965	41537	336568	37384	303931	33759
5	0.4460	85331	11593	259711	38275	259711	38275	236267	34820
6	0.5387	32788	5019	86087	14095	86087	14095	77594	12705
7	0.5200	19780	3403	53360	9724	53360	9724	48186	8781
8	0.5200	14982	2554	40416	7770	40416	7770	36497	7016
Total		1029727	76312	8548338	253070	1364681	149586	1246483	136188

Year:	**2009**	**F multiplie**	**0.8707**	**Fbar:**	**0.4545**				
Age	F	CatchNos	Yield	StockNos	Biomass	SSNos(Jan)	SSB(Jan)	SSNos(ST)	SSB(ST)
0	0.0270	81077	1118	3521756	352	0	0	0	0
1	0.1613	299616	9205	2539505	37348	0	0	0	0
2	0.2497	262573	18321	1305652	69230	261130	13846	242269	12846
3	0.3133	191620	18661	781889	66807	586417	50105	540610	46192
4	0.5200	101568	11231	274002	30434	246602	27391	222688	24735
5	0.4460	59807	8125	182026	26826	182026	26826	165595	24405
6	0.5387	51844	7936	136118	22287	136118	22287	122689	20088
7	0.5200	15245	2623	41126	7495	41126	7495	37138	6768
8	0.5200	16920	2885	45646	8775	45646	8775	41219	7924
Total		1080270	80105	8827721	269554	1499065	156725	1372209	142957

Input units are thousands and kg - output in tonnes

Table 3.7.5 **WESTERN BALTIC HERRING.**
Short-term prediction multiple option table, Status quo F.

MFDP version 1a
Run: WBSS GeoMean 5 years
Western Baltic Herring (combined sex; plus group)
Time and date: 14:54 18/03/2007
Fbar age range: 3-6

2007 Biomass	SSB	FMult	FBar	Landings
258094	153608	1.00	0.5220	89783

2008 Biomass	SSB	FMult	FBar	Landings	2009 Biomass	SSB
253070	142291	0.00	0.0000	0	354999	214596
	141933	0.05	0.0261	5159	349193	209545
	141576	0.10	0.0522	10211	343510	204624
	141219	0.15	0.0783	15159	337949	199831
	140864	0.20	0.1044	20006	332505	195162
	140510	0.25	0.1305	24753	327175	190614
	140156	0.30	0.1566	29404	321958	186183
	139804	0.35	0.1827	33960	316851	181866
	139453	0.40	0.2088	38424	311850	177660
	139102	0.45	0.2349	42798	306953	173561
	138752	0.50	0.2610	47084	302158	169568
	138403	0.55	0.2871	51284	297463	165676
	138056	0.60	0.3132	55401	292864	161883
	137709	0.65	0.3393	59435	288360	158187
	137363	0.70	0.3654	63390	283949	154584
	137018	0.75	0.3915	67266	279627	151073
	136674	0.80	0.4176	71066	275394	147650
	136330	0.85	0.4437	74791	271247	144314
	135988	0.90	0.4698	78444	267183	141061
	135646	0.95	0.4959	82026	263202	137890
	135306	1.00	0.5220	85538	259301	134799
	134966	1.05	0.5481	88982	255478	131784
	134627	1.10	0.5742	92360	251731	128845
	134290	1.15	0.6003	95673	248059	125979
	133953	1.20	0.6264	98922	244460	123184
	133617	1.25	0.6525	102110	240933	120458
	133281	1.30	0.6786	105237	237474	117800
	132947	1.35	0.7047	108305	234084	115207
	132614	1.40	0.7308	111316	230760	112678
	132281	1.45	0.7569	114269	227501	110211
	131949	1.50	0.7830	117168	224305	107805
	131619	1.55	0.8091	120013	221172	105457
	131289	1.60	0.8352	122805	218099	103166
	130960	1.65	0.8613	125545	215085	100931
	130631	1.70	0.8874	128235	212128	98751
	130304	1.75	0.9135	130875	209229	96623
	129978	1.80	0.9396	133467	206384	94547
	129652	1.85	0.9657	136012	203594	92520
	129327	1.90	0.9918	138511	200857	90543
	129003	1.95	1.0179	140965	198171	88612
	128680	2.00	1.0441	143374	195535	86728

Input units are thousands and kg - output in tonnes

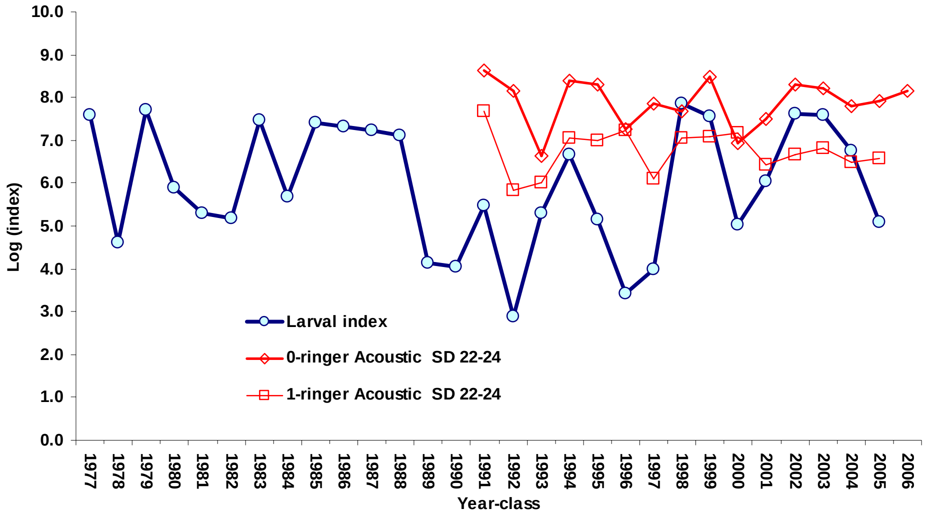


Figure 3.5.1 **WESTERN BALTIC HERRING. Recruitment indices (natural log) adjusted to year-class, versus time. Estimates of the larval index for 2006 were not available.**

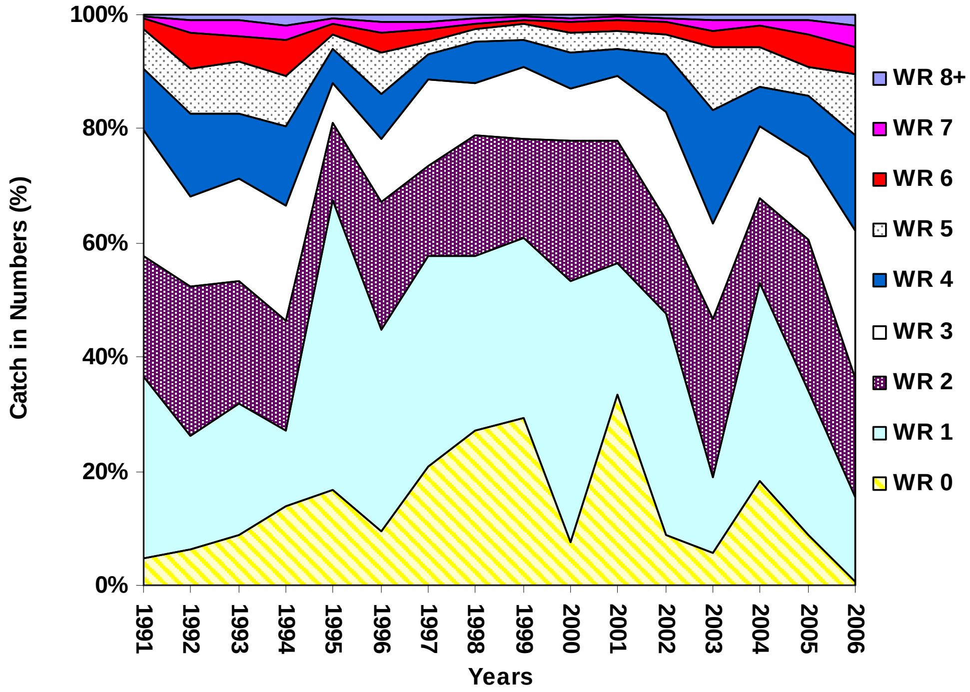


Figure 3.6.1 WESTERN BALTIC HERRING.
Proportions of age groups (numbers) in the total catch.

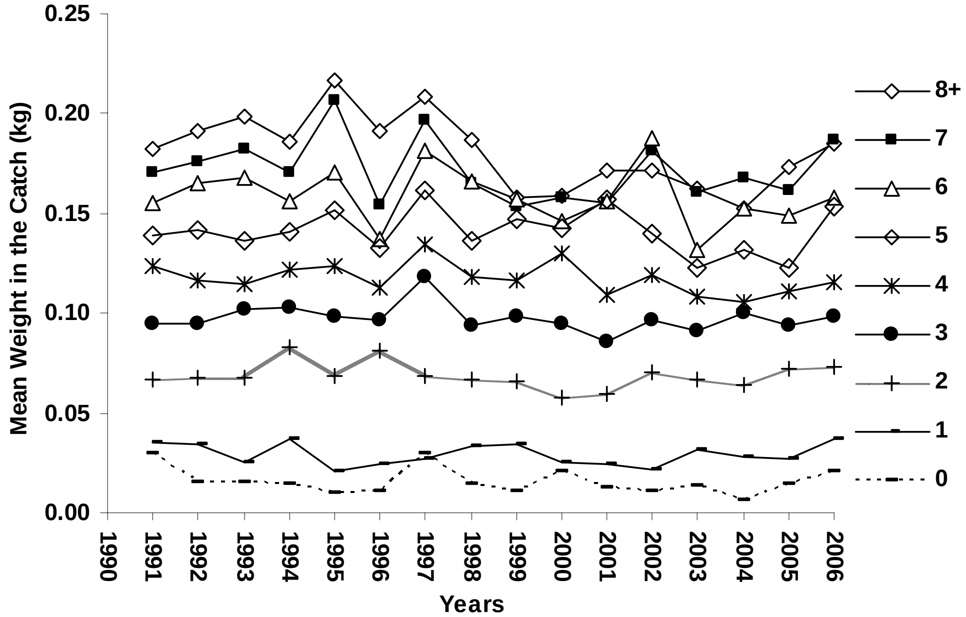
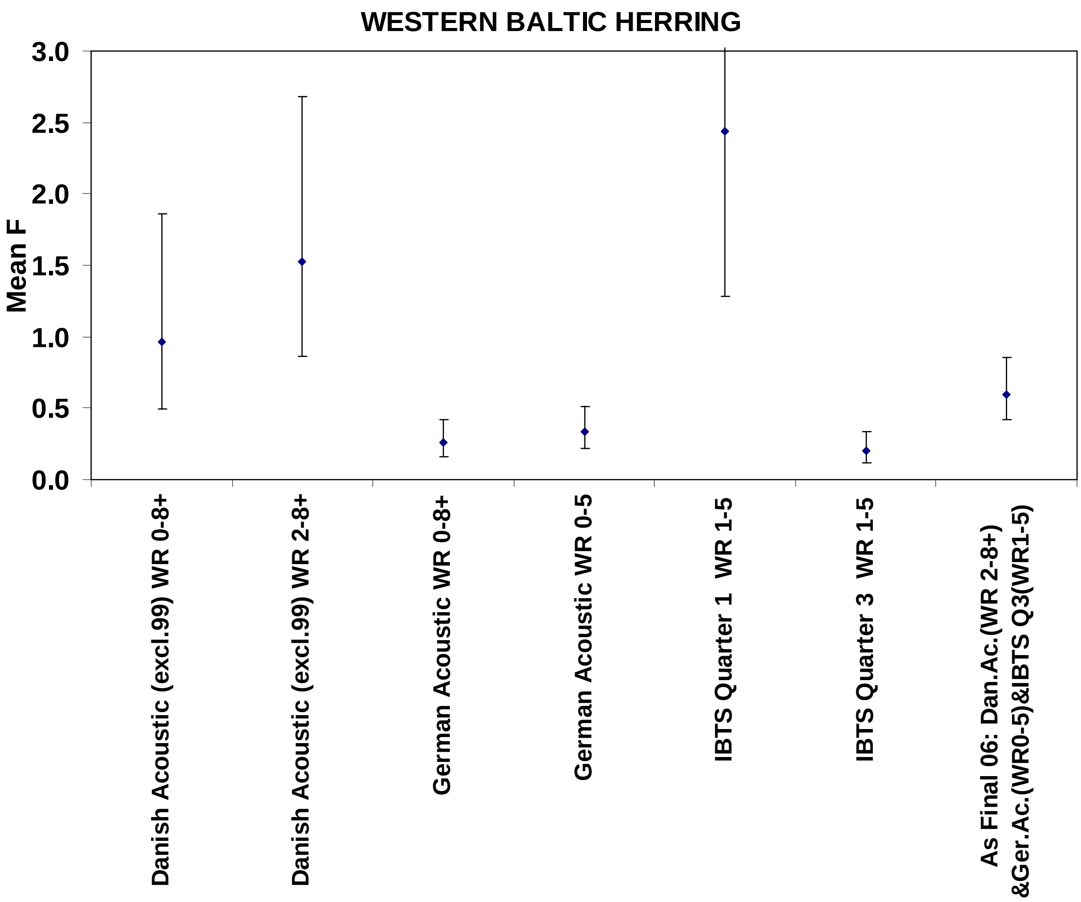


Figure 3.6.2 WESTERN BALTIC HERRING.
Mean weight in the catch (kg).



Fleet No.	Survey	Area	Quarter	WR	Mean F 2006	Lower 95%CL	Upper 95%CL	SSB (t) 2006
1a	Danish Acoustic (excl.99) WR 0-8+	Div. IIIa incl. Katt.	3	0-8+	0.962	0.497	1.860	130,434
1b	Danish Acoustic (excl.99) WR 2-8+	Div. IIIa incl. Katt.	3	2-8+	1.523	0.865	2.683	96,154
2a	German Acoustic WR 0-8+	SD 22, 23, 24	4	0-8+	0.261	0.163	0.416	281,441
2b	German Acoustic WR 0-5	SD 22, 23, 24	4	0-5	0.336	0.220	0.512	228,135
3	IBTS Quarter 1 WR 1-5	Kattegat	1	1-5	2.435	1.285	4.614	69,325
4	IBTS Quarter 3 WR 1-5	Kattegat	3	1-5	0.201	0.119	0.339	385,493
1b+2b+4	As Final 06: Dan.Ac.(WR 2-8+) &Ger.Ac.(WR0-5)&IBTS Q3(WR1-5)	SD 24	1-2	0-8+	0.597	0.416	0.857	184,516

Figure 3.6.3 **WESTERN BALTIC HERRING. Estimates of mean F and SSB by ICA runs by individual fleets and catch at age data for 1991-2006.**

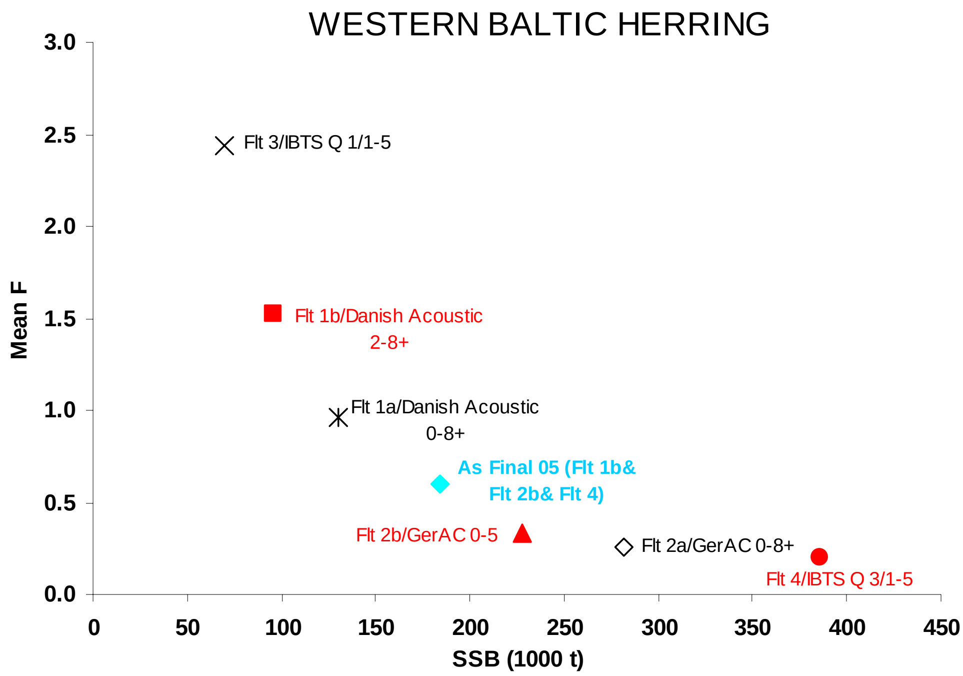


Figure 3.6.4 **WESTERN BALTIC HERRING.**
Estimates of mean F and SSB in terminal year by ICA runs by individual fleets and catch at age data for 1991-2006.

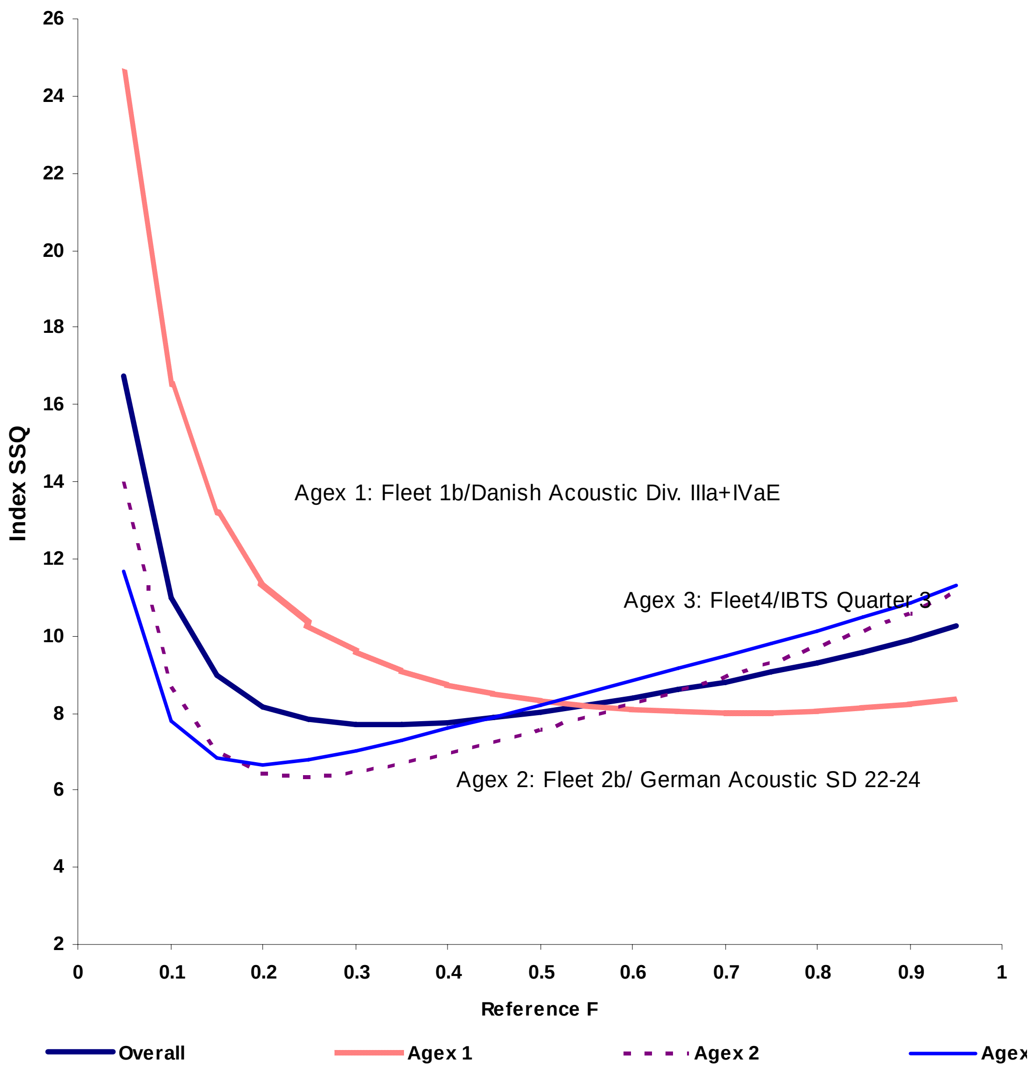


Figure 3.6.5 **WESTERN BALTIC HERRING. Output from ICA Final Run 2007. Index sum of squares of deviations between model and observations (survey index) as a function of the reference F in 2006.**

Agex 1: Fleet 1b/Dansih Acoustic in Division IIIa+IVaE, ages 2-8+
Agex 2: Fleet 2b/ German Acoustic in SD 22-24, ages 0-5
Agex 3: Fleet 4/IBTS Quarter 3, ages 1-5

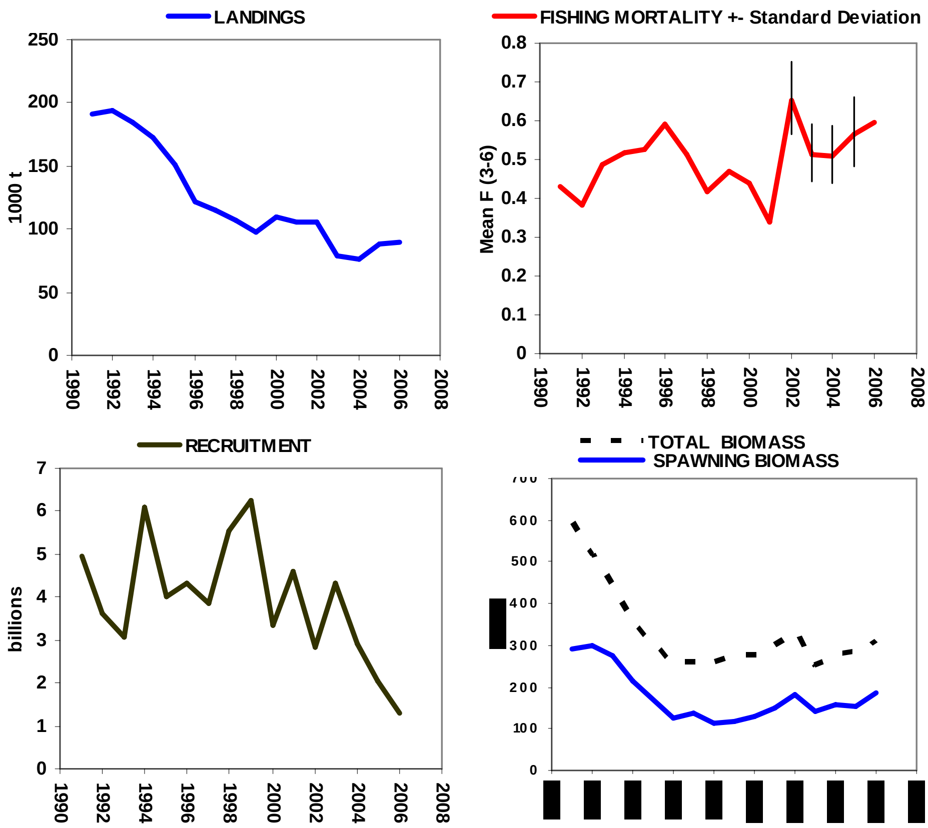


Figure 3.6.6 **WESTERN BALTIC HERRING.**
Output from ICA Final Run 2007: Stock Summary

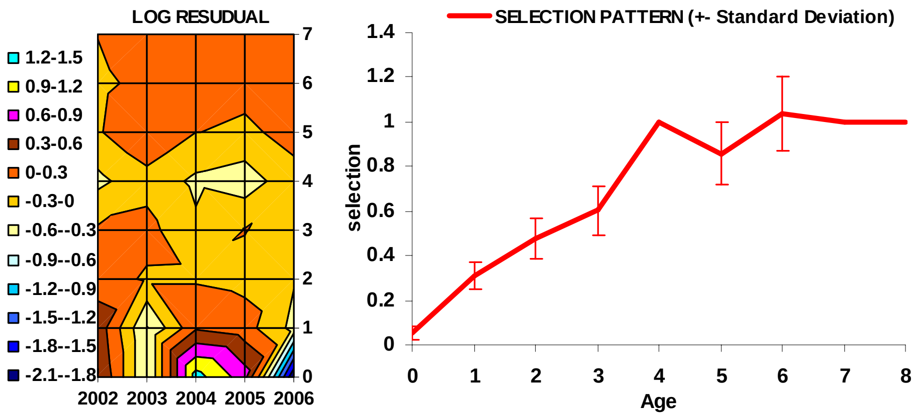


Figure 3.6.7 **WESTERN BALTIC HERRING.**
Output from ICA Final Run 2007.
Separable Model Diagnostics: Log Residual&Selction Pattern

(Age 0 is still included in the log residual & year residuals, although age o was down-weighted (0.1) in the catch)

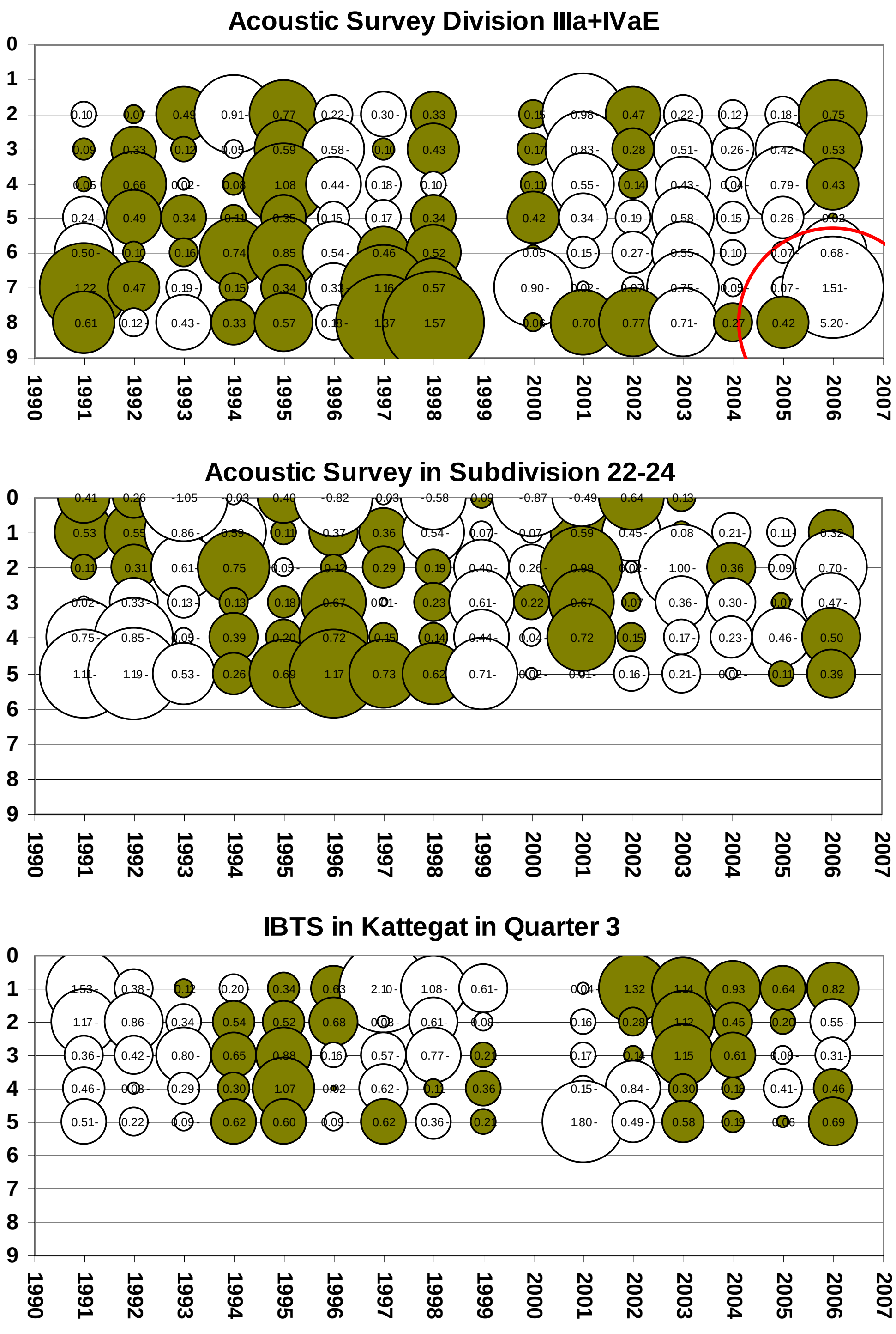


Figure 3.6.8 **WESTERN BALTIC HERRING. ICA Final Run 2007. Log catchability residuals plots.**

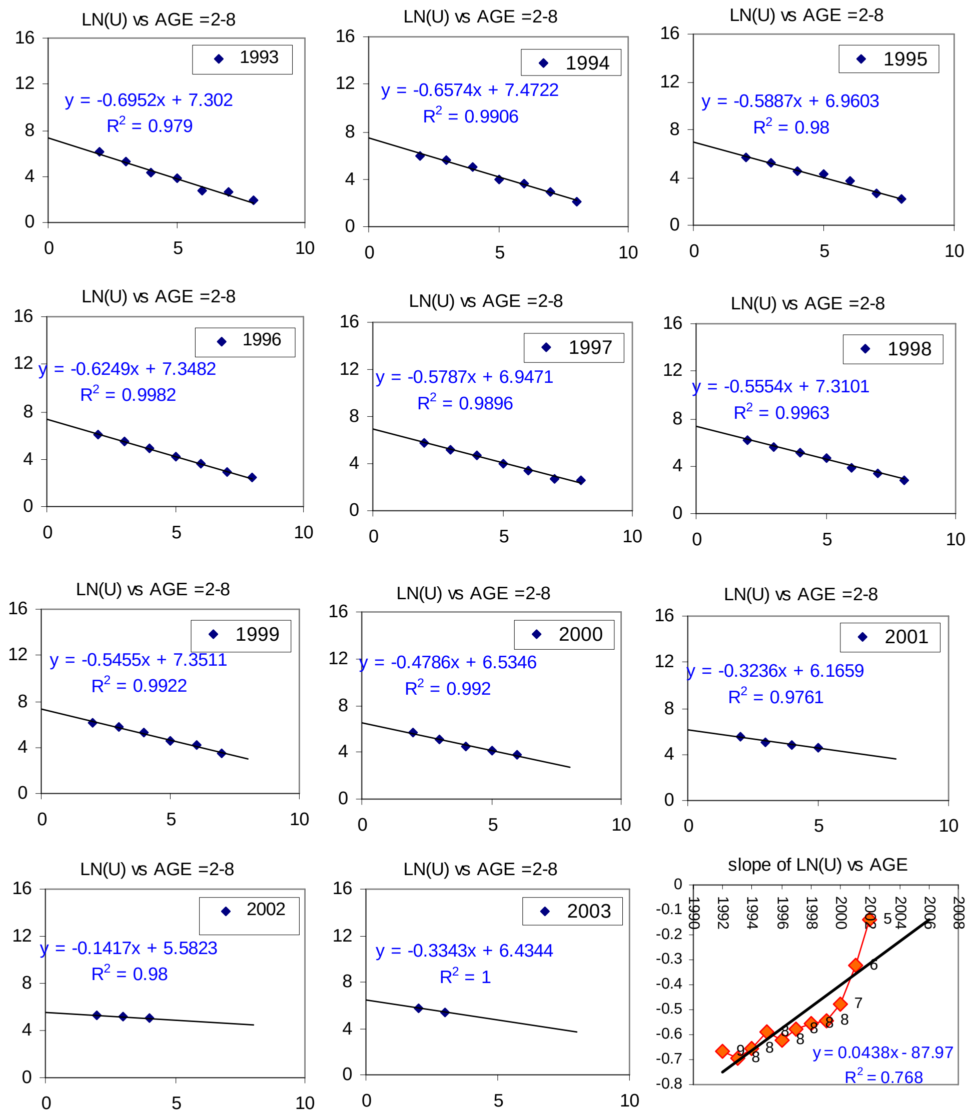


Figure 3.6.9a **WESTERN BALTIC HERRING.**
Log Catch vs Age for successive cohorts and their resulting slopes estimates.
CATCH IN NUMBER (CANUM), Ages=1-8

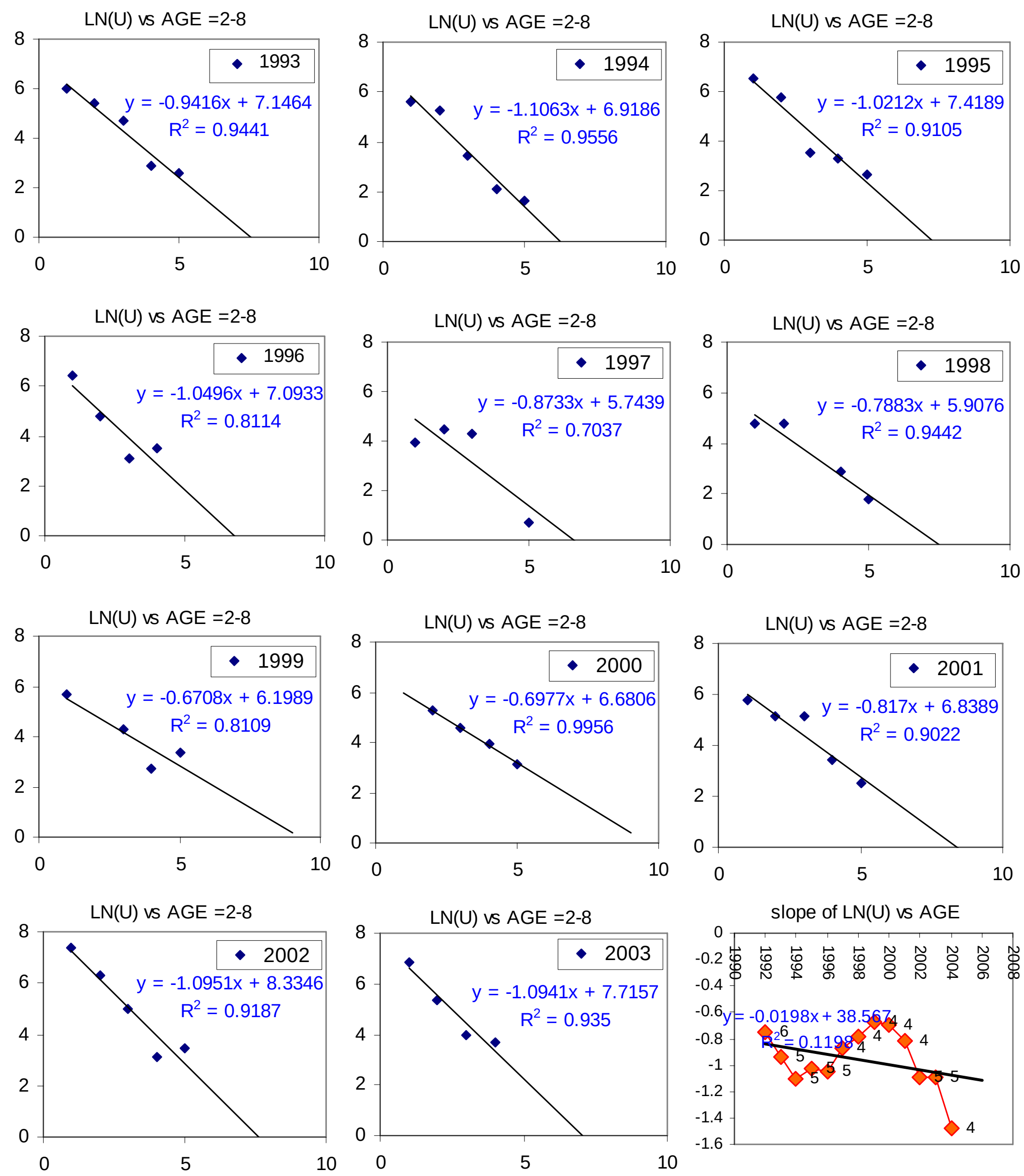


Figure 3.6.9b **WESTERN BALTIC HERRING.**
Log Catch vs Age for successive cohorts and their resulting slopes estimates
ACOUSTIC SURVEY IN DIV IIIa+IVaE, ages=2-8

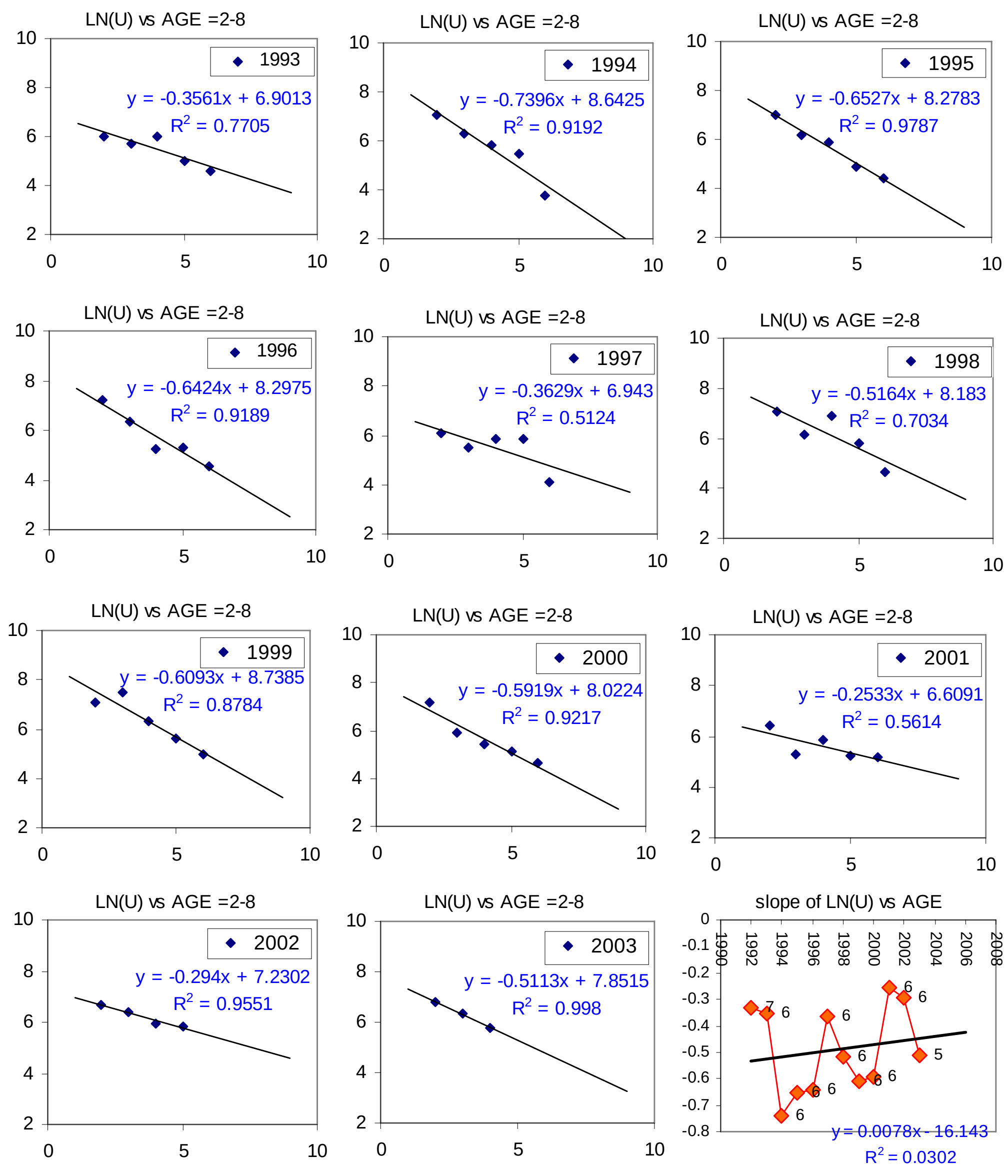


Figure 3.6.9c **WESTERN BALTIC HERRING.**
Log Catch vs Age for successive cohorts and their resulting slopes estimates
ACOUSTIC SURVEY IN SD 22-24 ages=0-5

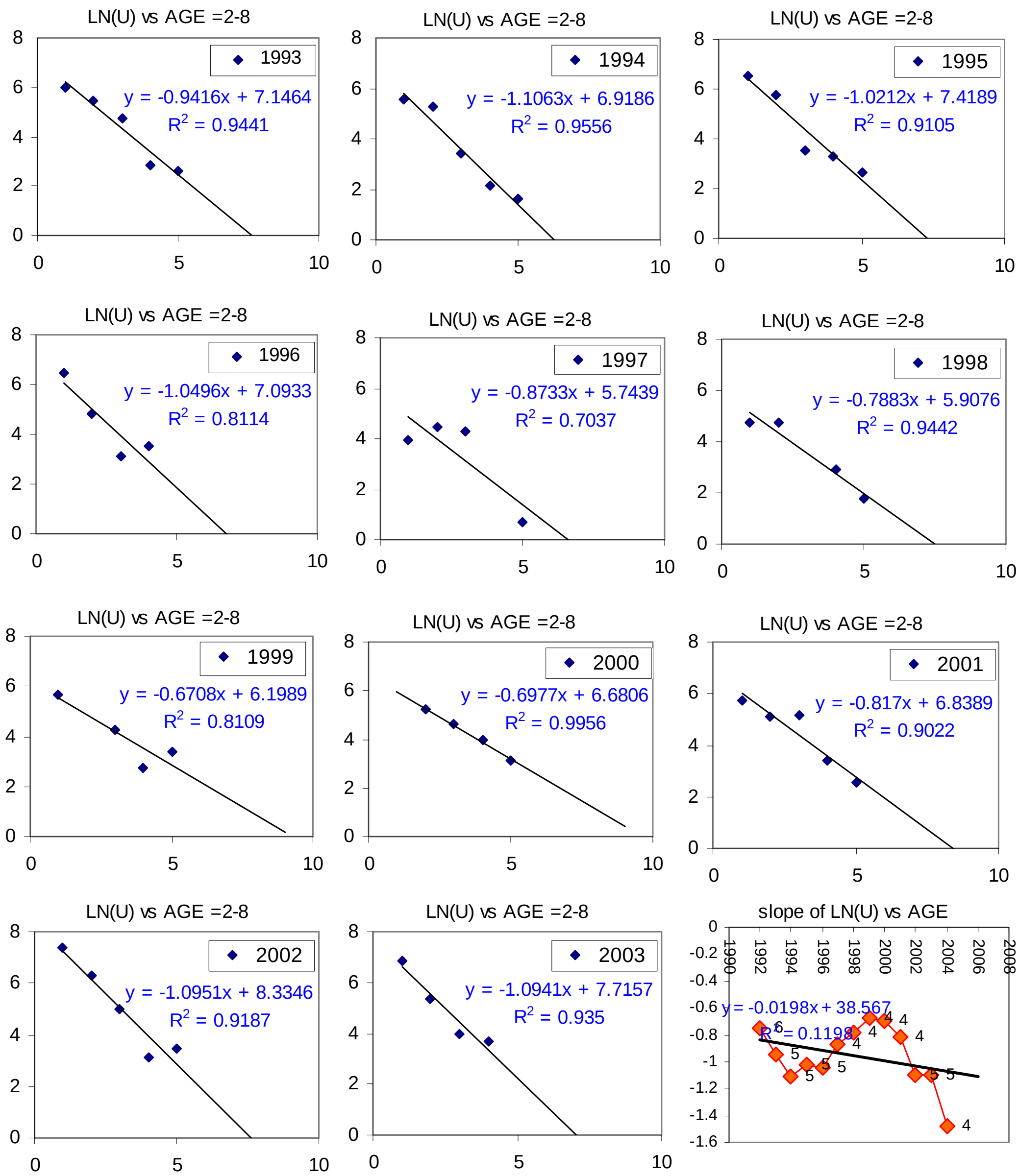
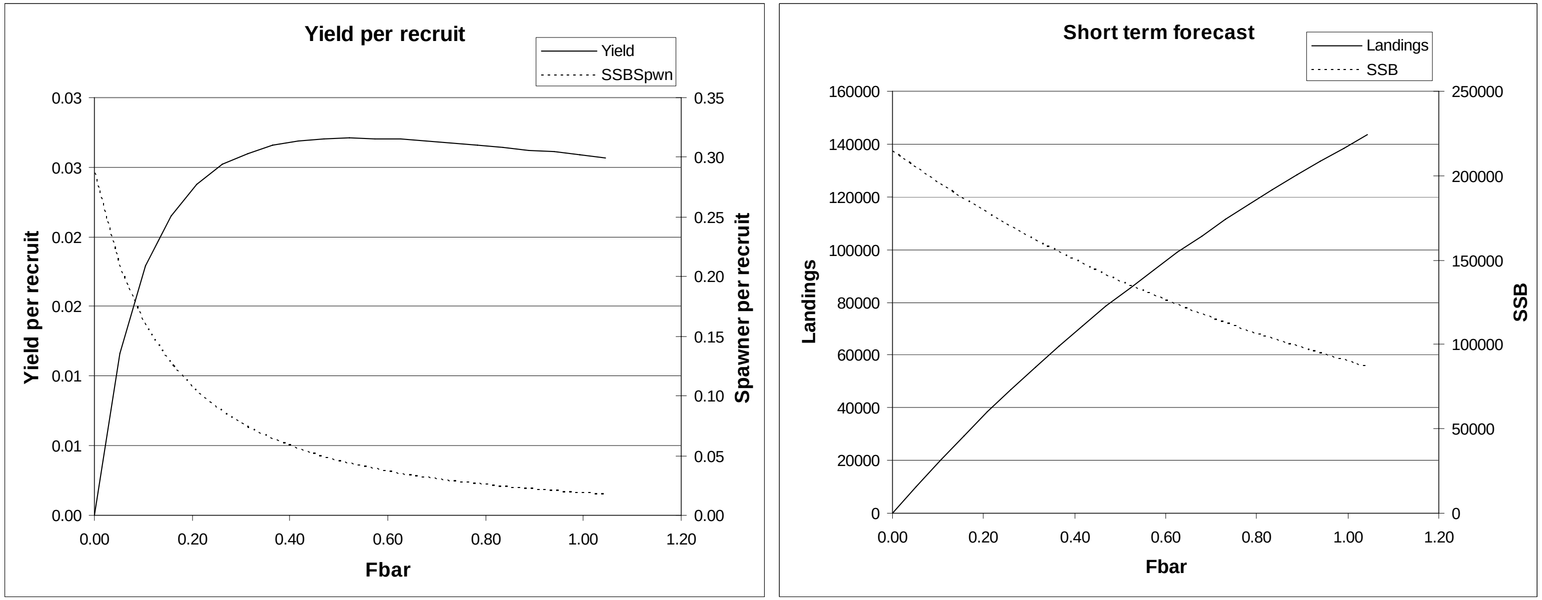


Figure 3.6.9d **WESTERN BALTIC HERRING.**
Log Catch vs Age for successive cohorts and their resulting slopes estimates
IBTS IN KATTEGAT QUARTER 3, ages=1-5



MFYPR version 2a
Run: WBSS GeaMean 5 years_MFYPR
Time and date: 14:56 18/03/2007

Reference point	F multiplier	Absolute F
Fbar(3-6)	1.0000	0.5220
FMax	1.0117	0.5282
F0.1	0.4203	0.2194
F35%SPR	0.4177	0.2181

Weights in kilograms

MFDP version 1a
Run: WBSS GeoMean 5 years
Western Baltic Herring (combined sex; plus group)
Time and date: 14:54 18/03/2007
Fbar age range: 3-6

Input units are thousands and kg - output in tonnes

Figure 3.7.1 **WESTERN BALTIC HERRING. Long and short term yield and SSB, derived by MFYPR v2a**

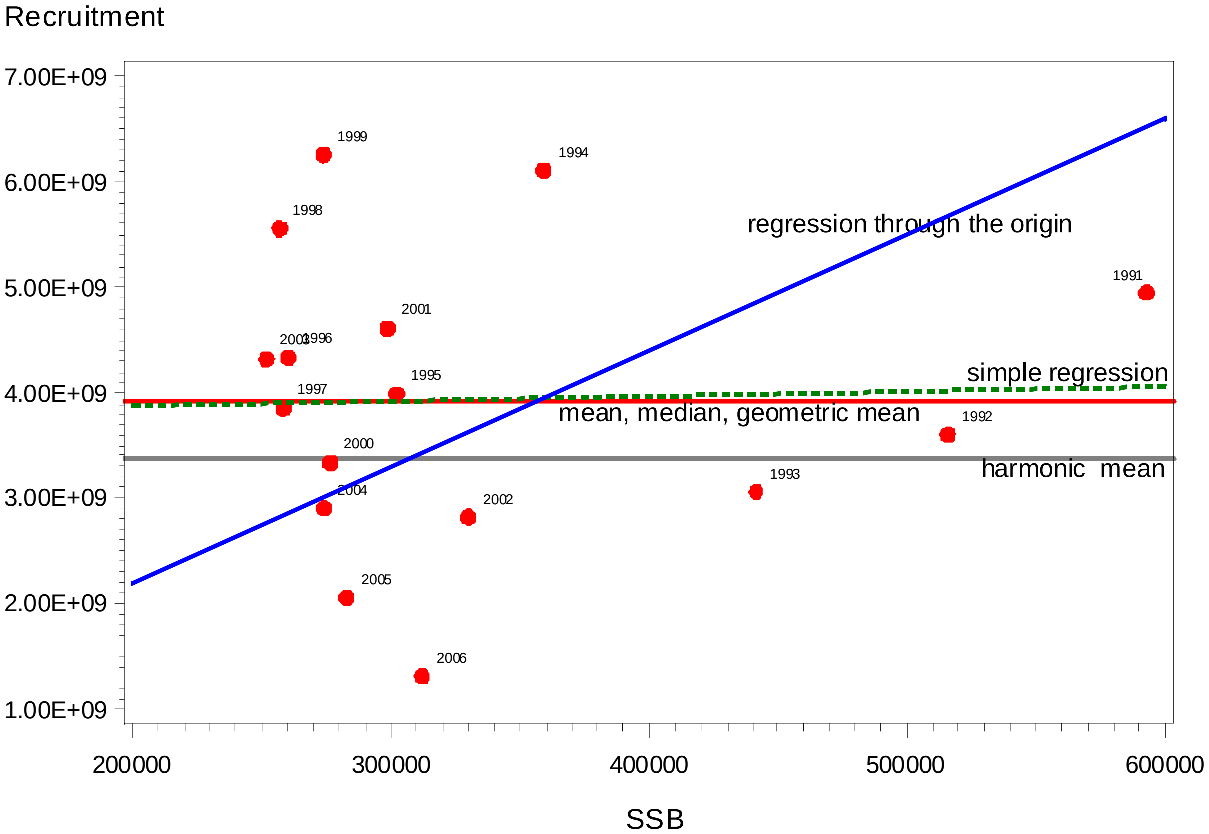


Figure 3.8.1 **Western Baltic Herring. Various recruitment measures.**

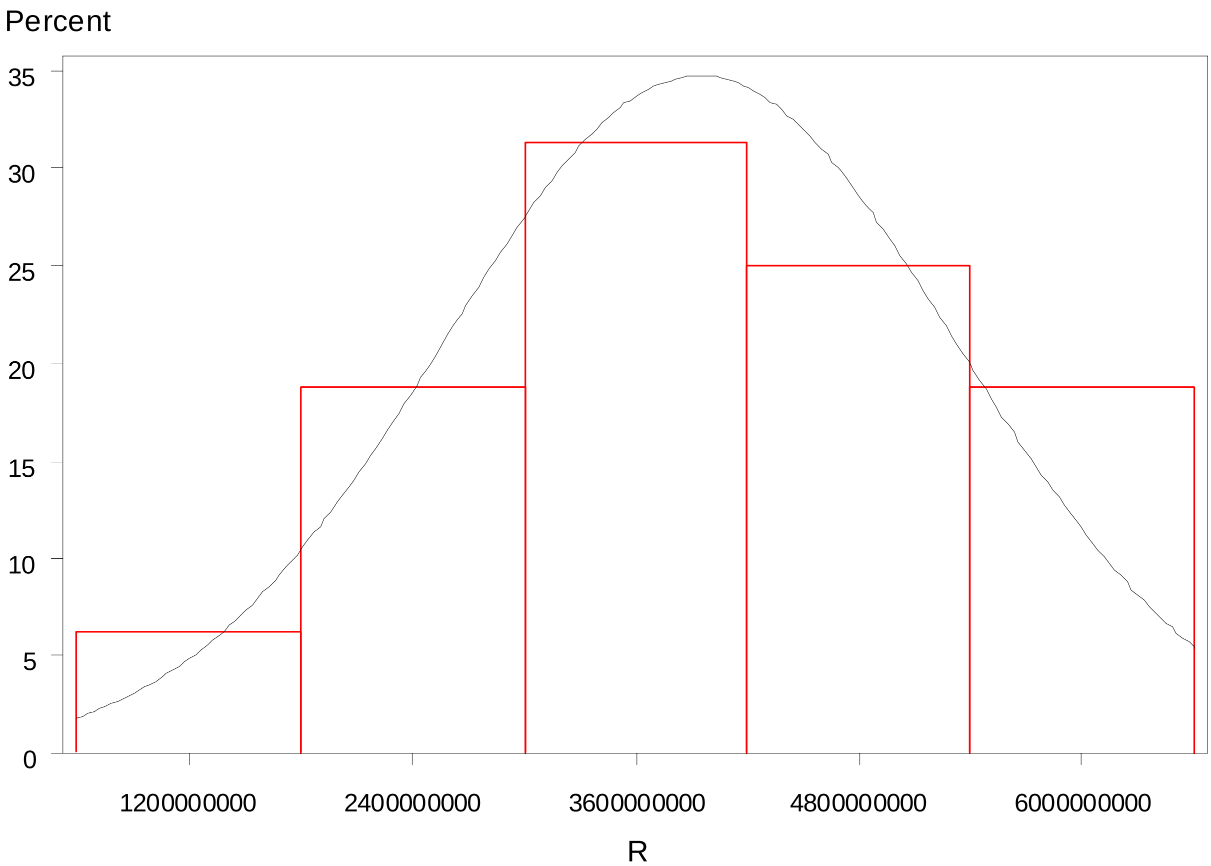


Figure 3.8.2 **Western Baltic Herring. Histogram of recruitment.**

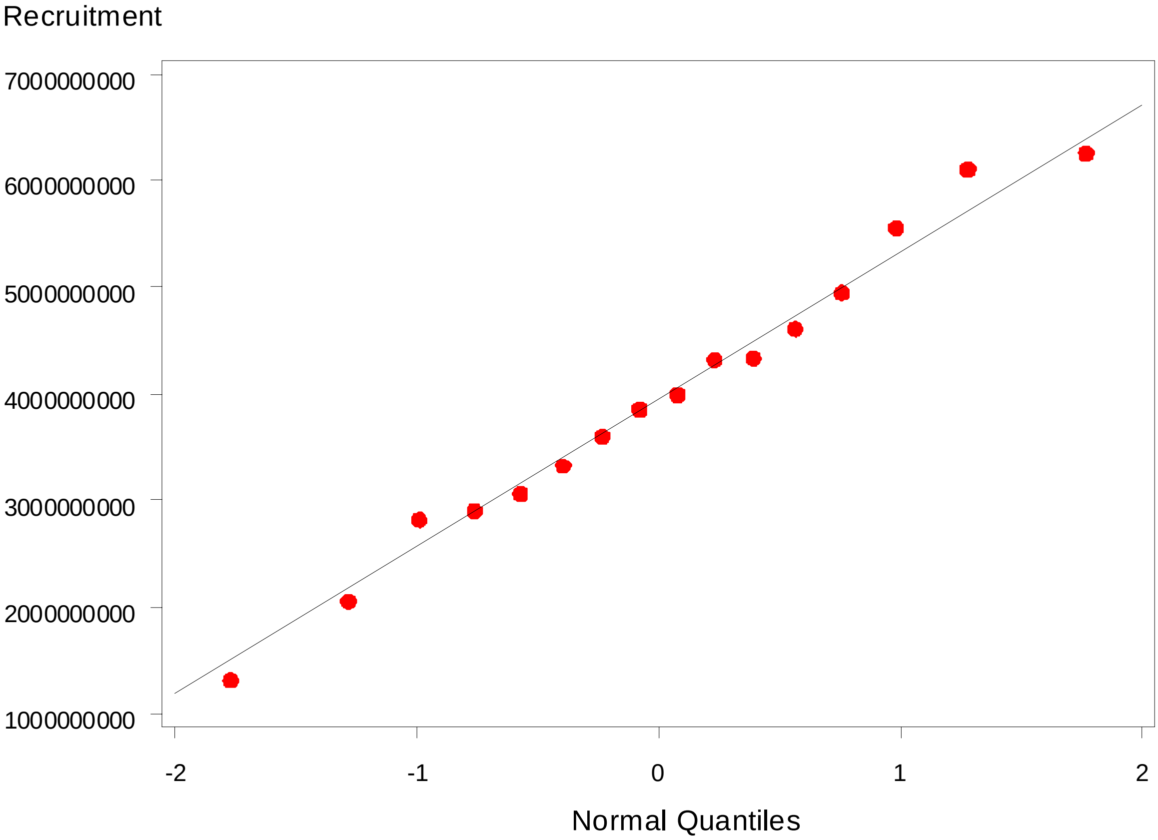


Figure 3.8.3 **Western Baltic Herring. QQ plot of recruitment.**

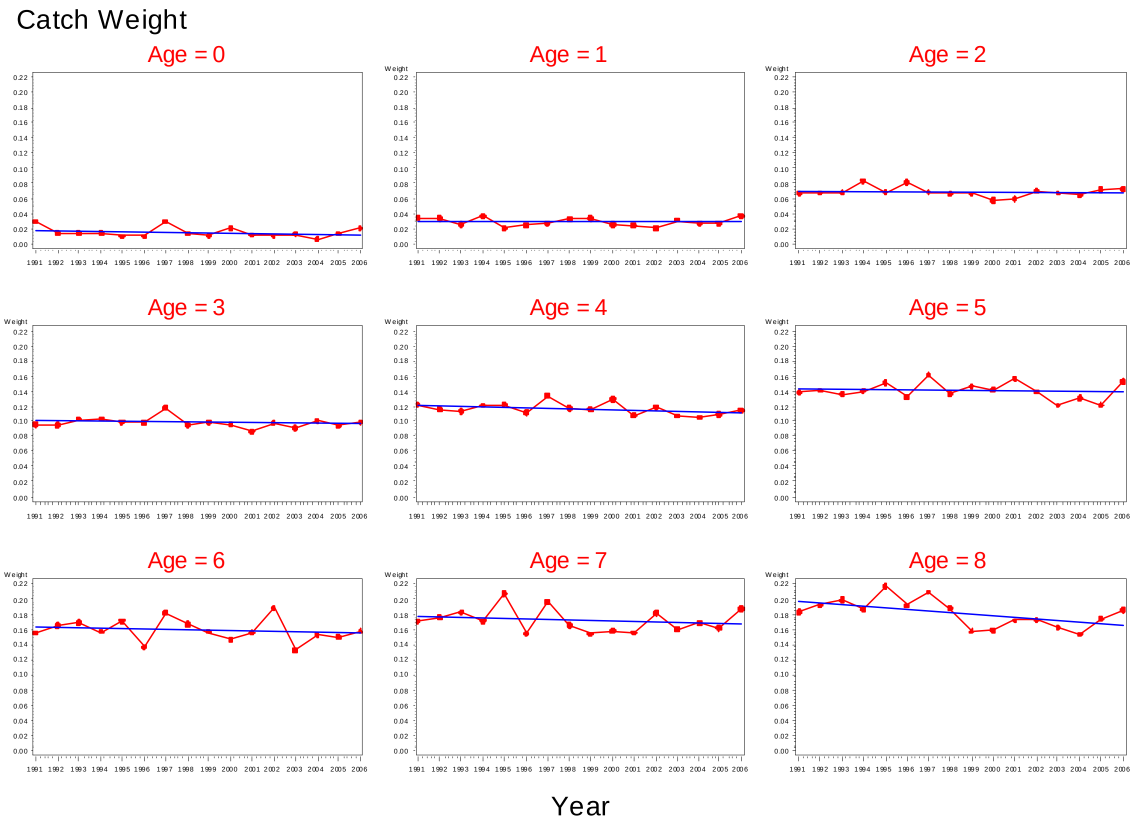


Figure 3.8.4 **Western Baltic Herring. Trends in catch weight by age (1991 – 2006, ages 0 – 8+).**

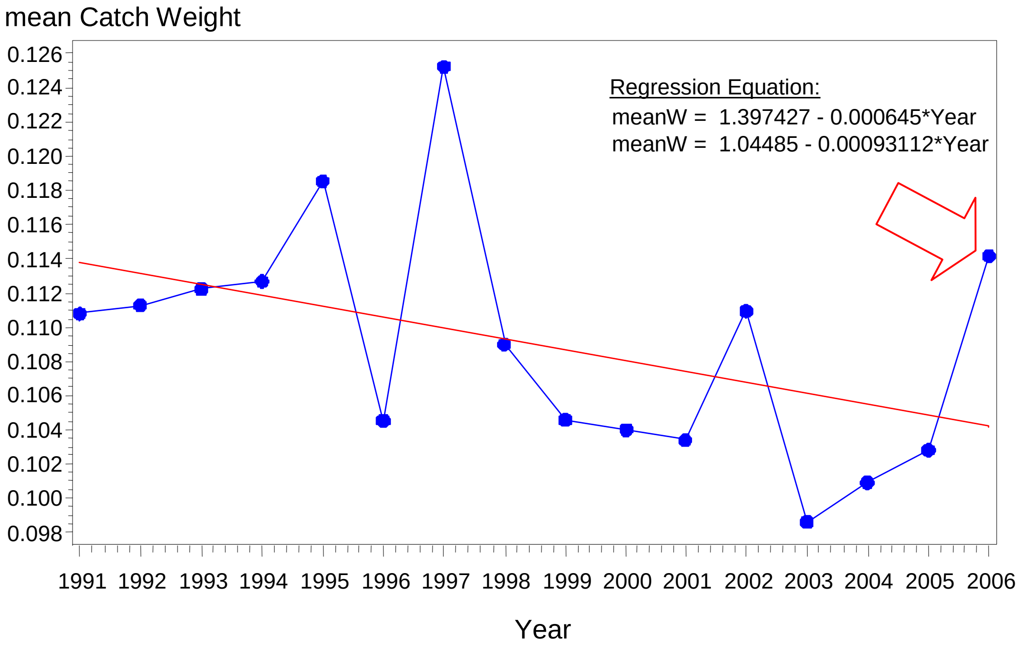


Figure 3.8.5 Western Baltic Herring. Trend of mean weight in the catch (1991 – 2006, ages 0 – 8+). Ignoring the 2006 value (indicated by the arrow) leads to the second regression equation.

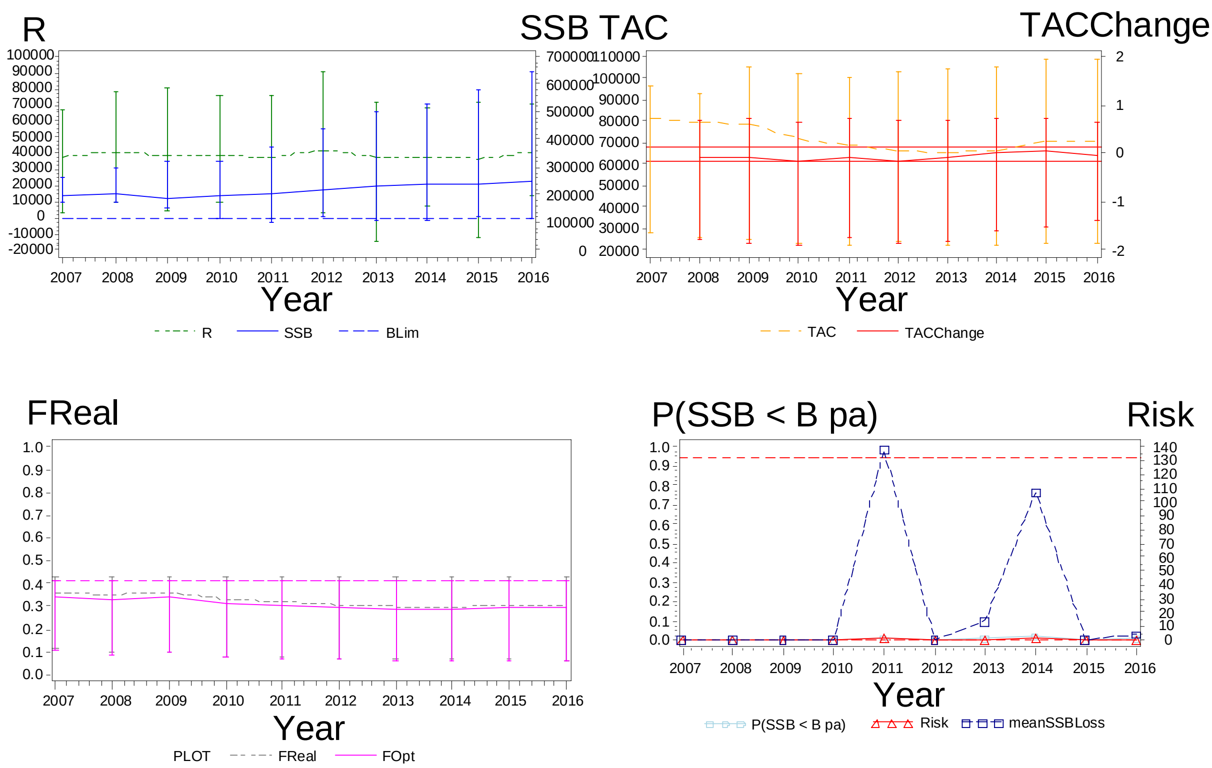


Figure 3.8.6 Western Baltic Herring. Optimization A. B_{pa} = lower SSB limit.

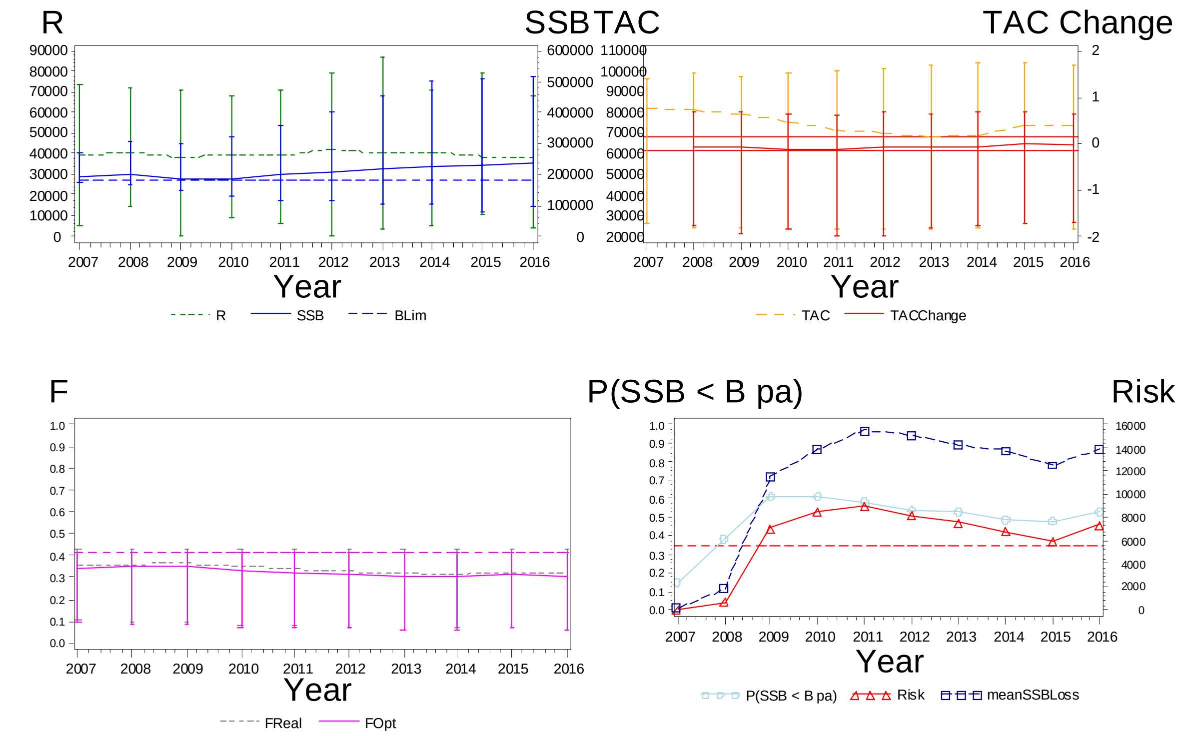


Figure 3.8.7 **Western Baltic Herring. Optimization B. B_{pa} = lower SSB limit.**

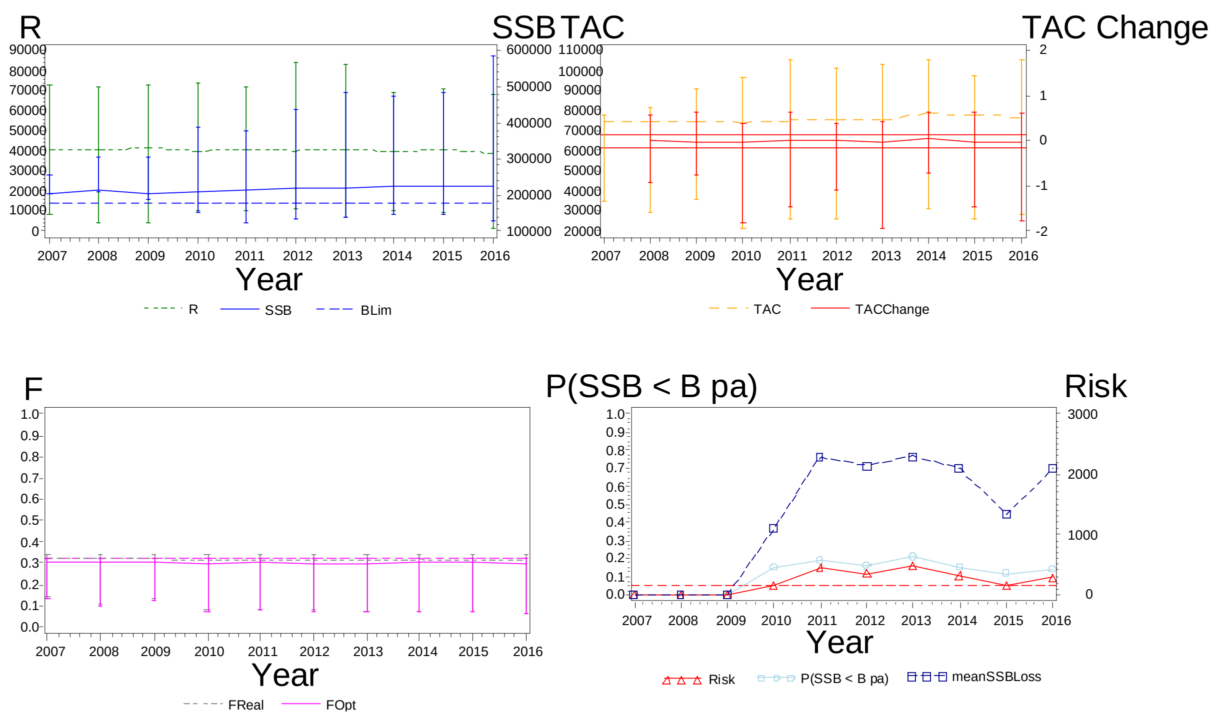


Figure 3.8.8 **Western Baltic Herring. Optimization C. B_{pa} = lower SSB limit.**

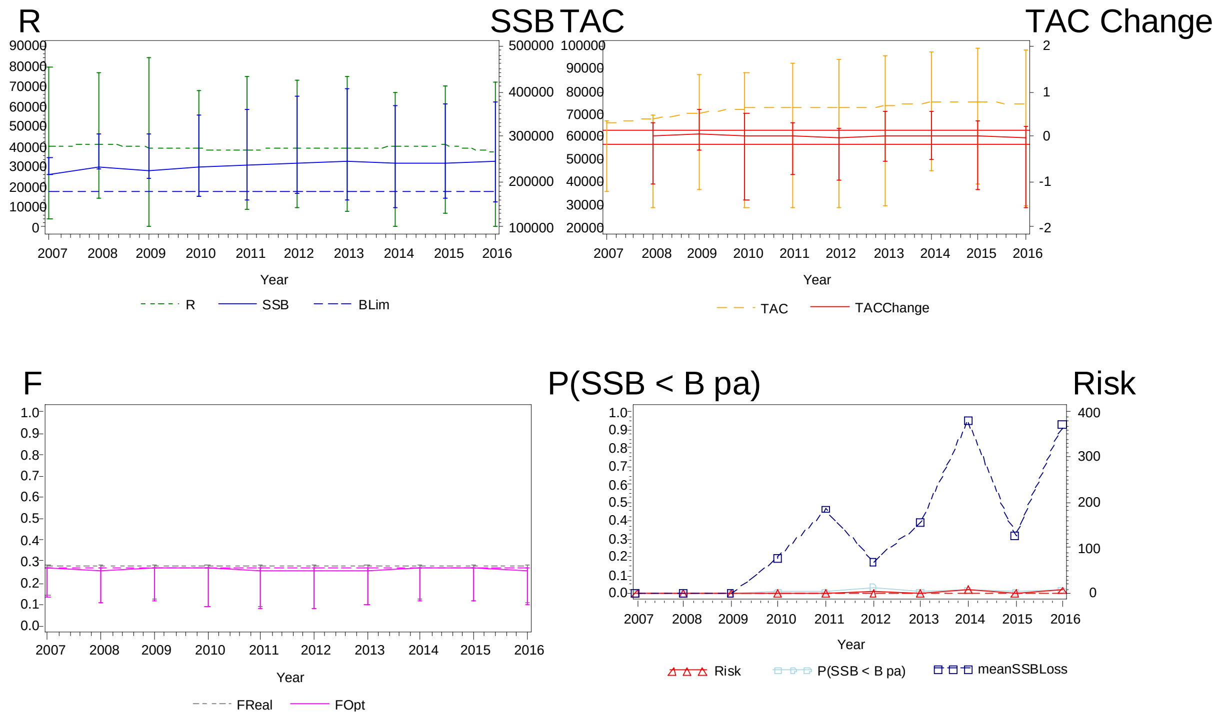


Figure 3.8.9 **Western Baltic Herring. Optimization D. B_{pa} = lower SSB limit.**

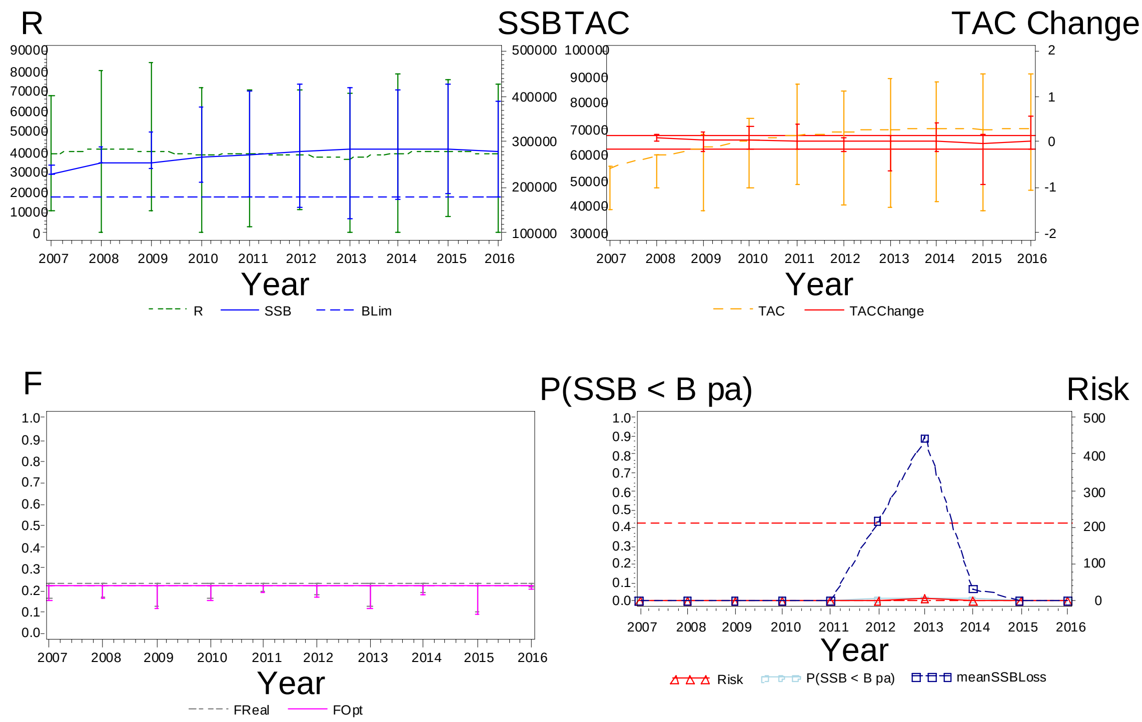


Figure 3.8.10 **Western Baltic Herring. Optimization E. B_{pa} = lower SSB limit.**

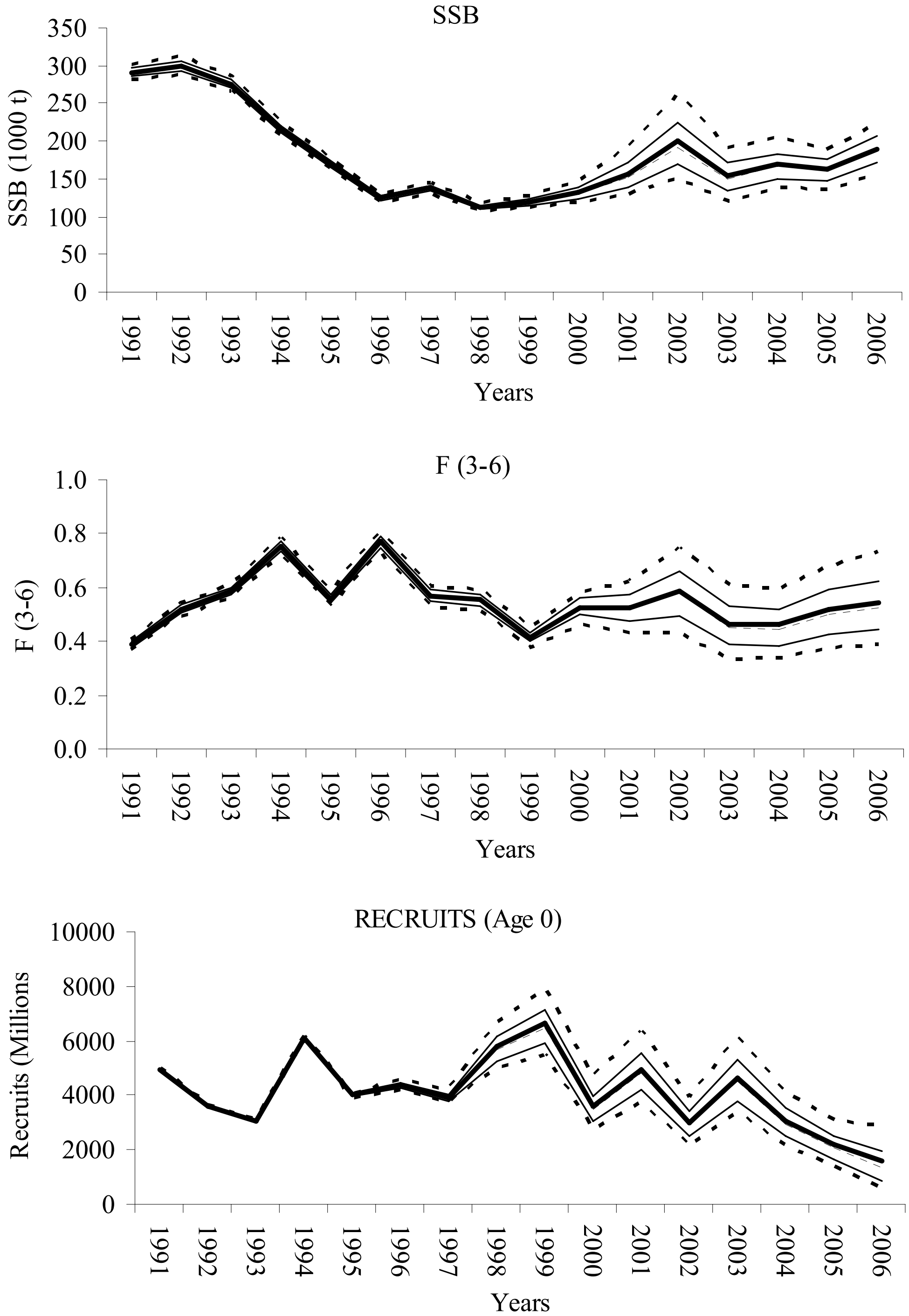


Figure 3.9.1 **WESTERN BALTIC HERRING.**
Historic uncertainty in the Final model fit (ICA assessment).
Percentiles 10, 25, 50, 75 and 90 %.

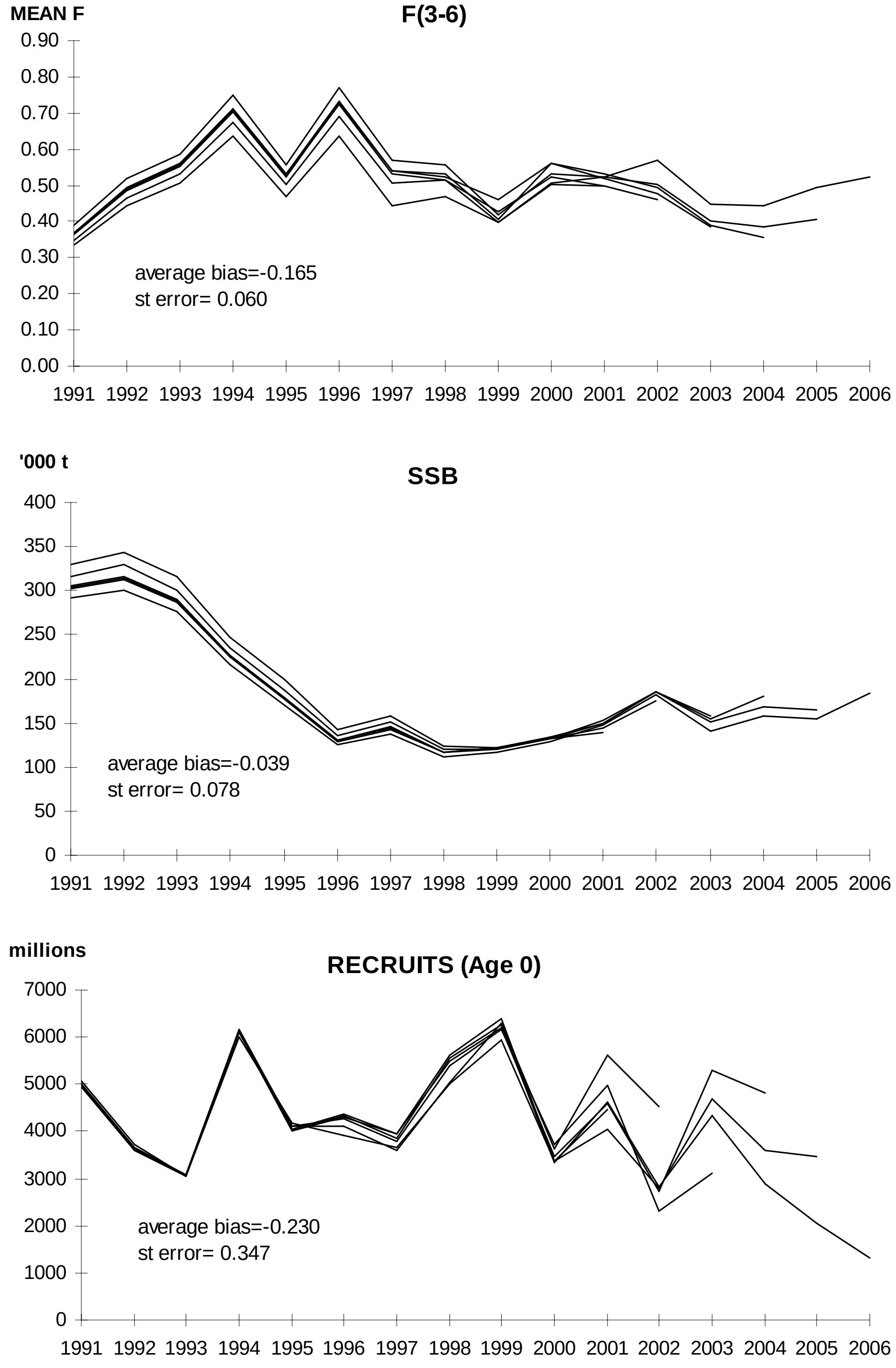


Figure 3.9.2 **WESTERN BALTIC HERRING: Restrospective Analysis (ICA)**

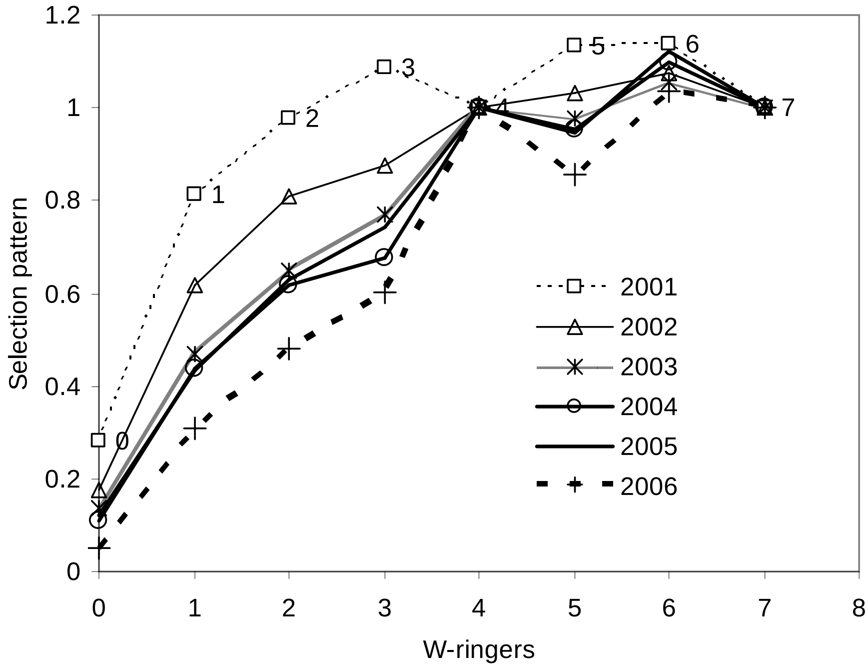


Figure 3.9.3 **WESTERN BALTIC HERRING. Restrospective selection pattern**

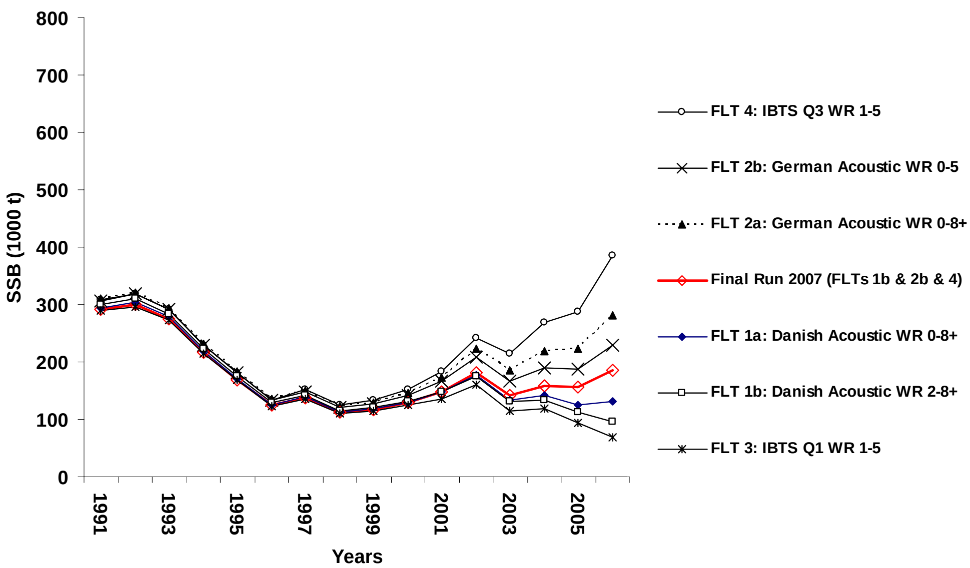


Figure 3.9.4 **WESTERN BALTIC HERRING. SSB estimates from ICA model with separate indices and with indices combined (Final Run 2007).**

4 Celtic Sea and Division VIIj Herring

4.1 The Fishery

The herring fisheries to the south of Ireland in the Celtic Sea and in Division VIIj exploit herring that have a protracted period from September to February. For the purpose of stock assessment and management, these areas have been combined since 1982. The management unit covers all of Divisions VIIg,h,j and k and the southern part of Division VIIa.

4.1.1 Advice and management applicable to 2006 – 2007

ACFM Advice

The TAC in 2006 was 11 050 t, and in 2007 is 9 393 t. In 2006, ACFM considered the current level of SSB to be uncertain, but maybe below B_{pa} and possibly even below B_{lim}. There was no short term forecast undertaken but given the risk to the stock indicated by low recruitment, ACFM advised that, fishing should not proceed unless accompanied by a recovery plan. It was proposed that this plan should include the closure of spawning areas and further reduction in catches.

EU Proposal

In 2006, the EU produced a proposal for the management of this stock, though no explicit recovery plan was developed for the stock. However in 2006, the European Commission produced a proposal on fishing opportunities for 2007. This stock was classified as being “outside safe biological limits”. For this stock, the Commission proposed that a TAC for 2007 be set to bring the stock within safe biological limits, but not entailing more than a ± 15% fluctuation in TAC from year to year. However the Commission noted that the TAC should in no case be set at a level that will lead to an increase in F or a decrease in SSB, even if this results in a greater than 15% reduction in TAC.

Irish Preliminary Recovery Plan Proposal

Based on the ICES advice, a preliminary rebuilding plan was proposed by Ireland. This plan had the following elements:

1) stepwise 15% reduction in catch year on year
2) Indefinite closure of spawning box C (Figure 4.1.1.1a), but with a derogation for vessels below 15m length allowed to catch a maximum of 8% of the quota. If the catch of fish <23 cm exceeds 50% then the small scale fishery would be stopped.

This proposal was evaluated by STECF in November 2006. STECF advised that a 15% reduction in TAC for 2007 results in a high risk that the stock would be below B_{pa} in 2008. STECF acknowledged that there were no low risk strategies available at present that would bring the stock to B_{pa} in 2008, and that even having no catch represents some risk that SSB would be below B_{pa}

The Irish plan was not explicitly implemented, though the current TAC represents a 15% reduction on that for 2006.

Each year, a different “spawning box” is closed for a two week period, at a time corresponding to the nominal peak in spawning activity in that area (Figure 4.1.1.1a). In 2006/2007 box A was closed and in 2007/2008 Box B will be closed.

Local Irish Management Plan

A committee was established to manage the Irish fishery for this stock, on a local basis. This committee, therefore, has responsibility for management of the entire fishery for this stock at present. The committee stated its intention to follow 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 would 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.

4.1.2 The fishery in 2006/2007

The landings in this fishery since 1958 are shown in Figure 4.1.2.1.

