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

11– 19 March 2008

ICES Headquarters, Copenhagen

ICES International Council for the Exploration of the Sea

CIEM Conseil International pour l'Exploration de la Mer

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Executive Summary

The ICES herring assessment working group (HAWG) met for 9 days in March 2008 to assess the state of 7 herring stocks and 3 sprat stocks. HAWG carried out a benchmark assessment on **Western Baltic spring spawning herring**. The following issues were explored:

- consistencies in catch data and indices
- settings within the catch at age assessment model ICA
- model exploration using AMCI in addition to ICA
- retrospective performance

The final 2008 assessment shows differences in the SSB and fishing mortality in the range of 2 – 12% compared with last years assessment. This magnitude of change is acceptable because although the model settings are similar the tuning indices have been changed. The spawning stock biomass at spawning time in 2007 is estimated at approximately 133 000 t, declining from approximately 150 000 t in 2006. The estimated number of 0-wr in 2007 is 1.01 billion, the lowest observed during the 17 year duration of the current assessment, and continuing the downward trend in recruitment for this stock observed since 1999. Retrospective analysis suggests the assessment method gives a consistent perception of the stock, with no historic bias in the terminal SSB, and a weak tendency to over-estimate the terminal fishing mortality. The retrospective pattern in recruitment shows some variability, but is generally free from bias. Based on yield per recruit analysis and simulations carried out during the meeting and during WKHMP (2008), a proxy for the long term maximum sustainable exploitation rate should be a level of fishing mortality that should not exceed F = 0.25.

The spawning stock biomass at spawning time of the **North Sea herring** in 2007 is estimated at approximately 0.98 million t, declining from 1.25 million t in 2006. The abundance of 0-wr fish in 2008 (2007 year class) is low, which gives the sixth consecutive year of poor recruitment. The strong 1998 and 2000 year classes are still evident in the population, with the 2000 year class at 6-wr in 2007 and the 1998 year class at 8-wr. Mean $F_{2\text{-}6}$ in 2007 is estimated at around 0.33, which is above the management agreement target F of 0.25, while mean $F_{0\text{-}1}$ is 0.06, below the agreed $F_{0\text{-}1}$ of 0.12, and lower than 2006. The 2007 recruitment (0-wr in 2008) is estimated at 9 222 million, which is 78% below the geometric mean recruitment value (1981-2007)..

Herring in Division VIa (North) is currently fluctuating at a low level and is being exploited above F_{msy}. The recruitment has been low since 1998, the 2001 and 2002 year classes are very weak.

The current level of SSB for **herring in Division VIa (South)** is uncertain but likely to be below B_{pa} and $B_{lim.}$ F is likely to be above F_{pa} and also above F_{lim}. There is no evidence that large year classes have recruited to the stock in recent years.

The stock size of **Celtic Sea herring** continues to be uncertain. In recent years SSB has been lower than B_{pa} and possibly B_{lim}, and F has been high. The stock is currently composed mainly of younger fish. No exceptional year classes have entered the fisheries in recent years.

The state of the stock in the **herring in the Irish Sea (Division VIIA (North))** is unknown. Based on the most recent estimates of trends from surveys it seems likely that the stock has been relatively stable. The recent catches are stable.

For **sprat in the North Sea** the available information is inadequate to estimate the absolute stock size. However, relative trends in biomass from an exploratory assessment indicate that the stock has fluctuated around a median level for the past 10 years.

The new data available for **sprat in Division IIIa** were too sparse to perform any exploratory runs. The total landings increased from 12 200 t in 2006 to 15 700 t in 2007.

There was no sampling of the catch of **sprat in VIId,e** in 2007. The catch was at the same low level as in recent years.

The fishery on **Clyde herring** has been closed in 2007.

HAWG answered one special request from the European Commission (EC-DG FISH 27.03.2007-02) on management of North Sea and Western Baltic herring. 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.

1 Introduction

1.1 Participants

Steven Beggs	UK/Northern Ireland
Massimiliano Cardinale	Sweden
Maurice Clarke	Ireland
Lotte Worsøe Clausen	Denmark
Dorothy Jane Dankel	Norway
Jørgen Dalskov	Denmark (by correspondence)
Mark Dickey-Collas	The Netherlands
Afra Egan	Ireland
Tomas Gröhsler (Co-Chair)	Germany
Joachim Gröger	Germany
Emma Hatfield (Co-Chair)	UK/Scotland (by correspondence)
Philipp Hebel	Germany (Guest)
Niels Hintzen	The Netherlands
Cecilie Kvamme	Norway
Henrik Mosegaard	Denmark
Peter Munk	Denmark
Mark Payne	Denmark
Beatriz Roel	UK/England & Wales
Norbert Rohlf	Germany
John Simmonds	UK/Scotland
Jörn Schmidt	Germany
Dankert Skagen	Norway
Else Torstensen	Norway
Yves Verin	France

Contact details for each participant are given in Annex 1.

1.2 Terms of Reference

2007/2/ACOM02

The Herring Assessment Working Group for the Area South of 62ºN [HAWG] (Co-Chairs: Tomas Gröhsler*, Germany and Emma Hatfield*, UK) will meet at ICES Headquarters, 11–19 March 2008 to:

a) compile, update, analyse and document time-series of relevant fisheries, environmental data and regulatory changes (see Generic ToRs)

b) conduct an update assessment for the North Sea autumn-spawning herring stock in Division IIIa, Subarea IV, and Division VIId;

c) conduct a benchmark assessment for Spring-spawning herring in Division IIIa and Subdivisions 22–24 (Western Baltic) (Generic ToR (5));

d) collate, review and, when essential, revise working documents on data and/or assessments of the status and forecasts for:

- i) Celtic Sea herring
- ii) Herring in VIa south and VIIbc
- iii) Herring in VIa north
- iv) Sprat in the North Sea
- v) Sprat in IIIa
- vi) Sprat in VIId+e.

The assessments will be carried out in National Laboratories coordinated in the table below:

FishStock	Name	Stock Coordinator	Assesssment Coordinator 1	Assessment Coordinator 2
her-3a22	Herring in Subdivisions 22-24 and Division IIIa (spring-spawners)	DK	GER	DK
her-47d3	Herring in Subarea IV, Divisions VIId & IIIa (autumn-spawners)	GER	NL	UK S
her-irls	Celtic Sea and Division VIIj herring	IRL	IRL	
her-irlw	Herring in Divisions VIa (South) and VIIb,c	IRL	IRL	
her-nirs	Irish Sea herring (Division VIIa)	UK NI	UK NI	
her-vian	Herring in Division VIa (North)	UK S	UK S	
spr-ech	Sprat in Divisions VIId,e	UK E	UK E	
spr-kask	Sprat in Division IIIa	NO	NO	DK
spr-nsea	Sprat in the North Sea (Subarea IV)	DK	DK	NO

HAWG will report by 1 April 2008 for the attention of ACOM.

1.3 Working Group's response to ad hoc requests

1.3.1 Request by European Commission (EC-DG FISH 27.03.2007-02) on management of North Sea and Western Baltic herring.

The ICES workshop on herring management plans (WKHMP) (ICES 2008 ACOM:27) met to consider the management plan of North Sea herring and continue the development of a management plan for Western Baltic spring spawning herring. Whilst the purpose of the workshop was to answer the terms of reference, it also was an opportunity to further develop tools for testing management plans and for the exchange of expertise between scientists and other stakeholders. The request was the following:

a) evaluate the management plans agreed between Norway and the European Community concerning herring of North Sea origin:
   - i) With particular respect to :
     - 1) achieving the highest yields long-term from these stocks;
     - 2) ensuring conformity with the precautionary approach;
     - 3) achieving yields as stable as possible, consistent with achieving a high yield from the stocks and achieving conformity with precautionary principles.
   - ii) provide recommendations on any appropriate alterations to the target fishing mortality rate(s) (para. 2), the rule concerning stability of TACs (para 5), or the degressive rate of fishing mortality at lower stock sizes (para. 3).
   - iii) Consider what (if any) limits on TAC variations could be applied to the TAC for herring by-catches in the North Sea

iv) Advise on the circumstances in which para. 6 should apply, and the action to be taken in such circumstances.

v) comment on any other pertinent aspect of the management plan.

b) identify multi-annual plans for Herring Western Baltic, Kattegat, Skagerrak (Sub-Div 22-24) :

i) Of the following form

1) the sum of the regulated catches for the stock of spring-spawning herring in the Western Baltic, the Skagerrak and the Kattegat ("the stock") shall be set according to a fishing mortality of [A].