In 2006-2007, 40 vessels took part in the Irish fishery. These are categorised as follows:

- 7 Pelagic RSW trawlers from 45 m to 27 m
- 6 Polyvalent RSW trawlers 24 m to 33 m
- 8 Polyvalent tank hold trawlers from 19 m to 26 m
- 19 Polyvalent dryhold trawlers from 10 m to 27 m

The fishery took place in the third, fourth and first quarter. Most vessels under 20 m reported landings of less than 100 t for the assessment period while a number of RSW vessels reported landings greater than 1 000 t. In addition small incidental landings, typically less than a tonne were reported by a number of other vessels. The term “Polyvalent” refers to a segment of the Irish fleet, licensed to catch a variety of species, under Irish law. “Pelagic” segment vessels are confined to fishing pelagic species.

The third quarter fishery took place between the Kinsale gas fields and Labadie Bank, being prosecuted by Polyvalent RSW and Polyvalent tank hold boats, in late August (Figure 4.1.1.1b). The fourth quarter fishery lasted from the third week of November to the 20th December., being largely restricted to VIIa south. In the first quarter of 2007 the fishery was constrained by bad weather and the loss of two vessels, being only open from the 2nd to the 19th of January. The fishery closed early due to search and rescue efforts. When the fishery was open landings came from the spawning grounds in VIIg (Figure 4.1.1.1b). Overall about 900 t were taken from around Waterford harbour, by smaller vessels.

The Irish quota is managed by allocating individual quotas to vessels on a weekly basis. Participation in the fishery is restricted to licensed vessels. The licensing requirements have been changed in recent years. Previously, vessels had to participate in the fishery each season to maintain their licence. Now 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. The efficiency of these vessels has improved, however. 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.

4.1.3 The catches in 2006/2007

The estimated national catches from 1988–2006 for the combined areas by year and by season (1 April–31 March) are given in Table 4.1.3.1 and Table 4.1.3.2 respectively. The catch, taken during the 2006/2007 season was under 7 000 t having declined from almost 9 500 t in the previous season (Figure 4.1.2.1.).

There are no estimates of discards for this fishery. Anecdotal reports from fishermen suggest that discarding is not a feature of this fishery at present.

4.2 Biological composition of the catch

4.2.1 Catches in numbers-at-age

Catch numbers at age are available for the period 1958/1959 to 2006/2007. These data include discards, until 1997, and afterwards no discard estimates have been available (Table 4.2.1.1). In 2006/2007, there was a strong dominance of 2-ringers (2003/2004 year class). This cohort was strong the previous season also. These two ringers are stronger than any year class since 2000/2001. The 4-ringers (2001/2002 year class) were weak as in previous seasons (Table 4.2.1.1). It is important to note that the weakness of 4-ringers tends to inflate the proportions of the other important age groups in the catches. However the yearly mean standardised plots (Figure 4.2.1.1.) shows that 2-ringers have been the dominant age in catches in general throughout the series. It can also be seen that although younger fish always predominated, there is a marked truncation of the age profile since the 1980s. In most recent years this effect seems to have accentuated.

The overall proportions at age were similar in all sampled metiers (division*quarter), see Figure 4.2.1.2. The quarter 3 fishery in VIIg produced greater proportions of 5 ringers than elsewhere. As usual, VIIj catches had a different age distribution to the other areas. Table 4.2.1.2 shows that there were very small fish recorded in VIIaS and that largest fish were caught in VIIg and VIIj.

4.2.2 Movements of fish

Juveniles

It was shown that fish of Celtic Sea origin are present in the western Irish Sea, and then return south as 1- and 2-ringers (Molloy et al. 1993). This was endorsed by Brophy and Danilowicz, (2002) and confirmed by the WESTHER project (Hatfield et al., 2007 WD). Historic larval survey data from the 1980s (Stock Annex) show that autumn and winter spawning was taking place in the eastern Celtic Sea (ICES, 2006). Thus juveniles of Celtic Sea origin present in the Irish Sea cannot be distinguished on the basis of spawner type alone. This creates problems with some techniques that could be used to separate Irish sea catches by spawning origin. Further work is required on the effect of this juvenile mixing on the assessment of the Celtic Sea stock.

Adults

The quarter 3 fishery targets offshore feeding aggregations of herring in VIIg. It is not known where these fish spawn. However a combination of positional data from the commercial fishery (August) and acoustic surveys (September to December) in this area displays a seasonally progressive movement towards the traditional spawning grounds inshore (Stock Annex). The WESTHER project (Hatfield et al. 2007 WD), shows that VIIj spawners were found feeding in VIIg. This supports the current assessment and management units. Even though VIIj fish display a different age profile and recruitment dynamic, they feed in the same region as fish that return to spawn in VIIg and VIIaS. It is not known if fish from VIIe also feed in this area (Stock Annex).

4.2.3 Quality of catch and biological data

Biological sampling of the catches throughout the region was comprehensive, except in VIIj. The spasmodic nature of the fishery in that area makes sample acquisition difficult, (Table 4.2.3.1). Under the Data Collection Programme the sampling of this stock is well above that required by the Minimum Programme (Section 1.5). An analysis of precision of Irish herring catch at age data shows excellent quality data (CVs < 7%) for the main ages in the catches from this stock.

The quality of catch data has varied over time. Table 4.2.3.2 presents a rudimentary history of the Irish fishery since 1958. The quality of landings data has improved in most recent years, particularly since 2004, when a low tolerance for water in catches was introduced. The change in water content, changes in control and the demise of the roe fishery all point to better data quality. These factors may bias the data in the respective periods, and such biases need to be considered when examining long term stock dynamics.

Discarding was a major feature of the fishery during from 1983 to 1997, when the fishery sought fish of a particular roe quality, discarding early stage, spent and young fish. Though discarding 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.

In 1991 the working group revised the catches, to account for possible underreporting. This was done by calculating the catch associated with the roe production in Ireland (ICES, 1991). In 1992, this procedure was reversed because of concerns that the roe production data used included material from stocks other than this one (ICES, 1992). The 1991 revision scaled up the working group catch in the period 1983/1984 to 1990/1991 by between 20 and 34%. Though this approach was not without its problems it could be an indicator of the scale of unaccounted landings in the roe fishery period (1983-1997). The realised catch in this period may have even higher, partly at least due to further unaccounted discarding. 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

Acoustic surveys of this stock have been carried out since 1990, with the exception of 1997. Up until 1996, two acoustic surveys were carried out annually. In 1997 there was no research vessel available to do the survey. Since 1998, usually only one winter survey was conducted (Table 4.3.1.1). The acoustic series was revised (ICES, 2006; Stock Annex). This series dates from 1995 and is presented in Table 4.3.1.2.

The acoustic survey of the 2006/2007 season was carried out in October 2006, on the Celtic Explorer, and was the most comprehensive in the current time series. The survey track began at the northern boundary of VIIj, covering the SW bays in zig-zags and parallel transects. The main broad scale survey in VIIg and VIIaS adapted a parallel transect design transect spacing of 4nmi in areas of low historic abundance and 2nmi spacing in areas of high historic abundance. The survey extended 78 nmi offshore (Figure 4.3.1.1a) to include the offshore trawl grounds. A detailed survey of autumn spawning grounds was undertaken after the main broad scale survey was complete. Spawning grounds were surveyed working in an east to west progression using either 1nmi parallel transects for larger grounds or detection using the vessels sonar for discreet spawning beds In total the combined survey transect length was 2 901 nmi.

The south western region contributed little herring to the overall estimate (Figure 4.3.1.1b). This area has previously been the dominant area for juvenile herring. Small amounts of herring were encountered during the broad scale survey, appearing in mixed schools over a relatively small geographical area. Traditional inshore herring spawning areas in VIIg and VIIaS were found to contain the greatest herring biomass, and made up 77% of the TSB.

The age structured index of biomass and catch numbers from acoustic surveys in this area, is shown in Table 4.3.1.2. In 2006/2007 the SSB estimate was 35 974 t.

The percentage age composition in the survey and the commercial fishery are compared in Figure 4.3.1.2. The survey displayed the same age distribution as the commercial fishery, both showing a strong predominance of 2-ringers and the very low abundance of 1 and 4-ringers. The survey showed somewhat lower numbers of 5 and 6-ringers and did not pick up any older fish.

4.3.2 Other surveys

Previous working groups examined the utility of other surveys as tuning indices. These surveys included the EVHOE quarter 4 IBTS survey, the Irish Groundfish quarter 4 IBTS survey and the UK (E&W) quarter 1 Portuguese high headline survey (ICES, 2005; 2006, Stock Annex). None of these surveys were particularly useful, all having noisy data and strong year effects. However the Irish survey did pick up the weakness of the 2001/2002 year class.

Existing surveys that may have utility for tuning the assessment are the DARDNI Groundfish Survey of the Irish Sea, Northern Ireland and the UK quarter 4 western GFS. It is known that juveniles from the Celtic Sea are present in the Irish Sea. If it is possible to distinguish these fish from native Irish Sea herring, in the AFBI survey then this survey could offer potential for a recruit index for Celtic Sea herring.

Given that this fishery is dependent on recruiting year classes, a recruit survey would be very helpful.

4.4 Mean weights-at-age and maturity-at-age

The mean weights in the catch over time are presented in Figure 4.4.1, with stock weights displayed in Figure 4.4.2. There has been an overall downward trend in mean weights at age since the mid-1980’s. The values for 2006/2007 for the important age groups are among the lowest in the series. This trend in mean weights at age is similar to those seen in VIaN, the Irish Sea and to a lesser extent, the North Sea.

Mean weights in the stock at spawning time were calculated from biological samples, excepting VIIg quarter 3. The numbers of fish sampled for 7 to 9 ring were low.

The current assessment considers 50% of 1-ringers to be mature, but the percentage is higher, at least in commercial catches. A new project to develop maturity ogives for this stock from catch and survey data started in 2006 (Lynch, in prep). This project will also examine long term changes in biological parameters. It is known that more than 50% of 1-ringers are mature in some years.

4.5 Recruitment

At present there are no recruitment estimates for this stock that can be used for predictive purposes. The 2003 recruitment was estimated as weak in the 2004 assessments, and appears to be the weakest in the series. There is little information in the assessment on the strength of recruitment in any year, because these 1-ringers are poorly represented in the catches.

A rudimentary analysis of recruitment, in comparison with long term geometric mean, over the time series suggests a historical pattern as follows:

1958-1972: Mostly above average, strong year class roughly every 5th year

1973-1980: Low recruitment, all below average.

1981-1995: Mostly above average, strong year class roughly every 5th year

1996-recent: Around average, with one very poor year class.

Variance around estimated recruitment is broadly similar in all periods.

The possibility that the stock has entered a new period of low productivity will be investigated further.

4.6 Assessment

This stock is scheduled for benchmark assessment in 2007. The last time the assessment of this stock was accepted by ACFM as a basis for management advice was 2001. In 2006, the working group continued to conduct exploratory assessments and no final assessment was put forward. The most important information considered by the 2005 working group was weakness of the 2001 year class.

4.6.1 Data exploration

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 4.6.1.1. It can be seen that 1-ringers, and the oldest ages, have a noisy signal, being poorly represented in the catches. 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 (Figure 4.2.1.1.). There was an increase in ratios in 1998, that seems quite abrupt. 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, showing raw total mortality Z per year class, were constructed for each year class in the catch at age data and for year classes in the acoustic time series where enough data were available. These are displayed in Figure 4.6.1.2, and the Z estimated over 2-7 ringer is shown in Table 4.6.1.1.. Total mortality was low for cohorts 1956 to 1964 (Figure 4.6.1.3.). 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. There is a marked secondary peak in all the cohorts, corresponding to the 2001/2002 fishing season. It is considered that this corresponds to the closure of Spawning Box C in that year, which shifted exploitation to the western part of the Celtic Sea where older fish are usually caught.

Cohort catch curves are shown for the catch at age data (Figure 4.6.1.4) and for the acoustic survey (Figure 4.6.1.5). 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.

4.6.2 Exploratory Assessments

In 2007, exploratory assessments were conducted to investigate a number of issues.

- Validity of separable assumption
- Shape of the exploitation pattern
- Choice of the separable period.
- WINBUGS Bayesian analysis
- Use of simple stage structured model

All these were performed on the revised acoustic series, that was described in ICES (2006).

ICA and XSA assessments

In each case, the same procedure as previous years was used to deal with the assumption that 50% of 1-ringers are mature. Therefore recruitment at 1-ring was replaced with geometric mean (1958-2004), and the SSB was recalculated based on the stock weights, maturity ogive and population numbers in the final year.

The ICA base case exploratory run was set using similar settings as in previous years. The separable period was set at 6 years (Table 4.6.2.1). This was considered valid because of the *a priori* assumption that the exploitation pattern shifted in 2001. This shift is visible in the cohort catch curves (Section 4.6.1 and Figure 4.6.1.2). After 2001, the summer feeding ground fishery also developed, and this is captured in this separable period. Shorter and longer separable periods were also tested. The residual pattern for the base case and the run with 8 year separable period are shown in Figure 4.6.2.1. There was no appreciable improvement in model fit when extending the separable period beyond the base case 6 years. Shorter separable periods were not considered informative based on the *a priori* assumption nor were they considered sufficiently long to achieve a good model fit. There were no differences in the survey index residuals (Figure 4.6.2.2).

It seems that exploitation pattern may not be flat topped. This is supported by the 2005 observation, from bycatch samples from demersal seine net vessels, that older herring were present but not well represented in the catches. Selection at oldest true age tested in ICA by screening over the range 1 to 0.7, relative to 3-ringer. Though the dome shaped pattern may be more appropriate, it did not improve the residual pattern (Figure 4.6.2.1).

Assessments of this stock have used 9-ring as the plus group. However, in recent years, few fish older than 6-ring occur in catches. Therefore a reduction in the plus group to 7-ring was investigated. Again, this did not improve the residual pattern (Figure 4.6.2.1).

A comparison XSA and ICA was conducted, because there were concerns about the validity of the separable assumption. The XSA was run with low shrinkage, whilst the ICA base case was run with no shrinkage. There were no diagnostics that could be used to choose one model over the other. The catchability residual pattern from the XSA shows strong year effects (Figure 4.6.2.3). However, HAWG considered that ICA to be more useful for this stock. This is because XSA was considered to be more influenced by the older ages, due to the weighting procedures. These older ages are not present in catches. On the other hand, ICA is more influenced by younger ages, and was considered more useful in this stock where younger ages are dominant. It was also considered that ICA is more robust to noise in the survey data.

None of these exploratory cohort analyses are better than any other, and all have poor residual patterns. This shows that there are inconsistencies with the input data, rather than the models themselves. The input data are simply very noisy and this cannot be dealt with by choosing one model over another. Therefore it is necessary to evaluate the information available, in the light of the model assumptions and also based on the exploration of the raw data.

Comparison of the recruitment, SSB and F from the trial assessment runs using XSA and ICA are presented in Figure 4.6.2.4. All runs of ICA show very similar trends over time and in the most recent years. Thus, the recent stock history is reasonably clear, whatever model or setting is used.

Changing the separable period did not change stock perception appreciably. Changing the selection pattern did not change trends in the outputs over time, but it did introduce a positive scaling factor on SSB over time. Reducing the plus group to 7-ring, did not change perception of the SSB or recruitment. However, it should be noted that the mean F trend is different, simply because it is calculated over 2-5 ring and not 2-7. This was to avoid including the plus group in the mean F calculation.

XSA displays the same trends in SSB and recruitment as the ICA base case. However, F in the final three years is higher from the XSA run, relative to ICA (Figure 4.6.2.4). Both models show very high F in 2003. This trend was also shown in the log catch ratio (Figure 4.2.1.1). XSA follows the trend in the log catch ratios, that continue to be high in the main ages (2-5) after 2003.

Catch Survey Analysis

An exercise using Catch Survey Analysis (CSA, Mesnil) was undertaken to explore the results of using a comparatively simple model to assess the state of the stock. The population dynamics is described by the following model:

$$N_{y+1} = (N_y + R_y)e^{-M} - C_y e^{-M(1-\tau)} \qquad [1]$$

where:

y : time step, typically annual. Years may be defined either on a calendar basis or as the interval between regular surveys. The year range is [1, Y].

Ny : population size, in number, of fully recruited animals at start of year y;

Ry : population size, in number, of recruits at start of year y;

Cy : catch in number during year y (known);

My : instantaneous rate of natural mortality (equal for both stages, assumed);

τ : fraction of the year when the catch is taken, e.g. 0 if the fishing season is early in the year, or 0.5 if the catch is taken midway through the year or, by resemblance with Pope's (1972) cohort approximation, evenly over the year.

Estimating the time series of Ny and Ry given the catches is the basic task of any assessment but, as with other methods, this requires additional information in the form of relative indices ny and ry of abundance for each stage, typically from surveys, which are assumed to be proportional to absolute population sizes Ny and Ry. The indices are deemed to be measured with some (log-normal) observation error:

$$N_y = q_n N_y \exp(n_y); \qquad y = 1, \; Y \qquad (2)$$

$$Ry = q_r R_y \exp(\delta_y); \qquad y = 1 \; Y\text{-}1 \qquad (3)$$

where:

qn and qr : catchability coefficients of fully-recruited and recruits, respectively, in the survey, supposed to be constant with time;

η and δ : normally distributed random variables.

A constraint must be imposed whereby the survey catchability of the recruits is some fraction s of that of the fully-recruited:

$$S = q_r/q_n \qquad (4)$$

Data used (Table 4.6.2.2) were the catch numbers from 1995 to date, the stock weights at ages 2 and 3+, the acoustic survey series of the numbers of the 2 year-old group (taken as recruits) and the numbers of age 3 and older, fully recruited ages (Table 4.6.2.2). Natural mortality (M) was estimated as a weighted mean based on the stock numbers at age 2+ matrix and equal to 0.21.

The model was run assuming that catches take place in the middle of the year. As it appears that the catchability ratio *s* cannot be estimated together with other parameters, the model was run iteratively for a set of values of *s*. A minimum in the sum of squares was found for $s = 0.6$. Results presented correspond to the parameter scenario yielding the best fit.

The model estimated total biomass for the period 1995 – 2006 is shown in Figure 4.6.2.5. The SSB trajectory as estimated by ICA base case run shows a similar biomass level and declining trend. However, CSA is suggesting a further decline in biomass in the recent couple of years. Comparison between the estimated numbers at age scaled by their corresponding catchabilities and the survey indices suggests a difficulty in fitting the data given the number of missing observations (Figure 4.6.2.5).

It should be noted that CSA is not directly comparable with VPA models, and that the age group that is termed "recruits" at 2-ring is not the same as recruitment (1-ring) in the VPA analysis. It should also be noted that 2-ring is the first fully selected age in the acoustic series and therefore the estimated ratio of catchability (s) between 2- and 3+ in CSA may not be appropriate. However, this effect could be associated with M, which is expected to be correlated with the estimation of S.

However the CSA run does show the same overall downward trends as the VPAs. The overall trend, for a fall in biomass since 1997 is supported by CSA.

Exploration of Celtic Sea assessment with WINBUGS

To explore the Celtic Sea data set further and to explicitly incorporate error in the assessment a Bayesian model was set up in WINBUGS (see section 1.6). The code is included in Table 4.6.2.3. The model has been set up as a statistical catch at age approach for the period where survey data is available (1995 to 2006) The early part of the series is derived from a VPA with starting numbers from 1995. The catch at age is fitted with a logistic selection function that can change from year to year. The example shown has allowed only a slow change in selection.

The results of an assessment run are illustrated in Figure 4.6.2.6 and indicate considerable uncertainty in SSB in the terminal year with signs that $F_{2\text{-}5}$ has reduced in recent years. The flexible selection pattern shows a twist in selection over years, with a steeper logistic curve in later years compared to earlier years. The scatter plots of modelled catch against observed catch and modelled survey against observed survey (Figure 4.6.2.7) show that the catch fits more closely in the model than the survey.

This model exploration is very preliminary, there has been no evaluation of the influence of priors, though they are thought to be uninformative, and only a limited range of flexible selection has been tested.

Estimates of uncertainty

This approach does show the large uncertainty around F since the mid 1990s. This is also displayed in the uncertainty analaysis from the ICA base case (Figure 4.6.2.6). Although mean F is calculated over different age ranges between WINBUGS and ICA, it is clear that median F estimates for 2002 were lower than other recent estimates. Also, F in subsequent years may be declining, though there is very large uncertainty. Most recent SSB is very poorly estimated.

The uncertainty analysis, based on bootstrapping of the ICA base case run , shows that uncertainty began to increase very markedly from 1995 onwards. This is most likely explained by inconsistencies between cohort representation in the survey and the commercial catch at age data. These uncertainty estimates are based on bootstrapping of the variance covariance matrix. The lack of uncertainty in earlier years is because this is a traditional VPA and not because there was less uncertainty in that period.

Exploration of recruitment dynamics

The trend in recruitment anomalies (Ra) of Celtic Sea herring was analysed in order to conduct a rudimentary analysis of the effect of environmental conditions (SST and NAO winter index) on recruitment dynamic. The approach used here has been advocated by recent works of Stige et al. (2006), and Cardinale and Hjelm (2006):

The logarithm of the ratio between the annual numbers of recruits and the SSB is considered a robust proxy for the recruitment success (Rs) of a stock and ideal for disentangling environmental to adult biomass effect on recruitment (Beverton 2002, Cardinale and Hjelm 2006, Stige et al. 2006). According to the models (Ricker 1954) and Beverton and Holt (1995), this ratio is a linear function of SSB:

(1) ln (R/SSB) = a + b SSB

where other effects can be modelled as predictors in (1).

Therefore, the variability around the relationship between Rs and SSB can be considered as a proxy for recruitment anomalies (Ra) and assumed to be partially determined by the stochasticity in the physical environment (Beverton 2002) as well as other biotic factors. The rationale behind this approach is mathematically formalized in the classical Ricker (1954) or Beverton and Holt (1995) recruitment functions where the number of recruits in a fish species is generally related to egg number or SSB, a proxy of egg production (Myers and Barrowman 1996) and these functions are in turn based on sound ecological mechanisms (e.g. cannibalism and predation).

Thus, after fitting (1), the standardized residuals (R_a) for this stock were estimated (Figure 4.6.2.9). There was a consistent period of low recruitment in the 1970s, and a consistent period of high recruitment in the early 1980s. The current period is characterised by more variable recruitment around the mean, and this may be more like the situation in the 1960s, though at that time there was a more positive tendency in the anomalies. Thus, the current period is either similar to the 1960s, but with less extremes, or else it is a less fluctuating new state.

Beverton and Holt (1995), Ricker (1954) and Hockey Stick models were applied to the observed SSB-R relationship and compared with the standardized residuals against Ra. Residual patterns were similar in all cases (Figure 4.6.2.9).

Time series of SST for the Celtic Sea were obtained from Rayner at al (2003). SST data for peak spawning (December), in the winter (January-February) and during the entire spawning season (September to March) were available. There was no discernible relationship between the residual patterns with SST or the Hurrel Index of NAO over the time series.

The analysis of productivity of herring stocks (Section 1.8.3) shows that numbers of recruits per spawner has remained quite constant throughout the series. This is in contrast to Irish Sea and North Sea herring that both displayed larger changes in productivity (Figure 1.8.3.2c). The results of this analysis suggest that median long term yield in this stock would not be higher than 17 000 t, assuming that the stock recruit relationships used are truly representing the reality. It should be pointed out that this is a preliminary analysis and that stochastic simulations should be carried out to investigate the risk associated with such a catch policy. However it can be concluded that the management committee objective of building the stock to a level concomitant with catches of 20 000 to per year is not achievable. This accords with yield per recruit calculations conducted by Burd and Bracken (1966) that suggested long-term yields of between 12 000 and 15 000.

Conclusions

The stock history was divided into a number of time periods to aid a long term understanding of the stock dynamics (Table 4.6.2.4). 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. There is a clear trend for fewer older fish in the catch than in earlier times. Only the cohorts from before the stock collapsed and a few from the late 1980s contributed many older fish 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. The period of sustained below geometric mean recruitment only occurred once in the stock history, from roughly 1973 to 1980. The periods before and after that were more variable though producing high recruitments. The current recruitment pattern seems to oscillate around geometric mean. The 2001 year class was very weak and the 2003 year class seems very strong. If the stock is to recover, this recent cohort should be allowed to contribute to the stock in the next years.

Possible bias may exist in the data in the above history, due to unaccounted mortality. In particular, during the roe fishery from 1983 to 1997, realised catches would have been higher and though the actual catch in more recent periods is not without error, but accuracy is considered to have improved a lot.

Though no final assessment run was conducted by the working group, it is clear that there is an overall downward trend in SSB in recent years. There is a retrospective bias, so that the final SSB is often overestimated. There was an upturn in SSB and a downturn in F in 2002, but the trend was continued after that. F was high in 2000 and again in 2003. However the uncertainty in these F estimates are very large. The 2001 year class was the lowest in the series. Now that 4 observations of this cohort are available in the data, this confirms earlier perceptions of the weakness of this year class. Uncertainty in estimated recruitment was high from 1997 to 2002, but since the uncertainty is much lower, lending belief to estimates of the fully recruited year classes.

The systemic problem in this assessment remains: that the incoming year class is not well estimated, in the absence of a recruit index. The 2003 year class seems very strong however. In the absence of recruit survey information, it is necessary to deal with the data available and to use this to produce management advice. Though current stock size is unknown and F poorly estimated, it is still possible to put forward some information basis of advice. Trends in mortality have increased in recent years, SSB has declined since the mid 1990s, condition of fish has declined. Though the absolute SSB level is unknown it probably below Bpa and possibly below Blim.

The stock has not displayed strong changes in productivity (recruits per spawner) over time. Nor is there any evidence of an environmental driven regime shift, in contrast to the North and Irish Sea. However recruitment dynamics are somewhat different to previous periods, with less variability.

4.7 Short term projections

There was no final assessment and consequently no short term projections.

4.8 Medium term projections

A yield per recruit was conducted in 2007, see Figure 4.8.1. $F_{0.1}$ and F at 35% of spawners per recruit are both estimated as 0.19. F_{med} is estimated at 0.28.

4.9 Precautionary and yield based reference points

Biological reference points were discussed in detail at the working groups in the late 1990s (ICES 1998; ICES 1999). A summary of this discussion was presented in the 2002 HAWG report (ICES 2002). The SGPRP (ICES, 2003) reviewed the methodology for the calculation of biological reference points, and applied a segmented regression to the stock and recruit data from the 2002 HAWG assessment, finding a breakpoint at 61 306 t. This change point was considered very high. HAWG decided that the first priority for this stock should be to achieve a stable assessment and that once this was done the reference points would be reinvestigated.

There is still considerable instability in the assessment, so there is no basis for a revision of reference points at this point. $\mathbf{B}_{pa}$ 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.

A recent management strategy simulation (STECF, 2006; Kelly and Campbell, 2006) estimate the break point in a hockey stick stock recruit model to be around 44,000 t. This suggested that the definition of PA points for this stock were unsuitable e.g. B_{pa} should be B_{lim}, and that an HCR should be devised with a trigger biomass far enough above Blim to prevent recruitment impairment given assessment uncertainty. It is important to differentiate between a breakpoint for the purposes of harvest strategy development, and precautionary reference points for the purposes of advice.

4.10 Quality of the Assessment

No assessment was conducted, and the basic data and exploratory analyses are presented above. However to investigate possible retrospective patterns in the past few years, a retrospective analysis was created using the ICA base case. This is presented in Figure 4.10.1. There is no appreciable retrospective pattern in F. The ICA base case tends to over estimate recruitment and SSB in the terminal year, though it should be noted that these estimates are always adjusted by using geometric mean for 1-ringers.

Though no assessment is put forward all the trial assessments show the same downward trend, that the stock has declined since the mid 1990s, to a lower level.

4.11 Management Considerations

Though this was a benchmark assessment, no final assessment was conducted, despite a lot of exploratory work. However, there are certain pieces of information that can be obtained from the available data, that can be used to frame management considerations.

Recent recruitment has fluctuated around the mean, with a poor and an evidently good year class. SSB has shown an overall downward trend since 1994. The truncation of age groups in the catches, the decreasing SSB, increasing F in recent years and the poor recent recruitment (2001) are causes for concern. There seems to be one very good recruitment (2003) must be utilised to help rebuild the stock. The stock is probably at as low a level as when it previously collapsed. It is not possible to estimate current stock size, with precisions. Such poor precision should not be the main consideration for management. Instead, management should try to reverse the overall trend, and bring the stock back to a higher overall level.

HAWG advocates a structured approach to the development of a rebuilding plan for this stock. Much useful work on this subject has been presented in the recent SGMAS report, and it is proposed to proceed along these lines. In particular attention should be placed on the knowledge base available. The most important issues are considered to be:

- Stock characteristics, historically and in the present period
- Decreases over time in growth and condition of the fish
- There is a time lag between the estimation of incoming year classes in the assessment, and their appearance in the fishery.
- Apparent lack of changes in environmental regime
- Development of new management objectives, since the current aspiration now appear unattainable.
- Interact with stakeholders concerns, fleet segments and processing sector issues, management issues.

It is hoped to develop a rebuilding plan in the next year. This will be developed with stakeholders and following best practice as outlined in SGMAS.

Table 4.1.3.1. Celtic Sea and Division VIIj herring. Landings by quota year (t), 1988–2006. (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
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

Table 4.1.3.2. Celtic Sea & Division VIIj herring landings (t) by assessment year (1st April–31st March) 1988/1989-2006/2007. (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
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

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

Table 4.2.1.2. Celtic Sea & Division VIIj herring. Length frequency distributions of the Irish catches (raised numbers in '000s) in the 2006/2007 season in the Celtic Sea and VIIj fishery.

	2006					2007		
	7g Q3	7aS Q4 Harbour	7aS Q4 CS	7g Q4	7J Q4	7aS Q1 Harbour	7g Q1	Totals
15		2						2
15.5								
16								
16.5								
17		3						3
17.5								
18								
18.5								
19			6			3		9
19.5		2	6					7
20	13	6	23	3		9	8	62
20.5	63	33	12	3	10	45	16	182
21	234	128	138	16	23	75	164	777
21.5	537	298	467	27	39	192	328	1887
22	1301	615	1101	117	29	194	781	4139
22.5	1692	627	1331	155	8	285	1398	5496
23	2280	776	1648	205	2	295	1765	6972
23.5	1857	630	1660	213	8	274	1640	6282
24	2147	466	1377	187	6	219	1922	6324
24.5	2141	389	1187	165	6	184	1562	5635
25	2078	299	686	157	8	109	1297	4634
25.5	1465	236	444	107	33	64	781	3130
26	1661	268	254	91	33	72	883	3260
26.5	1983	217	277	72	81	36	641	3306
27	1471	151	167	77	122	30	656	2675
27.5	777	58	69	43	130	8	359	1444
28	366	27	63	21	147		164	789
28.5	152	8	17	11	97		31	316
29	44	2		3	25		16	89
29.5	32				10		16	58
30	6				4			10

Table 4.2.3.1 Celtic Sea & Division VIIj (2006/2007). Sampling intensity of commercial catches.

ICES area	Year	Quarter	Landings (t)	No. Samples	Aged	. Measured	Aged/1000 t
VIIg	2006	3	2957	13	893	3532	302
VIIg	2006	4	193	2	170	627	882
VIIg	2007	1	1624	9	658	2494	405
Sub-total			4773	24	1721	6653	1589
VIIaS_inside harbour	2006	4	568	30	1159	3328	2041
VIIaS_outside harbour	2006	4	1186	13	751	1897	633
VIIaS_inside harbour	2007	1	224	4	250	693	1116
Sub-total			1978	47	2160	5918	3790
VIIj	2006	4	135	2	152	398	1122
Total Celtic Sea			6887	73	4033	12969	6501

Table 4.2.3.2 Celtic Sea & Division VIIj herring. 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 estimate**	**Skipper 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 4.3.1.1. Celtic Sea & Division VIIj herring. 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.

Season	No.	Type	Old SSB	Revised SSB
1990/1991	**2**	**Autumn and winter spawners**	**91**	**-**
1991/1992	**2**	**Autumn and winter spawners**	**77**	**-**
1992/1993	**2**	**Autumn and winter spawners**	**71**	**-**
1993/1994	**2**	**Autumn and winter spawners**	**90**	**-**
1994/1995	**2**	**Autumn and winter spawners**	**51**	**-**
1995/1996	**2**	**Autumn and winter spawners**	**114**	**36**
1996/1997	**1**	**Autumn spawners**	**146**	**151**
1997/1998	**-**	**No survey**	**-**	**-**
1998/1999	**1**	**Autumn spawners**	**111**	**100**
1999/2000	**1**	**Feeding phase**	**23**	**-**
1999/2000	**1**	**Winter-spawners**	**26**	**-**
2000/2001	**2**	**Autumn and winter spawners**	**32**	**20**
2001/2002	**2**	**Pre-spawning**	**74**	**95**
2002/2003	**1**	**Pre-spawning**	**39**	**41**
2003/2004	**1**	**Pre-spawning**	**86**	**20**
2004/2005	**1**	**Pre-spawning**	**10**	**-**
2005/2006	**1**	**Pre-spawning**	**30**	**33**
2006/2007	**1**	**Pre-spawning**	**36**	**36**

Table 4.3.1.2. 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
0	202	3	-	0	-	25	40	0	24	-	2	-
1	25	164	-	30	-	102	28	42	13	-	65	21
2	157	795	-	186	-	112	187	185	62	-	137	211
3	38	262	-	133	-	13	213	151	60	-	28	48
4	34	53	-	165	-	2	42	30	17	-	54	14
5	5	43	-	87	-	1	47	7	5	-	22	11
6	3	1	-	25	-	0	33	7	1	-	5	1
7	1	15	-	24	-	0	24	3	0	-	1	-
8	2	0	-	4	-	0	15	0	0	-	0	-
9	2	2	-	2	-	0	52	0	0	-	0	-
Abundance	469	1338	-	656		256	681	423	183		312	305
SSB	36	151		100		20	95	41	20		33	36
CV	53	26		36		100	88	49	34		48	35

Table 4.6.1.1. Celtic Sea and VIIj herring.

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 4.6.2.1. . Celtic Sea and VIIj herring. Settings used in exploratory VPA type assessments.

Name	ICA Base case	ICA 7+	ICA Sep=8	ICA S=0.7	XSA low
Separable period	**6**	**6**	**8**	**6**	**-**
Selection at oldest true age	**1**	**1**	**1**	**0.7**	**-**
Plus group	**9 ring**	**7 ring**	**9 ring**	**9 ring**	**9 ring**
Mean F age range	**2-7**	**2-5**	**2-7**	**2-7**	**2-7**
Shrinkage	**No**	**No**	**No**	**No**	**Low (1.5)**

Table 4.6.2.2. Celtic Sea and VIIj herring. Input data for CSA trial assessment. CatRec and CatFul refer to catch numbers at 2-ring and 3+ ring respectively. Urec and Ufull refer to survey abundance at 2-ring and 3+ ring respectively. Wrec and Wfull refer to weights in the spawning stock for 2-ring and 3+ ring respectively.

Year	CatRec	CatFull	Urec	Ufull	Wrec	Wfull
1995	9450	71590	157.3	85.2	0.126	0.173008
1996	3476	68496	795.3	375.6	0.118	0.15978
1997	3849	101520			0.124	0.152527
1998	5818	75959	186.3	440.4	0.121	0.164057
1999	14274	79548			0.12	0.164147
2000	9953	46029	111.9	15.6	0.111	0.165149
2001	15724	49789	186.7	426.2	0.107	0.150619
2002	3495	27318	185.2	196.9	0.115	0.150171
2003	2711	51554	61.7	83	0.1	0.137398
2004	4276	78895			0.127	0.14077
2005	15419	34276	137.1	110	0.103	0.147259
2006	1460	22642	210.5	73.3	0.104	0.136832

Table 4.6.2.3. Celtic Sea and VIIj herring. WINBUGS code used for exploration of Celtic Sea herring

```
model
for (i in 1:I3) {
FAV[i] ~ dunif(.001,2)  # i1 number of years of catch
# selection function priors - alternative to current selection
S1C~dunif(0.1,6)                # catch ojive 50% age
S2C~dunif(0.2,6)                # catch ojive 95% age - S1C

#  Define  the  priors  for  survey  Q    values  coefficients  of
proportionality
for (j in 1:ACA) {
QAC[j]~dunif(.0001,20)     # fit 1.36,
for (i in 1:(I3-1))  {
Nstar[i] ~ dnorm(1000,.000000000000064)
for (i in 1:I2){
Nin[i]<-1000*pow(10,i/5)
Nvar[i]<-.00001/pow(Nin[i]/4,2)
Nstar2[i] ~ dnorm(Nin[i],Nvar[i])

# Define the observation priors
tauy ~ dgamma(0.001,0.001)
sigy <- pow(1/tauy,.5)
# separate variance for Acoustic survey if required
#tauAC ~ dgamma(0.001,0.001)
#sigAC <- pow(1/tauAC,.5)
# constrained flexibility in selection – use next line to be fully
flexible
taus <- 100  #   vary to change flexibility of separable model (low
values increase flexibility)
#taus ~ dgamma(0.001,0.001)
sigs <- pow(1/taus,.5)

################# main algorithm
## Selection curve as 2 parameter logistic function with random walk –
constrained to limit flexibility
S1CV[1]<-S1C
S2CV[1]<-S2C
for (i in 2:I3) {
ch1[i]~dnorm(0,taus)
ch2[i]~dnorm(0,taus)
ch2s[i]<-max(0.05,ch2[i])
S1CV[i]<-S1CV[i-1]+ch1[i]
S2CV[i]<-S2CV[i-1]+ch2s[i]
for (i in 1:I3 ){
for (j in 1:I2) {
FA[j,i]<-1/(1+exp(-2.944439*(age[j]-S1CV[i])/(S2CV[i])))
# selection pattern for catch
FAP[i]<-1/(1+exp(-2.944439*(agep-S1CV[i])/(S2CV[i])))

######### population component of the likelihood
# Define the system process for the population data
# stop any negative population numbers
for (i in 2:I3) {
N[1,i]<-max(Nstar[i-1],10)
for (i in 1:I2) {
N[i,1]<-max(Nstar2[i],10)

### set op selection period first
# start with matrix of Fs

for (i in 1:I3){
for (j in 1:I2){
F[j,i]<-FA[j,i]*FAV[i]            # fishing mortality
INTF[j,i]<-F[j,i]/FA[j,i]
FP[i]<-FAP[i]*FAV[i]   # fishing mortality
#Calculate N for ages 2 and greater and years after first year
```

```
for (i in 2:I3){
for (j in 2:I2){
N[j,i]<-N[j-1,i-1]*exp(F[j,i]+M[j,i])
for (i in 1:I3){
NP[i]<-CANUMP[i]*(FP[i]+MP[i])/FP[i]/(1-exp(-FP[i]-MP[i]))

#Then VPA part  start with Ns age 0 to max age minus 2
#Then get Fs from Ns
# Mean F to set F on oldest real age and plus group
for (i in (I3+1):I1){
for (j in 2:(I2)){
N[j,i]<-N[j-1,i-1]*exp(M[j,i])+CANUM[j,i]*exp(M[j,i]/2)
F[j,i]<-log(N[j,i]/N[j-1,i-1])-M[j,i]
INTF[j,i]<-F[j,i]/FA[j,I3]
# calculate mean F and use selection to get F oldest real age and plus
group
FAV[i]<-mean(INTF[2:(I2-1),i])
# set Fs
F[1,i]<-FAV[i]*FA[1,I3]
FP[i]<-FAV[i]*FAP[I3]
# then set Ns for oldest ages
N[1,i]<-CANUM[1,i]*(F[1,i]+M[1,i])/F[1,i]/(1-exp(-F[1,i]-M[1,i]))
NP[i]<-CANUMP[i]*(FP[i]+MP[i])/FP[i]/(1-exp(-FP[i]-MP[i]))
# now cycle back in years

## Observation / objective function
for (i in 1:I1){
for (j in 1:I2){
SSBa[j,i]<-N[j,i]*exp((-F[j,i]*FPROP[j,i]-
M[j,i]*MPROP))*WEST[j,i]*MATPROP[j,i] ## at spawning time
SSB[i]<-sum(SSBa[,i])+NP[i]*exp((-FP[i]*FPROPP[i]-
MP[i]*MPROP))*WESTP[i]*MATPROPP[i] ## at spawning time
Fbar[i]<-(F[4,i]+F[5,i]+F[6,i]+F[7,i])/4  ####  hard  wired  1-4  here
should be flexible

## Acoustic survey
for (i in 1:ACY) {
for (j in 1:ACA) {
ModAC[j,i]<-  log(QAC[j]*N[ACAind[j],ACYind[i]])       #    log  N  with
constant multiplier at correct time of year set to 0 - 1st jan
ObsAC[j,i]~dnorm(ModAC[j,i],tauy)
# 2 Catch  ##### assuming 25 survey values !!!!
for (i in 1:I3){
for (j in 1:(I2-1)){
ObsCatchMod[j,i]<-log(N[j,i]*F[j,i]/(F[j,i]+M[j,i])*(1-exp(-F[j,i]-
M[j,i])))
ObsCatch[j,i] ~ dnorm(ObsCatchMod[j,i],tauy)
# End of model
```

Table 4.6.2.4. Celtic Sea and VIIj herring. Time periods in the history of the stock.

	1958-1972	1973-1978	1978-1980	1981-1983	1983-1995	1996-1997	1998-2004	2004-2007
MW (2-ring) kg	0.146	0.181	0.179	0.158	0.135	0.121	0.115	0.112
ML 2-ring (cm)	~25.5	27.3	27.2	26.85	-	-	-	23.5
Z (cohort catch curve)	0.22 to 0.93	0.42 to 1.12	0.74 to 0.93	0.62 to 0.74	0.49- to 0.89	88 to1.01	~0.48	-
GM recruitment 10^6	493	180	168	587	534	484	314	-
Recruitment anomaly	-1.3 to 2.3	-1.2 to -0.7	-0.4 to 0.8	0.2 to 1.6	-1.2 to 2.4	-0.8 to 0	-1 to 0.7	-
SSB (000 t)	79 to 126	29 to 59	28- to 0	32 to 63	63 to 81	52 to 59	22 to 44	?
F	0.16 to 0.64	0.34 to 0.61	0.34 to 0.65	0.59 to 0.8	0.36 to 0.95	0.46 to 0.58	0.4 to 1.2	?

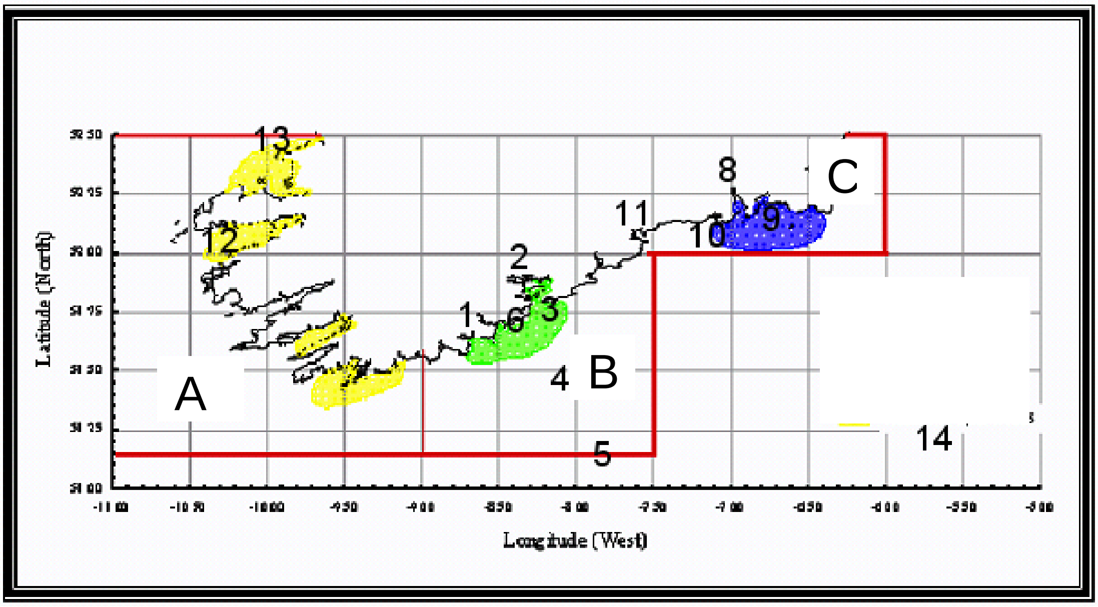


Figure 4.1.1.1a. Celtic Sea and VIIj herring, areas mentioned in the text and spawning boxes A, B and C, south of Ireland. One of these boxes is closed each season, under EU legislation. 1 Courtmacsherry, 2 Cork Harbour, 3 Daunt Rock, 4 Kinsale Gas Field (Rigs), 5 Labadie Bank, 6 Kinsale, 8 Waterford 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.

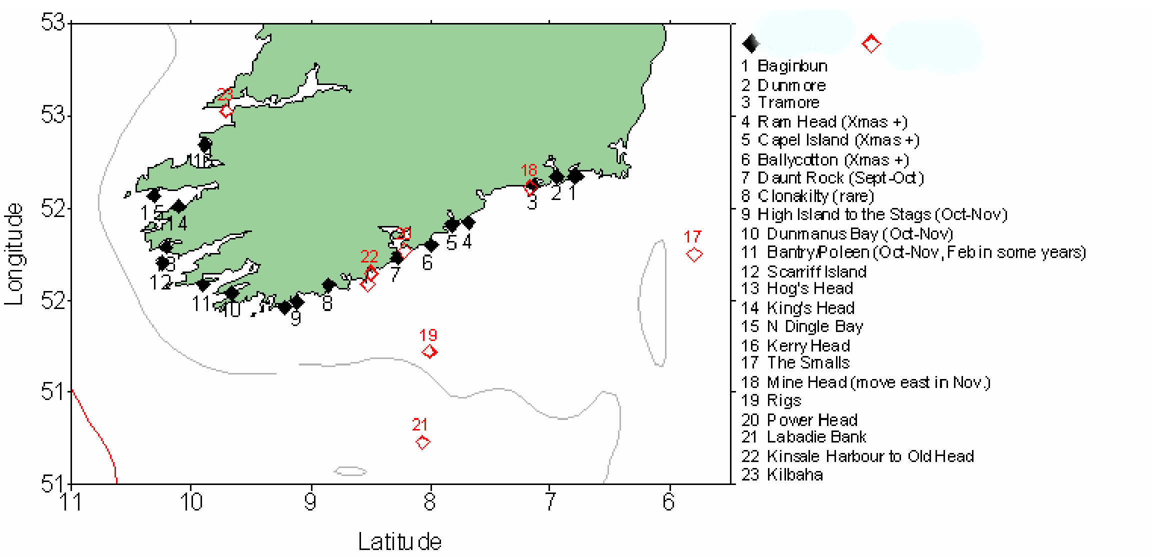


Figure 4.1.1.1b. Celtic Sea and VIIj herring, Location of non-spawning (open symbol) and spawning (closed symbol) herring in the Celtic Sea and SW of Ireland. Based on expert fishermens' personal information.

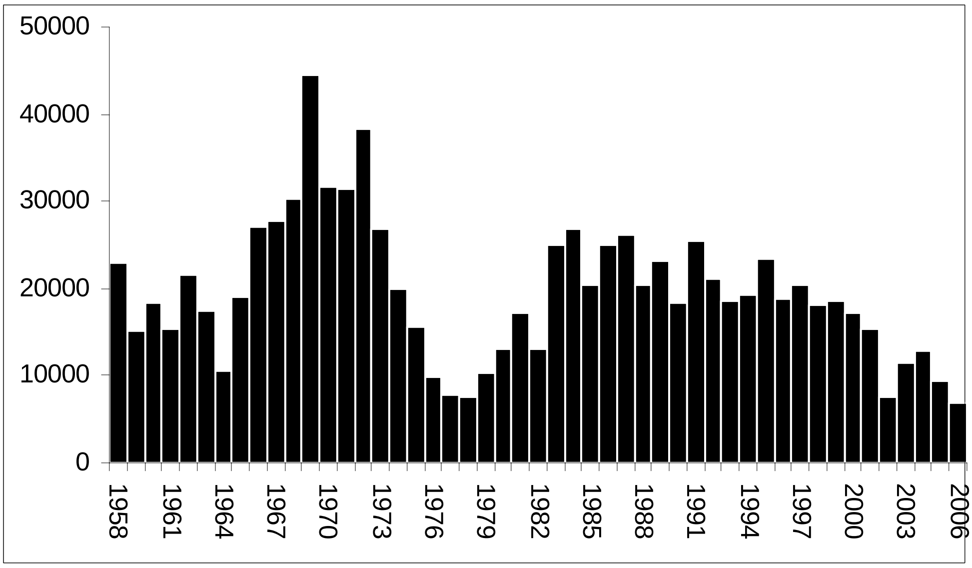


Figure 4.1.2.1 Celtic Sea and Division VIIj – working group estimates of herring landings per season.

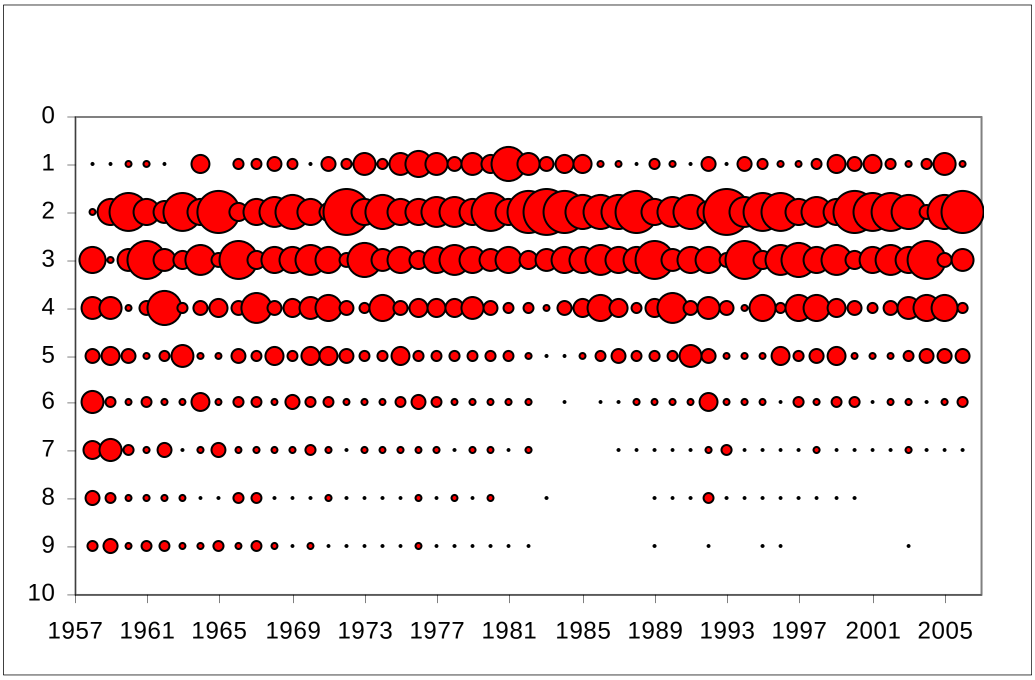


Figure 4.2.1.1. Celtic Sea and Division VIIj. Catch numbers at age standardised by yearly mean.

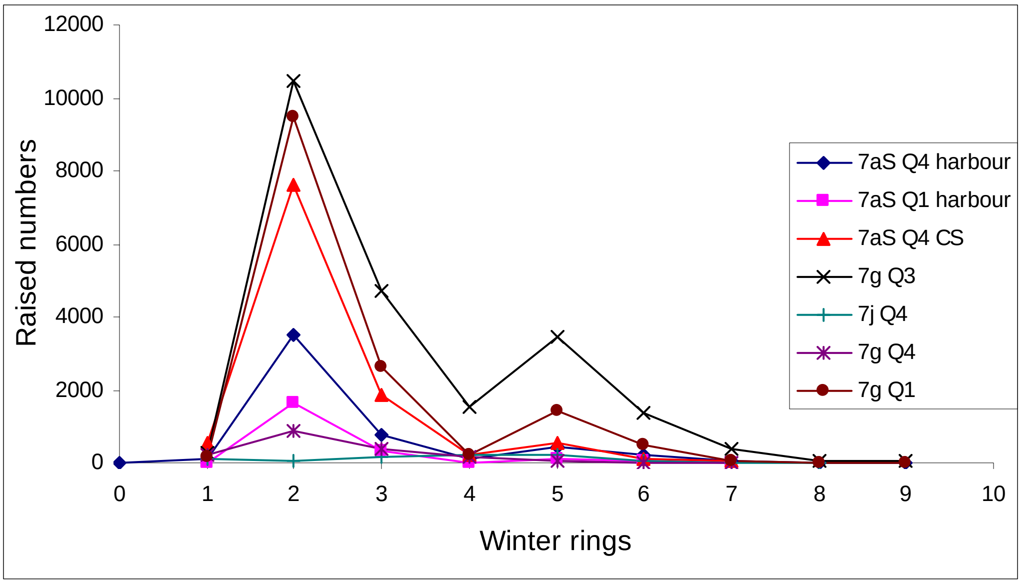


Figure 4.2.1.2. Celtic Sea and Division VIIj – percentage age composition by metier (ICES Division and quarter).

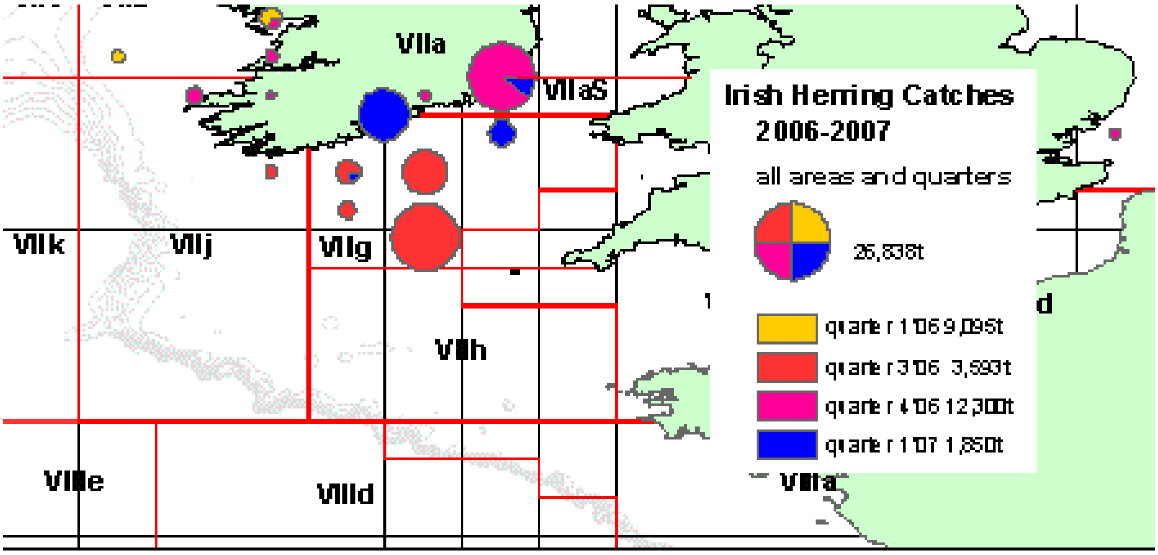


Figure 4.1.3.2. Celtic Sea and VIIj herring. Irish official herring catches by statistical rectangle in 2006/2007.

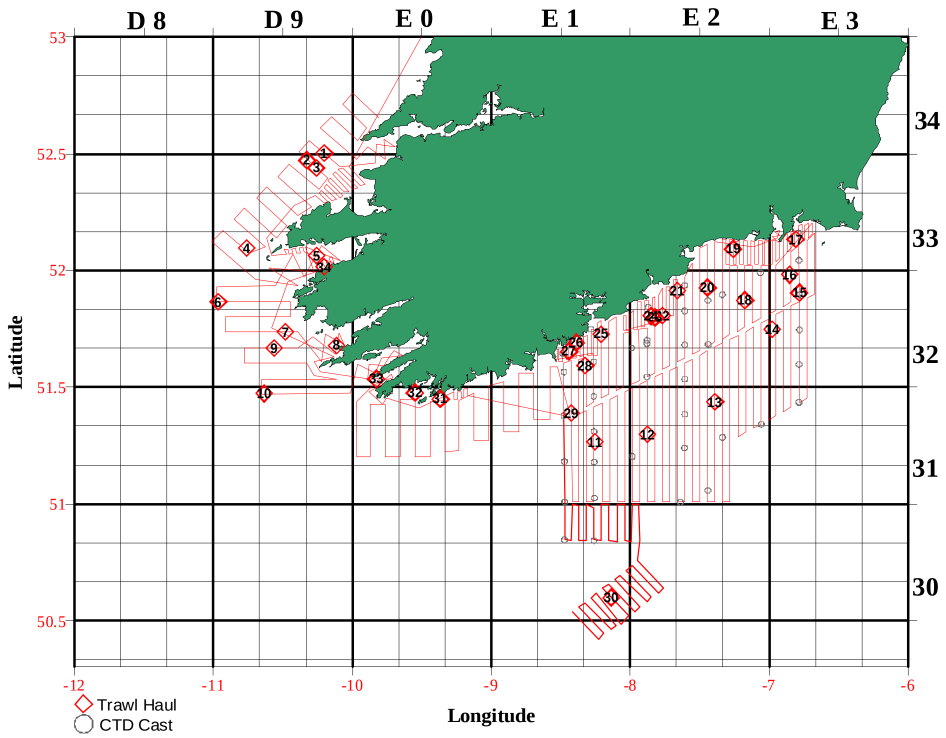


Figure 4.3.1.1a Celtic Sea and VIIj herring. Celtic Sea and Division VIIj acoustic survey 2006, survey track and haul positions from acoustic survey, October 2006.

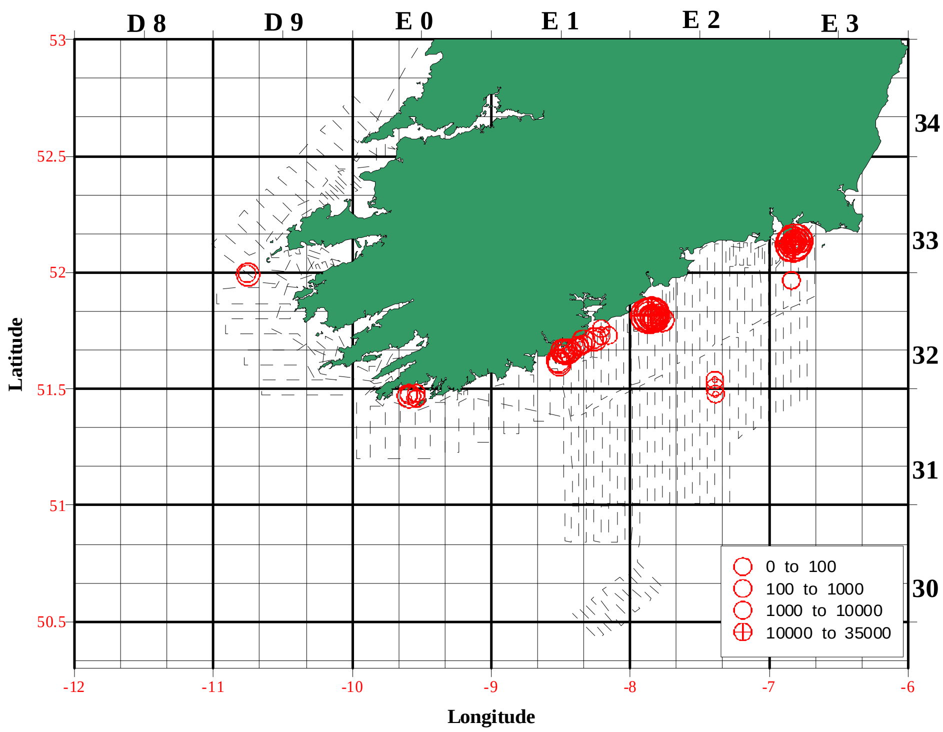


Figure 4.3.1.1b. Celtic Sea and VIIj herring. Celtic Sea and Division VIIj acoustic survey 2006, total Sa values attributed to herring.

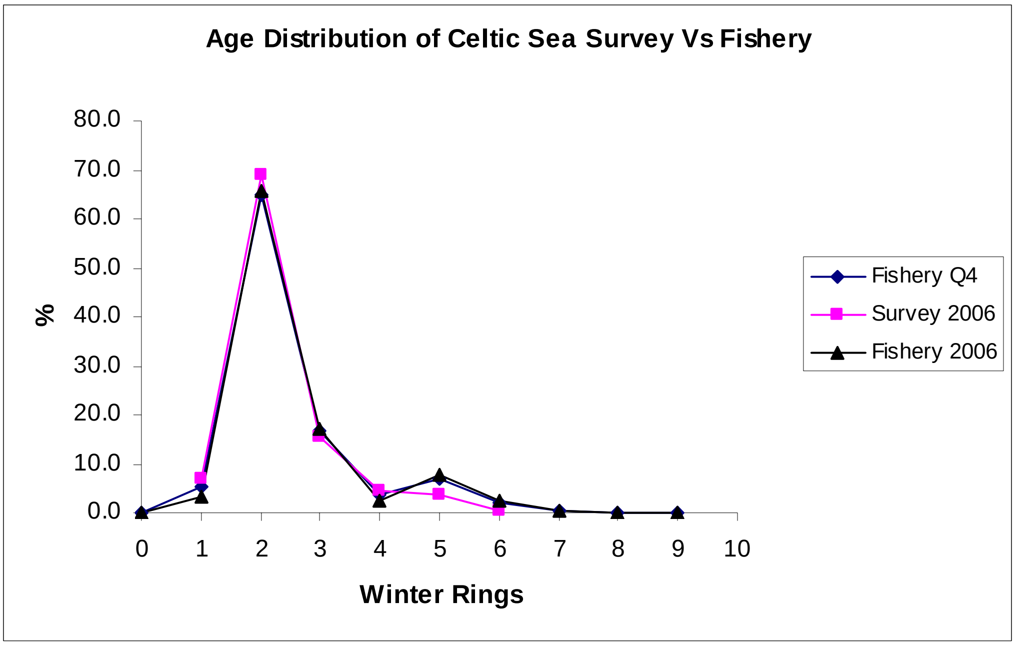


Figure 4.3.1.2. Celtic Sea and VIIj herring. The percentage age composition in the survey and the commercial fishery 2006.

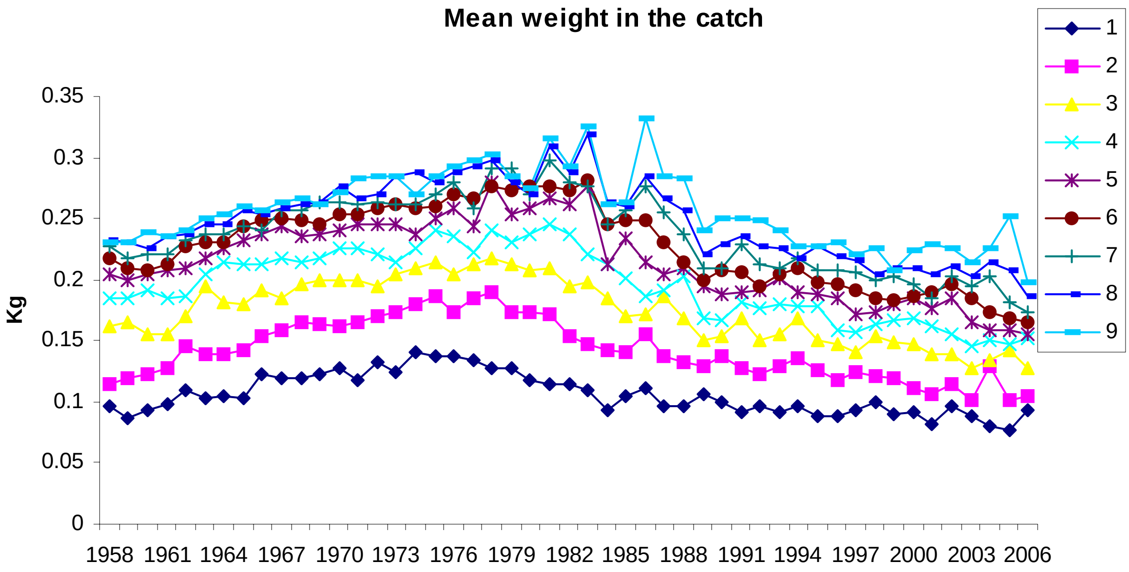


Figure 4.4.1. Celtic Sea and VIIj herring, trends over time in mean weights in the catch.

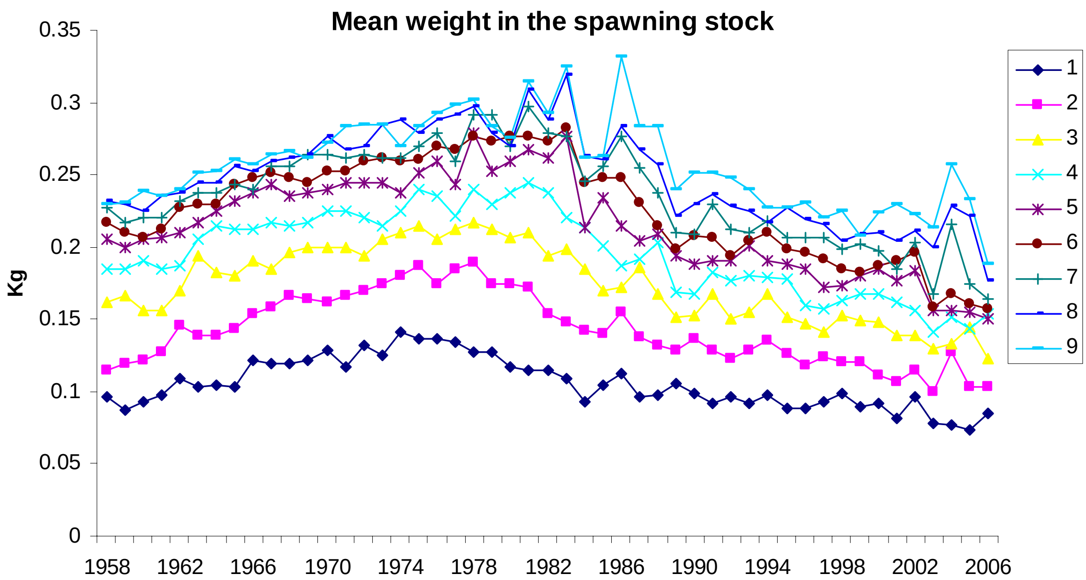
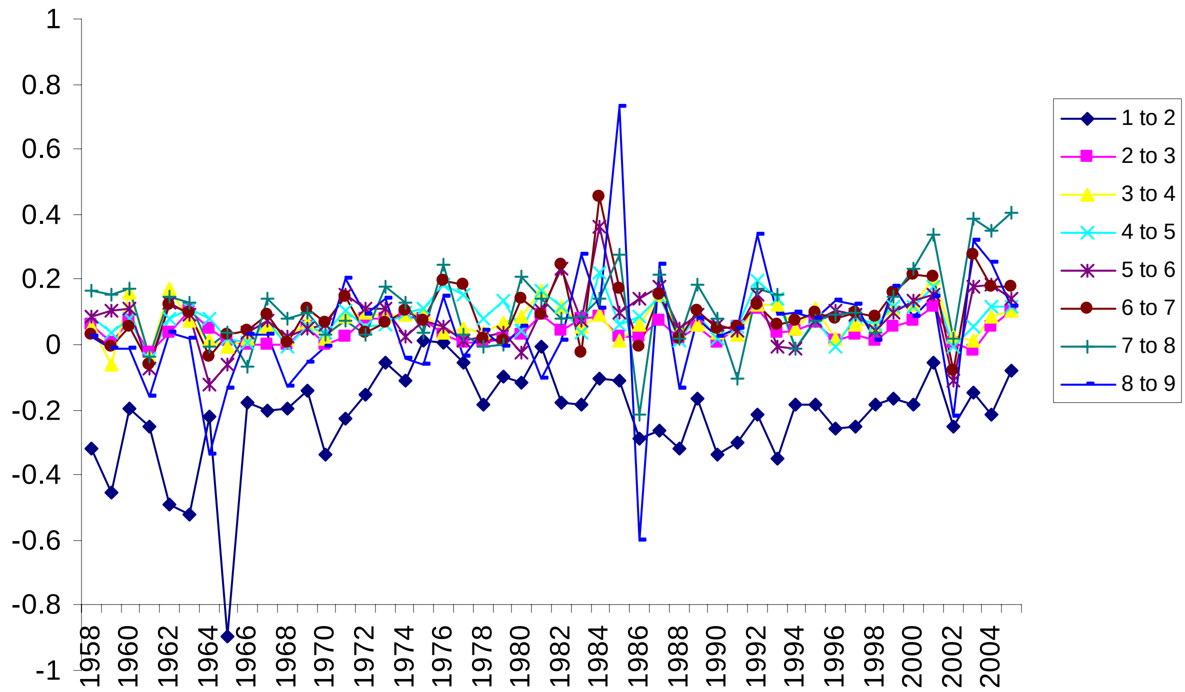


Figure 4.4.2. Celtic Sea and VIIj herring, trends over time in mean weights in the stock at spawning time.



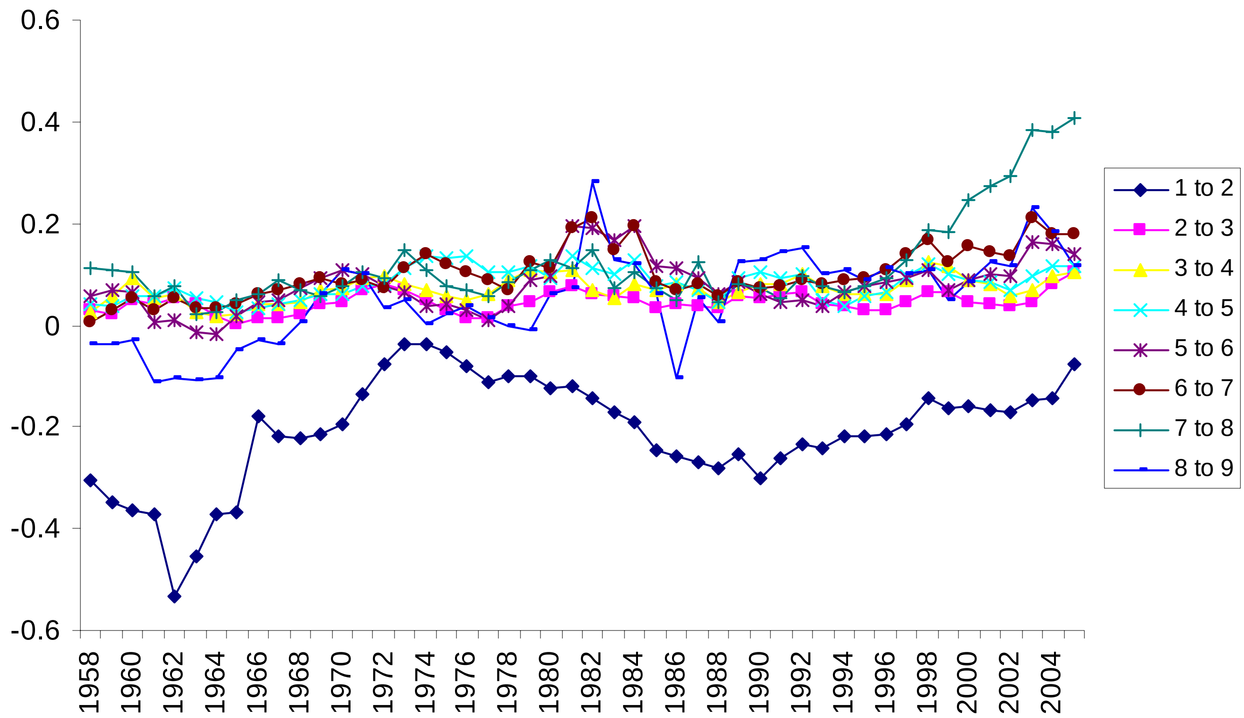


Figure 4.6.1.1. Celtic Sea and VIIj herring. Log catch ratios (above) and log catch ratios smoothed with a 4 year moving average for each age group for the time series 1958-2006.

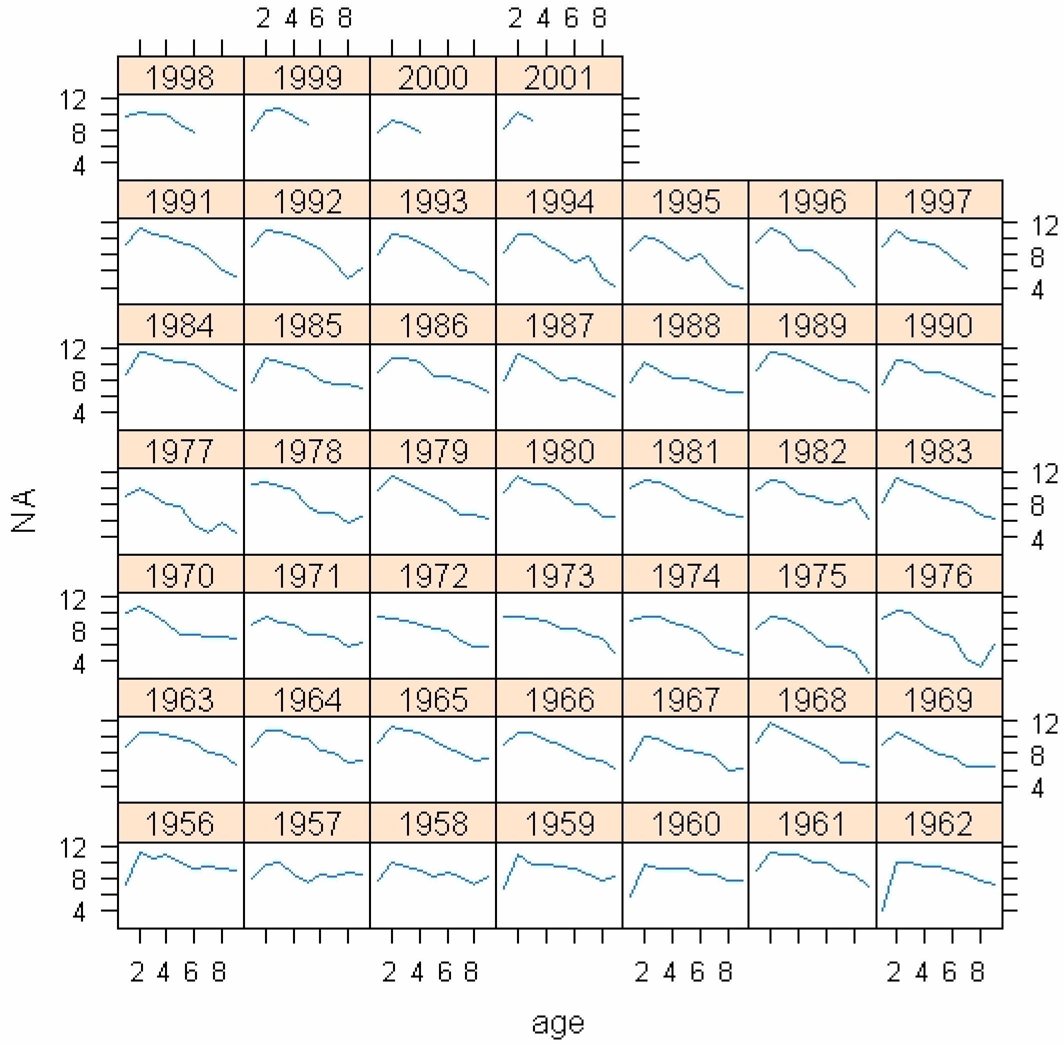


Figure 4.6.1.2. Celtic Sea and VIIj herring. Cohort catch curves for the time series of catch at age data. Age in winter rings on the horizontal axis and log transformed catch numbers at age on the vertical axis.

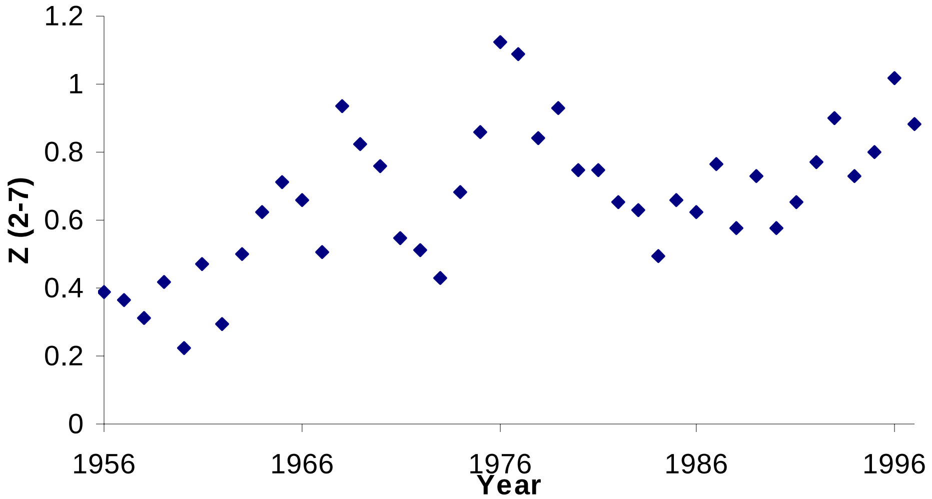


Figure 4.6.1.3. Celtic Sea and VIIj herring. Total mortality (Z) estimated from cohort catch curves (2-7 ringer) for cohorts 1958 to 1997.

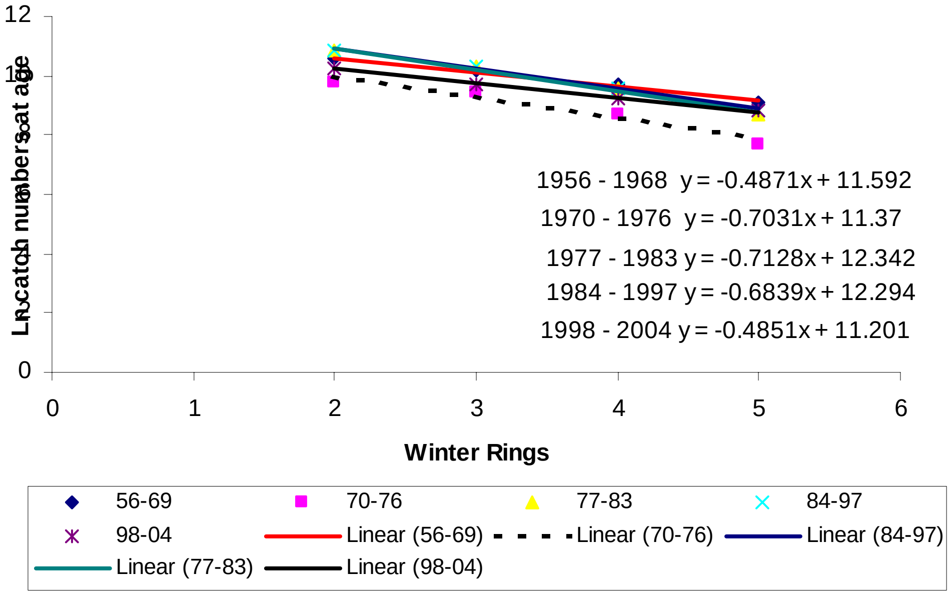


Figure 4.6.1.4. Celtic Sea and VIIj herring. Cohort catch curves (2-5 ringer), averaged over several year classes, from catch at age data.

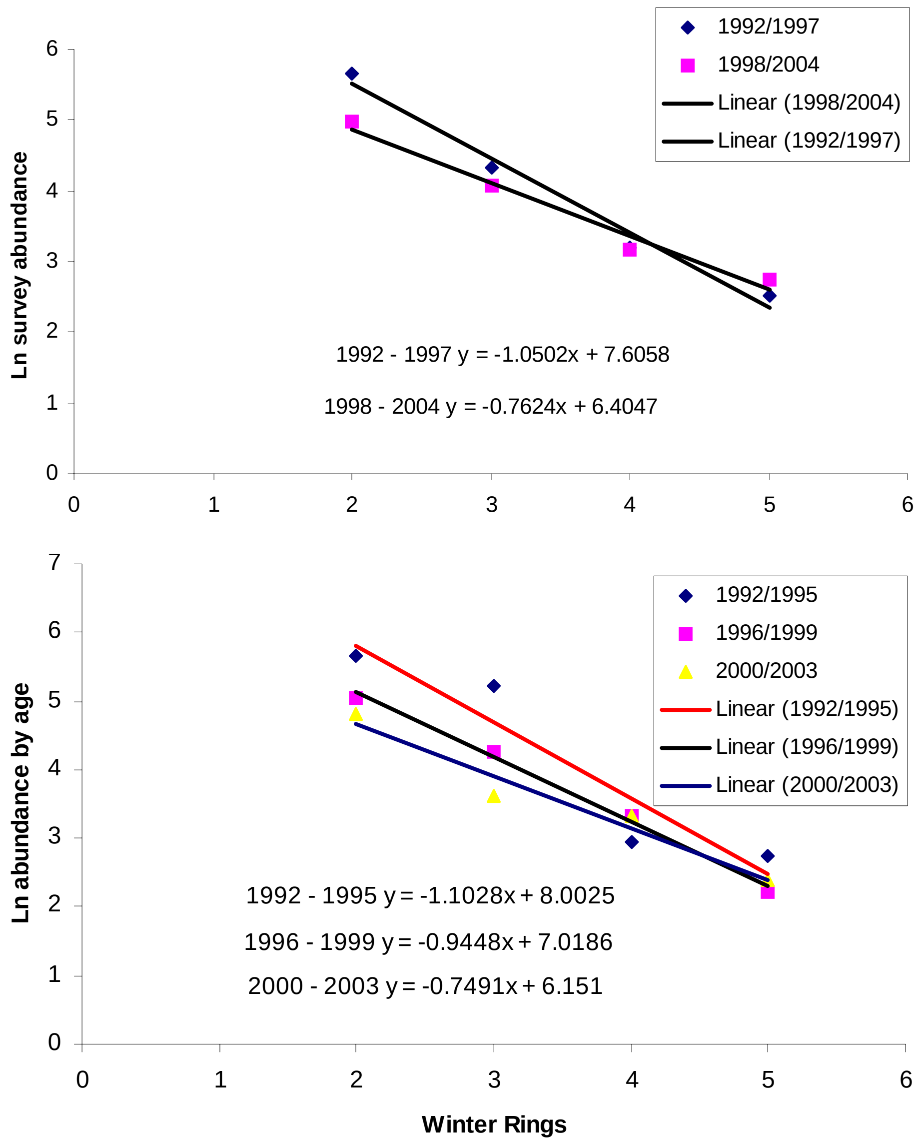


Figure 4.6.1.5. Celtic Sea and VIIj herring. Cohort catch curves (2-5 ring) based on acoustic survey abundance. Upper panel shows means for two periods, and below for three time periods, over the same series of surveys.

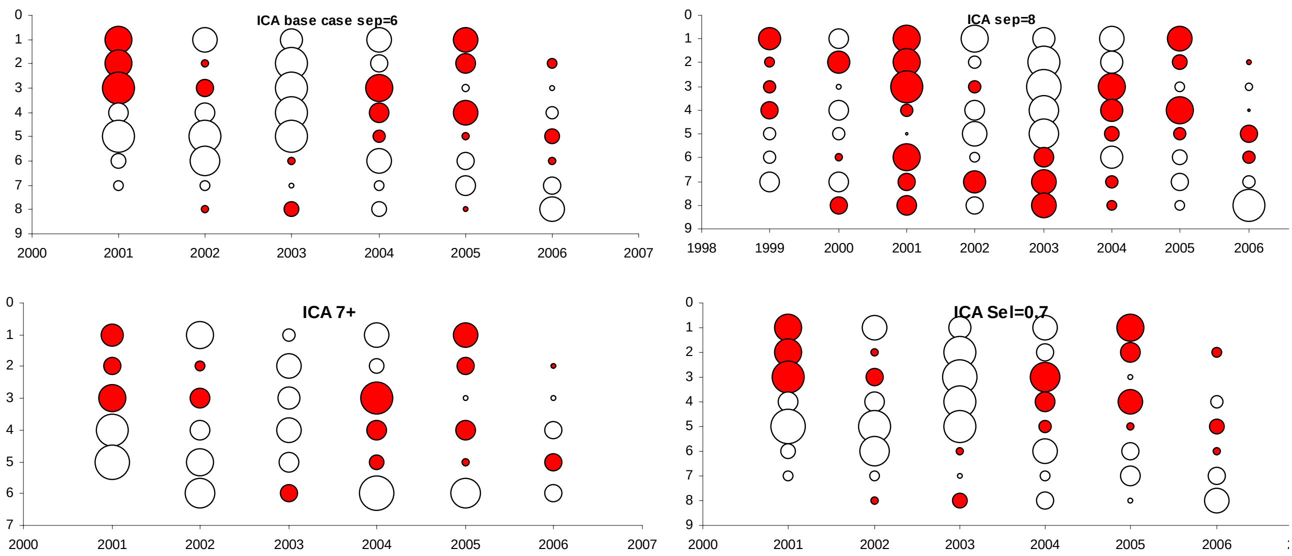


Figure 4.6.2.1. Celtic Sea and VIIj herring. Separable model residuals for four ICA exploratory assessments.

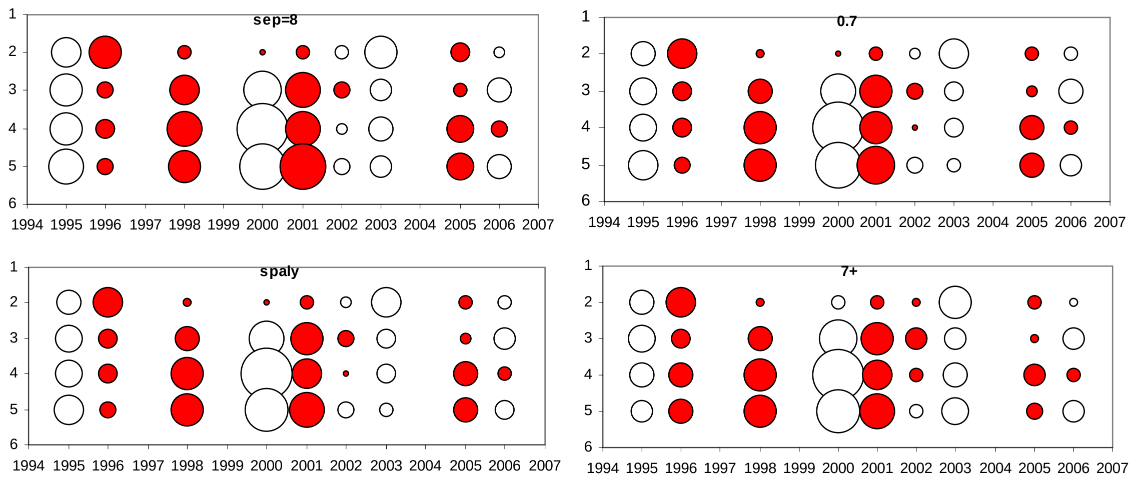


Figure 4.6.2.2. Celtic Sea and VIIj herring. Survey index residuals from four ICA exploratory runs.

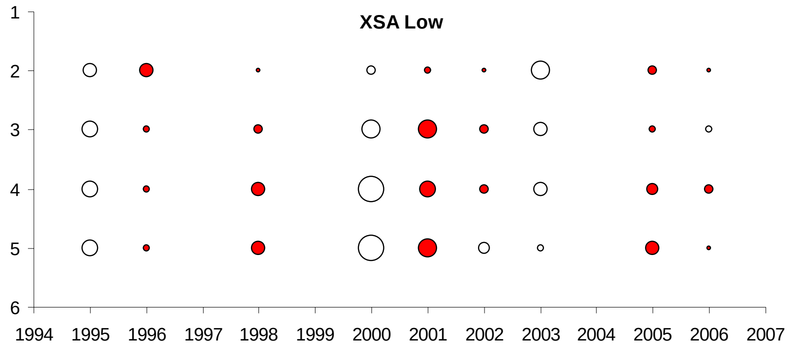


Figure 4.6.2.3. Celtic Sea and VIIj herring. Log catchability residuals for XSA run, with low shrinkage.

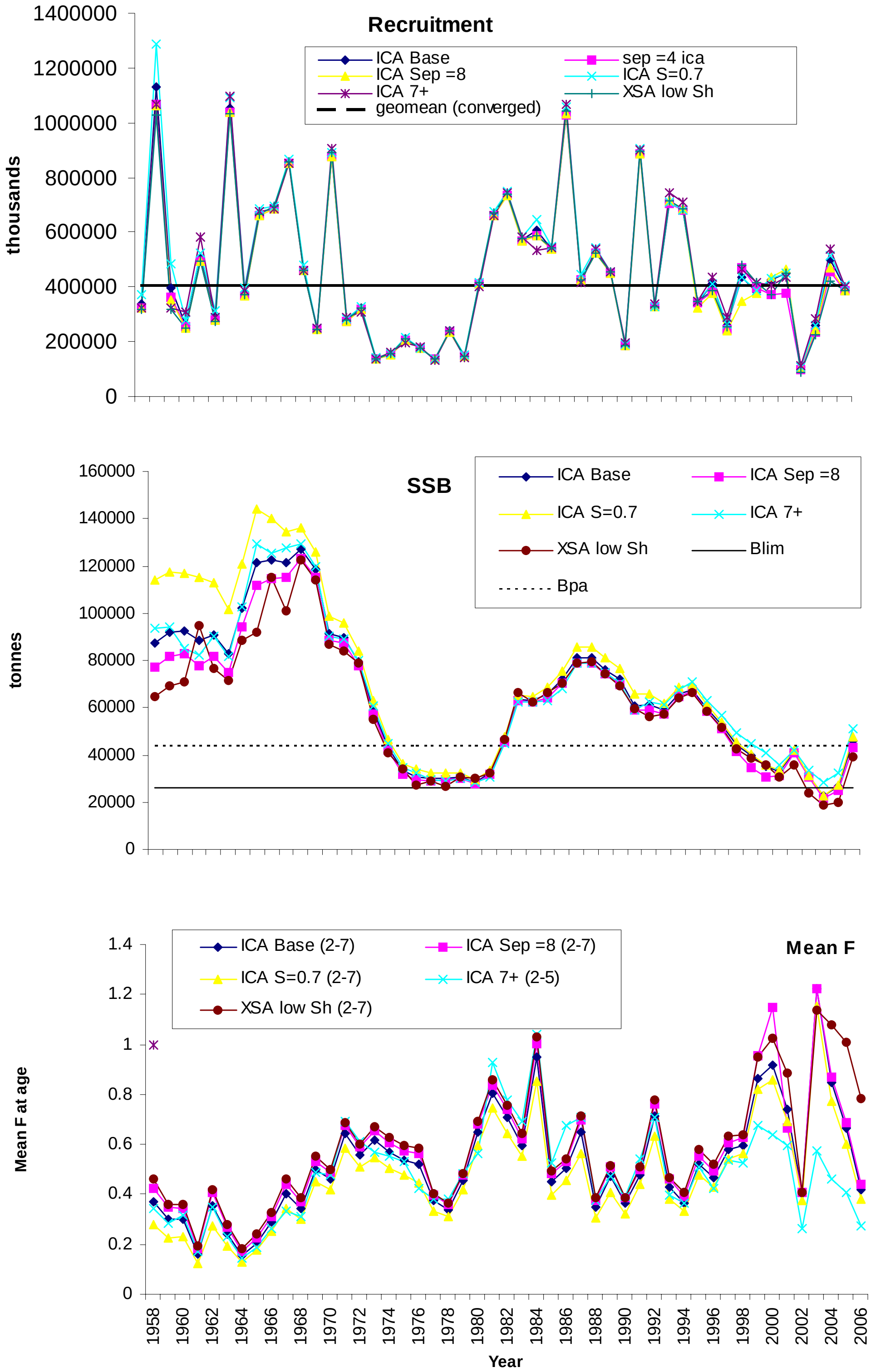


Figure 4.6.2.4. Celtic Sea and VIIj herring. Exploratory assessment using ICA and XSA.

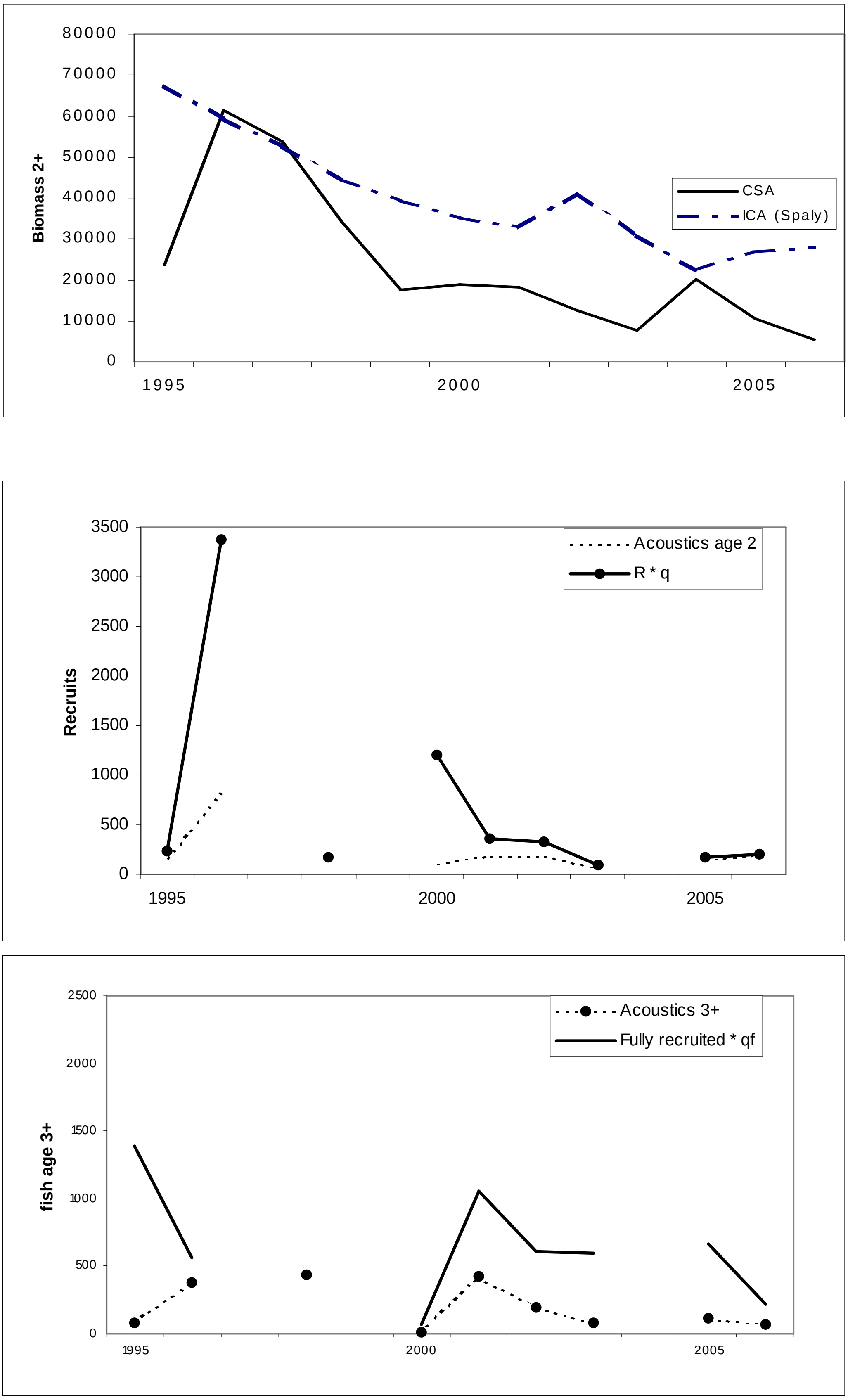


Figure 4.6.2.5. Celtic Sea and VIIj herring. Results of CSA trial assessment. Top panel, total biomass (2+), compared with ICA Base Case (spaly). Middle panel recruits (2-ring) estimated by acoustics and CSA estimates (solid line). Bottom panel, 3+ ruing acoustic index and estimated by acoustics and CSA estimates (solid line.

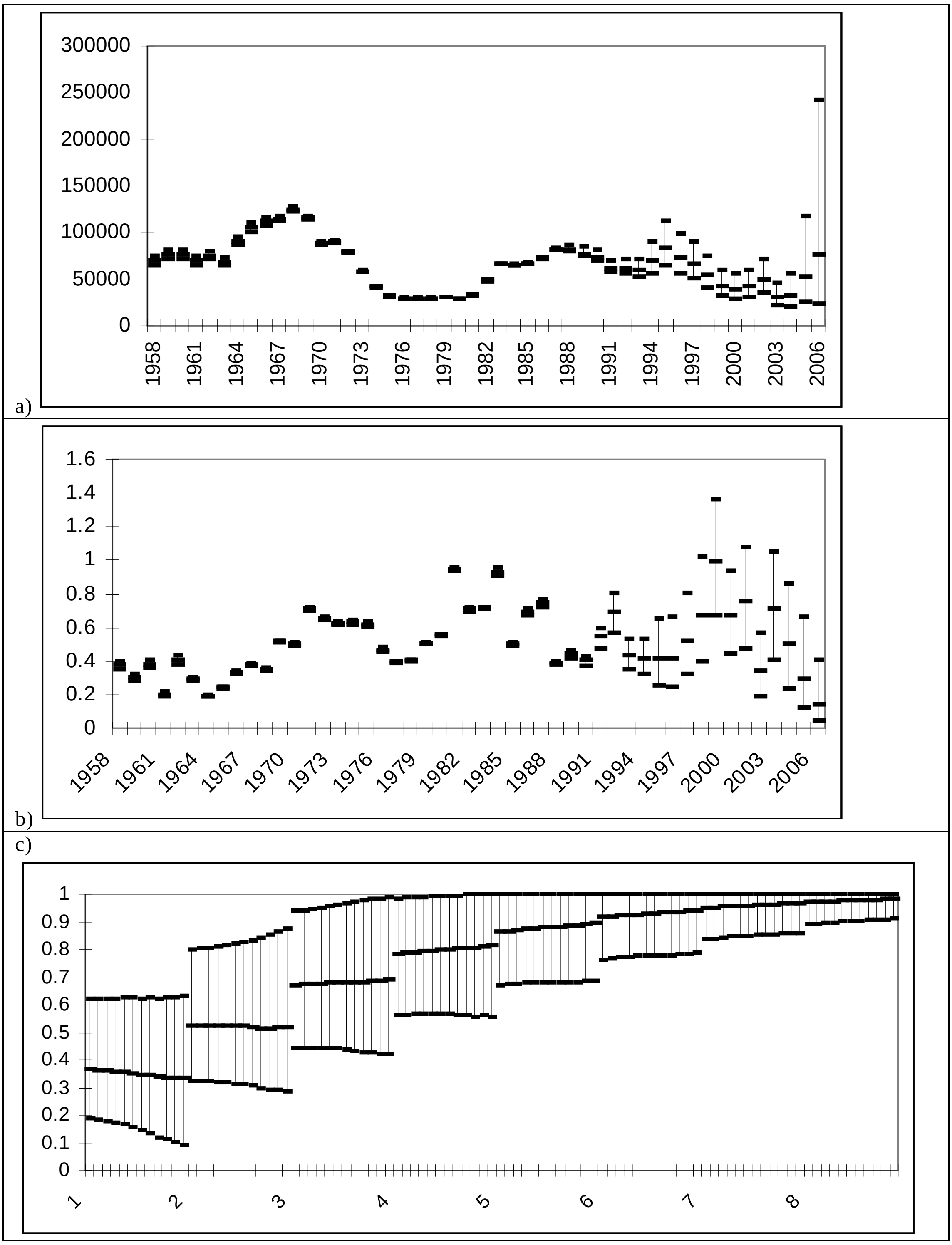


Figure 4.6.2.6. Celtic Sea and VIIj herring. WINBUGS estimates of a) SSB and b) mean F ages 2-5 showing the large uncertainty in SSB in the final year and recent decline in F, c) heavily constrained flexible selection (each bar is an age (1-8) by a year(1995 to 2006) sequentially by year in groups of ages, pattern rising with age from 1 to 8, with declining means and wider intervals in later years at age 1; higher values and narrower intervals at age 8 in later years.

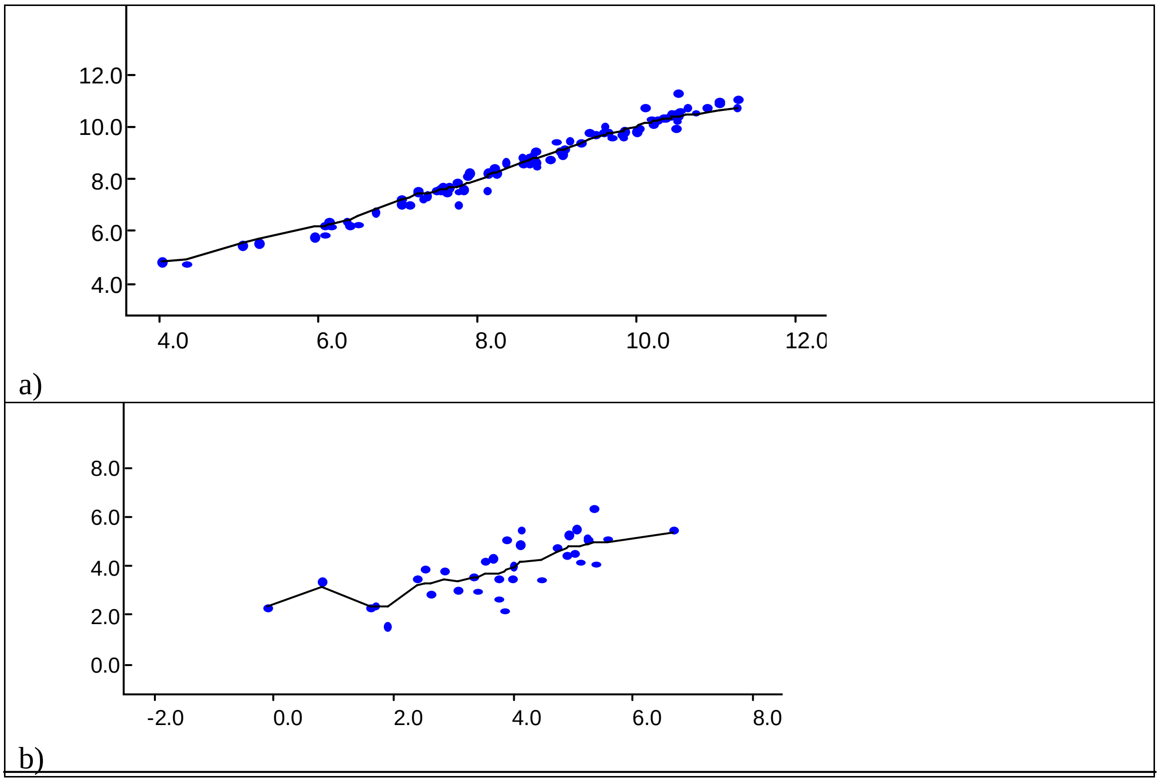


Figure 4.6.2.7. Celtic Sea and VIIj herring. Comparison of model fit a) log modelled catch on observed catch, b) log modelled survey estimate on log survey observation. The variance of the survey is greater than variance of the catch.

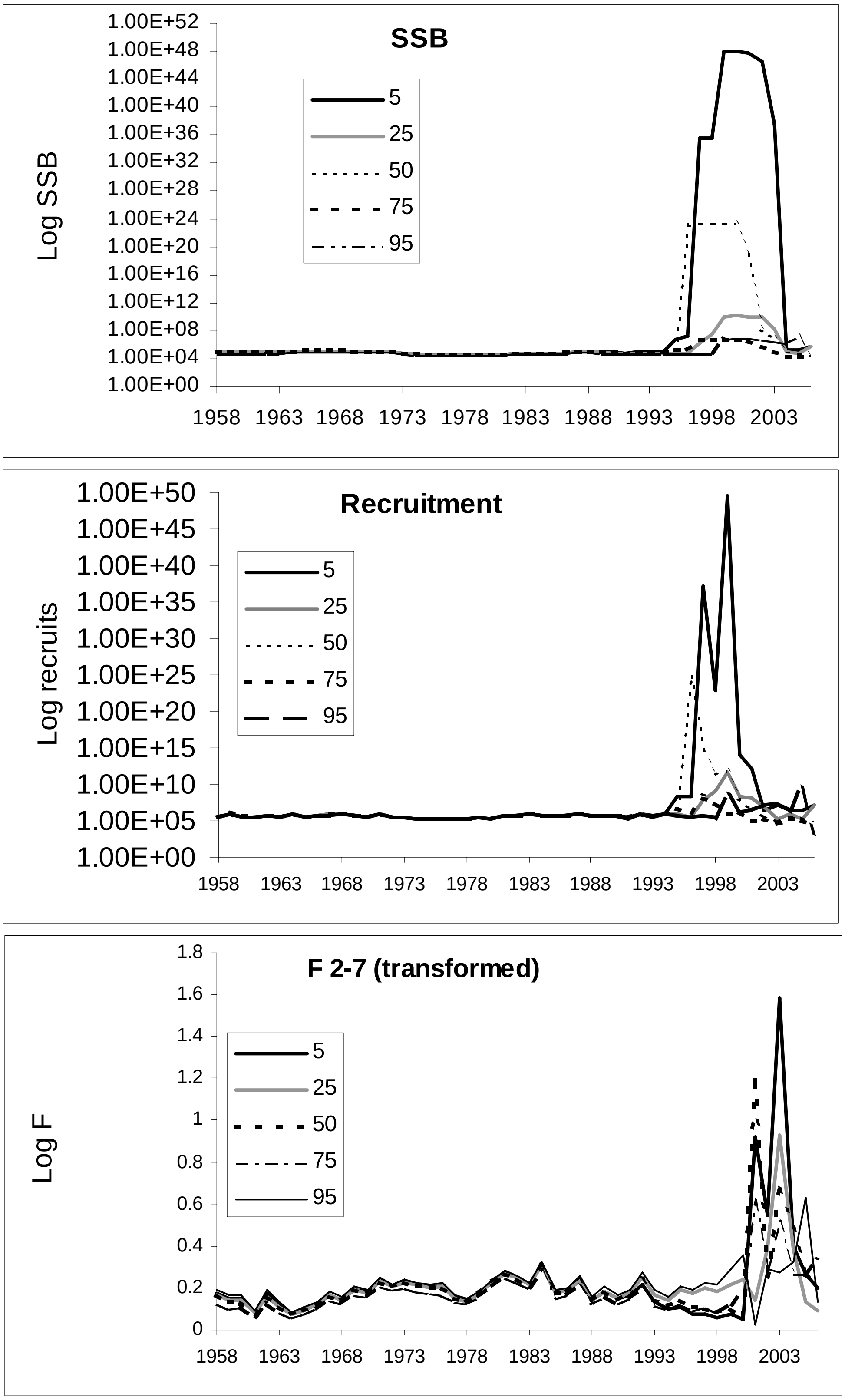
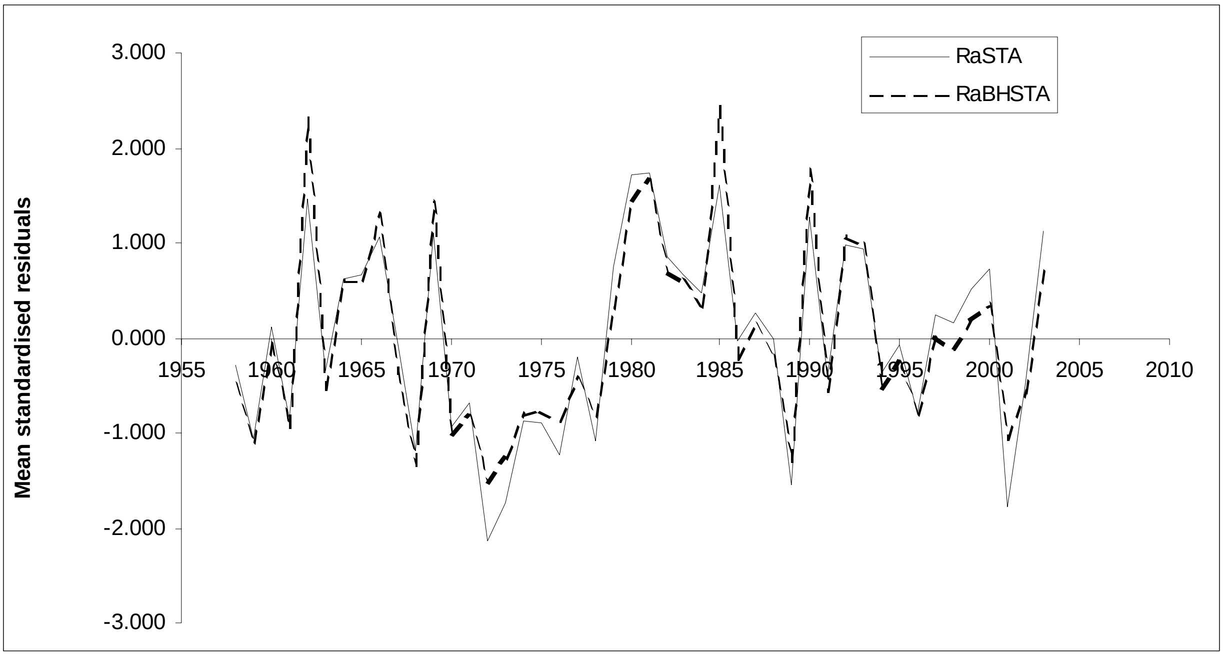


Figure 4.6.2.8. Celtic Sea and VIIj herring. Uncertainty around recruitment, SSB and mean F (2-7 ring) from ICA base case trial assessment. F transformed by addition of 1 and log transformed.



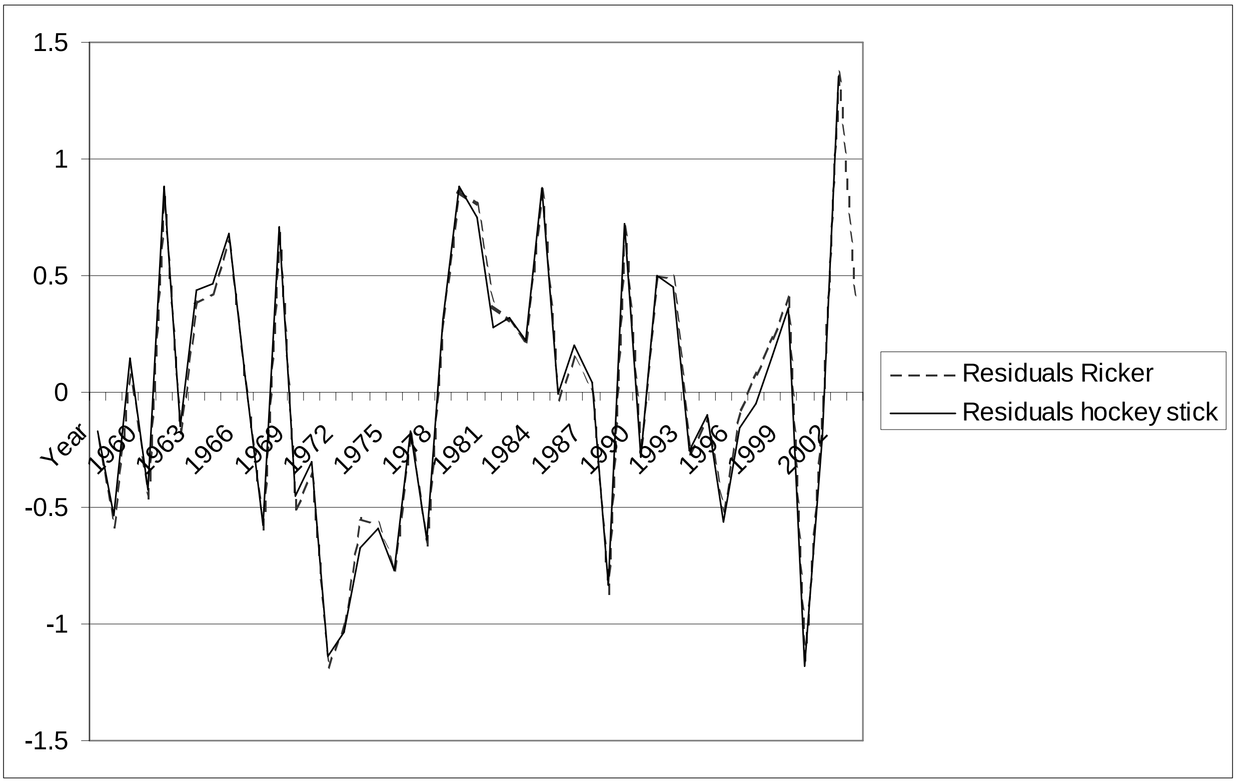
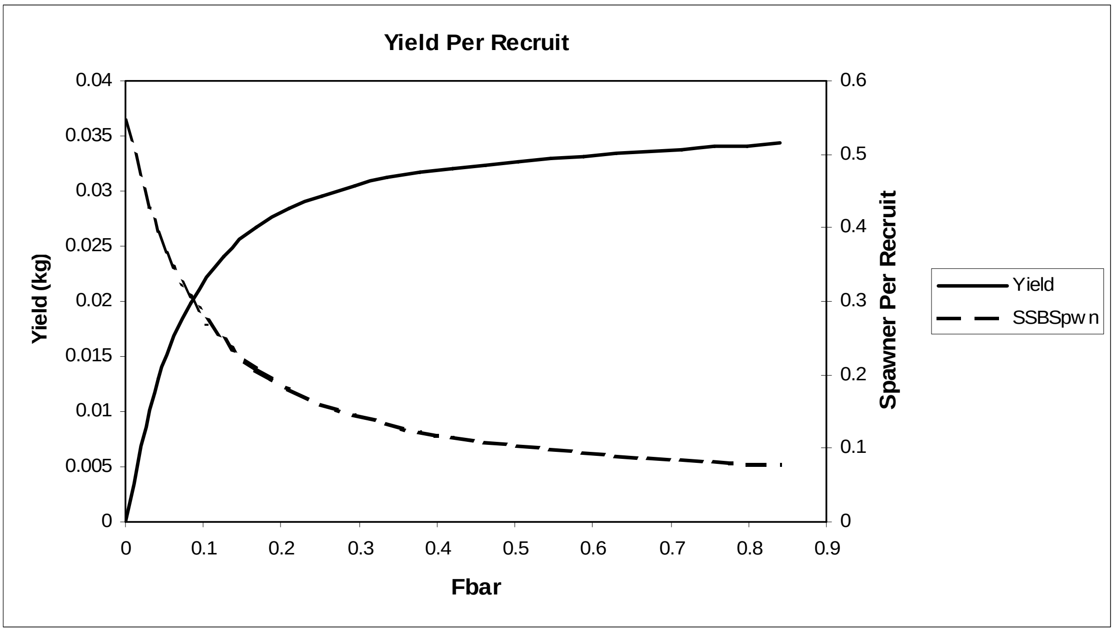


Figure 4.6.2.9. Celtic Sea and VIIj herring. Residual patterns around the stock recruit model fit. Upper panel, Beverton and Holt model and R/SSB residuals. Lower panel, Ricker and Hockey Stick Model.



Reference point	F multiplier	Absolute F
Fbar(2-7)	1.0000	0.4196
FMax	>=1000000	0.0000
F0.1	0.4454	0.1869
F35%SPR	0.4578	0.1921
Flow	0.2054	0.0862
Fmed	0.6631	0.2783
Fhigh	3.0566	1.2827

Figure 4.8.1. Celtic Sea and VIIj herring. Yield per recruit and spawners per recruit analysis.

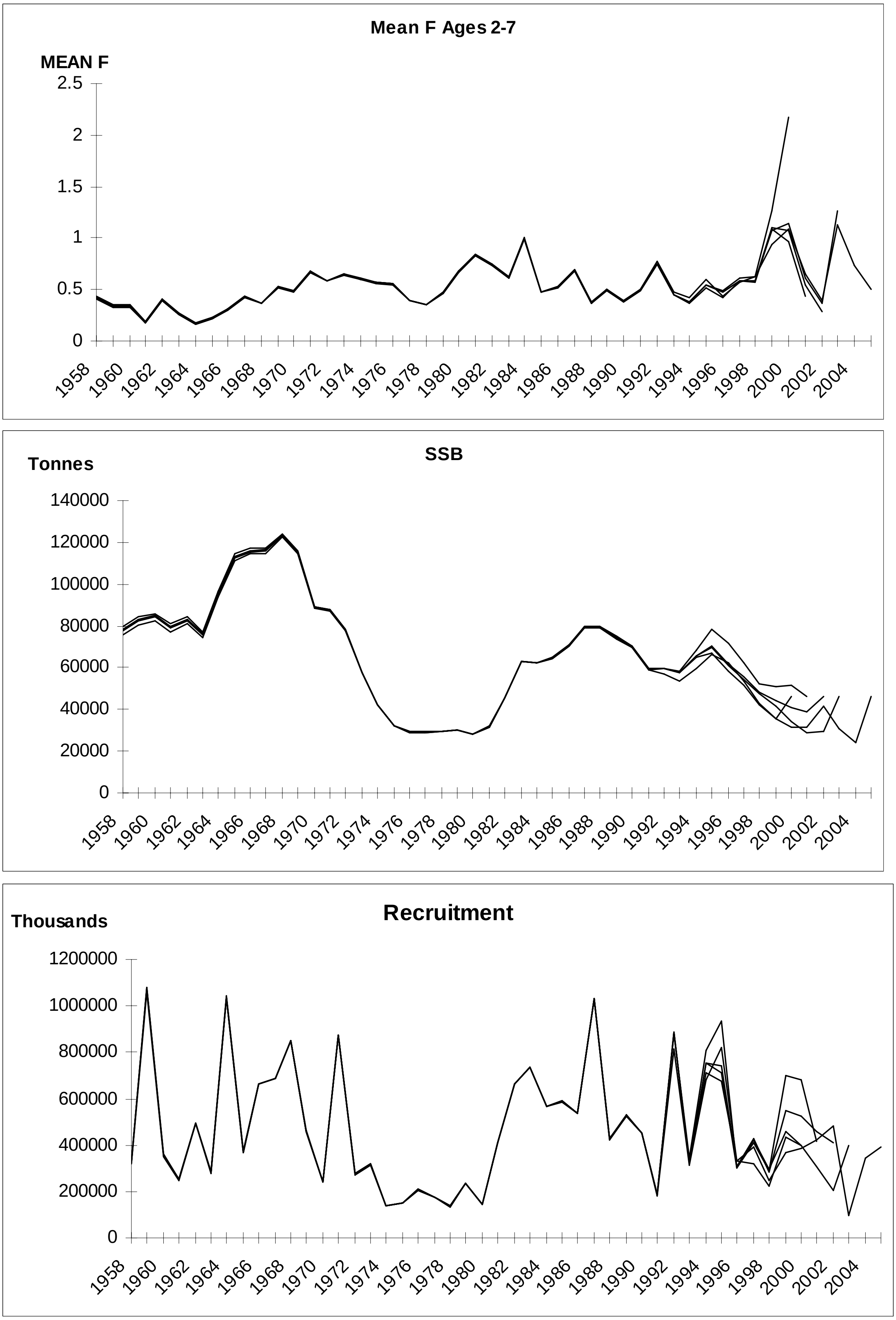


Figure 4.10.1. Celtic Sea and VIIj herring. Retrospective pattern in F, SSB and recruitment from ICA base case run.

5 West of Scotland Herring

5.1 The Fishery

5.1.1 ACFM Advice Applicable to 2006 and 2007

ACFM reported in 2006 that the state of the stock was uncertain. Exploratory assessments confirmed earlier perceptions of a lightly exploited stock (F<=0.2), but the level of the current biomass was uncertain. The recent level of fishing mortality was felt to be low and decreasing. The SSB, although uncertain was around $\mathbf{B}_{pa}$. Given that the perception of the stock was the same as the previous year, the 2006 TAC should also be applicable in 2007.

There are no explicit management objectives for this stock. A $\mathbf{B}_{lim}$ of 50 000 t has been agreed by ACFM for this stock. A candidate HCR (see below) was presented by ACFM in 2005 with the statement that it “seems to maintain the stock inside precautionary limits” and ACFM agreed that it might be adopted subject to an evaluation of a year-on-year TAC constraint.

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.
F = 0	if SSB falls below B_{lim}.	

The agreed TAC for 2007 is 34 000 t, which is in accordance with the HCR above. The TAC in 2006 was 34 000 t.

5.1.2 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 2006 the dominant year classes were 1999 and 2000 (6 and 5 ringers respectively). It appears that the 2001 year class is not strong as was originally supposed, but relatively weak.

In 2006, the Scottish trawl fleet fished in areas similar to the freezer trawler fishery, and not in the coastal areas in the southern part of VIa (N). The Northern Irish fleet fished in both the north and the south of VIa (N). In contrast to most of the previous years’ fisheries, in 2006 98% of the fishery was prosecuted in quarter 3 and was distributed only in the northern part of the area. In the past there has been a much more even distribution of effort, both temporally and spatially.

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 2006, however, there was no misreporting from IVa into VIa (N). New sources of information on catch misreporting from the UK became available in 2006 (changes to catches will be discussed in the section below). This information was associated with a stricter enforcement regime that may be responsible for the lack of that area misreporting in 2006.

5.1.3 Catches in 2006 and Allocation of Catches to Area for VIa (North)

For 2006, the preliminary report of official catches corresponding to the VIa (N) herring stock unit total 34 230 t, compared with the TAC of 34 000 t. The Working Group's estimates of area misreported and unallocated catches are 6 884 t. An additional 163 t of herring has been reported as discarded. At such a low level currently, discarding is not perceived to be a problem.

The Working Group’s best estimate of removals from the stock in 2006 is 27 346 t (Table 5.1.1).

There were three revisions to the catch data time series in 2006. An incorrect allocation of fish to the plus group in the Dutch catches in 2004 and 2005 affected the 2004 VIaN catch and the allocations for that year had to be recalculated. Landings data were also revised with respect to reallocation of catches from area VIaN to VIaS, for the years 2000 - 2005 (see Section 6.1.2). Thirdly, a readjustment of catch figures was necessary from 2001 to 2004 in light of new information on misreporting from the UK. The resulting changes to the catch figures are documented in Table 5.1.1.

5.2 Biological composition of the catch

Catch and sample data, by country and by quarter, are detailed in Table 5.2.1. The number of samples used to allocate an age-distribution for the VIa (N) catches increased back up to the 2003 levels in 2006, after a few years of very poor sampling. There were 39 samples available in 2006, obtained from the Scottish, German and Dutch fleets. These were used to allocate a mean age-structure (weighted by the sampled catch) to unsampled catches, in the same quarter, or in adjacent quarters if no samples were available in the corresponding quarter. If no sampling data were available for a quarter, a mean age-structure of all samples from adjacent quarters was used. 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, 1998) and compared to the new ICES Intercatch (Section 1.5.5). The samples obtained came from the major fisheries by fleet, area and season and are thought to be representative of the catches.

Catch in number-at-age information is given in Table 5.2.2. Three reasonable year classes can be seen clearly in the catch-at-age table: 1998, 1999 and 2000 at 7-, 6- and 5-ring respectively in 2006. The 2001 year class, previously thought to be abundant is not at all dominant in the catch numbers-at-age in 2006 as 4-ring fish. 1-ring herring in the catch are variable 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 2006 acoustic survey was carried out from 1- 21 July using a chartered commercial fishing vessel (MFV *Enterprise*). The total biomass estimate obtained, 471 700 t, represents an almost doubling on the previous year (187 500 in 2005) and is a return to the higher levels seen from 1998 to 2004 (Table 5.3.1). The abundance by year class is consistent with previous years and also with results from the adjacent North Sea area. The 1998 year class is depleted but still apparent; there were a significant number of 2 and 5-ring fish seen on the survey (the 2003 and 2000 year classes respectively). The observed spatial distribution was different to previous years. Herring were found in some areas similar to those in previous surveys (Figures 2.3.1.5 and 5.1) i.e., to the west of the Hebrides, but there were two other areas of concentration in 2006 that are not usually seen, to the north of NW Scotland, around 59º 30'N, 5º 30'W and in the south Minch to the north of the island of Coll. Further details are available in the Report of the Planning Group for Herring Surveys (ICES 2007/LRC:01). The same year classes seen in the catch can be seen clearly at 3-ring and older in the acoustic survey table. However, the 2003 year class at 2-ring in 2006 is considerably more dominant in the survey than in the catch and is the largest 2-ring abundance in the survey since the appearance of the abundant 2000 year class in 2003. To what extent this is a reflection of the high abundance of fish in the survey round Coll, a known area of abundance for younger herring, is unknown.

5.4 Mean weights-at-age and maturity-at-age

5.4.1 Mean Weight-at-age

Weights-at-age in the catches and weights-at-age in the stock from acoustic surveys are given in Table 5.4.1 and are used in the assessment. The weights-at-age in the catch are comparable to previous years. The weights-at-age in the stock, for 3 to 8-ringers, are higher than in 2005 and are consistent with the longer time series.

5.4.2 Maturity Ogive

The maturity ogive is obtained from the acoustic survey and collated in Table 5.4.2 for the period 1992 to 2006.

In 2006, maturity for 2 and 3-ring herring is more similar to the 2004 values than to the 2005 values with all herring above 3-ring being mature.

5.5 Recruitment

There are no specific recruitment indices for this stock. Although both catch and acoustic survey have 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 need to be replaced for prediction years.

5.6 Assessment of VIa (North) herring

5.6.1 Data Exploration and Preliminary Modelling

In the 2007 HAWG, the VIa (North) assessment is a scheduled update assessment and there is no evidence that there are any specific modelling issues to be addressed. However, after worries about the low catch and survey values last year, the exclusion of the low survey values in the assessment was explored this year. This model has been explored in much detail in recent years and is perceived to be reasonably well behaved with the settings used (see HAWG 2005). Therefore the model and the model settings used below are the same as last year's assessment and these will not be explored in detail this year. All exploratory assessments of the stock were carried out by fitting an integrated catch-at-age model (ICA version 1.4w described in the methods section in the 2003 Working Group report (ICES 2003/ACFM:17, Section 1.6.1). An age-structured index was available from the acoustic survey from 1987, 1991 - 2006 (Section 5.3.1).

In 2006 there were several revisions to the historical data that required exploration (Tables 5.1.1, 5.2.2 and 5.4.1). An exploratory assessment was performed to investigate the effects these revisions had on our perception of the stock. The text table below shows the change in spawning stock biomass (SSB), F and total stock biomass (TSB) in the terminal year for last year's (the 2006 working group) assessment and the assessment repeated but with the revised input data. It also shows the overall change for the 2005 estimates from this year's assessment.

	SSB	**F**	**TSB**
2006 assessment, using original data for 2005 estimates	64 110	0.203	94 611
2006 assessment, using revised data for 2005 estimates	71 291	0.153	102 437
2007 assessment, using revised data for 2005 estimates	88 261	0.126	111 054

The catch revision resulted in a slightly lower catch over the period 2000 – 2005 and this gives a small upward revision (10%) in SSB and consequent decrease in F for the assessment with revised data. In the 2007 assessment the increased biomass in the 2006 survey results in upward revision of the SSB value for 2005 (by 27%) and a consequent decrease in F.

It was decided this year to explore the use of the two low survey values in the time series, from 1997 and 2005. It was decided to consider the inclusion or exclusion of both, as they are similar, rather than one or the other individually. The 1997 value (Table 5.3.1) has never been included in the tuning index. It is the lowest in the time series and was conducted almost a month earlier than all the other surveys. The 2005 survey value was the second lowest in the time series and coupled with a low level of catch. In last year's working group, exploration of the assessment showed quite different stock perceptions depending on whether the survey tuning index was included or excluded in the assessment runs. Both the 1997 and 2005 survey SSB estimates show the same relative year effect (Table 5.3.1).

With the revised data set ICA was then run for the time-series 1958-2006, to compare the exploratory model fits for this year. The full time series, 1957-2006, was unable to be used because, currently, ICA is only able to be run on a maximum time series of 49 years.

The separable model residual patterns for the two runs (excluding the 1997 and 2005 surveys and then including both surveys) are very similar (Figure 5.6.1). The magnitude and location of residuals shown in the bubble plots are consistent and the year residuals follow the same pattern. The age residuals values are all small and there are no trends with age. However, the values are slightly larger when both the 1997 and 2005 surveys are included.

The survey residuals patterns for the two runs are mostly similar (Figure 5.6.2). The magnitude and location of residuals shown in the bubble plots are mostly consistent and show strong year effects, whether the two surveys are included or excluded. In both runs it can be seen that the survey residuals show a better pattern in the period prior to 1998, with fewer year effects and less pattern in the distribution of positive and negative residuals. In the later period, for both runs, there is a twisting of the pattern, with a switch from strong negative to positive residuals for the early ages and vice versa for the older ages. This pattern is reflected in the year residuals and most likely caused by conflicting signals seen in the catch and survey data (and explored in details in the 2006 HAWG – see the log catch-ratio plots in Figure 5.6.4. therein). Examination of the year residuals shows that the two low survey values produce residuals of the same magnitude to others in the time series. There is little difference between the two runs in terms of the residual plots.

A plot to compare the reference F (from the parameter estimates) in the terminal year (Figure 5.6.3) shows small differences when the two surveys are either excluded or included in the assessment. The run excluding the two surveys has a marginally wider confidence interval, and although the value of F is lower excluding the two low surveys the two values are essentially the same. The inclusion or exclusion also has a minimal effect on the estimate of q.

Figure 5.6.4 shows the values for SSB and F produced by the two assessment runs. There is a minimal difference between the two values for both SSB and F, with a higher SSB, and therefore lower F, with the run excluding the two low surveys. These differences are within the bounds of the confidence intervals of the assessment.

Retrospective analyses of the assessment from 2006 to 2002 were carried out, and are compared with the two runs excluding and including the 1997 and 2005 acoustic surveys. Figure 5.6.5 shows the SSB, mean $F_{3\text{-}6}$ and recruitment from ICA assessments, with an 8 year separable period. Generally, in the year of assessment recruitment is very poorly estimated. However, in these assessments there is broad agreement in the patterns of recruitment. The retrospective patterns of SSB converge around 2000. The exploratory assessment values are broadly central within the retrospective pattern, i.e., there is no discernable bias. This, coupled with the patterns in the residuals and reference F discussed above, suggests that the assessment is not sensitive to the inclusion or exclusion of the two low survey values in 1997 and 2005. It was therefore decided to include both survey values in future assessments.

5.6.2 Stock Assessment

This is an update assessment using the same settings as in 2006, with the 8 year separable period moved forward one year from 1998 - 2005 to 1999 – 2006, using the complete survey time series.

Assessment of the stock was carried out by fitting an integrated catch-at-age model (ICA version 1.4w). The model settings are the same as in 2005 and 2006. The run log is shown in Table 5.6.1. The input data are given in Tables 5.6.2 to 5.6.8. The output data are given in Tables 5.6.9 to 5.6.18.

The assessment results in an SSB for 2006 of 77 800 t and a mean fishing mortality (3 to 6-ringers) of 0.276. Figure 5.6.6 illustrates the stock trends from the assessment (8 year separable period). The model diagnostics (Tables 5.6.13 to 5.6.18 and Figure 5.6.7) show that the total residuals by age and year between the catch and separable model are reasonably trend-free. The acoustic survey residuals are of a higher magnitude than the catch residuals and show more evidence of year effects. There is also a switch from a strongly positive pattern in 2000 to some large negative values in 2005, discussed above in Section 5.6.1. The large 1998 year class is still reasonably abundant in the catch and survey data in 2006. The 2000 year class is most prevalent in the catch data (5-ringers). This year's estimate of SSB for 2005 is 88 261 t, compared with 64 110 t in last year's assessment run including the 2005 (but excluding the 1997) survey. The assessment run shows an increased catch, decreased recruitment and decreased SSB with an increased F in the last four years.

The outcome of the assessment this year confirms earlier perceptions of a fairly lightly exploited stock although F is higher than in previous years (F<=0.28). This year the assessment of the current biomass is more certain than last year. Catch has increased on last year (almost doubled). The SSB has decreased by 45% since its previous high value in 2002, and by around 30% since 2004, likely a result of lower recruitment and an increased catch.

Recruitment for the 2001 year classes onwards shows the longest series of low recruitments in the time series (Table 5.6.14).

5.7 Short term projections

5.7.1 Deterministic short-term projections

Short-term projections were carried out using MFDP. Input data are stock numbers on 1st January in 2007 from the 2006 ICA assessment (Section 5.6.2, Table 5.6.10), with geometric mean replacing recruitment for both 1- and 2-ring in 2007. In 2007, the geometric mean was calculated for the time series 1989 – 2005, a period showing lower productivity than earlier in time (see Section 1.8.3). This was felt necessary given that there is evidence for poor recruitment in recent year classes (Table 5.6.10). The selection pattern used is as estimated by ICA (Table 5.6.13). 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., 2004 - 2006) (Table 5.7.1.1). Two scenarios for deterministic short-term projections are presented: F *status quo* and a second option with TAC constraint. The results of short-term projection is shown in the text table below, illustrating that at *status quo* F catches can be expected to be stable at around 21 000 t.

SCENARIO	2007	2008	2009
1 – *status quo* F	F_{2007}= F_{2006} = 0.276 *Status quo* F Catch = 21 832 t	F_{2008}= F_{2006} = 0.276 *Status quo* F Catch = 20 772 t	F_{2009}= F_{2006} = 0.276 *Status quo* F Catch = 21 044 t SSB = 77 309 t
TAC Constraint	F_{2007} = 0.46 *TAC Constraint* Catch = 34 000 t	F_{2008}= F_{int} = 0.20 F management plan intermediate SSB = 69 015	F_{2009}= F_{int} = 0.20 F management plan intermediate SSB = 75 403 t

There is a proposed management plan (Section 5.1.1) that may be implemented in 2008. This relates to work carried out in the last 5 years by HAWG. It has therefore been included in the projections.

The results of the F *status quo* short-term projections can be seen in Tables 5.7.1.2 – 5.7.1.3. Table 5.7.1.2 shows single option predictions for 2008 and 2009. Table 5.7.1.3 shows the multiple options for 2008. SSB rises from approximately 74 000 t in 2007 to around 77 000 t in 2009. The results of the TAC constraint for 2007 short-term projections can be seen in Tables 5.7.1.4 – 5.7.1.5. With the current TAC of 34 000 t, and the current decreased SSB in the assessment, F in 2007 is high, at F=0.46, far higher than the proposed upper F value in the management plan of F=0.25. If the stock is subsequently fished even at F=0.20 in 2008, SSB will decrease to around 69 000 t. Continued fishing at F=0.20 in 2009 will lead to an increase to 75 400 t. These projections may be considered to be conservative, based on a reduced geometric mean recruitment of 605 million. Table 5.6.10 allows a calculation of a value for 3 recent (2001 – 2003) year classes of around 265 million. However, the 2003 year class is well represented in the 2006 acoustic survey so the strength of the recruitment signal is unclear.

So, under both scenarios the assessment gives a starting position of SSB being below 75 000 t (B_{trig} in the proposed management rule). At F *status quo* the projection shows the stock rebuilding to an SSB around 77 000 t in 2009 with a corresponding catch of 21 000 t. At the current TAC though F is very high and the stock can only rebuild to around B_{trig} in 2009 at F=0.20.

5.7.2 Yield-per-recruit

A yield-per-recruit analysis was carried out using MFYPR to provide yield-per-recruit plots for the data produced in the assessment run described above (Figure 5.7.2.1) The values for $\mathbf{F}_{0.1}$ and $\mathbf{F}_{med}$ (0.17 and 0.27 respectively) are very similar to last year's values derived which were the same regardless of whether the 2005 acoustic survey was included or excluded. These reference points therefore appear to be stable. These may be compared with the current F (2006 assessment) of 0.276.

5.8 Medium term projections and HCR performance

Medium term projections were used extensively at the 2005 HAWG to evaluate HCRs for this area. This work was developed further through 2006 and is now published (Simmonds and Keltz 2007). There is no evidence that the stock diagnostics have changed, so the proposed rule (Section 5.1.1) should be adequate to protect the stock. Currently medium term management implications are not affected by the recommendations of WESTHER (Section 1.3.1).

5.9 Precautionary and yield based reference points

The biomass limit point B_{lim} is 50,000 t. There are no agreed precautionary reference points for this stock. The proposed management rule has a B_{trig} at 75 000 t.

5.10 Quality of the Assessment

The HAWG considers the assessment this year to be as reliable as usual. This assessment has rather high variability, but this has been taken into account within the proposed HCR (Section 5.1.1). The influence of catch revisions was explored and seen to make little difference to the assessment outcome. Similarly, the behaviour of the two low survey SSB estimates was explored in the assessment through their inclusion or exclusion. Again, the assessment outcomes were very similar and well within the bounds of the confidence intervals of the assessment.

Retrospective analyses of the assessment from 2006 to 2002 were carried out, and are compared with the two runs excluding and including the 1997 and 2005 acoustic surveys. Figure 5.6.5 shows the SSB, mean F_{3-6} and recruitment from ICA assessments, with an 8 year separable period. In these assessments there is broad agreement in the patterns of recruitment. The retrospective patterns of SSB converge around 2000. The exploratory assessment values are broadly central within the retrospective pattern, i.e., there is no discernable bias. The results suggested that the assessment is not sensitive to the inclusion or exclusion of the two low survey values in 1997 and 2005. It was therefore decided to include both survey values in future assessments. The retrospective pattern supports the perception of a noisy but fairly well balanced assessment that has been assumed for the HCR considerations (Simmonds and Keltz 2007)

5.11 Management Considerations

In 2006, the stock was more heavily exploited than it has been since 1999. This recent increased F is associated with: increased enforcement, reducing area misreporting from area IVa (Section 5.1.2), a roll-over TAC advised for 2007 due to some uncertainty with the assessment. Values since 2001 show the longest series of low recruitments in the time series (the 2001 to 2003 year classes (Table 5.6.14)), although the 2003 value is uncertain as it is seen as high in the survey and low in the fishery. Recruitment at 1wr in 2006 and 2007 is uncertain. In 2007, if the TAC, set as a roll-over TAC, is taken, F is predicted to reach F=0.46. F in 2006 was above the F=0.25 recommended as the upper fishing mortality in the proposed management plan. The short-term projections, based on a lower geometric mean (Sections 1.8.3 and 5.7) reflecting the current lower productivity of this stock, suggest that SSB will only rebuild to around the proposed B_{trig} of 75 000 t in 2009 if F remains at F=0.20 in both 2008 and 2009. Considering the roll-over TAC for 2007 and the high F in 2006, a 15% restriction on TAC change is not advisable for 2008.

Following the recommendations from WESTHER (Hatfield *et al.* WD 2007) HAWG considers that in the absence of any evaluated and coordinated management strategy for the herring to the west of the British Isles, the current separation of management units (VIa(N), VIa(S), Irish Sea and Celtic Sea) affords the best possible protection for local spawning stocks. However it does not afford protection to the fish of one stock distributed in another management area at feeding time.

Provided both the spawning fisheries (VIa(S), Irish Sea and Celtic Sea) and the fishery in the mixing area (predominantly VIa(N)) are maintained at an F that would be sustainable for each component, this should afford protection for these units, in the short term. HAWG considers that further work is required on examining the issues surrounding surveys, assessment and management of each of the current three management units to the north of the area. This can be initiated, partly through a new study group or study contract. 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 previously endorsed plans for VIa(N) should be continued, until or unless some alternative strategy is found to be more useful.

Table 5.1.1 Herring in VIa (N). Catch in tonnes by country, 1983-2006. These figures do not in all cases correspond to the official statistics and cannot be used for management purposes.

Country	1983	1984	1985	1986	1987	1988	1989	1990
Denmark		96						
Faroes	834	954	104	400				326
France	1313		20	18	136	44	1342	1287
Germany	6283	5564	5937	2188	1711	1860	4290	7096
Ireland				6000	6800	6740	8000	10000
Netherlands	20200	7729	5500	5160	5212	6131	5860	7693
Norway	7336	6669	4690	4799	4300	456		1607
UK	31616	37554	28065	25294	26810	26894	29874	38253
Unallocated	-4059	16588	-502	37840	18038	5229	2123	2397
Discards							1550	1300
Total	63523	75154	43814	81699	63007	47354	53039	69959
Area-Misreported		-19142	-4672	-10935	-18647	-11763	-19013	-25266
WG Estimate	63523	56012	39142	70764	44360	35591	34026	44693
Source (WG)	1985	1986	1987	1988	1989	1990	1991	1992

Country	1991	1992	1993	1994	1995	1996	1997	1998
Denmark								
Faroes	482							
France	1168	119	818	274	3672	2297	3093	1903
Germany	6450	5640	4693	5087	3733	7836	8873	8253
Ireland	8000	7985	8236	7938	3548	9721	1875	11199
Netherlands	7979	8000	6132	6093	7808	9396	9873	8483
Norway	3318	2389	7447	8183	4840	6223	4962	5317
UK	32628	32730	32602	30676	42661	46639	44273	42302
Unallocated	-10597	-5485	-3753	-4287	-4541	-17753	-8015	-11748
Discards	1180	200		700			62	90
Total	50608	51578	56175	54664	61271	64359	64995	65799
Area-Misreported	-22079	-22593	-24397	-30234	-32146	-38254	-29766	-32446
WG Estimate	28529	28985	31778	24430	29575	26105	35233*	33353
Source (WG)	1993	1994	1995	1996	1997	1997	1998	1999

Country	1999	2000	2001	2002	2003	2004	2005	2006
Denmark								
Faroes				800	400	228	1810	570
France	463	870	760	1340	1370	625	613	701
Germany	6752	4615	3944	3810	2935	1046	2691	3152
Ireland	7915	4841	4311	4239	3581	1894	2880	4352
Netherlands	7244	4647	4534	4612	3609	8232	5132	7008
Norway	2695							
UK	36446	22816	21862	20604	16947	17706	17494	18284
Unallocated	-8155			878	-7			
Discards						123	772	163
Total	61514	37789	35411	36283	28835	29854	31392	34230
Area-Misreported	-23623	-19467	-11132	-8735	-3581	-7218	-17263	-6884
WG Estimate	29736	18322$^{\$}$	24556$^{\$}$	32914$^{\$}$	28081$	25021$^{\$}$	14129$^{\$}$	27346
Source (WG)	2000	2001	2002	2003	2004	2005	2006	2007

***WG estimate for 1997 has been revised according to the Bayesian assessment (see text Section 5.1.3 of 2000 report). $^{\$}$Revised at HAWG 2007.**

Table 5.2.1 Herring in VIa (N). Catch and sampling effort by nations participating in the fishery in 2006.

PERIOD : 1

Country	Sampled Catch	Official Catch	No. of samples	No. measured	No. aged	SOP %
Germany	33.00	33.00	3	574	295	95.01
Germany discard	5.00	5.00	1	23	23	97.78
Ireland	0.00	632.00	0	0	0	0.00
N. Ireland	0.00	12.00	0	0	0	0.00
Netherlands	0.00	350.00	0	0	0	0.00
Scotland	0.00	261.00	0	0	0	0.00
Scotland discard	158.00	158.00	1	35	0	99.47
Period Total	196.00	1451.00	5	632	318	98.68

Sum of Offical Catches:	1451.00
Unallocated Catch:	-944.00
Working Group Catch:	507.00

PERIOD : 2

Country	Sampled Catch	Official Catch	No. of samples	No. measured	No. aged	SOP %
England & Wales	0.00	18.00	0	0	0	0.00
Period Total	0.00	18.00	0	0	0	0.00

Sum of Offical Catches:	18.00
Unallocated Catch:	0.00
Working Group Catch:	18.00

PERIOD : 3

Country	Sampled Catch	Official Catch	No. of samples	No. measured	No. aged	SOP %
England & Wales	0.00	2854.00	0	0	0	0.00
Faroes	0.00	570.00	0	0	0	0.00
France	0.00	701.00	0	0	0	0.00
Germany	3119.00	3119.00	5	1440	111	100.42
N. Ireland	0.00	757.00	0	0	0	0.00
Netherlands	4438.00	6314.00	4	404	100	99.73
Scotland	14382.00	14382.00	25	4329	1061	99.99
Period Total	21939.00	28697.00	34	6173	1272	100.00

Sum of Offical Catches:	28697.00
Unallocated Catch:	-1876.00
Working Group Catch:	26821.00

PERIOD : 4

Country	Sampled Catch	Official Catch	No. of samples	No. measured	No. aged	SOP %
Ireland	0.00	3720.00	0	0	0	0.00
Netherlands	0.00	344.00	0	0	0	0.00
Period Total	0.00	4064.00	0	0	0	0.00

Sum of Offical Catches:	4064.00
Unallocated Catch:	-4064.00
Working Group Catch:	0.00

Table 5.2.2 Herring in VIa (N). Estimated catch numbers-at-age (thousands), 1976-2006. N.B. In this table "age" refers to number of rings (winter rings in the otolith).

AGE	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
1	69053	34836	22525	247	2692	36740	13304	81923	2207	40794	33768
2	319604	47739	46284	142	279	77961	250010	77810	188778	68845	154963
3	101548	95834	20587	77	95	105600	72179	92743	49828	148399	86072
4	35502	22117	40692	19	51	61341	93544	29262	35001	17214	118860
5	25195	10083	6879	13	13	21473	58452	42535	14948	15211	18836
6	76289	12211	3833	8	9	12623	23580	27318	11366	6631	18000
7	10918	20992	2100	4	8	11583	11516	14709	9300	6907	2578
8	3914	2758	6278	1	1	1309	13814	8437	4427	3323	1427
9	12014	1486	1544	0	0	1326	4027	8484	1959	2189	1971
	1987	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**
1	19463	1708	6216	14294	26396	5253	17719	1728	266	1952	1193
2	65954	119376	36763	40867	23013	24469	95288	36554	82176	37854	55810
3	45463	41735	109501	40779	25229	24922	18710	40193	30398	30899	34966
4	32025	28421	18923	74279	28212	23733	10978	6007	21272	9219	31657
5	50119	19761	18109	26520	37517	21817	13269	7433	5376	7508	23118
6	8429	28555	7589	13305	13533	33869	14801	8101	4205	2501	17500
7	7307	3252	15012	9878	7581	6351	19186	10515	8805	4700	10331
8	3508	2222	1622	21456	6892	4317	4711	12158	7971	8458	5213
9	5983	2360	3505	5522	4456	5511	3740	10206	9787	31108	9883
	1998	**1999**	**2000$**	**2001$**	**2002$**	**2003$**	**2004$**	**2005**	**2006**		
1	9092	7635	3569	143	992	56	0	183	132		
2	74167	35252	18162	81030	38482	33332	6844	9633	6691		
3	34571	93910	17264	14943	93975	46866	22223	23237	9186		
4	31905	25078	40674	9306	9014	53767	27815	20602	13645		
5	22872	13364	12264	24482	18114	7463	45782	10238	41068		
6	14372	7529	7121	9281	28016	4345	3916	9783	27782		
7	8641	3251	3083	6625	9040	12818	7642	1015	20973		
8	2825	1257	1452	4611	1548	9188	8481	1195	3042		
9	3327	1089	456	1001	1423	1408	4008	1431	5089		

$ revised at HAWG 2007

Table 5.3.1 Herring in VIa (N). Estimates of abundance 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	1987	1991	1992	1993	1994	1995	1996	1997#	1998
1	249 100	338 312	74 310	2 760	494 150	441 240	41 220	792 320	1 221 700
2	578 400	294 484	503 430	750 270	542 080	1103 400	576 460	641 860	794 630
3	551 100	327 902	210 980	681 170	607 720	473 220	802 530	286 170	666 780
4	353 100	367 830	258 090	653 050	285 610	450 270	329 110	167 040	471 070
5	752 600	488 288	414 750	544 000	306 760	152 970	95 360	66 100	179 050
6	111 600	176 348	240 110	865 150	268 130	187 100	60 600	49 520	79 270
7	48 100	98 741	105 670	284 110	406 840	169 080	77 380	16 280	28 050
8	15 900	89 830	56 710	151 730	173 740	236 540	78 190	28 990	13 850
9+	6 500	58 043	63 440	156 180	131 880	201 500	114 810	24 440	36 770
SSB:	273 000*	452 000	351 460	866 190	533 740	452 120	370300	140 910	375 890

AGE	1999	2000	2001	2002	2003	2004	2005	2006
1	534 200	447 600	313 100	424 700	438 800	564 000	50 200	112 300
2	322 400	316 200	1 062 000	436 000	1 039 400	274 500	243 400	835 200
3	1 388 800	337 100	217 700	1 436 900	932 500	760 200	230 300	387 900
4	432 000	899 500	172 800	199 800	1 471 800	442 300	423 100	284 500
5	308 000	393 400	437 500	161 700	181 300	577 200	245 100	582 200
6	138 700	247 600	132 600	424 300	129 200	55 700	152 800	414 700
7	86 500	199 500	102 800	152 300	346 700	61 800	12 600	227 000
8	27 600	95 000	52 400	67 500	114 300	82.200	39 000	21 700
9+	35 400	65 000	34 700	59 500	75 200	76.300	26 800	59 300
SSB:	460 200	500 500	359 200	548 800	739 200	395 900	187 500	471 700

***Biomass of 2+ ringers in November.**

 # The 1997 survey is not on the same basis as the other years, it was conducted in June (all other surveys were carried out in July).

Table 5.4.1 Herring in VIa (N). Mean weights-at-age (g). N.B. In this table "age" refers to number of rings (winter rings in the otolith).

Weights in the catch

Age	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001[$]	2002[$]	2003[$]	2004[$]	2005	2006
1	82	79	84	91	89	83	105	81	89	97	76	83	49	107	60	0	108	91
2	142	129	118	122	128	142	142	134	136	138	130	137	140	146	145	154	133	158
3	145	173	160	172	158	167	180	178	177	159	158	164	163	163	160	173	163	168
4	191	182	203	194	197	190	191	210	205	182	175	183	183	173	169	195	185	193
5	190	209	211	216	206	195	198	230	222	199	191	201	192	160	186	216	211	208
6	213	224	229	224	228	201	213	233	223	218	210	215	196	179	200	220	226	225
7	216	228	236	236	223	244	207	262	219	227	225	239	205	187	194	199	234	244
8	204	237	261	251	262	234	227	247	238	212	223	281	225	245	186	190	256	262
9+	243	247	271	258	263	266	277	291	263	199	226	253	272	281	294	311	250	275

[$] Revised at HAWG 2007

Weight in the stock from acoustic surveys

Age	Historical	1994	1995	1996	1997[#]	1998	1999	2000	2001	2002	2003	2004	2005	2006
1	90	52	45	45	57	65	54	62	62	62	64	54	75	75
2	164	150	144	140	150	138	137	141	132	153	138	136	130	135
3	208	192	191	180	189	177	166	173	170	177	176	157	154	166
4	233	220	202	209	209	193	188	183	190	198	190	180	167	185
5	246	221	225	219	225	214	203	194	198	212	204	189	180	192
6	252	233	226	222	233	226	219	204	212	215	213	202	191	204
7	258	241	247	229	248	234	225	211	220	225	217	213	213	211
8	269	270	260	242	266	225	235	222	236	243	223	214	203	224
9+	292	296	293	263	287	249	245	230	254	259	228	206	228	231

[#] The 1997 survey is not on the same basis as the other years, it was conducted in June (all other surveys were carried out in July).

Table 5.4.2 Herring in VIa (N). Maturity ogive used in estimates of spawning stock biomass taken from acoustic surveys. Values measured in 1997 were measured in June whilst other values are measured in July. The mean value 92-96 is used in the assessment for the years 1976-1991 and 1997.

Year \Age (Winter ring)	2	3	>3
Mean 92-96	0.57	0.96	1.00
1992	0.47	1.00	1.00
1993	0.93	0.96	1.00
1994	0.48	0.92	1.00
1995	0.19	0.98	1.00
1996	0.76	0.94	1.00
1997	0.41	0.88	1.00
1998	0.85	0.97	1.00
1999	0.57	0.98	1.00
2000	0.45	0.92	1.00
2001	0.93	0.99	1.00
2002	0.92	1.00	1.00
2003	0.76	1.00	1.00
2004	0.83	0.97	1.00
2005	0.84	1.00	1.00
2006	0.81	0.97	1.00

Table 5.6.1. Herring in VIa (N). ICA run log for the maximum-likelihood ICA calculation for the 8 year separable period. N.B. In this table "age" refers to number of rings (winter rings in the otolith).

```
Integrated Catch at Age Analysis
                         --------------------------------

                                Version 1.4 w

                                K.R.Patterson
                         Fisheries Research Services
                              Marine Laboratory
                                  Aberdeen

 Enter the name of the index file -->index.txt
canum.txt
weca.txt
 Stock weights in 2007  used for the year 2006
west.txt
 Natural mortality in 2007  used for the year 2006
natmor.txt
 Maturity ogive in 2007  used for the year 2006
matprop.txt
 Name of age-structured index file (Enter if none) : -->fleet.txt
 Name of the SSB index file (Enter if none) -->
No indices of spawning biomass to be used.
 No of years for separable constraint ?--> 8
 Reference age for separable constraint ?--> 4
 Constant selection pattern model (Y/N) ?-->y
 S to be fixed on last age ?-->    1.000000000000000
 First age for calculation of reference F ?--> 3
 Last age for calculation of reference F ?--> 6
 Use default weighting (Y/N) ?-->n
Enter relative weights at age
 Weight for age 1-->    0.100000000000000
 Weight for age 2-->    1.000000000000000
 Weight for age 3-->    1.000000000000000
 Weight for age 4-->    1.000000000000000
 Weight for age 5-->    1.000000000000000
 Weight for age 6-->    1.000000000000000
 Weight for age 7-->    1.000000000000000
 Weight for age 8-->    1.000000000000000
 Weight for age 9-->    1.000000000000000
Enter relative weights by year
 Weight for year 1999-->    1.000000000000000
 Weight for year 2000-->    1.000000000000000
 Weight for year 2001-->    1.000000000000000
 Weight for year 2002-->    1.000000000000000
 Weight for year 2003-->    1.000000000000000
 Weight for year 2004-->    1.000000000000000
 Weight for year 2005-->    1.000000000000000
 Weight for year 2006-->    1.000000000000000
Enter new weights for specified years and ages if needed
 Enter year, age, new weight or -1,-1,-1 to end.  -1 -1   -1.000000000000000
 Is the last age of FLT01:West Scotland Summer Acoustic Surv a plus-group (Y--
>y
You must choose a catchability model for each index.

Models:   A  Absolute:  Index = Abundance . e
          L  Linear:    Index = Q. Abundance . e
          P  Power:     Index = Q. Abundance^ K .e

   where Q and K are parameters to be estimated, and
   e is a lognormally-distributed error.

 Model for FLT01:West Scotland Summer Acoustic Surv  is to be A/L/P ?-->L
There are     1  missing observations for fitting the separable model.

 Fit a stock-recruit relationship (Y/N) ?-->n
 Enter lowest feasible F-->   2.0000000000000000E-02
 Enter highest feasible F-->    0.500000000000000
```

Table 5.6.1. continued.

```
Mapping the F-dimension of the SSQ surface
    F                  SSQ
+--------+------------------
    0.02        24.6629625622
    0.05        18.5215370791
    0.07        15.7314308304
    0.10        14.1887205898
    0.12        13.2642785681
    0.15        12.6892217095
    0.17        12.3276628470
    0.20        12.1036117615
    0.22        11.9717621751
    0.25        11.9035962620
    0.27        11.8806036817
    0.30        11.8903233353
    0.32        11.9241681744
    0.35        11.9761582713
    0.37        12.0419641658
    0.40        12.1185300471
    0.42        12.2035857405
    0.45        12.2954848038
    0.47        12.3930296221
    0.50        12.4953627496
Lowest SSQ is for F =     0.277
-----------------------------------------------------------------
No of years for separable analysis : 8
Age range in the analysis : 1  . . . 9
Year range in the analysis : 1958  . . . 2006
Number of indices of SSB : 0
Number of age-structured indices : 1
Parameters to estimate : 38
Number of observations : 216
Conventional single selection vector model to be fitted.
-----------------------------------------------------------------
 Survey weighting to be Manual (recommended) or Iterative (M/I) ?-->M
 Enter weight for FLT01:West Scotland Summer Acoustic Surv  at age 1-->    0.100000000000000
 Enter weight for FLT01:West Scotland Summer Acoustic Surv  at age 2-->    1.000000000000000
 Enter weight for FLT01:West Scotland Summer Acoustic Surv  at age 3-->    1.000000000000000
 Enter weight for FLT01:West Scotland Summer Acoustic Surv  at age 4-->    1.000000000000000
 Enter weight for FLT01:West Scotland Summer Acoustic Surv  at age 5-->    1.000000000000000
 Enter weight for FLT01:West Scotland Summer Acoustic Surv  at age 6-->    1.000000000000000
 Enter weight for FLT01:West Scotland Summer Acoustic Surv  at age 7-->    1.000000000000000
 Enter weight for FLT01:West Scotland Summer Acoustic Surv  at age 8-->    1.000000000000000
 Enter weight for FLT01:West Scotland Summer Acoustic Surv  at age 9-->    1.000000000000000
Enter estimates of the extent to which errors
in the age-structured indices are correlated
across ages. This can be in the range 0 (independence)
to 1 (correlated errors).
  Enter value for FLT01:West Scotland Summer Acoustic Surv-->    1.000000000000000
 Do you want to shrink the final fishing mortality (Y/N) ?-->N
Seeking solution. Please wait.
Aged index weights
FLT01:West Scotland Summer Acoustic Surv
 Age   :       1     2     3     4     5     6     7     8     9
 Wts :     0.011 0.111 0.111 0.111 0.111 0.111 0.111 0.111 0.111
F in 2006  at age 4  is 0.238034  in iteration 1
 Detailed, Normal or Summary output (D/N/S)-->D
 Output page width in characters (e.g. 80..132) ?--> 132
 Estimate historical assessment uncertainty ?-->y
 Sample from Covariances or Bayes MCMC (C/B) ?-->c
 Use default percentiles (Y/N)  ?-->y
 How many samples to take  ?--> 1000
 Enter SSB reference level (e.g. MBAL, Bpa..) [t]-->   5.0000000000000000E+04
Succesful exit from ICA
```

Table 5.6.2. Herring in VIa (N). Catch number at age (millions). N.B. In this table "age" refers to number of rings (winter rings in the otolith).

Output Generated by ICA Version 1.4

Herring VIa (north) (run: ICAPGF08/I08)

Catch in Number

AGE	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972
1	15.62	53.09	3.56	13.08	55.05	11.80	26.55	299.48	211.68	207.95	220.25	37.71	238.23	207.71	534.96
2	30.98	67.97	102.12	45.20	92.81	78.25	82.61	19.77	500.85	27.42	94.44	92.56	99.01	335.08	621.50
3	145.39	35.26	60.29	61.62	22.28	53.45	70.08	62.64	33.46	218.69	21.00	71.91	253.72	412.82	175.14
4	39.07	116.39	22.78	33.13	67.45	11.86	26.68	59.38	60.50	37.07	159.12	23.31	111.90	302.21	54.20
5	24.91	24.95	48.88	22.50	44.36	40.52	7.28	22.27	40.91	39.25	13.99	211.24	27.74	101.96	66.71
6	27.63	17.33	11.63	12.41	19.76	26.17	24.23	5.12	19.34	29.79	23.58	21.01	142.40	25.56	25.72
7	17.41	17.00	10.35	5.34	24.14	8.69	18.64	22.89	5.56	11.77	15.68	42.76	21.61	154.42	10.34
8	9.86	7.37	6.35	4.81	6.15	13.66	8.80	18.93	17.81	5.53	6.38	26.03	27.07	16.82	55.76
9	7.16	8.60	4.62	2.58	7.08	6.09	15.10	19.53	27.08	25.80	10.81	26.21	24.08	32.00	16.63

AGE	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
1	51.17	309.02	172.88	69.05	34.84	22.52	0.25	2.69	36.74	13.30	81.92	2.21	40.79	33.77	19.46
2	235.63	124.94	202.09	319.60	47.74	46.28	0.14	0.28	77.96	250.01	77.81	188.78	68.84	154.96	65.95
3	808.27	151.03	89.07	101.55	95.83	20.59	0.08	0.10	105.60	72.18	92.74	49.83	148.40	86.07	45.46
4	131.48	519.18	63.70	35.50	22.12	40.69	0.02	0.05	61.34	93.54	29.26	35.00	17.21	118.86	32.02
5	63.07	82.47	188.20	25.20	10.08	6.88	0.01	0.01	21.47	58.45	42.53	14.95	15.21	18.84	50.12
6	54.64	49.68	30.60	76.29	12.21	3.83	0.01	0.01	12.62	23.58	27.32	11.37	6.63	18.00	8.43
7	18.24	34.63	12.30	10.92	20.99	2.10	0.00	0.01	11.58	11.52	14.71	9.30	6.91	2.58	7.31
8	6.51	22.47	13.12	3.91	2.76	6.28	0.00	0.00	1.31	13.81	8.44	4.43	3.32	1.43	3.51
9	32.22	21.04	13.70	12.01	1.49	1.54	0.00	0.00	1.33	4.03	8.48	1.96	2.19	1.97	5.98

AGE	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
1	1.71	6.22	14.29	26.40	5.25	17.72	1.73	0.27	1.95	1.19	9.09	7.63	3.57	0.14	0.99
2	119.38	36.76	40.87	23.01	24.47	95.29	36.55	82.18	37.85	55.81	74.17	35.25	18.16	81.03	38.48
3	41.73	109.50	40.78	25.23	24.92	18.71	40.19	30.40	30.90	34.97	34.57	93.91	17.26	14.94	93.98
4	28.42	18.92	74.28	28.21	23.73	10.98	6.01	21.27	9.22	31.66	31.91	25.08	40.67	9.31	9.01
5	19.76	18.11	26.52	37.52	21.82	13.27	7.43	5.38	7.51	23.12	22.87	13.36	12.26	24.48	18.11
6	28.55	7.59	13.30	13.53	33.87	14.80	8.10	4.21	2.50	17.50	14.37	7.53	7.12	9.28	28.02
7	3.25	15.01	9.88	7.58	6.35	19.19	10.52	8.80	4.70	10.33	8.64	3.25	3.08	6.62	9.04
8	2.22	1.62	21.46	6.89	4.32	4.71	12.16	7.97	8.46	5.21	2.83	1.26	1.45	4.61	1.55
9	2.36	3.50	5.52	4.46	5.51	3.74	10.21	9.79	31.11	9.88	3.33	1.09	0.46	1.00	1.42

Table 5.6.2. Herring in VIa (N). Catch number at age (millions). Continued

Catch in Number

AGE	2003	2004	2005	2006
1	0.06	0.00	0.18	0.13
2	33.33	6.84	9.63	6.69
3	46.87	22.22	23.24	9.19
4	53.77	27.82	20.60	13.64
5	7.46	45.78	10.24	41.07
6	4.34	3.92	9.78	27.78
7	12.82	7.64	1.01	20.97
8	9.19	8.48	1.19	3.04
9	1.41	4.01	1.43	5.09

Table 5.6.3. Herring in VIa (N). Weight in the catch (kg). N.B. In this table "age" refers to number of rings (winter rings in the otolith).

Weights at age in the catches (Kg)

AGE	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972
1	0.07900	0.07900	0.07900	0.07900	0.07900	0.07900	0.07900	0.07900	0.07900	0.07900	0.07900	0.07900	0.07900	0.07900	0.07900
2	0.10400	0.10400	0.10400	0.10400	0.10400	0.10400	0.10400	0.10400	0.10400	0.10400	0.10400	0.10400	0.10400	0.10400	0.10400
3	0.13000	0.13000	0.13000	0.13000	0.13000	0.13000	0.13000	0.13000	0.13000	0.13000	0.13000	0.13000	0.13000	0.13000	0.13000
4	0.15800	0.15800	0.15800	0.15800	0.15800	0.15800	0.15800	0.15800	0.15800	0.15800	0.15800	0.15800	0.15800	0.15800	0.15800
5	0.16400	0.16400	0.16400	0.16400	0.16400	0.16400	0.16400	0.16400	0.16400	0.16400	0.16400	0.16400	0.16400	0.16400	0.16400
6	0.17000	0.17000	0.17000	0.17000	0.17000	0.17000	0.17000	0.17000	0.17000	0.17000	0.17000	0.17000	0.17000	0.17000	0.17000
7	0.18000	0.18000	0.18000	0.18000	0.18000	0.18000	0.18000	0.18000	0.18000	0.18000	0.18000	0.18000	0.18000	0.18000	0.18000
8	0.18300	0.18300	0.18300	0.18300	0.18300	0.18300	0.18300	0.18300	0.18300	0.18300	0.18300	0.18300	0.18300	0.18300	0.18300
9	0.18500	0.18500	0.18500	0.18500	0.18500	0.18500	0.18500	0.18500	0.18500	0.18500	0.18500	0.18500	0.18500	0.18500	0.18500

AGE	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
1	0.09000	0.09000	0.09000	0.09000	0.09000	0.09000	0.09000	0.09000	0.09000	0.08000	0.08000	0.08000	0.06900	0.11300	0.07300
2	0.12100	0.12100	0.12100	0.12100	0.12100	0.12100	0.12100	0.12100	0.12100	0.14000	0.14000	0.14000	0.10300	0.14500	0.14300
3	0.15800	0.15800	0.15800	0.15800	0.15800	0.15800	0.15800	0.15800	0.15800	0.17500	0.17500	0.17500	0.13400	0.17300	0.18300
4	0.17500	0.17500	0.17500	0.17500	0.17500	0.17500	0.17500	0.17500	0.17500	0.20500	0.20500	0.20500	0.16100	0.19600	0.21100
5	0.18600	0.18600	0.18600	0.18600	0.18600	0.18600	0.18600	0.18600	0.18600	0.23100	0.23100	0.23100	0.18200	0.21500	0.22000
6	0.20600	0.20600	0.20600	0.20600	0.20600	0.20600	0.20600	0.20600	0.20600	0.25300	0.25300	0.25300	0.19900	0.23000	0.23800
7	0.21800	0.21800	0.21800	0.21800	0.21800	0.21800	0.21800	0.21800	0.21800	0.27000	0.27000	0.27000	0.21300	0.24200	0.24100
8	0.22400	0.22400	0.22400	0.22400	0.22400	0.22400	0.22400	0.22400	0.22400	0.28400	0.28400	0.28400	0.22300	0.25100	0.25300
9	0.22400	0.22400	0.22400	0.22400	0.22400	0.22400	0.22400	0.22400	0.22400	0.29500	0.29500	0.29500	0.23100	0.25800	0.25600

Table 5.6.3. Herring in VIa (N). Weight in the catch (kg). Continued

Weights at age in the catches (Kg)

AGE	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
1	0.08000	0.08200	0.07900	0.08400	0.09100	0.08900	0.08300	0.10600	0.08100	0.08900	0.09700	0.07600	0.08340	0.04900	0.10700
2	0.11200	0.14200	0.12900	0.11800	0.11900	0.12800	0.14200	0.14200	0.13400	0.13600	0.13800	0.13000	0.13730	0.14000	0.14600
3	0.15700	0.14500	0.17300	0.16000	0.18300	0.15800	0.16700	0.18100	0.17800	0.17700	0.15900	0.15800	0.16370	0.16300	0.16300
4	0.17700	0.19100	0.18200	0.20300	0.19600	0.19700	0.19000	0.19100	0.21000	0.20500	0.18200	0.17500	0.18290	0.18300	0.17300
5	0.20300	0.19000	0.20900	0.21100	0.22700	0.20600	0.19500	0.19800	0.23000	0.22200	0.19900	0.19100	0.20140	0.19200	0.16000
6	0.19400	0.21300	0.22400	0.22900	0.21900	0.22800	0.20100	0.21400	0.23300	0.22300	0.21800	0.21000	0.21470	0.19600	0.17900
7	0.24000	0.21600	0.22800	0.23600	0.24400	0.22300	0.24400	0.20800	0.26200	0.21900	0.22700	0.22500	0.23940	0.20500	0.18700
8	0.21300	0.20400	0.23700	0.26100	0.25600	0.26200	0.23400	0.22700	0.24700	0.23800	0.21200	0.22300	0.28120	0.22500	0.24500
9	0.22800	0.24300	0.24700	0.27100	0.25600	0.26300	0.26600	0.27700	0.29100	0.26300	0.19900	0.22600	0.25260	0.27200	0.28100

AGE	2003	2004	2005	2006
1	0.06000	0.00000	0.10840	0.09080
2	0.14500	0.15400	0.13270	0.15800
3	0.16000	0.17300	0.16320	0.16760
4	0.16900	0.19500	0.18450	0.19290
5	0.18600	0.21600	0.21080	0.20760
6	0.20000	0.22000	0.22580	0.22510
7	0.19400	0.19900	0.23410	0.24430
8	0.18600	0.19000	0.25560	0.26150
9	0.29400	0.31100	0.24960	0.27500

Table 5.6.4. Herring in VIa (N). Weight in the stock (kg). N.B. In this table "age" refers to number of rings (winter rings in the otolith).

Weights at age in the stock (Kg)

AGE	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972
1	0.09000	0.09000	0.09000	0.09000	0.09000	0.09000	0.09000	0.09000	0.09000	0.09000	0.09000	0.09000	0.09000	0.09000	0.09000
2	0.16400	0.16400	0.16400	0.16400	0.16400	0.16400	0.16400	0.16400	0.16400	0.16400	0.16400	0.16400	0.16400	0.16400	0.16400
3	0.20800	0.20800	0.20800	0.20800	0.20800	0.20800	0.20800	0.20800	0.20800	0.20800	0.20800	0.20800	0.20800	0.20800	0.20800
4	0.23300	0.23300	0.23300	0.23300	0.23300	0.23300	0.23300	0.23300	0.23300	0.23300	0.23300	0.23300	0.23300	0.23300	0.23300
5	0.24600	0.24600	0.24600	0.24600	0.24600	0.24600	0.24600	0.24600	0.24600	0.24600	0.24600	0.24600	0.24600	0.24600	0.24600
6	0.25200	0.25200	0.25200	0.25200	0.25200	0.25200	0.25200	0.25200	0.25200	0.25200	0.25200	0.25200	0.25200	0.25200	0.25200
7	0.25800	0.25800	0.25800	0.25800	0.25800	0.25800	0.25800	0.25800	0.25800	0.25800	0.25800	0.25800	0.25800	0.25800	0.25800
8	0.26900	0.26900	0.26900	0.26900	0.26900	0.26900	0.26900	0.26900	0.26900	0.26900	0.26900	0.26900	0.26900	0.26900	0.26900
9	0.29200	0.29200	0.29200	0.29200	0.29200	0.29200	0.29200	0.29200	0.29200	0.29200	0.29200	0.29200	0.29200	0.29200	0.29200

Table 5.6.4. Herring in VIa (N). Continued.

Weights at age in the stock (Kg)

AGE	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
1	0.09000	0.09000	0.09000	0.09000	0.09000	0.09000	0.09000	0.09000	0.09000	0.09000	0.09000	0.09000	0.09000	0.09000	0.09000
2	0.16400	0.16400	0.16400	0.16400	0.16400	0.16400	0.16400	0.16400	0.16400	0.16400	0.16400	0.16400	0.16400	0.16400	0.16400
3	0.20800	0.20800	0.20800	0.20800	0.20800	0.20800	0.20800	0.20800	0.20800	0.20800	0.20800	0.20800	0.20800	0.20800	0.20800
4	0.23300	0.23300	0.23300	0.23300	0.23300	0.23300	0.23300	0.23300	0.23300	0.23300	0.23300	0.23300	0.23300	0.23300	0.23300
5	0.24600	0.24600	0.24600	0.24600	0.24600	0.24600	0.24600	0.24600	0.24600	0.24600	0.24600	0.24600	0.24600	0.24600	0.24600
6	0.25200	0.25200	0.25200	0.25200	0.25200	0.25200	0.25200	0.25200	0.25200	0.25200	0.25200	0.25200	0.25200	0.25200	0.25200
7	0.25800	0.25800	0.25800	0.25800	0.25800	0.25800	0.25800	0.25800	0.25800	0.25800	0.25800	0.25800	0.25800	0.25800	0.25800
8	0.26900	0.26900	0.26900	0.26900	0.26900	0.26900	0.26900	0.26900	0.26900	0.26900	0.26900	0.26900	0.26900	0.26900	0.26900
9	0.29200	0.29200	0.29200	0.29200	0.29200	0.29200	0.29200	0.29200	0.29200	0.29200	0.29200	0.29200	0.29200	0.29200	0.29200

AGE	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
1	0.09000	0.09000	0.09000	0.09000	0.09000	0.07500	0.05200	0.04200	0.04500	0.05700	0.06600	0.05400	0.06200	0.06200	0.06200
2	0.16400	0.16400	0.16400	0.16400	0.16400	0.16200	0.15000	0.14400	0.14000	0.15000	0.13800	0.13700	0.14100	0.13200	0.15300
3	0.20800	0.20800	0.20800	0.20800	0.20800	0.19600	0.19200	0.19100	0.18000	0.18900	0.17600	0.16600	0.17300	0.17000	0.17700
4	0.23300	0.23300	0.23300	0.23300	0.23300	0.20600	0.22000	0.20200	0.20900	0.20900	0.19400	0.18800	0.18300	0.19000	0.19800
5	0.24600	0.24600	0.24600	0.24600	0.24600	0.22600	0.22100	0.22500	0.21900	0.22500	0.21400	0.20300	0.19400	0.19800	0.21200
6	0.25200	0.25200	0.25200	0.25200	0.25200	0.23400	0.23300	0.22700	0.22200	0.23300	0.22600	0.21900	0.20400	0.21200	0.21500
7	0.25800	0.25800	0.25800	0.25800	0.25800	0.25400	0.24100	0.24700	0.22900	0.24800	0.23400	0.22500	0.21100	0.22000	0.22500
8	0.26900	0.26900	0.26900	0.26900	0.26900	0.26000	0.27000	0.26000	0.24200	0.26600	0.22500	0.23500	0.22200	0.23600	0.24300
9	0.29200	0.29200	0.29200	0.29200	0.29200	0.27600	0.29600	0.29300	0.26300	0.28700	0.24900	0.24500	0.23000	0.25400	0.25900

AGE	2003	2004	2005	2006
1	0.06400	0.05900	0.07510	0.07500
2	0.13800	0.13800	0.12960	0.13500
3	0.17600	0.15900	0.15380	0.16600
4	0.19000	0.18000	0.16650	0.18500
5	0.20400	0.18900	0.18020	0.19200
6	0.21300	0.20200	0.19110	0.20400
7	0.21700	0.21300	0.21250	0.21100
8	0.22300	0.21400	0.20300	0.22400
9	0.22800	0.20600	0.22840	0.23100

Table 5.6.5. Herring in VIa (N). Natural mortality. N.B. In this table “age” refers to number of rings (winter rings in the otolith).

Natural Mortality (per year)

AGE	1957	1958	1959	1960	1961	----	2002	2003	2004	2005	2006
1	1.0000	1.0000	1.0000	1.0000	1.0000	----	1.0000	1.0000	1.0000	1.0000	1.0000
2	0.3000	0.3000	0.3000	0.3000	0.3000	----	0.3000	0.3000	0.3000	0.3000	0.3000
3	0.2000	0.2000	0.2000	0.2000	0.2000	----	0.2000	0.2000	0.2000	0.2000	0.2000
4	0.1000	0.1000	0.1000	0.1000	0.1000	----	0.1000	0.1000	0.1000	0.1000	0.1000
5	0.1000	0.1000	0.1000	0.1000	0.1000	----	0.1000	0.1000	0.1000	0.1000	0.1000
6	0.1000	0.1000	0.1000	0.1000	0.1000	----	0.1000	0.1000	0.1000	0.1000	0.1000
7	0.1000	0.1000	0.1000	0.1000	0.1000	----	0.1000	0.1000	0.1000	0.1000	0.1000
8	0.1000	0.1000	0.1000	0.1000	0.1000	----	0.1000	0.1000	0.1000	0.1000	0.1000
9	0.1000	0.1000	0.1000	0.1000	0.1000	----	0.1000	0.1000	0.1000	0.1000	0.1000

Table 5.6.6. Herring in VIa (N). Proportion mature. N.B. In this table “age” refers to number of rings (winter rings in the otolith).

AGE	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972
1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2	0.5700	0.5700	0.5700	0.5700	0.5700	0.5700	0.5700	0.5700	0.5700	0.5700	0.5700	0.5700	0.5700	0.5700	0.5700
3	0.9600	0.9600	0.9600	0.9600	0.9600	0.9600	0.9600	0.9600	0.9600	0.9600	0.9600	0.9600	0.9600	0.9600	0.9600
4	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
5	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
6	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
7	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
8	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
9	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

AGE	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2	0.5700	0.5700	0.5700	0.5700	0.5700	0.5700	0.5700	0.5700	0.5700	0.5700	0.5700	0.5700	0.5700	0.5700	0.5700
3	0.9600	0.9600	0.9600	0.9600	0.9600	0.9600	0.9600	0.9600	0.9600	0.9600	0.9600	0.9600	0.9600	0.9600	0.9600
4	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
5	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
6	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
7	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
8	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
9	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

Table 5.6.6. Herring in VIa (N). Proportion mature. Continued

Proportion of fish spawning

AGE	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2	0.5700	0.5700	0.5700	0.5700	0.4700	0.9300	0.4800	0.1900	0.7600	0.5700	0.8500	0.5700	0.4500	0.9300	0.9200
3	0.9600	0.9600	0.9600	0.9600	1.0000	0.9600	0.9200	0.9800	0.9400	0.9600	0.9700	0.9800	0.9200	0.9900	1.0000
4	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
5	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
6	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
7	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
8	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
9	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

AGE	2003	2004	2005	2006
1	0.0000	0.0000	0.0000	0.0000
2	0.7600	0.8300	0.8400	0.8100
3	1.0000	0.9700	1.0000	0.9650
4	1.0000	1.0000	1.0000	1.0000
5	1.0000	1.0000	1.0000	1.0000
6	1.0000	1.0000	1.0000	1.0000
7	1.0000	1.0000	1.0000	1.0000
8	1.0000	1.0000	1.0000	1.0000
9	1.0000	1.0000	1.0000	1.0000

Table 5.6.7. Herring in VIa (N). Tuning indices. N.B. In this table "age" refers to number of rings (winter rings in the otolith).

AGE-STRUCTURED INDICES

AGE	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1	249.1	*******	*******	*******	338.3	74.3	2.8	494.2	460.6	41.2	792.3	1221.7	534.2	447.6	313.1
2	578.4	*******	*******	*******	294.5	503.4	750.3	542.1	1085.1	576.5	641.9	794.6	322.4	316.2	1062.0
3	551.1	*******	*******	*******	327.9	211.0	681.2	607.7	472.7	802.5	286.2	666.8	1388.0	337.1	217.7
4	353.1	*******	*******	*******	367.8	258.1	653.0	285.6	450.2	329.1	167.0	471.1	432.0	899.5	172.8
5	752.6	*******	*******	*******	488.3	414.8	544.0	306.8	153.0	95.4	66.1	179.1	308.0	393.4	437.5
6	111.6	*******	*******	*******	176.3	240.1	865.2	268.1	187.1	60.6	49.5	79.3	138.7	247.6	132.6
7	48.1	*******	*******	*******	98.7	105.7	284.1	406.8	169.2	77.4	16.3	28.1	86.5	199.5	102.8
8	15.9	*******	*******	*******	89.8	56.7	151.7	173.7	236.6	78.2	29.0	13.8	27.6	95.0	52.4
9	6.5	*******	*******	*******	58.0	63.4	156.2	131.9	201.5	114.8	24.4	36.8	35.4	65.0	34.7

x 10 ^ 3

Table 5.6.7. Herring in VIa (N). Tuning indices. Continued

AGE	2002	2003	2004	2005	2006
1	424.7	438.8	564.0	50.2	112.3
2	436.0	1039.4	274.5	243.4	835.2
3	1436.9	932.5	760.2	230.3	387.9
4	199.8	1471.8	442.3	423.1	284.5
5	161.7	181.3	577.2	245.1	582.2
6	424.3	129.2	55.7	152.8	414.7
7	152.3	346.7	61.8	12.6	227.0
8	67.5	114.3	82.2	39.0	21.7
9	59.5	75.2	76.3	26.8	59.3

x 10 ^ 3

Table 5.6.8. Herring in VIa (N). Weighting factors for the catch in numbers. N.B. In this table “age” refers to number of rings (winter rings in the otolith).

Weighting factors for the catches in number

AGE	1999	2000	2001	2002	2003	2004	2005	2006
1	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000
2	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
3	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
4	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
5	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
6	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
7	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
8	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

Table 5.6.9. Herring in VIa (N). Fishing mortality (per year). N.B. In this table “age” refers to number of rings (winter rings in the otolith).

Fishing Mortality (per year)

AGE	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972
1	0.0112	0.0387	0.0087	0.0158	0.0375	0.0087	0.0430	0.0613	0.3610	0.1388	0.0880	0.0200	0.1148	0.0348	0.3667
2	0.0899	0.1026	0.1634	0.2487	0.2532	0.1144	0.1293	0.0675	0.2357	0.1221	0.1456	0.0804	0.1116	0.4157	0.2360
3	0.2887	0.1483	0.1316	0.1485	0.1980	0.2408	0.1505	0.1448	0.1647	0.1623	0.1371	0.1669	0.3485	0.9815	0.4273
4	0.3323	0.3742	0.1282	0.0944	0.2281	0.1460	0.1726	0.1747	0.1926	0.2626	0.1618	0.2106	0.3985	0.8603	0.2988
5	0.2726	0.3259	0.2368	0.1616	0.1583	0.1865	0.1129	0.1908	0.1571	0.1652	0.1340	0.2975	0.3680	0.6770	0.4065
6	0.3484	0.2758	0.2215	0.0781	0.1866	0.1186	0.1457	0.0974	0.2254	0.1472	0.1271	0.2714	0.2985	0.6015	0.3156
7	0.3788	0.3334	0.2352	0.1347	0.1916	0.1050	0.1044	0.1788	0.1311	0.1864	0.0968	0.3163	0.4369	0.5381	0.4610
8	0.2641	0.2431	0.1785	0.1467	0.2024	0.1417	0.1323	0.1318	0.1843	0.1671	0.1310	0.2063	0.3015	0.6358	0.3353
9	0.2641	0.2431	0.1785	0.1467	0.2024	0.1417	0.1323	0.1318	0.1843	0.1671	0.1310	0.2063	0.3015	0.6358	0.3353

AGE	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
1	0.0778	0.3341	0.1367	0.1924	0.0914	0.0395	0.0003	0.0048	0.0354	0.0274	0.0435	0.0030	0.0544	0.0606	0.0144
2	0.5022	0.4950	0.7354	0.7647	0.3477	0.2917	0.0005	0.0007	0.3203	0.6556	0.3863	0.2271	0.2077	0.5419	0.2771
3	0.5864	0.7719	0.8823	1.2087	0.5926	0.2636	0.0007	0.0004	0.4284	0.5959	0.5888	0.4929	0.2985	0.4626	0.3198
4	0.6284	0.9095	0.8540	1.0803	0.9222	0.5135	0.0003	0.0006	0.3965	0.8017	0.4885	0.4372	0.2977	0.3925	0.2956
5	0.5920	0.9282	0.9018	0.8904	0.9450	0.7370	0.0002	0.0002	0.3031	0.7157	0.9598	0.4396	0.3061	0.5421	0.2540
6	0.6037	1.2029	0.9864	1.0643	1.4519	1.0791	0.0014	0.0002	0.3057	0.5600	0.7760	0.6481	0.3160	0.6294	0.4403
7	0.3436	0.8659	1.0168	1.0864	0.8636	0.9782	0.0023	0.0016	0.2990	0.4465	0.7275	0.5833	0.9442	0.1742	0.5002
8	0.5225	0.8122	0.8596	0.9699	0.7973	0.6057	0.0009	0.0006	0.3308	0.6129	0.6072	0.4411	0.3758	0.4464	0.3365
9	0.5225	0.8122	0.8596	0.9699	0.7973	0.6057	0.0009	0.0006	0.3308	0.6129	0.6072	0.4411	0.3758	0.4464	0.3365

AGE	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
1	0.0029	0.0112	0.0527	0.1138	0.0104	0.0475	0.0032	0.0006	0.0036	0.0012	0.0302	0.0023	0.0016	0.0017	0.0019
2	0.1942	0.1332	0.1592	0.1903	0.2521	0.4692	0.2220	0.3575	0.1954	0.2261	0.1640	0.1941	0.1298	0.1447	0.1556
3	0.3018	0.2916	0.2273	0.1477	0.3449	0.3318	0.3954	0.3094	0.2344	0.2964	0.2264	0.3304	0.2209	0.2463	0.2649
4	0.3213	0.2063	0.3117	0.2303	0.1915	0.2381	0.1596	0.3561	0.1375	0.3784	0.4567	0.2669	0.1784	0.1989	0.2139
5	0.2674	0.3104	0.4373	0.2285	0.2502	0.1398	0.2246	0.1877	0.1829	0.5227	0.4574	0.3554	0.2376	0.2649	0.2849
6	0.2011	0.1395	0.3501	0.3703	0.2957	0.2397	0.1068	0.1714	0.1123	0.7227	0.6374	0.2829	0.1892	0.2109	0.2268
7	0.2695	0.1386	0.2423	0.3067	0.2648	0.2427	0.2391	0.1454	0.2623	0.7759	0.8623	0.2791	0.1866	0.2081	0.2237
8	0.2467	0.1870	0.2674	0.2376	0.2561	0.2857	0.2137	0.2565	0.1816	0.4575	0.4390	0.2669	0.1784	0.1989	0.2139
9	0.2467	0.1870	0.2674	0.2376	0.2561	0.2857	0.2137	0.2565	0.1816	0.4575	0.4390	0.2669	0.1784	0.1989	0.2139

Table 5.6.9. Herring in VIa (N). Fishing mortality (per year). Continued.