2) notwithstanding paragraph 1 above, the sum of the regulated catches shall not be altered by more than [B] % with respect to the sum of the regulated catches for the previous year.

3) Notwithstanding paragraphs 1 and 2, in the event that the spawning stock size for the stock is estimated at less than [C tonnes / appropriate model-specific units], the sum of the regulated catches for the stock shall be adapted to assure rebuilding of the spawning stock size to above [C] without incurring the restriction referred to in Paragraph 2. ICES should propose a TAC-setting calculation in such cases.

ii) ICES is asked to identify combinations of values for A, B and C that would assure management of the stock that would conform to the precautionary approach, i.e. a low risk of stock depletion, stable catches and sustained high yield.

iii) ICES should explore other relevant scenarios on its own initiative, but should include at least scenarios where A = fishing mortality = 0.25 (by analogy with North Sea and west of Scotland herring) or F0.1= 0.22 and B = limit on TAC changes = 15%.

iv) ICES is also invited to suggest other approaches to the multi-annual management of this stock on its own initiative.

WKHMP provided a report which includes a description of the relevance of understanding recruitment dynamics when testing management plans and a discussion on precautionary reference points and managing stocks in a precautionary manner (Chapter 1). Management principles and precautionary reference points are discussed further in the NS herring Section 2.9. The current North Sea herring management plan is given in Table 2.12.1.

Management plan of the North Sea autumn spawning herring

The simulations reported by WKHMP confirm the conclusion by ACFM in 2005 that the performance of the current harvest rule is marginal in the present situation of reduced recruitment. Using the rule will lead to an equilibrium biomass just above B_{lim} (estimated by WKHMP as < 1.1Mt). A further reduction in recruitment, higher overfishing or less reliable assessments will all lead to a level of risk of SSB falling below B_{lim} that is incompatible with the precautionary approach. Therefore WKHMP considered that the realised fishing mortality rate from the current rule is too high and recommended that it be reduced by about 20%. Based on the conclusions of WKHMP, and adapted by HAWG, such a reduction could be achieved in one (or a combination) of four ways:

- by directly reducing the target $F_{ages\ 2\text{-}6}$ from 0.25 to 0.20 and $F_{ages\ 0\text{-}1}$ from 0.12 to 0.05,
- by increasing the trigger point from 1.3Mt
- by reducing the fishing mortality on juveniles
- by reducing F at biomass below 0.8Mt.

The rule to constrain the interannual variation in TACs appears to work well under the assumptions of continued low recruitment, and 15% permitted change is within the acceptable range. Currently the WG considers that the use of this rule is acceptable. However, HAWG considers that the continued use of the 15% rule at all levels of biomass may again cause problems if environmental change again switches the productivity regime. Under such circumstances this part of the rule may need to be reviewed again.

WKHMP did not consider the application of limits on variation in the TAC for herring by-catches in the North Sea.

Since WKHMP reported, another assessment has been carried out by HAWG with another year of data. This has shown that there is no increase in the recruitment, and it is likely that the recruitment is as low as in the late 1970s. This suggests that the equilibrium biomass under the current management rule may in fact be lower than that estimated by WKHMP at approximately 950 000 tonnes. This is based on only 6 years of data from the current productivity regime and given the poor understanding of the reasons for the reduced recruitment, the consequences for the stock are unknown if the stock is maintained too close to, or falls below, B_{lim}. Given this aspect of the study provided by WKHMP the WG strongly reinforces the recommendation to reduce slightly the target F as discussed above.

The HAWG considers that the advice from WKHMP to be an excellent basis for advice on a suitable HCR for NS herring

Management plan of the western Baltic spring spawning herring

Currently the formulation of a management plan for WBSS is at an early stage and, given the present knowledge of the biology and state of the assessment of WBSS, WKHMP emphasised that the results presented are preliminary. The main preliminary conclusions are:-

- Simulations suggest that a target F should be set no higher than 0.25.
- Exploration of different juvenile selection patterns indicates that at high fishing mortalities the risk to SSB being below B_{lim} increases with increasing juvenile selection.
- The limit on the year-to-year variation in TAC is recommended to be 15%
- All runs indicate a need for a high trigger level in SSB, however, as the state of the stock is not well defined a specific recommendation on the level of this SSB trigger cannot be given by WKHMP at present.

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 Related Working Group Chairs [AMAWGC]

HAWG was informed about the AMAWGC meeting in February 2008. The presentation focussed on the outline of the new advisory process in ICES. The role of data compilation workshops, benchmark workshops and expert groups (former assessment working groups) was discussed. Expert Groups have an important new role in the advisory process because they will be tasked with providing a first draft of the advice.

The new developments in management strategies, integrated advice, multispecies modelling, INTERCATCH, FLR, contents of working group reports, documenting data and methods, stock annex and drafting advice were also discussed at AMAWGC, and were taken into account when the HAWG 2008 report was put together.

1.4.2 The Planning Group for Herring Surveys [PGHERS]

The Planning Group for Herring Surveys (PGHERS) met in January 2008 (ICES, 2008/LRC:01).

Review of larvae surveys in 2007/2008: Six survey metiers were covered in the North Sea. Larvae abundance is reduced in all observed areas, with the exception of the Buchan area. However, the Multiplicative Larval Abundance Index indicates that the SSB has increased compared to last year.

Coordination of larvae surveys for 2008/2009: The Netherlands and Germany will undertake seven larvae surveys in the North Sea. Surveys in the Baltic Sea will monitor the Greifswalder Bodden area and calculate a recruitment index (N20) for the western Baltic Sea.

North Sea acoustic surveys in 2007: Six acoustic surveys were carried out in summer 2007 covering the North Sea and west of Scotland. The estimate of North Sea spawning stock biomass (SSB) is 1.2 million t (2.1 million t in 2006). The survey shows only one particularly strong year class of herring (2000). Growth of this 2000 year class seems still to be slower than average. Individuals of this year class were almost the same size and weights as the younger 2001 year class. The west of Scotland survey estimates a decrease in SSB to 299 000 tonnes. The survey was unusual in detecting virtually no immature fish this year.

Western Baltic acoustic surveys in 2007: A joint German-Danish acoustic survey was carried out in October in the western Baltic. The estimate of western Baltic spring spawning herring is 115 000 t in SD 22-24, half of the biomass of 2006 (214 000 t), and the lowest biomass estimate in the time series since 1993. The estimated total sprat biomass is 110 000 t. This indicates a weak upcoming year class.

Status of the FishFrame database: FishFrame was used to combine the national data into the integrated survey result, both for herring and sprat. FishFrame performed well.

Sprat: The total sprat biomass was estimated as 353 000 t in the North Sea (452 000 t in 2006). In most recent years the majority of the stock consists of mature sprat, but in 2007 roughly 1/3 of the sprat biomass was immature fish. Sprat were almost exclusively found in the eastern and southern parts of the North Sea. In Division IIIa, sprat abundance has increased and the total biomass was estimated to be 59 000 t. Most sprat of this stock were immature, one-year old fish (> 95 %).