Fishing Mortality (per year)

AGE	2003	2004	2005	2006
1	0.0017	0.0015	0.0010	0.0021
2	0.1437	0.1257	0.0794	0.1731
3	0.2447	0.2141	0.1352	0.2947
4	0.1977	0.1729	0.1092	0.2380
5	0.2632	0.2303	0.1454	0.3170
6	0.2095	0.1833	0.1157	0.2523
7	0.2067	0.1809	0.1142	0.2490
8	0.1977	0.1729	0.1092	0.2380
9	0.1977	0.1729	0.1092	0.2380

Table 5.6.10. Herring in VIa (N). Population abundance (1 January, millions). N.B. In this table "age" refers to number of rings (winter rings in the otolith).

Population Abundance (1 January)

AGE	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972
1	2212.7	2207.1	647.5	1317.9	2357.3	2154.7	993.2	7931.8	1073.2	2509.7	4107.2	3000.7	3441.3	9575.7	2676.2
2	415.9	804.9	781.2	236.1	477.2	835.3	785.8	350.0	2744.5	275.2	803.6	1383.7	1082.0	1128.6	3402.2
3	636.7	281.6	538.2	491.5	136.4	274.5	551.9	511.5	242.4	1606.2	180.4	514.7	945.8	716.9	551.7
4	144.8	390.6	198.8	386.3	346.9	91.6	176.6	388.7	362.4	168.3	1118.1	128.8	356.6	546.5	220.0
5	109.4	94.0	243.1	158.2	318.0	249.8	71.6	134.5	295.3	270.4	117.1	860.6	94.4	216.6	209.2
6	98.4	75.4	61.4	173.6	121.8	245.7	187.6	57.9	100.5	228.4	207.4	92.7	578.3	59.1	99.6
7	57.8	62.8	51.8	44.5	145.3	91.5	197.4	146.7	47.5	72.6	178.4	165.3	63.9	388.2	29.3
8	44.5	35.8	40.7	37.0	35.2	108.5	74.5	160.9	111.0	37.7	54.5	146.5	109.0	37.4	205.1
9	32.3	41.8	29.6	19.9	40.6	48.4	127.9	166.1	168.8	175.9	92.5	147.5	97.0	71.1	61.2

AGE	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
1	1075.1	1675.0	2116.7	614.5	626.1	916.0	1219.4	892.1	1667.5	777.7	3036.2	1152.7	1214.2	904.6	2148.7
2	682.3	365.9	441.2	679.2	186.5	210.2	323.9	448.5	326.6	592.1	278.4	1069.4	422.8	423.1	313.2
3	1990.6	305.9	165.2	156.6	234.2	97.6	116.3	239.8	332.0	175.7	227.7	140.1	631.3	254.5	182.3
4	294.6	906.7	115.7	56.0	38.3	106.0	61.4	95.2	196.3	177.1	79.3	103.5	70.1	383.5	131.2
5	147.6	142.2	330.4	44.6	17.2	13.8	57.4	55.5	86.1	119.5	71.9	44.0	60.5	47.1	234.3
6	126.1	73.9	50.9	121.3	16.6	6.0	6.0	51.9	50.2	57.5	52.8	24.9	25.7	40.3	24.8
7	65.7	62.4	20.1	17.2	37.9	3.5	1.9	5.4	47.0	33.5	29.7	22.0	11.8	16.9	19.4
8	16.7	42.2	23.7	6.6	5.2	14.4	1.2	1.7	4.9	31.5	19.4	13.0	11.1	4.1	12.9
9	82.8	39.5	24.8	20.2	2.8	3.6	8.9	9.1	4.9	9.2	19.5	5.8	7.3	5.7	21.9

x 10 ^ 6

Table 5.6.10. Herring in VIa (N). Population abundance (1 January, millions). Continued.

Population Abundance (1 January)

AGE	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
1	927.0	880.1	438.5	384.7	799.7	602.4	855.3	668.1	866.0	1538.7	482.4	307.4	1726.8	955.6	921.2
2	779.2	340.0	320.2	153.0	126.3	291.1	211.3	313.7	245.6	317.4	565.4	172.2	112.8	634.3	350.9
3	175.9	475.3	220.5	202.3	93.7	72.7	134.9	125.4	162.5	149.7	187.6	355.5	105.1	73.4	406.6
4	108.4	106.5	290.7	143.8	142.9	54.3	42.7	74.4	75.3	105.3	91.1	122.5	209.2	69.0	47.0
5	88.3	71.1	78.4	192.6	103.4	106.8	38.8	33.0	47.1	59.4	65.2	52.2	84.9	158.3	51.1
6	164.5	61.2	47.2	45.8	138.7	72.8	84.0	28.0	24.7	35.5	31.9	37.4	33.1	60.5	109.9
7	14.4	121.7	48.1	30.1	28.6	93.4	51.9	68.3	21.4	20.0	15.6	15.2	25.5	24.8	44.4
8	10.7	10.7	95.9	34.2	20.0	19.9	66.3	36.9	53.4	14.9	8.3	6.0	10.4	19.1	18.2
9	11.3	21.6	24.7	22.1	25.6	15.8	55.6	45.4	196.5	28.2	9.8	4.9	2.9	5.8	7.7

AGE	2003	2004	2005	2006	2007
1	363.6	259.4	168.2	112.2	400.6
2	338.3	133.5	95.3	61.8	41.2
3	222.5	217.0	87.2	65.2	38.5
4	255.4	142.6	143.4	62.4	39.8
5	34.3	189.7	108.6	116.4	44.5
6	34.8	23.9	136.3	84.9	76.7
7	79.3	25.5	18.0	109.9	59.7
8	32.1	58.3	19.3	14.5	77.5
9	8.2	26.5	14.5	25.2	28.3

x 10 ^ 6

Table 5.6.11. Herring in VIa (N). Predicted catch in number. N.B. In this table "age" refers to number of rings (winter rings in the otolith).

Predicted Catch in Number

AGE	1999	2000	2001	2002	2003	2004	2005	2006
1	453.	1703.	1050.	1089.	397.	248.	102.	148.
2	26365.	11899.	74071.	43848.	39264.	13674.	6295.	8526.
3	91161.	18944.	14586.	86129.	43965.	38051.	10019.	15159.
4	27357.	32575.	11858.	8625.	43665.	21587.	14131.	12601.
5	14905.	17114.	35145.	12093.	7576.	37200.	13998.	30165.
6	8781.	5439.	10974.	21262.	6272.	3810.	14191.	18066.
7	3542.	4134.	4440.	8480.	14114.	4027.	1848.	23090.
8	1331.	1625.	3289.	3345.	5487.	8828.	1900.	2931.

x 10 ^ 6

Table 5.6.12. Herring in VIa (N). Predicted index values. N.B. In this table "age" refers to number of rings (winter rings in the otolith).

Predicted Age-Structured Index Values

AGE	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1	805.6	*******	*******	*******	136.6	300.5	221.8	322.6	252.4	326.6	581.0	179.3	116.0	651.9	360.8
2	747.8	*******	*******	*******	383.0	305.7	626.0	519.9	716.8	613.1	779.3	1435.7	430.1	291.9	1627.7
3	620.6	*******	*******	*******	756.3	314.7	245.9	440.7	429.2	579.6	516.0	671.9	1203.1	377.4	260.1
4	487.3	*******	*******	*******	553.6	561.7	208.3	170.9	267.3	305.0	373.7	309.9	462.1	828.1	270.0
5	822.5	*******	*******	*******	685.5	363.5	398.7	138.2	119.9	172.0	180.1	204.9	173.4	300.5	552.4
6	75.4	*******	*******	*******	144.8	456.6	247.2	306.5	98.7	89.9	92.7	87.1	123.8	115.5	208.7
7	51.4	*******	*******	*******	88.5	86.2	284.5	158.3	219.5	64.4	45.5	33.9	45.5	80.0	77.0
8	34.2	*******	*******	*******	95.8	55.6	54.3	188.2	102.5	154.4	37.0	20.9	16.4	30.2	54.7
9	66.2	*******	*******	*******	70.4	80.7	49.0	179.6	143.1	645.8	79.7	28.0	15.3	9.6	18.9

AGE	2002	2003	2004	2005	2006
1	347.7	137.3	97.9	63.5	42.4
2	895.3	868.5	346.2	253.4	156.2
3	1426.1	789.1	782.6	328.4	225.0
4	182.4	1000.8	566.5	589.8	239.1
5	176.5	119.9	674.3	404.3	394.6
6	375.7	120.1	83.5	495.0	286.3
7	136.6	246.4	80.5	58.8	333.6
8	51.7	91.9	169.4	58.0	40.7
9	25.0	26.8	87.4	49.6	80.3

x 10 ^ 3

Table 5.6.13. Herring in VIa (N). Fitted selection pattern. N.B. In this table "age" refers to number of rings (winter rings in the otolith).

Fitted Selection Pattern

AGE	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972
1	0.0338	0.1034	0.0681	0.1675	0.1645	0.0595	0.2494	0.3507	1.8746	0.5285	0.5439	0.0952	0.2882	0.0405	1.2271
2	0.2707	0.2741	1.2745	2.6357	1.1099	0.7837	0.7492	0.3863	1.2240	0.4651	0.9003	0.3819	0.2801	0.4832	0.7897
3	0.8687	0.3963	1.0270	1.5736	0.8679	1.6495	0.8722	0.8288	0.8555	0.6180	0.8476	0.7926	0.8746	1.1408	1.4301
4	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
5	0.8205	0.8710	1.8478	1.7127	0.6937	1.2774	0.6540	1.0923	0.8156	0.6291	0.8282	1.4125	0.9235	0.7869	1.3602
6	1.0487	0.7370	1.7285	0.8272	0.8178	0.8123	0.8439	0.5578	1.1704	0.5607	0.7856	1.2888	0.7492	0.6992	1.0560
7	1.1399	0.8909	1.8349	1.4277	0.8398	0.7195	0.6048	1.0232	0.6807	0.7098	0.5986	1.5016	1.0964	0.6254	1.5427
8	0.7948	0.6497	1.3924	1.5545	0.8871	0.9705	0.7667	0.7542	0.9569	0.6364	0.8097	0.9795	0.7567	0.7390	1.1222
9	0.7948	0.6497	1.3924	1.5545	0.8871	0.9705	0.7667	0.7542	0.9569	0.6364	0.8097	0.9795	0.7567	0.7390	1.1222

Table 5.6.13. Herring in VIa (N). Fitted selection pattern. Continued.

Fitted Selection Pattern

AGE	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
1	0.1238	0.3674	0.1601	0.1781	0.0991	0.0770	0.9852	8.4923	0.0892	0.0341	0.0890	0.0069	0.1826	0.1543	0.0488
2	0.7992	0.5443	0.8612	0.7079	0.3771	0.5680	1.5602	1.2790	0.8078	0.8178	0.7909	0.5195	0.6976	1.3804	0.9375
3	0.9333	0.8487	1.0331	1.1188	0.6426	0.5134	2.2456	0.7761	1.0805	0.7433	1.2054	1.1273	1.0028	1.1785	1.0818
4	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
5	0.9422	1.0205	1.0560	0.8242	1.0248	1.4352	0.7316	0.4369	0.7645	0.8927	1.9649	1.0054	1.0282	1.3810	0.8591
6	0.9608	1.3227	1.1551	0.9852	1.5744	2.1014	4.3343	0.3234	0.7711	0.6986	1.5887	1.4824	1.0615	1.6034	1.4895
7	0.5469	0.9521	1.1907	1.0056	0.9365	1.9048	6.9537	2.7709	0.7541	0.5570	1.4893	1.3342	3.1718	0.4438	1.6923
8	0.8316	0.8930	1.0066	0.8978	0.8646	1.1795	2.7076	1.1113	0.8343	0.7644	1.2432	1.0089	1.2625	1.1373	1.1385
9	0.8316	0.8930	1.0066	0.8978	0.8646	1.1795	2.7076	1.1113	0.8343	0.7644	1.2432	1.0089	1.2625	1.1373	1.1385

AGE	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
1	0.0091	0.0544	0.1691	0.4940	0.0545	0.1994	0.0200	0.0018	0.0260	0.0032	0.0661	0.0087	0.0087	0.0087	0.0087
2	0.6044	0.6457	0.5108	0.8260	1.3166	1.9708	1.3908	1.0038	1.4216	0.5974	0.3590	0.7272	0.7272	0.7272	0.7272
3	0.9393	1.4135	0.7292	0.6411	1.8012	1.3936	2.4765	0.8688	1.7051	0.7833	0.4957	1.2382	1.2382	1.2382	1.2382
4	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
5	0.8322	1.5044	1.4030	0.9920	1.3065	0.5872	1.4068	0.5271	1.3302	1.3814	1.0015	1.3318	1.3318	1.3318	1.3318
6	0.6258	0.6763	1.1234	1.6077	1.5441	1.0069	0.6688	0.4812	0.8171	1.9098	1.3956	1.0601	1.0601	1.0601	1.0601
7	0.8387	0.6720	0.7775	1.3314	1.3830	1.0195	1.4978	0.4082	1.9084	2.0503	1.8882	1.0459	1.0459	1.0459	1.0459
8	0.7678	0.9066	0.8580	1.0313	1.3375	1.2002	1.3386	0.7203	1.3210	1.2089	0.9613	1.0000	1.0000	1.0000	1.0000
9	0.7678	0.9066	0.8580	1.0313	1.3375	1.2002	1.3386	0.7203	1.3210	1.2089	0.9613	1.0000	1.0000	1.0000	1.0000

AGE	2003	2004	2005	2006
1	0.0087	0.0087	0.0087	0.0087
2	0.7272	0.7272	0.7272	0.7272
3	1.2382	1.2382	1.2382	1.2382
4	1.0000	1.0000	1.0000	1.0000
5	1.3318	1.3318	1.3318	1.3318
6	1.0601	1.0601	1.0601	1.0601
7	1.0459	1.0459	1.0459	1.0459
8	1.0000	1.0000	1.0000	1.0000
9	1.0000	1.0000	1.0000	1.0000

Table 5.6.14. Herring in VIa (N). Stock summary. N.B. In this table "age" refers to number of rings (winter rings in the otolith).