Coordination of acoustic surveys in 2008: Seven acoustic surveys will be carried out in the North Sea, west of Scotland and the Irish Sea in July 2008. A survey in the western Baltic will be carried out 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. Real-time fishing comparison trials were conducted in 2006, deploying both samplers in a single frame. Sea water volume filtered by the Gulf VII is significantly lower then the Gulf III. Although it looks like the Gulf III is catching a slightly higher number of smaller larvae, numbers of larvae per m^3 water filtered does not differ significantly between the Gulf III and Gulf VII. Thus the larvae surveys are considered as unbiased by the change in gear.

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

The ICES Study Group on recruitment variability in North Sea planktivorous fish (SGRECVAP) met for a second time in early May 2007 to further consider the population dynamics (especially recruitment) of herring, sandeel and Norway pout in the North Sea. SGRECVAP first met in 2006, when worries were expressed about the apparent synchronous serial poor recruitment in those species since 2001. A detectable change in the recruitment of herring and Norway pout in the North Sea was either caused by a reduction in productivity in the early 2000s or by a longer cycle of decline since the 1980s. There was only a biomass signal on the recruitment of sandeel. The productivity of all three stocks is low at present.

The lack of any properly funded research project on the recruitment of planktivorous fish in the North Sea meant that the activities of SGRECVAP were limited to list potential hypotheses, stimulate further investigations and carry out preliminary analysis. Data sets of environmental data were compiled to explore the hypotheses listed by SGRECVAP 2006. Specifically wind, temperature, water density, water colour, flow, copepods, chaetognaths, total zooplankton, nauplii, the ratio of *Calanus finmarchicus* and *Calanus helgolandicus* and the abundance of predatory fish were investigated.

A change in the North Sea environment has occurred at the same time as the poor recruitment in herring and the downward trend in Norway pout. It is likely that the poor recruitment in North Sea herring is a result of poor survival of larvae from the central and northern components of the stock. In the spawning areas of herring and Norway pout (in the central and northern North Sea) the sea temperatures have increased markedly, with a commensurate reduction in water density. The trend in herring recruitment since 1998 is similar to the trend in declining water density at the main herring spawning sites.

The zooplankton time series were investigated for spring, autumn and annual signals. The well known shift from *Calanus finmarchicu*s to *C. helgolandicus* was clearly seen, but process studies are required to determine whether this is important for the productivity of planktivorous fish. Overall from 1950 to the present, only the central North Sea shows large variability in the zooplankton community and the standing stock of chlorophyll. In the northern North Sea only the abundance of *Calanus* sp. copepodites showed a declining trend. However in the central North Sea, the total abundance of copepods, the abundance of adult *Calanus* sp. and *Calanus* copepodites all showed declining trends. The trend in the zooplankton was similar to those in the recruitment residuals of the fish (i.e. late 1980s and around 2000). Chaetognaths showed a declining trend until the 1980s.

There has been a recent increase in mackerel, horse mackerel, sardine and anchovy in the North Sea. Preliminary investigations suggest that mackerel and horse mackerel are not the cause of the poor recruitment as they do not overlap spatially and temporally with the larvae of herring or Norway pout. Spatial data on anchovy and sardine were not available to SGRECVAP, so this needs further exploration.

Suitable coupled bio-physical models are not currently available for North Sea herring, sandeel and Norway pout. Their development should be encouraged to investigate the mechanisms that determine year class strength and explain the commensurate signals seen in the environmental time series. SGRECVAP could not recommend any indices as predictors for trends in productivity. The trends in productivity cannot be predicted, and there is no evidence to suggest a change in trend. The assumption that poor recruitment will continue is valid under the precautionary approach. Therefore stock projections should assume that the period of poor recruitment will continue.

1.4.4 Workshop on Reference Points in the Baltic [WKREFBAS]

The Workshop met at ICES HQ, 12–14 February 2008. The main outcomes of the workshop relevant for HAWG were (a) reference limits for the predator species cod cannot be defined without considering both changes in the biomass of its prey and the environment condition for spawning and recruitment; (b) management should focus on fishing mortality reference points over biomass ones.

WKREFBAS focused on the analysis mainly on fishing mortality reference points of eastern Baltic cod. Once the eastern Baltic cod stock has recovered under the current F-based EC management plan the appropriateness of the B_{lim} (160 000 t) will be better determined but the poor landings data, uncertain discard data, and age reading problems will need to be addressed first in the short-term.

Under the current situation, WKREFBAS considered reference points for the pelagic stock of herring and sprat to be appropriate to sustain catches and spawning stock biomass in the long term.

For the eastern Baltic cod stock, WKREFBAS considers that results (sustainable F of 0.3 to 0.4) obtained by AGLTA (ICES 2005) are still appropriate for describing the long-term dynamic of the stock and investigating possible long-term fishing mortality. Only with a substantial reduction in assessment and implementation errors might a higher F be possible.

It is timely to investigate existing, and any potential, limit and precautionary reference points for Baltic stocks in the context of biological interaction. A three species model (cod-sprat-herring) was investigated during the workshop and the results are presented in the report. WKREFBAS used SMS (the successor to MSVPA) to evaluate the impact on the eastern Baltic cod stock of the size of the sprat and herring stocks for a range of fishing mortalities. The SMS (Stochastic Multi-Species) model is a stock assessment model including species interaction estimated from a parameterised size dependent food selection function. Reference limits for the predator species cod cannot be defined without considering changes in the biomass of its prey and the environment condition for spawning and recruitment. These considerations make it impossible to achieve MSY predicted by single species assessment, simultaneously for cod, sprat and herring.

In the limited time available, it was not possible to suggest a management plan for the clupeid stocks (herring and sprat) in response to the additional request from the European Community for advice on the establishment of a multi-annual plan for pelagic fish stocks in the Baltic and further work is indicated; e.g. including studies of density dependent growth.

An internationally coordinated stomach sampling and field program should be agreed and undertaken in the Baltic Sea. Furthermore, WGIAB (Working Group on integrated assessment in the Baltic) should consider the issue of spatial overlap between species and their eggs, larvae, juveniles and adults in their discussions on the key processes in the Baltic.

1.4.5 The Study Group on Management Strategies [SGMAS]

SGMAS has not met since the previous HAWG, but is scheduled to meet in November 2008. So far, it has provided guidelines for evaluation of management strategies. Recently, it has started to assemble experience with past and ongoing evaluations, and to explore strategies for stocks with a limited information base. It also has suggested a stronger interaction with stakeholders and managers in the process of developing management strategies. These suggestions have been tried with some success with e.g. the NEA mackerel.

For the future, it is envisaged that SGMAS will act as a forum for assembling and integrating information from related expert groups to give comprehensive guidelines that take the broader experience across groups into account in the development and evaluation of management strategies. It will continue to assemble experience from development and evaluation work, and maintain and update its inventory of relevant software.

1.4.6 Workshop on the Integration of Environmental information into fisheries management Strategies [WKEFA]

ICES held a workshop on the Integration of Environmental Information into Fisheries Management Strategies and Advice (WKEFA, ICES CM 2007/ACFM:25) in 2007. Following a preparatory meeting in February which developed a strategy and identified a number of relevant case studies, the main WKEFA workshop co-sponsored by ICES, EUROCEAN, and GLOBEC met from 18- 22 June 2007. Fourteen case studies involving a wide range of demersal and pelagic stocks, as well as some generic stock simulations, were presented in detail over the first two days. Pelagic stocks included two sardine stocks, two anchovy stocks, one herring and one sprat stock. Of these North Sea herring is dealt with by this assessment WG. The main results from the case studies and the demonstrated influence of environmental change on the stocks are summarised in the WKEFA report.