STOCK SUMMARY

Year	Recruits Age 1 thousands	Total Biomass tonnes	Spawning Biomass tonnes	Landings tonnes	Yield /SSB ratio	Mean F Ages 3- 6	SoP (%)
1958	2212700	521599	213788	59669	0.2791	0.3105	133
1959	2207110	560404	229855	65221	0.2837	0.2810	137
1960	647460	452889	266482	63759	0.2393	0.1795	176
1961	1317900	459481	266665	46353	0.1738	0.1206	171
1962	2357340	567345	255902	58195	0.2274	0.1927	129
1963	2154720	599628	279650	49030	0.1753	0.1730	143
1964	993210	547433	325431	64234	0.1974	0.1454	173
1965	7931830	1145548	331998	68669	0.2068	0.1519	116
1966	1073170	870956	443967	100619	0.2266	0.1850	98
1967	2509730	848638	473104	90400	0.1911	0.1843	123
1968	4107180	968245	448629	84614	0.1886	0.1400	125
1969	3000720	994218	484835	107170	0.2210	0.2366	132
1970	3441280	1010076	451154	165930	0.3678	0.3534	136
1971	9575740	1522522	322203	207167	0.6430	0.7801	98
1972	2676160	1121975	449079	164756	0.3669	0.3621	97
1973	1075080	805073	388257	210270	0.5416	0.6026	95
1974	1674990	578215	205535	178160	0.8668	0.9531	88
1975	2116660	437091	108162	114001	1.0540	0.9061	98
1976	614530	265951	74599	93642	1.2553	1.0609	100
1977	626140	164986	53217	41341	0.7768	0.9779	109
1978	915990	172660	50015	22156	0.4430	0.6483	99
1979	1219400	220389	76219	60	0.0008	0.0007	99
1980	892140	257150	126093	306	0.0024	0.0004	99
1981	1667530	367133	133595	51420	0.3849	0.3585	103
1982	777670	308579	111549	92360	0.8280	0.6683	96
1983	3036180	434311	82975	63523	0.7656	0.7033	97
1984	1152680	360340	123173	56012	0.4547	0.5044	105
1985	1214240	355762	152361	39142	0.2569	0.3046	99
1986	904610	321966	138659	70764	0.5103	0.5066	95
1987	2148730	392008	129575	44360	0.3423	0.3274	102
1988	927030	346130	155111	35591	0.2295	0.2729	97
1989	880110	331958	172862	34026	0.1968	0.2369	98
1990	438460	282168	164407	44693	0.2718	0.3316	101
1991	384680	217644	133997	28529	0.2129	0.2442	93
1992	799660	226087	110473	28985	0.2624	0.2706	99
1993	602380	192193	105026	31778	0.3026	0.2373	100
1994	855320	186474	96351	24430	0.2536	0.2216	100
1995	668080	165737	77034	29575	0.3839	0.2562	99
1996	866000	203681	123385	26105	0.2116	0.1668	95
1997	1538700	224251	79138	35233	0.4452	0.4801	99
1998	482370	189672	103762	33353	0.3214	0.4445	100
1999	307380	147028	87029	29736	0.3417	0.3089	99
2000	1726800	211001	75351	18322	0.2432	0.2065	100
2001	955630	224184	121998	24556	0.2013	0.2303	99
2002	921180	242966	137261	32914	0.2398	0.2476	99
2003	363590	198298	128104	28081	0.2192	0.2288	99
2004	259390	157963	110412	25021	0.2266	0.2002	98
2005	168210	118948	88261	14129	0.1601	0.1264	99
2006	112240	111054	77787	27346	0.3515	0.2755	100

```
 -----------------------------------------------------------------
 No of years for separable analysis : 8
 Age range in the analysis : 1  . . . 9
 Year range in the analysis : 1958  . . . 2006
 Number of indices of SSB : 0
 Number of age-structured indices : 1

 Parameters to estimate : 38
 Number of observations : 216

 Conventional single selection vector model to be fitted.
-----------------------------------------------------------------
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Table 5.6.15. Herring in VIa (N). Parameter estimates. N.B. In this table "age" refers to number of rings (winter rings in the otolith).

PARAMETER ESTIMATES

Parm. No.		Maximum Likelh. Estimate	CV (%)	Lower 95% CL	Upper 95% CL	-s.e.	+s.e.	Mean of Param. Distrib.
Separable model : F by year								
1	1999	0.2669	16	0.1941	0.3669	0.2269	0.3139	0.2704
2	2000	0.1784	16	0.1294	0.2461	0.1514	0.2102	0.1808
3	2001	0.1989	16	0.1443	0.2742	0.1689	0.2343	0.2016
4	2002	0.2139	16	0.1537	0.2977	0.1807	0.2532	0.2170
5	2003	0.1977	17	0.1390	0.2811	0.1651	0.2366	0.2009
6	2004	0.1729	19	0.1179	0.2537	0.1422	0.2103	0.1763
7	2005	0.1092	21	0.0720	0.1655	0.0883	0.1350	0.1117
8	2006	0.2380	24	0.1466	0.3866	0.1859	0.3049	0.2454
Separable Model: Selection (S) by age								
9	1	0.0087	38	0.0041	0.0186	0.0060	0.0128	0.0094
10	2	0.7272	15	0.5378	0.9833	0.6234	0.8482	0.7359
11	3	1.2382	14	0.9400	1.6310	1.0758	1.4251	1.2505
	4	1.0000		Fixed : Reference Age				
12	5	1.3318	12	1.0369	1.7105	1.1722	1.5132	1.3427
13	6	1.0601	12	0.8320	1.3507	0.9368	1.1996	1.0682
14	7	1.0459	12	0.8178	1.3377	0.9226	1.1858	1.0542
	8	1.0000		Fixed : Last true age				
Separable model: Populations in year 2006								
15	1	112248	94	17606	715632	43623	288831	175449
16	2	61823	34	31313	122063	43694	87475	65661
17	3	65199	27	37852	112302	49403	86045	67757
18	4	62387	24	38568	100917	48812	79737	64294
19	5	116367	22	74576	181577	92735	146022	119404
20	6	84945	22	54906	131419	67990	106128	87077
21	7	109862	21	71478	168857	88228	136800	112536
22	8	14511	21	9469	22238	11671	18043	14860
Separable model: Populations at age								
23	1999	5959	29	3324	10681	4424	8026	6229
24	2000	10435	23	6523	16691	8211	13261	10739
25	2001	19125	21	12623	28975	15472	23640	19559
26	2002	18220	19	12332	26919	14930	22235	18585
27	2003	32094	20	21614	47657	26232	39267	32754
28	2004	58333	20	39170	86871	47607	71476	59550
29	2005	19283	20	12780	29094	15633	23785	19712
Age-structured index catchabilities								
FLT01:West Scotland Summer Acoustic Sur								
Linear model fitted. Slopes at age :								
30	1 Q	.6517	65	.3483	4.498	.6517	2.404	1.549
31	2 Q	3.270	21	2.663	6.158	3.270	5.015	4.143
32	3 Q	4.519	21	3.683	8.486	4.519	6.918	5.719
33	4 Q	4.608	21	3.757	8.647	4.608	7.050	5.830
34	5 Q	4.257	21	3.468	8.003	4.257	6.521	5.390
35	6 Q	4.084	21	3.323	7.709	4.084	6.274	5.180
36	7 Q	3.673	21	2.983	6.976	3.673	5.666	4.670
37	8 Q	3.369	21	2.729	6.448	3.369	5.224	4.297
38	9 Q	3.831	21	3.113	7.260	3.831	5.900	4.866

Table 5.6.16. Herring in VIa (N). Residuals about the model fit. N.B. In this table "age" refers to number of rings (winter rings in the otolith).

RESIDUALS ABOUT THE MODEL FIT

Separable Model Residuals

Age	1999	2000	2001	2002	2003	2004	2005	2006
1	2.824	0.740	-1.994	-0.093	-1.957	*******	0.587	-0.108
2	0.290	0.423	0.090	-0.131	-0.164	-0.692	0.425	-0.242
3	0.030	-0.093	0.024	0.087	0.064	-0.538	0.841	-0.501
4	-0.087	0.222	-0.242	0.044	0.208	0.253	0.377	0.080
5	-0.109	-0.333	-0.362	0.404	-0.015	0.208	-0.313	0.309
6	-0.154	0.269	-0.168	0.276	-0.367	0.027	-0.372	0.430
7	-0.086	-0.293	0.400	0.064	-0.096	0.641	-0.599	-0.096
8	-0.058	-0.113	0.338	-0.771	0.516	-0.040	-0.464	0.037

AGE-STRUCTURED INDEX RESIDUALS

Age	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1	-1.174	*******	*******	*******	0.907	-1.397	-4.387	0.426	0.602	-2.070	0.310	1.919	1.527	-0.376	-0.142
2	-0.257	*******	*******	*******	-0.263	0.499	0.181	0.042	0.415	-0.062	-0.194	-0.592	-0.288	0.080	-0.427
3	-0.119	*******	*******	*******	-0.836	-0.400	1.019	0.321	0.096	0.325	-0.589	-0.008	0.143	-0.113	-0.178
4	-0.322	*******	*******	*******	-0.409	-0.778	1.143	0.514	0.521	0.076	-0.805	0.419	-0.067	0.083	-0.446
5	-0.089	*******	*******	*******	-0.339	0.132	0.311	0.797	0.244	-0.590	-1.002	-0.135	0.575	0.269	-0.233
6	0.392	*******	*******	*******	0.197	-0.643	1.253	-0.134	0.640	-0.394	-0.627	-0.094	0.113	0.763	-0.454
7	-0.067	*******	*******	*******	0.109	0.204	-0.002	0.944	-0.260	0.184	-1.029	-0.190	0.641	0.913	0.289
8	-0.765	*******	*******	*******	-0.064	0.020	1.028	-0.080	0.837	-0.681	-0.243	-0.412	0.518	1.146	-0.044
9	-2.322	*******	*******	*******	-0.194	-0.240	1.160	-0.309	0.343	-1.727	-1.182	0.273	0.839	1.909	0.606

Age	2002	2003	2004	2005	2006
1	0.200	1.162	1.751	-0.236	0.975
2	-0.720	0.180	-0.232	-0.040	1.676
3	0.008	0.167	-0.029	-0.355	0.545
4	0.091	0.386	-0.247	-0.332	0.174
5	-0.088	0.414	-0.156	-0.500	0.389
6	0.122	0.073	-0.405	-1.175	0.370
7	0.109	0.342	-0.264	-1.540	-0.385
8	0.266	0.218	-0.723	-0.396	-0.628
9	0.866	1.031	-0.136	-0.616	-0.303

Table 5.6.17. Herring in VIa (N). Parameters of distributions. N.B. In this table "age" refers to number of rings (winter rings in the otolith).

PARAMETERS OF THE DISTRIBUTION OF ln(CATCHES AT AGE)

Separable model fitted from 1999 to 2006

Variance	0.2327
Skewness test stat.	0.1837
Kurtosis test statistic	-0.1246
Partial chi-square	0.9624
Significance in fit	0.0000
Degrees of freedom	34

PARAMETERS OF THE DISTRIBUTION OF THE AGE-STRUCTURED INDICES

DISTRIBUTION STATISTICS FOR FLT01:West Scotland Summer Acoustic Sur

Linear catchability relationship assumed

Age	1	2	3	4	5	6	7	8	9
Variance	0.0277	0.0324	0.0208	0.0286	0.0234	0.0393	0.0430	0.0404	0.1286
Skewness test stat.	-2.1467	2.8769	0.5223	0.5584	-0.5677	0.2240	-1.3030	0.8948	-0.7400
Kurtosis test statisti	1.2959	3.0106	0.4148	-0.1743	-0.2572	-0.1417	0.6315	-0.6440	-0.1253
Partial chi-square	0.0364	0.0414	0.0259	0.0361	0.0306	0.0512	0.0616	0.0596	0.1912
Significance in fit	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Number of observations	17	17	17	17	17	17	17	17	17
Degrees of freedom	16	16	16	16	16	16	16	16	16
Weight in the analysis	0.0111	0.1111	0.1111	0.1111	0.1111	0.1111	0.1111	0.1111	0.1111

Table 5.6.18. Herring in VIa (N). Analysis of variance. N.B. In this table "age" refers to number of rings (winter rings in the otolith).

Unweighted Statistics

Variance

	SSQ	Data	Parameters	d.f.	Variance
Total for model	114.2258	216	38	178	0.6417
Catches at age	22.9376	63	29	34	0.6746
Aged Indices					
FLT01:West Scotland Summer Acoustic Su	91.2882	153	9	144	0.6339

Weighted Statistics

Variance

	SSQ	Data	Parameters	d.f.	Variance
Total for model	8.5512	216	38	178	0.0480
Catches at age	7.9126	63	29	34	0.2327
Aged Indices					
FLT01:West Scotland Summer Acoustic Su	0.6387	153	9	144	0.0044

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 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. The terminal year values are not applicable. N.B. In this table "age" refers to number of rings (winter rings in the otolith).

2007

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
1	604957	1	0	0.67	0.67	0.0697	2.08E-03	0.0664
2	222089	0.3	0.81	0.67	0.67	0.1342	0.173093	0.148233
3	38521	0.2	0.965	0.67	0.67	0.1596	0.29474	0.167933
4	39755	0.1	1	0.67	0.67	0.177167	0.238033	0.1908
5	44494	0.1	1	0.67	0.67	0.187067	0.317018	0.211467
6	76688	0.1	1	0.67	0.67	0.199033	0.252339	0.223633
7	59721	0.1	1	0.67	0.67	0.212167	0.248971	0.2258
8	77499	0.1	1	0.67	0.67	0.213667	0.238033	0.2357
9	28319	0.1	1	0.67	0.67	0.2218	0.238033	0.278533

2008

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
1	604957	1	0	0.67	0.67	0.0697	2.08E-03	0.0664
2	.	0.3	0.81	0.67	0.67	0.1342	0.173093	0.148233
3	.	0.2	0.965	0.67	0.67	0.1596	0.29474	0.167933
4	.	0.1	1	0.67	0.67	0.177167	0.238033	0.1908
5	.	0.1	1	0.67	0.67	0.187067	0.317018	0.211467
6	.	0.1	1	0.67	0.67	0.199033	0.252339	0.223633
7	.	0.1	1	0.67	0.67	0.212167	0.248971	0.2258
8	.	0.1	1	0.67	0.67	0.213667	0.238033	0.2357
9	.	0.1	1	0.67	0.67	0.2218	0.238033	0.278533

2009

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
1	604957	1	0	0.67	0.67	0.0697	2.08E-03	0.0664
2	.	0.3	0.81	0.67	0.67	0.1342	0.173093	0.148233
3	.	0.2	0.965	0.67	0.67	0.1596	0.29474	0.167933
4	.	0.1	1	0.67	0.67	0.177167	0.238033	0.1908
5	.	0.1	1	0.67	0.67	0.187067	0.317018	0.211467
6	.	0.1	1	0.67	0.67	0.199033	0.252339	0.223633
7	.	0.1	1	0.67	0.67	0.212167	0.248971	0.2258
8	.	0.1	1	0.67	0.67	0.213667	0.238033	0.2357
9	.	0.1	1	0.67	0.67	0.2218	0.238033	0.278533

Table 5.7.1.2. Herring in VIa (N). Short-term prediction single option table, *status quo* F. N.B. In this table "age" refers to number of rings (winter rings in the otolith).

Year:	**2007**	**F multiplier:**	**1**	**Fbar:**	**0.276**				
Age	F	CatchNos	Yield	StockNos	Biomass	SSNos(Jan)	SSB(Jan)	SSNos(ST)	SSB(ST)
1	0.0021	796	53	604957	42166	0	0	0	0
2	0.1731	30628	4540	222089	29804	179892	24142	131025	17583
3	0.2947	8956	1504	38521	6148	37173	5933	26685	4259
4	0.238	8030	1532	39755	7043	39755	7043	31698	5616
5	0.317	11534	2439	44494	8323	44494	8323	33648	6294
6	0.2523	16310	3647	76688	15263	76688	15263	60563	12054
7	0.249	12552	2834	59721	12671	59721	12671	47270	10029
8	0.238	15653	3689	77499	16559	77499	16559	61793	13203
9	0.238	5720	1593	28319	6281	28319	6281	22580	5008
Total		110177	21832	1192043	144259	543541	96215	415260	74047

Year:	2008	F multiplier:	0.907	Fbar:	0.25				
Age	F	CatchNos	Yield	StockNos	Biomass	SSNos(Jan)	SSB(Jan)	SSNos(ST)	SSB(ST)
1	0.0019	722	48	604957	42166	0	0	0	0
2	0.157	27987	4149	222088	29804	179892	24141	132445	17774
3	0.2673	29551	4963	138377	22085	133534	21312	97636	15583
4	0.2159	4348	830	23487	4161	23487	4161	19007	3367
5	0.2875	6758	1429	28352	5304	28352	5304	21869	4091
6	0.2289	5719	1279	29322	5836	29322	5836	23523	4682
7	0.2258	10390	2346	53915	11439	53915	11439	43341	9196
8	0.2159	7799	1838	42128	9001	42128	9001	34092	7284
9	0.2159	13970	3891	75466	16738	75466	16738	61071	13546
Total		107244	20772	1218093	146534	566096	97933	432985	75523

Year:	2009	F multiplier:	0.907	Fbar:	0.25				
Age	F	CatchNos	Yield	StockNos	Biomass	SSNos(Jan)	SSB(Jan)	SSNos(ST)	SSB(ST)
1	0.0019	722	48	604957	42166	0	0	0	0
2	0.157	27992	4149	222131	29810	179926	24146	132471	17778
3	0.2673	30031	5043	140623	22443	135701	21658	99220	15836
4	0.2159	16053	3063	86718	15363	86718	15363	70176	12433
5	0.2875	4082	863	17125	3204	17125	3204	13209	2471
6	0.2289	3753	839	19243	3830	19243	3830	15438	3073
7	0.2258	4067	918	21104	4478	21104	4478	16965	3599
8	0.2159	7205	1698	38923	8317	38923	8317	31498	6730
9	0.2159	15873	4421	85742	19018	85742	19018	69387	15390
Total		109778	21044	1236567	148628	584483	100013	448364	77309

Table 5.7.1.3. Herring in VIa (N). Short-term prediction multiple option table,. *status quo* F.

2007				
Biomass	SSB	FMult	FBar	Landings
144259	74047	1	0.276	21832

2008					2009	
Biomass	SSB	FMult	FBar	Landings	Biomass	SSB
146534	87464	0	0	0	167097	106296
.	86186	0.0907	0.025	2286	165059	102908
.	84928	0.1814	0.05	4522	163066	99639
.	83689	0.2721	0.075	6711	161117	96486
.	82469	0.3628	0.1	8852	159212	93445
.	81267	0.4535	0.125	10948	157348	90510
.	80083	0.5442	0.1499	12999	155525	87678
.	78917	0.6349	0.1749	15006	153743	84946
.	77768	0.7256	0.1999	16969	152000	82309
.	76637	0.8163	0.2249	18891	150295	79765
.	75523	0.907	0.25	20772	148628	77309
.	74425	0.9977	0.2749	22613	146997	74939
.	73344	1.0884	0.2999	24415	145402	72652
.	72279	1.1791	0.3249	26178	143842	70444
.	71231	1.2698	0.3499	27904	142317	68312
.	70198	1.3605	0.3749	29594	140824	66254
.	69180	1.4512	0.3999	31247	139365	64267
.	68178	1.5419	0.4248	32866	137937	62349
.	67191	1.6326	0.4498	34450	136540	60497
.	66218	1.7233	0.4748	36001	135174	58708
.	65260	1.814	0.4998	37519	133838	56981

Table 5.7.1.4. 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:	2007	F multiplier:	1.6789	Fbar:	0.46				
Age	F	CatchNos	Yield	StockNos	Biomass	SSNos(Jan)	SSB(Jan)	SSNos(ST)	SSB(ST)
1	0.0035	1335	89	604957	42166	0	0	0	0
2	0.2906	48739	7225	222089	29804	179892	24142	121104	16252
3	0.4948	13740	2307	38521	6148	37173	5933	23337	3725
4	0.3996	12504	2386	39755	7043	39755	7043	28445	5040
5	0.5322	17552	3712	44494	8323	44494	8323	29130	5449
6	0.4236	25291	5656	76688	15263	76688	15263	53996	10747
7	0.418	19483	4399	59721	12671	59721	12671	42209	8955
8	0.3996	24376	5746	77499	16559	77499	16559	55452	11848
9	0.3996	8907	2481	28319	6281	28319	6281	20263	4494
Total		171928	34000	1192043	144259	543541	96215	373935	66510

Year:	2008	F multiplier:	0.907	Fbar:	0.25				
Age	F	CatchNos	Yield	StockNos	Biomass	SSNos(Jan)	SSB(Jan)	SSNos(ST)	SSB(ST)
1	0.0019	722	48	604957	42166	0	0	0	0
2	0.157	27947	4143	221775	29762	179637	24107	132258	17749
3	0.2673	26275	4412	123036	19637	118729	18949	86811	13855
4	0.2159	3559	679	19228	3407	19228	3407	15560	2757
5	0.2875	5750	1216	24122	4512	24122	4512	18606	3480
6	0.2289	4612	1031	23644	4706	23644	4706	18968	3775
7	0.2258	8755	1977	45427	9638	45427	9638	36518	7748
8	0.2159	6586	1552	35577	7602	35577	7602	28790	6152
9	0.2159	11886	3311	64206	14241	64206	14241	51958	11524
Total		96091	18369	1161970	135669	510570	87162	389470	67040

Year:	2009	F multiplier:	0.907	Fbar:	0.25				
Age	F	CatchNos	Yield	StockNos	Biomass	SSNos(Jan)	SSB(Jan)	SSNos(ST)	SSB(ST)
1	0.0019	722	48	604957	42166	0	0	0	0
2	0.157	27992	4149	222131	29810	179926	24146	132471	17778
3	0.2673	29988	5036	140424	22412	135509	21627	99080	15813
4	0.2159	14273	2723	77103	13660	77103	13660	62396	11054
5	0.2875	3342	707	14020	2623	14020	2623	10814	2023
6	0.2289	3193	714	16372	3259	16372	3259	13134	2614
7	0.2258	3280	741	17018	3611	17018	3611	13680	2902
8	0.2159	6071	1431	32795	7007	32795	7007	26539	5671
9	0.2159	13468	3751	72755	16137	72755	16137	58877	13059
Total		102330	19300	1197575	140683	545498	92070	416991	70914

Table 5.7.1.5. Herring in VIa (N). Short-term prediction multiple option table, with TAC constraint.

2007				
Biomass	SSB	FMult	FBar	Landings
144259	66510	1.6789	0.46	34000

2008					2009	
Biomass	SSB	FMult	FBar	Landings	Biomass	SSB
135669	77538	0	0	0	157046	96900
.	76415	0.0907	0.025	2020	155242	93866
.	75309	0.1814	0.05	3996	153477	90940
.	74220	0.2721	0.075	5931	151752	88115
.	73148	0.3628	0.1	7824	150064	85389
.	72091	0.4535	0.125	9677	148413	82759
.	71050	0.5442	0.1499	11491	146798	80220
.	70025	0.6349	0.1749	13266	145218	77769
.	69015	0.7256	0.1999	15003	143673	75403
.	68020	0.8163	0.2249	16704	142162	73119
.	67040	0.907	0.25	18369	140683	70914
.	66075	0.9977	0.2749	19999	139237	68785
.	65124	1.0884	0.2999	21594	137822	66730
.	64188	1.1791	0.3249	23156	136438	64745
.	63265	1.2698	0.3499	24685	135084	62828
.	62356	1.3605	0.3749	26182	133760	60977
.	61460	1.4512	0.3999	27647	132464	59189
.	60578	1.5419	0.4248	29082	131196	57462
.	59709	1.6326	0.4498	30486	129955	55794
.	58853	1.7233	0.4748	31861	128742	54182
.	58010	1.814	0.4998	33208	127554	52625

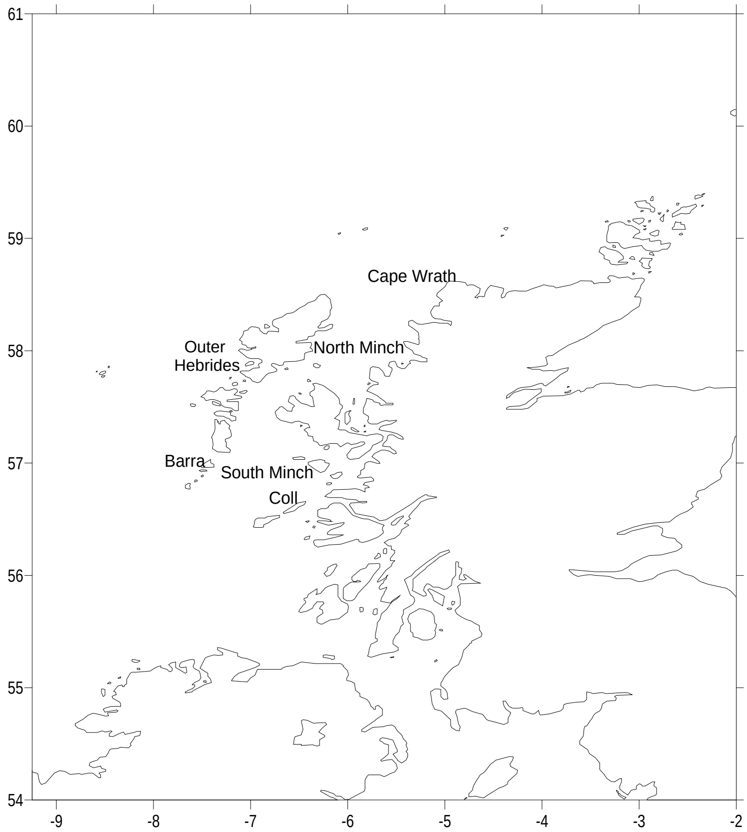


Figure 5.1. Herring in VIa (North). Map to show place names to the west of Scotland of relevance to the fishery and survey descriptions.

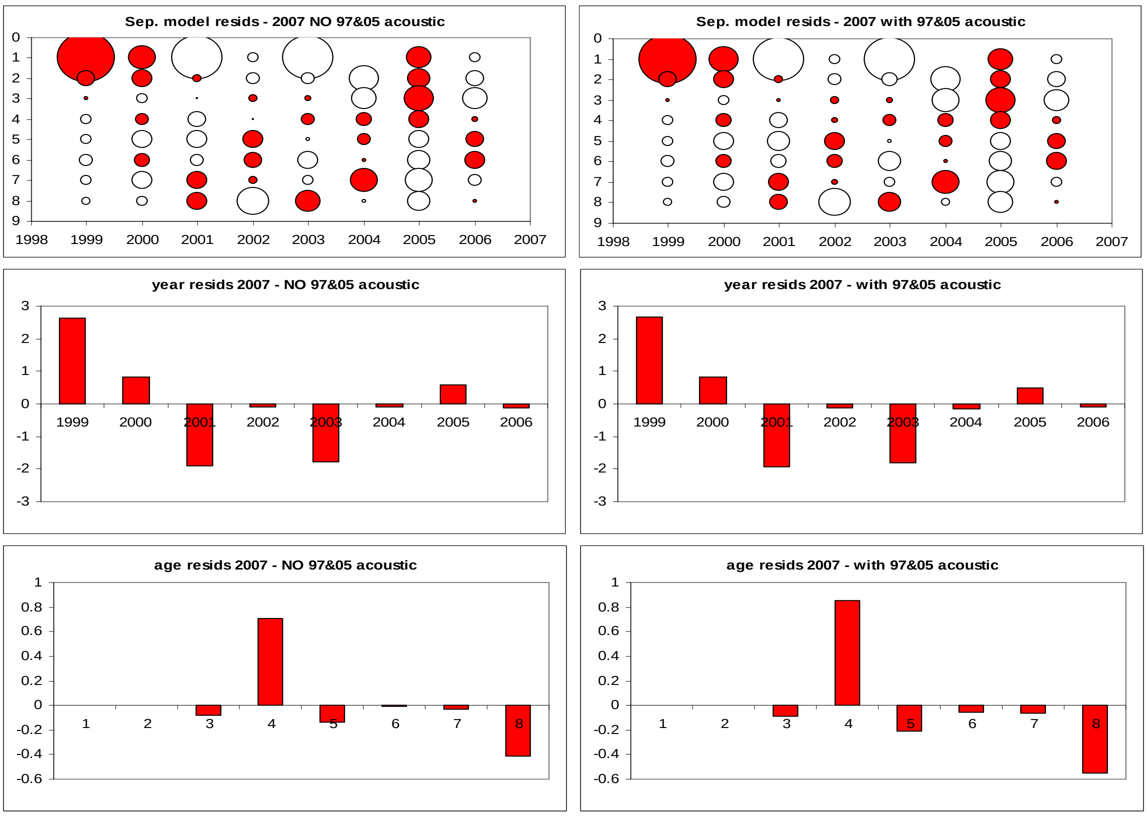


Figure 5.6.1. Herring in VIa (North). Herring in VIa (North). Separable model residual plots for the two exploratory assessments with data from 1958-2006. Left panels have the 1997 and 2005 acoustic surveys excluded; right panels include the 1997 and 2005 surveys.

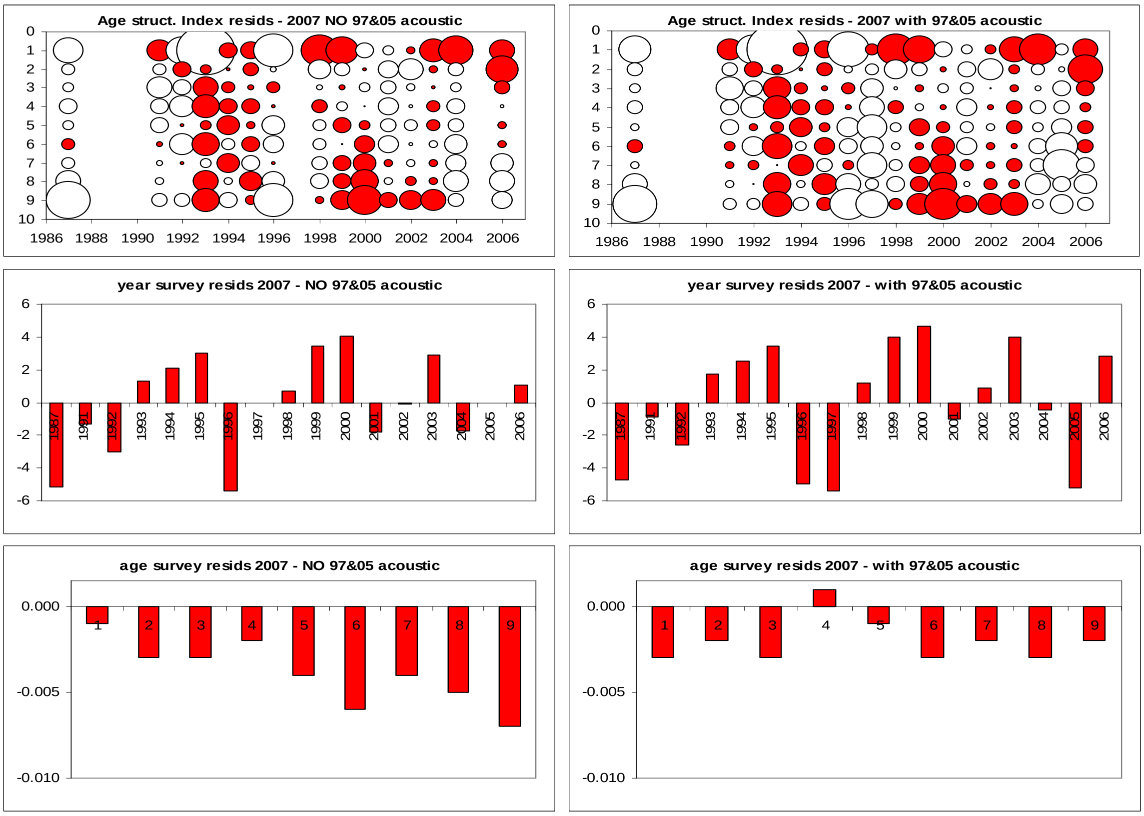


Figure 5.6.2. Herring in VIa (North). Survey residual plots for the two exploratory assessments with data from 1958-2006. Left panels have the 1997 and 2005 acoustic surveys excluded; right panels include the 1997 and 2005 surveys.

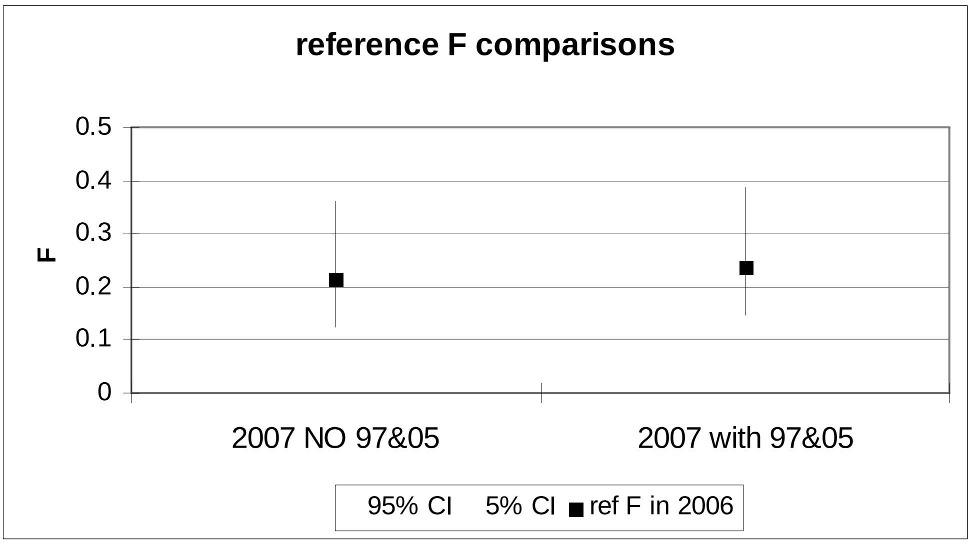


Figure 5.6.3. Herring in VIa (North). Plot to show the value of reference F (and 95% confidence intervals) obtained from the two exploratory assessment runs with the 1997 and 2005 acoustic surveys both excluded and included.

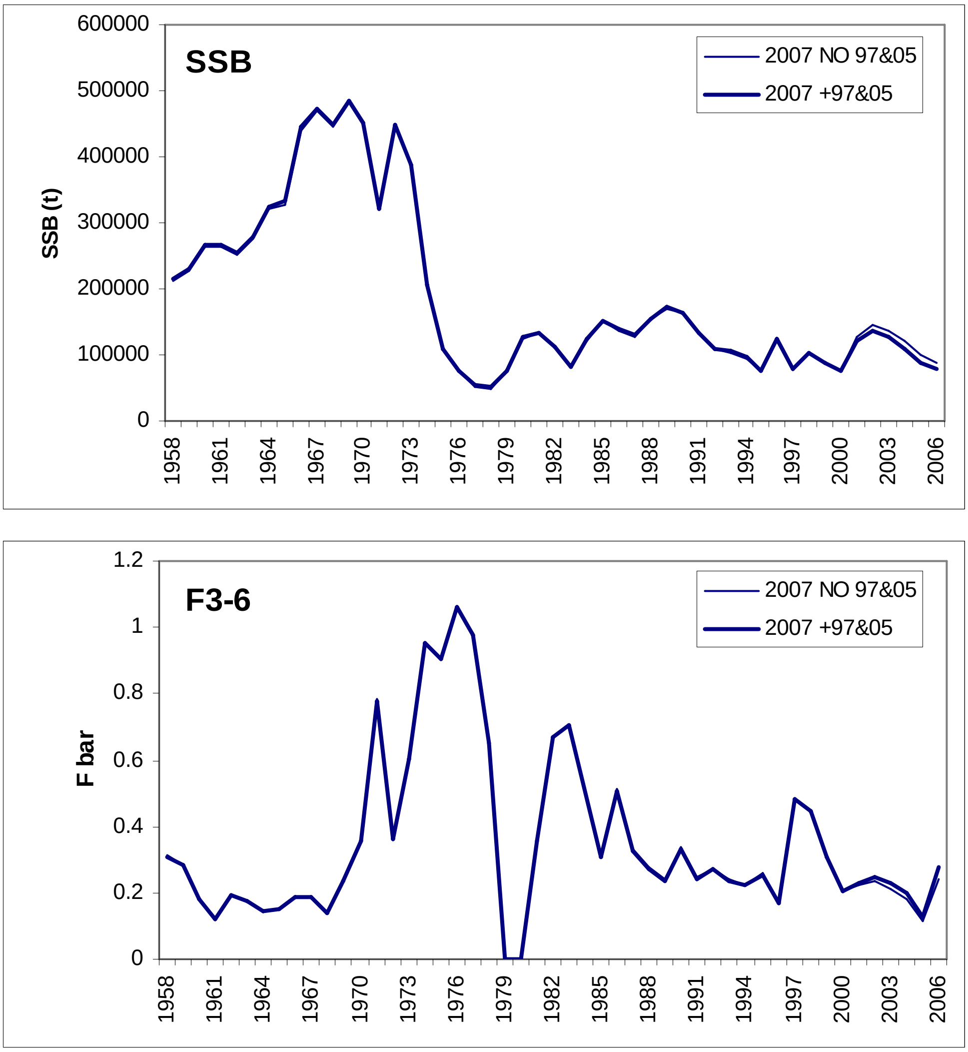
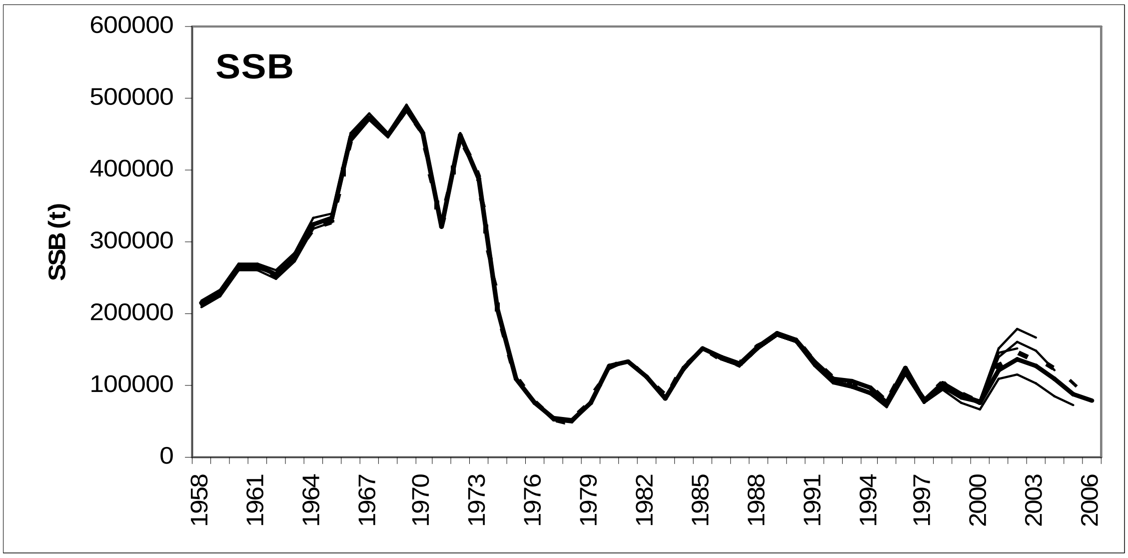
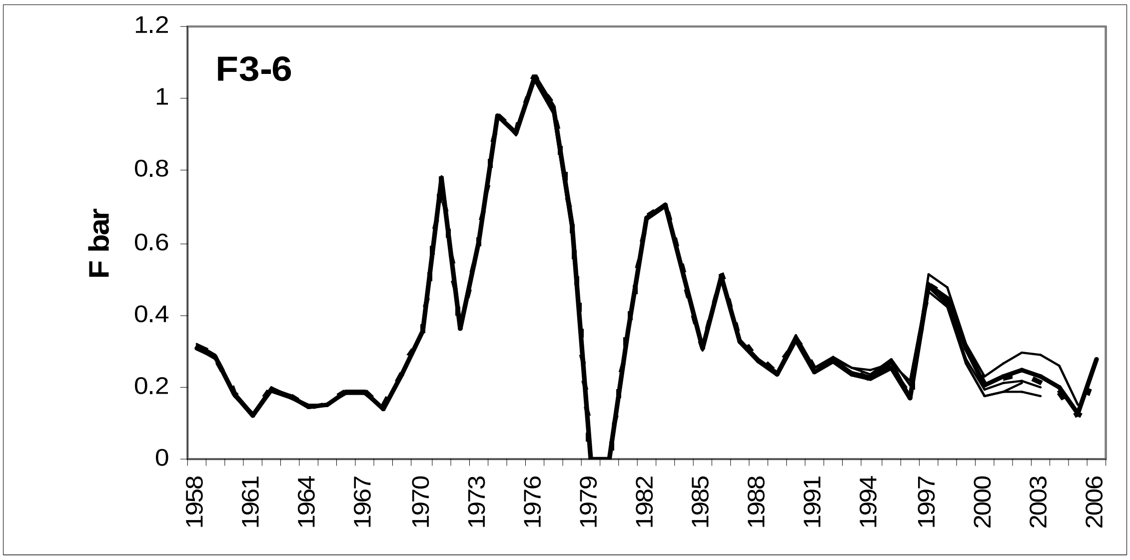


Figure 5.6.4. Herring in VIa (North). F and SSB from the two assessment runs both excluding and including the 1997 and 2005 acoustic surveys.





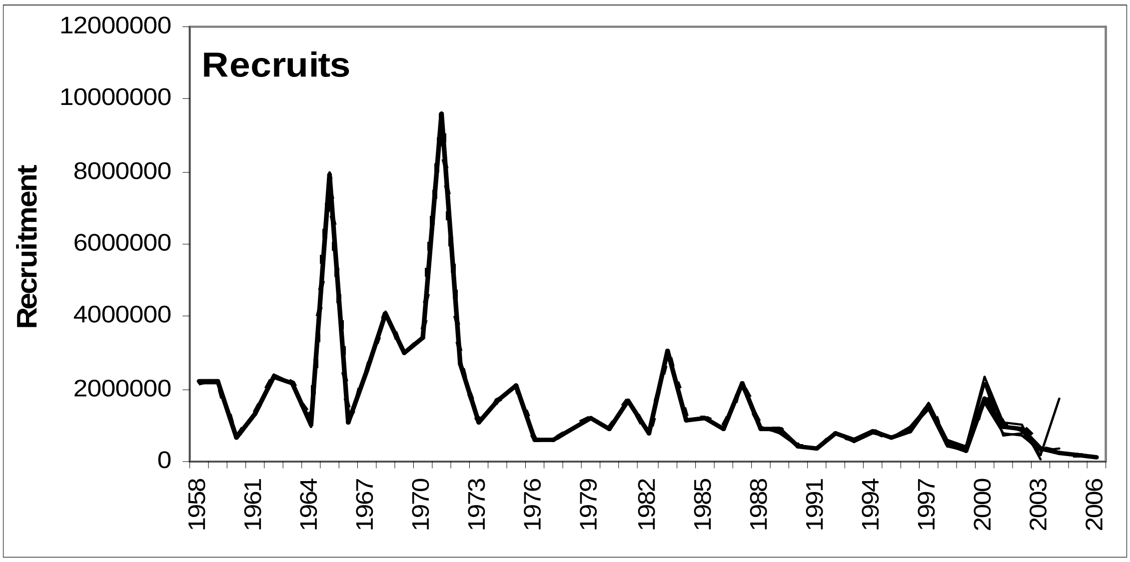


Figure 5.6.5. Herring in VIa (North). Analytical retrospective patterns (2006 to 2002) of SSB, mean F3-6 and recruitment from the assessments both excluding (dashed thicker line) and including (solid thicker line) the 1997 and 2005 acoustic surveys.

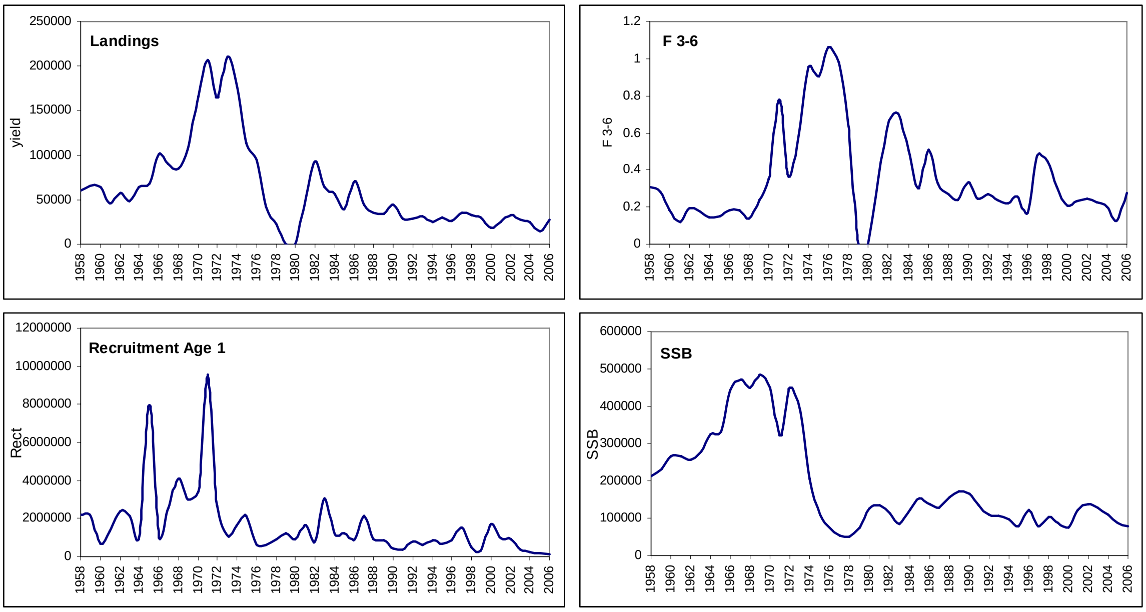


Figure 5.6.6. Herring in VIa (North). Illustration of stock trends from the assessment (8 year separable period). Summary of estimates of landings, fishing mortality at $F_{3\text{-}6}$, recruitment at 1-ring, spawning stock biomass at spawning time in the final assessment run including both the 1997 and 2005 acoustic survey.

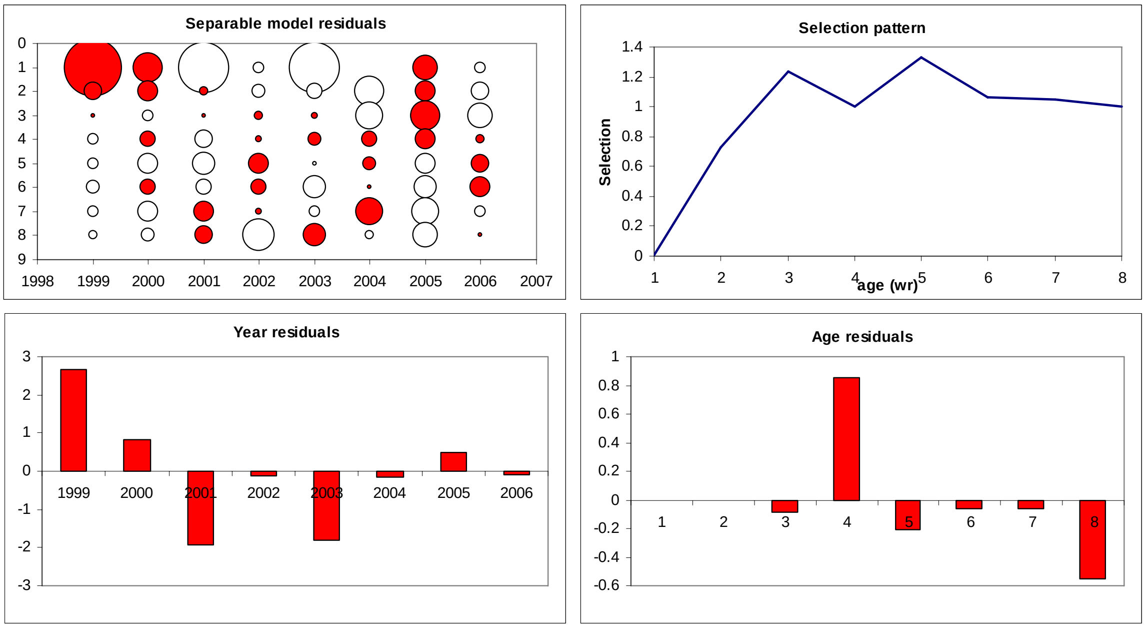
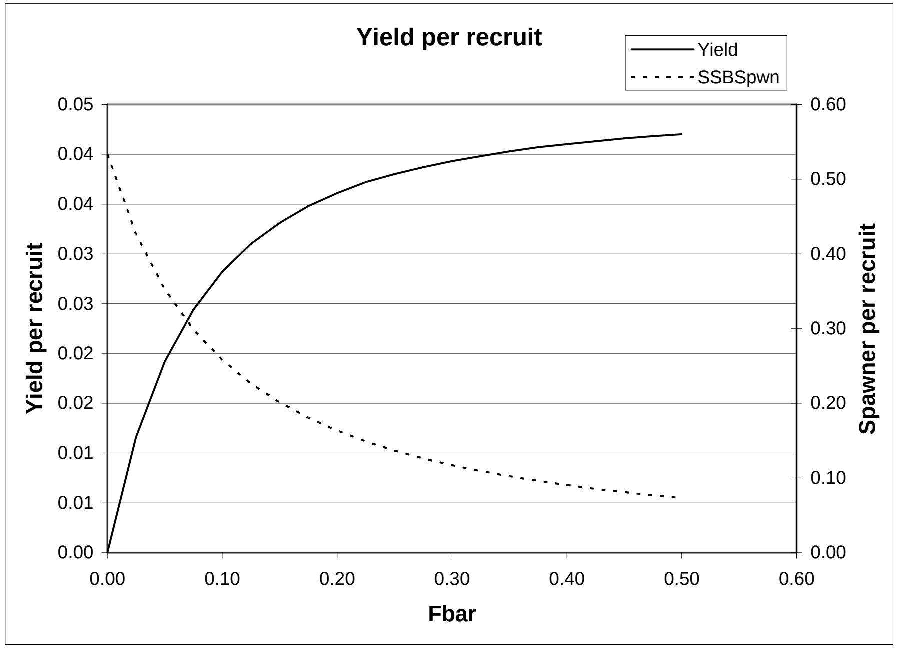
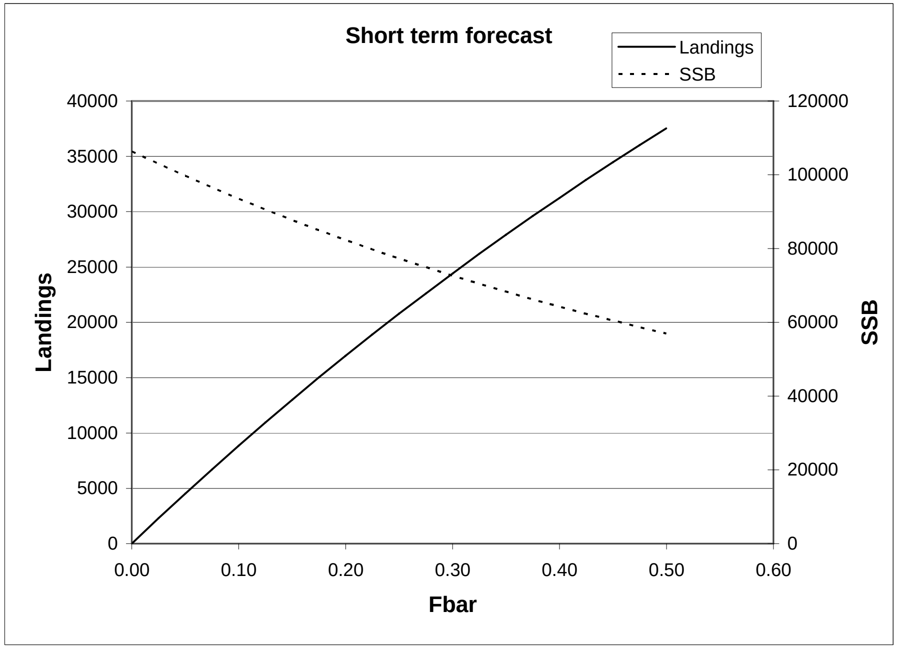


Figure 5.6.7. Herring in VIa (North). Herring in VIa (N). Illustration of selection patterns diagnostics, from deterministic calculation (8-year separable period). Top left, a contour plot of selection pattern residuals. Top right, estimated selection (relative to 4-ringers) +/- standard deviation. Bottom, marginal totals of residuals by year and ring.





MFYPR version 2a
Run: testB Fstqu
Time and date: 11:16 20/03/2007

Reference point	F multiplier	Absolute F
Fbar(3-6)	1.0000	0.2755
FMax	65.0334	17.9188
F0.1	0.6409	0.1766
F35%SPR	0.6052	0.1667
Flow	0.3107	0.0856
Fmed	1.0094	0.2781
Fhigh	2.6750	0.7371

Weights in kilograms

MFDP version 1a
Run: test3A
Herring VIa (north) (run: ICAPGF08/I08)
Time and date: 18:25 19/03/2007
Fbar age range: 3-6

Input units are thousands and kg - output in tonnes

Figure 5.7.2.1. Herring in VIa (North). Yield-per-recruit and short-term forecast from the assessment including the 2005 acoustic survey.

6 Herring in Divisions VIa (South) and VIIb,c

6.1 The Fishery

6.1.1 Advice and management applicable to 2006 – 2007

The TAC for this area in 2006 was 15 400 t with a decrease to 13 860 t in 2007. For 2007, ICES advised fishing should not be allowed unless accompanied by a recovery plan, and stated that such a plan would include further reductions in catch.

In 2006, ICES considered the current SSB to be unknown, but likely to be below B_{pa} (110 000 t). For SSB to be above B_{lim} (81 000 t) there would have to have been very strong recruitment in recent years but no evidence has been found for such year classes. Fishing mortality has reduced in recent years but is likely to be above F_{pa} (0.22) and $F_{lim.}$ (0.33). This stock has been classified as being outside safe biological limits.

In 2000, an Irish committee was established to manage the Irish fishery for this stock. The committee stated its intention to follow 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.

These objectives form the basis for the recovery plan that is being developed for this stock. STECF was asked to provide a preliminary evaluation of these objectives and stated that the aims outlined in this plan would be difficult to attain. Rebuilding the stock to above B_{pa} would not be achievable given that there have been no strong year classes recruited to this fishery in recent years. Maintaining annual catches of 25 000 t also would not be viable under current conditions. STECF concluded that no further TAC increases should be allowed if these aims are to be achieved.

The Pelagic RAC recommended that a management plan similar to that in VIa North be developed and the finalisation of this plan should await the recommendations of the WESTHER project.

6.1.2 Catches in 2006

The working group estimates of landings recorded by each country from this fishery from 1988 – 2006 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 2006 was almost 15 000 t, compared with about 13 500 t in 2005. The working group catches in these areas from 1970 –2006 are shown in Figure 6.1.2.1.

In 2007 landings data were revised with respect to reallocation of catches between area VIaS and VIaN, in 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 for the years 2000-2005. 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.

There were no estimates of discards reported for 2006 and anecdotal reports from the industry are that discarding is not a major problem in this fishery at the present time.

6.1.3 The fishery in 2006

A total of 48 boats categorised as follows took part in the fishery in 2006:

- 22 Pelagic RSW boats from 27m to 134m
- 6 polyvalent RSW boats 24m to 33m
- 8 polyvalent tank hold boats 19m to 26m
- 12 polyvalent dry hold boats 14m to 27m

Polyvalent is a term used to define part of the Irish fleet licensed to catch pelagic and demersal fish.

In 2006 the majority of catches were reported from quarters 1 and 4 in VIaS with comparatively small catches reported from VIIb. In the first quarter the season opened on the 2nd of January and closed on the 15th February. Fishing reopened in the fourth quarter on the 1st October and closed on the 7th of December when the quota was exhausted. The distribution of catches in 2006 strongly reflects the size of the quota, the allocation system and the licensing conditions of the boats. Therefore as the quota was small and quickly caught effort was skewed towards those spawning grounds closest to the fleet base of Killybegs. Because pelagic RSW vessels are not allowed inside the Irish 12 mile limits, spawning grounds within territorial waters are comparatively lightly targeted. Within VIIb many of the herring spawning grounds are within the six mile limit and therefore accessible only to polyvalent vessels that receive a comparatively small cut of the quota. These factors raise the question of whether the fishery and sampling programme is representative of the stock. A map showing the spawning grounds of herring in this area and current perception of herring movements is shown in Figure 6.1.3.1.

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. One ringers are never well represented in the catch. Generally it is found that 1 ringers do not show up in the catch until quarter 4. The proportions of 2, 3, and 4 ringers in 2006 accounted for 18%, 29% and 25% respectively. 2006 shows a similar age profile to 2005 with a peak in 3 ringers.

Two ringers dominate the catch in quarter 4 while in quarter 1, dominance is shared between 3 and 4 ringers. Overall quarter 1 had a greater proportion of older age classes which represent the larger spring spawners. There is little evidence for 1 ringers being an important component of landings in this area.

The length distributions of the catches taken per quarter by the Irish fleet are shown in Table 6.2.2.2. A particular aspect of the first quarter fishery in VIaS has been the appearance of large spring spawning fish off the north coast in late January and early February. These fish are usually over 31 cm in total length. Herring from quarter 1 show a wider length distribution (20cm – 35.5cm) than those from quarter 4 (21.5cm – 29.5cm).

6.2.2 Quality of the catch and biological data

The quality of landings data has improved in recent years, particularly since September 2004. At that time a new 2% tolerance for water in catches was also introduced. Before that time, the tolerance was 20%. This suggests that the data pre and post 2004 are not directly comparable. Enforcement of the TAC improved since the late 1990s and again in 2004 and is now extremely strong.

Discarding, throughout the time series is not considered to be a big a problem, however estimates are not available. The fishery on this stock was not so reliant on roe and thus the incentive to discard was less than in the Celtic Sea fishery.

The numbers of samples and the associated biological data are shown in Table 6.2.2.1. Along with the need to obtain more samples from the larger RSW vessels there is also a requirement to sample the opportunistic catches that occur in VIIb.

Precision estimates for the Irish catch at age data for this stock are presented in Section 1.5.3. They show excellent levels of precision (CV <4%) for the main ages in the catches.

6.3 Fishery Independent Information

6.3.1 Ground Fish Surveys

There are currently no recruitment indices available for this stock. The western IBTS fourth quarter surveys (Ireland and UK-Scotland) offer the possibility of recruit indices. The Irish survey only began in 2003 and the time series is too short. These surveys should be investigated in future years, when the time series is longer. However the WESTHER project (2007) shows that juveniles from this stock and from VIaN mix together in areas such as Stanton Bank. This report also shows that juveniles of VIaS origin are found in Sea Lochs in VIaN. Therefore, survey information from VIaN, particularly the Scottish IBTS survey will be useful for this stock, if it is possible to identify the proportion of VIaS fish.

6.3.2 Acoustic Surveys

Acoustic surveys have been conducted in this area since 1994. In the mid 1990s, surveys were undertaken in summer. The timing changed in 1999 with the surveys being carried out in the winter. The 2007 survey was the 9th in the current time series. The new series of winter surveys aims to measure the abundance of spawning and pre-spawning spring spawning components. This component is considered to be the dominant component at present. A problem with the winter acoustic survey series has been synchronising the survey with the peak spawning event to ensure maximal containment of the stock.

The January 2007 survey track and SA values attributed to herring are shown in Figures 6.3.2.1 and 6.3.2.2. Details of the acoustic surveys in this area are presented in Table 6.3.2.1. The survey started in the south, covering the main bays and inlets into the north of VIIb, and moved in a northerly direction to correspond with the timing of spawning, ending at Malin Head in VIaS. Poor weather affected the survey and significant alterations had to be made to the original cruise track.

The majority of fish recorded during the survey were mature, accounting for 98% of the biomass and 97% of the abundance. Spent fish accounted for 51% of the total biomass and total abundance. This dominance of spent fish would seem to indicate that the main spawning event in this region had already taken place and/or the spring spawning fish had not moved inshore to spawn yet. Less than 2% of the total stock biomass was made up of juvenile herring and less than 3% of the total stock numbers.

The age profile from this survey is similar to the 2006 survey with 3 and 4 ringers being the dominant year classes representing 56.7% and 20.8% by numbers respectively of the total stock biomass. Overall the numbers of older fish present in the biological samples has decreased. The age range present in the 2007 survey was 1-7 while in 2006 it was 1-9.

The age distribution of the abundance estimate from the acoustic survey and from the commercial fishery in 2006 is presented in Figure 6.3.2.3. The quarter one fishery shows slightly greater amounts of 4 ringers, with 3 and 5 ringers also present in significant amounts. The age profiles from the last four acoustic surveys are plotted in Figure 6.3.2.3.

The total biomass estimate for the area surveyed in 2007 was 14 222 t with an SSB of 13 974 t. This is a significant decrease from the 2006 estimate which was 27 750 t with an SSB of 27 200 t. Poor weather may have effected the quality of the estimate in 2007.

This survey is not considered a good indicator of stock development. This is because of the protracted nature of the spawning period, from October to at least February, whilst the survey is conducted in early January. Also it has been shown by the WESTHER project (Hatfield *et al*. 2007 WD) that some fish of VIaS origin are present in VIaN. These fish are picked up in the VIaN acoustic survey and are not accounted for in tuning the VIaS assessment. In light of the WESTHER results HAWG recommends that the utility of the VIaS winter survey be evaluated. A likely alternative is to conduct a survey in July corresponding with the VIaN survey, and extending south from 56° 30 N to at least VIIb. Such a survey would be coordinated by PGHERS.

6.4 Mean weights-at-age and maturity-at-age

The mean weights (kg) at age in the catches in 2006 are based on Irish catches and are very similar to 2005 for ringers 1-7 (Table 6.4.1.1). These mean weights display quite a stable pattern over the time series, although variable weights are only available from the early 1980s (Figure 6.4.4.1.).

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 (Table 6.4.1.2). The time series since 1986 is shown in Figure 6.4.4.2.

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.

6.5 Recruitment

Recruits (1-ringers) are poorly represented in the catch at age data. In addition, they rarely appear in the fishery until quarter 4. Thus there is little fishery dependent information on recruitment strength. The converged separable VPAs (Figure 6.6.2.1) show episodic good recruitments roughly every 3-4 years. Good recruitments often occurred in subsequent years. The 1981 and 1985 year classes were abnormally good, and the 1983 year class was also well above the strength of any others.

6.6 Stock Assessment

6.6.1 Trends and patterns in basic data

The numbers at age from the catch and the survey have been mean standardised by year and are presented in Figure 6.6.1.1. The timing of the acoustic surveys changed in 2003. The early surveys were carried out in quarter 4 while the later ones were in quarter 1. The survey age profile reflects this change in timing.

Since the mid nineties there has been a pronounced shift in the age composition of the catches from old fish to younger fish and this has been maintained in 2007, with 2 – 5 ringers making up the bulk of the catch. The numbers of 1 ringers in the survey and the catch is very low in 2006 and 2007. As in previous years the catch numbers at age do not suggest strong incoming recruitment and there is no information in the survey abundance to refute this. The catch and survey data also show a decrease in the numbers of older fish.

The log catch ratios (ln $C_{a,y}$/ $C_{a+1,y+1}$) are presented in Figure 6.6.1.2 and are smoothed with a 4-year running average to show the main trends. 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.

Cohort catch curves, were constructed for each year class in the catch at age data (Figure 6.6.1.3). These catch curves show signals in total mortality over the time series. Low mortality seems evident on the very large 1981, 1985 and 1988 year classes. These represent three of the biggest year classes recruited to this fishery. Increasing mortality can be seen from 1990 on, whilst the 1970s cohorts show lower Z.

Figure 6.6.1.4 shows the catch curves from fishery and the survey age data averaged over a number of years. Total mortality has displayed an upward trend since the early 1980s. Increasing mortality in recent years is clearly evident. In the late seventies mortality was at its lowest (0.2). Since the mid nineties mortality has shown an increase to 0.7. The survey displays broadly similar mortality signal to the catch.

6.6.2 Exploratory Assessments

Following the procedure of recent years, a separable VPA was used to screen over three terminal fishing mortalities, 0.2, 0.4 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 age 4 (winter rings). ICA was also used in 2007 with the split tuning series. This assessment is still exploratory, and no assessment has been accepted by ACFM in recent years.

Three assessments using the separable VPA are presented, based on the three choices of terminal F. Recruitment, SSB and mean F are plotted in Figure 6.6.2.1, with last year's results, for comparative purposes. 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 and 0.6 are presented in Tables 6.6.2.1, 6.6.2.2 and 6.6.2.3 respectively. Residual plots for the three trial assessments are presented in Figure 6.6.2.2. A strong negative residual pattern can be seen in 6 ringers.

Under each scenario of terminal F, the current assessment suggests declining fishing mortality since 2002, with a sharp increase in 2006. The landings have been fluctuating in recent years with 2006 the highest since 2000.

Recruitment appears to have remained stable at a low level when F=0.4 or 0.6. A higher level of recruitment can be seen when except when 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. 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. However these 1-ringer fish are poorly selected in the fishery and thus there is little information in the catch at age matrix on their strength in the final year.

SSB is either stable at a low level or declining slightly, assuming terminal F of 0.4 or 0.6 and possibly increasing at F values of 0.2. If SSB is stable, it is stable at the lowest level in the series and is considerably lower than the current levels of B_{pa} and B_{lim}. If using an F=0.2 is more realistic then SSB is at a level just at B_{lim}. Only a terminal F of 0.2 suggests some good recruitments in recent years however there is no evidence in the raw catch numbers at age to suggest that this is so.

A number of assessments were conducted in ICA using the same procedure as last year with the split survey time series using ages three and four. Results of recruitment, SSB and mean F from the ICA runs, compared with the VPA runs are presented in Figures 6.6.2.3. The 2007 acoustic survey is included in one run and excluded in the other. The ICA runs show similar patterns of recruitment and SSB. Inclusion of the 2007 survey shows mean F at a higher level.

The separable model and survey residuals from the ICA runs are presented in Figure 6.6.2.4. The year and age residuals are presented in Figure 6.6.2.5. The magnitude and location of residuals shown in the bubble plots are consistent. A switch from positive to negative residuals can be seen in the age residuals when the 2007 survey is removed.

A scatter plot was produced, plotting F and SSB in the terminal year to present the precision of the different runs, with and without the 2007 survey (Figure 6.6.2.6). Inclusion of the 2007 survey shows more variation in F while exclusion of the survey shows more variation in SSB. HAWG therefore concluded that ICA was not an informative model with which to provide management advice.

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.

6.9 Precautionary and yield based reference points

In 2007 the technical basis for the selection of the precautionary reference points was examined based on methods used by SGPRP (ICES 2001 ACFM:11). 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 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.

6.10 Quality of the Assessment

In light of current uncertainties no assessment was conducted.

6.11 Management Considerations

The results of the non-tuned assessment suggest that SSB may be stable at a low level but estimates of SSB for this stock are uncertain. Though the peak in SSB in the 1980s may have been an isolated event the HAWG suggests that this stock should be exploited with great caution.

Little information on recruitment is currently available and it is unlikely that it is above average. 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. The TAC increased from 14 000 t to 15 400 t in 2006. The management of the Irish fishery (which takes most of the catch) has improved in recent years with stricter quota enforcement in place. Certainly every effort should be taken to maintain catches below the current level. HAWG notes that increased accuracy in the catch data over the past 4 years gives a greater confidence in the perception of stock development.

Management objectives were reviewed by STECF and HAWG agrees with this review. It was concluded that rebuilding the stock to levels above B_{pa} and maintaining annual catches of 25,000 t would not be achievable. HAWG commends aspects of the plan such as the regulation of effort through tight enforcement of catch quotas, and this should be continued and if necessary intensified. The closed season from March to October has been maintained and is also commended.

Table 6.1.2.1. VIa(S) and VIIb,c herring. Estimated Herring catches in tonnes, 1988–2006. 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
France	-	-	-	-	515	-	-	-	-
Germany, Fed.Rep.	-	-	-	-	-	-	-	-	-
Ireland	25200	16325	10164	11278	13072	12921	10950	13351	14840
Netherlands	2500	1868	1234	2088	366	-	64	-	353
UK (N.Ireland)	-	-	-	-	-	-	-	-	-
UK (England + Wales)	-	-	-	-	-	-	-	-	-
UK Scotland	-	-	-	-	-	-	-	-	6
Total landings	27700	18193	11398	13366	13953	12921	11014	13351	15199
Area misreported/Unallocated	11200	7916	8448	1390	3873	3581	2813	2880	3994
Discards	-	-	-	-	-	-	-	-	
WG catch	38900	26109	19846	14756	17826	16502	13827	16231	19193

Table 6.2.1.1 VIa(S) & VIIb,c herring. Catch in numbers-at-age (winter rings) from 1970 to 2006.

	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

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

Table 6.2.2.1 VIa(S) and VIIb,c herring. Sampling intensity of catches in 2006.

ICES area	Year	Quarter	Landings (t)	No. Samples	No. aged	No. Measured	Aged/1000 t
VIaS	2006	1	7789	22	1400	4246	180
VIaS	2006	4	5419	25	1342	4706	248
VIIb	2006	1	675	5	286	1031	424
VIIb	2006	4	957	2	101	260	106
Total North West			14840	54	3129	10243	957

Table 6.2.2.2. VIa(S) and VIIb,c herring. Length distribution of Irish catches/quarter (thousands) 2006.

Length cm	Quarter 1	Quarter 1	Quarter 4	Quarter 4
	VIaS	VIIb,c	VIaS	VIIb,c
20	39			
20.5	39			
21	91			
21.5	220	48	4	
22	220	132	4	
22.5	414	346	4	43
23	518	575	22	43
23.5	1269	803	138	86
24	2111	1642	299	107
24.5	2435	1981	464	236
25	3678	2757	477	364
25.5	4222	3061	491	450
26	5063	3470	584	514
26.5	6721	4745	620	599
27	7822	4675	696	921
27.5	7200	3595	446	856
28	5789	2590	201	792
28.5	3302	1281	98	321
29	1619	616	40	171
29.5	777	208	9	43
30	453	55		21
30.5	207	14		
31	233	0		
31.5	78			
32	78			
32.5	78			
33	52			
33.5	91			
34	78			
34.5	39			
35	13			
35.5	39			
Nos./t	7059	6015	6811	5817

Table 6.3.2.1. VIa(S) & VIIb,c herring. Details of acoustic surveys of herring in VIaS and VIIbc, 1994– 2007.

Year	Type	Biomass	SSB	Reference
1994	Feeding phase	-	353,772	Fernandes, 1994
1995	Feeding phase	137,670	125,800	Fernandes, 1995
1996	Feeding phase	34,290	12,550	Fernandes, 1996
1997	-	-	-	-
1998	-	-	-	-
1999	Autumn spawners	23,762	22,788	Breslin, 1999
2000	Autumn spawners	21,000	20,500	Breslin and Griffin, 2001
2001	Autumn spawners	11,100	9,800	Breslin and Griffin, 2002
2002	Winter spawners	8,900	7,200	Breslin and Griffin, 2003
2003	Winter spawners	10,300	9,500	Breslin and Griffin, 2003
2004	Winter spawners	41,700	41,399	Griffin, 2004
2005	Winter spawners	71,253	66,138	O Donnell *et al*., 2005
2006	Winter spawners	27,770	27,200	O Donnell *et al*., 2006
2007	Winter spawners	14,222	13,974	O Donnell *et al*., 2007

Table 6.3.2.2. VIa(S) & VIIb,c herring. Time series of acoustic surveys since 1999.

Winter rings	1999	2000	2001	2002	2003	2004	2005	2006	2007
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
2	104.77	60.88	52.33	14.05	26.26	3.9	56.91	6.9	3.5
3	32.53	48.96	6.41	24.23	30.02	62.35	93.51	86.7	59.8
4	11.34	25.57	6.47	14	11.08	54.93	109.87	57.5	21.9
5	1.65	9.43	2.63	5.79	2.94	80.07	100.8	27.9	11.7
6	0.94	2.35	1.94	5.7	0.64	47.14	56.54	16	6.35
7	0.3	1.28	0.12	5.06	0.94	13.81	21.16	4.8	1.86
8	0.17	0.43	0.24	2.73	0.3	11.77	24.64	4.8	-
9+	0.11	0.75	0.07	4.07	0.14	-	12.74	1.3	-
Abundance (millions)	170.8	160.36	97.9	111.33	82.6	274.06	485.29	202.9	105.41
Total Biomass (t)	23,762	21,048	11,062	8,867	10,300	41,700	71,253	27,770	14,222
SSB (t)	22,788	20,500	9,800	6,978	9,500	41,300	66,138	27,200	13,974
CV	-	-	-	-	-	-	-	49%	44%

Table 6.4.1.1. VIa(S) & VIIb,c herring. Mean weight-at-age (winter rings) in the catch, 1970 to 2006.

	1	2	3	4	5	6	7	8	9+
1970	0.110	0.129	0.165	0.191	0.209	0.222	0.231	0.237	0.241
1971	0.110	0.129	0.165	0.191	0.209	0.222	0.231	0.237	0.241
1972	0.110	0.129	0.165	0.191	0.209	0.222	0.231	0.237	0.241
1973	0.110	0.129	0.165	0.191	0.209	0.222	0.231	0.237	0.241
1974	0.110	0.129	0.165	0.191	0.209	0.222	0.231	0.237	0.241
1975	0.110	0.129	0.165	0.191	0.209	0.222	0.231	0.237	0.241
1976	0.110	0.129	0.165	0.191	0.209	0.222	0.231	0.237	0.241
1977	0.110	0.129	0.165	0.191	0.209	0.222	0.231	0.237	0.241
1978	0.110	0.129	0.165	0.191	0.209	0.222	0.231	0.237	0.241
1979	0.110	0.129	0.165	0.191	0.209	0.222	0.231	0.237	0.241
1980	0.110	0.129	0.165	0.191	0.209	0.222	0.231	0.237	0.241
1981	0.110	0.129	0.165	0.191	0.209	0.222	0.231	0.237	0.241
1982	0.110	0.129	0.165	0.191	0.209	0.222	0.231	0.237	0.241
1983	0.090	0.129	0.165	0.191	0.209	0.222	0.231	0.237	0.241
1984	0.106	0.141	0.181	0.210	0.226	0.237	0.243	0.247	0.248
1985	0.077	0.122	0.161	0.184	0.196	0.206	0.212	0.225	0.230
1986	0.095	0.138	0.164	0.194	0.212	0.225	0.239	0.208	0.288
1987	0.085	0.102	0.150	0.169	0.177	0.193	0.205	0.215	0.220
1988		0.098	0.133	0.153	0.166	0.171	0.183	0.191	0.201
1989	0.080	0.130	0.141	0.164	0.174	0.183	0.192	0.193	0.203
1990	0.094	0.138	0.148	0.160	0.176	0.189	0.194	0.208	0.216
1991	0.089	0.134	0.145	0.157	0.167	0.185	0.199	0.207	0.230
1992	0.095	0.141	0.147	0.157	0.165	0.171	0.180	0.194	0.219
1993	0.112	0.138	0.153	0.170	0.181	0.184	0.196	0.229	0.236
1994	0.081	0.141	0.164	0.177	0.189	0.187	0.191	0.204	0.220
1995	0.080	0.140	0.161	0.173	0.182	0.198	0.194	0.206	0.217
1996	0.085	0.135	0.172	0.182	0.199	0.209	0.220	0.233	0.237
1997	0.093	0.135	0.155	0.181	0.201	0.217	0.217	0.231	0.239
1998	0.095	0.136	0.145	0.173	0.191	0.196	0.202	0.222	0.217
1999	0.106	0.144	0.145	0.163	0.186	0.195	0.200	0.216	0.222
2000	0.102	0.129	0.154	0.172	0.180	0.184	0.204	0.203	0.204
2001	0.086	0.122	0.139	0.167	0.183	0.188	0.222	0.222	0.213
2002	0.097	0.127	0.140	0.155	0.175	0.196	0.204	0.218	0.226
2003	0.102	0.134	0.150	0.167	0.183	0.196	0.216	0.210	0.228
2004	0.085	0.140	0.150	0.167	0.182	0.193	0.222	0.221	0.285
2005	0.105	0.135	0.150	0.162	0.174	0.188	0.200	0.237	0.296
2006	0.106	0.137	0.141	0.158	0.169	0.178	0.199	0.221	0.243

Table 6.4.1.2. VIa(S) & VIIb,c herring. Mean weight at age (winter rings) in the stock 1970 to 2006.

	1	2	3	4	5	6	7	8	9+
1970	0.120	0.169	0.210	0.236	0.260	0.273	0.283	0.290	0.296
1971	0.120	0.169	0.210	0.236	0.260	0.273	0.283	0.290	0.296
1972	0.120	0.169	0.210	0.236	0.260	0.273	0.283	0.290	0.296
1973	0.120	0.169	0.210	0.236	0.260	0.273	0.283	0.290	0.296
1974	0.120	0.169	0.210	0.236	0.260	0.273	0.283	0.290	0.296
1975	0.120	0.169	0.210	0.236	0.260	0.273	0.283	0.290	0.296
1976	0.120	0.169	0.210	0.236	0.260	0.273	0.283	0.290	0.296
1977	0.120	0.169	0.210	0.236	0.260	0.273	0.283	0.290	0.296
1978	0.120	0.169	0.210	0.236	0.260	0.273	0.283	0.290	0.296
1979	0.120	0.169	0.210	0.236	0.260	0.273	0.283	0.290	0.296
1980	0.120	0.169	0.210	0.236	0.260	0.273	0.283	0.290	0.296
1981	0.120	0.169	0.210	0.236	0.260	0.273	0.283	0.290	0.296
1982	0.120	0.169	0.210	0.236	0.260	0.273	0.283	0.290	0.296
1983	0.120	0.169	0.210	0.236	0.260	0.273	0.283	0.290	0.296
1984	0.120	0.169	0.210	0.236	0.260	0.273	0.283	0.290	0.296
1985	0.100	0.150	0.196	0.227	0.238	0.251	0.252	0.269	0.284
1986	0.098	0.169	0.209	0.238	0.256	0.276	0.280	0.287	0.312
1987	0.097	0.164	0.206	0.233	0.252	0.271	0.280	0.296	0.317
1988	0.097	0.164	0.206	0.233	0.252	0.271	0.280	0.296	0.317
1989	0.138	0.157	0.168	0.182	0.200	0.217	0.227	0.238	0.245
1990	0.113	0.152	0.170	0.180	0.200	0.217	0.225	0.233	0.255
1991	0.102	0.149	0.174	0.190	0.195	0.206	0.226	0.236	0.248
1992	0.102	0.144	0.167	0.182	0.194	0.197	0.214	0.218	0.242
1993	0.118	0.166	0.196	0.205	0.214	0.220	0.223	0.242	0.258
1994	0.098	0.156	0.192	0.209	0.216	0.223	0.226	0.230	0.247
1995	0.090	0.144	0.181	0.203	0.217	0.226	0.227	0.239	0.246
1996	0.086	0.137	0.186	0.206	0.219	0.234	0.233	0.249	0.253
1997	0.094	0.135	0.169	0.194	0.210	0.224	0.231	0.230	0.239
1998	0.095	0.136	0.145	0.173	0.191	0.196	0.202	0.222	0.217
1999	0.104	0.145	0.154	0.174	0.200	0.222	0.230	0.240	0.246
2000	0.100	0.134	0.157	0.177	0.197	0.207	0.217	0.230	0.245
2001	0.091	0.125	0.150	0.172	0.191	0.200	0.203	0.203	0.216
2002	0.092	0.127	0.146	0.170	0.190	0.201	0.210	0.227	0.229
2003	0.094	0.131	0.155	0.175	0.192	0.203	0.232	0.222	0.243
2004	0.081	0.133	0.151	0.175	0.194	0.207	0.238	0.233	0.276
2005	0.095	0.127	0.15	0.172	0.185	0.196	0.223	0.234	0.274
2006	0.092	0.130	0.133	0.162	0.177	0.186	0.209	0.238	0.247

Table 6.6.2.1. VIa(S) and VIIb,c herring VPA run with a terminal F value of 0.2

	Traditional vpa	Terminal populations from weighted Separable populations					
	RECRUITS Age 1	**TOTALBIO**	**TOTSPBIO**	**LANDINGS**	**YIELD/SSB**	**SOPCOFAC**	**FBAR 3- 6**
1970	408071	207776	132321	20306	0.1535	0.8968	0.1754
1971	819057	226409	116628	15044	0.129	0.8707	0.1569
1972	736983	236280	122113	23474	0.1922	0.8975	0.1993
1973	537069	269391	156208	36719	0.2351	1.0162	0.2822
1974	594689	206306	93840	36589	0.3899	0.9762	0.4436
1975	410989	202278	100330	38764	0.3864	1.1237	0.4294
1976	691964	191879	69543	32767	0.4712	1.0472	0.4922
1977	585087	183576	78762	20567	0.2611	1.0778	0.3122
1978	1058130	228970	73952	19715	0.2666	1.0161	0.2573
1979	985833	268323	106500	22608	0.2123	1.0664	0.2652
1980	537870	204052	102250	30124	0.2946	0.9636	0.3842
1981	688029	221958	103766	24922	0.2402	1.0312	0.3056
1982	705717	232349	114538	19209	0.1677	1.0301	0.2201
1983	2329553	432025	109938	32988	0.3001	1.0042	0.3548
1984	971952	351102	185754	27450	0.1478	0.9688	0.2008
1985	1239791	358277	189803	23343	0.123	0.9846	0.1679
1986	952516	370399	224951	28785	0.128	0.9834	0.1777
1987	3259194	570764	196859	48600	0.2469	0.9488	0.3394
1988	483629	433212	304867	29100	0.0955	0.9992	0.2663
1989	718183	379758	227522	29210	0.1284	1.001	0.1789
1990	814900	345154	196803	43969	0.2234	1.0006	0.2558
1991	504653	272198	170015	37700	0.2217	0.9971	0.2403
1992	417747	219608	136119	31856	0.234	0.9951	0.2711
1993	617099	235622	117057	36763	0.3141	1.006	0.3509
1994	808342	216674	97624	33908	0.3473	0.998	0.3579
1995	469304	165722	85128	27792	0.3265	1.0525	0.4606
1996	839948	171639	63840	32534	0.5096	0.9955	0.5758
1997	833969	175635	65668	27225	0.4146	1.0016	0.5243
1998	540324	145104	53968	38895	0.7207	0.9988	0.9901
1999	408888	118142	46802	26109	0.5579	1.0018	0.6415
2000	497246	111116	39994	19846	0.4962	1.0011	0.4825
2001	538478	105801	39230	14756	0.3761	0.9988	0.574
2002	783099	133642	41089	17826	0.4338	0.9991	0.5939
2003	716622	144382	54941	16502	0.3004	1.002	0.4799
2004	966748	165637	66434	13727	0.2066	1.0006	0.3534
2005	677170	172553	83331	16231	0.1948	0.9986	0.2729
2006	**719186***	153260	83256	19193	0.2305	1.0012	0.2962

*__Geometric Mean__

Table 6.6.2.2. VIa(S) and VIIbc herring VPA run using a terminal F or 0.4

	Traditional vpa	Terminal populations from weighted Separable populations					
	RECRUITS	**TOTALBIO**	**TOTSPBIO**	**LANDINGS**	**YIELD/SSB**	**SOPCOFAC**	**FBAR 3- 6**
	Age 1						
1970	410032	210399	134556	20306	0.1509	0.8968	0.173
1971	823254	229010	118641	15044	0.1268	0.8707	0.1545
1972	741516	238996	124179	23474	0.189	0.8975	0.1969
1973	540877	273561	159650	36719	0.23	1.0162	0.2792
1974	599167	208666	95557	36589	0.3829	0.9762	0.4385
1975	414983	204973	102350	38764	0.3787	1.1237	0.4227
1976	698972	194408	71082	32767	0.461	1.0472	0.4831
1977	591728	186339	80494	20567	0.2555	1.0778	0.3054
1978	1072111	232538	75644	19715	0.2606	1.0161	0.252
1979	1001405	272919	108830	22608	0.2077	1.0664	0.2592
1980	546204	207827	104772	30124	0.2875	0.9636	0.3748
1981	697257	226411	106790	24922	0.2334	1.0312	0.2963
1982	715599	237053	117724	19209	0.1632	1.0301	0.2135
1983	2361195	439725	113516	32988	0.2906	1.0042	0.3446
1984	985025	357959	190515	27450	0.1441	0.9688	0.1951
1985	1252949	364604	194337	23343	0.1201	0.9846	0.1633
1986	961062	376681	229931	28785	0.1252	0.9834	0.1733
1987	3284004	578250	201680	48600	0.241	0.9488	0.3315
1988	486477	439577	310384	29100	0.0938	0.9992	0.2601
1989	721159	384662	231650	29210	0.1261	1.001	0.1753
1990	816703	349269	200453	43969	0.2193	1.0006	0.2516
1991	505125	275173	172752	37700	0.2182	0.9971	0.2367
1992	417763	221921	138287	31856	0.2304	0.9951	0.2685
1993	616918	237482	118841	36763	0.3093	1.006	0.3484
1994	807110	218009	99002	33908	0.3425	0.998	0.3561
1995	466567	165891	85550	27792	0.3249	1.0525	0.459
1996	835181	171280	63915	32534	0.509	0.9955	0.5757
1997	824808	174509	65455	27225	0.4159	1.0016	0.5258
1998	529858	143336	53284	38895	0.73	0.9988	1.0001
1999	392621	115155	45655	26109	0.5719	1.0018	0.6584
2000	459930	105417	38246	19846	0.5189	1.0011	0.5023
2001	466995	95863	36208	14756	0.4075	0.9988	0.6145
2002	609927	111274	35436	17826	0.503	0.9991	0.6694
2003	492592	108879	42501	16502	0.3883	1.002	0.5894
2004	570276	109723	45776	13727	0.2999	1.0006	0.4923
2005	346083	101829	49083	16231	0.3307	0.9986	0.4383
2006	**680531***	78952	39681	19193	0.4837	1.0012	0.5909

***Geometric Mean**

Table 6.6.2.3 VIa(S) and VIIb,c herring VPA run using a terminal F or 0.6

	Traditional vpa	Terminal populations from weighted Separable populations					
	RECRUITS	**TOTALBIO**	**TOTSPBIO**	**LANDINGS**	**YIELD/SSB**	**SOPCOFAC**	**FBAR 3- 6**
	Age 1						
1970	411213	211932	135859	20306	0.1495	0.8968	0.1716
1971	825795	230537	119814	15044	0.1256	0.8707	0.1532
1972	744260	240598	125389	23474	0.1872	0.8975	0.1955
1973	543173	276043	161696	36719	0.2271	1.0162	0.2774
1974	601866	210080	96582	36589	0.3788	0.9762	0.4355
1975	417395	206593	103559	38764	0.3743	1.1237	0.4188
1976	703209	195933	72009	32767	0.455	1.0472	0.4777
1977	595724	188005	81539	20567	0.2522	1.0778	0.3014
1978	1080517	234688	76665	19715	0.2572	1.0161	0.2489
1979	1010739	275684	110234	22608	0.2051	1.0664	0.2557
1980	551172	210092	106288	30124	0.2834	0.9636	0.3693
1981	702747	229080	108607	24922	0.2295	1.0312	0.291
1982	721477	239869	119635	19209	0.1606	1.0301	0.2098
1983	2379992	444320	115660	32988	0.2852	1.0042	0.3389
1984	992740	362043	193359	27450	0.142	0.9688	0.1918
1985	1260704	368363	197037	23343	0.1185	0.9846	0.1607
1986	966100	380409	232889	28785	0.1236	0.9834	0.1709
1987	3298613	582680	204538	48600	0.2376	0.9488	0.3269
1988	488160	443343	313648	29100	0.0928	0.9992	0.2567
1989	722942	387565	234091	29210	0.1248	1.001	0.1733
1990	817816	351708	202611	43969	0.217	1.0006	0.2492
1991	505466	276937	174369	37700	0.2162	0.9971	0.2347
1992	417844	223298	139570	31856	0.2282	0.9951	0.267
1993	616928	238603	119901	36763	0.3066	1.006	0.3469
1994	806747	218847	99829	33908	0.3397	0.998	0.355
1995	465670	166095	85830	27792	0.3238	1.0525	0.458
1996	833589	171242	64019	32534	0.5082	0.9955	0.5752
1997	821778	174191	65437	27225	0.416	1.0016	0.5261
1998	526419	142771	53075	38895	0.7328	0.9988	1.0029
1999	387245	114179	45285	26109	0.5766	1.0018	0.664
2000	448025	103587	37678	19846	0.5267	1.0011	0.5092
2001	444829	92734	35226	14756	0.4189	0.9988	0.6294
2002	553642	104054	33634	17826	0.53	0.9991	0.6987
2003	418556	97271	38485	16502	0.4288	1.002	0.6367
2004	439292	91364	39031	13727	0.3517	1.0006	0.5645
2005	241132	78995	37806	16231	0.4293	0.9986	0.5454
2006	**664351***	55680	25297	19193	0.7587	1.0012	0.8829
	*** Geometric Mean**						

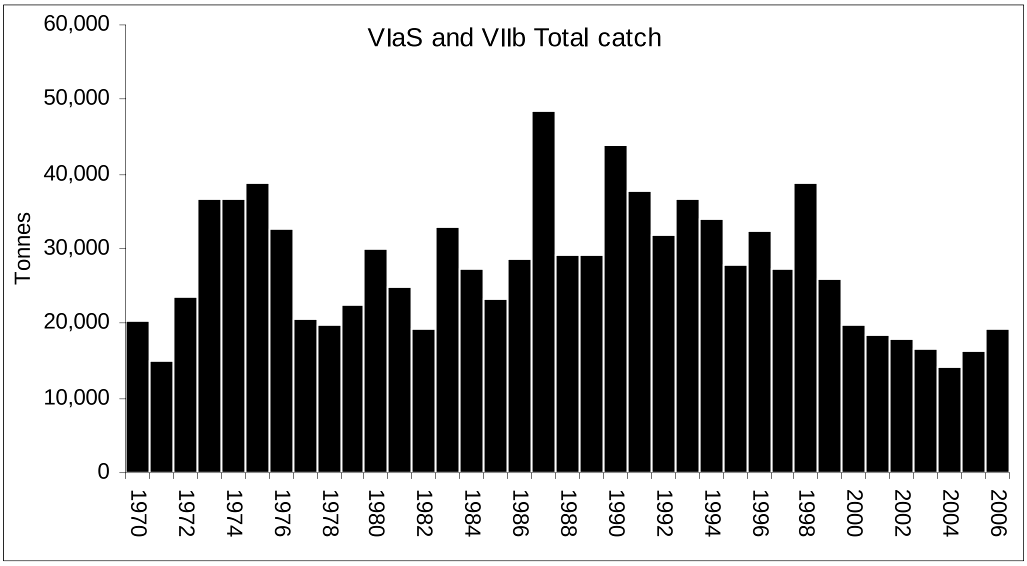


Figure 6.1.2.1. VIa(S) & VIIb,c herring. Working group estimate of catches from 1970-2006.

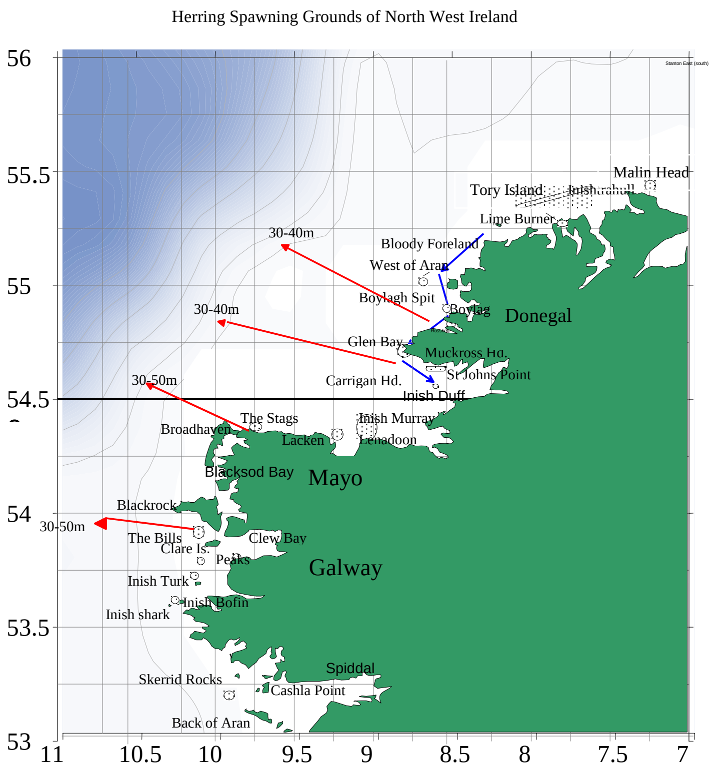


Figure 6.1.3.1. VIa(S) & VIIb,c herring. Northwest coast herring spawning grounds with arrows showing industry perceptions of herring movement.

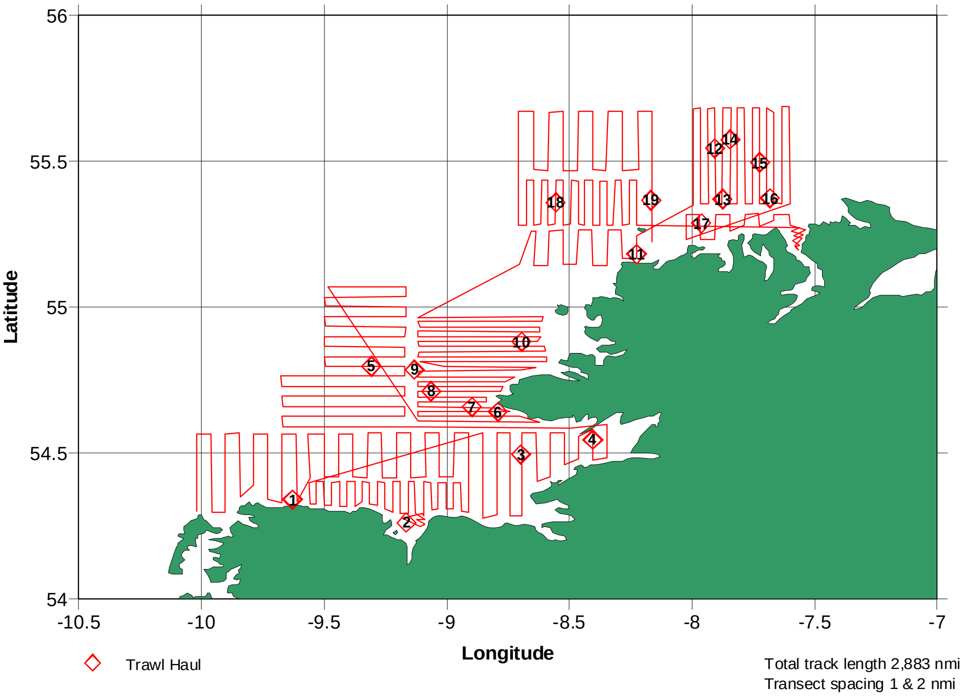


Figure 6.3.2.1 VIa(S) & Division VIIb,c herring. Cruise track and trawl positions during the 2007 northwest herring acoustic survey.

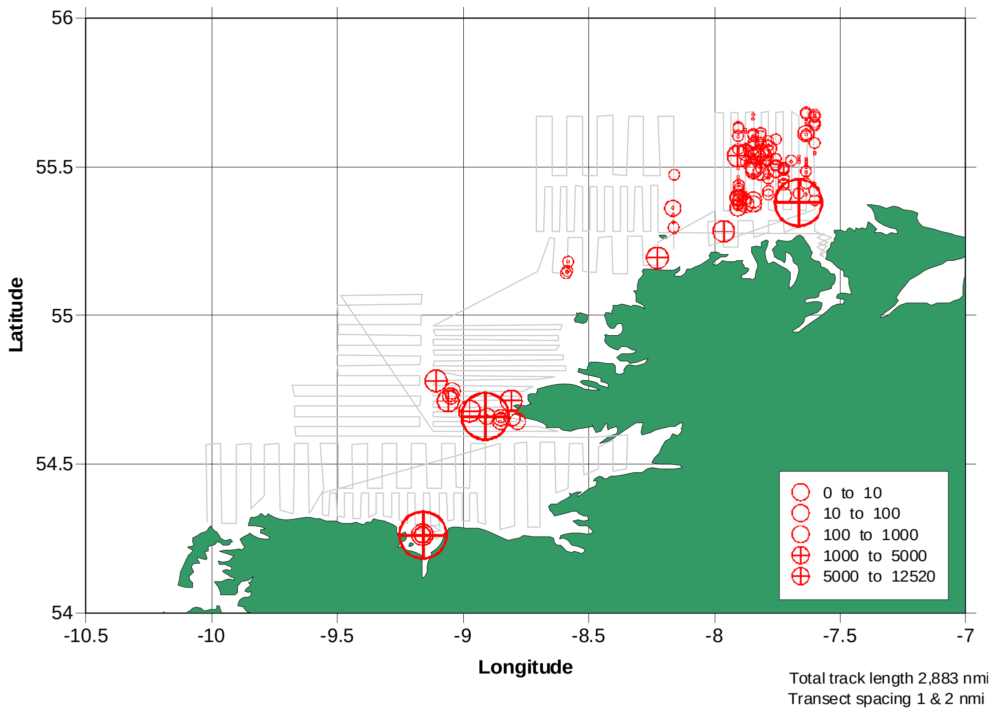
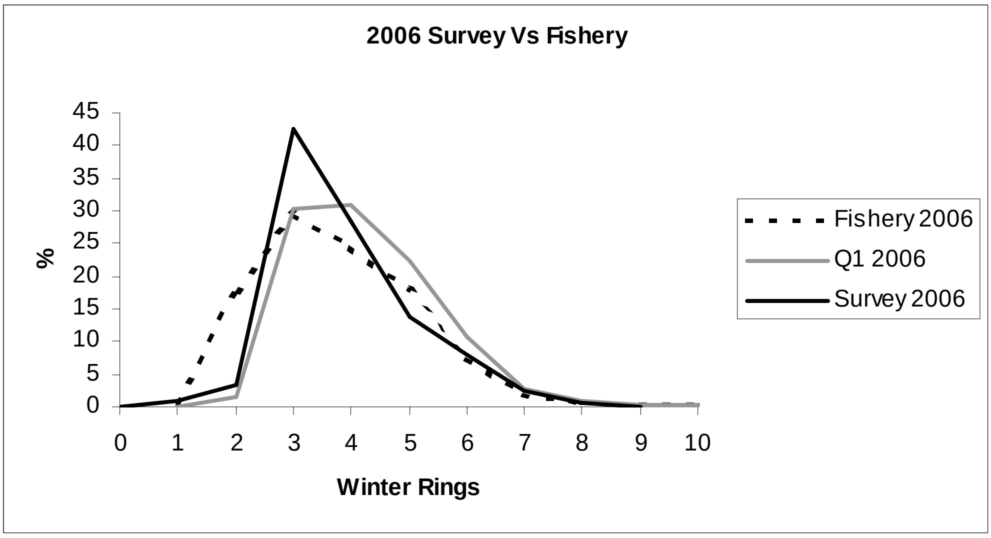


Figure 6.3.2.2 VIa(S) & Division VIIb,c herring. Post plot showing the distribution of total herring SA values obtained during the 2007 northwest herring acoustic survey.



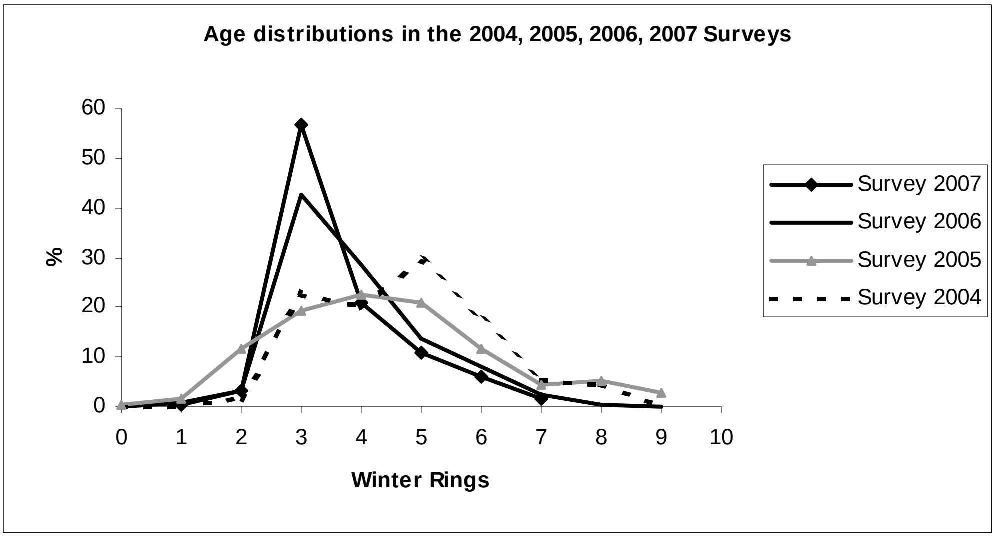


Figure 6.3.2.3. VIa(S) & Division VIIb,c herring. Age (winter rings) distributions of the abundance estimate from the 2006 and 2007 acoustic surveys and of the fishery in 2006 (Above). Age distribution of the abundance estimates from 4 acoustic surveys; 2004, 2005, 2006 and 2007 (below).

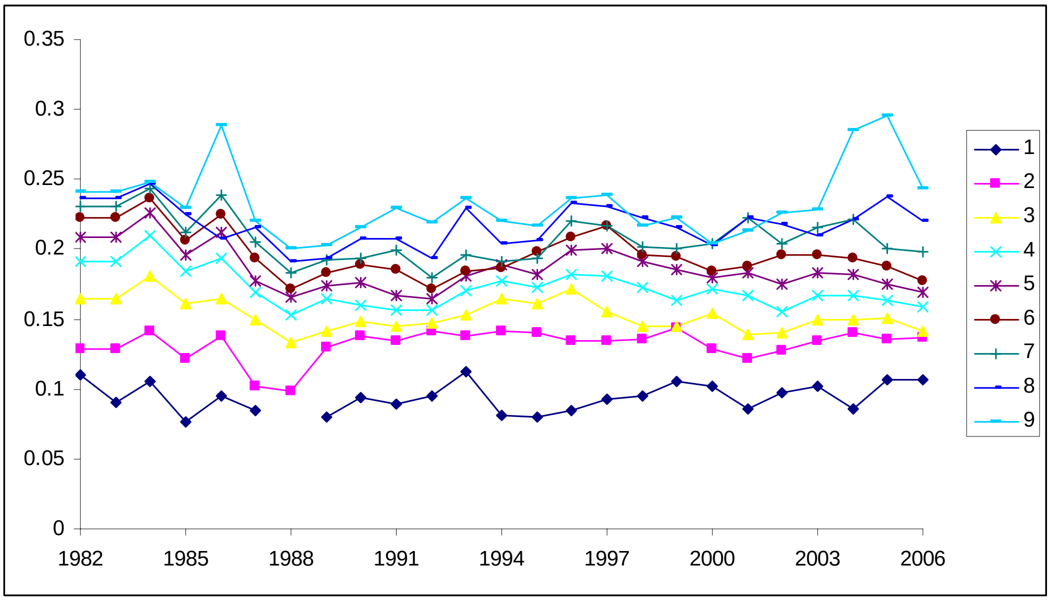


Figure 6.4.4.1. VIa(S) & Division VIIb,c herring. Mean weight in the catch 1982 – 2006.

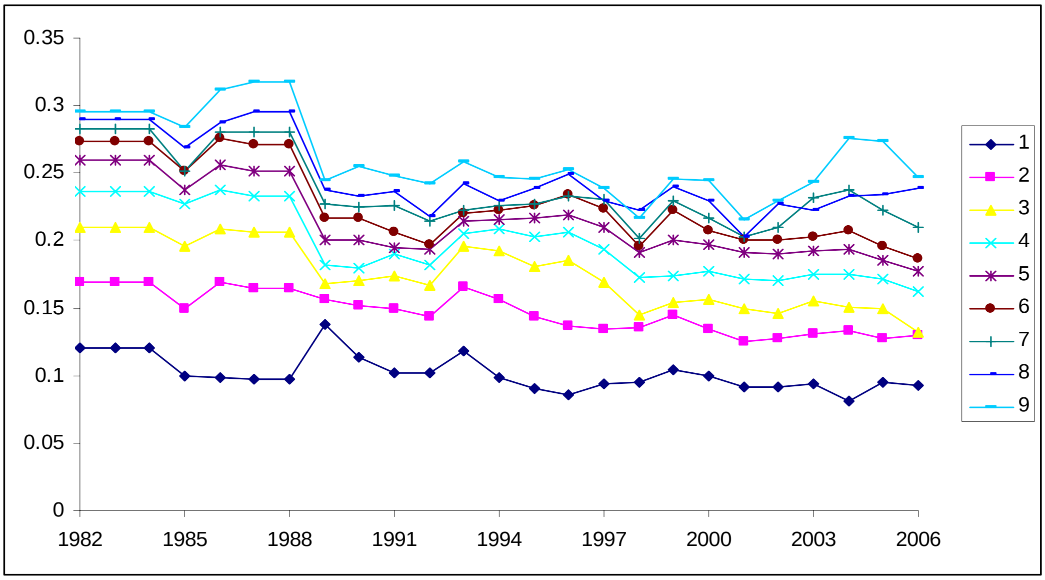
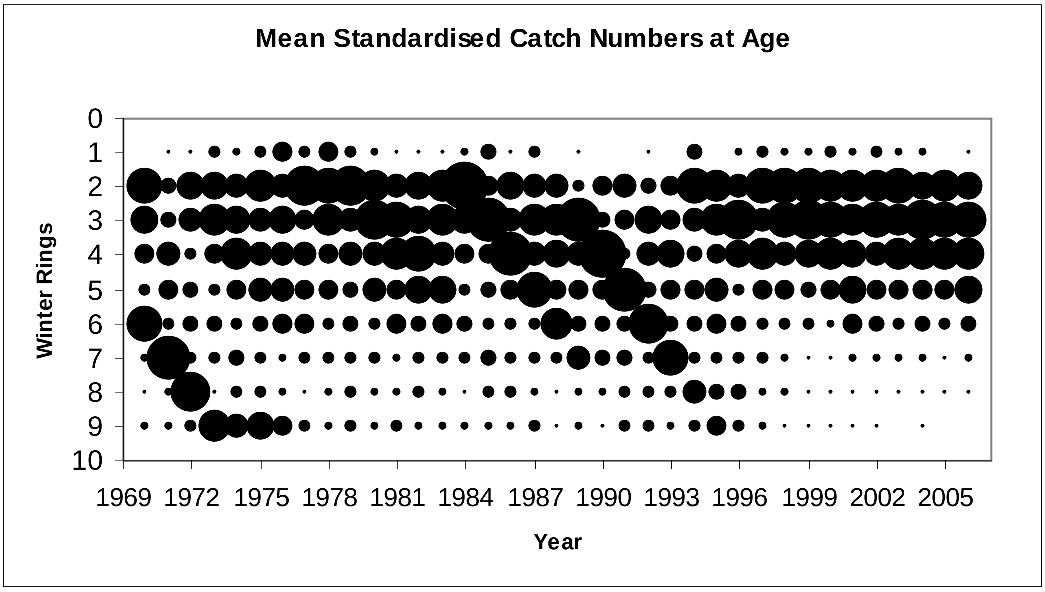


Figure 6.4.4.2. VIa(S) & Division VIIb,c herring. Mean weight in the stock 1982 – 2006.



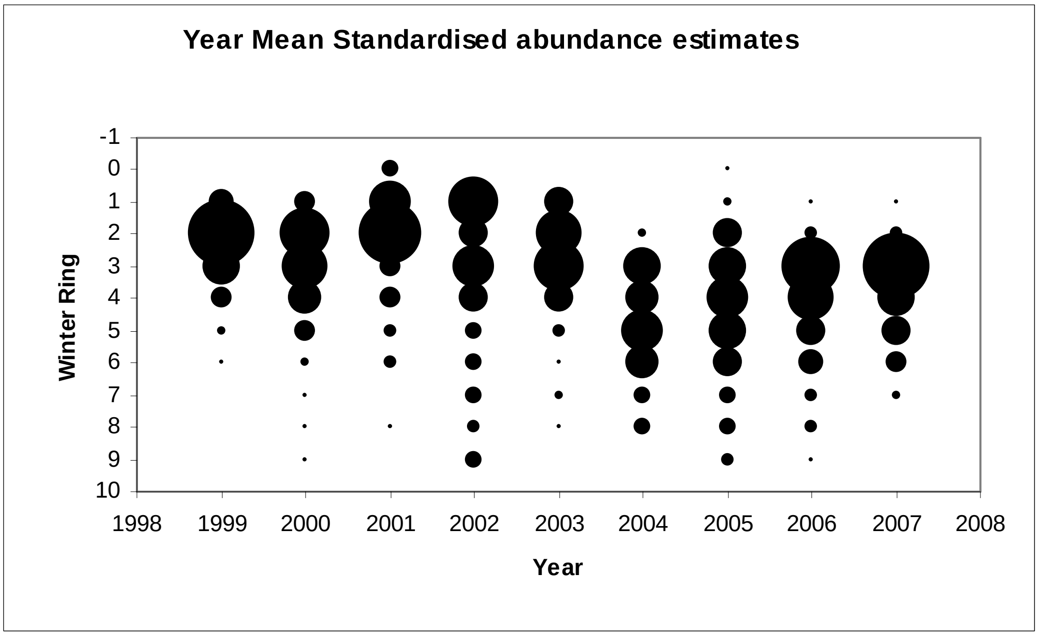
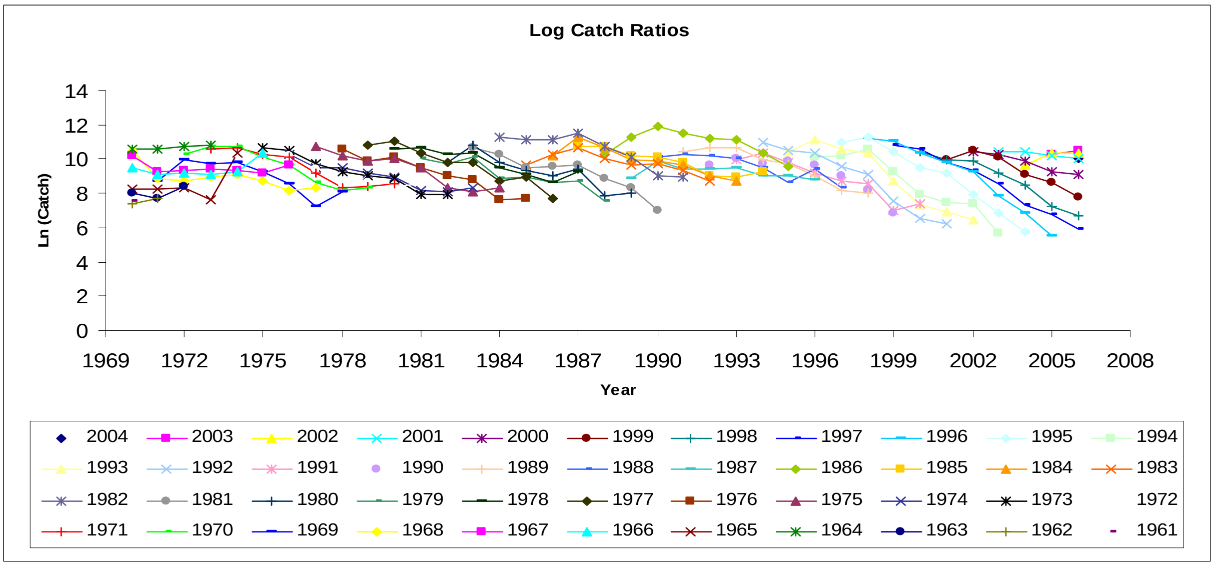


Figure 6.6.1.1 VIa(S) & Division VIIb,c herring. Mean standardised catch numbers at age standardised by year for the fishery (above) and the survey (below)



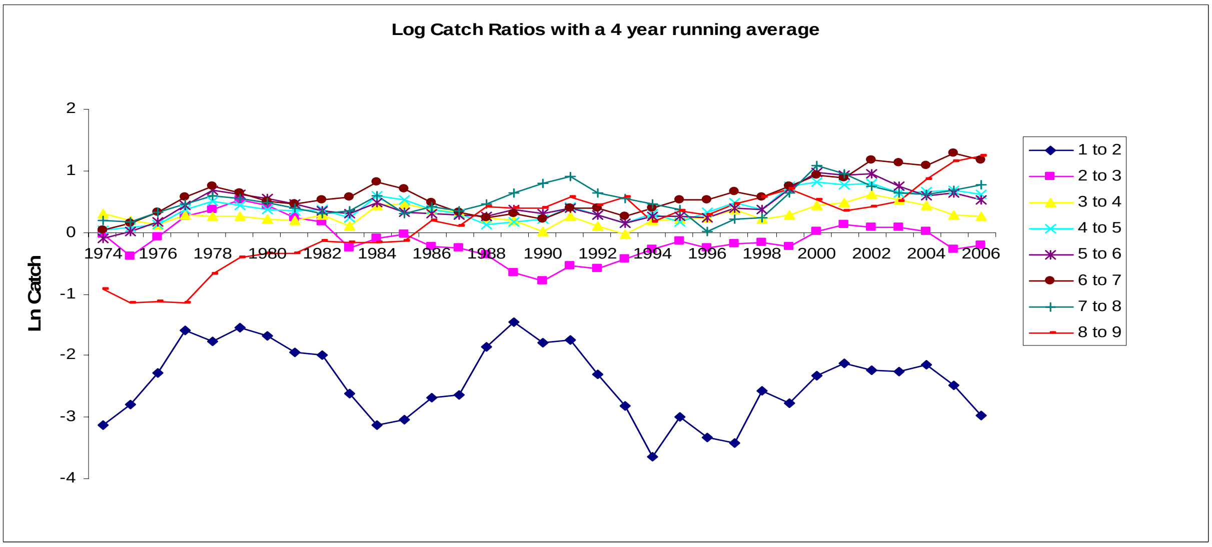


Figure 6.6.1.2. VIa (S) and VIIb,c herring. Log catch ratios by year (upper) and log catch ratios with a four-year running average (lower).

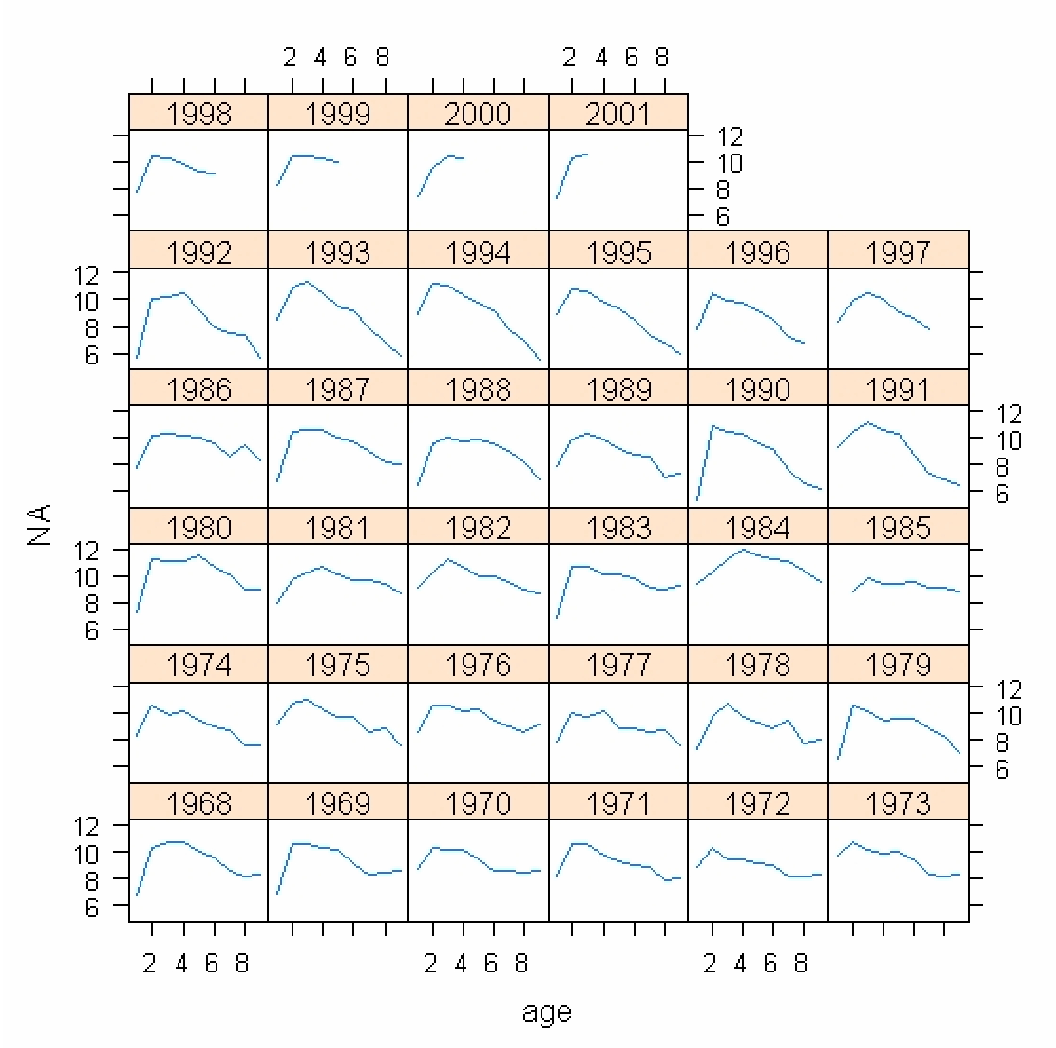


Figure 6.6.1.3: VIa(S) and VIIb,c herring. Cohort catch curves for the time series of catch at age data.

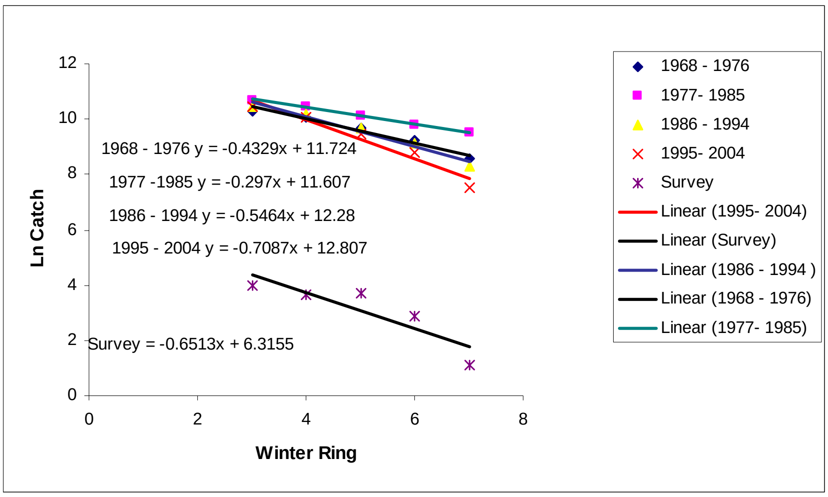


Figure 6.6.1.4: VIa(S) and VIIb,c herring. Mean log catch numbers at age for ages 3 –7 from the fishery and mean abundance estimates at age from the acoustic survey.

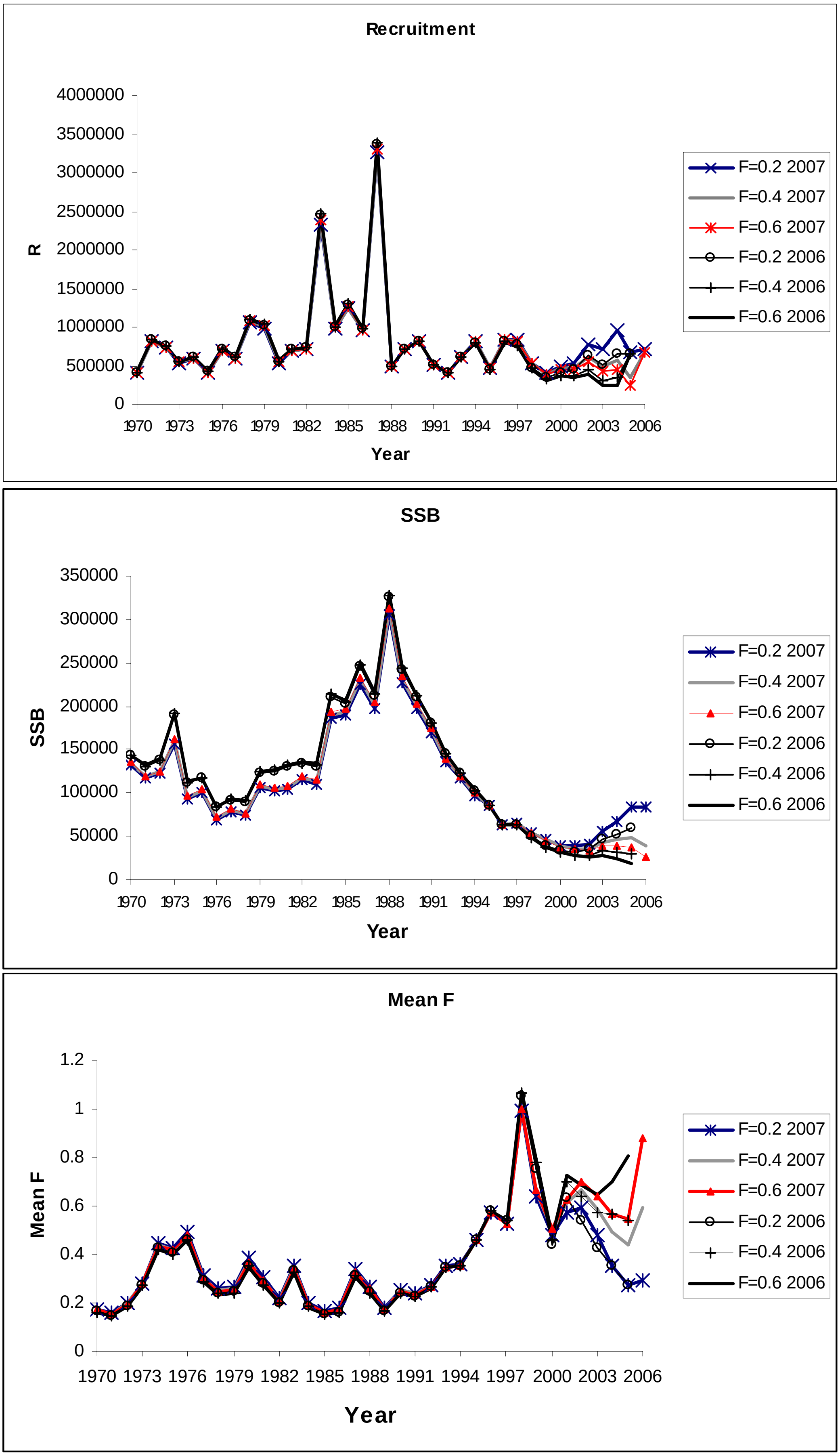


Figure 6.6.2.1. VIa(S) and VIIb,c herring comparison of three separable VPA runs of the current working group and the 2006 working group, using values of 0.2, 0.4 and 0.6 for terminal F.

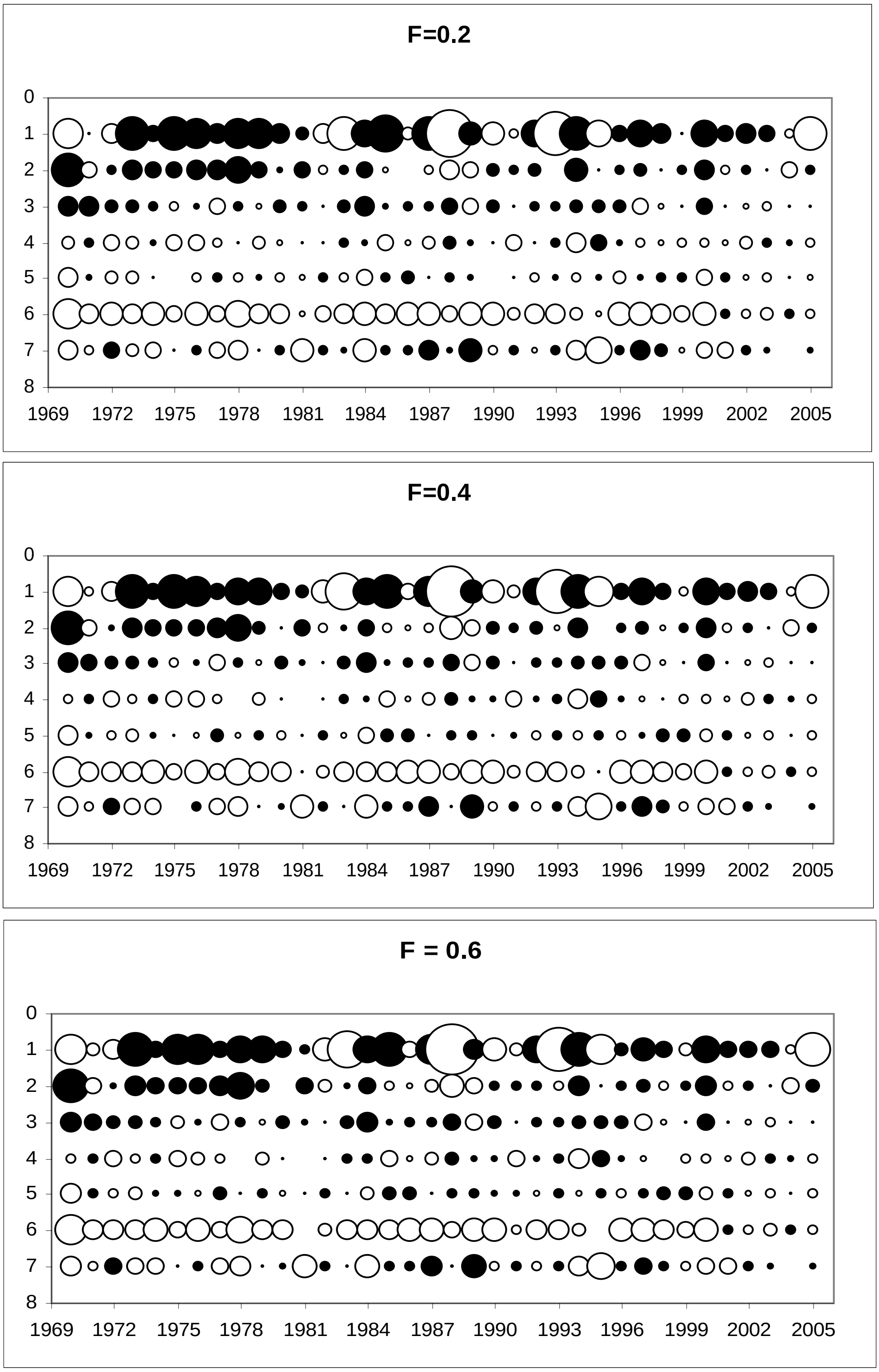


Figure 6.6.2.2. VIa(S) and VIIb,c herring – Residuals from three separable VPA runs using terminal F values of 0.2 (upper), 0.4 (middle) and 0.6 (lower). Black indicates positive residuals and white indicates negative.

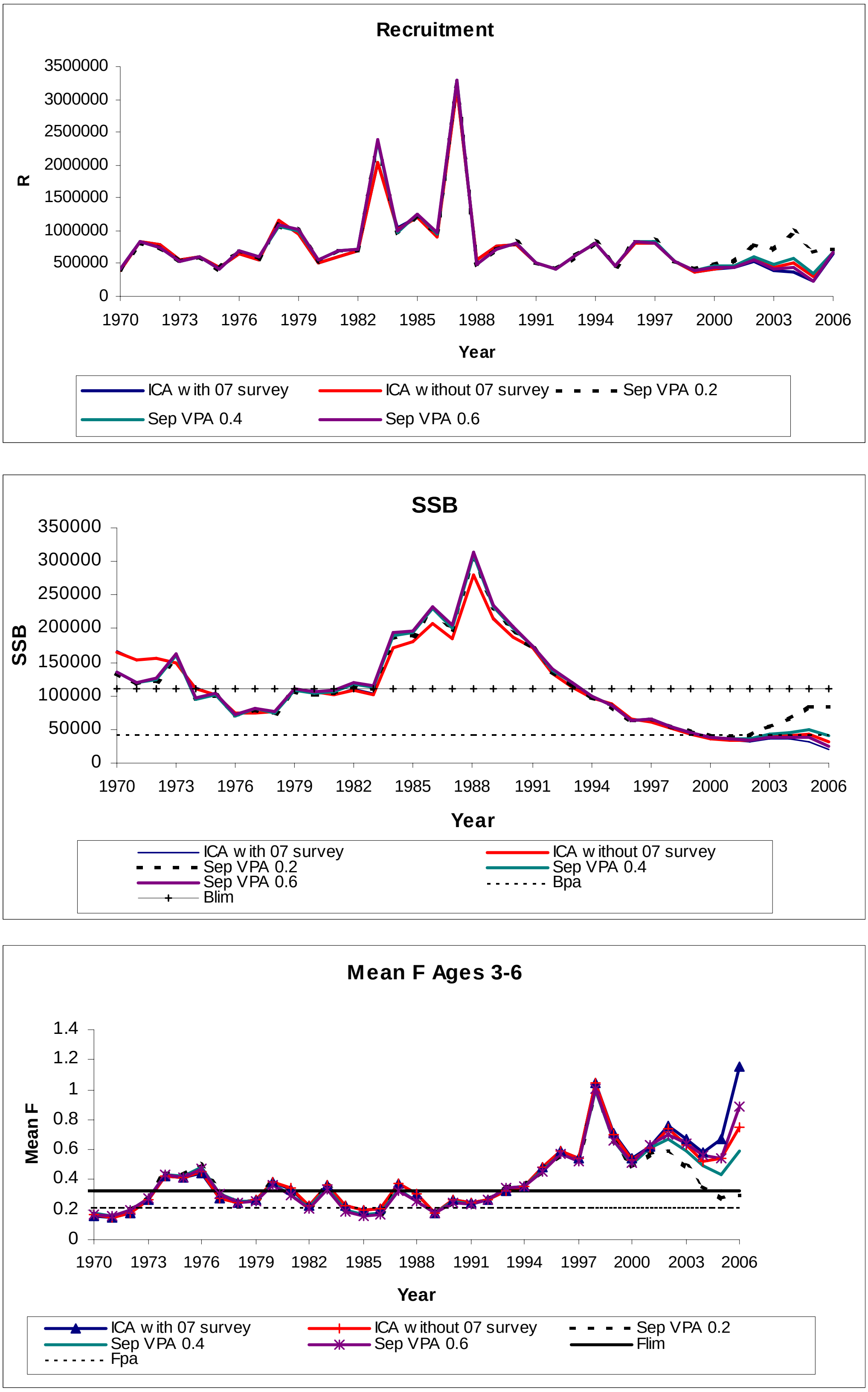


Figure 6.6.2.3. VIa(S) and VIIb,c herring – Results from two ICA runs and the three separable VPA runs.

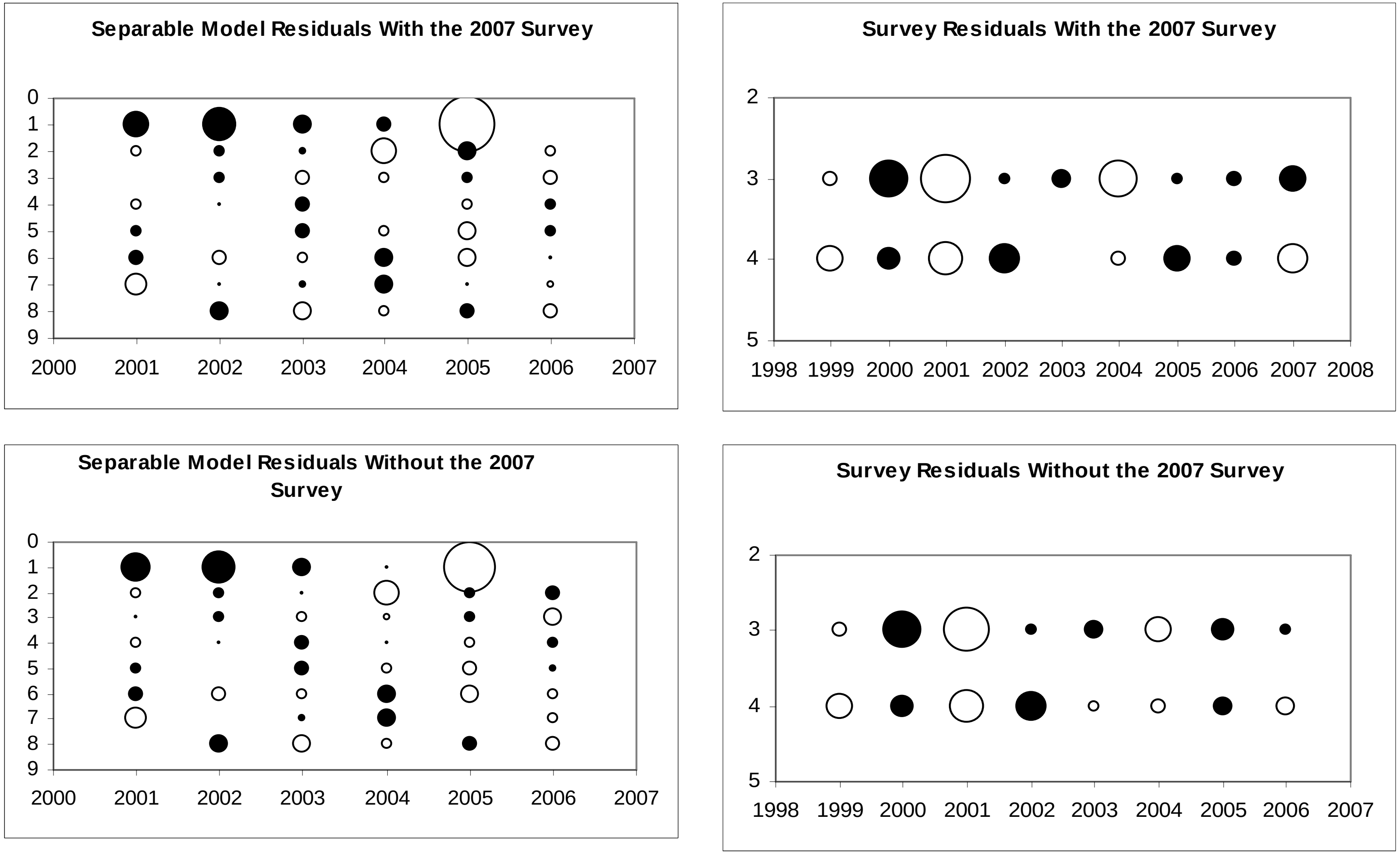


Figure 6.6.2.4. VIa(S) and VIIb,c herring – Separable model and survey residual patterns from ICA runs including and excluding the 2007 acoustic survey.

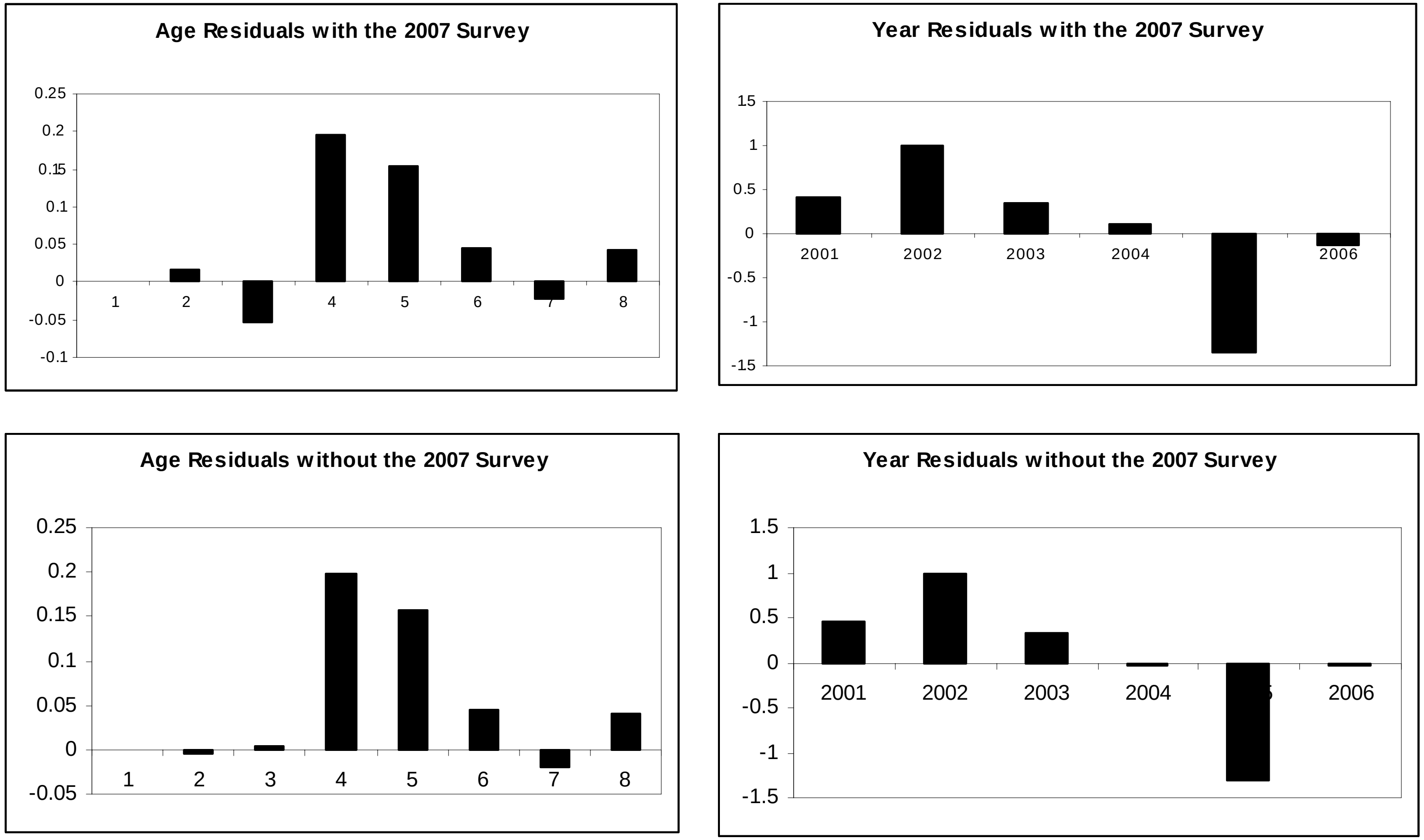


Figure 6.6.2.5. VIa(S) and VIIb,c herring – Year and age residual patterns from ICA runs including and excluding the 2007 acoustic survey.

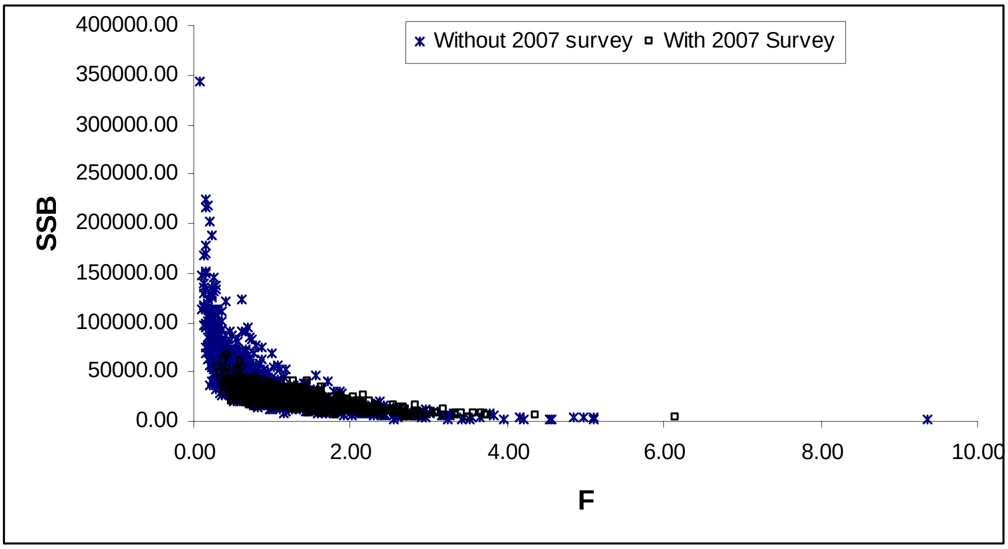


Figure 6.6.2.6. VIa(S) and VIIb,c herring. Scatter plot of estimates of F and SSB for the terminal year using parameter estimate variance-covariance matrix estimates in a bootstrap evaluation of the precision of the assessments, both including and excluding the 2007 acoustic survey.

7 Irish Sea Herring [Division VIIA(North)]

7.1 The Fishery

7.1.1 Advice and Management Applicable to 2006 and 2007

The WG did not present the results of a final assessment to ACFM in 2006 due to uncertainties in the estimates of F and SSB observed in the exploratory ICA runs. The exploratory analysis did suggest however that the SSB has been relatively stable for the last 10 years, and fishing mortality has not increased above the recent average.

ACFM subsequently advised that a *status quo* TAC of 4 800 t be adopted for 2006, partitioned as 3 500 t to the UK and 1 250 t to the Republic of Ireland.

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 in 2006, having returned in 2005 after many years of absence. 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.

7.1.2 The Fishery in 2006

The catches reported from each country for the period 1986 to 2006 are given in Table 7.1.1, and total catches from 1961 to 2006 in Figure 7.1.1. Reported international landings in 2006 for the Irish Sea amounted to 4 402 t with UK vessels acquiring extra quota through swaps with the Republic of Ireland. As with recent years the majority of the catch of herring in VIIa(N) was taken during the 3rd quarter.

The 2006 VIIa(N) herring fishery opened in August, with activity based mainly to the west of the Isle of Man. The majority of catches taken during August and September were by a pair of UK pair trawlers. One pair of polyvalent RSW Republic of Ireland vessels also took part in the fishery. Catches were reported from the last week in August to the third week in September.

September saw the opening of the Mourne fishery, limited to boats under 40ft, fishing with driftnets. This fishery saw reasonable catches of herring in 2005 for the first time in many years and again operated in 2006 landing catches of ~20 t during October and November. Fishing by the UK pair trawlers recommenced in November and continued through to December.

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 2006 and a graphical representation is given in Figure 7.2.1. The predominant year class in 2006 landings was the 2-ringers (2003-year class) with the highest catch seen since 1999. The large numbers of 3-ringers observed in 2005 catches continue to be detected in 2006 catches as 4-ringers. The catch in numbers at length is given in Table 7.2.2 for 1991 to 2006.

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 data arising from both the Republic of Ireland and Northern Ireland laboratories. 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. 20 samples were processed from the 3rd quarter fishery and 2 from the driftnet fishery operating during the 4th quarter (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 last year's assessment, the SSB estimates from the survey are calculated using the same (annually varying) maturity ogives that are input to ICA (see Table 7.3.3 estimated from the commercial catch data).

The acoustic survey in 2006 was carried out over 11 days in the period 30th August to 9th September. A survey design of stratified, systematic transects was employed, as in previous years (Figure 7.2.2.A). 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., 2005 WD 23; (see Annex 2). Sampling intensity was high during the 2006 survey with 28 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)

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 west of the Isle of Man (Figure 7.2.2.B). 0-group herring were found to be abundant to the west of the Isle of Man and in the north eastern Irish Sea (Figure 7.2.3.B). Mixed 1+ herring targets were scattered evenly around the Isle of Man, with larger shoals off the north western coast (Figure 7.2.3.A). Comparing the mixed herring distributions with 2005 highlighted the shift in biomass distribution from the east to the west Isle of Man. This shift in biomass between the eastern and western coasts is a pattern observed throughout the acoustic time-series and is thought to be associated with the timing of migration to the spawning grounds.

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 date of the acoustic survey.

The estimate of herring SSB of 16 332 t for 2006 is a marked reduction on last years estimate (Table 7.2.4). The approximate coefficient of variation (CV) of 0.22 is low due in part to the scattered nature of the mixed herring targets detected during the survey. The biomass estimate of 33 136 t for 1+ ringers is also a reduction on last year, whilst the approximate CV of 0.24 is an improvement. Given the approximate CVs of the estimates, it is not possible to discern any trend in 1+ biomass or SSB since 1999.

The estimate of the herring population, excluding 0-ring fish, is given in Table 7.2.5. The age composition from the acoustic survey was similar to the catch-at-age data with higher proportion catches of 2 and 3-ringers.

7.2.4 Larvae surveys

Northern Ireland undertook a herring larvae survey over the period 6th to 10th November 2006. The survey followed the methods and designs of previous surveys in the time-series (see Annex 2). The production estimate for 2006 in the NE Irish Sea was the third highest in the time series and well above the series average (Table 7.2.6). Herring larvae were found to be most abundant to the southeast and northeast of the Isle of Man and less abundant in the western Irish Sea (Figure 7.2.4).

7.2.5 Groundfish surveys of Area VIIa(N)

Groundfish surveys (Annex 2), carried out by Northern Ireland since 1991 in the Irish Sea, 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. New values were added to the time-series in 2006 and are shown in Table 7.2.7.

7.3 Mean length, weight, maturity and natural mortality-at-age

Mean lengths-at-age were calculated using the catch data and are given for the years 1985 to 2006 in Table 7.3.1. In general, mean lengths have been relatively stable over the last few years and this trend has continued in 2006.

Mean weights-at-age in the catch are given in Table 7.3.2. 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).

Mean weights-at-age in the third-quarter catches (for the whole time-series 1961 to present) have been used as estimates of stock weights at spawning time. 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).

Maturity-at-age (in the catches) for each year (1961 to 2005) are given in Table 7.3.3. 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.

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. These are based on the natural mortality rates estimated for herring in the North Sea using MSVPA.

7.4 Recruitment

An estimate of total abundance of 1-ringers is provided by the Northern Ireland acoustic survey. However, there is evidence that a fraction of those is of Celtic Sea origin. Separation of the trawl catches of juveniles into autumn and winter spawning components, based on otolith microstructure and/or length composition, 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

In 2006 two fishery independent survey indices were used as tuning indices to run ICA: Northern Irish larvae production (NINEL) and the age dis-aggregated abundance index from the acoustic survey (ACAGE). The preliminary modelling used catch-at-age data derived from the landings, extending back to 1961.

2006 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. Due to the continuing problems associated with mixing of Irish Sea and Celtic Sea juveniles the groundfish surveys were considered unsuitable tuning fleets and are not considered further. The survey series available for inclusion in an assessment using the ICA package are documented in Appendix 2.

Initial fits within integrated catch-at-age analysis (ICA), were performed with NINEL and ACAGE. The following model settings were used:

Separable constraint over the 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-rings in the acoustic survey weighted to 0.1.

Correlated errors assumed i.e., = 1.0

No shrinkage applied

The initial fit corresponds to the same procedure as last year (SPALY).

Examination of the initial fit SSQ surface (Figure 7.5.1) showed large discrepancies in the overall minima of reference F for the NINEL tuning index and ACAGE index. The NINEL tuning index showed a minimum at between 0.36 and 0.56 while the ACAGE index returned no readily discernible minimum. This highlighted the contrasting effect of these separate tuning indices on the deterministic calculation of the 6-year separable period. Comparison of reference Fs estimated in the SPALY run and ICA runs using one index at a time (NINEL, ACAGE) highlighted the variation in mean F (2-6) and associated deviation (Figure 7.5.2). The NINEL index indicated the lowest reference F (0.246) compared to the acoustic index (1.847), with the SPALY run indicating a reference F (1.177) intermediate between the two. The ACAGE reference F was estimated with very wide confidence intervals reflected also in the SPALY estimate.

Historical trends in log catch ratios along cohorts were investigated to give some indication of trends in Z over the time-series (Figure 7.5.3). The mean depletion rates of cohorts show a very high rate during the 1975 to 79 year classes (Figure 7.5.4). This period corresponds to a time of intensive fishing activity and associated high landings in the Irish Sea. Since the 1980 to 84 year classes the data suggest that total mortality has been slowly increasing. Estimates since 2000 shown a further decline in Z but are not accurate as the recruiting year classes since then have not passed fully through the fishery.

Inter-annual variation in the proportion catch at age (%) estimated from catch at age and the acoustic survey was explored to consider the signal generated by these data (Figure 7.5.5). Strong year and age effects were shown to occur throughout both time-series at all age classes (rings). Increases in proportion catches at age 2 were shown over the time-series in the acoustic surveys, while at age 8 a downward trend is seen from 1994 to present in both the catch and acoustic data. Age 1 were not included in the analysis due to the possible mixing effects with Celtic Sea fish and the reduced selectivity to the fishery.

Year effects were evident in every age class and seemed to be consistent between the acoustic and catch data during the early part of the time-series, however during 2000/2001 this consistency became uncoupled. This seems not the case for the age 2 class however, were an apparent contrasting pattern between the catch and acoustic survey is evident throughout the time- series. Comparing the proportion catch-at-age data with the ICA age and year residuals in the separable period it can be seen that the year effect from 2003 is evident in both. (Figure 7.5.9).

The year effects present in the age 2 catch and acoustic data were investigated further through examination of the spatial distribution of adult herring (1+ring) biomass during the acoustic survey. The shift in biomass between the eastern and western coasts surrounding the Isle of Man is an anomaly observed throughout the acoustic time-series and is thought to be associated with the timing of migration to the spawning grounds (Figure 7.5.6). An oscillating pattern of biomass distribution is observed where the bulk of adult herring biomass is either found on the western or eastern coast of the Isle of Man. A significant correlation of the annual ratio of the proportion in catch at age 2 between the acoustic and catch data, and the annual western adult herring (1+) biomass estimate was found (Figure 7.5.7). This correlation suggests that the timing of migration and distribution of herring have a significant effect on the resulting catch at age 2 arising from the fishery. As the landings from this fishery mainly arise from 1 operational unit it is not surprising that strong year effects are seen in the catch-at-age data. This will have major implications for the precision of the assessment in VIIa(N) and may explain the contrasting signal between the catch at age and acoustic tuning index.

Two-stage biomass model

In 2005 a Two-Stage Biomass model for the assessment of Irish Sea VIIa herring given additional variance in the recruitment index was presented by Roel and De Oliveira (2005 WD10). In 2006 due to the uncertainty in the outputs from the SPALY ICA run and the mixing of 0-group Irish and Celtic Sea recruits in the management area, the model was not attempted at the 2006 HAWG.

7.5.2 Conclusion to explorations

The results from the exploratory runs carried out with ICA using NINEL and ACAGE as tuning indices indicate a low precision in reference F(2-6) in 2006 (Figure 7.5.2). Exploration of proportion at age data suggests that conflicting year effects are present in the acoustic and catch at age data, particularly since 2000/2001 (Figure 7.5.5). These conflicting signals are contributing to the poor model fit in the separable period as shown by the year residuals generated from ICA (Figure 7.5.9). These year effects therefore may also explain the low precision in reference F generated by the model.

It is evident from the exploratory analysis that there is a contrast in the proportion catch at age between the acoustic and catch at age data. There is evidence that the inter-annual variation in the migration and distribution of herring surrounding the Isle of Man has an inter-annual effect on the age class selectivity of this fishery. This effect is shown to be significantly associated with the age 2 year classes, the most abundant in numbers at age in the stock (Table 7.2.1). This violates the separable assumption of ICA.

Further investigation into a more robust assessment model for this stock that does not assume separability is required.

7.5.3 Stock Assessment

The results presented correspond to SPALY ICA runs using the acoustics data as an age-structured index (ACAGE) and the Northern Ireland larval survey (NINEL) as an index of biomass (Figure 7.5.8 - 7.5.10). The outputs shown are an updated exploratory assessment and no analytical assessment is presented this year. The model settings are the same as for 2005. The run log for the assessment is shown in Table 7.5.1. The output from ICA assessment, the residuals and fitted values are given in Tables 7.5.2 –7.5.19. This assessment provides information on the relative trends of the converged period of the VPA for this stock. However it does not provide reliable information on the period covered by the 6-year separable period.

7.6 Stock and Catch Projection

7.6.1 Deterministic short-term predictions

No short-term predictions were included in the 2006 assessment.

7.6.2 Yield-per-recruit

For a yield-per-recruit analysis refer to last years report.

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 until there is agreement that advice based on the assessment can be provided.

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

The different survey series for Irish Sea herring are characterised by generally poor precision caused by the very patchy distribution of the fish as well as assumptions inherent in the methods (e.g. target strength, larval growth and mortality; relationship between larval production and SSB, constant selectivity in the separable period). Nonetheless, there is evidence of some coherence between the longer-term signals in the different survey series. The acoustic survey provides estimates of abundance at age but the juveniles in the area are a mixture of at least two adjacent stocks (Celtic Sea and VIIa(N)). Separation of trawl catches of juveniles into autumn and winter spawning components, based on otolith microstructure and/or length composition, could result in acoustic and trawl survey indices of juveniles appropriate for the Irish Sea assessment. However information from historical herring larval surveys in the Celtic Sea suggest that a considerable autumn spawning component existed in certain years. This may undermine attempts to separate the Celtic and Irish Sea juvenile components.

Retrospective analysis of the assessment with data from 2004 to 2006 was carried out (Figure 7.5.11). The retrospectives for SSB and F_{2-6} from the ICA assessment (NINEL + ACAGE show instability in the estimation of SSB during the 6-year separable period. The tendency to over-estimate SSB in the last assessment year was shown to be a continuing trend. The retrospective pattern of $F_{2\text{-}6}$ is relatively stable, however the addition of data in 2006 had the effect to revise F upwards. As this was an exploratory assessment these data should be taken as an exploratory exercise. The estimation of recruitment in the final year is not considered reliable (Figure 7.5.11). There is a systematic bias in the retrospective pattern arising from ICA.

For many years, the assessment for this stock has not been accepted by ACFM. Both the catches and survey data are noisy. From the exploratory analysis it can be seen that some of this noise may arise from the apparent inter-annual variation in herring migration patterns.

Given the noise in the data it is difficult to detect abrupt changes in the stock dynamics. Nevertheless some inferences can be made that are quite robust, even though the absolute estimates of SSB and fishing mortality may be less reliable. In particular, it seems likely that the stock is relatively stable at a level close to Bpa, and that the fishing mortality has been relatively stable since the late 1990’s.

7.10 Spawning and Juvenile Fishing Area Closures

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.

7.11 Management considerations

The catches have been low in recent years and the fishing activity has not varied considerably as shown from landing data (Figure 7.1.1). There is evidence of a contraction in the age structure of this stock in both the catch and survey data (Figure 7.5.5). A further reduction in precision was noted in the 2006 assessment with the SSB estimated to be below B_{pa} and above $B_{lim.}$ Analytical retrospectives show considerable downward revision of SSB in subsequent assessments in recent years, placing SSB below the B_{pa}. Though the exact level of the stock is unclear from the current assessment model the trends indicate that SSB remains relatively stable. Recruitment is approximately average for the period since the 1980s when a change in the productivity of this stock was observed (Section 1.8.3). Therefore, the maintenance of recommended catch levels at current levels 4 800 t, in the short-term, should not be detrimental to the stock.

A review of the model (ICA) currently employed in the assessment of this stock is recommended in light of the inter-annual variation in age class selectivity of the fishery.

Table 7.1.1 Irish Sea Herring Division VIIa(N). Working group catch estimates in tonnes by country, 1987-2006. 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
Ireland	1 153	581
UK	3 234	3821
Unallocated	-	-
Total	4 387	4 402

Table 7.2.1 Irish Sea Herring Division VIIa(N). Catch in numbers (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

Table 7.2.2 Irish Sea Herring Division VIIa(N). Catch-at-length data 1991-2006. Numbers of fish in thousands. Table amended with 1990 year-class removed, see 2005 report.

LENGTH	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
14																
14.5																
15		95														
15.5		169							10							
16		343			21	21	17		19	12	9					2
16.5	2	275			55	51	94		53	49	27			13	1	44
17	1	779		84	139	127	281	26	97	67	53			25	39	140
17.5	4	1106		59	148	200	525	30	82	97	105			84	117	211
18	31	1263		69	300	173	1022	123	145	115	229			102	291	586
18.5	56	1662		89	280	415	1066	206	135	134	240	36		114	521	726
19	168	1767	39	226	310	554	1720	317	234	164	385	18		203	758	895
19.5	174	1189	75	241	305	652	1263	277	82	97	439	0	29	269	933	1246
20	454	1268	75	253	326	749	1366	427	218	109	523	0	73	368	943	984
20.5	341	705	57	270	404	867	1029	297	242	85	608	18	215	444	923	1443
21	469	705	130	400	468	886	1510	522	449	115	1086	307	272	862	1256	1521
21.5	296	597	263	308	782	1258	1192	549	362	138	1201	433	290	1007	1380	1621
22	438	664	610	700	1509	1530	2607	1354	1261	289	1748	1750	463	1495	1361	2748
22.5	782	927	1224	785	2541	2190	2482	1099	2305	418	1763	1949	600	2140	1448	3629
23	1790	1653	2016	1035	4198	2362	3508	2493	4784	607	2670	2490	1158	2089	1035	4358
23.5	1974	1156	2368	1473	4547	2917	3902	2041	4183	951	2254	1552	1380	2214	1256	2920
24	2842	1575	2895	2126	4416	3649	4714	3695	4165	1436	3489	1029	1273	2054	1276	3679
24.5	2311	2412	2616	2564	3391	4077	4138	2769	3397	1783	4098	758	1249	2269	1083	2431
25	2734	2792	2207	3315	3100	4015	5031	2625	2620	2144	5566	776	1163	1749	1086	3438
25.5	2596	3268	2198	3382	2358	3668	3971	2797	1817	1791	4785	1335	1211	1206	584	2198
26	3278	3865	2216	3480	2334	2480	3871	3115	1694	1349	3814	1570	1140	823	438	1714
26.5	2862	3908	2176	2617	1807	2177	2455	2641	1547	840	2243	1552	1573	587	203	605
27	2412	3389	2299	2391	1622	1949	1711	2992	1475	616	1489	776	1607	510	165	445
27.5	1449	2203	2047	1777	990	1267	1131	1747	867	479	644	433	1189	383	60	155
28	922	1440	1538	1294	834	906	638	1235	276	212	496	162	726	198	45	104
28.5	423	569	944	900	123	564	440	170	169	58	179	108	569	51	18	9
29	293	278	473	417	248	210	280	111	61	42	10	36	163		12	46
29.5	129	96	160	165	56	79	59	92		12	0	36	129			
30	82	70	83	9	40	32	8	84		6	9		43			
30.5	36	36	15	27	5	0	5	3					43			
31	12	2	4		1	2							43			
31.5	3															
32																
32.5																
33																
33.5																
34																

Table 7.2.3 Irish Sea Herring Division VIIa(N). Sampling intensity of commercial landings in 2006.

Quarter	Country	Landings (t)	No. samples	No. fish measured	No. fish aged	Estimation of discards
1	Ireland	0	-	-	-	-
	UK (N. Ireland)	0.03	0	0	0	No
	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	581	8	2248	549	No
	UK (N. Ireland)	3 307	12	1406	586	No
	UK (Isle of Man)	*	-	-	-	-
	UK (Scotland)	0	-	-	-	-
	UK (England & Wales)	0	-	-	-	-
4	Ireland	0	-	-	-	-
	UK (N. Ireland)	514	2	576	100	No
	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 1989-2006. 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	25-26 Sept			18000	-	-	-
1990	Douglas Bank	26-27 Sept			26,600	-	-	-
1991	Western Irish Sea	26 July - 8 Aug	12,760	0.23			66,000[1]	0.20
1992	Western Irish Sea + IOM east coast	20-31 July	17,490	0.19			43,200	0.25
1994	Area VIIa(N)	28 Aug - 8 Sep	31,400	0.36	25,133	-	68,600	0.10
	Douglas Bank	22-26 Sept			28,200	-	-	-
1995	Area VIIa(N)	11-22 Sept	38,400	0.29	20,167	-	348,600	0.13
	Douglas Bank	10-11 Oct		-	9,840	-	-	-
	Douglas Bank	23-24 Oct			1,750	0.51	-	-
1996	Area VIIa(N)	2-12 Sept	24,500	0.25	21426	0.25	-[2]	-
1997	Area VIIa(N)-reduced	8-12 Sept	20,100	0.28	10,702	0.35	46,600	0.20
1998	Area VIIa(N)	8-14 Sept	14,500	0.20	9,157	0.18	228,000	0.11
1999	Area VIIa(N)	6-17 Sept	31,600	0.59	21,040	0.75	272,200	0.10
2000	Area VIIa(N)	11-21 Sept	40,200	0.26	33,144	0.32	234,700	0.11
2001	Area VIIa(N)	10-18 Sept	35,400	0.40	13,647	0.42	299,700	0.08
2002	Area VIIa(N)	9-20 Sept	41,400	0.56	25,102	0.83	413,900	0.09
2003	Area VIIa(N)	7-20 Sept	49,500	0.22	24,390	0.24	265,900	0.10
2004	Area VIIa(N)	6-10, 15/16, 28/29 Sept	34,437	0.41	21,593	0.41	281,000	0.07
2005	Area VIIa(N)	29 Aug - 14 Sept	36,866	0.37	31,445	0.42	141,900	0.10
2006	Area VIIa(N)	30 Aug - 9 Sept	33,136	0.24	16,332	0.22	143,200	0.09

[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 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

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 2005.

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

SE = Standard Error

* 2005 Index value amended

Table 7.2.7 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 7.2.7 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 7.3.1 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

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

*** 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

* Average for the preceding nine years

Table 7.5.1 Irish Sea herring VIIa(N). ICA run log for the maximun-likelihood ICA calculation for the 6 year separable period. N.B. In this table “age” refers to number of rings (winter rings in the otolith).

```
          Integrated Catch at Age Analysis
          --------------------------------

             Version 1.4 w

             K.R.Patterson
          Fisheries Research Services
            Marine Laboratory
              Aberdeen

             8 March 1998

 Enter the name of the index file -->index.txt
canum.txt
weca.txt
 Stock weights in 2007 used for the year 2006
west.txt
 Natural mortality in 2007 used for the year 2006
natmor.txt
 Maturity ogive in 2007 used for the year 2006
matprop.txt
 Name of age-structured index file (Enter if none) : -->fleet.txt
 Name of the SSB index file (Enter if none) -->ssb.txt
 No of years for separable constraint ?--> 6
 Reference age for separable constraint ?--> 4
 Constant selection pattern model (Y/N) ?-->y
 S to be fixed on last age ?-->    1.000000000000000
 First age for calculation of reference F ?--> 2
 Last age for calculation of reference F ?--> 6
 Use default weighting (Y/N) ?-->n
Enter relative weights at age
 Weight for age 1-->    0.100000000000000
 Weight for age 2-->    1.000000000000000
 Weight for age 3-->    1.000000000000000
 Weight for age 4-->    1.000000000000000
 Weight for age 5-->    1.000000000000000
 Weight for age 6-->    1.000000000000000
 Weight for age 7-->    1.000000000000000
 Weight for age 8-->    1.000000000000000
Enter relative weights by year
 Weight for year 2001-->    1.000000000000000
 Weight for year 2002-->    1.000000000000000
 Weight for year 2003-->    1.000000000000000
 Weight for year 2004-->    1.000000000000000
 Weight for year 2005-->    1.000000000000000
 Weight for year 2006-->    1.000000000000000
Enter new weights for specified years and ages if needed
 Enter year, age, new weight or -1,-1,-1 to end.  -1 -1   -1.000000000000000
 Is the last age of FLT01: Northern Ireland acoustic surveys a plus-group (Y-->y
You must choose a catchability model for each index.

Models:   A  Absolute:  Index = Abundance . e
          L  Linear:    Index = Q. Abundance . e
          P  Power:     Index = Q. Abundance^ K .e

   where Q and K are parameters to be estimated, and
   e is a lognormally-distributed error.
```

Table 7.5.1 Irish Sea herring VIIa(N). ICA run log. Continued.

```
Model for   NINEL  is to be A/L/P ?-->L
 Model for FLT01: Northern Ireland acoustic surveys  is to be A/L/P ?-->L
 Fit a stock-recruit relationship (Y/N) ?-->n
 Enter lowest feasible F-->   5.0000000000000003E-02
 Enter highest feasible F-->    2.000000000000000
Mapping the F-dimension of the SSQ surface

    F             SSQ
+--------+-------------------
    0.05       40.5170011998
    0.15       25.0575743055
    0.26       21.7289232269
    0.36       20.2684502580
    0.46       19.4963702773
    0.56       19.0839131174
    0.67       18.9080410189
    0.77       18.9640071024
    0.87       19.0929695403
    0.97       19.2200050477
    1.08       19.3624089461
    1.18       19.5210624269
    1.28       19.6900076497
    1.38       19.8652996585
    1.49       20.0443517626
    1.59       20.2255253074
    1.69       20.4078796970
    1.79       20.5910148832
    1.90       20.7749871199
    2.00       20.9602857842
Lowest SSQ is for F =     0.698
-----------------------------------------------------------------
No of years for separable analysis : 6
Age range in the analysis : 1  . . . 8
Year range in the analysis : 1961  . . . 2006
Number of indices of SSB : 1
Number of age-structured indices : 1
Parameters to estimate : 32
Number of observations : 160
Conventional single selection vector model to be fitted.
-----------------------------------------------------------------
 Survey weighting to be Manual (recommended) or Iterative (M/I) ?-->M
 Enter weight for   NINEL-->    1.000000000000000
 Enter weight for FLT01: Northern Ireland acoustic surveys  at age 1-->    0.100000000000000
 Enter weight for FLT01: Northern Ireland acoustic surveys  at age 2-->    1.000000000000000
 Enter weight for FLT01: Northern Ireland acoustic surveys  at age 3-->    1.000000000000000
 Enter weight for FLT01: Northern Ireland acoustic surveys  at age 4-->    1.000000000000000
 Enter weight for FLT01: Northern Ireland acoustic surveys  at age 5-->    1.000000000000000
 Enter weight for FLT01: Northern Ireland acoustic surveys  at age 6-->    1.000000000000000
 Enter weight for FLT01: Northern Ireland acoustic surveys  at age 7-->    1.000000000000000
 Enter weight for FLT01: Northern Ireland acoustic surveys  at age 8-->    1.000000000000000
Enter estimates of the extent to which errors
in the age-structured indices are correlated
across ages. This can be in the range 0 (independence)
to 1 (correlated errors).
  Enter value for FLT01: Northern Ireland acoustic surveys-->    1.000000000000000
 Do you want to shrink the final fishing mortality (Y/N) ?-->N
Seeking solution. Please wait.
SSB index weights
  1.000
Aged index weights
FLT01: Northern Ireland acoustic surveys
 Age  :      1     2     3     4     5     6     7     8
 Wts :    0.012 0.125 0.125 0.125 0.125 0.125 0.125 0.125
F in 2006  at age 4  is 1.177082  in iteration 1
 Detailed, Normal or Summary output (D/N/S)-->D
 Output page width in characters (e.g. 80..132) ?--> 80
 Estimate historical assessment uncertainty ?-->y
 Sample from Covariances or Bayes MCMC (C/B) ?-->c
 Use default percentiles (Y/N)  ?-->y
 How many samples to take  ?--> 100
 Enter SSB reference level (e.g. MBAL, Bpa..) [t]-->   1.0000000000000000E+04
Succesful exit from ICA
```

Table 7.5.2 Irish Sea herring VIIa(N). Catch number-at-age (millions). N.B. In this table "age" refers to number of rings (winter rings in the otolith).

Output Generated by ICA Version 1.4

Herring Irish Sea

Catch in Number

AGE	1961	1962	1963	1964	1965	1966	1967	1968
1	4.54	0.38	4.84	1.51	0.85	0.94	4.44	1.02
2	11.47	12.30	9.44	18.10	27.08	15.05	40.92	30.18
3	2.63	7.34	2.34	4.35	8.18	15.64	5.60	13.46
4	12.43	1.81	2.89	0.71	0.99	2.00	4.63	4.08
5	0.24	5.43	2.26	0.53	0.71	0.12	1.35	0.82
6	0.48	0.19	2.26	0.71	0.99	0.35	0.00	0.61
7	1.20	0.19	0.55	0.00	0.42	0.12	0.00	0.00
8	2.15	0.67	0.62	0.18	0.71	0.00	0.00	0.00

x 10 ^ 6

Catch in Number

AGE	1969	1970	1971	1972	1973	1974	1975	1976
1	1.32	5.61	12.17	40.64	42.15	43.25	33.33	34.74
2	42.80	31.18	66.92	46.66	32.74	109.55	48.24	56.16
3	16.91	33.63	31.94	26.95	38.24	39.75	39.41	20.78
4	12.68	16.47	29.41	13.18	11.49	24.51	10.84	15.22
5	1.32	12.61	5.07	13.75	6.92	10.65	7.87	4.58
6	2.64	1.75	3.55	6.76	5.07	4.99	4.21	2.81
7	0.53	2.10	1.01	2.66	2.59	5.15	2.09	2.42
8	0.00	1.05	1.01	1.67	2.60	1.63	1.64	1.27

x 10 ^ 6

Catch in Number

AGE	1977	1978	1979	1980	1981	1982	1983	1984
1	30.28	15.54	11.77	5.84	5.05	5.10	1.31	1.17
2	39.04	36.95	38.27	25.76	15.79	16.03	12.16	8.42
3	22.69	13.41	23.49	19.51	3.20	5.67	5.60	7.24
4	6.75	6.78	4.25	8.52	2.79	2.15	2.82	3.84
5	4.52	1.74	2.20	1.98	2.30	0.33	0.45	2.22
6	1.46	1.34	1.05	0.91	0.33	1.11	0.48	0.38
7	0.91	0.67	0.40	0.36	0.29	0.14	0.26	0.23
8	1.12	0.35	0.29	0.23	0.24	0.38	0.06	0.48

x 10 ^ 6

Catch in Number

AGE	1985	1986	1987	1988	1989	1990	1991	1992
1	2.43	4.49	2.23	2.61	1.16	2.31	2.00	12.15
2	10.05	15.27	12.98	21.25	6.39	12.84	9.75	6.89
3	17.34	7.46	6.15	13.34	12.04	5.73	6.74	6.74
4	13.29	8.55	3.00	7.16	4.71	9.70	2.83	6.69
5	7.21	4.53	4.18	4.61	1.88	3.60	5.07	3.26
6	2.65	3.20	2.78	5.08	1.25	1.66	1.49	5.12
7	0.67	1.46	2.33	3.23	1.56	1.04	0.72	1.04
8	0.72	0.88	1.67	4.21	1.96	1.62	0.81	0.39

x 10 ^ 6

Table 7.5.2 Irish Sea herring VIIa(N). Catch number-at-age (millions). Continued.

Catch in Number

AGE	1993	1994	1995	1996	1997	1998	1999	2000
1	0.65	1.97	3.20	5.34	9.55	3.07	1.81	1.22
2	14.64	7.00	21.33	17.53	21.39	11.88	16.93	3.74
3	3.01	12.17	3.39	9.76	7.56	3.88	5.94	5.87
4	3.02	1.83	5.27	1.16	7.34	4.45	1.57	2.07
5	2.90	2.57	1.20	3.60	1.64	6.67	1.48	0.56
6	1.61	2.10	1.15	0.78	2.28	1.03	1.99	0.35
7	2.18	1.28	0.93	0.96	0.84	2.05	0.44	0.25
8	0.85	1.99	1.45	1.36	1.43	0.45	0.62	0.15

x 10 ^ 6

Catch in Number

AGE	2001	2002	2003	2004	2005	2006
1	2.71	0.18	0.69	3.23	8.69	5.67
2	11.47	9.02	4.69	8.83	13.98	15.25
3	7.15	1.89	3.35	5.41	10.56	8.20
4	13.05	1.87	2.56	2.16	3.29	6.32
5	3.39	2.40	0.88	0.62	1.42	1.33
6	0.94	0.95	2.95	0.21	0.41	0.61
7	0.65	0.47	0.87	0.67	0.29	0.26
8	0.80	0.34	0.61	0.13	0.37	0.25

x 10 ^ 6

Table 7.5.3 Irish Sea herring VIIa(N). Weight in the catch (kg). N.B. In this table "age" refers to number of rings (winter rings in the otolith).

Weights at age in the catches (Kg)

AGE	1961	1962	1963	1964	1965	1966	1967	1968
1	0.08200	0.06700	0.06700	0.07800	0.06500	0.09200	0.09300	0.09100
2	0.12300	0.12500	0.13100	0.12900	0.13200	0.14000	0.14900	0.15300
3	0.17800	0.15200	0.18400	0.15600	0.17600	0.18500	0.18000	0.19600
4	0.19800	0.17700	0.20800	0.17100	0.19200	0.21800	0.19900	0.23100
5	0.23200	0.19900	0.22800	0.22600	0.21000	0.25800	0.22300	0.24600
6	0.22600	0.21400	0.23400	0.24000	0.23000	0.25300	0.24300	0.26900
7	0.25300	0.27500	0.26600	0.00000	0.27200	0.22500	0.22700	0.23400
8	0.24800	0.25100	0.25800	0.29600	0.26500	0.26400	0.27500	0.26400

Table 7.5.3 Irish Sea herring VIIa(N). Weight in the catch (kg). Continued.

Weights at age in the catches (Kg)

AGE	1969	1970	1971	1972	1973	1974	1975	1976
1	0.07400	0.10100	0.10800	0.07400	0.07400	0.07400	0.07400	0.07400
2	0.15200	0.16200	0.15800	0.15500	0.15500	0.15500	0.15500	0.15500
3	0.20400	0.20600	0.18900	0.19500	0.19500	0.19500	0.19500	0.19500
4	0.23100	0.22500	0.21400	0.21900	0.21900	0.21900	0.21900	0.21900
5	0.25400	0.24500	0.22500	0.23200	0.23200	0.23200	0.23200	0.23200
6	0.26600	0.25100	0.26600	0.25100	0.25100	0.25100	0.25100	0.25100
7	0.23900	0.26900	0.24100	0.25800	0.25800	0.25800	0.25800	0.25800
8	0.27000	0.25800	0.24100	0.27800	0.27800	0.27800	0.27800	0.27800

Weights at age in the catches (Kg)

AGE	1977	1978	1979	1980	1981	1982	1983	1984
1	0.07400	0.07400	0.07400	0.07400	0.07400	0.07400	0.07400	0.07600
2	0.15500	0.15500	0.15500	0.15500	0.15500	0.15500	0.15500	0.14200
3	0.19500	0.19500	0.19500	0.19500	0.19500	0.19500	0.19500	0.18700
4	0.21900	0.21900	0.21900	0.21900	0.21900	0.21900	0.21900	0.21300
5	0.23200	0.23200	0.23200	0.23200	0.23200	0.23200	0.23200	0.22100
6	0.25100	0.25100	0.25100	0.25100	0.25100	0.25100	0.25100	0.24300
7	0.25800	0.25800	0.25800	0.25800	0.25800	0.25800	0.25800	0.24000
8	0.27800	0.27800	0.27800	0.27800	0.27800	0.27800	0.27800	0.27300

Weights at age in the catches (Kg)

AGE	1985	1986	1987	1988	1989	1990	1991	1992
1	0.08700	0.06800	0.05800	0.07000	0.08100	0.09600	0.07300	0.06200
2	0.12500	0.14300	0.13000	0.12400	0.12800	0.14000	0.12300	0.11400
3	0.15700	0.16700	0.16000	0.16000	0.15500	0.16600	0.15500	0.14000
4	0.18600	0.18800	0.17500	0.17000	0.17400	0.17500	0.17100	0.15500
5	0.20200	0.21500	0.19400	0.18000	0.18400	0.18700	0.18100	0.16500
6	0.20900	0.22800	0.21000	0.19800	0.19500	0.19500	0.19000	0.17400
7	0.22200	0.23900	0.21800	0.21200	0.20500	0.20700	0.19800	0.18100
8	0.25800	0.25400	0.22900	0.23200	0.21800	0.21800	0.21700	0.19700

Weights at age in the catches (Kg)

AGE	1993	1994	1995	1996	1997	1998	1999	2000
1	0.08900	0.07000	0.07500	0.06700	0.06400	0.08000	0.06900	0.06400
2	0.12700	0.12300	0.12100	0.11600	0.11800	0.12300	0.12000	0.12000
3	0.15700	0.15300	0.14600	0.14800	0.14600	0.14800	0.14500	0.14800
4	0.17100	0.17000	0.16400	0.16200	0.16500	0.16300	0.16700	0.16800
5	0.18200	0.18000	0.17600	0.17700	0.17600	0.18100	0.17600	0.18800
6	0.19100	0.18900	0.18100	0.19900	0.18800	0.17700	0.18800	0.20400
7	0.19800	0.20200	0.19300	0.20000	0.20400	0.18800	0.19000	0.20000
8	0.21200	0.21200	0.20700	0.21400	0.21600	0.22200	0.21000	0.21300

Weights at age in the catches (Kg)

AGE	2001	2002	2003	2004	2005	2006
1	0.06700	0.08500	0.08100	0.07300	0.06700	0.06400
2	0.10600	0.11300	0.11600	0.10700	0.10300	0.10500
3	0.13900	0.14400	0.13600	0.13000	0.13600	0.13100
4	0.15600	0.16700	0.16000	0.15700	0.15600	0.14900
5	0.16800	0.18000	0.16700	0.16500	0.16600	0.16400
6	0.18500	0.18400	0.17200	0.18700	0.18000	0.17700
7	0.19800	0.19100	0.18600	0.20000	0.19100	0.18400
8	0.20500	0.21700	0.19900	0.20500	0.20900	0.21000

Table 7.5.4 Irish Sea herring VIIa(N). Weight in the stock (kg). N.B. In this table "age" refers to number of rings (winter rings in the otolith).

Weights at age in the stock (Kg)

AGE	1961	1962	1963	1964	1965	1966	1967	1968
1	0.08200	0.06700	0.06700	0.07800	0.06500	0.09200	0.09300	0.09100
2	0.12300	0.12500	0.13100	0.12900	0.13200	0.14000	0.14900	0.15300
3	0.17800	0.15200	0.18400	0.15600	0.17600	0.18500	0.18000	0.19600
4	0.19800	0.17700	0.20800	0.17100	0.19200	0.21800	0.19900	0.23100
5	0.23200	0.19900	0.22800	0.22600	0.21000	0.25800	0.22300	0.24600
6	0.22600	0.21400	0.23400	0.24000	0.23000	0.25300	0.24300	0.26900
7	0.25300	0.27500	0.26600	0.00000	0.27200	0.22500	0.22700	0.23400
8	0.24800	0.25100	0.25800	0.29600	0.26500	0.26400	0.27500	0.26400

Weights at age in the stock (Kg)

AGE	1969	1970	1971	1972	1973	1974	1975	1976
1	0.07400	0.10100	0.10800	0.07400	0.07400	0.07400	0.07400	0.07400
2	0.15200	0.16200	0.15800	0.15500	0.15500	0.15500	0.15500	0.15500
3	0.20400	0.20600	0.18900	0.19500	0.19500	0.19500	0.19500	0.19500
4	0.23100	0.22500	0.21400	0.21900	0.21900	0.21900	0.21900	0.21900
5	0.25400	0.24500	0.22500	0.23200	0.23200	0.23200	0.23200	0.23200
6	0.26600	0.25100	0.26600	0.25100	0.25100	0.25100	0.25100	0.25100
7	0.23900	0.26900	0.24100	0.25800	0.25800	0.25800	0.25800	0.25800
8	0.27000	0.25800	0.24100	0.27800	0.27800	0.27800	0.27800	0.27800

Weights at age in the stock (Kg)

AGE	1977	1978	1979	1980	1981	1982	1983	1984
1	0.07400	0.07400	0.07400	0.07400	0.07400	0.07400	0.07400	0.07600
2	0.15500	0.15500	0.15500	0.15500	0.15500	0.15500	0.15500	0.14200
3	0.19500	0.19500	0.19500	0.19500	0.19500	0.19500	0.19500	0.18700
4	0.21900	0.21900	0.21900	0.21900	0.21900	0.21900	0.21900	0.21300
5	0.23200	0.23200	0.23200	0.23200	0.23200	0.23200	0.23200	0.22100
6	0.25100	0.25100	0.25100	0.25100	0.25100	0.25100	0.25100	0.24300
7	0.25800	0.25800	0.25800	0.25800	0.25800	0.25800	0.25800	0.24000
8	0.27800	0.27800	0.27800	0.27800	0.27800	0.27800	0.27800	0.27300

Weights at age in the stock (Kg)

AGE	1985	1986	1987	1988	1989	1990	1991	1992
1	0.08700	0.06800	0.05800	0.07000	0.08100	0.07700	0.07000	0.06100
2	0.12500	0.14300	0.13000	0.12400	0.12800	0.13500	0.12100	0.11100
3	0.15700	0.16700	0.16000	0.16000	0.15500	0.16300	0.15300	0.13600
4	0.18600	0.18800	0.17500	0.17000	0.17400	0.17500	0.16700	0.15100
5	0.20200	0.21500	0.19400	0.18000	0.18400	0.18800	0.18000	0.15900
6	0.20900	0.22900	0.21000	0.19800	0.19500	0.19600	0.18900	0.17100
7	0.22200	0.23900	0.21800	0.21200	0.20500	0.20700	0.19500	0.17900
8	0.25800	0.25400	0.22900	0.23200	0.21800	0.21700	0.21400	0.19100

Weights at age in the stock (Kg)

AGE	1993	1994	1995	1996	1997	1998	1999	2000
1	0.08800	0.07300	0.07200	0.06700	0.06300	0.07300	0.06800	0.06300
2	0.12600	0.12600	0.12000	0.11500	0.11900	0.12100	0.12100	0.12000
3	0.15700	0.15400	0.14700	0.14800	0.14800	0.15000	0.14500	0.14900
4	0.17100	0.17400	0.16800	0.16200	0.16700	0.16600	0.16800	0.17100
5	0.18300	0.18100	0.18000	0.17700	0.17800	0.17900	0.17800	0.18800
6	0.19100	0.19000	0.18500	0.19500	0.18900	0.19000	0.18900	0.20400
7	0.19800	0.20300	0.19700	0.19900	0.20600	0.20000	0.19900	0.20500
8	0.21400	0.21400	0.21200	0.21200	0.21400	0.23000	0.21400	0.21500

Table 7.5.4 Irish Sea herring VIIa(N). Weight in the stock (kg). Continued.

Weights at age in the stock (Kg)

AGE	2001	2002	2003	2004	2005	2006
1	0.06600	0.08500	0.08100	0.06700	0.06700	0.06400
2	0.10500	0.11300	0.11600	0.11400	0.10300	0.10500
3	0.13900	0.14400	0.13600	0.14400	0.13600	0.13100
4	0.15600	0.16700	0.16000	0.16100	0.15600	0.14900
5	0.16700	0.18000	0.16700	0.17000	0.16600	0.16400
6	0.18300	0.18400	0.17200	0.19200	0.18000	0.17700
7	0.19900	0.19100	0.18600	0.20200	0.19100	0.18400
8	0.20500	0.21700	0.19900	0.20500	0.20700	0.22000

Table 7.5.5 Irish Sea herring VIIa(N). Natural mortality. N.B. In this table "age" refers to number of rings (winter rings in the otolith).

Natural Mortality (per year)

AGE	1961	1962	1963	1964	1965	1966	1967	1968
1	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
2	0.3000	0.3000	0.3000	0.3000	0.3000	0.3000	0.3000	0.3000
3	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000
4	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000
5	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000
6	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000
7	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000
8	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000

Natural Mortality (per year)

AGE	1969	1970	1971	1972	1973	1974	1975	1976
1	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
2	0.3000	0.3000	0.3000	0.3000	0.3000	0.3000	0.3000	0.3000
3	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000
4	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000
5	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000
6	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000
7	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000
8	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000

Natural Mortality (per year)

AGE	1977	1978	1979	1980	1981	1982	1983	1984
1	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
2	0.3000	0.3000	0.3000	0.3000	0.3000	0.3000	0.3000	0.3000
3	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000
4	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000
5	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000
6	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000
7	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000
8	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000

Table 7.5.5 Irish Sea herring VIIa(N). Natural mortality. Continued.

Natural Mortality (per year)

AGE	1985	1986	1987	1988	1989	1990	1991	1992
1	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
2	0.3000	0.3000	0.3000	0.3000	0.3000	0.3000	0.3000	0.3000
3	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000
4	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000
5	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000
6	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000
7	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000
8	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000

Natural Mortality (per year)

AGE	1993	1994	1995	1996	1997	1998	1999	2000
1	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
2	0.3000	0.3000	0.3000	0.3000	0.3000	0.3000	0.3000	0.3000
3	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000
4	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000
5	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000
6	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000
7	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000
8	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000

Natural Mortality (per year)

AGE	2001	2002	2003	2004	2005	2006
1	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
2	0.3000	0.3000	0.3000	0.3000	0.3000	0.3000
3	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000
4	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000
5	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000
6	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000
7	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000
8	0.1000	0.1000	0.1000	0.1000	0.1000	0.0000

Table 7.5.6 Irish Sea herring VIIa(N). Proportion mature. N.B. In this table "age" refers to number of rings (winter rings in the otolith).

Proportion of fish spawning

AGE	1961	1962	1963	1964	1965	1966	1967	1968
1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0200	0.0000
2	0.2200	0.2400	0.3400	0.5300	0.6100	0.4700	0.3700	0.8800
3	0.6300	0.8300	0.8800	0.8100	0.9000	0.9100	0.7500	0.9400
4	1.0000	0.9200	0.8900	1.0000	1.0000	1.0000	0.8300	0.9400
5	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
6	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
7	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
8	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

Table 7.5.6 Irish Sea herring VIIa(N). Proportion mature. Continued.

Proportion of fish spawning

AGE	1969	1970	1971	1972	1973	1974	1975	1976
1	0.0000	0.0200	0.1500	0.1100	0.1200	0.3600	0.4000	0.0700
2	0.7100	0.9200	0.8700	0.8800	0.7700	0.9900	0.9900	0.9600
3	0.9200	0.9400	0.9700	0.9000	0.8900	0.9600	1.0000	0.9800
4	0.9400	0.9600	0.9800	1.0000	0.9700	1.0000	0.9400	1.0000
5	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
6	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
7	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
8	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

Proportion of fish spawning

AGE	1977	1978	1979	1980	1981	1982	1983	1984
1	0.0300	0.0400	0.0000	0.2000	0.1900	0.1000	0.0200	0.0000
2	0.9200	0.8100	0.8400	0.8800	0.8900	0.8000	0.7300	0.6900
3	0.9600	0.8800	0.8100	0.9500	0.9000	0.8900	0.8800	0.8300
4	1.0000	0.9100	0.7800	0.9500	0.9400	0.9100	0.9000	0.9300
5	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
6	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
7	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
8	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

Proportion of fish spawning

AGE	1985	1986	1987	1988	1989	1990	1991	1992
1	0.1400	0.3100	0.0000	0.0000	0.0700	0.0600	0.0400	0.2800
2	0.6200	0.7300	0.8500	0.9000	0.6300	0.6600	0.3000	0.4800
3	0.7100	0.6600	0.9100	0.9600	0.9300	0.9000	0.7400	0.7200
4	0.8800	0.8100	0.8700	0.9900	0.9500	0.9500	0.8200	0.8100
5	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
6	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
7	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
8	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

Proportion of fish spawning

AGE	1993	1994	1995	1996	1997	1998	1999	2000
1	0.0000	0.1900	0.1000	0.0200	0.0400	0.3000	0.0200	0.1400
2	0.4600	0.6800	0.8600	0.6000	0.8200	0.8300	0.8400	0.7900
3	0.9900	0.9900	0.9400	0.9600	0.9500	0.9700	0.9500	0.9900
4	1.0000	0.9700	0.9900	0.8300	1.0000	0.9900	0.9700	1.0000
5	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
6	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
7	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
8	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

Proportion of fish spawning

AGE	2001	2002	2003	2004	2005	2006
1	0.1500	0.0200	0.1100	0.1140	0.2000	0.1900
2	0.5400	0.9200	0.7600	1.0000	0.9700	0.8900
3	0.8800	0.9500	0.9500	0.9700	0.9900	1.0000
4	0.9700	0.9800	0.9700	1.0000	1.0000	1.0000
5	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
6	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
7	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
8	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

Table 7.5.7 Irish Sea herring VIIa(N). Indices of spawning biomass.

INDICES OF SPAWNING BIOMASS

NINEL

	1989	1990	1991	1992	1993	1994	1995	1996
1	999990.	999990.	999990.	999990.	38300.	71200.	15100.	4700.

x 10 ^ -3

NINEL

	1997	1998	1999	2000	2001	2002	2003	2004
1	29100.	5800.	16700.	35500.	55300.	31500.	15800.	22700.

x 10 ^ -3

NINEL

	2005	2006
1	26400.	43000.

x 10 ^ -3

Table 7.5.8 Irish Sea herring VIIa(N). Tuning indices. N.B. In this table "age" refers to number of rings (winter rings in the otolith).

AGE-STRUCTURED INDICES

FLT01: Northern Ireland acoustic surveys

AGE	1994	1995	1996	1997	1998	1999	2000	2001
1	66.83	319.12	11.34	134.15	110.44	157.76	78.52	387.56
2	68.29	82.26	42.37	49.98	27.31	77.72	103.44	93.40
3	73.53	11.94	67.47	14.81	8.08	34.02	105.29	10.19
4	11.86	29.25	8.95	10.98	9.27	5.11	27.54	17.49
5	9.30	4.57	26.47	1.75	6.48	10.26	8.07	7.70
6	7.55	3.50	4.17	4.55	1.78	13.52	5.43	1.37
7	3.87	4.89	5.91	0.57	2.25	1.59	4.90	0.63
8	10.12	6.89	5.82	1.91	0.78	6.29	2.36	2.26

x 10 ^ 3

FLT01: Northern Ireland acoustic surveys

AGE	2002	2003	2004	2005	2006
1	390.98	349.22	241.01	94.33	374.73
2	71.94	220.01	115.53	109.94	96.62
3	31.70	31.98	29.59	97.11	15.63
4	24.80	4.74	15.40	17.02	9.98
5	31.28	3.92	2.07	8.03	0.53
6	14.83	4.09	2.30	0.81	0.37
7	2.76	0.98	0.24	0.61	0.48
8	4.46	0.91	0.24	5.80	0.05

x 10 ^ 3

Table 7.5.9 Irish Sea herring VIIa(N). Fishing mortality (per year). N.B. In this table "age" refers to number of rings (winter rings in the otolith).

Fishing Mortality (per year)

AGE	1961	1962	1963	1964	1965	1966	1967	1968
1	0.1170	0.0115	0.0628	0.0111	0.0113	0.0041	0.0205	0.0029
2	0.5188	1.0712	0.8232	0.6476	0.4992	0.5076	0.4399	0.3265
3	0.3229	0.8201	0.6489	1.4069	0.7588	0.6572	0.3835	0.2683
4	0.8148	0.3655	0.8795	0.3925	1.7251	0.3943	0.3898	0.5059
5	0.1902	0.9356	0.9327	0.3402	0.7466	0.9496	0.4476	0.0976
6	0.8888	0.2046	1.2420	0.7661	1.7251	0.9496	0.2848	0.3326
7	0.7432	0.9995	1.2420	0.3925	1.4040	0.9496	0.3898	0.5059
8	0.7432	0.9995	1.2420	0.3925	1.4040	0.9496	0.3898	0.5059

Fishing Mortality (per year)

AGE	1969	1970	1971	1972	1973	1974	1975	1976
1	0.0056	0.0187	0.0394	0.1669	0.1045	0.2144	0.1529	0.2308
2	0.2773	0.3048	0.5838	0.3633	0.3459	0.8267	0.7550	0.7979
3	0.3273	0.3904	0.6319	0.5330	0.6187	1.0229	0.9122	0.9851
4	0.4120	0.5778	0.6659	0.5543	0.4324	1.0212	0.8453	1.1184
5	0.2694	0.8175	0.3103	0.6714	0.5617	0.8039	0.9959	0.9671
6	0.4555	0.6013	0.5015	0.7639	0.4952	0.9135	0.7750	1.1177
7	0.4713	0.7059	0.7482	0.7727	0.6654	1.2552	1.1702	1.3485
8	0.4713	0.7059	0.7482	0.7727	0.6654	1.2552	1.1702	1.3485

Fishing Mortality (per year)

AGE	1977	1978	1979	1980	1981	1982	1983	1984
1	0.1601	0.1055	0.1480	0.0665	0.0415	0.0384	0.0096	0.0152
2	0.8649	0.5468	0.7747	1.1511	0.4579	0.3100	0.2051	0.1321
3	1.0124	0.9445	0.9027	1.4452	0.4350	0.3147	0.1792	0.1919
4	1.0189	0.9528	0.8774	0.9753	0.7950	0.5569	0.2416	0.1707
5	1.1271	0.7043	0.8481	1.2766	0.6813	0.1738	0.1875	0.2716
6	0.8553	1.1506	1.1379	0.9413	0.6508	0.7351	0.3671	0.2164
7	1.3292	1.1523	1.2450	1.6120	0.8013	0.5627	0.3238	0.2641
8	1.3292	1.1523	1.2450	1.6120	0.8013	0.5627	0.3238	0.2641

Fishing Mortality (per year)

AGE	1985	1986	1987	1988	1989	1990	1991	1992
1	0.0277	0.0443	0.0140	0.0408	0.0130	0.0341	0.0499	0.1050
2	0.3012	0.4276	0.3003	0.3088	0.2259	0.3392	0.3421	0.4279
3	0.4657	0.4095	0.3255	0.6198	0.3070	0.3459	0.3200	0.4513
4	0.5999	0.4182	0.2712	0.7358	0.4380	0.4115	0.2727	0.5718
5	0.4860	0.3713	0.3295	0.7496	0.3795	0.6228	0.3484	0.5067
6	0.5289	0.3670	0.3634	0.7398	0.4106	0.5993	0.5053	0.6244
7	0.6296	0.5540	0.4409	0.8247	0.4654	0.6255	0.4992	0.7000
8	0.6296	0.5540	0.4409	0.8247	0.4654	0.6255	0.4992	0.7000

Fishing Mortality (per year)

AGE	1993	1994	1995	1996	1997	1998	1999	2000
1	0.0167	0.0161	0.0408	0.0776	0.1301	0.0251	0.0514	0.0326
2	0.3086	0.4469	0.4254	0.5943	0.9984	0.4211	0.3246	0.2438
3	0.3589	0.4886	0.4346	0.3761	0.6028	0.5207	0.4124	0.1888
4	0.3541	0.3650	0.3842	0.2456	0.5114	0.8395	0.3900	0.2327
5	0.4625	0.5089	0.3851	0.4367	0.5692	1.1013	0.6600	0.2084
6	0.4460	0.6355	0.4006	0.4120	0.4828	0.7575	1.0832	0.2790
7	0.5250	0.6800	0.5660	0.6027	0.9269	0.9513	0.7757	0.3205
8	0.5250	0.6800	0.5660	0.6027	0.9269	0.9513	0.7757	0.3205

Table 7.5.9 Irish Sea herring VIIa(N). Fishing mortality (per year). Continued.

Fishing Mortality (per year)

AGE	2001	2002	2003	2004	2005	2006
1	0.0265	0.0155	0.0233	0.0154	0.0232	0.0299
2	0.5424	0.3165	0.4761	0.3157	0.4737	0.6102
3	0.7468	0.4358	0.6556	0.4347	0.6523	0.8402
4	1.0462	0.6105	0.9184	0.6089	0.9137	1.1771
5	0.8609	0.5024	0.7557	0.5011	0.7519	0.9686
6	0.7643	0.4460	0.6709	0.4448	0.6675	0.8599
7	1.0462	0.6105	0.9184	0.6089	0.9137	1.1771
8	1.0462	0.6105	0.9184	0.6089	0.9137	1.1771

Table 7.5.10 Irish Sea herring VIIa(N). Population abundance (1 January, millions). N.B. In this table "age" refers to number of rings (winter rings in the otolith).

Population Abundance (1 January)

AGE	1961	1962	1963	1964	1965	1966	1967	1968
1	64.45	52.49	125.15	216.52	118.79	359.36	345.12	553.89
2	32.38	21.09	19.09	43.24	78.78	43.21	131.65	124.38
3	10.45	14.28	5.35	6.21	16.76	35.43	19.27	62.82
4	23.28	6.20	5.15	2.29	1.24	6.43	15.03	10.75
5	1.45	9.32	3.89	1.93	1.40	0.20	3.92	9.21
6	0.85	1.08	3.31	1.39	1.24	0.60	0.07	2.27
7	2.38	0.32	0.80	0.86	0.58	0.20	0.21	0.05
8	4.28	1.10	0.91	0.57	0.97	0.35	0.19	0.25

x 10 ^ 6

Population Abundance (1 January)

AGE	1969	1970	1971	1972	1973	1974	1975	1976
1	372.62	478.15	496.82	412.67	666.58	348.35	367.27	261.67
2	203.17	136.31	172.64	175.71	128.48	220.90	103.41	115.95
3	66.47	114.06	74.45	71.34	90.52	67.35	71.59	36.01
4	39.33	39.23	63.21	32.40	34.27	39.92	19.83	23.54
5	5.87	23.57	19.92	29.38	16.84	20.13	13.01	7.70
6	7.56	4.05	9.42	13.22	13.59	8.69	8.15	4.35
7	1.47	4.34	2.01	5.16	5.57	7.49	3.15	3.40
8	0.16	2.17	2.01	3.24	5.59	2.37	2.48	1.78

x 10 ^ 6

Population Abundance (1 January)

AGE	1977	1978	1979	1980	1981	1982	1983	1984
1	319.58	243.50	133.68	142.89	195.72	213.34	215.55	122.54
2	76.42	100.17	80.61	42.41	49.19	69.07	75.53	78.54
3	38.68	23.84	42.95	27.52	9.94	23.05	37.53	45.58
4	11.01	11.51	7.59	14.26	5.31	5.27	13.78	25.69
5	6.96	3.60	4.02	2.86	4.86	2.17	2.73	9.79
6	2.65	2.04	1.61	1.56	0.72	2.23	1.65	2.05
7	1.29	1.02	0.58	0.47	0.55	0.34	0.97	1.03
8	1.58	0.53	0.42	0.30	0.45	0.92	0.22	2.16

Table 7.5.10 Irish Sea herring VIIa(N). Population abundance (1 January, millions). Continued.

Population Abundance (1 January)

AGE	1985	1986	1987	1988	1989	1990	1991	1992
1	140.44	163.37	253.28	102.90	141.03	108.69	64.73	191.15
2	44.40	50.26	57.50	91.88	36.34	51.21	38.64	22.65
3	50.98	24.34	24.28	31.55	49.99	21.48	27.02	20.33
4	30.80	26.20	13.23	14.36	13.90	30.11	12.44	16.07
5	19.59	15.30	15.61	9.13	6.22	8.11	18.05	8.57
6	6.75	10.91	9.55	10.16	3.90	3.85	3.94	11.53
7	1.49	3.60	6.84	6.01	4.39	2.34	1.91	2.15
8	1.62	2.16	4.91	7.83	5.50	3.63	2.17	0.81

x 10 ^ 6

Population Abundance (1 January)

AGE	1993	1994	1995	1996	1997	1998	1999	2000
1	61.48	194.79	126.35	112.38	122.56	195.48	56.96	60.15
2	63.31	22.24	70.51	44.62	38.26	39.59	70.13	19.90
3	10.94	34.45	10.54	34.14	18.25	10.44	19.25	37.55
4	10.60	6.26	17.30	5.59	19.19	8.18	5.08	10.43
5	8.21	6.73	3.93	10.66	3.95	10.41	3.19	3.11
6	4.67	4.68	3.66	2.42	6.23	2.03	3.13	1.49
7	5.59	2.71	2.24	2.22	1.45	3.48	0.86	0.96
8	2.17	4.22	3.51	3.15	2.47	0.77	1.20	0.56

x 10 ^ 6

Population Abundance (1 January)

AGE	2001	2002	2003	2004	2005	2006	2007
1	72.71	67.15	122.33	116.51	134.03	936.17	131.70
2	21.42	26.05	24.32	43.97	42.20	48.18	334.26
3	11.56	9.23	14.06	11.19	23.75	19.47	19.39
4	25.46	4.48	4.88	5.98	5.93	10.13	6.88
5	7.48	8.09	2.20	1.76	2.94	2.15	2.82
6	2.29	2.86	4.43	0.94	0.97	1.25	0.74
7	1.02	0.96	1.66	2.05	0.54	0.45	0.48
8	1.29	0.77	1.05	0.29	0.64	0.36	0.23

x 10 ^ 6

Table 7.5.11 Irish Sea herring VIIa(N). Weighting factors in number. N.B. In this table "age" refers to number of rings (winter rings in the otolith).

Weighting factors for the catches in number

AGE	2001	2002	2003	2004	2005	2006
1	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000
2	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
3	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
4	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
5	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
6	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
7	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

Table 7.5.12 Irish Sea herring VIIa(N). Predicted SSB Index values. N.B. In this table "age" refers to number of rings (winter rings in the otolith).

NINEL

	1989	1990	1991	1992	1993	1994	1995	1996
1	999990.	999990.	999990.	999990.	26079.	29563.	32874.	26987.

x 10 ^ -3

NINEL

	1997	1998	1999	2000	2001	2002	2003	2004
1	22487.	25459.	26884.	29206.	14550.	15840.	13501.	20443.

x 10 ^ -3

NINEL

	2005	2006
1	20277.	34521.

x 10 ^ -3

Table 7.5.13 Irish Sea herring VIIa(N). Predicted age-structured Index values. N.B. In this table "age" refers to number of rings (winter rings in the otolith).

Predicted Age-Structured Index Values

FLT01: Northern Ireland acoustic survey Predicted

AGE	1994	1995	1996	1997	1998	1999	2000	2001
1	236.7	150.7	130.4	136.7	236.0	67.4	72.2	87.7
2	49.7	160.3	89.4	56.6	90.3	171.9	51.8	44.6
3	59.6	19.0	64.2	29.0	17.6	35.2	81.3	16.5
4	11.7	31.8	11.4	32.0	10.7	9.3	21.5	28.5
5	10.0	6.4	16.7	5.6	9.9	4.2	5.8	8.5
6	6.2	5.7	3.8	9.2	2.4	2.9	2.6	2.7
7	3.2	2.8	2.7	1.4	3.3	0.9	1.5	0.9
8	7.8	7.1	6.2	3.8	1.2	2.1	1.4	1.8

x 10 ^ 3

FLT01: Northern Ireland acoustic survey Predicted

AGE	2002	2003	2004	2005	2006
1	81.6	147.9	141.7	162.0	1126.0
2	64.2	53.2	108.5	92.5	95.3
3	16.6	21.5	20.2	36.3	25.9
4	6.9	6.0	9.3	7.3	10.3
5	12.1	2.7	2.6	3.6	2.3
6	4.3	5.7	1.4	1.2	1.4
7	1.2	1.6	2.5	0.5	0.4
8	1.5	1.6	0.6	1.0	0.5

x 10 ^ 3

Table 7.5.14 Irish Sea herring VIIa(N). Fitted selection pattern. N.B. In this table "age" refers to number of rings (winter rings in the otolith).

Fitted Selection Pattern

AGE	1961	1962	1963	1964	1965	1966	1967	1968
1	0.1436	0.0316	0.0714	0.0282	0.0066	0.0105	0.0527	0.0058
2	0.6367	2.9310	0.9360	1.6499	0.2894	1.2874	1.1284	0.6454
3	0.3963	2.2437	0.7378	3.5842	0.4399	1.6668	0.9838	0.5303
4	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
5	0.2334	2.5598	1.0605	0.8666	0.4328	2.4084	1.1483	0.1930
6	1.0908	0.5597	1.4122	1.9518	1.0000	2.4084	0.7305	0.6574
7	0.9121	2.7348	1.4122	1.0000	0.8138	2.4084	1.0000	1.0000
8	0.9121	2.7348	1.4122	1.0000	0.8138	2.4084	1.0000	1.0000

Fitted Selection Pattern

AGE	1969	1970	1971	1972	1973	1974	1975	1976
1	0.0136	0.0323	0.0591	0.3011	0.2416	0.2100	0.1809	0.2064
2	0.6730	0.5275	0.8767	0.6554	0.8000	0.8095	0.8932	0.7134
3	0.7944	0.6756	0.9490	0.9617	1.4310	1.0016	1.0791	0.8808
4	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
5	0.6539	1.4147	0.4660	1.2113	1.2991	0.7872	1.1781	0.8647
6	1.1057	1.0406	0.7531	1.3782	1.1453	0.8945	0.9169	0.9994
7	1.1439	1.2215	1.1236	1.3941	1.5389	1.2291	1.3843	1.2058
8	1.1439	1.2215	1.1236	1.3941	1.5389	1.2291	1.3843	1.2058

Fitted Selection Pattern

AGE	1977	1978	1979	1980	1981	1982	1983	1984
1	0.1571	0.1107	0.1687	0.0681	0.0522	0.0690	0.0398	0.0889
2	0.8489	0.5739	0.8829	1.1802	0.5759	0.5566	0.8489	0.7739
3	0.9936	0.9912	1.0288	1.4818	0.5471	0.5650	0.7418	1.1245
4	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
5	1.1062	0.7391	0.9665	1.3089	0.8569	0.3122	0.7762	1.5911
6	0.8394	1.2075	1.2969	0.9652	0.8186	1.3199	1.5194	1.2681
7	1.3046	1.2094	1.4189	1.6529	1.0079	1.0103	1.3400	1.5475
8	1.3046	1.2094	1.4189	1.6529	1.0079	1.0103	1.3400	1.5475

Fitted Selection Pattern

AGE	1985	1986	1987	1988	1989	1990	1991	1992
1	0.0461	0.1059	0.0515	0.0554	0.0298	0.0830	0.1829	0.1836
2	0.5020	1.0225	1.1071	0.4196	0.5157	0.8244	1.2542	0.7483
3	0.7763	0.9792	1.1999	0.8423	0.7009	0.8408	1.1732	0.7893
4	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
5	0.8101	0.8878	1.2148	1.0187	0.8663	1.5137	1.2773	0.8861
6	0.8817	0.8777	1.3400	1.0055	0.9373	1.4564	1.8527	1.0920
7	1.0495	1.3249	1.6254	1.1208	1.0625	1.5203	1.8303	1.2242
8	1.0495	1.3249	1.6254	1.1208	1.0625	1.5203	1.8303	1.2242

Fitted Selection Pattern

AGE	1993	1994	1995	1996	1997	1998	1999	2000
1	0.0473	0.0441	0.1062	0.3158	0.2544	0.0299	0.1317	0.1399
2	0.8716	1.2244	1.1072	2.4201	1.9525	0.5017	0.8322	1.0478
3	1.0137	1.3386	1.1313	1.5317	1.1789	0.6203	1.0574	0.8113
4	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
5	1.3062	1.3943	1.0024	1.7781	1.1131	1.3119	1.6922	0.8957
6	1.2597	1.7412	1.0427	1.6776	0.9441	0.9023	2.7774	1.1992
7	1.4826	1.8630	1.4733	2.4543	1.8126	1.1332	1.9890	1.3776
8	1.4826	1.8630	1.4733	2.4543	1.8126	1.1332	1.9890	1.3776

Table 7.5.14 Irish Sea herring VIIa(N). Fitted selection pattern. Continued.

Fitted Selection Pattern

AGE	2001	2002	2003	2004	2005	2006
1	0.0254	0.0254	0.0254	0.0254	0.0254	0.0254
2	0.5184	0.5184	0.5184	0.5184	0.5184	0.5184
3	0.7138	0.7138	0.7138	0.7138	0.7138	0.7138
4	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
5	0.8229	0.8229	0.8229	0.8229	0.8229	0.8229
6	0.7305	0.7305	0.7305	0.7305	0.7305	0.7305
7	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
8	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

Table 7.5.15 Irish Sea herring VIIa(N). Stock summary. N.B. In this table "age" refers to number of rings (winter rings in the otolith).

STOCK SUMMARY

Year	Recruits Age 1 thousands	Total Biomass tonnes	Spawning Biomass tonnes	Landings tonnes	Yield /SSB ratio	Mean F Ages 2- 6	SoP (%)
1961	64450	17929	4380	5710	1.3036	0.5471	99
1962	52490	11871	2665	4343	1.6296	0.6794	100
1963	125140	15051	1866	3947	2.1144	0.9053	100
1964	216510	24764	2326	3593	1.5441	0.7107	99
1965	118790	22304	4737	5923	1.2502	1.0910	99
1966	359350	47404	5324	5666	1.0642	0.6917	99
1967	345110	59163	8025	8721	1.0866	0.3891	99
1968	553880	87182	21555	8660	0.4018	0.3062	100
1969	372610	84996	29670	14141	0.4766	0.3483	99
1970	478140	111218	34796	20622	0.5926	0.5384	100
1971	496820	116486	33362	26807	0.8035	0.5387	100
1972	412670	91145	31869	27350	0.8582	0.5772	112
1973	666570	104707	29577	22600	0.7641	0.4908	100
1974	348340	91334	27801	38640	1.3899	0.9176	99
1975	367270	68075	20527	24500	1.1935	0.8567	102
1976	261660	53764	12870	21250	1.6510	0.9972	99
1977	319580	48500	8731	15410	1.7649	0.9757	95
1978	243490	42472	9571	11080	1.1577	0.8598	92
1979	133680	34029	7929	12338	1.5560	0.9082	92
1980	142890	26893	5313	10613	1.9972	1.1579	97
1981	195720	26786	7132	4377	0.6136	0.6040	90
1982	213340	33549	9938	4855	0.4885	0.4181	98
1983	215540	39351	13556	3933	0.2901	0.2361	98
1984	122530	37958	17192	4066	0.2365	0.1966	96
1985	140440	37619	12404	9187	0.7406	0.4763	102
1986	163360	34479	13195	7440	0.5638	0.3987	97
1987	253280	36011	12665	5823	0.4597	0.3180	103
1988	102900	32828	12844	10172	0.7919	0.6308	105
1989	141030	30246	10947	4949	0.4520	0.3522	100
1990	108680	27605	9996	6312	0.6314	0.4637	101
1991	64720	20250	7253	4398	0.6063	0.3577	100
1992	191140	23240	6401	5270	0.8233	0.5164	101
1993	61470	20883	6883	4409	0.6405	0.3860	101
1994	194780	26974	7803	4828	0.6187	0.4890	102
1995	126350	24586	8677	5076	0.5850	0.4060	99
1996	112370	22087	7123	5301	0.7442	0.4129	100
1997	122560	20888	5935	6651	1.1205	0.6329	100
1998	195470	25104	6720	4905	0.7299	0.7280	100
1999	56950	17592	7096	4127	0.5816	0.5740	99
2000	60150	14764	7709	2002	0.2597	0.2305	100
2001	72710	14761	3840	5461	1.4219	0.7921	99
2002	67150	13062	4181	2393	0.5723	0.4622	100
2003	122330	17071	3563	2399	0.6732	0.6953	99
2004	116500	16345	5396	2531	0.4690	0.4610	100
2005	134030	18382	5352	4387	0.8197	0.6918	99
2006	936160	69769	9112	4402	0.4831	0.8912	99

No of years for separable analysis : 6
Age range in the analysis : 1 . . . 8
Year range in the analysis : 1961 . . . 2006
Number of indices of SSB : 1
Number of age-structured indices : 1

Parameters to estimate : 32
Number of observations : 160

Conventional single selection vector model to be fitted.

Table 7.5.16 Irish Sea herring VIIa(N). Parameter estimates. N.B. In this table "age" refers to number of rings (winter rings in the otolith).

PARAMETER ESTIMATES

Parm. No.		Maximum Likelh. Estimate	CV (%)	Lower 95% CL	Upper 95% CL	-s.e.	+s.e.	Mean of Param. Distrib.
Separable model : F by year								
1	2001	1.0462	17	0.7396	1.4800	0.8765	1.2488	1.0627
2	2002	0.6105	19	0.4184	0.8907	0.5035	0.7402	0.6219
3	2003	0.9184	17	0.6461	1.3054	0.7676	1.0989	0.9333
4	2004	0.6089	20	0.4109	0.9024	0.4982	0.7443	0.6213
5	2005	0.9137	20	0.6084	1.3724	0.7425	1.1245	0.9336
6	2006	1.1771	30	0.6420	2.1583	0.8639	1.6038	1.2348
Separable Model: Selection (S) by age								
7	1	0.0254	53	0.0090	0.0719	0.0149	0.0432	0.0292
8	2	0.5184	21	0.3393	0.7921	0.4176	0.6436	0.5307
9	3	0.7138	20	0.4732	1.0768	0.5788	0.8804	0.7297
	4	1.0000	Fixed : Reference Age					
10	5	0.8229	18	0.5686	1.1909	0.6814	0.9937	0.8376
11	6	0.7305	18	0.5047	1.0574	0.6049	0.8822	0.7436
	7	1.0000	Fixed : Last true age					
Separable model: Populations in year 2006								
12	1	936165	62	272694	3213882	498939	1756537	1141166
13	2	48176	38	22575	102810	32724	70923	51917
14	3	19468	28	11063	34258	14591	25974	20294
15	4	10129	25	6132	16730	7841	13084	10466
16	5	2152	26	1275	3631	1647	2810	2230
17	6	1253	26	746	2107	962	1634	1298
18	7	447	27	262	763	341	587	464
Separable model: Populations at age								
19	2001	1021	37	487	2140	700	1490	1097
20	2002	962	30	529	1749	709	1305	1007
21	2003	1656	25	996	2755	1277	2147	1713
22	2004	2048	26	1228	3414	1578	2658	2119
23	2005	541	24	335	876	424	692	558
SSB Index catchabilities								
NINEL								
Linear model fitted. Slopes at age :								
24	1 Q	.3788E-02	11	.3399E-02	.5291E-02	.3788E-02	.4748E-02	.4268E-02
Age-structured index catchabilities								
FLT01: Northern Ireland acoustic survey								
Linear model fitted. Slopes at age :								
25	1 Q	2.604	96	1.030	45.49	2.604	17.99	10.92
26	2 Q	3.916	31	2.905	9.836	3.916	7.296	5.610
27	3 Q	2.898	31	2.151	7.267	2.898	5.393	4.149
28	4 Q	2.641	31	1.958	6.636	2.641	4.922	3.784
29	5 Q	2.342	31	1.734	5.911	2.342	4.378	3.362
30	6 Q	2.284	31	1.686	5.824	2.284	4.299	3.294
31	7 Q	2.090	32	1.531	5.457	2.090	3.997	3.046
32	8 Q	3.322	31	2.450	8.497	3.322	6.266	4.798

Table 7.5.17 Irish Sea herring VIIa(N). Residuals about the model fit. N.B. In this table "age" refers to number of rings (winter rings in the otolith).

RESIDUALS ABOUT THE MODEL FIT

Separable Model Residuals

Age	2001	2002	2003	2004	2005	2006
1	0.810	-1.295	-0.944	1.048	1.497	-1.125
2	0.379	0.383	-0.540	-0.160	0.004	-0.235
3	0.248	-0.452	-0.616	0.406	0.012	-0.215
4	-0.194	-0.049	-0.095	-0.188	-0.036	-0.064
5	-0.201	-0.243	-0.238	-0.064	-0.046	0.034
6	-0.223	-0.031	0.352	-0.410	-0.083	-0.137
7	0.020	0.119	-0.091	-0.284	-0.066	-0.130

SPAWNING BIOMASS INDEX RESIDUALS

NINEL

	1989	1990	1991	1992	1993	1994	1995	1996
1	*******	*******	*******	*******	0.384	0.879	-0.778	-1.748

NINEL

	1997	1998	1999	2000	2001	2002	2003	2004
1	0.258	-1.479	-0.476	0.195	1.335	0.687	0.157	0.105

NINEL

	2005	2006
1	0.264	0.220

AGE-STRUCTURED INDEX RESIDUALS

FLT01: Northern Ireland acoustic survey

Age	1994	1995	1996	1997	1998	1999	2000	2001
1	-1.265	0.750	-2.442	-0.019	-0.759	0.850	0.084	1.486
2	0.317	-0.667	-0.746	-0.124	-1.195	-0.794	0.691	0.739
3	0.211	-0.463	0.049	-0.670	-0.779	-0.035	0.259	-0.479
4	0.017	-0.083	-0.240	-1.070	-0.141	-0.598	0.249	-0.487
5	-0.071	-0.335	0.461	-1.164	-0.424	0.886	0.334	-0.101
6	0.205	-0.496	0.103	-0.703	-0.313	1.524	0.749	-0.688
7	0.205	0.542	0.769	-0.899	-0.383	0.533	1.209	-0.368
8	0.260	-0.027	-0.061	-0.688	-0.394	1.110	0.550	0.221

FLT01: Northern Ireland acoustic survey

Age	2002	2003	2004	2005	2006
1	1.566	0.859	0.531	-0.541	-1.100
2	0.113	1.419	0.063	0.173	0.013
3	0.647	0.400	0.384	0.983	-0.504
4	1.273	-0.238	0.507	0.843	-0.028
5	0.953	0.367	-0.242	0.792	-1.451
6	1.229	-0.328	0.481	-0.428	-1.330
7	0.847	-0.502	-2.358	0.135	0.283
8	1.088	-0.584	-0.862	1.763	-2.363

Table 7.5.18 Irish Sea herring VIIa(N). Residuals about the model fit. N.B. In this table "age" refers to number of rings (winter rings in the otolith).

PARAMETERS OF THE DISTRIBUTION OF ln(CATCHES AT AGE)

Separable model fitted from 2001 to 2006

Variance	0.1604
Skewness test stat.	-1.3362
Kurtosis test statistic	-0.7806
Partial chi-square	0.3876
Significance in fit	0.0000
Degrees of freedom	19

PARAMETERS OF DISTRIBUTIONS OF THE SSB INDICES

DISTRIBUTION STATISTICS FOR NINEL

Linear catchability relationship assumed
Last age is a plus-group

Variance	0.7314
Skewness test stat.	-1.1024
Kurtosis test statistic	-0.0949
Partial chi-square	3.0379
Significance in fit	0.0022
Number of observations	14
Degrees of freedom	13
Weight in the analysis	1.0000

PARAMETERS OF THE DISTRIBUTION OF THE AGE-STRUCTURED INDICES

DISTRIBUTION STATISTICS FOR FLT01: Northern Ireland acoustic survey

Linear catchability relationship assumed

Age	1	2	3	4	5	6	7	8
Var.	0.0173	0.0652	0.0371	0.0472	0.0688	0.0838	0.1083	0.1380
Skewness test stat.	-0.7499	0.2397	0.2030	0.6711	-0.7876	0.6155	-1.7267	-0.6703
Kurtosis test statisti	-0.3934	-0.3673	-0.7772	-0.0180	-0.4037	-0.4711	0.8804	0.2343
Partial chi-square	0.0175	0.0698	0.0441	0.0607	0.0987	0.1272	0.1714	0.2468
Significance in fit	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Number of observations	13	13	13	13	13	13	13	13
Degrees of freedom	12	12	12	12	12	12	12	12
Weight in the analysis	0.0125	0.1250	0.1250	0.1250	0.1250	0.1250	0.1250	0.1250

Table 7.5.19 Irish Sea herring VIIa(N). Analyses of variance. N.B. In this table "age" refers to number of rings (winter rings in the otolith).

ANALYSIS OF VARIANCE

Unweighted Statistics

Variance

	SSQ	Data	Parameters	d.f.	Variance
Total for model	88.8698	160	32	128	0.6943
Catches at age	10.0940	42	23	19	0.5313
SSB Indices					
NINEL	9.5084	14	1	13	0.7314
Aged Indices					
FLT01: Northern Ireland acoustic surve	69.2674	104	8	96	0.7215

Weighted Statistics

Variance

	SSQ	Data	Parameters	d.f.	Variance
Total for model	13.3817	160	32	128	0.1045
Catches at age	3.0481	42	23	19	0.1604
SSB Indices					
NINEL	9.5084	14	1	13	0.7314
Aged Indices					
FLT01: Northern Ireland acoustic surve	0.8252	104	8	96	0.0086

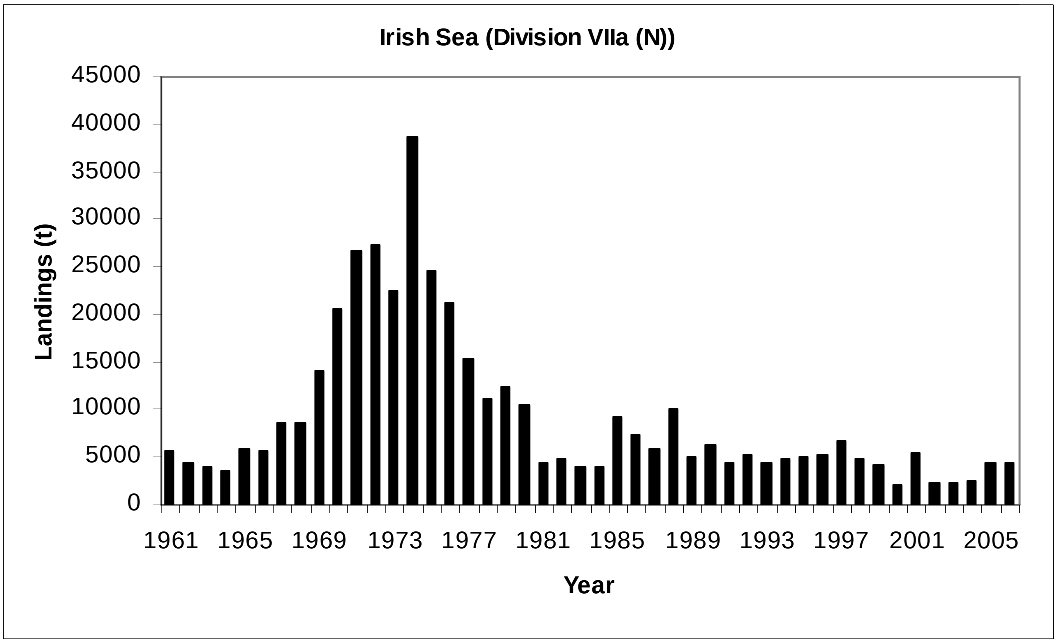


Figure 7.1.1 Irish Sea herring VIIa(N). Landings of herring from VIIa(N) from 1961 to 2006.

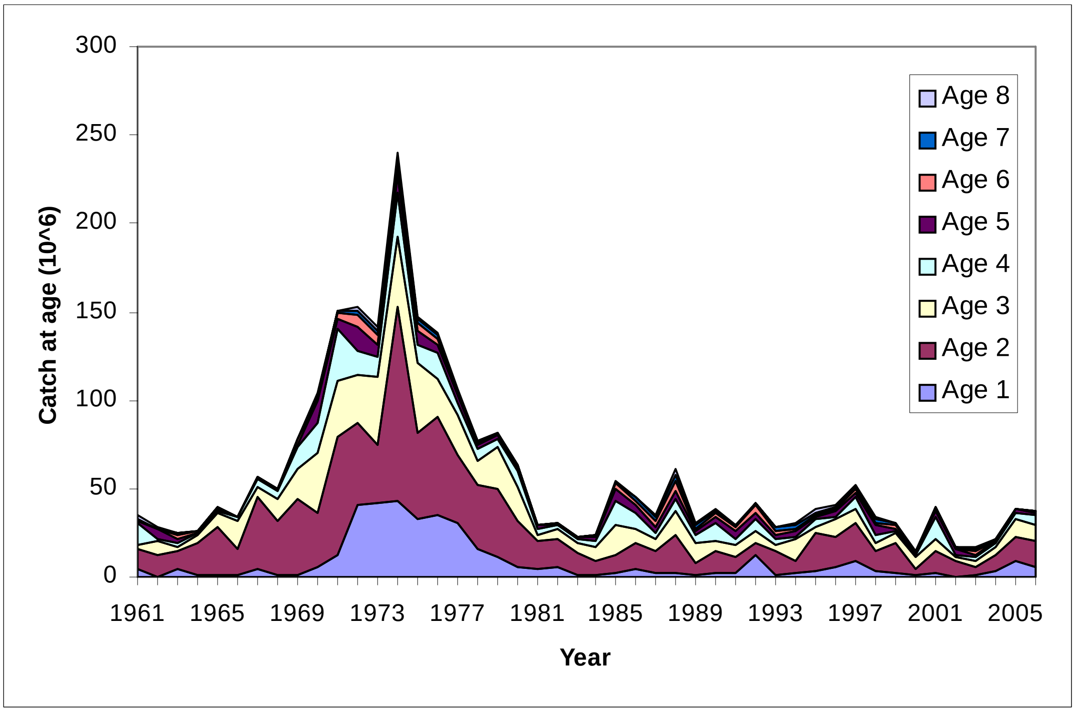


Figure 7.2.1 Irish Sea herring VIIa(N). Landings (catch-at-age) of herring from VIIa(N) from 1961 to 2006.

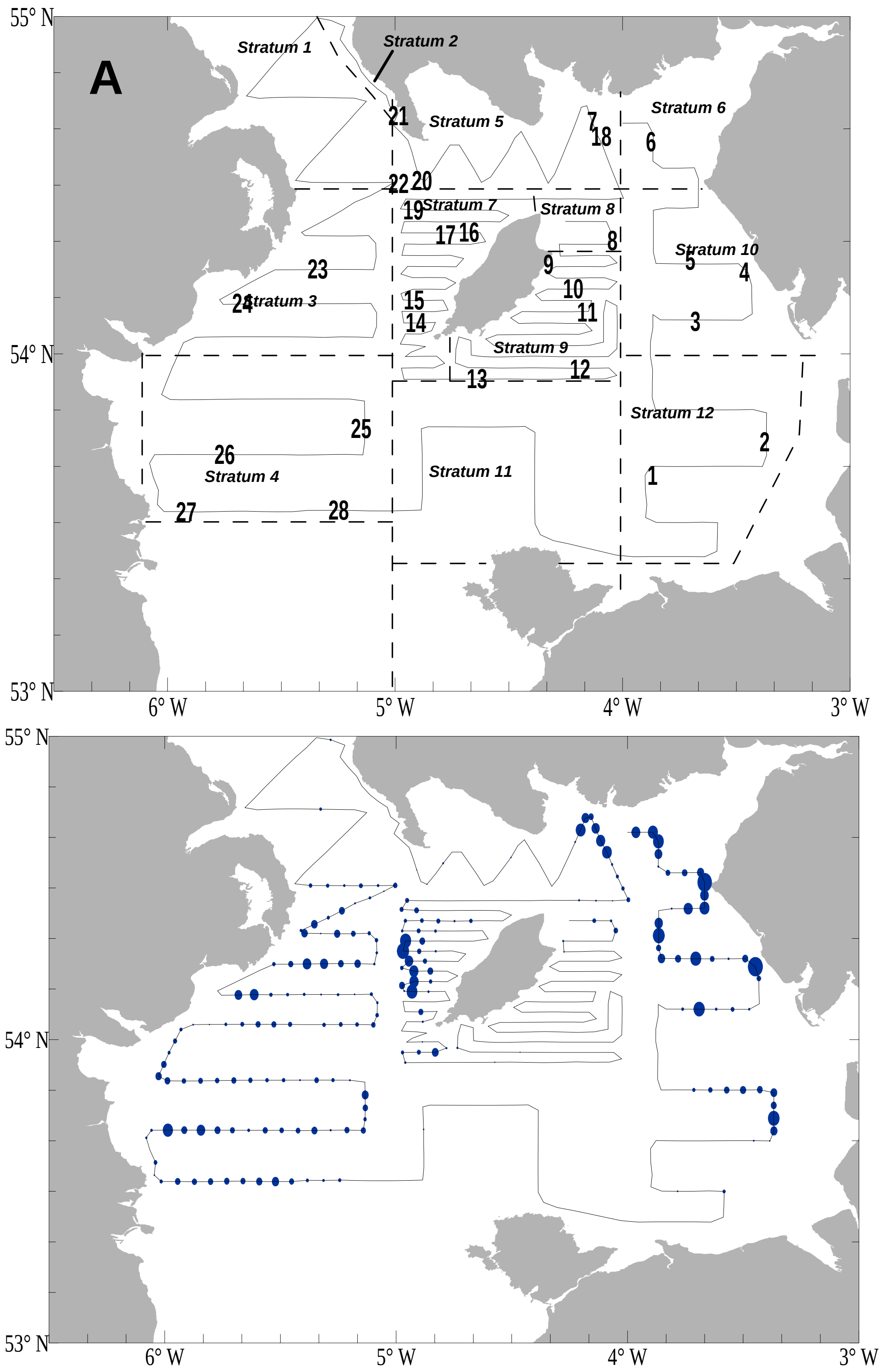


Figure 7.2.2 Irish Sea herring VIIa(N). A) Transects, stratum boundaries and trawl positions for the 2006 acoustic survey; (B) Density distribution of sprats (size of ellipses is proportional to square root of the fish density (t n.mile^{-2}) per 15-minute interval). Maximum density was 330 t n.mile^{-2}.

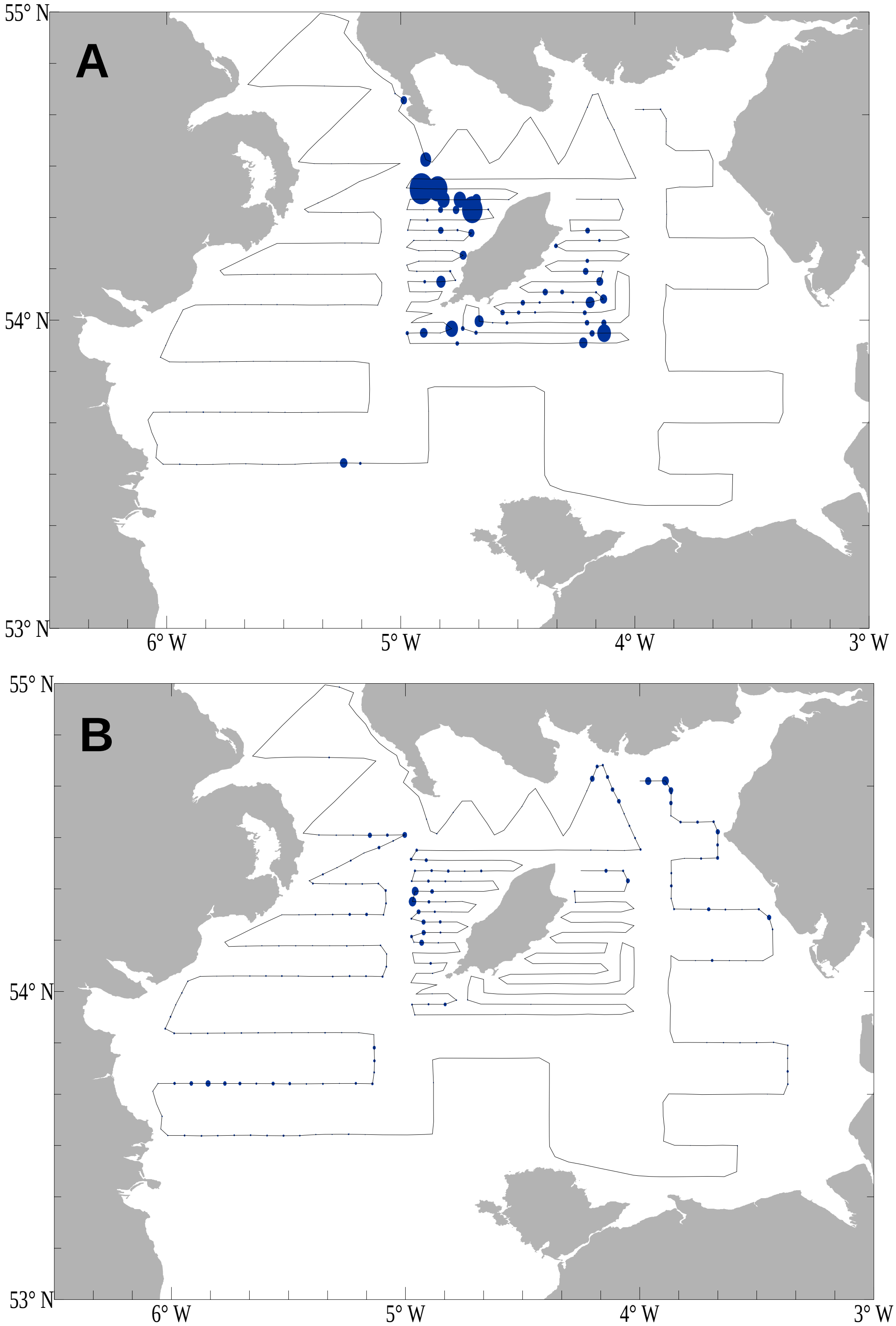


Figure 7.2.3 Irish Sea herring VIIa(N). (A) Density distribution of 1-ring and older herring (size of ellipses is proportional to square root of the fish density (t n.mile^{-2}) per 15-minute interval). Maximum density was 1100 t n.mile^{-2}. (B) Density distribution of 0-ring herring. Maximum density was 100 t n.mile^{-2}. Note: same scaling of ellipse sizes on above figures.

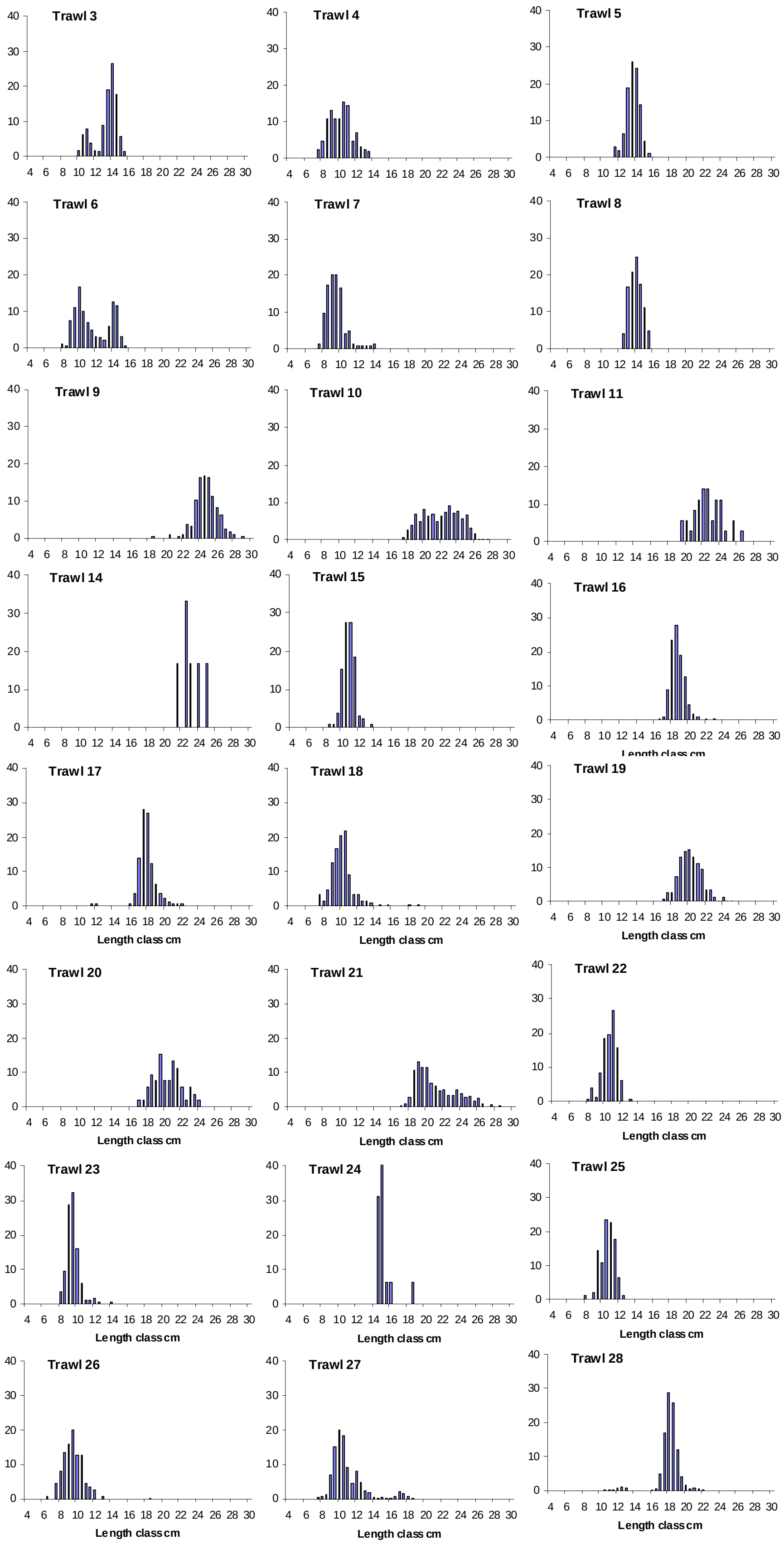


Figure 7.2.4 **Irish Sea herring VIIa(N). Percentage length compositions of herring in each trawl sample in the September 2006 acoustic survey. Trawl 1 and 2 excluded for representation purposes only.**

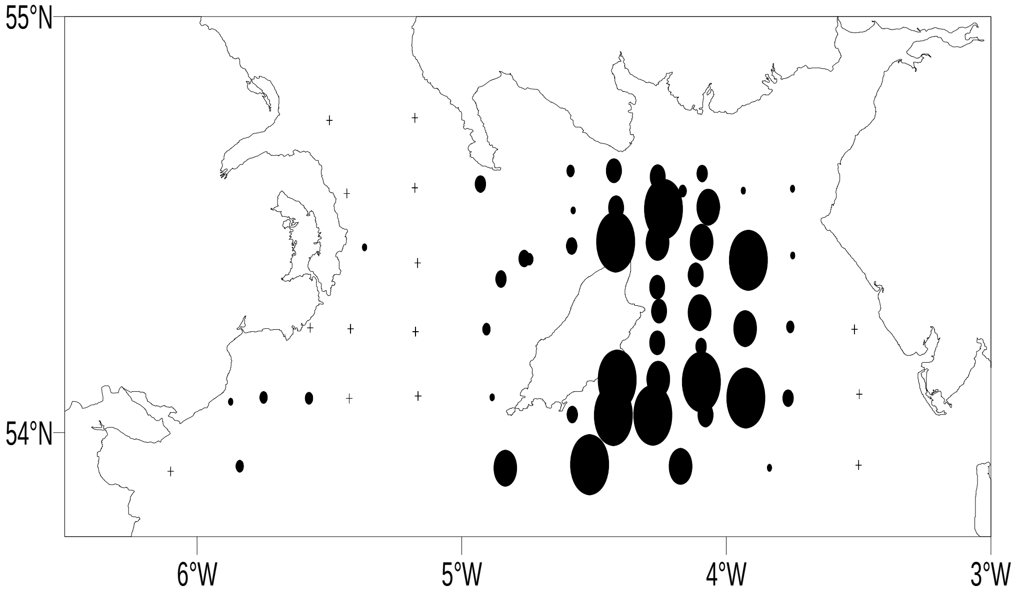


Figure 7.2.5 Irish Sea herring VIIa(N). Estimates of larval herring abundance in the Northern Irish Sea, 6th to 10th November 2006. Areas of the circles are proportional to herring abundance (maximum abundance = 188 per m²).

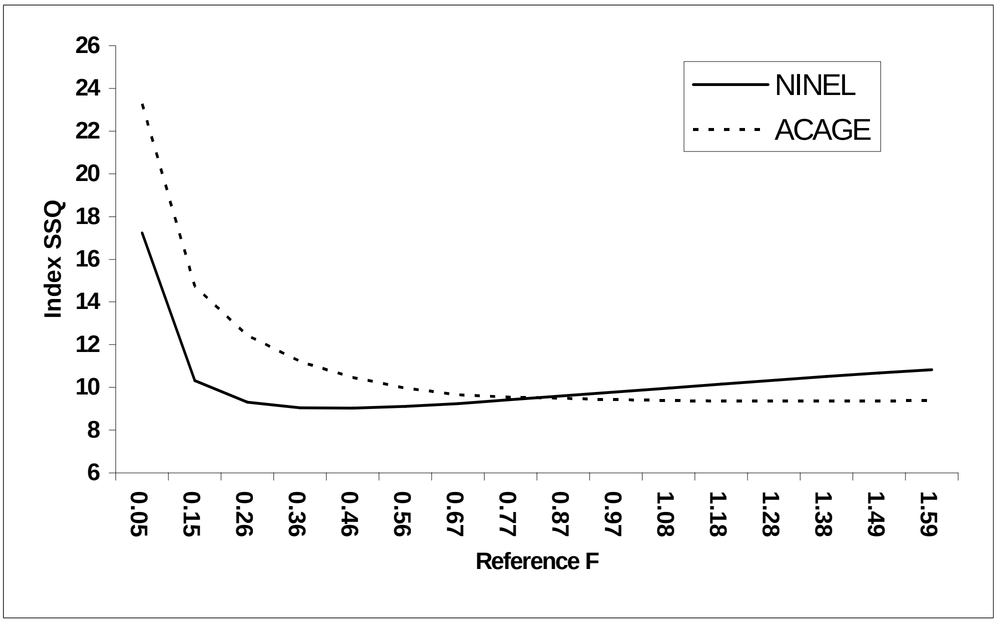


Figure 7.5.1 **Irish Sea herring VIIa(N). SSQ surface for the deterministic calculation of the 6-year separable period.**

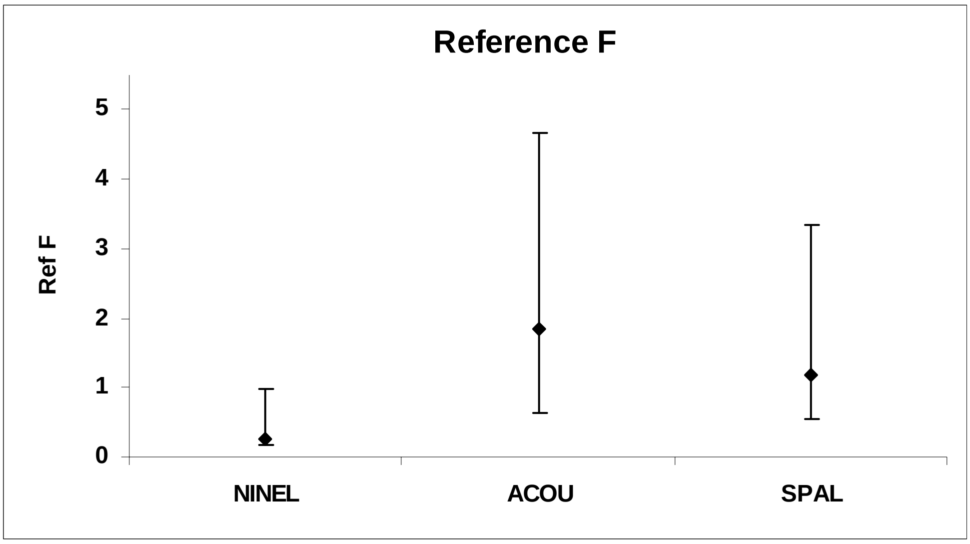


Figure 7.5.2 **Irish Sea herring VIIa(N). Comparison of mean reference $F_{2\text{-}6}$ for NINEL tuning index (NINEL), ACAGE tuning index (ACOU) and SPALY run (SPAL).**

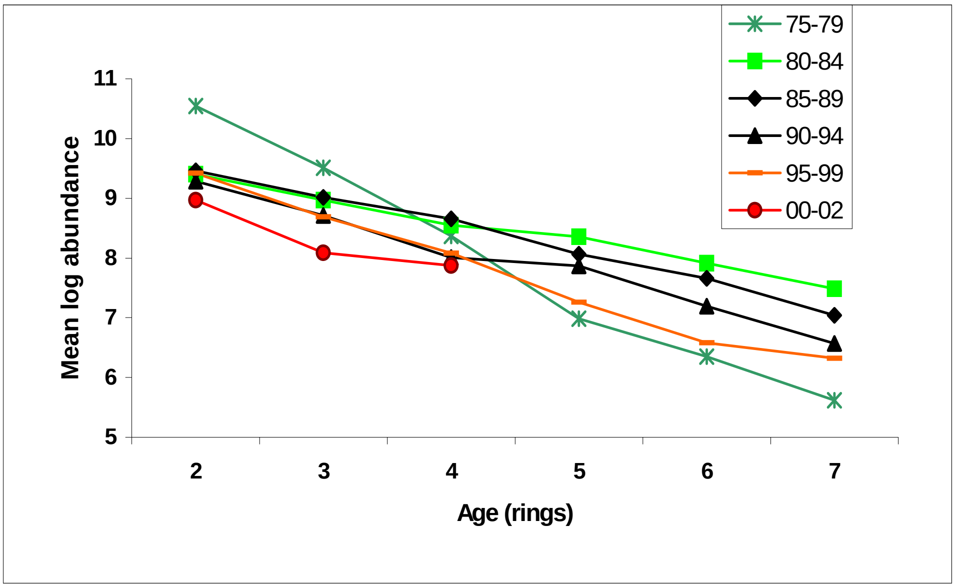


Figure 7.5.3 **Irish Sea herring VIIa(N). Change in mean log abundance of year classes (1975 to 2002) per age class 2 to 7 (rings) for 5 year periods.**

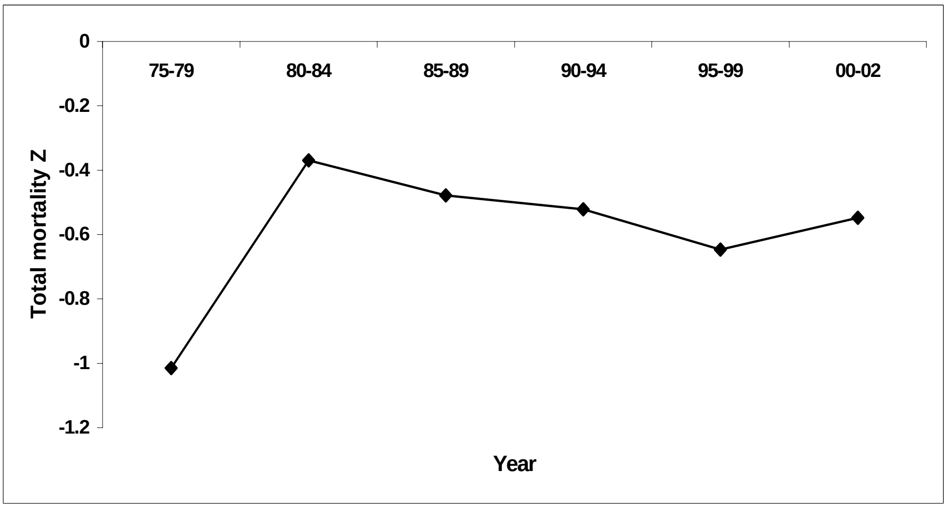


Figure 7.5.4 **Irish Sea herring VIIa(N). Change in mean total mortality (Z) of year classes (1975 to 2002) for age classes (rings) 2 to 7 for 5 year periods.**

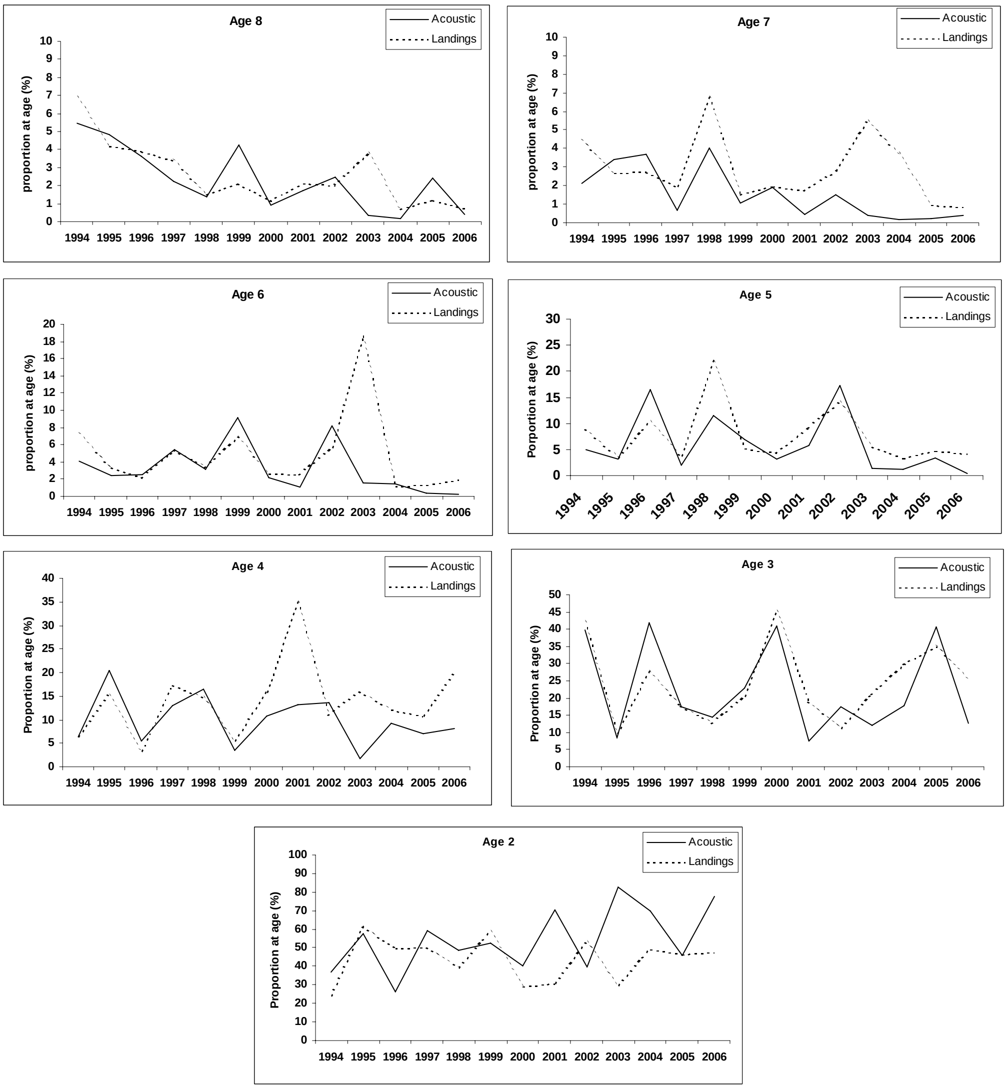


Figure 7.5.5 Irish Sea herring VIIa(N). Inter-annual comparisons of proportion (%) catch at age (rings) between catch and the acoustic survey.

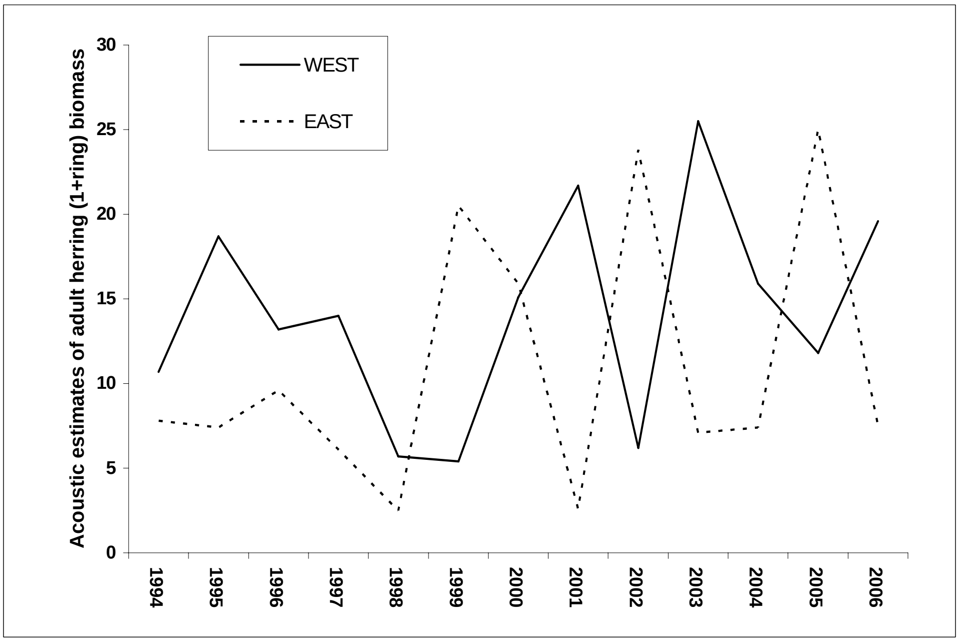


Figure 7.5.6 Irish Sea herring VIIa(N). Time-series of shifts in adult herring (1+ring) biomass distribution between the west and east Isle of Man coasts estimated from acoustic surveys 1994-2006.

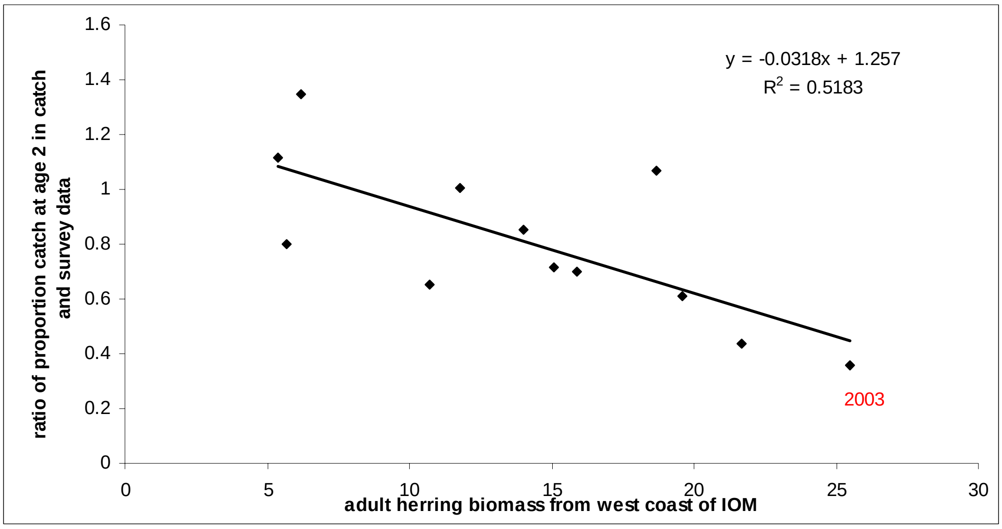


Figure 7.5.7 Irish Sea herring VIIa(N). Relationship between adult biomass distribution and ratio of age 2 proportion catch between acoustic and catch data. Year 2003 highlighted as year with largest discrepancy between catch and acoustic data.

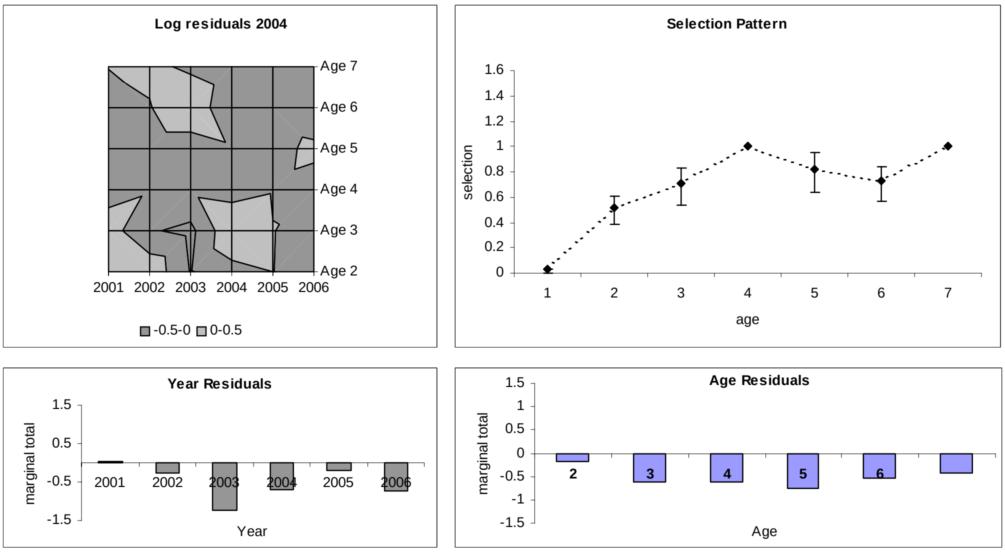


Figure 7.5.8 Irish Sea herring VIIa(N). Illustration of selection patterns diagnostics, from the deterministic calculation (6-year separable period). Top left, a contour plot of selection pattern residuals. Top right, estimated selection (relative to age 4), error bars standard deviation. Bottom, marginal totals of residuals by year and age.

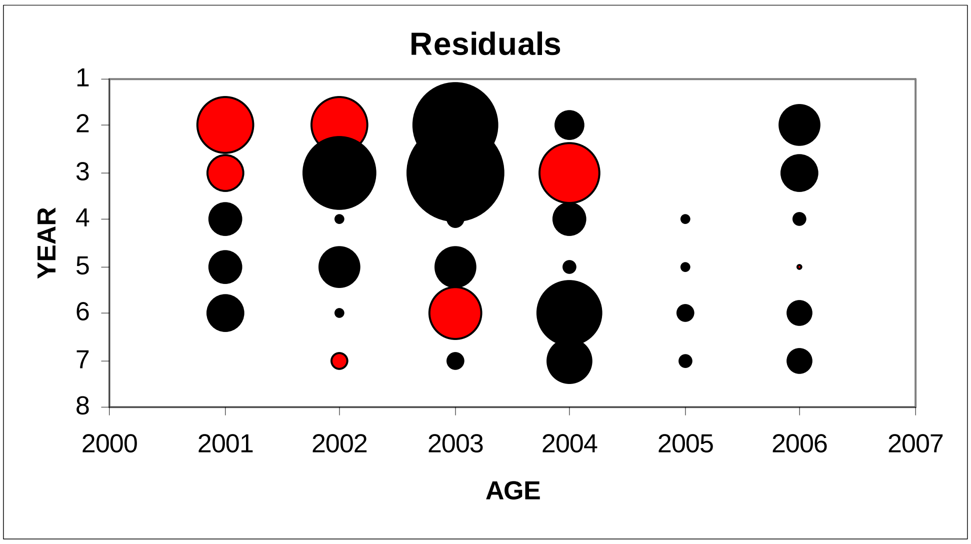


Figure 7.5.9 Irish Sea herring VIIa(N). Bubble plot of age and year residuals from ICA SPALY run (6-year separable period). Largest residual = -0.616. Black bubbles negative.

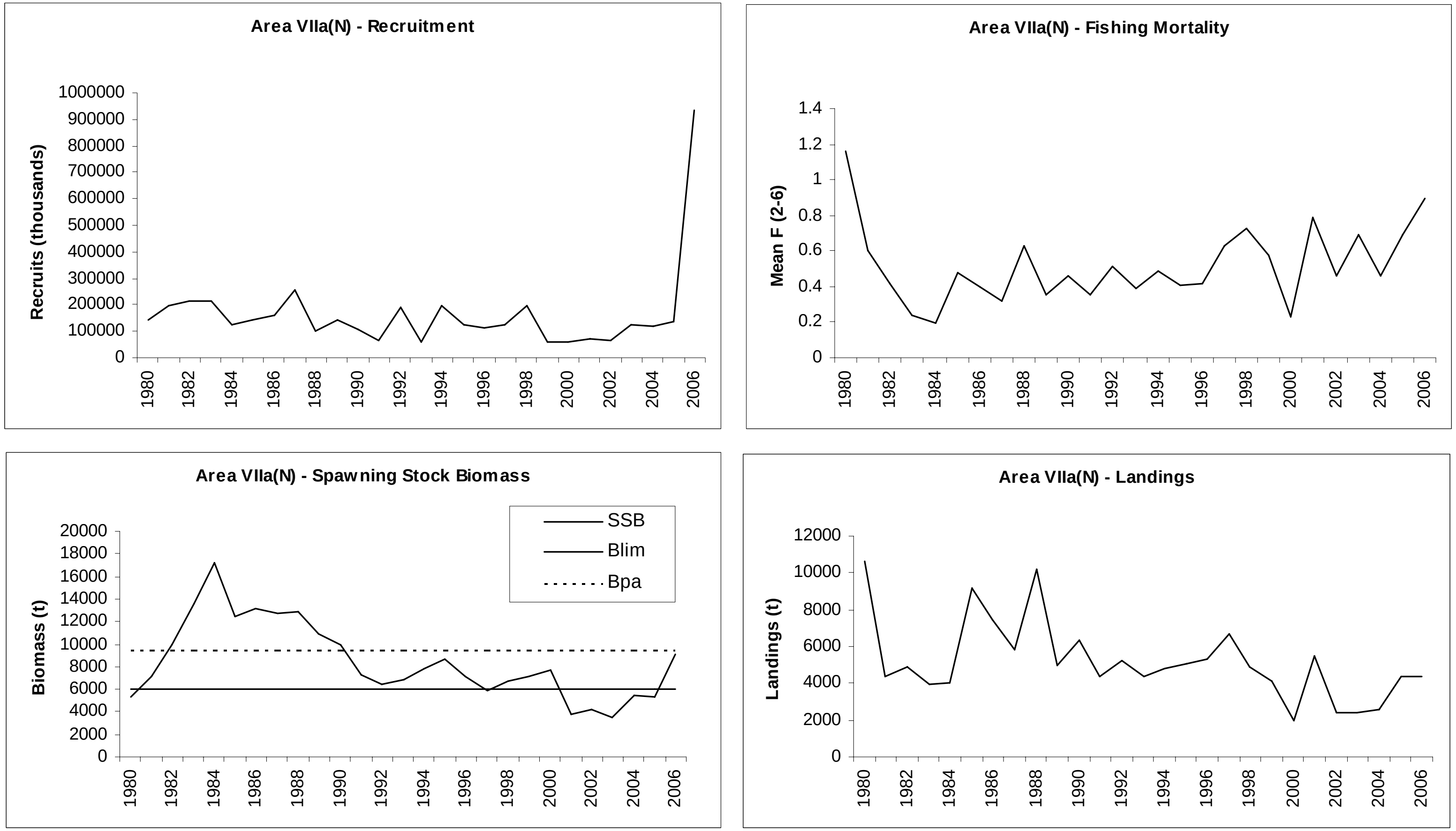


Figure 7.5.10 Irish Sea herring VIIa(N). Illustration of stock trends from deterministic calculation (6-year separable period). Summary of estimates of landings, fishing mortality-at-age 4, recruitment at age 1 and SSB at spawning.

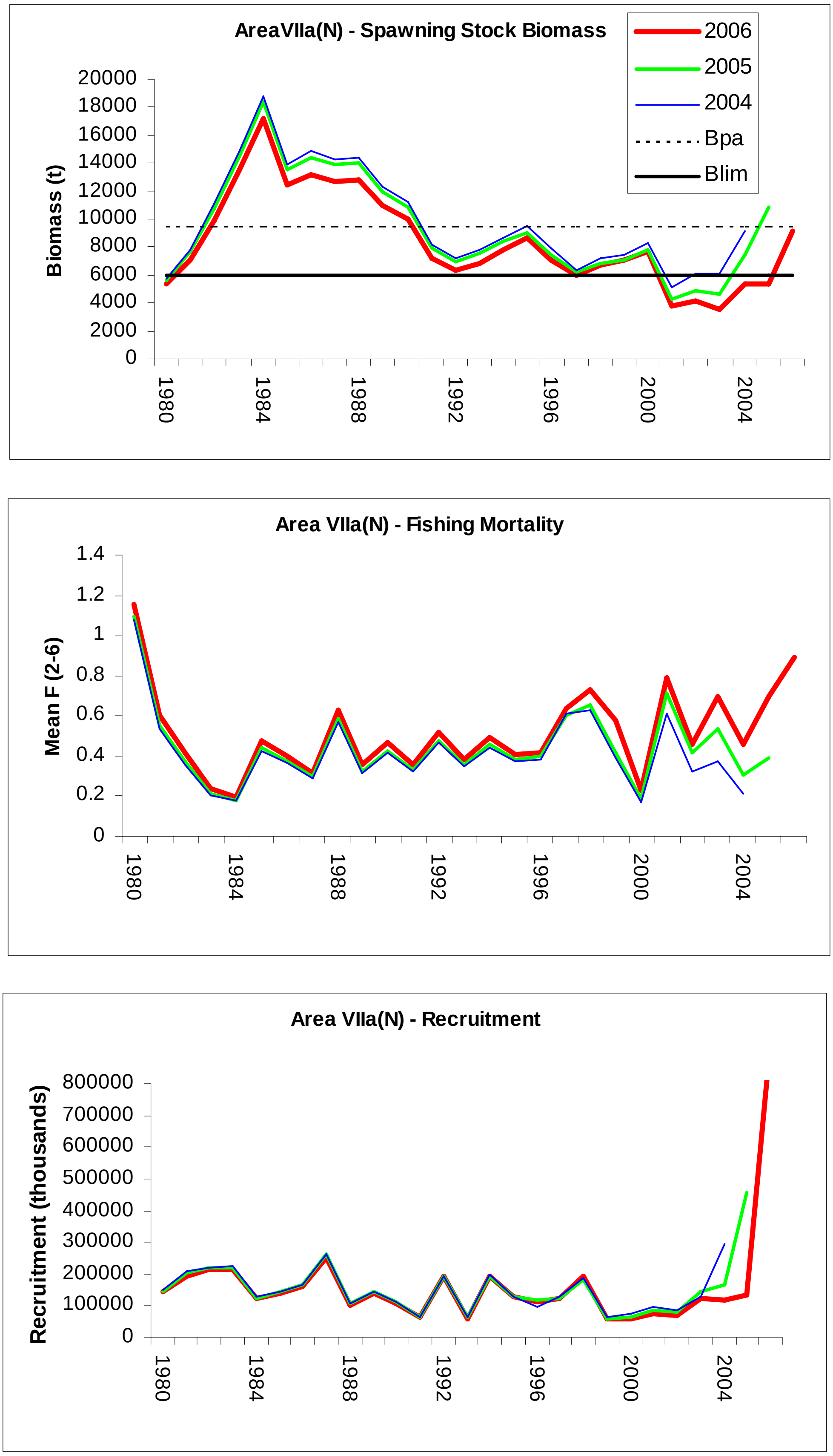


Figure 7.5.11 **Irish Sea herring VIIa(N). Retrospective trends in fishing mortality (F 2-6), SSB and recruitment (1-ringers) from ICA SPALY run.**

8 Sprat in the North Sea

8.1 The Fishery

8.1.1 ACFM advice applicable for 2005 and 2006

From 2002 to 2005 the TAC set by management for Subarea IV (EU zone) and Division IIa (EU zone) has been 257 000 t. The advice from 2005 was that a constant exploitation rate was expected to generate landings of 244 000 in 2005.

ACFM in 2006 advised to set the TAC in 2006 to well below the TAC of 2005. Though relative trends in the biomass indicated an increase over most of the time series, the estimated recruitment of the 2005 year class to the 2006 fishery was low. The TAC set for 2006 was 282 700 t. A mid year revision of the TAC resulted in a final TAC for 2006 of 175 000 t.

There have been no explicit management objectives for this stock.

For 2007 a preliminary TAC is set at 175 000 t.

8.1.2 Total landings in 2006

Landing statistics for sprat for the North Sea by area and country are presented in Table 8.1.1 for 1996–2006. Landings data prior to 1996 are considered unreliable. As in previous years, sprat from the fjords of western Norway are not included in the landings for the North Sea. Landings from the fjords are presented separately (Table 8.1.2) due to uncertainties in stock identity. Table 8.1.3 shows the landings for 1996–2005 by year, quarter, and area in the North Sea. Generally, most of the landings are taken in the second half of the year. This was also seen in 2006, but about 41% were taken in the first quarter. The Norwegian vessels are not allowed to fish in the 2nd and 3rd quarters in the EU and the Norwegian zone and not allowed to fish in the Norwegian zone until the quota in the EU-zone has been taken.

The landings in 2006 were 113 710 t, mainly taken by the Danish fleets. This was the lowest landings since 1997 and represents a reduction of 45% compared to 2005 where the landings were the highest recorded since mid 1990s. The Norwegian sprat fishery caught nearly 10 000 tonnes of sprat in the North Sea in 2006 after three years with nearly no landings.

The quarterly and annual distributions of landings by rectangle for Subarea IV are shown in Figures 8.1.1–8.1.2.

8.2 Biological composition of the catch

8.2.1 By-catch in the North Sea sprat fishery

Only data on by-catch from the Danish fishery were available to the Working Group (Table 8.2.1). The Danish sprat fishery has in general been conducted with minor by-catch of herring. The total amount of herring caught as by-catch in the sprat fishery in 2006 is less than 10% of the total landings. The herring by-catch decreased in 2006 and was the lowest since 1999.

8.2.2 Landings in number

The biological sampling from 1996 onwards is considered reliable and the estimated quarterly landings-at-age in numbers for the period are presented in Table 8.2.2. Denmark and Norway provided age data of commercial landings in 2006 for all quarters fished. These data were used to raise the landings data from the North Sea. The landings by UK (England) were minor and unsampled (Table 8.2.3). In 1996-2005 1-ringer sprat dominated the landings (54-96%), while the 2-ringers in 2006 (2004 year class) made a larger part of the landings (47%). The majority of the total sprat landings by numbers are normally taken in the second part of the year, but in 2006 more than 50% were taken in the first quarter.

8.2.3 Quality of landings and biological data

The sampling intensity for biological samples, *i.e.*, age and weight-at-age, is given in Table 8.2.3. The sampling level in 2006 improved compared to 2005, considering number measured and aged. 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 tonnes landed. This sampling level is lower than the guidelines (1 sample per 1000 tonnes) previously used by the HAWG, but as the fishery was carried out in a limited area and a limited season, the recommended sampling level can be regarded as adequate.

In 2006 a total of 601 samples were collected from the Danish vessels taking part in the industrial fisheries in the North Sea in order to estimate species distribution of the industrial landings. The sampling figure for 2005 was 680 samples. The total landings from the Danish small mesh fishery in 2006 were 415 000 t (all species) and at the same level as in 2005 (408 000 t). The recommended sampling levels for species composition were achieved.

8.3 Fishery Independent Information

The IBTS (February) sprat indices (no. per hour) in Div. IVb were previously used as an index of abundance of sprat in the North sea. The historical data were revised in 1995 (ICES 1995/Assess:13) and 1999 (ICES 1999/ACFM:12). The IBTS Working Group redefined the sprat index to be calculated as an area weighted mean by rectangles for the entire North Sea sprat stock. New calculations were carried out in 2001 (ICES 2000/D:07). The fishing gear used in the IBTS-survey was standardised in 1983 and the data series from 1984 onwards are considered as comparable (Table 8.3.1).

The IBTS data by rectangle are given in Figure 8.3.1a-c for age groups 1, 2 and 3+. Sprat at all ages were found in the south-east, with the highest concentrations in the more central area of Division IVb and Division IVc. The mean lengths (mm) of age group 1 by rectangles was in general in the range of 62 to 96 mm (Figure 8.3.2). The largest mean length, 102 mm, were in the rectangles 39F0 and 38F0, two rectangles with small landings of sprat

The acoustic surveys for the North Sea Herring in June-July have estimated sprat abundance since 1996 (ICES 2006/LRC:04). No sprat were recorded in the northern part of the North Sea (Figure 8.3.3). The highest abundance and biomass were observed in the south - eastern North Sea. Due to inappropriate coverage of this area during the first period of survey time series, the acoustic estimates are not thought to be representative for the years prior to 2003. In 2004 0-group sprat (<5-6 cm) were for the first time recorded by this survey contributing to 34% of the total abundance It is, however, not clear whether the component of 0-ringer were recruiting from autumn-spawning sprat or from an early spring-spawning component (ICES 2004/AFM:18). The length distribution indicates that only the largest of this age group have been sampled and the abundance of 0-group sprat is thus considered an underestimate. In this period no sprat have been reported in the northern areas.

From 2003 the estimates are considered comparable with regards to area covered and are given in the text table below. There was a decrease in numbers and biomass from 2005 to 2006 with the 2004-year class still being the strongest in this period.

	Numbers					Biomass				
Year	0	1	2	3+	Sum	0	1	2	3+	Sum
2003	0	25 292	3 984	339	29 616	0,0	198,8	61,3	6,0	266,1
2004	17 400	28 940	5 180	99	51 620	19,4	266,6	71,5	2,1	359,6
2005	0	70 175	5 533	1 106	76 814	0,0	479,6	67,4	16,8	563,8
2006	0	22 889	20 480	809	44 179	0,0	166,4	273,0	12,7	452,1

8.4 Mean weights-at-age and maturity-at-age

Mean weights (g) at age in the landings in 2006 are presented by quarter in Table 8.4.1. The table includes mean weights-at-age for 1996-2005 for comparison.

Data on maturity by age, mean weight and length by age during the 2006 summer acoustic survey are presented by the PGHERS for the North Sea (ICES 2007/LRC:01) and given in Table 8.4.2. The overall mean weight-at-age for the 1-group was lower for both immature and mature in 2006 compared to 2005. A higher proportion of the 1-group was mature in 2006 than in the year before, 94 % vs. 57% by number, respectively. By biomass the proportions were 96% and 93%.

8.5 Recruitment

The 2005 - index of 1-group (2004 year class) was the highest for the whole time-series (see Table 8.3.1), both in absolute and relative terms. The high level of the 1-group in 2005 was seen in most samples and not only confined to few single hauls. In 2007 the IBTS-index for the 2004 year-class (3-group) is still abundant and represents one of the highest 3-group indices for the period. The 1-group index from February 2006 was one of the lowest for the period and the lowest since 1996. The total index was higher than last year, but still lower than the average (1068) for 1984-2007. The 2005 year class appeared as one of the smallest year classes as 1-ringer in the 2006-IBTS-data. In 2007, the same year class is estimated as the highest 2-group index in the time series.

8.6 Data Exploration and Assessment

Assessing the sprat in the North Sea has always been problematic for a variety of reasons. In this section, an elementary exploration of the data is presented to outline the extent of some of these problems. Section 8.7 describes exploratory runs with CSA which has been the assessment procedure employed in later years.

Sprat is a short lived species where the landings are dominated by ages 1-2 and, to some extent, age 3. Accordingly, the number of observations from each cohort throughout its life-span is low, making the final estimate of the abundance and mortality of a year class very vulnerable to noise in the data. Furthermore, the fishing mortality is probably not large compared to the assumed natural mortality, so the liberty to model the dynamics of the stock is, to a large extent, limited by the assumption on natural mortality.

The information available at present is landings (in numbers at age) and the IBTS 1st quarter indices (at age). There may also be the potential for the application of acoustic survey data in the future; however, at present, the time-series of this information is of not of sufficient length to justify its use.

Survey data

IBTS survey indices are available for North Sea sprat for recruits (age 1) and older (age 2+) from 1984 – 2007 (Figure 8.6.1 and Table 8.3.1). The indices for the recruits are highly variable, with a large peak at remarkably regular intervals of 5 years. There is no obvious biological reason for this periodicity. The age 2+ index also shows periodic fluctuations, but not as clearly as for the recruits. The correlation between the age 1 IBTS index and the age 2+ index in the subsequent year (Figure 8.6.2) is weak ($r^2 = 0.05$), and in particular, many large indices at age 2+ are associated with small indices at age 1. An analysis using only the age 2 year class, instead of the combined age 2+ group, gave comparable results.

The survey indices are driven by a few large catches from a small number of stations (Figure 8.6.3), which may explain some of the noise in the survey data. In the extreme year 1989, more than half the total age 1 index was due to a single haul. In more normal years, 40-70% of the total catch came from the 10 largest hauls (Figure 8.6.3).

Another source of variance in the survey indices may be problems with age reading. Possible variations in the time when the sprat recruit to the survey can add further noise.

The log of the ratio between age 1 and age 2 indices within the same year classes can be used as a metric of the mortality signal in the data, modified by the catchabilities (Figure 8.6.4). The ratio is highly variable and lacks any clear trend, suggesting a high level of noise in the survey data.

Landing data

The annual landings in numbers at ages 1 and 2, and the corresponding log landing ratio (LLR), are shown in Figure 8.6.5 for the years 1996 - 2006. The ratios show a marked increase over time due to the increasing trend in landings at age 1 and more stable landings at age 2. These trends may be due to either an increase in total mortality or an increased selection at age 1 in the fishery or by predators. The 2004 year class, which was consistently strong in the survey (Figure 8.6.1), gave rise to relatively large landings first at age 1 and then at age 2, suggesting that the fishery may have targeted this year class. However, the mechanisms behind such behaviour in an industrial fishery are unclear.

Conclusions with regard to the data

The inferences that can be drawn from these analyses are:

1. The survey data are generally noisy, with an apparent periodic cycle in both age 1 and age 2+ groups occurring without a clear explanation. However, the correlation between age-group indices in successive years is poor, also likely due to uncertainty in the survey. One major contribution to this noise may be that in most years the indices are driven by a small number of hauls.

2. The log age-index ratio for the IBTS survey is dominated by noise. Hence, there is no clear mortality signal in the survey data.

3. The log landings ratio shows a consistent increasing trend for ages 1-2 since 1996 which is caused by increasing landings at age 1 and constant or slightly decreasing catches at older ages. This could indicate either an increasing F or a change in exploitation pattern with higher preference for age 1. Without some change in selection, the increase in F would have been quite marked.

Further exploration is required including incorporation of acoustic surveys and/or length-based assessment methods.

8.7 Assessment with CSA

As in previous years, an attempt was made to assess North Sea sprat using the CSA method. The method is described in Section 1.6.2, and in detail in the 2006 HAWG report (ICES CM 2006/ACFM:20). Briefly, a new year-class is entered each year and reduced according to the reported landings (without error) and the assumed natural mortality. Only two ages are considered in the method; recruits (age 1) and older individuals (ages 2+). The model is fitted to survey indices for the two age groups. The assessment was carried out using the CSAo V3 software obtained through the ICES website (http://www.ices.dk/committe/acfm/wg/asoft/CSA/) with catch and IBTS q1 survey indices from 1996 onwards. An average natural mortality for sprat of 0.75 was assumed, based on the estimated mortalities from an MSVPA analysis for the years 1996-2003 (ICES CM 2005/D:06) raised to the IBTS q1 age-group indices for the appropriate year.

Experience has shown that the survey catchability ratio, *s*, (*i.e.* the catchability at the youngest age relative to the older ages, q_1/q_{2+}) required by the model cannot be firmly estimated. The method employed in both this year and previous years has been to scan a range of *s* values to find the best fit (Figure 8.7.1; note the logarithmic scale for biomass). In the sprat case, the best model fit is obtained at a catchability ratio of 1.075 and this value has been used in the results presented below. However, the terminal year biomass scales extremely strongly with the choice of this parameter (Figure 8.7.1); the dependence of biomass on *s* is even stronger than exponential in form.

This phenomenon can be understood in terms of the structure of the CSA model. The natural mortality of sprat appears to be significantly higher than the fishing mortality, and thus the relative impact of the catch data on the stock dynamics is low. Thus, while the catches are the only absolute measure of abundance available to the model, their contribution to the dynamics is small. Furthermore, the model interprets these catches literally (*i.e.* without error) and fits the stock parameters to the indices. In scenarios where the survey-quality is high, the method can be expected to perform well; however, when the survey data are poor and/or conflicting, the model will attempt to eliminate the effect of the catch data by making the biomass extremely large (essentially ignoring this data) and fitting the indices as closely as possible. This appears to be the case with this stock; by changing the catchability parameter, *s*, we are changing the effective weighting of the indices with respect to each other, and thus forcing the model to go to new extremes to fit them correctly.

Thus, given the inability to fix the *s* value independently of the model and noting the breadth of the minima in the *s* vs SSQ relationship, the values of the biomass given by the CSA model cannot be considered to have any meaning in absolute terms; rather, they must be considered a measure of the relative abundance of sprat in the North Sea. This philosophy has been employed throughout the remainder of the section.

The input and main results from the key run are presented in Table 8.7.1 and 8.7.2. The CSA model generated a time series of the estimated recruit and mature age-groups and IBTS q1 indices; comparison with the actual indices shows good agreement between the raw data and the fit (Figure 8.7.2). From the size of each individual age-group it is then possible to calculate a time series of the total stock biomass (Figure 8.7.3). The total stock has decreased by approximately 50% from the ten-year high observed in 2005, and is now at an average value for this period. Exploratory runs performed with different values of *s* gave qualitatively similar results, both in terms of the quality of fit to the IBTS indices and the dynamics of the total stock biomass, but rescaled.

The fishing mortality estimates from the CSA model are remarkably low without any clear trend (Figure 8.7.4). The trends seen in the log landings ratios (Figure 8.6.5) are not reproduced by CSA. The average fishing mortality over the period 1996-2003 is 0.16, well below that derived via MSVPA (ICES CM 2005/D:06) which was 0.71 on average over the same period. However, the total stock-biomass, and thus the fishing mortality, *F**, scale with the catchability ratio, *s*. The discrepancy between the CSA and MSVPA F values can be explained in terms of this scaling.

A retrospective analysis of the stock using the CSA model was limited by the relatively short time series of reliable catch data and only three retrospective runs were feasible (Figure 8.7.5). A strong bias can be seen towards the data point in the terminal year, which had the effect of dragging the total stock biomass upwards. However, the retrospective analyses for the previous two years are in close agreement. This phenomenon is most likely due to unrepresentative values of the 2007 IBTS indices; the increasing trend in these indices in recent years (Figure 8.6.1) tends to contradict the decreasing trend in the biomass as estimated by CSA (Figure 8.7.3).

In conclusion, although the CSA method appears to be a sensible approach to assessing this short-lived species, the noise in the survey data, together with the sensitivity of the model to this noise, make the determination of absolute stock estimates infeasible. Hence, other model formulations should be considered for the future, including the use of more catch-independent data, such as acoustic surveys, to get firmer estimates of the stock. The CSA model does, however, provide a relative estimate of the total stock biomass, and thus is a useful measure of the stock dynamics. The 2007 total-stock-biomass shows a reduction of 50% from the 10-year high in 2005.

The HAWG briefly considered preliminary explorations with a length based method (lcs – Skagen WD). Again, it is limited what can be inferred from the data, and the results are sensitive to the way the model is conditioned. Besides avoiding problems with ageing, the underlying operating model in lcs is more complex than in CSA, implying that more assumptions are required to estimate the remaining parameters, but also giving more freedom to condition the model according to the insight in the fishery and the stock. Although this approach may be promising, the model is still under development and it would be premature to consider this as an alternative at present. However, the HAWG recommends that ICES be prepared to present IBTS survey indices also by length classes in the future in order to facilitate the use of length-based models of this type.

8.8 North Sea Sprat Forecasts

A catch prediction for the assessment year was provided in the past on the basis of a linear regression of catch (as estimated by landings) versus the IBTS sprat index summed over all age groups. The results for 2007 (Figure 8.8.1) indicate a catch in the coming year of 196 kt (agreed TAC for 2007 is 175 kt). Although such a method has been common in previous years the approach is less than ideal. The relationship between estimated biomass and catch is subject to many different factors such as uncertainty in the stock estimate, recruitment variability and the fact that the TAC is not always taken for this fishery, and is thus not an ideal management strategy.

A framework was developed in an attempt to provide a sounder basis for making short-term forecasts for the North Sea sprat. The CSA model described above was used as the basis for projecting the current estimate of total-stock-biomass forward in time to 2008; although this method has some shortcomings, it can still provide a useful tool in such a scenario. The deterministic equation underpinning the method (Section 1.6.2) was used as described above, but statistical uncertainty was also incorporated by propagating random variations in each of the input variables through the model. For an assumed 2007 catch, and randomly drawn input parameters, it was possible to obtain an estimate of the 2008 total-stock-biomass; by then repeating this process many thousands of times, it was possible to obtain an estimate of both the expected biomass and the confidence intervals surrounding it.

Careful consideration was paid to the variances in the input values. The 2007 North Sea sprat biomass, survey catchability, q_n, and their variances were obtained from the output of the CSA model for an *s* value of 1.075 and a natural mortality of 0.75, based on a non-parametric bootstrap performed by the software. An estimate of the variance in the 2007 IBTS sprat age 1 (recruits) index was provided by ICES, based on a similar bootstrapping method. The natural mortality of sprat was assumed to be log-normally distributed with a variance based on the analysis of values provided by the SGMSNS 2005 MSVPA (ICES CM 2005/D:06). A typical exploitation pattern for the fishery was estimated based on the output of the CSA model from 1996-2006 and was used to determine the mean weight-in-catch. Finally, the sprat recruitment for 2008 was assumed to log normally distributed about the geometric mean, also obtained from the output of the CSA model.

The 2008 sprat forecast is a linearly decreasing function of total catch taken during 2007 (Figure 8.8.2), as expected from the CSA model; the slope of the line agrees with that predicted analytically from CSA. The variance about the median value is log-normally distributed as expected and analysis shows it to be driven by the uncertainty in the coming year's recruitment in the first instance, and that in the 2007 stock biomass in the second.

The interpretation of these results should be tempered by our understanding of the limitations of the CSA model. The CSA method produces a relative estimate of the total stock biomass whose scaling is driven by the *s* parameter, which was assumed to be constant in the forecast model above. The choice of *s* is again critical as it will scale the 2007 biomass and thus change the impact of removing a fixed tonnage from the stock. Exploratory runs were performed for different *s* values by re-estimating all parameters from scratch, based on the appropriate CSA model run. Forecasts of the 2008 biomass based on $s = 0.7$ show an increased dependence on catch (Figure 8.8.3), while those made with $s = 1.3$ were almost independent of catch.

The utility of this forecast method is thus limited by the validity of the CSA method. However, further refinements of the core model, as discussed above, can potentially improve the quality of the North Sea sprat assessment, and thus also of this forecast approach.

8.9 Quality of the Assessment

Due to the nature of the methods employed, the assessment of this stock is heavily dependent on the quality of the IBTS sprat indices. An investigation of the structure of these metrics revealed significant questions about their reliability; it was found that the ten largest hauls commonly comprised 40-70% of the index, and in some exceptional years more than 50% of the index was driven by a single haul. In addition, HAWG is aware of problems in the IBTS with the timing of recruitment to the survey; some sprat that hatch in autumn may not be fully recruited by February in the next year.

The quality of the assessment is also severely limited by the inability of the CSA model to provide an absolute estimate of the stock biomass. The key to this method is the catchability ratio, *s*; whilst it is possible to obtain a "best-guess" value via SSQ profiling, the minimum is extremely broad and the resulting estimate is thus uncertain. HAWG is not aware of any method to estimate this factor independently of the model and must thus rely on the fitted value; the parameter thus reflects uncertainties in the survey indices, rather than the fundamental physical and/or ecological processes it is supposed to capture. The biomass in the terminal year is shown to be an extremely strong function of this parameter, and thus the assessment of the absolute 2007 biomass is meaningless.

Investigations have shown that the relative trends in the assessment time-series produced by CSA are independent of the value of the *s* parameter. The fit of the model to IBTS sprat indices is generally good, and in this regard, CSA is able to provide useful information about the state of the stock in relative terms.

8.10 Management Considerations

The size of the North Sea sprat stock is mostly driven by the recruiting year class. Thus, the fishery in a given year will be dependent on that year's incoming year-class and only in-year catch forecasts are available. The sprat stock in the previous two years has been dominated by the very strong 2004 year class; this group has now passed through the fishery and the estimated biomass has returned to an average value. The 2006 year class, as indicated by the 2007 IBTS q1 age 1 index, is marginally below the ten-year geometric mean. The IBTS index describing the recruitment of the 2005 year class (*i.e*. the 2006 age 1 index) was particularly weak, but the effect does not appear to have propagated through into the 2007 age 2+ index, which shows an increase to one of its highest observed levels. The combined IBTS index for 2007 is high (80^{th} percentile) but contradicts the relative estimate of biomass obtained from the CSA model (50^{th} percentile). Due to inconsistencies in the age structure of the 2007 IBTS indices (particularly the absence of any effect due to the weak recruitment of the 2005 year-class), HAWG believes that the relative estimate obtained from the model is the more reliable of the two metrics.

There are indications that larvae from autumn spawning will over-winter as larvae and metamorphose the year after. A better understanding of the stock structure and spatial distribution of sprat in the North Sea, the spawning seasons and recruitment from a possible autumn spawning is required.

Uncertainties in both the assessment method and the survey indices make the current understanding 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.

Table 8.1.1. Sprat in the North Sea. Catches (' 000 t) 1996-2006. 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.

Country	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
					Division IVa West (North Sea) stock						
Denmark				0.7		0.1	1.1		0.0		0.0
Netherlands											
Norway											
Sweden						0.1					
UK(Scotland)											
Total	0.0	0.0	0.0	0.7	0.0	0.2	1.1		0.0	0.0	0.0
					Division IVa East (North Sea) stock						
Denmark	0.3										0.0
Norway											
Sweden											
Total	0.3	0.0	0.0	0.0	0.0	0.0	0.0				0.0
					Division IVb West						
Denmark	1.8	82.2	21.1	13.2	18.8	11.1	16.3	22.0	53.8	53.3	8.0
Norway	1.9	2.3				0.9	0.0				
UK(Engl.&Wales)											
UK(Scotland)				0.8							
Total	3.7	84.5	21.1	14.0	18.8	12.0	16.3	22.0	53.8	53.3	8.0
					Division IVb East						
Denmark	74.7	10.9	98.2	147.1	144.1	132.9	109.8	130.9	122.2	150.7	71.5
Germany											
Norway	50.9	0.8	15.3	13.1	0.9	5.0			0.1		0.8
Sweden	0.5		1.7	2.1		1.4				0.0	
UK(Scotland)				0.6	0.0						
Total	126.1	11.7	115.2	162.9	145.0	139.3	109.8	131.0	122.2	150.7	72.3
		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
France							0.0				
Netherlands				0.2			0.0				
Norway		0.1	16.0	5.7	1.8	3.6	0.0				9.0
UK(Engl.&	2.6	1.4	0.2	1.6	2.0	2.0	1.6	1.3	1.5	1.6	0.5
Total	6.5	7.2	28.0	10.8	32.0	18.7	16.4	23.6	18.3	3.6	33.4
		Total North Sea									
Denmark	80.7	98.8	131.1	164.3	191.1	157.2	142.0	175.2	192.7	206.0	103.4
France	0.0	0.0	0.0	0.0	0.0	0.0					
Germany	0.0	0.0	0.0	0.0	0.0	0.0					
Netherlands	0.0	0.0	0.0	0.2	0.0	0.0					
Norway	52.8	3.2	31.3	18.8	2.7	9.5	0.0	0.0	0.1	0.0	9.8
Sweden	0.0	0.0	0.0	2.7	0.0	1.4					
UK(Engl.&	2.6	1.4	0.2	1.6	2.0	2.0	1.6	1.3	1.5	1.6	0.5
UK(Scotlar	0.0	0.0	0.0	0.8	0.0	0.0					
Total	136.1	103.4	162.6	188.4	195.9	170.1	143.6	176.5	194.3	207.7	113.7

Table 8.1.2. Sprat catches ('000 t) in the fjords of western Norway, 1985-2006.

1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
7.1	2.2	8.3	5.3	2.4	2.7	3.2	3.8	1.9	5.3	3.7	3.3	3.1	2.5	3.3	2.6	1.4	1.1	2.2	0.4	1.2	1.3

[1] = preliminary

Table 8.1.3. Sprat in the North Sea. Catches (tonnes) by quarter*. Catches in fjords of Western Norway excluded.

Year	Quarter	Area					Total
		IVaW	IVaE	IVbW	IVbE	IVc	
1996	1		459	2,471	81,020	6,103	90,053
	2			615	2,102	18	2,735
	3			242	6,259		6,501
	4		353	411	36,273	386	37,423
Total			812	3,739	125,654	6,507	136,712
1997	1			1,025	147	7,089	8,261
	2			189	1,054		1,243
	3		3	27,487	569		28,059
	4		81	55,814	9,878		65,773
Total			84	84,515	11,648	7,089	103,336
1998	1			1,917	3,726	1,616	7,259
	2		4	529	206	4	743
	3			4,926	55,155	215	60,296
	4			13,712	54,433	25,984	94,129
Total			4	21,084	113,520	27,819	162,427
1999	1			450	20,862	9,071	30,383
	2			108	1,048		1,156
	3	1	17	7,840	121,186	415	129,459
	4	679	31	5,550	19,731	1,167	27,158
Total		680	48	13,948	162,827	10,653	188,156
2000	1			2,686	15,440	28,063	46,189
	2			1,599	123	45	1,767
	3			14,405	116,901	1,216	132,522
	4			158	12,522	2,718	15,398
Total				18,848	144,986	32,042	195,876
2001	1	115		1,643	39,260	9,716	50,734
	2	0		699	372		1,071
	3	0		947	43,226	481	44,655
	4	79		8,681	56,421	8,538	73,719
Total		194		11,970	139,279	18,735	170,177
2002	1	1,136		222	1,960	2,790	6,108
	2			122	313	93	528
	3			9,131	61,373	647	71,151
	4			6,809	46,133	12,911	65,853
Total		1,136		16,284	109,779	16,441	143,640
2003	1			6,008	5,451	7,727	19,185
	2			57	568	26	652
	3			3,593	52,614	165	56,372
	4			12,389	72,240	15,651	100,280
Total				22,047	130,873	23,570	176,489
2004	1			76	751	1,831	2,657
	2	7		125	135	16	283
	3			627	53,533	496	54,657
	4			52,927	67,757	15,937	136,622
Total		7	0	53,755	122,177	18,280	194,219
2005	1			5,776	5,762	2,457	13,995
	2			145	2,370	123	2,638
	3			39,783	67,747		107,530
	4			7,630	74,844	1,033	83,507
Total		0	0	53,334	150,723	3,613	207,670
2006	1	25	22	1,866	11,847	33,534	47,294
	2			146	44	8	198
	3			3,523	36,528	8	40,059
	4	2		2,557	24,022	77	26,658
Total		27	22	8,092	72,441	33,627	114,209

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 1998-2006.

	Year	Sprat	Herring	Horse-mackerel	Whiting	Haddock	Mackerel	Cod	Sandeel	Other species	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
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

Table 8.2.2 North Sea Sprat. Catch in numbers (millions) by quarter and by age 1996-2006.

Year	Quarter	Age						
		0	1	2	3	4	5+	Total
1996	1		524.7	4,615.4	2,621.9	316.4	11.3	8,089.7
	2		1.9	241.5	32.7	15.5	0.3	291.9
	3		400.5	100.7	22.9	0.3		524.5
	4		1,190.7	1,069.0	339.6	5.6		2,604.8
	Total		2,117.9	6,026.6	3,017.0	337.8	11.5	11,510.8
1997	1		74.4	314.0	229.2	55.3	2.5	675.4
	2		11.3	47.8	34.9	8.4	0.4	102.9
	3		1,991.9					1,991.9
	4	127.6	3,597.2	996.2	117.8	58.1	0.0	4,896.9
	Total	127.6	5,674.8	1,358.1	381.9	121.8	2.8	7,667.1
1998	1		683.2	537.2	18.3	0.1		1,238.8
	2		70.9	55.3	1.8			127.9
	3	74.2	3,356.6	693.3				4,124.2
	4	772.4	4,822.4	2,295.1	483.5	39.5		8,412.8
	Total	846.6	8,933.1	3,580.9	503.6	39.6		13,903.7
1999	1		728.1	2,226.0	554.2	86.6	9.2	3,604.2
	2		38.6	58.4	18.1	2.6		117.7
	3		12,919.0	38.9				12,957.8
	4	105.0	2,143.2	211.5				2,459.7
	Total	105.0	15,828.9	2,534.8	572.3	89.2	9.2	19,139.5
2000	1		559.2	3,177.3	797.5	247.5	72.0	4,853.7
	2		6.8	107.4	60.1	12.8	0.5	187.6
	3		9,928.9	1,111.9	77.8			11,118.6
	4		1,153.7	129.2	9.0			1,291.9
	Total		11,648.7	4,525.8	944.4	260.3	72.6	17,451.8
2001	1		746.3	3,197.7	1,321.9	22.2		5,023.1
	2		15.9	66.2	26.1			108.2
	3	0.4	3,338.8	299.9				3,559.1
	4	1,205.0	4,178.7	1,224.6	261.9			6,651.4
	Total	1,205.4	8,279.8	4,788.4	1,609.9	22.2		15,341.7
2002	1	0.0	104.7	400.3	30.2	11.2		546.4
	2	0.0	13.7	27.9	2.4	0.6		44.6
	3	40.9	5,745.6	582.1	42.3	4.1		6,415.0
	4	415.0	4,578.0	626.2	119.8	3.1		5,742.1
	Total	455.9	10,441.9	1,636.5	194.8	19.0		12,748.1
2003	1	0.0	1,953.9	1,218.9	85.3	11.3	0.0	3,269.3
	2	0.0	41.8	46.3	4.7	0.6	0.0	93.3
	3	1.1	3,481.3	772.0	42.9	0.0	0.0	4,297.2
	4	539.3	7,051.8	1,115.1	93.8	36.5	21.9	8,858.4
	Total	540.4	12,528.7	3,152.3	226.6	48.4	21.9	16,518.2
2004	1	0.0	16.5	214.0	26.3	1.6	0.6	259.0
	2	0.0	22.1	14.9	3.0	0.1	0.0	40.1
	3	210.0	3,661.9	558.2	31.4	0.0	0.0	4,461.5
	4	15,674.4	5,582.8	632.1	59.2	0.0	0.0	21,948.5
	Total	15,884.4	9,283.2	1,419.2	119.8	1.8	0.6	26,709.1