WKEFA discussed and formulated generic concepts for improving fisheries management strategies and advice considering interactions under four main aspects:

a) Entries and exits from populations (recruitment, natural mortality and migration)

b) Internal population processes, encompassing a range of aspects associated with growth maturation and reproduction

c) Location and habitat (including such aspects as vertical and horizontal movement)

d) Multi-species interactions

While it has been long accepted that ICES provides fisheries advice within the context of a varying environment, WKEFA indicated the need to take into account not only stochastic variability but also trends and shifts in the environment in the development of scientific advice. Changes in physical drivers at many scales of space and time act together which result in changes in habitat. Through complex linkages, these changes result in differences in fish location, growth, maturation and reproductive potential. These differences may then influence recruitment and abundance leading to changes in natural mortality due to different species interactions. The workshop concluded that the effects of environmental change on fisheries management are better addressed by separating variability according to the time scale of the changes.

For HAWG we have already evaluated productivity by stock and have incorporated this into the way recruitment is estimated for both short term and medium term projections.

Some aspects, such as catastrophic events, can only be dealt with through a willingness to remain aware through the collection of information and by observing and accounting for unusual events that may cause migration, mortality or recruitment failure. This is particularly relevant for recruitment of pelagic species. Some short term changes can be observed, estimated and brought into advice even where the complexity of the drivers is unknown. For example changes in growth and maturation can be brought directly into methods for estimating spawning stocks one or two years ahead and for estimating catch where TACs are required. Trends in mean weights have been taken into account this year for North Sea herring.

Combining such information can improve the performance of management but only if the errors in the information are included appropriately. There are a number of instances where environmental drivers have been clearly shown to explain variability in recruitment, such as Bay of Biscay anchovy, but once in use some have shown problems. This indicates that testing the utility of indicators in management simulations must be a requirement before they are formally applied, including developing implementation frameworks that are informative and robust to errors.

As habitats change, spatial distributions of fish change, both horizontally and vertically. These changes can interact with surveys and fisheries leading to the requirement to monitor and account for change in catchability in assessment tuning series. These differences may impact on recruit surveys, such as those for North Sea herring.

WKEFA considered that the approach needs to follow two avenues. Where explicit relationships exist between stock and the environment the mean of stochastic projections can be modified accordingly. Such situations include average temperature dependence, species interactions and food availability for different exploited stocks. Where no explicit relationships exist or there is no basis for predicting environmental drivers into the future, advice should be based on scenario testing along the lines of the evaluations of SGMAS management plans.

The workshop concluded the following as a general recommendation in light of climate change: rather than assuming that the mean of a given parameter derived from the (recent) past will best define the future, we should consider trends and attempt to estimate them. This calls for the development of a number of tools that evaluate estimates of current values and current trends in the presence of noise in both measurement and environment.

The workshop concluded with a number of explicit recommendations regarding which environmental information should be integrated into fisheries management strategies and advice:

- Productivity regime changes that require adapting management procedures or procedures robust to changing regimes
- Habitat changes that influence measurement and stock carrying capacity
- Growth and maturation changes that influence short- and medium-term advice
- Recruitment changes due to environmental influence in the short- and medium-term

Recommendations from WKEFA also include the use of multi-species models primarily for hypothesis testing and testing management procedures.

1.4.7 Linking Herring 2008 [ICES/GLOBEC sponsored symposium]

Herring: Linking biology, ecology and status of populations in the context of changing environments. The short name for this international symposium is Linking Herring. The symposium will take place from the 26th to 29th August 2008. The aim is to bring together specialists on all aspects of herring biology, assessment and management. The meeting seeks to link thematic areas and disciplines. It is hoped to pool experience and expertise to examine the status of herring populations around the world in the context of changing biological, physical and economic environments.

The following theme sessions will take place consecutively, being opened by six key note speakers:

1) Advances in herring biology: Audrey Geffen (Norway).
   - An update on new developments in biological studies

2) Counting Herring: John Simmonds (UK)
   - Qualitative and quantitative survey, assessment methods

3) Population Integrity: David Secor (USA)
   - Stock structure, identity and rigidity of stocks

4) Variable Production: Nils Christian Stenseth (Norway)
   - Reproduction, recruitment and life history strategies

5) Herring in the middle: Andrew Bakun (USA)
   - Trophic and ecological interactions

6) Managing change: Martin Pastoors (the Netherlands)
   - Management of herring populations in changing biological and social environments

The overall opening lecture is by Mike Sinclair.

The symposium is sponsored by ICES, PICES and GLOBEC and funding is available through MARBEF and EUROCEAN for participants. There is also a student fund for travel.

1.4.8 Study Group on the evaluation of assessment and management strategies of the western herring stocks [SGHERWAY]

SGHERWAY (Chair: Emma Hatfield, UK) will be established and will meet in Aberdeen, Scotland (UK) in December 2008.

The EU funded project WESTHER evaluated the uncertain stock identity of herring stocks to the west of the British Isles. Its results suggested a rearrangement of the stocks as they are currently assessed.

It has been recognised that there is a need to provide sound management advice for herring in the western areas, and in particular the importance of ensuring that there is no depletion of local components. HAWG, in 2007, 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.

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

i) Investigation of combined assessment of the three currently assessed stocks, VIaN, VIaS and VIIaN (to be called collectively the Malin Shelf or Malin/Hebrides Shelf stock), including an investigation of the utility of a combined acoustic survey

ii) Examination of alternative management strategies based on their ability to deliver protection to local populations and to provide cost effective information applicable for management of the two proposed stock units of herring to the west of the British Isles (Malin Shelf and Celtic Sea)

iii) Amendment of existing, or development of new, cost effective assessment and data collection schemes which will be required to support this management

SGHERWAY will therefore convene to resolve issues surrounding the assessment and management of the herring stocks to the west of the British Isles. Its impact is expected to be high. It is proposed that this would be the first of two meetings of SGHERWAY. It is intended that there would be ~10 participants, meeting for a week each time, with intersessional work as required.

An extra ToR was also added to the PGHERS ToRs (which met in January 2008) to examine the potential for a combined acoustic survey of the western areas identified in WESTHER. In response to this extra ToR it has been decided to increase the survey coverage in the summer of 2008 to cover VIaN (FRS-Scotland), VIaS, VIIb-c (MI-Ireland) and, hopefully, the Northern channel and Clyde areas (AFBINI-Northern Ireland) with required intercalibration. The results of this combined survey will be reported to SGHERWAY in December 2008.

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

PGCCDBS considered that the system of contact officers providing a link between ICES stock assessment Working Groups and PGCCDBS was insufficiently developed in 2007 to evaluate the success of this initiative. Furthermore, there did not appear to be a well-defined protocol for contacts officers to provide feedback from AWGs (assessment working groups).

The development of a Quality Assurance Framework (QAF) and associated data catalogue may prove a more appropriate link between AWGs and PGCCDBS by automating the reporting of data usage by the AWGs, reducing demands on already reduced WG time. The AWGs would still need to explain why certain data were not incorporated in assessments and this is likely to lead to more constructive scientific debate on data needs.

The ICES AMAWGC meeting in 2008 supported the development of a data catalogue to manage sampling meta-information so that the sampling summaries can be generated automatically. This should, at the same time, also suit the needs of STECF-SGRN when evaluating the compliance of Member States with the DCR (data collection regulation) and their National Programmes. The implementation of such a catalogue will be tested by introducing table templates (see text Tables 1 and 2) to the AWGs in 2008 to be filled in by the stock co-ordinators of the following stocks (expanded from the list AMAWGC proposed):

a) WGWIDE: NEA mackerel, NSS herring
b) WGSSDS: Haddock VIIb-k, Plaice VIIe
c) WGHMM: Iberian hake, Bay of Biscay sole
d) HAWG: North Sea herring
e) WGBFAS: eastern Baltic cod, Baltic sprat
f) WGNSSK: North Sea plaice

The proposed tables will be reviewed intersessionally (until end of March 2008) by Jørgen Dalskov, Ernesto Jardim, Christoph Stransky and Joël Vigneau and sent to the stock co-ordinators by early April 2008. These persons will also co-ordinate the collation of responses from the stock co-ordinators for consideration at the next PGCCDBS.

Table 1 - Example for data table per country

Parameter: Length distribution of landings/retained part			Country 1	Country 2	………	Responsibility
Conformity with protocol						Automatic from catalog
Coverage	Time (Q)	1				
		2				
		3				
		4				
	Space (ICES Div.)	VIa				
		VIb				
		VIIa				
		VIIb				
		VIIc				
	Tech/metier	Trawl 50mm				
		Trawl 90mm				
		Nets 120mm				
		Pots				
Sampling effort	No. of sampled trips					
	No. fish measured					
	No. different vessels					
Methods	Sampling strategy					
Data	Available					Stock coord.
	Processed					
	Used					

Table 2 - Example for data table per stock

Parameter: Length distribution of landings/retained part			Stock 1	Stock 2	....	Responsibility
Conformity with protocol						Automatic from catalog
Coverage	Time (Q)	1				
		2				
		3				
		4				
	Space (ICES Div.)	VIa				
		VIb				
		VIIa				
		VIIb				
		VIIc				
	Tech/metier	Trawl 50mm				
		Trawl 90mm				
		Nets 120mm				
		Pots				
Sampling effort	No. of sampled trips					
	No. fish measured					
	No. different vessels					
Methods	Sampling strategy					
Inference	Methods					Stock coord.
	Bias quality indicator (WKACCU)					
	Precision quality indicator (WKPRECISE)					

Quality Assurance Framework (QAF)

PGCCDBS developed during the last year a Quality Assurance Framework (QAF) for stock assessment input parameters. Issues about quality assurance are included in the current MoU between EC and ICES, committing ICES to communicate any problems regarding data collected under the DCR and be responsible about the quality control of the aggregated data used for assessment.

The main objectives of the QAF suggested are: (i) to guarantee the quality of the raw data used for assessment, (ii) promote transparency of the process of compiling parameters at the stock level and (iii) give feedback about the usage of the data available.

The approach proposed is based on a set of quality indicators computed for each parameter available for stock assessment. Such indicators can be qualitative or quantitative. At the moment three indicators are proposed: (i) compliance with protocols, (ii) coverage of the sampling achieved and (iii) precision of the estimates. These quality indicators are under development in ICES within two dedicated workshops, WKACCU in 2008 that will deal with (i) and (ii) and WKPRECISE in 2009 that will deal with (iii).

The indicators can be computed at the national level or stock level, although regarding stock assessment they are more important at the stock level.

An overview of the system is shown in the following diagram:

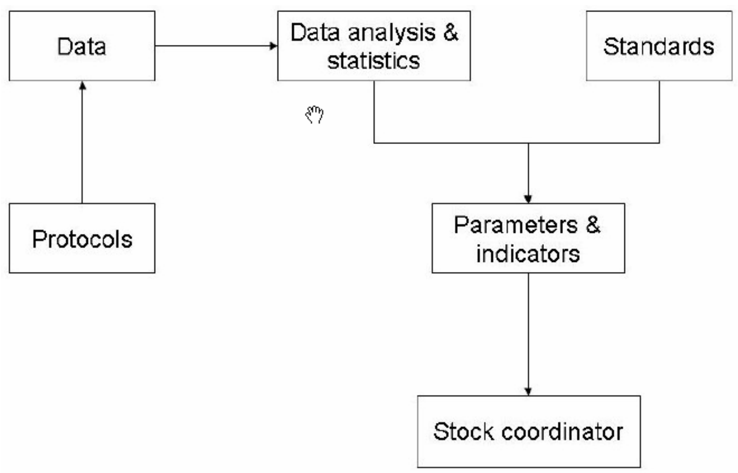


Figure 1 – Proposed mechanism for indicators construction.

Data collectors provide meta-data about the sampling carried out for each parameter to a public online data catalog (to be developed under the EC annual workplan), and provide data aggregated at the required level to stock coordinators (InterCatch). Based on this information stock coordinators compile input parameters for stock assessment and compute quality indicators. The meta-information about sampling and the quality indicators must be included in a specific section in the AWG report (see example Table 1 and Table 2 above) to: (i) provide additional information to the advice process; (ii) report back to data collectors; (iii) report to STECF/SGRN to evaluate conformity with NPs; (iv) report to PGCCDBS to evaluate possible problems.

The proposal (Figure 2) is that tasks regarding the compilation of data at the national level and the upload of meta-data to the data catalogue shall be under the remit of each Member State. Tasks regarding the analysis of the meta-data at the national level shall be under the remit of STECF/SGRN. Tasks regarding the stock coordinators' procedures shall be under the remit of ICES or other relevant scientific bodies.

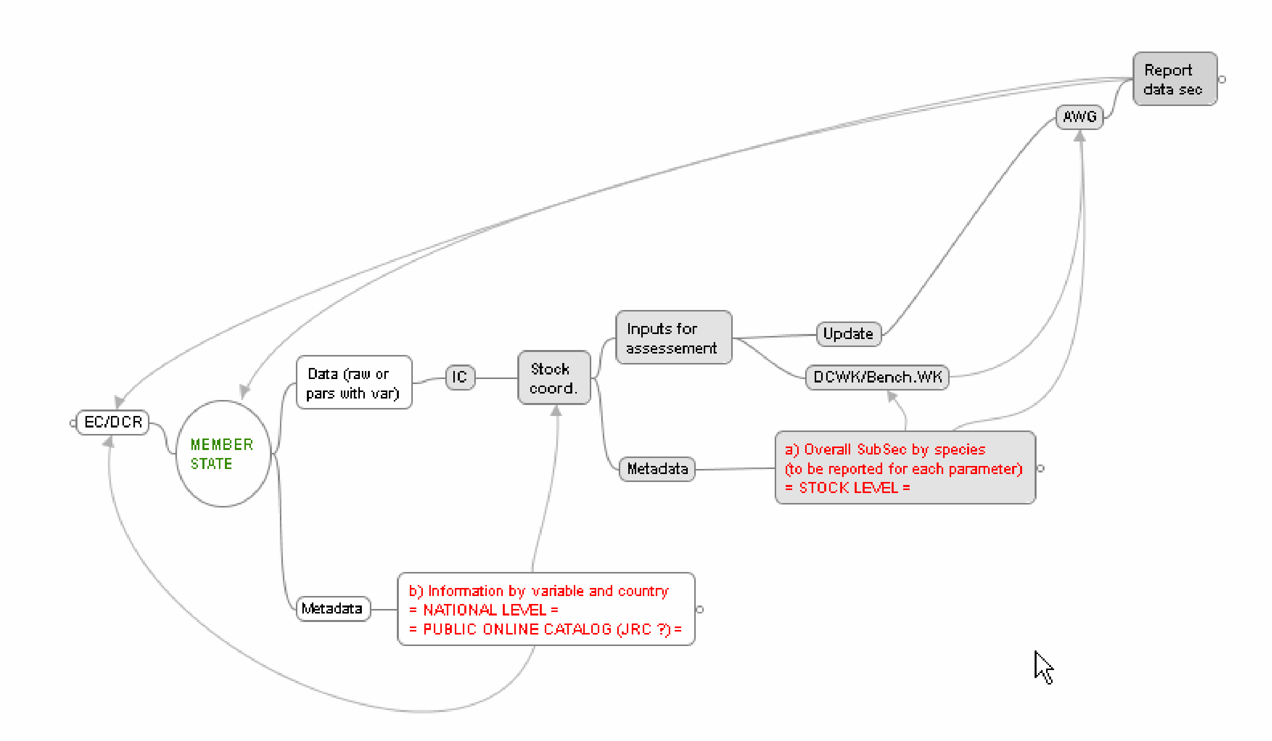


Figure 2 – Quality Assurance Framework suggested by PGCCDBS

The Planning Group developed the basic outline for a Quality Plan for information generated from sampling programs and used in stock assessments. The primary purposes of the Quality Plan are:

- To document the procedures and methods of sample collection, preparation and analysis
- To provide assurance as to the precision and accuracy of samples at the stock level
- To provide assurance as to the accuracy from using accepted standards
- To provide reliable information regarding the interpretation of data with respect to how, where and when samples were collected

Minimum requirements for national programs are:

- Development and adoption of written quality standards and procedures
- Verification for some or all self-reported data
- Development of timely compliance tracking and reporting procedures for self-reporting systems
- Estimates of variance should be provided with some or all estimates
- Defined goals for minimum levels of precision for sampling programs
- Development of metadata databases for some or all fishery-dependent databases
- Establishment of criteria for validation of data element quality in all data collection programs

Strategic quality planning is based on the development of a proactive quality assurance framework that identifies all activities aimed at preventing sampling errors. Quality control procedures are a part of the framework and are designed to detect errors in the samples already obtained.