2005	1	0.0	2,476.5	268.5	13.8	2.2	0.0	2,761.1
	2	0.0	499.6	23.4	4.3	4.9	0.0	532.1
	3	0.0	11,920.2	192.3	7.6	0.0	0.0	12,120.0
	4	302.5	7,467.9	191.1	0.0	0.0	0.0	7,961.6
	Total	302.5	22,364.3	675.3	25.7	7.0	0.0	23,374.8
2006	1	0.0	1,559.2	5,119.1	95.7	2.3	0.0	6,776.2
	2	0.0	5.8	21.5	0.2	0.0	0.0	27.4
	3	0.0	3,077.8	625.0	129.1	0.0	0.0	3,831.9
	4	0.0	2,048.5	416.0	85.9	0.0	0.0	2,550.4
	Total	0.0	6,691.2	6,181.6	310.8	2.3	0.0	13,185.9

Table 8.2.3. North Sea Sprat. Sampling for biological samples in 2006.

Country	Quarter	Landings ('000 tonnes)	No. samples	No. measured	No. aged
Denmark	1	36.63	17	2399	2399
	2	0.19	0	0	0
	3	39.95	9	918	918
	4	26.59	1	120	0
	Total	103.36	27	3437	3317
UK(England)	1	0.54	0	0	0
	2				
	3				
	4				
	Total	0.54	0	0	0
Norway	1	9.81	6	600	450
	2				
	3				
	4				
	Total	9.81	6	600	450
Total North Sea		113.71	33	4037	3767

Table 8.3.1 North Sea sprat. Abundance indices by age from IBTS (February) from 1984-2007

Year	Age					
	1	2	3	4	5+	Total
1984	233.758	329.003	39.608	6.200	0.292	608.861
1985	376.098	195.479	26.757	3.803	0.354	602.491
1986	44.188	73.538	22.010	1.233	0.243	141.212
1987	542.236	66.279	19.144	1.924	0.240	629.823
1988	98.606	884.065	61.800	6.991	0.000	1051.462
1989	2314.218	476.292	271.849	22.010	1.647	3086.016
1990	234.942	451.979	102.164	28.063	2.219	819.367
1991	676.784	93.381	23.330	2.631	0.118	796.244
1992	1060.780	297.691	43.248	7.234	0.531	1409.484
1993	1066.829	568.530	118.416	6.074	0.338	1760.187
1994	2428.357	938.159	92.161	3.593	0.504	3462.774
1995	1224.891	1036.404	87.329	2.516	0.764	2351.904
1996	186.131	383.534	146.839	18.284	0.744	735.532
1997	591.862	411.953	179.551	15.522	2.239	1201.127
1998	1171.050	1456.508	305.908	15.753	3.381	2952.600
1999	2534.528	562.098	80.347	4.828	0.445	3182.246
2000	1058.204	851.581	274.711	43.887	0.882	2229.265
2001	883.058	1057.001	185.466	17.548	0.345	2143.418
2002	1152.328	812.450	91.631	11.931	0.375	2068.715
2003	1842.261	309.918	44.491	1.022	0.040	2197.732
2004	1593.892	495.702	78.243	3.498	1.536	2172.871
2005	3053.458	267.892	36.385	0.868	0.000	3358.603
2006	421.803	1212.870	92.378	8.262	0.072	1735.385
2007	934.532	1772.646	293.834	13.572	0.026	3014.610

Table 8.4.1 North Sea Sprat. Mean weight (g) by quarter and by age for 1996 - 2006.

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		169,967
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

Table 8.4.2. North Sea sprat. Abundance, biomass, mean weight and length by age, maturity for the area east and west of 3°E and for the total North Sea.

	1I	1M	2I	2M	3I	3M	4M	TOTAL
	ABUNDANCE (MILL.)							
W of 3° E	1044.803	8022.540	12.030	17097.600	0.297	763.976	10.009	**26951.3**
E of 3° E	382.494	13439.539	0.343	3370.138	0.008	34.657	0.285	**17227.5**
Total North Sea	1427.297	21462.079	12.373	20467.738	0.305	798.633	10.294	**44178.7**
Immature total								**1439.7**
Mature total								**42728.4**
	BIOMASS (KT)							
W of 3° E	5.67	60.76	0.12	228.03	0.00	11.96	0.17	**306.7**
E of 3° E	1.54	98.44	0.00	44.81	0.00	0.54	0.00	**145.3**
Total North Sea	7.21	159.19	0.12	272.84	0.00	12.50	0.17	**452.0**
Immature total								**7.3**
Mature total								**444.7**
	MEAN WEIGHT (G)							
W of 3° E	5.4	7.6	10.1	13.3	11.6	15.7	16.6	
E of 3° E	4.0	7.3	10.1	13.3	11.6	15.6	16.6	
Total North Sea	5.0	7.4	10.1	13.3	11.6	15.7	16.	
	MEAN LENGTH (CM)							
W of 3° E	8.8	9.9	10.9	12.1	11.5	13.0	13.0	
E of 3° E	8.0	9.7	10.9	12.0	11.5	13.0	13.0	
Total North Sea	8.6	9.8	10.9	12.1	11.5	13.0	13.0	

Table 8.7.1. North Sea sprat. Input data to the CSA model. Catch in numbers (CatRec and CatFull), IBTS q1 abundance indices for age 1 (Irec) and age 2+ (Ifull), mean weights in the stock of recruits (Wrec) and mature individuals (Wfull), the catchability ratio (Srat) and the natural mortality, (M). Catches for the 2007 year are set to zero, as they are not used by the model. The 2007 Ifull index is used as a fitting parameter in this method but the Irec index for 2007 is not.

Year	CatRec	CatFull	Irec	Ifull	Wrec	Wfull	Srat	M
1996	2118	9393	186	549	4.5	9.67	1.075	0.75
1997	5675	1865	592	609	4.5	9.67	1.075	0.75
1998	8933	4124	1171	1782	4.5	9.67	1.075	0.75
1999	15829	3206	2535	648	4.5	9.67	1.075	0.75
2000	11649	5803	1058	1171	4.5	9.67	1.075	0.75
2001	8280	6420	883	1260	4.5	9.67	1.075	0.75
2002	10442	1850	1152	916	4.5	9.67	1.075	0.75
2003	12529	3449	1842	357	4.5	9.67	1.075	0.75
2004	9283	1542	1594	579	4.5	9.67	1.075	0.75
2005	22364	708	3053	305	4.5	9.67	1.075	0.75
2006	6691	6495	422	1314	4.5	9.67	1.075	0.75
2007	0	0	847	1841	4.5	9.67	1.075	0.75

Table 8.7.2 North Sea sprat. Summarised output from the CSA model showing the number of recruited (RecN) and mature (FullN) individuals, the total stock biomass (TSBiom), the estimated fishing mortality (F*), the harvest rates for recruits (HRrec) and mature individuals (HRfull), the catches of recruits (CatRec) and the fully recruited (CatFull), the catchability ratio (Sratio) and natural mortality (M) The table also gives the mature individual catchability (q), the sum of squares of error (SSQ), and the root-mean-square error (RMS).

Year	RecN	FullN	TSBiom	F*	HRrec	HRfull	CatRec	CatFull	Sratio	M
1996	14821.9	75801.6	799700	0.204	0.143	0.124	2118	9393	1.075	0.75
1997	86757.5	34896.1	727854	0.095	0.065	0.053	5675	1865	1.075	0.75
1998	79277.3	52283	862324	0.156	0.113	0.079	8933	4124	1.075	0.75
1999	183619	53170.7	1340447	0.124	0.086	0.06	15829	3206	1.075	0.75
2000	83347.8	98769	1330161	0.15	0.14	0.059	11649	5803	1.075	0.75
2001	59471.4	74031.3	983504	0.175	0.139	0.087	8280	6420	1.075	0.75
2002	55232.6	52959.1	760661	0.181	0.189	0.035	10442	1850	1.075	0.75
2003	87975.3	42657.9	808391	0.196	0.142	0.081	12529	3449	1.075	0.75
2004	70197.9	50725.3	806404	0.14	0.132	0.03	9283	1542	1.075	0.75
2005	277968.1	49680.1	1731263	0.108	0.08	0.014	22364	708	1.075	0.75
2006	34701.1	138912.9	1499443	0.117	0.193	0.047	6691	6495	1.075	0.75
2007	60110.5	72946.9	975893	0	0	0	0	0	1.075	0.75

q = 1.31E-02

SSQ = 4.02E+00
RMS = 3.65E-01

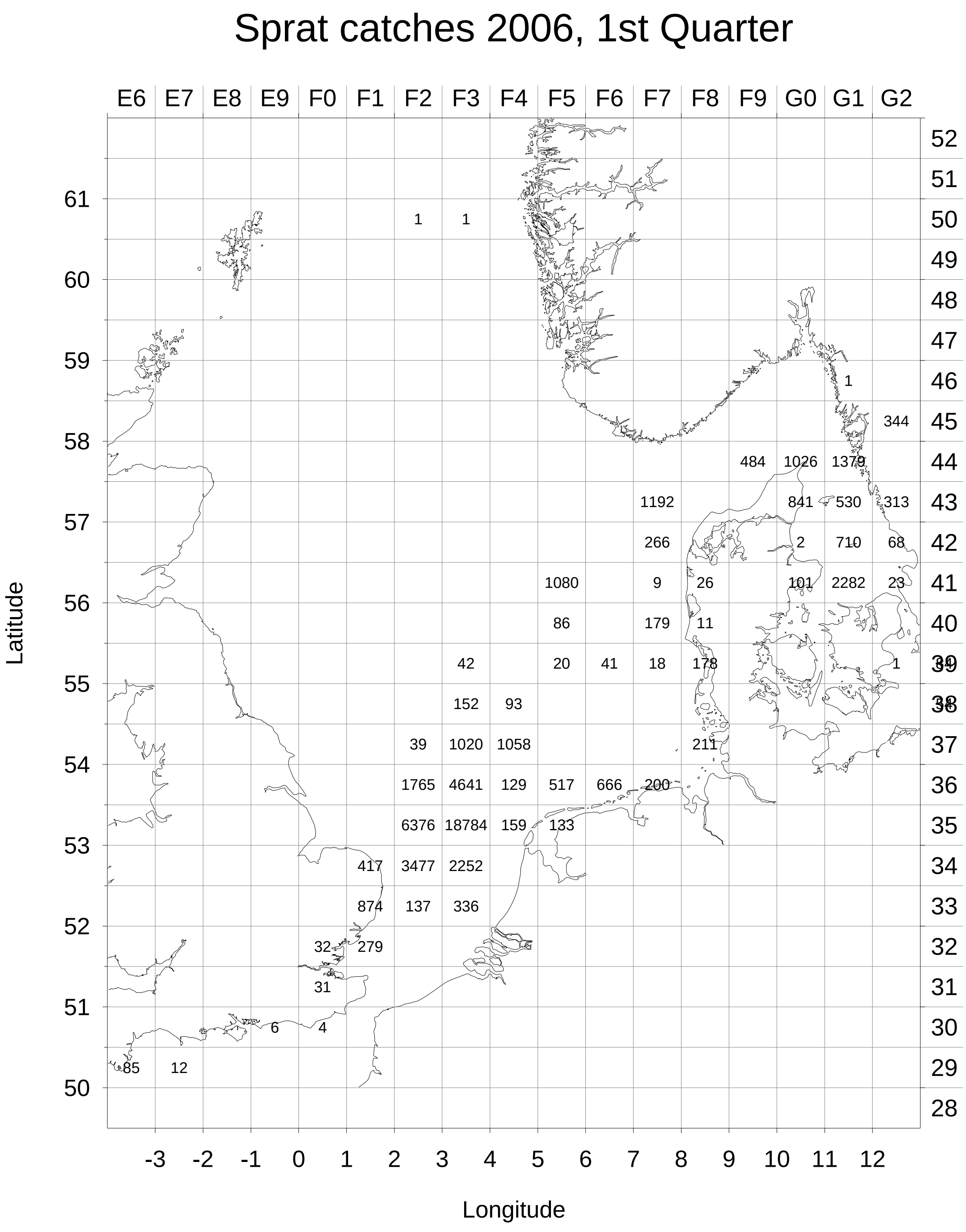


Figure 8.1.1a. Sprat catches (in tonnes) in the North Sea and Div. IIIa in 2006 by statistical rectangle. Working group estimates. First quarter.

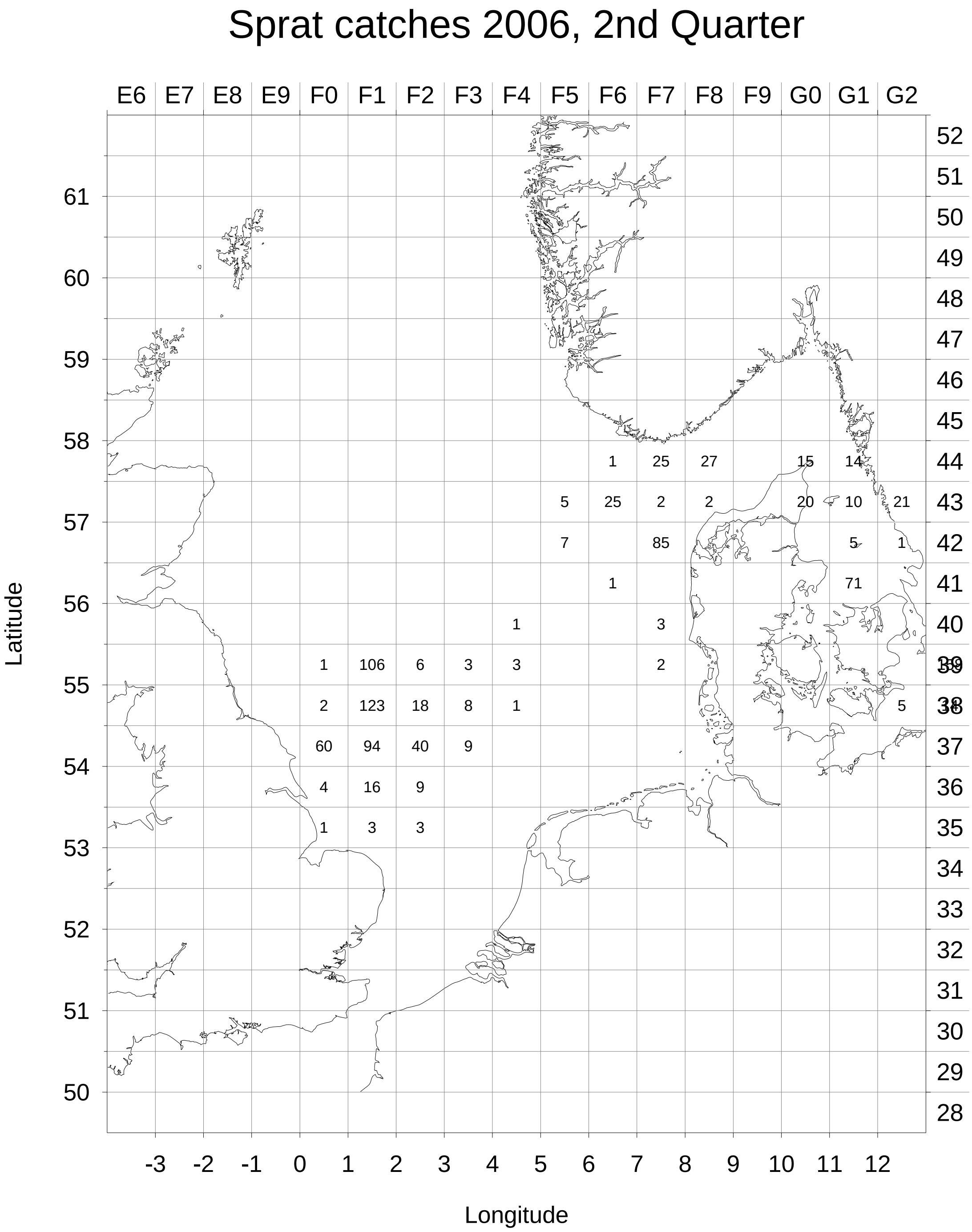


Figure 8.1.1b. Sprat catches (in tonnes) in the North Sea and Div. IIIa in 2006 by statistical rectangle. Working group estimates. Second quarter.

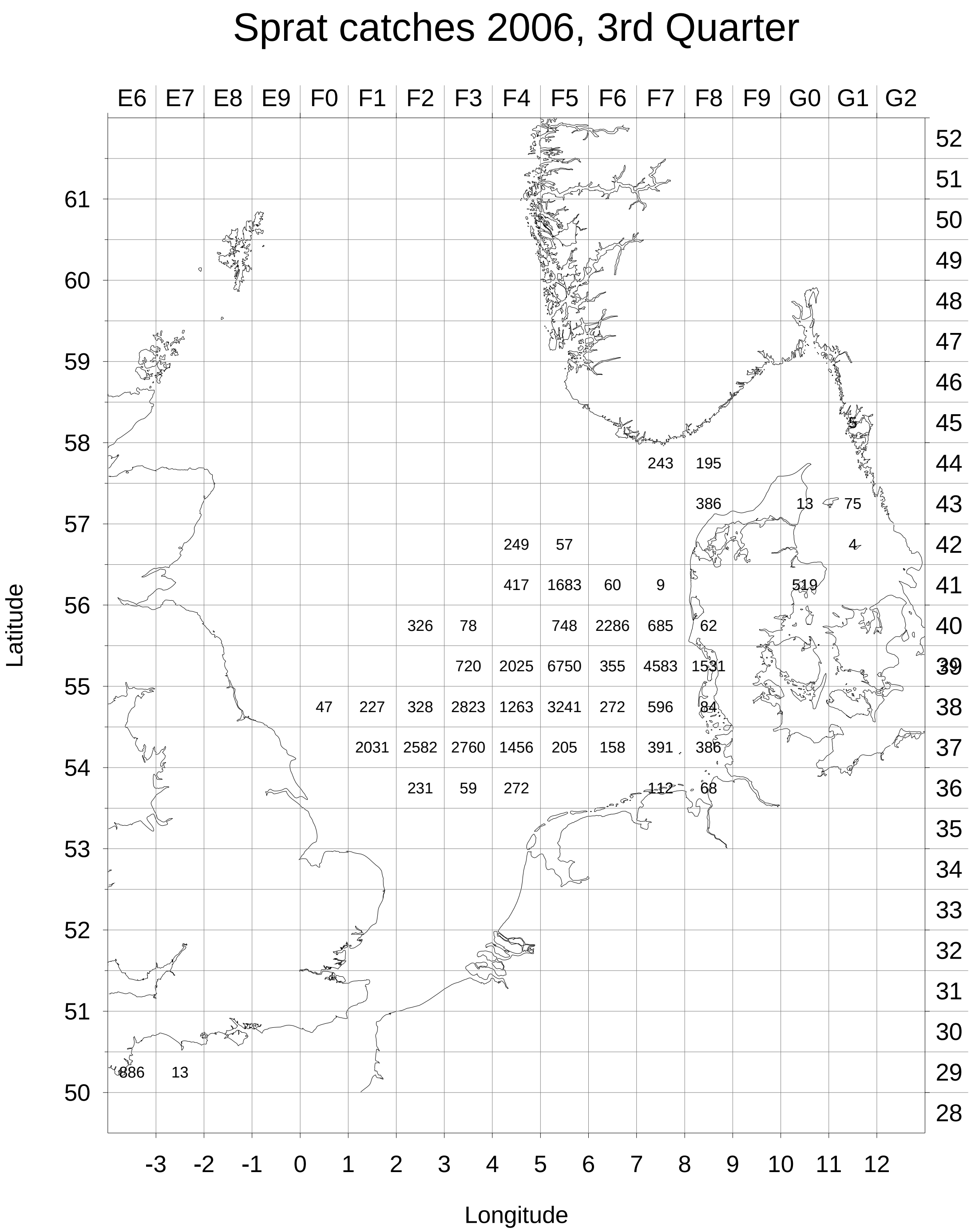


Figure 8.1.1c. Sprat catches (in tonnes) in the North Sea and Div. IIIa in 2006 by statistical rectangle. Working group estimates. Third quarter.

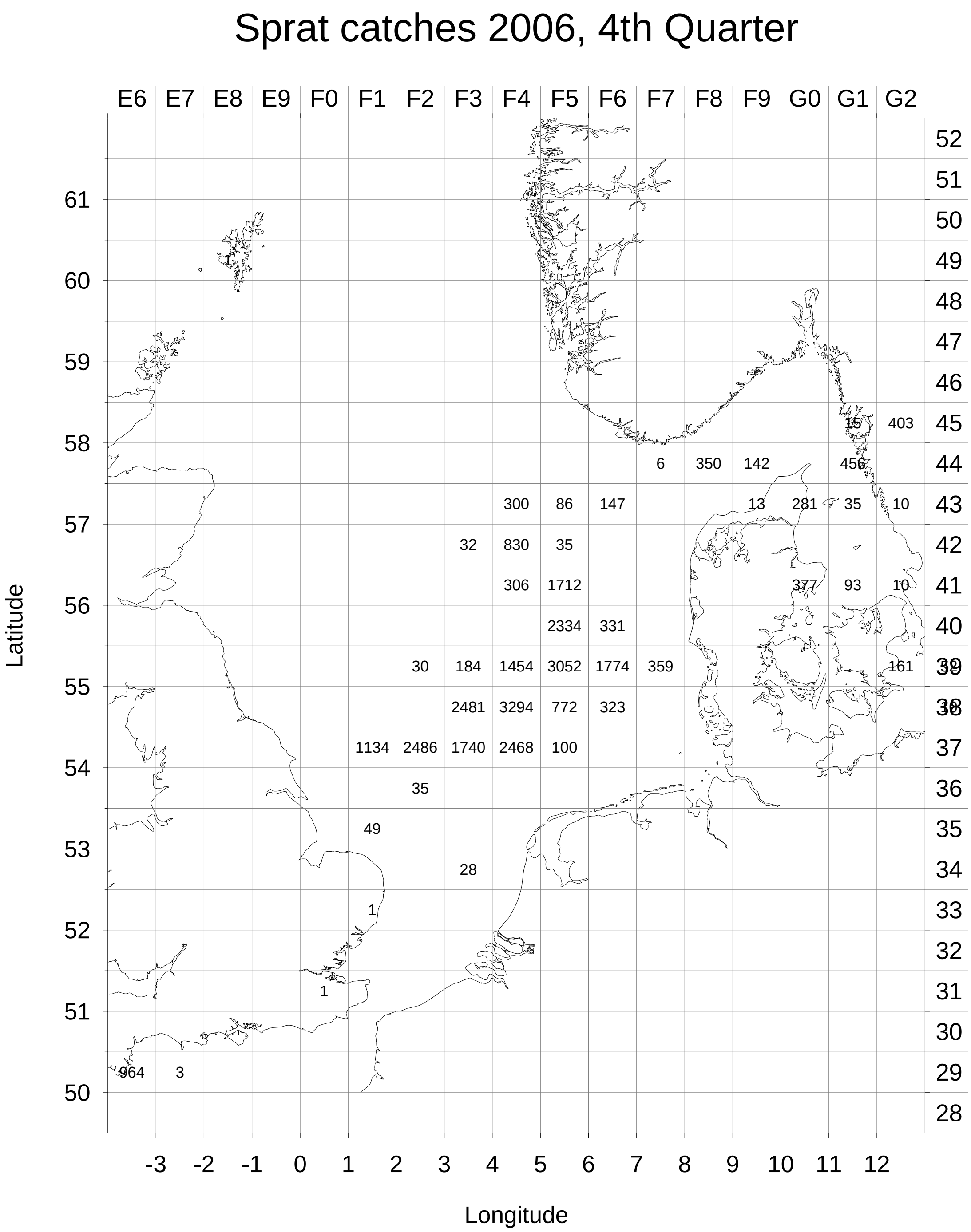


Figure 8.1.1d. Sprat catches (in tonnes) in the North Sea and Div. IIIa in 2006 by statistical rectangle. Working group estimates. Fourth quarter.

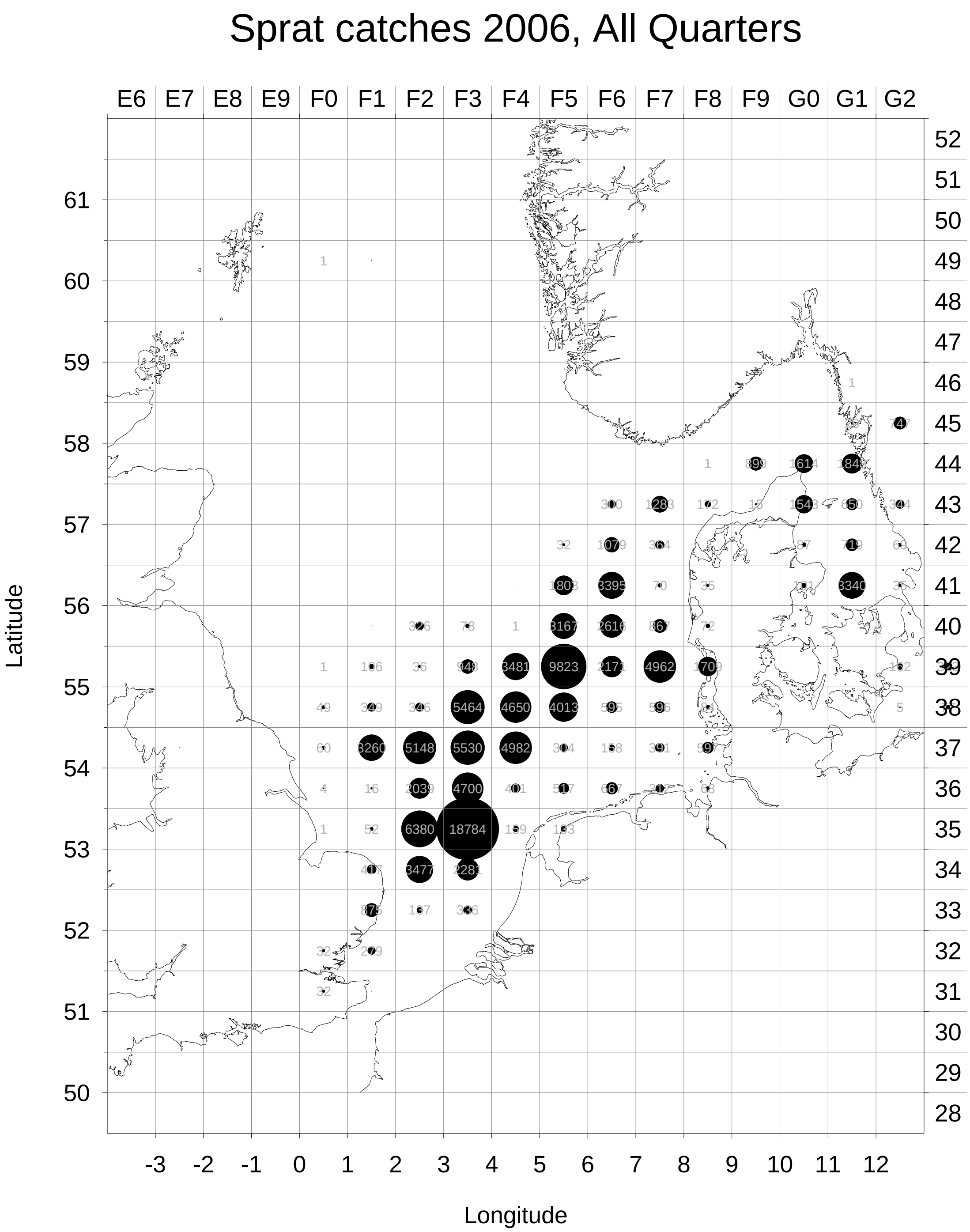


Figure 8.1.2. Sprat catches (in tonnes) in the North Sea and Div. IIIa in 2006 by statistical rectangles. Working group estimates.

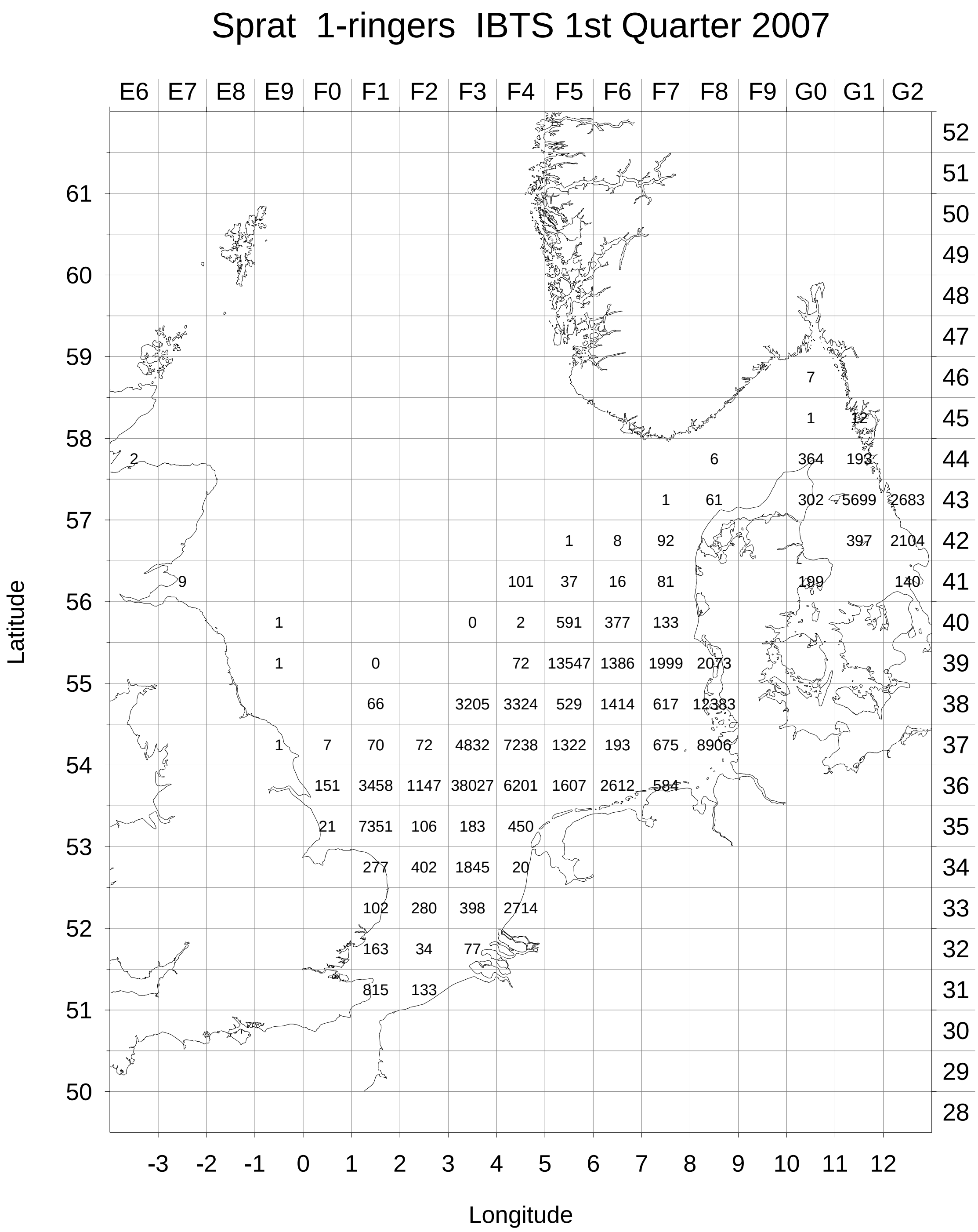


Figure 8.3.1a. Sprat. Distribution of age group 1 in the IBTS (February) 2007 in the North Sea and Division IIIa (Mean number per hour per rectangle).

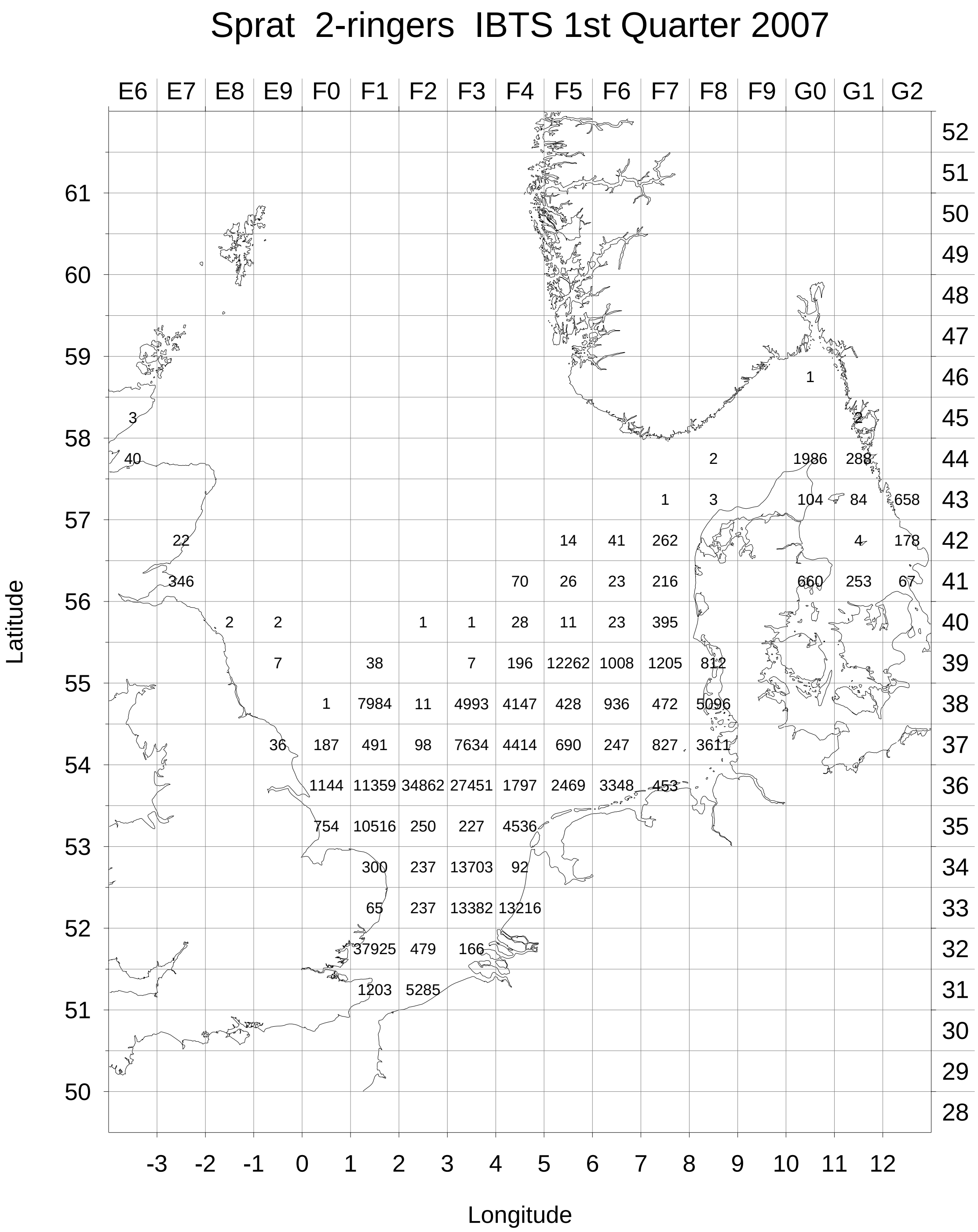


Figure 8.3.1b. Sprat. Distribution of age group 2 in the IBTS (February) 2007 in the North Sea and Division IIIa (Mean number per hour per rectangle).

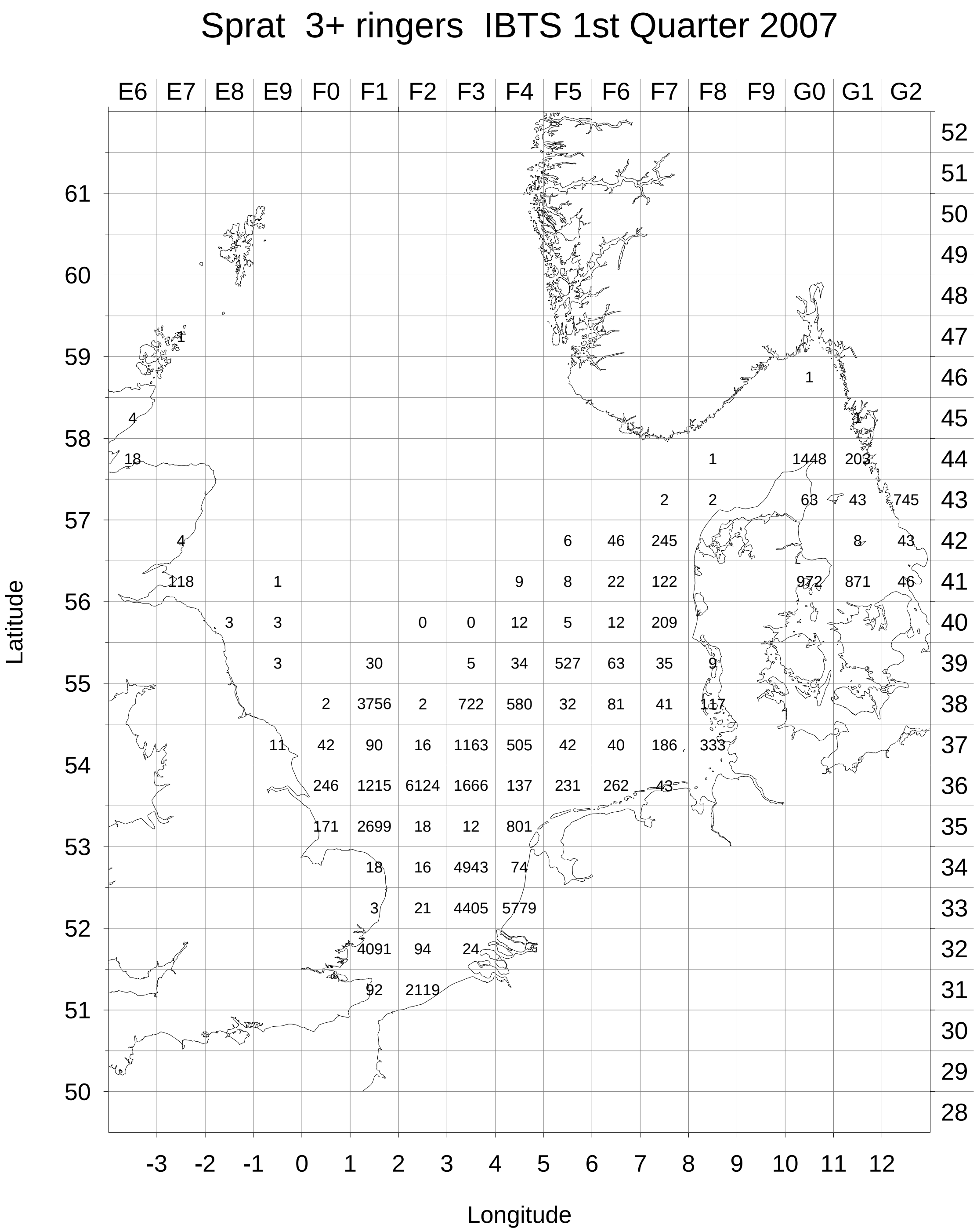


Figure 8.3.1c. Distribution of age group 3+ in the IBTS (February) 2007 in the North Sea and Division IIIa (Mean number per hour per rectangle).

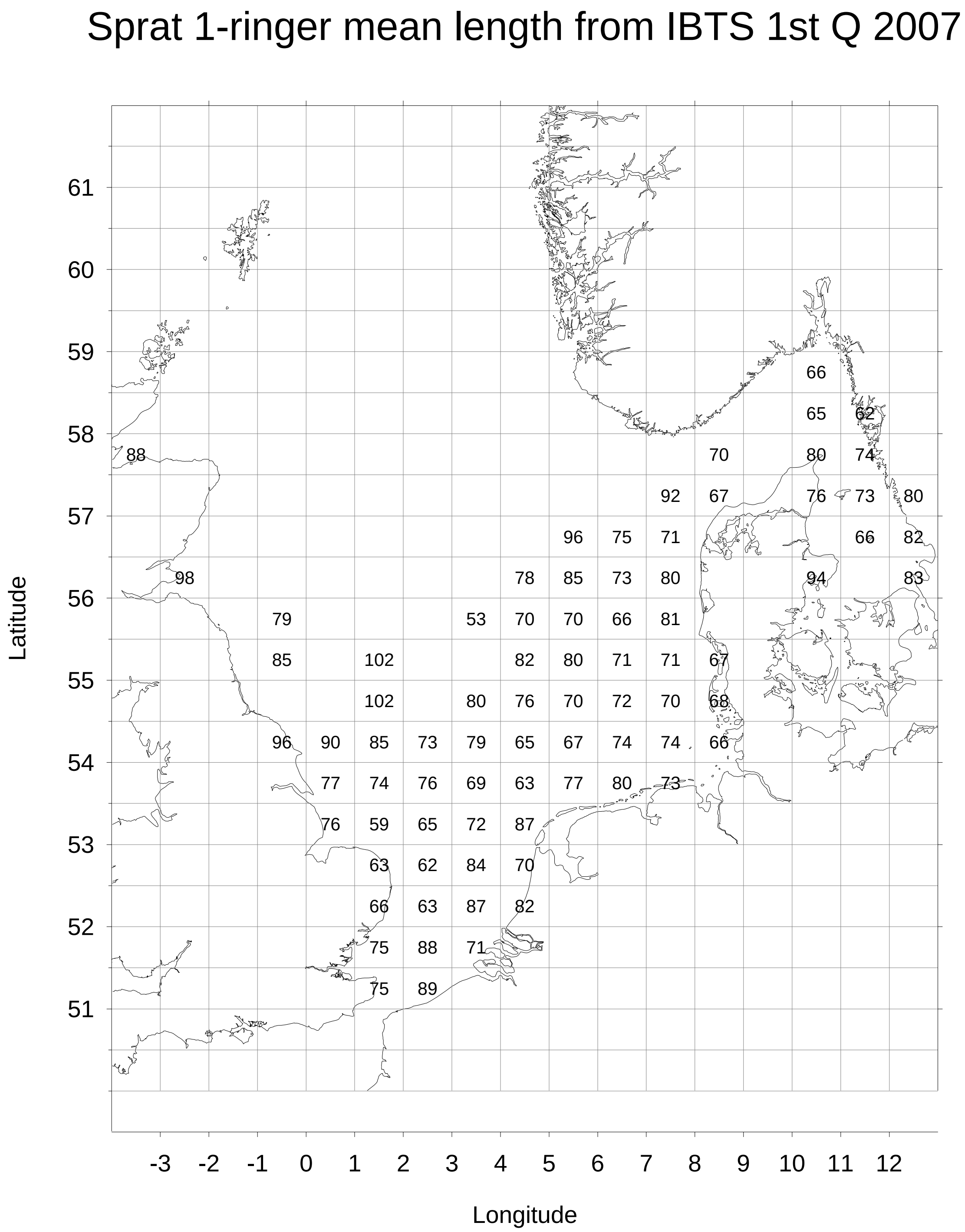


Figure 8.3.2. SPRAT. Mean length (mm) of age group 1 in the IBTS (February) 2007 in the North Sea and Division IIIa.

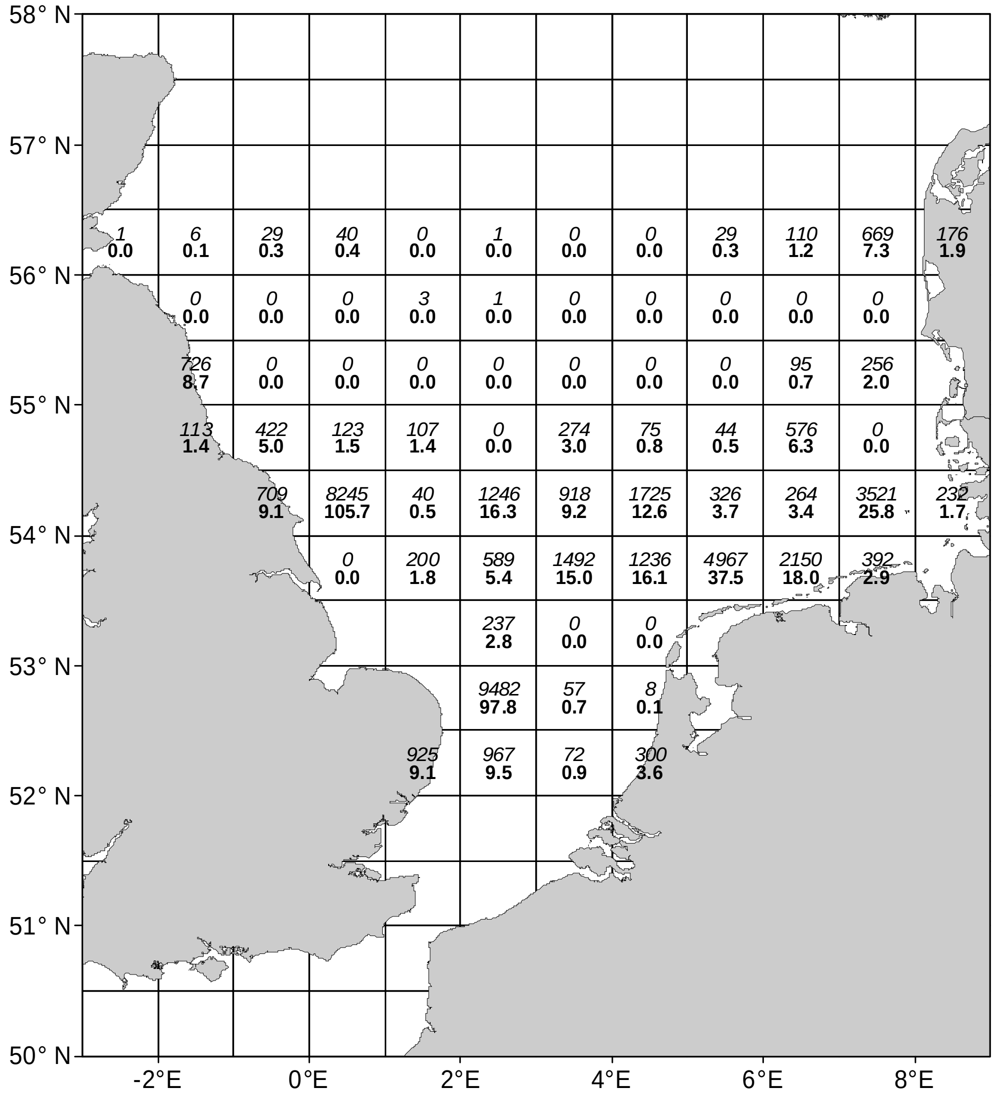


Figure 8.3.3. North Sea Sprat. Acoustic survey 2006. Abundance (upper figure in italics, in million individuals) and biomass (lower figure in bold, in kt) per statistical rectangle.

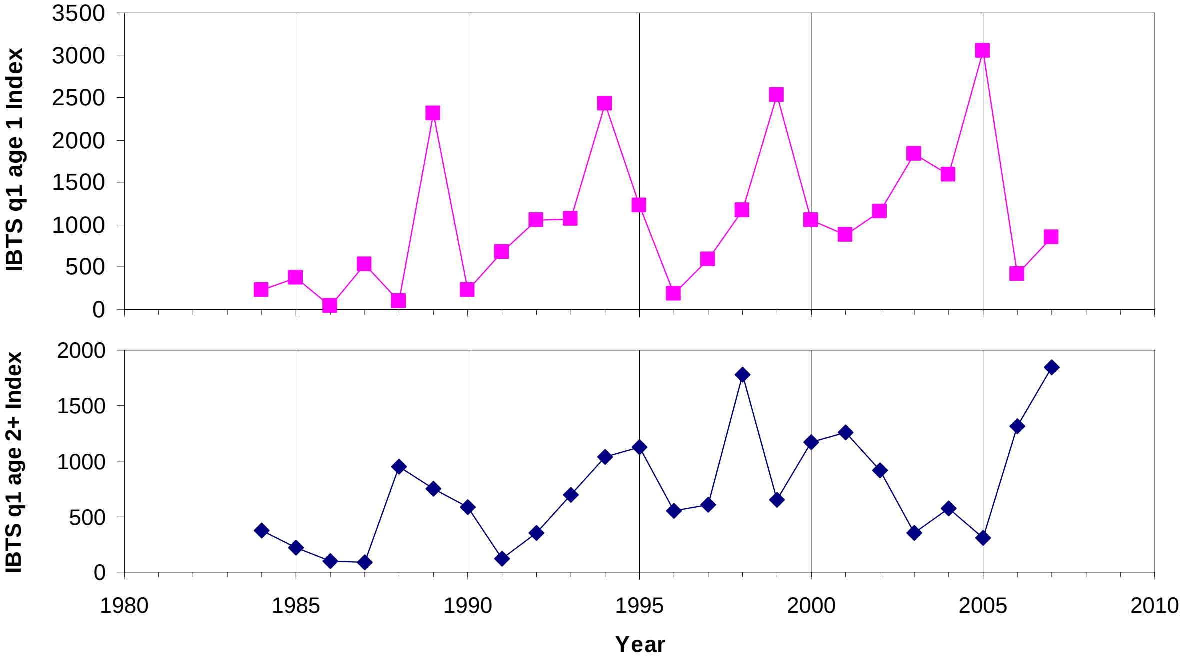


Figure 8.6.1 North Sea sprat. Observed IBTS survey indices for the period 1984 – 2007. Upper figure: recruits (age 1). Lower figure: adults (age 2+).

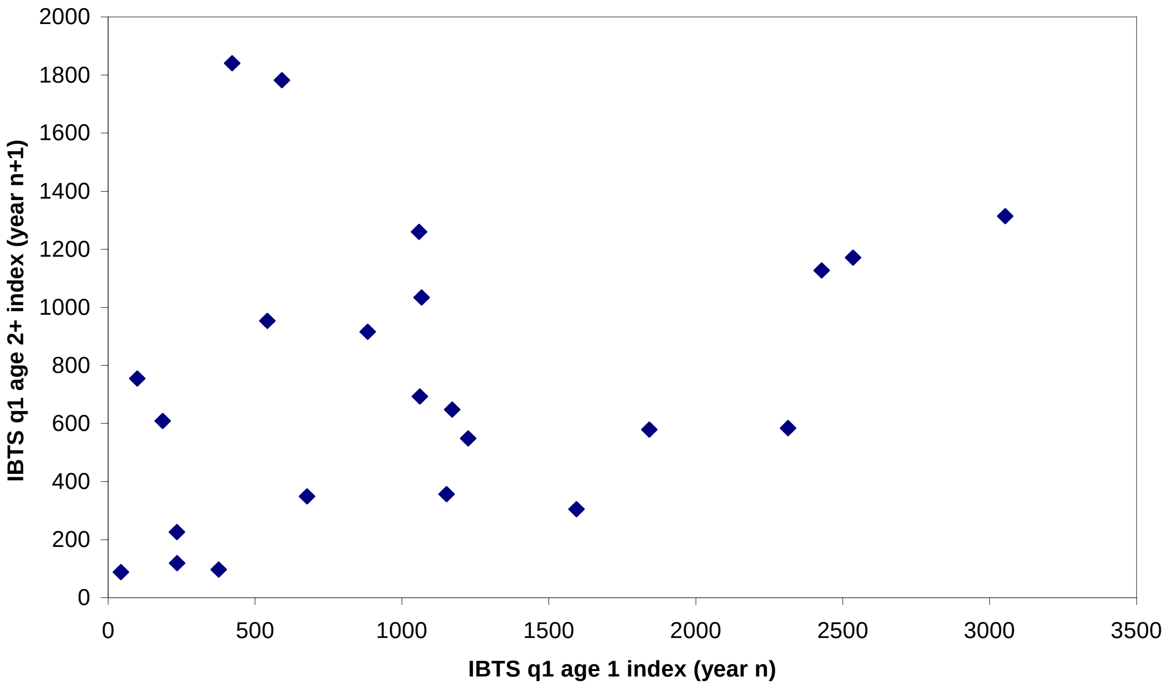


Figure 8.6.2 North Sea sprat. Correlation between age 1 IBTS index and age 2+ index in the following year. The correlation between the parameters is weak (R^2 = 0.05).

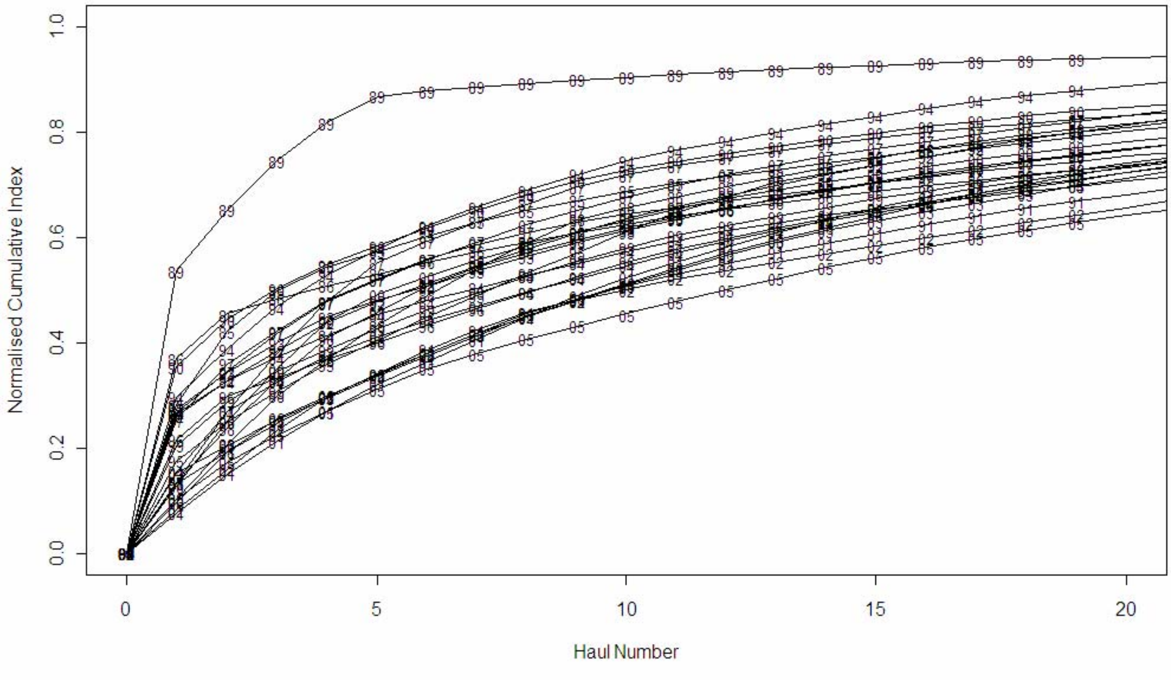


Figure 8.6.3 North Sea sprat. Normalised cumulative-distribution of the per-haul contribution to the IBTS q1 sprat age 1 survey index. The 300-450 individual-haul contributions to the IBTS index in each year are sorted by size and then aggregated to calculate a cumulative-distribution. The plot shows only the contributions for the 20 largest hauls. Numbers on each line indicate the year for the survey. Similar trends are seen for the IBTS q1 age 2+ index.

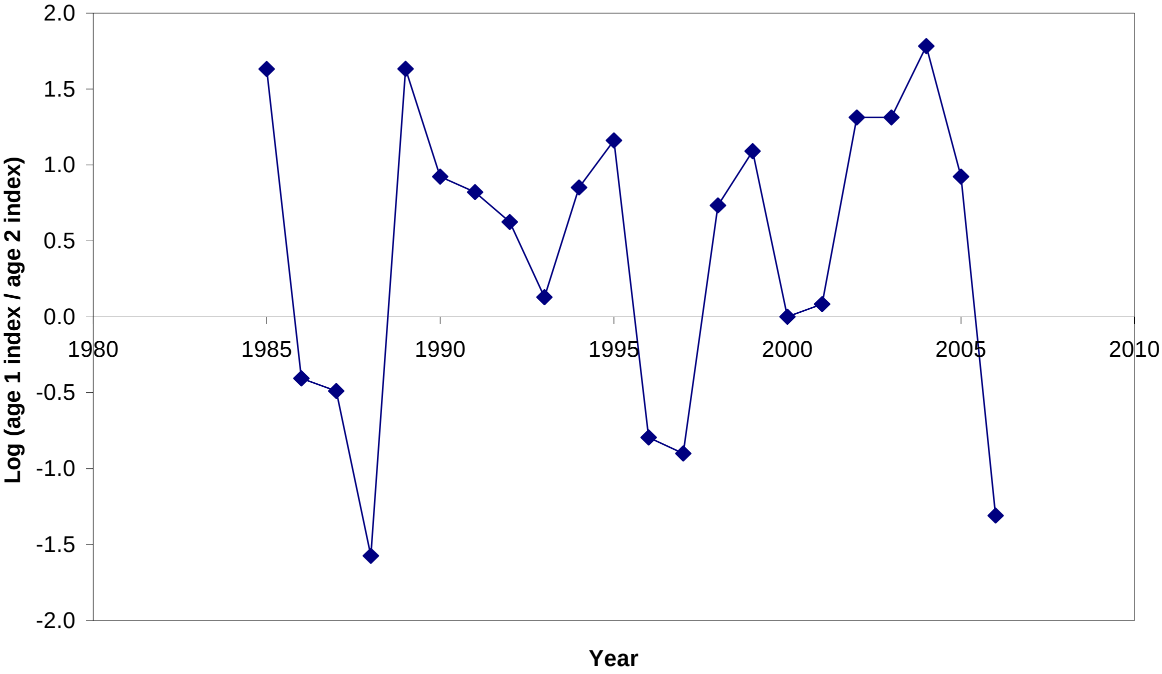


Figure 8.6.4 North Sea sprat. Log of the ratio between the age 1 IBTS index and the age 2 index in the subsequent year.

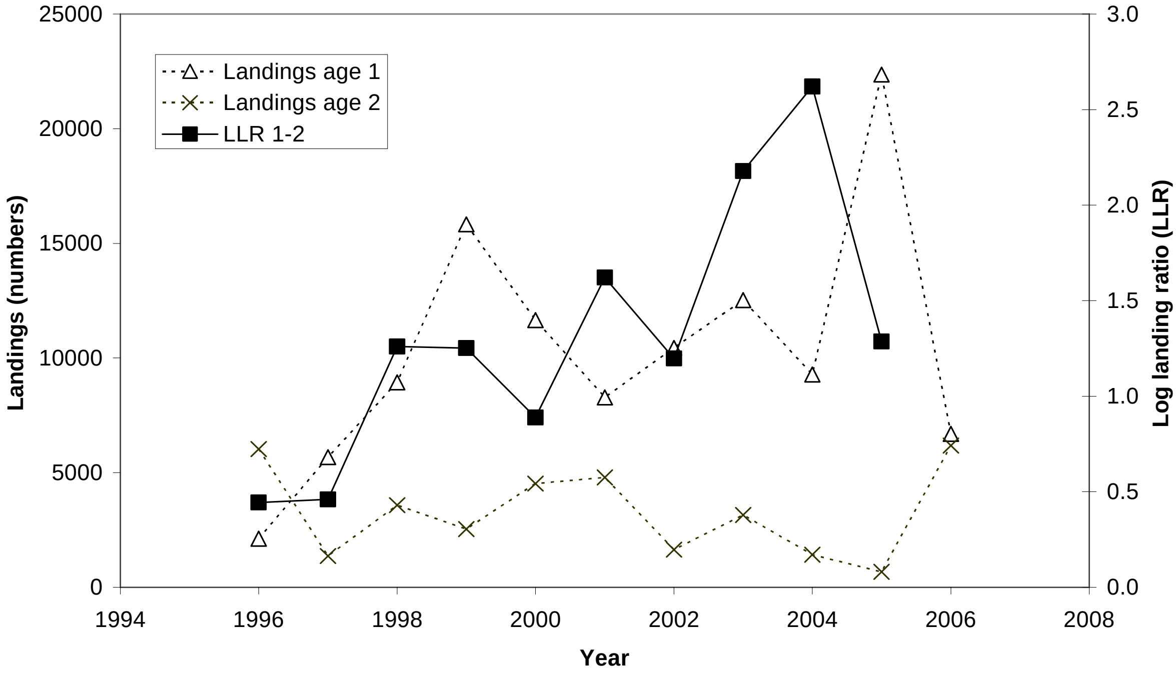


Figure 8.6.5 North Sea sprat. Log of the ratio between landings in two subsequent years from the same year class. The years indicated are landing years and the first in the pair for log landing ratios.

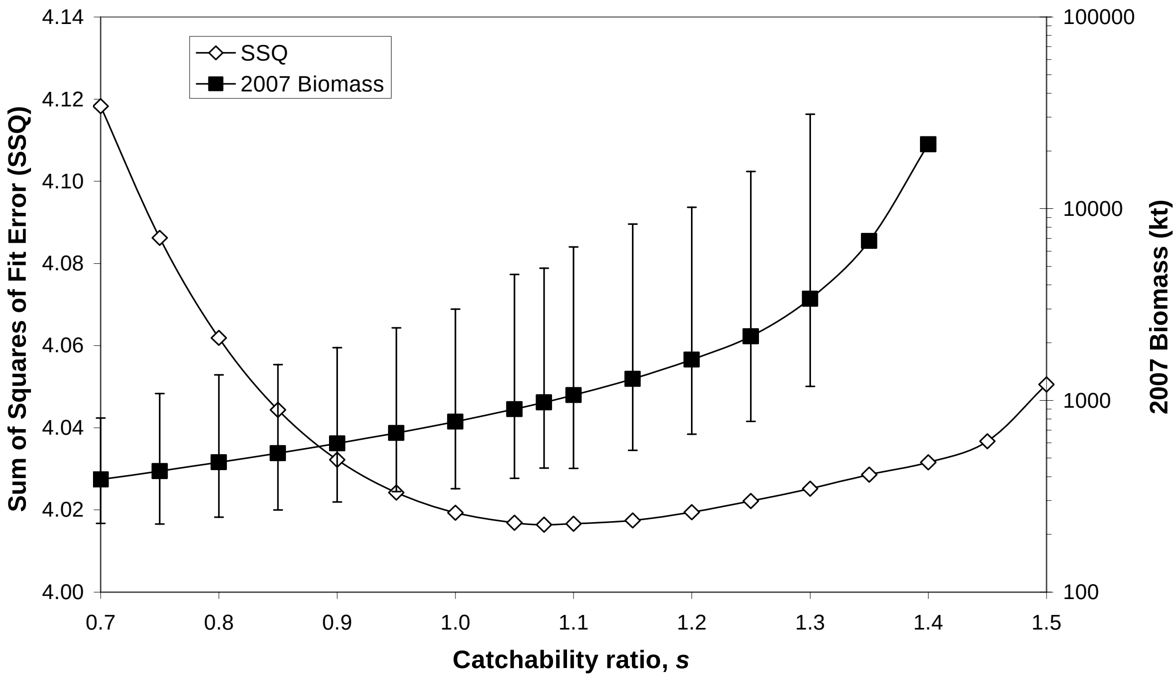


Figure 8.7.1 North Sea sprat. Fit of the CSA model (as described by the sum of squares of the fit error, SSQ) and estimated 2007 total stock biomass for a range of values of the catchability ratio s = q_1/q_{2+}. Note that the estimated 2007 biomass is plotted on a logarithmic scale. Error bars represent a 90% confidence interval in the biomass, estimated using the non-parametric bootstrapping algorithm in the CSA software. A minima in the *s* vs SSQ plot occurs at approximately *s* = 1.075

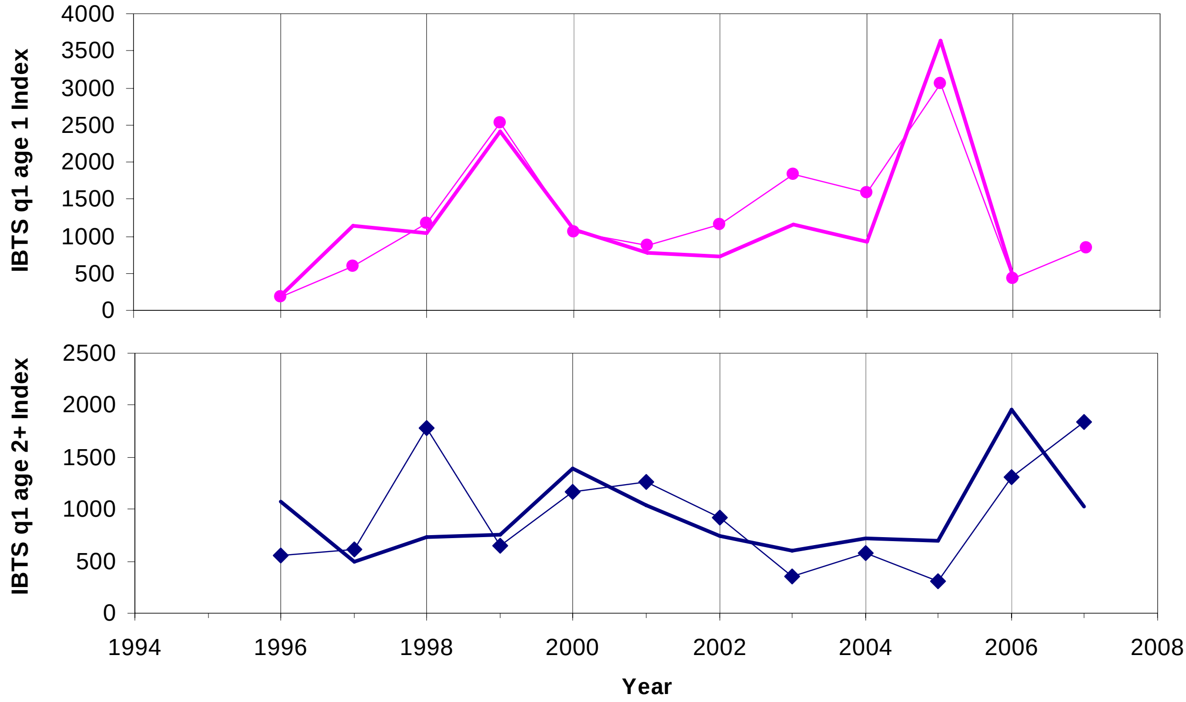


Figure 8.7.2 North Sea sprat. Comparison of the IBTS q1 indices (points with thin line) with the fit obtained from the CSA model (thick line). Upper figure: age 1 (recruits) group. Lower figure: age 2+ (mature) group.

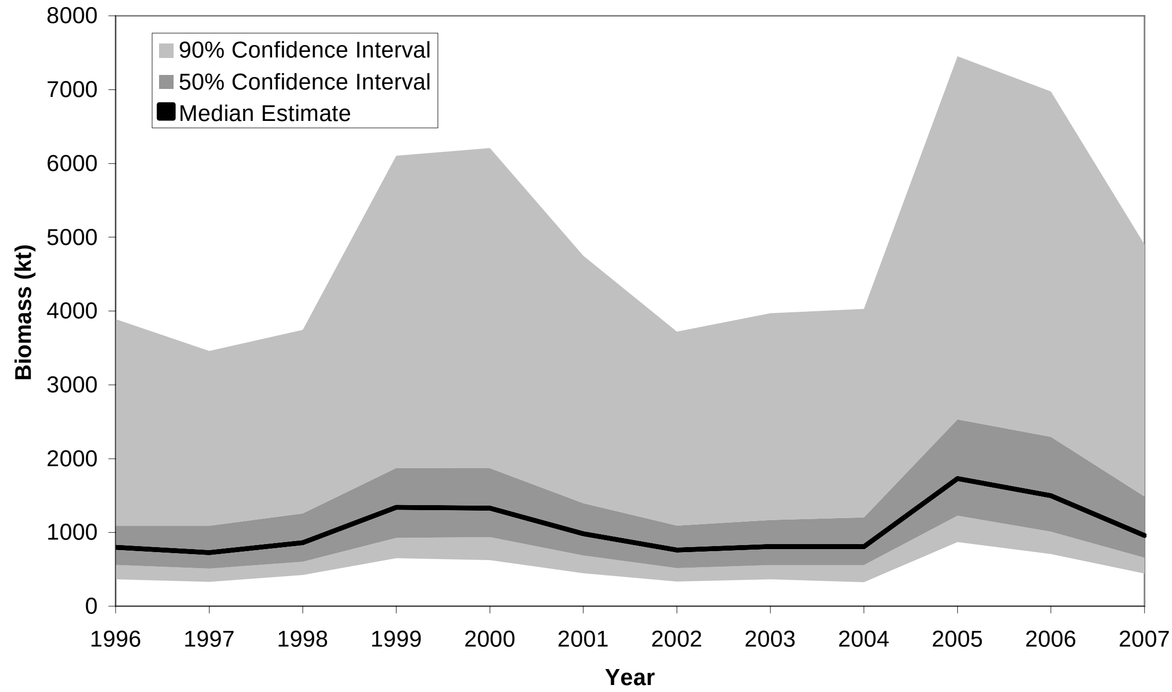


Figure 8.7.3 North Sea sprat. Biomass and associated confidence intervals for the time period 1996-2007 as estimated by CSA for a catchability ratio of 1.075 and a natural mortality of 0.75.

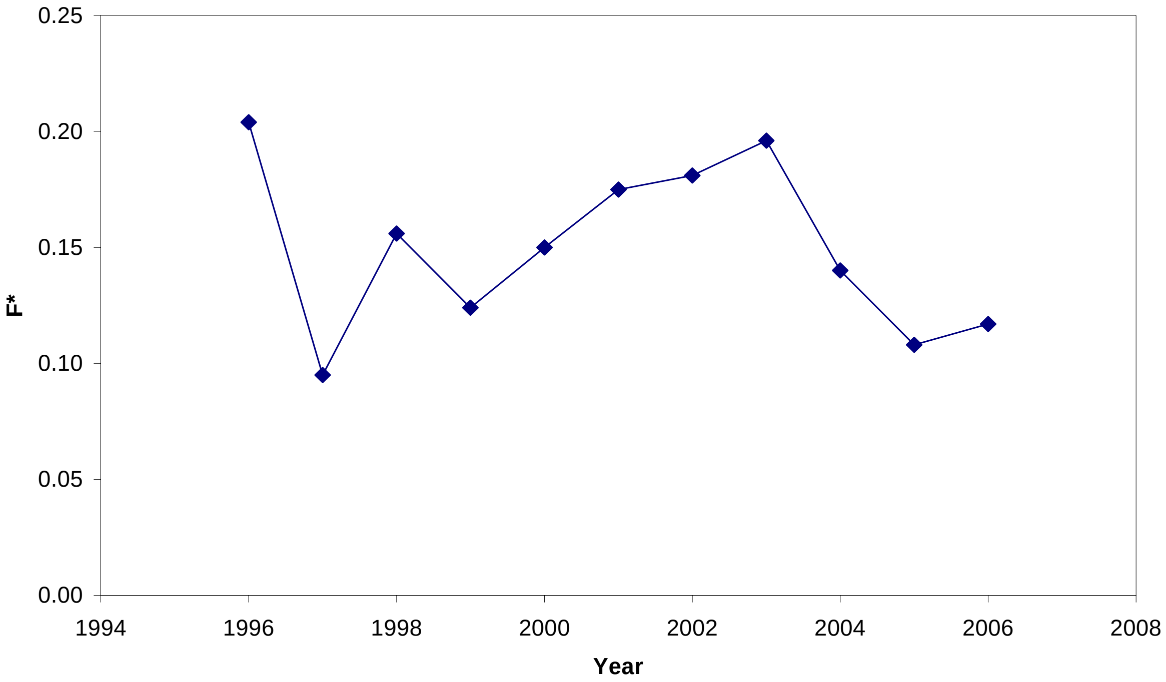


Figure 8.7.4 North Sea sprat. Effective fishing mortality (F*) as estimated by the CSA model for a natural mortality of 0.75 and a catchability ratio of *s* = 1.075.

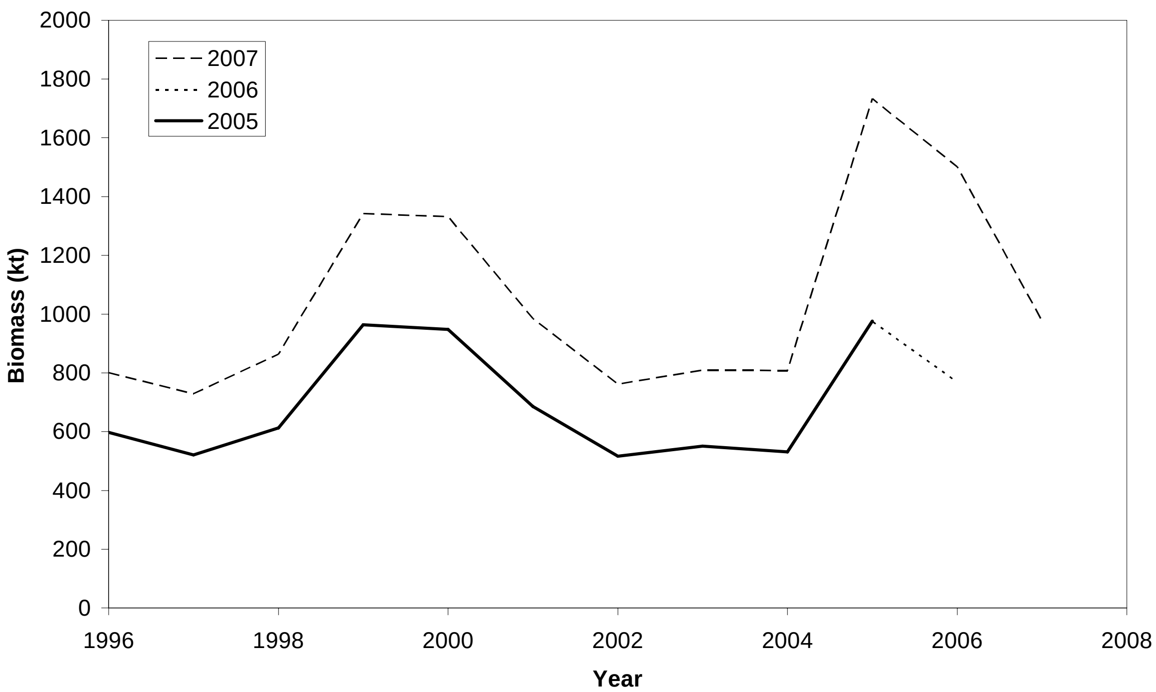


Figure 8.7.5 North Sea sprat. Retrospective analysis of biomass using the CSA model with a natural mortality of 0.75 and catchability ratio, *s* = 1.075.

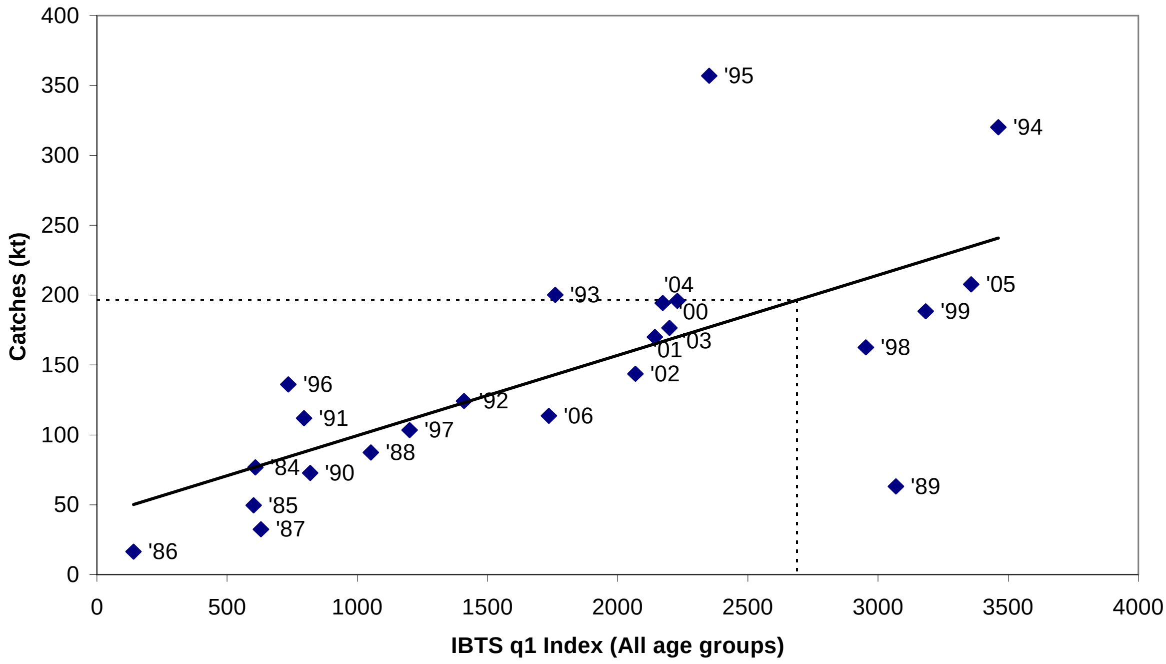


Figure 8.8.1 North Sea sprat. IBTS q1 indices vs total catch (1984-2006). A fitted regression line results in an R^2 coefficient of 0.47. The dotted line indicates the IBTS q1 index from 2007 (2688) and gives an estimated 2007 catch of 196 kt. Labels on the plot indicate the year in which the catch was taken.

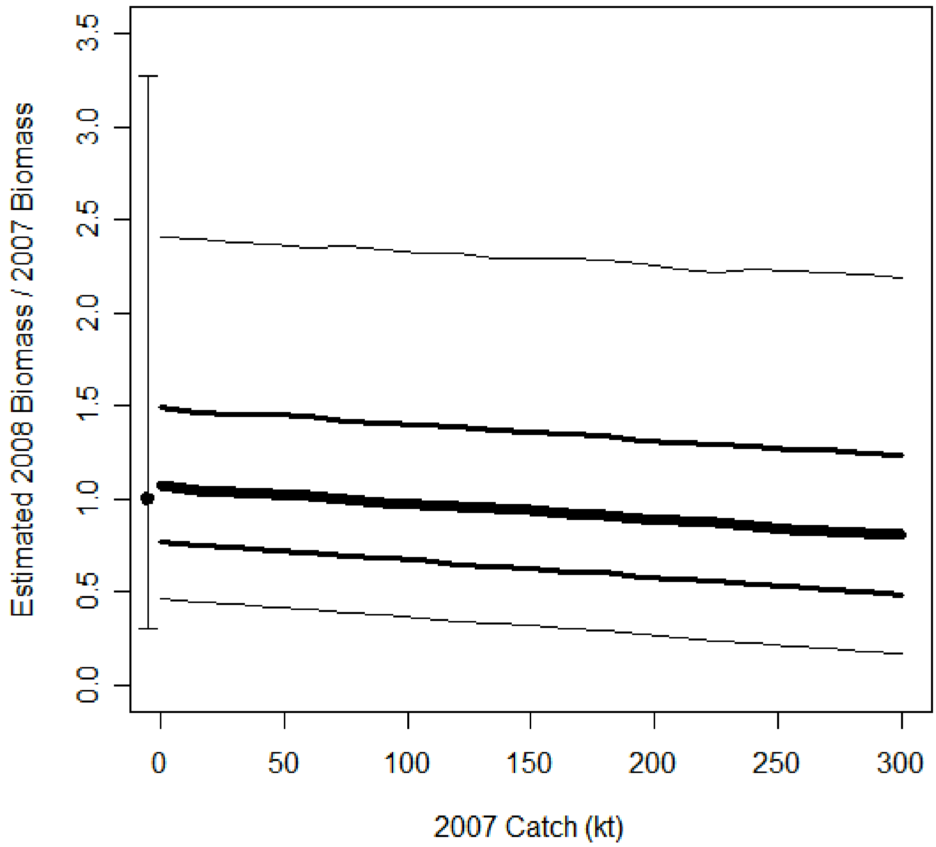


Figure 8.8.2 North Sea sprat. 2008 sprat biomass (normalised by the estimated 2007 biomass) forecast as a function of the 2007 sprat catch. The heavy central line represents the median estimate, with the lighter lines encompassing the 50% confidence interval and the lightest outlines covering the 90% interval. The point to the furthest left-hand side of the figure shows the estimated 2007 with 90% error bars. The forecast was prepared based on data from a CSA model run with s=1.075 and a natural mortality of 0.75.

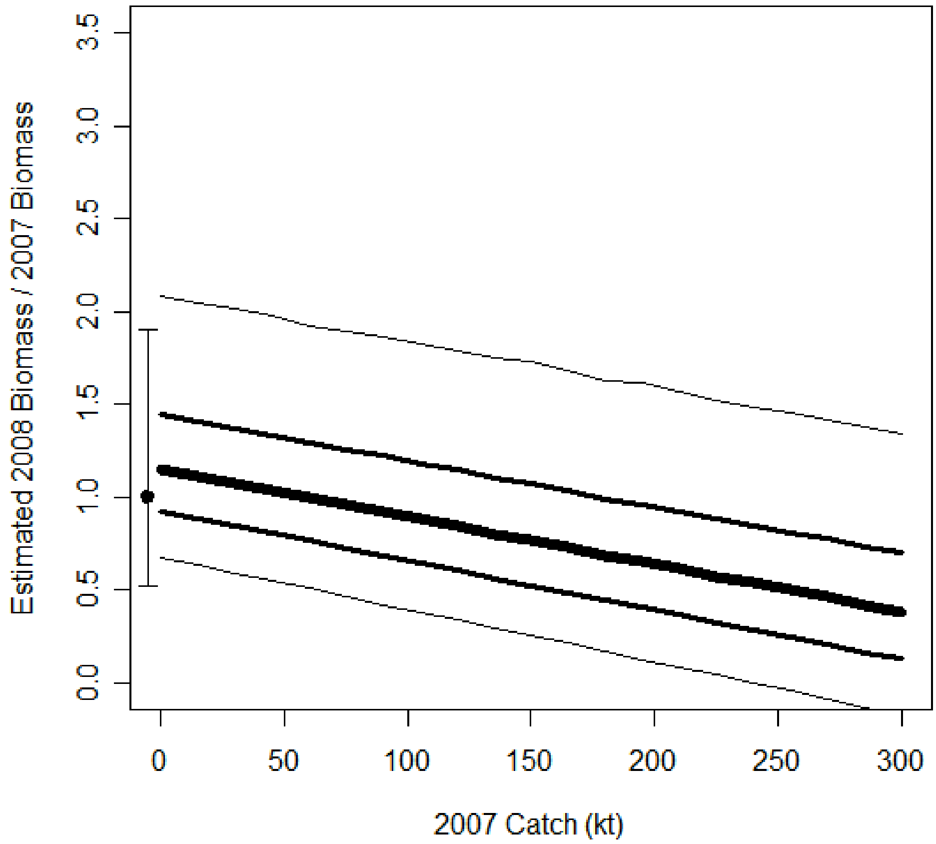


Figure 8.8.3 North Sea sprat. 2008 forecast biomass as a function of 2007 catch for the catchability ratio, s, of 0.7. All other parameters, including the axes of the figure, are the same as for Figure 8.8.2.

9 Sprat in Division IIIa

9.1 The Fishery

9.1.1 ACFM advice applicable for 2006 and 2007

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. No ACFM advice on sprat TAC has been given in recent years. The sprat TAC for 2006 was 52 000 t, with a by-catch quota of herring of 20 528 t for the EU fleet. For 2007 the TAC is set at 52 000t and the by-catch of herring at 15 396t.

9.1.2 Landings

The total landings almost doubled from 2004 to 2005 but decreased in 2006 to 12 570 t, the lowest landings since 1993 (Table 9.1.1). The table present the landings from 1996 onwards. Due to the implementation of the new Danish monitoring scheme, the data from 1996 and onwards are considered reliable in this context.

The reduction in landings in 2006 were mainly in the Danish fishery and seen in both Skagerrak and Kattegat. The Norwegian and Swedish landings include the coastal and fjord fisheries. 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). In the first quarter, most of the landings were from Kattegat. Later in the year the landings are mainly reported from the outer Skagerrak (Figures 8.1.1–8.1.2). In 2006 more than 65% of the total landings were taken in the 1st quarter. In the Norwegian fishery minor landings were taken in the 1st and 4th quarter.

The Danish monitoring scheme for management purposes for species composition in the landings of the Danish small-meshed fisheries has worked well in 2006. A total of 106 samples were collected from all small meshed landings taken in Division IIIa by Danish vessels in 2006. The sampling figure for 2005 was 315 samples. The decrease in number of samples is caused by a significant decrease in total landings for the area. The total landings from the Danish small mesh fishery in 2006 were 20,600 t (all species) compared to 56,800 t in 2005.

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 cod end and all 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.

There is a Swedish fishery directed at sprat with by-catches of herring. There is also a fishery carried out with small purse seiners at the West Coast of Sweden for human consumption.

The Norwegian sprat fishery in Division IIIa is a coastal/fjord purse seine fishery for human consumption.

9.2 Biological Composition of the Catch

9.2.1 Catches in number and weight-at-age

Total numbers of sprat taken in Div. IIIA in 2006, were the lowest for the period 1996-2006 (Table 9.2.1). Sprat of the 2004-year class (age 2) made more than 50% of the total numbers and was one of the largest 2-groups. Most of them were taken in the first quarter. In 2005, the same year class represented approximately 90% of the total number. The overall mean weight of the 2-group in 2006 were smaller than in 2005 (Table 9.2.2).

Denmark provided biological samples from all the quarters while Sweden provided biological samples from three of the quarters. No Norwegian samples were collected. Landings in 2006, 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.

9.3 Fishery-independent information

Acoustic estimates of sprat have been available from the ICES co-ordinated Herring Acoustic surveys in Div. IIIa since 1996. At the time of the surveys, sprat has mainly been recorded in the Kattegat (ICES CM 2006/LRC:04).

In 2005 the abundance and total biomass of sprat in the Kattegat was estimated to 4 570 million individuals, equivalent to 54,000 tonnes. In the south western part of the Skagerrak the respective figures were about 490 million individuals, equivalent to 5,800 tonnes.

In 2006 sprat was observed in the ICES squares 41G1-G2, 42G1-G2 and 44G0-G1, all in the Kattegat. The abundance and total biomass were estimated to 2 242 million individuals, a decrease of more than 50% compared to the previous year. The biomass was estimated to 34, 000t, of which immature fish made 63%.

The IBTS (February) sprat indices for 1984-2006 are presented in Table 9.3.1. The IBTS data are provided by rectangle in Figure 8.3.1 for age groups 1, 2 and 3+, and the mean length (mm) of 1-ringer sprat in Figure 8.3.2. 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.

The 2007 total IBTS index for 2007 declined compared to 2006-index which was very high, and the highest for the time series. This year the total index was one of the lowest for the period. The very strong 2004-year class, representing 77% of the total index last year, was not showing up as an extraordinary year class as 3 years old. The extraordinarily high index for 2-group sprat last year was based on one single haul, which gives rise to doubts over the validity of this index-value.

9.4 Mean weight-at-age

Mean weights-at-age (g) in the catches are presented, by quarter, in Table 9.2.2. The table includes mean weights-at-age for 1996-2005 for comparison. These have been very variable over time, but whether this is due to actual variation in mean weight or difficulties in ageing of sprat is uncertain.

9.5 Recruitment

For this stock the IBTS index for 1-group sprat in the first quarter is considered the most suitable recruitment index. The 1-group index for 2006 is at the level of the average for the time-series (1984-2006). The procedure for the survey did not differ from previous years. However, the index does not fully reflect strong and weak cohorts in sprat seen in the catch. This was also expressed in previous working group report (ICES 1998 ACFM :14). This can still be linked to difficulties in age determination

9.6 State of the Stock

No assessments of the sprat stock in Division IIIa have been presented since 1985 and this year is no exception. A Schaefer model was fit to the data in 1999 (ICES 1999/ACFM:12) but that attempt was not successful and was subsequently abandoned. In 2003 and 2004 the Working Group agreed to explore the data for sprat in Division IIIa by means of Catch-Survey Analysis (CSA) as performed for sprat in the North Sea (ICES 2003/ACFM:17). This was re-done last year with the time series 1994-2005. The mean weights used were the same as for the North Sea, except for the three most recent years, where mean weight at age was available from the IBTS database. The attempt was not successful, suggesting scaling problems and input-data problems, which have not yet been solved by the working group. No new input-data was available for the HAWG, thus no exploratory CSA-runs were made this year.

The signal in the IBTS (February)-index for 2007 indicates a decrease in the sprat stock from last year and appears to be one of the lowest for the time-series 1984-2006.

9.7 Projection of Catch and Stock

There is no relationship between the IBTS (February) index (no./h) and the total catch in the same year and the index is not considered useful for management of sprat in Division IIIa.

9.8 Reference Points

There are no reference points defined for this stock.

9.9 Management Considerations

Sprat in Division IIIa is short-lived 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, except for 1994 and 1995 when a directed sprat fishery was carried out with low by-catches of herring. The human consumption fishery takes only a minor proportion of the total catch. With 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 fishery was limited by quota restriction on sprat and not by by-catch restrictions on herring. The same situation may occur in 2007.

Attempts to assess this stock have demonstrated the need for:

- Development of a suitable biomass index
- Improvement of the ageing techniques

Effort should be allocated into the development of a more suitable method for projection of catch and stock. There is also a need for better knowledge of spawning seasons and possible recruitment from the North Sea stock.

Table 9.1.1 Division IIIa sprat. Landings in ('000 t) 1996-2006.
(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	0.0	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

Table 9.1.2. Division IIIa sprat. Landings of sprat ('000 t) by quarter by countries, 1996-2006.
(Data provided by the Working Group members)

	Quarter	Denmark	Norway	Sweden	Total
1996	1	5.6	+	4.2	9.8
	2	3.4		0.2	3.6
	3	+	0.4	+	0.4
	4	1.4	0.6	2.2	4.2
	Total	10.4	1.0	6.6	18.0
1997	1	0.7	-	0.3	1.0
	2	0.4	-	1.2	1.6
	3	2.3	-	0.1	2.4
	4	8.2	0.4	2.2	10.8
	Total	11.6	0.4	3.8	15.8
1998	1	4.0	0.1	0.1	4.2
	2	0.9		+	0.9
	3	1.1	0.3	0.4	1.8
	4	5.4	0.7	5.7	11.7
	Total	11.4	1.1	6.1	18.6
1999	1	3.5	0.0	4.0	7.5
	2	0.1		0.2	0.3
	3	7.4	0.1	1.9	9.4
	4	6.2	0.1	3.3	9.6
	Total	17.2	0.2	9.3	26.7
2000	1	4.1	0.1	2.3	6.5
	2	0.0		1.9	1.9
	3	4.8	0.1	0.0	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	0.0	1.4	5.2
	2	2.1		0.4	2.4
	3	5.9	0.0	0.1	6.0
	4	1.7	0.0	2.4	4.1
	Total	13.4	0.0	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	0.0	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

+ Catch record, but amount not precisely known.

[1] Preliminary figures

Table 9.2.1 **Division IIIa sprat**. Landed numbers (millions) of sprat by age groups in 1996-2006.

	Quarter	Age						Total
		0	1	2	3	4	5+	
1996	1		288.42	546.53	62.11	15.65	5.07	917.78
	2		0.89	414.10	42.76	0.71	0.06	458.51
	3		0.34	1.81	0.30	0.02		2.47
	4		31.19	165.65	27.34	2.03		226.21
	Total		320.84	1128.08	132.51	18.41	5.13	1,604.97
1997	1			3.43	18.31	20.60	4.59	46.94
	2		1.00	2.76	19.56	1.51	0.25	25.07
	3	4.35	209.25	9.51	1.92	6.24		231.26
	4	32.39	644.28	58.31	7.16	28.02		770.16
	Total	36.74	854.53	74.01	46.95	56.37	4.84	1,073.43
1998	1		14.91	103.38	94.00	76.99	6.34	295.61
	2		3.24	21.49	20.59	16.63	1.33	63.28
	3	53.62	26.03	41.84	5.65	0.74		127.88
	4	192.13	253.98	226.55	53.14	29.80		755.61
	Total	245.75	298.16	393.25	173.38	124.17	7.67	1,242.38
1999	1	0.0	560.5	158.0	151.2	77.4	6.8	953.9
	2		32.8	1.6	1.7	1.1	0.3	37.6
	3	9.6	741.7	46.7	6.3	5.9		810.0
	4	8.5	645.4	20.5	6.8	0.6	0.3	682.1
	Total	18.0	1,980.4	226.8	166.0	85.0	7.4	2,483.6
2000	1		116.6	384.3	40.3	7.3	1.6	550.0
	2		17.3	127.4	11.2			155.9
	3	2.1	223.3	51.4	12.2			289.1
	4	18.0	277.6	81.4	13.1	0.8		390.9
	Total	20.2	634.8	644.6	76.8	8.1	1.6	1,386.0
2001	1	0.0	342.6	173.0	73.3	10.0	1.6	600.4
	2	0.0	1746.4	13.4	0.4	0.0	0.0	1,760.2
	3	5.7	924.1	31.7	0.0	0.0	0.0	961.5
	4	22.9	488.1	39.1	18.5	1.5	0.5	570.6
	Total	28.6	3,501.2	257.2	92.2	11.5	2.1	3,892.8
2002	1	0.0	63.8	323.2	38.5	24.7	2.4	452.6
	2	0.0	185.5	63.2	4.8	1.0	0.0	254.5
	3	1.3	326.2	102.0	23.9	6.6	0.6	460.5
	4	21.3	205.4	45.9	10.6	5.9	0.4	289.6
	Total	22.5	780.9	534.3	77.9	38.2	3.4	1,457.2
2003	1	0.0	17.5	221.4	100.7	17.6	4.3	361.5
	2	0.0	2.6	49.8	24.0	5.5	2.1	84.1
	3	192.7	10.9	31.6	5.4	2.7	0.0	243.3
	4	321.6	131.7	100.6	42.5	3.4	2.3	602.2
	Total	514.3	162.7	403.4	172.6	29.2	8.8	1,291.1
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	1,302.3
	Total	883.9	1,197.5	113.9	121.1	38.3	9.3	2,364.2
2005	1	0.0	1609.1	185.6	25.5	17.4	5.1	1,842.7
	2	0.0	827.1	19.2	0.6	0.0	0.0	846.9
	3	1.8	1557.0	91.3	9.9	12.9	0.0	1,672.9
	4	11.5	447.4	60.5	7.3	4.0	0.7	531.3
	Total	13.4	4,440.6	356.6	43.3	34.2	5.8	4,893.9
2006	1	0.0	219.8	433.3	93.7	16.6	10.3	773.7
	2	0.0	7.5	17.8	1.6	0.3	0.0	27.2
	3	0.0	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	1,018.0

Table 9.2.2. **Division IIIa Sprat.** Quarterly mean weight-at-age (g) in the landings.
(1998-2006 Danish and Swedish data, 1996-1997 Danish data, 2006)

Year	Age							SOP
	Quarter	0	1	2	3	4	5+	Corrected landings
1996	1		9.2	10.6	14.2	17.4	17.7	9,724
	2		8.6	12.5	15.1	17.4	17.0	5,847
	3		4.2	10.9	15.5	21.0		26
	4		4.2	10.9	15.5	21.0		2,403
Weighted mean			8.7	7.6	14.8	19.6	17.7	18,000
1997	1			17.3	18.6	21.8	26.0	968
	2		8.3	17.6	20.0	22.1	31.0	489
	3	4.1	13.6	17.2	21.1			3,062
	4	4.7	14.7	17.5		19.5		11,176
Weighted mean		4.6	14.4	17.5	19.6	20.4	26.3	15,696
1998	1		6.6	14.0	18.0	19.0	21.3	4,828
	2		6.6	13.9	17.8	18.7	21.0	1,027
	3	4.6	17.7	20.7	22.1	24.7		1,718
	4	4.8	17.5	20.4	22.5	27.5		11,998
Weighted mean		4.8	16.9	18.5	19.6	21.2	21.2	19,570
1999	1		4.6	6.4	17.3	13.4	13.1	7,319
	2		5.3	17.1	18.6	22.2	17.8	264
	3	3.0	11.4	12.6	16.8	18.3		9,257
	4	4.8	13.9	17.6	20.8	21.2	23.5	9,521
Weighted mean		3.8	10.2	8.8	17.4	13.9	13.7	26,361
2000	1		5.3	13.1	15.3	20.7	22.7	6,438
	2		5.2	12.8	14.1			1,873
	3	4.3	16.6	18.0	21.9			4,897
	4	7.0	16.9	19.9	22.1	24.6		6,742
Weighted mean		6.7	14.3	14.3	17.3	21.1	22.7	19,949
2001	1		3.8	14.3	16.2	17.8	17.3	5,168
	2		3.7	6.5	21.0			6,598
	3	5.3	10.5	12.1		13.0		10,114
	4	5.1	12.0	19.7	22.6	19.3	25.6	7,200
Weighted mean		5.1	6.7	14.5	17.5	18.0	19.2	29,079
2002	1		5.7	12.7	17.3	19.3	20.6	5,411
	2		7.9	13.7	16.0	17.0		2,175
	3	8.0	12.4	15.1	18.1	17.0	17.0	5,900
	4	5.7	15.6	18.2	21.6	21.5	22.0	4,278
Weighted mean		5.8	11.6	13.7	18.1	19.2	20.1	17,763
2003	1		6.0	14.1	16.2	18.9	23.8	5,293
	2		5.0	16.0	17.6	21.6	22.8	1,401
	3	4.0	12.0	19.0	19.0	21.0		1,661
	4	8.9	16.4	21.1	21.7	25.2	24.3	8,211
Weighted mean		7.1	14.8	16.5	17.8	20.3	23.7	16,565
2004	1		4.6	14.6	17.8	17.3	17.3	4,392
	2		7.0	13.6	16.7	17.0	19.5	1,532
	3	3.0	14.1	16.7	20.0	21.4		4,075
	4	3.5	16.8	19.9	22.2	20.9	28.0	10,508
Weighted mean		3.5	10.4	16.3	18.4	17.8	17.9	20,508
2005	1		3.0	14.6	16.3	20.3	21.1	8,149
	2		5.4	11.7	26.8	0.0		4,723
	3	2.9	11.9	14.6	15.4	11.0		20,130
	4	3.3	13.1	19.1	20.1	21.1	23.1	7,300
Weighted mean		5.0	7.6	15.4	17.1	17.2	21.5	40,301
2006	1		5.0	12.2	15.4	15.2	18.5	8,279
	2		7.0	13.3	16.3	22.0		324
	3		11.2	17.4	20.3	18.6	22.8	1,440
	4	4.3	16.1	19.6	21.4	23.8	26.6	2,464
Weighted mean		4.3	6.8	13.6	16.8	16.1	19.4	12,507

Table 9.2.3 **Division IIIa sprat.** Sampling commercial landings for biological samples in 2006.

Country Area	Quarter	Landings (tonnes)	No. samples	No. meas.	No. aged
Denmark	1	5,428	31	3,132	3,024
	2	168	1	100	98
	3	1,343	13	1,319	1,319
	4	880	7	585	577
	Total	7,819	52	5,136	5,018
Norway	1	174	0	0	0
	2	-			
	3	-			
	4	129	0	0	0
	Total	303	0	0	0
Sweden	1	2,677	9	662	662
	2	156	1	76	76
	3	97			0
	4	1,455	11	697	697
	Total	4,385	21	1,435	1,435
Denmark		7,819	52	5,136	5,018
Norway		303	0	0	0
Sweden		4,385	21	1,435	1,435
	Total	12,507	73	6,571	6,453

Table 9.3.1. Division IIIa sprat. IBTS(February) indices of sprat per age group 1984-2006. (Mean number per hour per rectangle weighted by area. Only hauls taken in depths of 10-150 m are included).

Year	No Rect	No hauls	Age Group					
			1	2	3	4	5+	Total
1984	15	38	5675.45	868.88	205.10	79.08	63.57	6,892.08
1985	14	38	2157.76	2347.02	392.78	139.74	51.24	5,088.54
1986	15	38	628.64	1979.24	2034.98	144.19	37.53	4,824.58
1987	16	38	2735.92	2845.93	3003.22	2582.24	156.64	11,323.95
1988	13	38	914.47	5262.55	1485.07	2088.05	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	5993.64	598.71	263.97	202.90	76.04	7,135.25
1993	16	38	1589.92	4168.61	907.43	199.32	239.64	7,104.92
1994	16	38	1788.86	715.84	1050.87	312.65	70.11	3,938.32
1995	17	38	2204.07	1769.53	35.19	44.96	4.23	4,057.98
1996	15	38	199.30	5515.42	692.78	111.98	173.75	6,693.23
1997	16	41	232.65	391.23	1239.13	139.14	134.51	2,136.67
1998	15	39	72.25	1585.22	619.76	1617.71	521.52	4,416.46
1999	16	42	4534.96	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	6539.48	1144.34	676.71	92.37	45.87	8,498.77
2002	16	42	1180.52	1035.71	89.96	58.85	12.93	2,241.90
2003	17	46	462.64	1247.49	1172.13	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	3314.17	1563.16	470.84	837.09	538.37	6,722.82
2006	17		1323.59	11855.76	1753.92	299.05	159.23	15,391.55
2007			774.11	306.63	250.81	42.08	13.74	1,387.37

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 2005a). 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 last year's HAWG report (ICES 2005a).

There was zero sampling of the catch in 2006 for both Clyde herring and sprat in VIId,e. The catch of Clyde herring in 2006 was low (Table 10.1) as was the catch of sprat in VIId,e (Table 10.2).

Table 10.1 Herring from the Firth of Clyde. Catch in tonnes by country, 1955–2006. 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
Scotland	598	371	779	16	1	78	46	88	-	-	0.06
Other UK	127	475	310	240	0	392	335	240	-	318	512
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
Total	725	846	1089	256	1	480	381	328	0	318	512.06

[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 of sprat in VIId,e from 1985-2006

COUNTRY	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**		
Denmark								
France								
Netherlands								
UK (Engl.&Wales)	1 349	1 196	1 377	836	1 635	1 974		
Total	1 349	1 196	1 377	836	1 635	1 974		
* Preliminary								

11 Working Documents

WD 1. C., O'Donnell, A., Egan, D., Lynch, J., Boyd, D., Wall and L., Goddjin. Northwest Herring Acoustic Survey Cruise Report and Abundance Estimate, 2007. The Marine Institute, Fisheries Science Services, Galway.

WD 2. C., O'Donnell, I., Doonan, D., Lynch, A., Egan, J. Boyd, D., Wall and J., Ulgren. Acoustic Survey Cruise Report, ICES Divisions VIIb,j & g and VIIaS, Celtic Sea Herring Acoustic Survey, R.V. Celtic Explorer, 1 – 21 October 2006. The Marine Institute, Fisheries Science Services, Galway.

WD 3. L.A.W., Clausen, C., Ulrich-Rescan, M., van Deurs and D. Skagen. A Step Toward Improved Advice for the Stock Complex of IIIa, A review of EU Rolling Programme, FISH/2004/03.

WD 4. L.A.W., Clausen, C., Ulrich-Rescan, M., van Deurs and D. Skagen. Improved Advice For the Mixed Herring Stocks in the Skagerrak and Kattegat. EU Rolling Programme; FISH/2004/03, FINAL Report

WD 5. M., Clarke. and A., Egan. Revision of Recent Irish Landings Data for Herring in VIaN. The Marine Institute, Fisheries Science Services, Galway.

WD 6. J.P., Gröger, R.A., Rountree and M., Missong. Risk Assessment of North Sea Herring for Stock Rebuilding Purposes Using an Optimization Algorithm. Federal Research Centre for Fisheries, Institute for Sea Fisheries, Germany.

WD 7. J.P., Gröger, and N., Rohlf. Shedding Light on Recruitment Mysteries: Internal and External Signals in the Stock-Recruitment Relationship of North Sea Herring. Federal Research Centre for Fisheries, Institute for Sea Fisheries, Germany.

WD 8. D., Skagen. Estimating Population Abundance and Mortalities from Length Structured Catch and Survey Data. Approaches, the Program lcs and a Case Study with North Sea Sprat. Institute of marine Research, Bergen, Norway.

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WD 12. T. Gröhsler. German herring fisheries and stock assessment data in the western Baltic in 2006. Federal Research Centre for Fisheries, Institute for Baltic Sea Fisheries, Germany.

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Annex 1: List of Participants

HERRING ASSESSMENT WORKING GROUP FOR THE AREA SOUTH OF 62°N

13 - 22 March 2007

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Annex 2: Recommendations

HAWG 2007 makes the following recommendations:

RECOMMENDATION	ACTION
HAWG has a list of recommendations on the utility and development of INTERCATCH. See chapter 1.5.5 of the HAWG report for full details.	ICES Secretariat
HAWG recommends that all metiers with substantial catch should be sampled (including by-catches in the small meshed fishery).	National labs
HAWG recommends that a project and/or ICES study group be set up to consider the management of herring stocks to the west of the British Isles, in light of the findings of WESTHER. The full recommendation is in chapter 1.3 of this report.	ICES RMC, LRC, national labs, the European Commission
HAWG recommends that surveys used in stock assessments of herring and sprat, under the auspices of HAWG should qualify under the DCR and should be coordinated through PGHERS.	EU STECF, European Commission, Nationl Labs
HAWG recommends that the micro-increment analysis of otoliths (to determine spawning type) for herring in the North Sea be carried out on samples collected during the annual acoustic survey and on the commercial catches.	National Labs
HAWG recommends that ICES make available a time series of IBTS anchovy and sardine CPUE (with an assessment of variance) for the next meeting of HAWG in 2008.	ICES
HAWG recommends further work to identify the causes and dynamics of the serial poor recruitment of North Sea herring.	ICES WGRP, SGRECVAP
HAWG request that PGNAPES makes available for HAWG 2008, a time series of the abundance at age, of North Sea herring in the Norwegian Ecosystem survey (with variance), also with the associated target strengths used to determine those estimates of abundance.	ICES PGNAPES
HAWG requests that in 2008, Norway join the North Sea herring larvae surveys, in order to explore the spatial and temporal spread of herring larval production in the North Sea.	IMR
HAWG requests that ICES LRC change the name of the North Sea herring and sprat acoustic survey (as coordinated by PGHERS) to the North Sea Pelagic Fish Acoustic Survey.	ICES LRC and PGHERS
HAWG recommends the development of a harvest rule to determine the IVc – VIId sub-TAC on a scientific basis.	National labs, ACFM, SGMAS
HAWG recommends that effort should be allocated into the development of a more suitable method for projection of catch and stock for sprat in all areas. A length-based model is currently under development and should be tested on sprat in both areas. For this, data on length and weight in the stock and catch should be made available from national laboratories.	National labs and ICES data centre
HAWG requests that PGHERS makes the time series of acoustic sprat abundance (age dissagregated with variances) available to HAWG in 2008.	PGHERS
HAWG recommends that resources be made available to improve knowledge of spawning seasons and stock structures for sprat.	National laboratories and EU
HAWG requests that ICES prepare the North Sea sprat IBTS index as length and age based with estimates of variance in each.	ICES DATRAS

Terms of Reference for 2008

The Herring Assessment Working Group for the Area South of 62ºN (HAWG) (Co-Chairs: Tomas Gröhsler, Germany and Emma Hatfield, UK) will meet in Copenhagen, Denmark from 11 – 20 March 2008 to:

a) assess the status of and provide management options (by fleet where possible) for 2009 for:

- the North Sea autumn-spawning herring stock in Division IIIa, Subarea IV, and Division VIId (separately, if possible, for Divisions IVc and VIId). Forecasts should be provided by fleet if possible and taking into account the management plan agreed between the EU and Norway;
- the herring stocks in Division VIa and Sub-area VII;
- the stock of spring-spawning herring in Division IIIa and Subdivisions 22–24 (Western Baltic); Management options for Division IIIa shall be given by fleets taking into account that North Sea herring and Western Baltic herring are taken together in this Division;

b) assess the status of the sprat stocks in Subarea IV and Divisions IIIa and VIId,e;

c) for the stocks mentioned in a) and b) perform the tasks described in C.Res. 2007/2/ACFM01.

HAWG will report by 1 April to the attention of ACFM.

Annex 3: – Stock Annexes

Quality Handbook ANNEX: HAWG-herringWBSS

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:	21.03.2007
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&b east), Skagerrak (Sub-division 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 aslo take into account the few Norwegian Spring Spawners (NSS) caught in IVa north.

A third well defined stock component in ICES Division IIIa is winter-spawning Downs herring from spawning areas in the English Channel (Bridger, 1961). There is some disagreement on whether this stock in fact should be regarded as an extension of the NSAS. The contribution of Downs-herring to the mix-area of Division IIIa is likely to be relatively small (un-published data from otolith readings, DIFFRES), and Downs-herring are therefore included under NSAS for the stock assessment of herring in Division IIIa and Subdivision 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, submitted in December 2006).

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 areas in the North Sea works 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 seems 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 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, Sweeden, 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, submitted in December 2006).

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 of German herring cacthes 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.

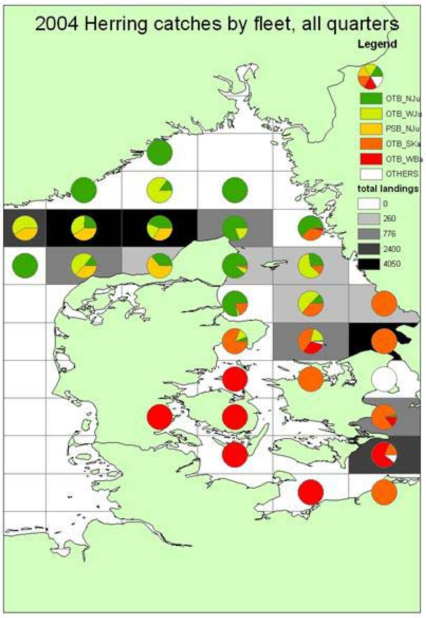

Figure A.2.1 Danish landings in IIIa by vessel and homeport.

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 disaggregation 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.

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).

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, 2006).

B.2. Biological parameters for the assesment

Mean weights-at-age in the catch in the 1st quarter were used as stock weights.

The proportions 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. Used in the final assessment.

The IBTS 3rd quarter survey in Div. IIIa, which is a part of the North Sea and Div. IIIa bottom trawl survey that is 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. 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). No data available for 2006. Not used in the final assessment.

B.4. Commercial CPUE

B.5. Other relevant data

C. Historical Stock Development

Model used: ICA
Software used: ICA Vs 1.4

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	1989 – last year data	2-8+
Tuning fleet 2	German Acoustic Survey SDs 22-24	1989 – last year data	0-5
Tuning fleet 3	IBTS Quarter 3	1991 – last years data	1-5
….			

D. Short-Term Projection

Model used: Age structured

Software used*:* MFDP Vs 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, where the geometric mean over the period of 5 years excluding the last year was used

Maturity: The same values as in the assessment is used for all years

F and M before spawning: The same ogive 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: None

Procedures used for splitting projected catches: Not relevant

E. Medium-Term Projections

Model used: none

Software used:

Initial stock size:

Natural mortality:

Maturity:

F and M before spawning:

Weight-at-age in the stock:

Weight-at-age in the catch:

Exploitation pattern:

Intermediate year assumptions:

Stock recruitment model used:
Uncertainty models used: none

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

Reference points have neither been defined nor proposed for this stock.

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

$$\text{EL} = \text{E}[\text{SSB}_{\text{lower limit}} - \text{SSB}_{\text{estimated}} \mid \text{SSB}_{\text{estimated}} < \text{SSB}_{\text{lower limit}}] \;. \quad (2)$$

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

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Quality Handbook ANNEX: Herring VIaS and VIIbc

Stock specific documentation of standard assessment procedures used by ICES.

Stock: Herring in VIaS and VIIbc

Working Group: Herring Assessment Working Group for the area south of 62^0 N.

Date:

A. General

A.1. Stock Definition

The herring to the northwest of Ireland comprise both autumn and winter spawning components. For the purpose of stock assessment and management, these areas have been separated from VIaN since 1982. Spawning in VIIb has traditionally taken place in the autumn and in VIaS, later in the autumn and in the winter.

A.2. Fishery

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. In 2000 the Irish North West Pelagic Management Committee was established to deal with the management of this stock. Landings have decreased markedly from about 44,000 t in 1990 to around 13,000 t in 2004. Landings have increased in 2006 in line with increases in the TAC.

B. Data

B.1. Commercial Catch

The commercial catches are provided by national laboratories belonging toe the nations that have quota for this stock. In recent years, only Ireland has caught herring in this area, so catch-at-age, mean weights and stock weights 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. This program (Patterson, 1998) gives outputs on sampling status and available biological parameters and documents actions taken to raise unsampled metiers using other data sets. The species co-ordinator allocates samples of catch numbers, mean length and mean weight-at-age to unsampled catches using appropriate samples by gear (fleet) area quarter and if an exact match is not available then a neighbouring area if the fishery extends to this area in the same quarter.

B.2. Biological

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. The data are obtained from market sampling and are processed as described above.

B.3. Survey

Acoustic Surveys

Acoustic surveys have been carried out in this area since 1994. The timing of these surveys has changed over this time. 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. The acoustic survey was first used to tune the assessment in 2006.

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 are used for the assessment. The number of larvae below each square metre was calculated and then multiplied by the area of the sea at each station (Grainger and McArdle, 1985). These surveys did not produce an index of stock size but they did provide valuable information on the distribution of very small larvae and on the location of the spawning grounds (Anon, 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.

Herring Tagging

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).

C. Historical Stock Development

Models used

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. 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 4 (winter rings). In 2006 ICA was used for the first time and the acoustic surveys used as a tuning fleet. The results of these exploratory assessments are presented in the WG report. No final assessment has been accepted by the working group in recent years.

Input data types and characteristics:

TYPE	NAME	YEAR RANGE	AGE RANGE	VARIABLE FROM YEAR TO YEAR YES/NO
Caton	Catch in tonnes	1970-2006	1-9	Yes
Canum	Catch at age in numbers	1970-2006	1-9	Yes
Weca	Weight at age in the commercial catch	1970-2006	1-9	Yes
West	Weight at age of the spawning stock at spawning time.	1970-2006	1-9	Yes
Mprop	Proportion of natural mortality before spawning	1970-2006	1-9	No
Fprop	Proportion of fishing mortality before spawning	1970-2006	1-9	No
Matprop	Proportion mature at age	1970-2006	1-9	No
Natmor	Natural mortality	1970-2006	1-9	No

Tuning data:

TYPE	NAME	YEAR RANGE	AGE RANGE
Tuning fleet 1	NWHAS	1999-2007	3-4

D. Short-Term Projection

Model used: Multi fleet Deterministic Projection (Smith, 2000).

Software used: MFDP Software

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.

F. Long-Term Projections

Not performed

G. Biological Reference Points

B_{pa} is set at 81,000 t and B_{lim} at 110,000 t. F_{pa} is a 0.22 and F_{lim} at 0.33.

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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: 17 March 2007

Authors: C. Zimmermann (ed.), J. Dalskov, M. Dickey-Collas, H. Mosegaard, P. Munk, J. Nichols, M. Pastoors, N. Rohlf, E.J. Simmonds, D. Skagen

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).

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 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 745,950 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 a lows of less than 100,000 tonnes in the late 1970s. The species has demonstrated a robustness in relation to recovery from such low levels once fishing mortality is curtailed in spite of recruitment levels being adversely affected.

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. This has the potential to seriously damage and destroy the spawning habitat and disturb spawning shoals and destroy spawn if carried out during the spawning season. 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.

Incidental Catch: The incidental catch of non-target species in the North Sea pelagic herring fishery in general is considered to be low. A recent study (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%. Mackerel, which are known to occur in mixed schools with herring in division IVa was the main by-catch species, accounting for 69% of by-catch by weight. Haddock (25.7% of by-catch by weight), horse mackerel *Trachurus trachurus* (4.8%) and whiting *Merlangius merlangus* (0.4%) were all present in samples. 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 3 rd and 4th quarters, after herring quotas had been exhausted.

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 recently been conducted on Scottish and Norwegian pelagic trawlers, based on observation of 222 hauls catching 9,889 tonnes fish (Napier et al, 2002) over 2000 - 2002. The overall discard rate was 4.2%, although that from pelagic trawlers of 6.6% was substantially higher than that from pursers (0.6%). These discard rates were higher than the overall figure of 2.8% recorded in an earlier study (Napier et al, 1999) which were evenly distributed between pursers and trawlers. Recent surveys of Dutch vessels show a discard rate of 5% of the catch. This indicates that the different discard rates between the different fishing types in the later study were more a function of fishing location and stock size compositions rather than any gear-specific size selectivity. Some discarding, in the form of wastage (i.e. fish left meshed in the net or in the cod-end of trawls), was associated with almost all pelagic catches but the actual quantities of fish involved were low (2% of total discarded fish). In both studies by Napier et al., most of the observed discarding occurred through slipping, i.e. opening the net and releasing the fish before they were pumped on-board. This occurred when catch volumes were too small, or the size of fish was too small or the fish were poor in quality. For both pursers and trawlers ‘poor’ fish quality was a significant cause of discarding. The size of the catch was also a significant cause of discarding from trawlers, either because the catch was too small or too large, with boats either discarding a small proportion or all of the catch. The recent 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. However surveys on the reasons why vessels discarded fish showed that larger discarding events (i.e. those >500 kg) were equally likely to the fish being of poor quality (trawlers) or the catch exceeded the vessel’s capacity or market requirements (pursers). No data on survival of discarded fish has been collected but it is considered likely that mortality rates will be significant.

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. This infers that the ecosystem level implications of incidental fish catches are 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 (see Section above) is also low, being around 3,250 tonnes (2000) and 750 tonnes (2001) for the Scottish and Norwegian and Scottish pursers and refrigerated seawater tank (RSW) pelagic trawlers operating in ICES division IVa. For both years, this was equivalent to about 10.4% by weight of the total landings. Of more concern are discards of herring from other pelagic fisheries, especially that for mackerel, where more substantial discarding of herring occurs when quotas for herring are exhausted. National reports to ICES over 1996 to 2002 suggest that total herring discards have varied between 1,500 tonnes to an unprecedented 17,000 tonnes in 2002 (reflecting onboard sampling by Scotland and Germany that observed substantial discards of herring in the mackerel fishery in the 3rd and 4th quarter in Division IVa (W)). Assuming a distribution and yield of the international mackerel fishery in IVa in 2002 to be similar to that in 2001, herring discards of all fleets could be as high as 50,000 t. This would increase the total catch in the North Sea by almost 15% and would certainly have an influence on the North Sea autumn spawning stock assessment and the perception of stock size. Discarding behaviour appears to have changed again in 2003, when herring TAC has been increased by 50%, and at the same time the mackerel TAC has been reduced by more than 5%.

Interactions with Rare, Protected or Icon Species: Interactions between the directed North Sea herring fishery with rare, protected or icon species are, in general, considered to be exceptional. 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. To date, no cetacean by-catch has been observed in the herring pelagic fishery in the North Sea. There is currently an ongoing observer programme in the UK monitoring cetacean by-catch rates in pelagic trawl fisheries with results due at the end of September 2003 and it is understood that this confirms that cetacean by-catch by the pelagic trawl fishery is negligible (Northridge, pers. comm.). 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.

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. Kuklik and Skóra (2003) refer to a single record of a harbour porpoise (*Phocoena*

phocoena) bycaught 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.

On 24 July 2003 the European Commission issued a proposal for a Council Regulation to address the problem of cetacean by-catch in various fisheries. For the North Sea (ICES IV) 5% of pelagic trawl fisheries would have to be monitored by observers. In the eastern channel 5% of pelagic trips would have to be monitored from April to November but 10% from December to March. The Commission has asked the Council to adopt this proposal by 1 July 2004.

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 (RIVO), 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, with sharks being 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, herring, are known to have been caught by pelagic trawls off the SW English coast (Bram Couperus (RIVO), 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 compared to the NW Scotland where 1-3 birds may be caught, esp. in grounds off St. Kilda (Aad Jonker (former freezer trawler skipper), pers. comm.). RIVO observers in the North Sea only recorded one incident of seabird by-catch over 10 trips (Bram Couperus (RIVO), 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 2003 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, 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.

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.

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. The WG is aware of the problem that this knowledge might be lost if the scientist leaves, and asks the national laboratories to ensure continuity in data provision. 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. This issue will have to be carefully considered in light of any future development by ICES of a standard platform to store all fisheries disaggregated data, particularly with regard to confidentiality.

The WG considered the need of a **long-term data storage** for commercial catches and sampling, and the documentation of any primary data processing of these data. From 2000 on (catch data for 1999), the latest (consistency checked) versions of the input files together with standard outputs and a documentation of filling-in decisions made by the co-ordinators, ideally in the SALLOC-formats, are stored in a separate "archive" folder. This is updated annually, and the complete collection (which is supposed to be kept confidential as it will contain data on misreporting and unallocated catches) will be available for WG members on request. As there was very little historical information available, WG members were asked to provide as much as possible national catch and historical data sets in any available format which is then stored in a "~historic" folder within "Archive". They will be consistency checked and transferred into a database system as soon as this is available. In 2007, INTERCATCH was used for the first time and compared to the SALLOC formats, no major differences were found.

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 is 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) annually since 1991, and provides the only tuning index for VIa (North) herring, By carrying out the co-ordinated survey at the same time from the Kattegat to South of the Hebrides 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 Herring Surveys ICES PGHERS.

At present, six surveys are carried out during late June and July covering most of the continental shelf north of 52°N in the North Sea and to the west of Scotland to a northern limit of 62°N. The eastern edge of the survey area is bounded by the Norwegian and Danish, Swedish and German coasts, and to the west by the shelf edge between 200 and 400 m depth. The surveys are reported individually in the report of the planning group for herring surveys, and a combined report is prepared from the data from all surveys. The combined survey results provide spatial distributions of herring abundance by number and biomass at age by statistical rectangle; and distributions of mean weight and fraction mature at age.

The acoustic recordings are carried out using Simrad EK60, EK500 and EY500 38 kHz sounder echo-integrator with transducers mounted on the hull, drop keel or towed bodies. 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, in the Skagerrak where short additional transects were carried out at 7.5 nmi spacing, and in the southern area where a 30 nmi 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 is reported through standardised data exchange format and combined at FRS Marine Lab Aberdeen. 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 be 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 is 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 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 program 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. Oblique hauls are made during night in at least two statistical rectangles.

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. The catches in DivisionIIIa is not included in this index. Table 2.3.3.1 in the HAWG report shows the time series of abundance estimates of 2-5+ ringers from the 1st quarter IBTS for the whole period.

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 Div 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 (Table 2.3.3.3 of HAWG report). 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 (see discussion of procedures in earlier reports (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 is used to calculate and 0-ringer index of autumn spawned herring in the North Sea. 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. A 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 of estimates for subareas as well as the total index are shown in the actual report's Table 2.3.3.4.

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. The surveys are carried out annually to map larval distribution and abundance. 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 sampler or one of its national modifications. 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 is 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:

$$\ln(\text{Indexyear,LAI unit}) = \text{MLAIyear} + \text{MLAI}_{\text{LAI}}\ \text{unit} + \text{uyear, LAI unit}$$

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. 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): 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 and 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 and 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 recently evaluated in a 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). 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.

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

Model used:

Details on input parameters and model setup for the final ICA assessment are presented in Table 2.6.2.1. of the most recent HAWG report. 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 program 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:

$$\begin{aligned}
&\sum_{a=0,y=1997}^{a=8,y=2002} \lambda_a \left(\ln(\hat{C}_{a,y}) - \ln(C_{a,y})\right)^2 + \\
&\sum_{y=1979}^{y=2002} \lambda_{mlai} \left(\ln(q_{mlai} \cdot \hat{SSB}_y^K) - \ln(MLAI_y)\right)^2 + \\
&\sum_{a=1,y=1983^{**}}^{a=5+,y=2003} \lambda_{a,ibtsa} \left(\ln(q_{a,ibtsa} \cdot \hat{N}_{a,y}) - \ln(IBTS_{a,y})\right)^2 + \\
&\sum_{a=1,y=1989}^{a=9+,y=2002} \lambda_{a,acoust} \left(\ln(q_{a,acoust} \cdot \hat{N}_{a,y}) - \ln(ACOUST_{a,y})\right)^2 + \\
&\sum_{y=1977}^{y=2003} \lambda_{mik} \left(\ln(q_{mik} \cdot \hat{N}_{0,y}) - \ln(MIK_y)\right)^2 + \\
&\sum_{y=1960}^{y=2002} \lambda_{ssr} \left(\ln(\hat{N}_{0,y+1}) - \ln\left(\frac{\alpha\,\hat{SSB}_y}{\beta + \hat{SSB}_y}\right)\right)^2
\end{aligned}$$

** 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: ICA (Patterson, 1998; Needle, 2000)

Model Options chosen:

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	1960-2006	1-9+	Yes
Weca	Weight at age in the commercial catch	1960-2006	1-9+	Yes (smoothed)
West	Weight at age of the spawning stock at spawning time.	1960-2006	1-9+	Yes (smoothed)
Mprop	Proportion of natural mortality before spawning	1960-2006	1-9+	No
Fprop	Proportion of fishing mortality before spawning	1960-2006	1-9+	No
Matprop	Proportion mature at age	1960-2006	1-9+	Yes (smoothed)
Natmor	Natural mortality	1960-2006	1-9+	No

Tuning data:

Type	Name	Year range	Age range (wr)
Tuning fleet 1	IBTS Q1	1984-2007	1-5
Tuning fleet 2	MIK	1992-2007	0
Tuning fleet 3	Acoustic	1989-2006	1--9+
Tuning fleet 4	MLAI	1973-2006	SSB

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 and was developed further last year. It is intended to continue to use this programme in the future. The good agreement between predicted biomass for the actual year and SSB taken from the assessment for the most recent year one year after demonstrates that the current prediction procedure for stock numbers is working well. In 2004, the Working Group has included prediction of low maturation into projections for 2005 and expects to monitor growth and maturation of North Sea herring carefully in the future and when deemed necessary will include these changes in predictions in the future.

Model used: Age-structured model, by fleet and area fished

Software used: MFSP

Initial stock size: output from ICA

Maturity: average of the two most recent years used

F and M before spawning: 0.67 for both (assumes spawning starts around September)

Weight at age in the stock: from last year in assessment (already smoothed, see assessment data description)

Weight at age in the catch: average of last two years BY FLEET

Exploitation pattern:

Intermediate year assumptions: Status quo F

Stock recruitment model used: Recent average recruitment (arithmetic, recent 10 years) is used, (unless there is some strong reason for using something else, e.g. if SSB is very low, we may use a prediction from the stock-recruit relationship)

Procedures used for splitting projected catches:

There are 4 values input for this parameter:

a) IBTS 1-ringer proportion in last assessment year (y) is used for 1-ringers in y

b) IBTS 1-ringer proportion in y+1 is used for 1-ringers in y+1, AND for 0-ringers in y.

c) GLM (between MIK index and IBTS 1-ringer proportion) is applied to MIK index in y+1 to predict proportion for 1-ringers in y+2, AND for 0-ringers in y+1

GLM, as in (c), is applied to the Average MIK index for 1981 to year y to predict proportion for 1-ringers in y+3 (not relevant), AND for 0-ringers in y+2 (relevant)

E. Medium-Term Projections – *still to be filled in -*

Model used:

Software used:

Initial stock size:

Natural mortality:

Maturity:

F and M before spawning:

Weight at age in the stock:

Weight at age in the catch:

Exploitation pattern:

Intermediate year assumptions:

Stock recruitment model used:

Uncertainty models used:

Initial stock size:
Natural mortality:
Maturity:
F and M before spawning:
Weight at age in the stock:
Weight at age in the catch:
Exploitation pattern:
Intermediate year assumptions:
Stock recruitment model used:

F. Long-Term Projections – *still to be filled in -*

Model used:

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 is a well functioning harvest control rule in place for this stock, and apart from B_{lim}, the current reference points are derived from this HCR. The target F in the HCR was adopted by ACFM as the F_{pa}, while the trigger point at which F should be reduced below the target is adopted as B_{pa}. The HCR was briefly revisited in 2004, and the results support the initial definitions of limits.

Reference points currently in use are: B_{lim} is 800 000 t (below this value poor recruitment has been experienced); B_{pa} be set at 1.3 mill. T (as part of a harvest control rule based on simulations); F_{lim} is not defined, F_{pa} be set at $F_{ages\ 0\text{-}1}= 0.12$, $F_{ages\ 2\text{-}6}= 0.25$ (as part of a harvest control rule).

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. This points strongly to an evolutionary history in which herring spawned in rivers and at some later date re-adapted to the marine environment. 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. 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. This is a relatively low fecundity for teleosts, probably because, in evolutionary terms, the benthic egg is a potentially less hazardous phase of development compared with the planktonic egg of most other teleosts. 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 6mm to 9mm long and are immediately planktonic. Their yolk sac lasts for a few days during which time they will begin to feed on phytoplankton and small planktonic animals. 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.

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 and are responsible for the very high fat content of the fish at this time.

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 and the Thames estuary. Juveniles of the spring spawning stocks found in the Baltic, Skagerrak and Kattegat 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 early part of the 20 th Century. 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. 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. The conclusions were the basis for establishing the working hypothesis that the North Sea autumn spawning herring comprise a complex of three separate stocks each with separate spawning grounds, migration routes and nursery areas, illustrated in the figure below.

The three stock units are:

- • The Buchan or Scottish group which spawn from July to early September in the Orkney Shetland area and 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 group, 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 group 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. As a consequence, North Sea autumn spawning herring have to be managed as a single unit.

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.

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. 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 rational 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. That period also witnessed the decline and eventual disappearance of a traditional autumn drift net fishery in the southern North Sea.

The annual landings from 1947 through to the early 1960’s were high, but stable, averaging around 650,000t. 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 83,500t although the total landings were still over 300,000t. 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.

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 52,000t. By 1981 the SSB had increased to over 200,000t. 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 re-opened 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 longterm 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 programme of research vessel and commercial catch sampling. This led to estimates of annual mortality up to 16% (Anon., 1993) which was of the same order as the estimate of fishing mortality at the time. It was recognised that the behavioural changes and catchability of infected fish affected the reliability of the estimate of prevalence of the disease in the population. The uncertainty about the effect on stock size varied between estimates of 5% to 10% and 20%. Continued monitoring of the progress of the disease showed that by 1994 the prevalence in the northern North Sea had fallen from 5% in 1992 to below 1% and confirmed that the infection did not appear to be spreading to younger fish. Ultimately it was concluded that the disease had caused high mortality in the northern North Sea during 1991 and subsequently declined to the point where by 1995 the 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 ACFM 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.

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 on 26 November 2004, the relevant parts of the text are included here for reference:

1. *Every effort shall be made to maintain a level of Spawning Stock Biomass (SSB) greater than the 800,000 tonnes (Blim).*
2. *Where the SSB is estimated to be above 1.3 million tonnes the Parties agree to set quotas for the directed fishery and for by-catches in other fisheries , reflecting a fishing mortality rate of no more than 0.25 for 2 ringers and older and no more than 0.12 for 0-1 ringers.*
3. *Where the SSB is estimated to be below 1.3 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 equal to:*

   0.25 – (0.15(1,300,000-SSB)/500,000) for 2 ringers and older, and*

   0.12 – (0.08(1,300,000-SSB)/500,000) for 0-1 ringers.*
4. *Where the SSB is estimated to be below 800,000 tonnes the Parties agree to set quotas for the directed fishery and for by-catches in other fisheries, reflecting a fishing mortality rate of less than 0.1 for 2 ringers and older and less than 0.04 for 0-1ringers.*
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. *Not withstanding paragraph 5 the Parties may, where considered appropriate, reduce the TAC by more than 15% compared to theTAC of the preceding year.*
7. *By-catches of herring may only be landed in ports where adequate sampling schemes to effectively monitor the landings have been set up. All catches landed shall be deducted from the respective quotas set, and the fisheries shall be stopped immediately in the event that the quotas are exhausted*
8. *The allocation of TAC for the directed fishery for herring shall be 29% to Norway and 71% to the Community. The by-catch quota for herring shall be allocated to the Community*
9. *A review of this arrangement shall take place no later than 31 December 2007 .*
10. *This arrangement enters in to force on 1 January 2005.*

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 2002, a new directive for the collection of fisheries data was implemented for all EU member states (Commission Regulation 1639/2001). The provisions in the “data directive” define specific sampling levels. As most of the nations participating in the fisheries on herring assessed here have to obey this data directive, the definitions applicable for herring and the area covered by HAWG are given below:

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

Exemptions to the above mentioned sampling rules are:

Concerning lengths:

(1) the national programme of a Member State can exclude the estimation of the length distribution of the landings for stocks for which TACs and quotas have been defined under the following conditions:

(i) the relevant quotas must correspond to less than 5 % of the Community share of the TAC or

to less than 100 tonnes on average during the previous three years;

(ii) the sum of all quotas of Member States whose allocation is less than 5 %, must account 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 programme of a Member State can exclude the estimation of the age distribution of the landings for stocks for which TACs and quotas have been defined under the following conditions:

(i) the relevant quotas correspond to less than 10 % of the Community share of the TAC or to

less than 200 tonnes on average during the previous three years;

(ii) the sum of all quotas of Member States whose allocation is less than 10 %, accounts for less than 25 % of the Community share of the TAC.

If the condition set out in point (i) is fulfilled, but not the condition set out in point (ii), the relevant Member States may set up a coordinated programme as mentioned for length sampling.

If appropriate, the national programme may be adjusted until 31 January of every year to take into account the exchange of quotas between Member States;

The HAWG reviewed the implementation of the new sampling regime for the EU countries in 2003. It was expected that the overall sampling level might be improved, and this was demonstrated e.g. for North Sea herring in 2002 and 2003. However, there is concern that the new regime may lead to a deterioration of sampling quality, because it does not assure an appropriate sampling of different métiers (each combination of fleet/nation/area and quarter). Given the diversity of the fleets harvesting most stocks assessed by HAWG, an appropriate spread of sampling effort over the different métiers is more important to the quality of catch at age data than a sufficient overall sampling level. The EU data directive appears to not assure this. 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.

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: TECHNICAL MINUTES

REVIEW OF CELTIC SEA STOCKS

Reviewers: Pablo Abaunza, Spain (chair)

Tiit Raid, Estonia

Peter Lewy, Denmark

Claus Hagebro, from ICES Secretariat

Chair of Herring Assessment Working Group: Mark Dickey-Collas, Netherlands

General:

The Celtic Sea's review group dealt with the revision of the following herring stocks assessed in the Herring Assessment Working Group (HAWG):

- Celtic Sea and Division VIIj herring (benchmark assessment)
- Herring in Division VIa (North) (West of Scotland herring) (Update assessment)
- Herring in Divisions Via (South) and VIIb,c. (Update assessment)
- Irish Sea Herring [Division VIIa]. (Update assessment)

The "Clyde" herring stock has very poor data with very low research intensity (only catch data) and as a result no advice for this stock was presented. Therefore, the Clyde herring stock was not considered in the reviewing process.

The reviewers commend the thorough report and the quality of the work developed in relation to the herring stocks in the Celtic Seas. Although there was only one benchmark assessment the effort to improve the knowledge on the state of the stock was significant in all the reviewed herring stocks (e.g. exploring with new assessment methods like Bayesian approaches or revising historical catch data).

The Review Group acknowledged the work made by HAWG in relation to identifying possible regime shifts in herring productivity and in exploring the relationship between these changes and the environmental variability. The reviewers consider that this is a very useful approach to understand the dynamics of the herring stocks and that it is in tune with the ecosystem approach. In this sense the reviewers would also like to support the concerns stated by the chair of the HAWG about some inaccuracies in the descriptions-recommendations on Celtic Seas raised by WGRED (Working Group on Regional Ecosystem Definition).

Assessment of Celtic Sea and Division VIIj herring (benchmark).

Stock identity has already been considered after the results provided from the EU-funded WESTHER project.

This stock has relatively good information on catches, and a high precision in catch at age data. However, the stock show a high variability in its dynamics which is also reflected in the tuning acoustic survey used for the assessment, which is very noisy. Therefore, there is no possibility to obtain precise estimates of the current SSB and F. Exploratory data analysis on cohort catch curves was carried out and various exploratory assessments are also presented, including Bayesian methods to account for a more realistic estimate of the uncertainty, simpler models (CSA), VPA-based methods (XSA) and statistical catch at age-like (ICA) in which different settings were explored. These assessments showed a similar declining trend for SSB in recent years.

The reviewers agreed with the WG conclusion that as there is no agreed final assessment, the basis for the catch advice is limited to overall trends qualitative assessment results rather than year specific estimates of mortality or biomass.

Catch tables (4.1.3.1 and 4.1.3.2) should be cross-checked for possible errors in the discard estimates.

The acoustic survey plays a key role in the assessment of this stock, since at this moment it is the only valuable information for tuning the assessment. The reviewers consider that a summary of the revision of the acoustic series made last year should also be included in the text, in addition to a more clear explanation of the survey design (i.e. if it is adaptive or not, changes in the timing in which the survey is carried out, etc.).

In relation to the assessment, catch residual plots indicate model problems with clear year and age effects. This could be due to the problems with the assumptions of separability. It is therefore important to investigate why this is the case for instance by investigating if the selection pattern changes over years. This could be done by using a model allowing for such changes.

In the report there is an extensive description of the strength of the recent year classes. However, the reviewers considered that compared with the historical series there is no any strong year class in the last decade (at most only of medium strength). On the other hand, it seems that there is an inconsistency between the recruitment series showed in figure 4.6.2.4 (a) and figure 4.10.1 (c). In figure 4.6.2.4 there is one point more. This makes the identification of particular cohorts more difficult, and should be checked changing also the text accordingly where appropriate.

The figure on the residual patterns around the stock recruitment model show clearly the absence of trends but the classical plot of stock-recruitment relationship should also be included to complement this information.

Herring in Division Via (North) (West of Scotland herring) (update)

Stock identity has already been considered after the results provided from the EU-funded WESTHER project. Catches have been revised with respect to reallocation and misreporting and sampling of catch improved in 2006. This new revision of historical data required exploration. An exploratory assessment (ICA) using the same settings as last year but using the new data set was carried out to look at possible changes in the perception of the state of the stock. The reviewers consider that it should be helpful to understand the impact of these data changes if a figure comparing the historical series of SSB and F between the assessment with the revised data and with the “old” data is included.

The inclusion or exclusion in the assessment of two low values in the historical series of the tuning survey was also explored and the differences were within the bounds of the confidence intervals of the assessment. The retrospective pattern supports the perception of a noisy but fairly well balanced assessment. The assessment showed a decreasing trend in SSB and that the stock was heavily exploited in 2006.

Deterministic short-term projections and yield-per-recruit analysis were also carried out using the standard software. The proposed management plan has also been included in the projections.

The reviewers agreed with last year’s conclusion that the SSB estimate is uncertain.

<u>Irish Sea herring (Division VIIa (North)) (update)</u>

Stock identity has already been considered after the results provided from the EU- funded WESTHER project

An exploratory assessment using the same settings as last year and two tuning surveys was carried out but no analytical assessment is presented. However, the chair of the HAWG informed that some of the input data corresponding to the last year of the exploratory assessment were wrong. This information was obtained after the HAWG a few weeks after the meeting and consequently it does not appear in the report. The state of the stock is therefore unknown but taking in consideration only the information from surveys it is likely that the SSB is stable at low level. The reviewers recommend checking the input data for the exploratory assessment as soon as possible. A contraction of the age structure is described in catches and from surveys information. Catches have also been low in recent years and fishing activity has not varied considerably. The HAWG considered that the maintenance of recent catches should not be detrimental to the stock.

The reviewers agreed with the WG conclusion that since there is no agreed final assessment, the basis for the catch advice is limited to overall trends qualitative assessment results rather than year specific estimates of mortality or biomass

<u>Herring in Division VIa (South) and VIIb,c</u> (update)

Stock identity has already been considered after the results provided from the EU-funded WESTHER project.

There is an exploratory assessment available for this stock based on a separable VPA. Although there is an abundance acoustic estimate since 5 years ago, the historical series is too short to consider it as a tuning survey in an analytical assessment. The reviewers would like to support the continuity of this survey series that could be used in the future assessments of this stock. In absence of an agreed assessment, it was not considered to carry out any predictions. The SSB estimates from this non-tuned assessment are uncertain but it is likely to be at historical low level in recent years. The figure 6.6.2.3 (b), shows the historical series of SSB, but the level of B_{lim} is erroneous and should be changed to the actual level of 81 000 t.

The reviewers agreed with the WG conclusion that this stock should be exploited with great caution and with that there is no agreed final assessment. The basis for the catch advice is limited to overall trends qualitative assessment results rather than year specific estimates of mortality or biomass

Annex 5: Technical Minutes

REVIEW OF NORTH SEA STOCKS

Participants	Reidar Toresen (chair)
	Eero Aro
	Steve Cadrin
	Andre Forest
	Morten Vinther

Wg chairs: Mark Dickey-Collas (HAWG), Chris Darby (WGNSSK)

Stocks assessed by the HAWG

Herring in IV

General comments:

An update assessment was completed. The stock is declining because of poor recruitment in recent 5 years.

There is some misreporting of catches by area and overshoot of landings. Some of the catch data has been revised. Some input data was adjusted.

Technical comments:

The RG questioned why the 3, 4 and 5 year old estimates of the IBTS surveys were used in the assessments.

The best estimate of the older ages is in the catch, but the RG questioned the quality of the catch data and sampling of catches.

The RG also had several questions about the surveys: Why does the IBTS survey perform badly, for age group 2? Why doesn't the acoustic survey pick up older ages? Why are there old fish in the catch and not in the surveys?

The RG also noted the inconsistent accounting of small-mesh herring fisheries, because the Norwegian catches of small herring are included in the A-fleet.

A minor statistical note is that Q-Q plots may not be optimal for such low sample sizes. When sample size is small (n<50), q-q plots are sensitive to the number of samples, particularly in the tails of the distribution. A more appropriate evaluation of normality for low sample sizes is ranked normal deviates, rather than quantiles (Sokal & Rohlf 1995). R code for the procedure:

```
rankit<- qnorm(ppoints(n))[order(b=variable)]
        qqplot (variable, rankit)#  makes quantile -quantile plot
xy1 <-qqplot (variable, rankit, plot=FALSE)# makes files with scores, normal quantiles
        r1<- lsfit (xy1$x, xy1$y)      #  makes linear fit
        abline (r1, lty=2, col="blue") # plots line based on intercept, slope
```

Conclusions:

The assessment was accepted.

SSB is under B_{trig} but is declining.

F is greater than target F (0.35). The management rule is not robust to implementation error. Last year managers agreed on a TAC that was greater than that indicated by the management rule.

A mistake in input data file was found this year. This only had a small impact on the assessment (less than 1%). The RG decided to use the present assessment, but the mistake needs to be addressed and corrected as basis for next year's assessment of the stock.

The large overshoot of F is explained with the fact that managers have agreed on too high TACs in recent years. This should be interpreted as implementation error of the Management Plan.

SSB is below B_{trig} of 1,3 million tones and decreasing.

F is above target F of 0,25, and increasing.

Recruitment is very low and has been low for 5 successive years.

Sprat in IV

General comments:

An experimental assessment was completed. Data from IBTS and a short time series of acoustic data is available. The assessment has never been used for advice. A regression between IBTS index and catch the following year has been used as catch forecast.

Technical comments:

The RG recommends that the WG try to develop the acoustic abundance estimates, and see if these could be used in assessments.

The RG proposes that a data transformation of the IBTS survey data should be explored to reduce the effect of a few large tows in the IBTS surveys.

Conclusions:

There is no evidence that the catch levels have created problems for the stock. An in-year recommendation should be made on the same basis as the recommendation made last year. However, the RG noted that if three points in the regression are removed (1989, 1994 and 1995) associated with a large-tow effect and years when there is a lot of herring in the catches (1994-1995), the regression may be more reliable?

Western Baltic spring spawners. Herring in IIIa

General comment:

An update assessment was completed. The assessment is noisy, with large residuals, and huge year-effects. Each source of input data covers only a portion of the stock.

Technical comments:

The RG noted that input data are all weighed 1, and recommended using the same weighing process for the data for this stock as for North Sea herring.

The RG concluded that the assessment is not reliable for status determination, because it lumps together information on different parts of the stock. Retrospective pattern for recruits are very bad. Residuals are large, and there are year-effects on the residuals of the assessment. The RG felt that the quality of the assessment is poor. The estimate of 0- group the most recent year is particularly bad.

The RG recommends that there should be a survey which covers all components of the stock.

Conclusions:

The assessment was accepted, with a recommendation that there should be a benchmark assessment next year.

SSB cannot be evaluated in relation to reference values because they are not defined, but SSB seems to have stabilized.

Fishing mortality seems to have stabilized at levels around 0,5, which is rather high for a herring stock.

There are signs of a declining trend in recruitment

SPRAT in IIIa

Landings since 1974.