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 2007 catch data was v1.6.4. These data were then further processed with the SALLOC-application (Patterson, 1998). This program gives the needed standard outputs on sampling status and biological parameters. It also clearly documents any decisions made by the species co-ordinators for filling in missing data and raising the catch information of one nation/quarter/area with information from another data set. This allows recalculation of data in the future, or storage and analyses in other tools like InterCatch (see section 1.5.4), choosing the same (subjective) decisions currently made by the WG. Ideally, all data for the various areas should be provided on the standard spreadsheet and processed similarly, resulting in a single output file for all stocks covered by this Working Group. One nation failed to deliver their data on time. A second one added information afterwards, which was not available in due time. With regard to the new demand for preparation of working documents for the specific stocks prior to the WG meeting, it is crucial to get timely access to the official national landings, collected by the national governmental agencies.

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

1.5.2 Sampling

Quality of sampling for the whole area

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

	OFFICIAL	SAMPLED	AGE	AGE READINGS
Area	catch (t)	catch (t)	readings	per 1000 t
IVa(E)	58550	52071	638	11
IVa(W)	198858	193218	8548	43
IVb	69435	43714	711	10
IVc	2354	242	26	11
VIId	31917	19772	419	13
VIIa(N)	4629	4629	1442	312
VIa(N)	33960	18366	1196	35
IIIa	87100	80900	14232	164
Celtic Sea,VIIj	7562	7562	3938	521
VIaS, VIIb,c	12661	12661	1751	138

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 started in 2005. However, there is scope for improvement, and more of these agreements have to be negotiated, especially between EU and non-EU countries, to reach a sufficient sampling coverage of these landings.

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 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 Stock Annex 3.

1.5.4 Intercatch

InterCatch is a web-based system for handling fish stock assessment data. National fish stock catches are imported to InterCatch. Stock coordinators then allocate sampled catches to unsampled catches, aggregate to stock level and download the output. The InterCatch stock output can then be used as input for the assessment models." Stock coordinators used InterCatch for the first time at the 2007 Herring Assessment Working Group. Comparisons between InterCatch and other legacy (previously used) systems were carried out in 2007 and again in 2008 and the maximum discrepancies between the systems are presented in the text table below. The IIIa WBSS herring stock was this year through a benchmark assessment process and the comparison between InterCatch and the current applied system was not performed as this analysis had a somewhat lower priority. However, the comparison will be performed shortly after the end of the HAWG during an InterCatch course hosted by ICES.

The stock coordinators in general found that InterCatch is a helpful tool that has the potential to reduce errors and reduce the work load of the stock coordinators. A number of improvements to the system were suggested by HAWG in 2007 (ICES/CM ACFM:11). Many of these improvements have been implemented and the outstanding ones are currently being examined. During the HAWG 2008 the group received substantial support from the ICES secretariat in applying InterCatch.

Maximum discrepancies between InterCatch and other systems used in 2008 are presented below and are generally small.

	North Sea	Celtic Sea, VIIj	VIaS, VIIb,c	VIIaN	VIaN
Catch in Tonnes (Caton)	0.00%	0.01%	0.01%	0.01%	0.00%
Catch numbers at age (Canum)	0.27%	0.01%	-0.01%	0.01%	-0.17%
Catch Weights (Weca)	0.00%	0.00%	0.16%	0.01%	0.17%

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 year ICA was replaced by FLICA which performs the same analysis but from an FLR platform. The exception was a quality control exercise for the benchmark assessment where the original ICA was used.

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 modelling 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 modelling 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 ongoing.

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 as predictor variables. This enhances the visual judgement of the quality of model fit, even though the nature of the data would suggest a reversal of predictor and dependent variables. It may be sensible to take this into account in the way the catchability models are fitted, but this would require changes in the ICA code itself. In addition, a Q-Q plot to show the distribution of the log residuals as compared to a normal distribution was added to the diagnostics output.

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

1.6.4 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.

1.6.5 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.

1.6.6 Management simulations

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

1.6.7 Two-stage biomass model

A two-stage biomass model allowing for an additional variance resulting from the mix of Celtic Sea and Irish Sea herring at the juvenile stage was used to explore the survey and catch data of Irish Sea herring.

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 two nations reported discards from their fleets in 2007. From those, only Scotland incorporated discards in the assessment data. The discard figures were raised to national landings (based on the spatial and temporal distribution of the fleet by metier), and used in the assessment of North Sea autumn spawning (see Section 2.3) and VIaN (see Section 5.1.3) herring. For the Netherlands, the estimates of herring discards of approximately 6 000 tonnes per year (from a fleet whose total landings is over 300 000 tonnes of fish per year in the ICES area) were not sampled at a high enough resolution to allocate the catch in individual stocks (Dickey-Collas & Helmond WD1; Borges et al. in press). Scotland monitored 12 trips and the Netherlands 12 trips in 2007.

In the Dutch fleet there appears to be little size selection for landed herring compared to discarded herring (Figure 1.7.1).

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

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

Conclusion

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

1.8 Ecosystem considerations, sprat and herring

HAWG acknowledges that changes in the environment, both the biotic and the abiotic, can have significant impact on the dynamics of herring populations and must therefore be considered when giving any advice on how to manage these stocks.

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, partly because it is difficult to incorporate their data in existing assessment models.

Although assessment working groups are generally populated by scientists with a “stock assessment” background, 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 time series that reflect the dynamics of the NE Atlantic and environments 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. HAWG hopes that WKOOP (The ICES Workshop on Operational Oceanographic Products) will help improve the delivery of oceanographic products to working groups.

To evaluate potential influence of the environment on fish stocks, the Workshop on the Integration of Environmental Information into Fisheries Management Strategies and Advice (WKEFA) was held in July 2007 at ICES (ICES CM 2007 /ACFM:25, see also chapter 1.4.6)

WKEFA had two major conclusions on the incorporation of environmental data:

- Where explicit relationships exist between stock and the environment the mean of stochastic projections can be modified accordingly. Such situations include average temperature dependence, species interactions and food availability for different exploited stocks
- Where no explicit relationships exist or there is no basis for predicting environmental drivers into the future, advice should be based on scenario testing along the lines of the evaluations of SGMAS management plans

To investigate the low recruitment in herring, Norway pout and sandeel since 2001, the Study Group on Recruitment Variability of North Sea Planktivorous Fish (SGRECVAP) had their second meeting in May 2007 in Plymouth (ICES CM 2007 /LRC:07). Although it was realised that the decrease in productivity goes in parallel to changes both in the abiotic and the biotic environment, the mechanisms could not be revealed.

HAWG assumes that ad-hoc workshops of this kind are necessary to get a better idea of the knowledge and information necessary from the Expert Groups in the Science Programme and will improve the overall connection of the different experts groups.

A special emphasis has to be placed on the change of climate as stated from the IPCC (IPCC 2007) and possible regime shifts due to this climate change and regime shifts due to other reasons. As regimes change they might influence both the carrying capacity and productivity of pelagic fish stocks. Thus knowledge of the drivers of the different ecosystem components is needed to ensure long term sustainable exploitation of fish resources. With this regard, HAWG welcomes the work of WKSPCLIM (ICES/PICES/GLOBEC-SPACC Workshop on Changes in distribution and abundance of clupeiform small fish in relation to climate variability and global change), which will meet in late 2008. Both studies of long term dynamics and recent events indicate that the productivity of many of the stocks assessed by HAWG is highly variable and also may suggest regime changes. Further multidisciplinary targeted studies, including experiments in controlled environment are required to address this variability and explain the underlying processes.

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 2007. HAWG considers the views of the Pelagic RAC as important, and welcomes the formation of this forum to give stakeholders a role in the advisory process. HAWG notes that the Pelagic RAC also has special 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.

1.10 Stock overview

Analytical assessment could be carried out for three of these ten 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.

1.10.1 North Sea autumn spawning herring

North Sea autumn spawning herring is the largest stock assessed by this WG. It 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 it dropped to 0.98 million tonnes in 2007. The current fishing mortality (F_{2-6}) is 0.33 and is well above the target F (F=0.25) prescribed by the management agreement. It is likely that the stock will decline further close to B_{lim} (800 000 t) by 2009. 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 most likely caused during the larvae phase of the North Sea herring.

1.10.1.1 Stock status

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

Based on the most recent estimates of SSB and fishing mortality, ICES classifies the stock as being at risk of having reduced reproductive capacity and at risk of being harvested unsustainably. SSB in 2007 was estimated at 0.98 million t, and is expected to remain below $\mathbf{B}_{pa}$ (1.3 million t) in 2008. All year classes since 2001 are estimated to be among the weakest since the late 1970s.

1.10.1.2 Mixed fisheries considerations

There are no mixed fishery considerations.

1.10.1.3 Ecosystem effects of fisheries

The herring fishery has no discard or by-catch issues nor does the fishing gear touch the seabed and is therefore supposed to have no effect on the benthic ecosystem.

1.10.1.4 Regulatory changes in the fisheries which have consequences for the assessment or projections

Landings taken in the North Sea but reported from other areas such as Divisions IIa and IIIa and from Division VIaN have increased in 2007 compared to 2006 (from 19 000 t to 26 000 t). The estimates of the total amount of catch in excess of the TAC in the human consumption fishery (excluding within-area misreporting) was about 40 000t which is similar to last year (roughly 12% of the TAC for human consumption).

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. This percentage was reduced to 40 % in 2007 and 30 % in 2008.

1.10.1.5 Agreed or proposed management plans

The current management objective is the agreed harvest control rule (HCR) presented at the end of the single stock advice. ICES was asked to review this harvest control rule in 2008. Detailed information can be found in Section 1.3.1.

1.10.1.6 Species interaction effects

Herring are an important prey species in the ecosystem and are also one of the dominant planktivorous fish.

1.10.2 Western Baltic spring spawning herring

Western Baltic spring spawning herring (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. In 2008 HAWG carried out a benchmark assessment which gave an estimated SSB for 2007 of 133 500 tonnes with a mean fishing mortality (ages 3-6) of 0.46. This is a decrease in SSB from approximately 163 000 tonnes in 2006. The estimated number of the 0-ringers in 2007 is 1.01 billion, the lowest observed during the 17 year duration of the current assessment, and continuing the downward trend in recruitment for this stock observed since 1999. This decrease is likely to continue at status quo fishing mortality under which SSB is predicted to decline from 133 500 t to 104 600 t in 2009 and further down to 89 000 t in 2010, which is considerably lower than the lowest values observed during the late 1990s.

1.10.2.1 Stock status

Spawning biomass in relation to precautionary limits	Fishing mortality in relation to precautionary limits	Fishing mortality in relation to highest yield	Fishing mortality in relation to agreed target	Comment
		Overfished		

In the absence of defined reference points, the state of the stock cannot be evaluated. An analytical assessment demonstrates that the SBB has been stable over a number of years but at a lower level than in the beginning of the time series. Fishing mortality has also been stable in the same period but larger than any proxy of F_{msy}. Recruitment has declined since 2003 and it is now at the lowest observed level. .

Based on F_{msy} (0.25) in both years, SSB in 2009 and 2010 is predicted to be 107 000 t and 110 900 respectively, thus impeding the otherwise subsequent decline in SSB.

1.10.2.2 Mixed fisheries considerations

There are no mixed fisheries considerations.

1.10.2.3 Ecosystem effects of fisheries

The herring fishery has no discard or by-catch issues nor does the gear touch the seabed and is therefore supposed to have no effect on the benthic ecosystem.

1.10.2.4 Regulatory changes in the fisheries which have consequences for the assessment or projections

Corrections for misreporting by area have been incorporated in the assessment. In recent years, ICES has calculated that a substantial part of the catch reported as taken in Division IIIa by fleet C was actually taken in Subarea IV. These catches have been allocated to the North Sea stock and accounted for 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. Working Group estimates may be underestimating the problem since not all countries supply this information to ICES.

The quota for the C fleet and the by-catch quota for the D fleet are set for the NSAS and the WBSS stocks together. The implication for the out-take of NSAS must be taken into account when setting quotas for the fleets that exploit these stocks. The Swedish industrial fishery has rapidly declined during the 1990s and it is currently no longer operating in the area. Therefore, there is no difference in age structure of the landings between vessels using different mesh sizes since both are basically targeting herring for human consumption.

The full consequence of the implementation of the ITQ system for herring is yet unknown as vessels still are changing status. However, a change in the behaviour in the Danish herring fishery indicates that vessels without an ITQ for herring are targeting a mixed sprat and herring fishery and land their catch for industrial purposes, whereas vessels with an ITQ for herring are primarily participating in the herring fishery for human consumption.

1.10.2.5 Agreed or proposed management plans

There are no agreed or proposed management plans for this stock.

1.10.2.6 Species interaction effects

Herring are an important prey species in the ecosystem and are also one of the dominant planktivorous fish.

1.10.3 Celtic Sea and Division VIIj herring

Celtic Sea and Division VIIj 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. The current levels of SSB and F are uncertain. In recent years SSB has been lower than B_{pa} and possibly B_{lim}, and F has been high. The Celtic Sea herring stock had a low productivity throughout the whole time series, compared to other stocks.

1.10.3.1 Stock status

Spawning biomass in relation to precautionary limits	Fishing mortality in relation to precautionary limits	Fishing mortality in relation to highest yield	Fishing mortality in relation to agreed target	Comment
Uncertain, but likely at risk of reduced reproductive capacity	Unknown	Unknown	NA	

The stock size is uncertain. In recent years SSB has been lower than B_{pa} and possibly B_{lim}, and F has been high. The stock is currently composed mainly of younger fish.

1.10.3.2 Mixed fisheries considerations

There are no mixed fisheries considerations.

1.10.3.3 Ecosystem effects of fisheries

Herring are an important prey species in the ecosystem and are also one of the dominant planktivorous fish. Herring fisheries tend to be clean with little by-catch of other fish. Overall there is a paucity of data relating to by-catch in this area.

1.10.3.4 Regulatory changes in the fisheries which have consequences for the assessment or projections

Since 2002 fishing has taken place in quarter 3, targeting fish during the feeding phase on the offshore grounds around the Kinsale Gas Fields. These fish tend to be fatter and in better condition than winter-caught fish. In 2003 the fishery opened in

July on the Labadie Bank and larger fish were caught than are normally found in the fishery. Only refrigerated storage vessels can prosecute this fishery. Traditional dry-hold boats are unable to participate.

1.10.3.5 Agreed or proposed management plans

There is no EU management plan for this stock. A local management committee manages the Irish fishery, and has the long term aspiration to build the stock to a level that can sustain catches of 20 000 t per year. ICES has evaluated this objective and found that it is not attainable at present.

In 2007, the committee proposed a 15% reduction in TAC for 2008, with future catch levels to be based on ICES advice. It also proposed to close VIIaS, and this was implemented in 2008.

There is ongoing work on developing a rebuilding plan. ICES has not evaluated this work.

1.10.3.6 Species interaction effects

Herring are an important prey species in the ecosystem and are also one of the dominant planktivorous fish.

1.10.4 West of Scotland herring

West of Scotland herring was, until recently, regarded as lightly exploited, but in 2007 the stock was more heavily exploited than it has been since 1999. Earlier data indicated the possibility of a 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 2007, however, there was no misreporting from IVa into VIa (N).

1.10.4.1 Stock status

Spawning biomass in relation to precautionary limits	Fishing mortality in relation to precautionary limits	Fishing mortality in relation to highest yield	Fishing mortality in relation to agreed target	Comment
Undefined	Undefined	Overexploited	NA	

Based on the most recent estimates of SSB and fishing mortality, ICES considers that the stock is currently fluctuating at a low level and is being exploited above F_{msy}. The recruitment has been low since 1998, the 2001 and 2002 year classes are very weak.

1.10.4.2 Mixed fisheries considerations

There are no mixed fishery considerations

1.10.4.3 Ecosystem effects of fisheries

Herring fisheries tend to be clean with little by catch of other fish. Scottish discard observer programs since 1999 indicate that discarding of herring in these directed fisheries are at a low level. These discard observer programs have recorded occasional catches of seals and zero catches of cetaceans.

The herring fishery does not touch the ground and is therefore supposed to have no effect on the benthic ecosystem.

1.10.4.4 Regulatory changes in the fisheries which have consequences for the assessment or projections

As a result of perceived problems of area misreporting of catch from IVa into VIa (N), Scotland introduced a fishery regulation in 1997 with the aim to improve reporting accuracy. Under this regulation, Scottish vessels fishing for herring were required to hold a license either to fish in the North Sea or in the west of Scotland area (VIa (N)). Only one licensed option could be held at any one time. However in 2004, the requirement to carry only a single licence was rescinded. Area misreporting of catch taken in area IVa into area VIa (N) then increased in 2004 and continued in 2005. It is possible, therefore, that the relaxation of this single area licence contributed to a resurgence in area misreporting. In 2007, as in 2006, there was no misreporting from IVa into VIa (N). New sources of information on catch misreporting from the UK became available in 2006 (see the 2007 HAWG report). This information was associated with a stricter enforcement regime that may be responsible for the lack of that area misreporting since 2006.

The Butt of Lewis box, (a seasonal closure to pelagic fishing of the spawning ground in the north west of the continental shelf in area VIa (North)) since the late 1970s has been opened to fishing following a STECF review in 2007. It has not been possible to show either beneficial or deleterious effects from this closure.

1.10.4.5 Agreed or proposed management plans

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}.	

ICES has not provided recommendations on a year on year constraint. The 2005 WG considered the risks associated with optional TAC constraint and found that for the above rule constraints on variation of 15% did not increase risks importantly. Greater constraint increased risk and reduced catches.

The agreed TAC for 2008 is 27 200 t, which is not in accordance with the HCR above and is therefore not precautionary. The TAC in 2007 was 34 000 t.

1.10.4.6 Species interaction effects

Herring are an important prey species in the ecosystem and are also one of the dominant planktivorous fish.

1.10.5 VIa South and VIIbc herring

VIa South and VIIbc herring 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.

1.10.5.1 Stock status

Spawning biomass in relation to precautionary limits	Fishing mortality in relation to precautionary limits	Fishing mortality in relation to highest yield	Fishing mortality in relation to agreed target	Comment
Uncertain	Uncertain	Unknown	NA	No accepted assessment but SSB is probably at a historically high level. F is likely to be high

The results of the non-tuned assessment suggest that the sharp decline in SSB may have stopped but the current level of SSB is uncertain but is likely to be below B_{lim}. There is no evidence that large year classes have recruited to the stock in recent years and F appears to have been reduced due to the decrease in catch. The perception of stock trends is consistent, even though the most recent estimates of SSB and F are uncertain.

1.10.5.2 Mixed fisheries considerations

There are no mixed fisheries considerations.

1.10.5.3 Ecosystem effects of fisheries

Herring fisheries tend to be clean with little by-catch of other fish. Interactions between marine mammals and fishing vessels in this area have not been well documented. The main gear used in this herring fishery does not touch the sea bed and is therefore thought to have no effect on the benthic ecosystem

1.10.5.4 Regulatory changes in the fisheries which have consequences for the assessment or projections

Changes to the management of this stock have influenced the way the fishery is prosecuted in space and time. The RSW vessels do not have access to the spawning grounds within a 12-mile limit. Fish on the spawning grounds are targeted largely by dry hold vessels only.

The implementation of the closed season from March to October has been successful in ensuring that the fishery mainly concentrates on the spawning component in this area. This regulation tends to confine effort to spawning components in this area, and to prevent fisheries on mixed components.

1.10.5.5 Agreed or proposed management plans

There are no agreed or proposed management plans for this stock.

1.10.5.6 Species interaction effects

Herring are an important prey species in the ecosystem and are also one of the dominant planktivorous fish.

1.10.6 VIIaN Irish Sea autumn spawing herring

Irish Sea autumn spawning herring comprises two spawning components (Manx and Mourne). These have been managed as one stock since 1984. 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 stable level. During this time period the contribution of the Mourne spawning component declined. Recent evidence from the Irish Sea herring larval survey and landings data however suggests the Mourne component may be showing signs of recovery.

There are irregular cycles in the productivity of herring stocks (weights-at-age and recruitment). There are many hypotheses as to the cause of these changes in productivity, but in most cases it is thought that the environment plays an important role (through transport, prey, and predation). Coincident periods of high and low production have been seen in the herring in VIaN and Irish Sea herring. Exploitation and management strategies must account for the likelihood of productivity changing. The Irish Sea herring stock showed a marked decline in productivity during the late 70s and has remained at a low level since then.

In the past decade there have been problems in assessing the stock. Exploration of the acoustic survey and landings data has shown that interannual variation in the migration of herring into the Irish Sea influences the selectivity of the fishery. This leads to a violation of assumptions in the separable period of ICA, however the converged period is indicative of trends. From the survey and catch data it seems likely that the stock has been relatively stable in recent years. The catches have been close to the TAC (4 800t) in recent years and the fishing patterns have been consistent. Evidence from catch-at-age and survey data suggests recent recruitment has been good.

The results of WESTHER, a recent EU-funded programme aiming to elucidate stock structures of herring throughout the western seaboard of the British Isles have recently been published. Using a combination of morphometric measurements, otolith structure, genetics and parasite loads the conductivity of stocks within and beyond the Irish Sea has been examined. The results of this programme are due to be discussed at SGHERWAY in light of the future assessment and management of stocks to the western British Isles.

1.10.6.1 Stock status

Spawning biomass in relation to precautionary limits	Fishing mortality in relation to precautionary limits	Fishing mortality in relation to highest yield	Fishing mortality in relation to agreed target	Comment
Unknown	Unknown	Unknown	Unknown	

ICES classifies the state of the stock as unknown. Based on the most recent estimates of trends from surveys it seems likely that the stock has been relatively stable. The recent catches are stable.

1.10.6.2 Mixed fisheries considerations

Discarding is not thought to be a feature of this fishery.

1.10.6.3 Ecosystem effects of fisheries

The Irish Sea herring fishery has no estimates of discard or by-catch. Discarding, however, is not thought to be a feature of this fishery. The gear used by the main fishing unit does not touch the seabed and is therefore thought to have no effect on the benthic ecosystem.

1.10.6.4 Regulatory changes in the fisheries which have consequences for the assessment or projections

No recent changes in the fishery have taken place.

1.10.6.5 Agreed or proposed management plans

There are no management plans for this stock.

1.10.6.6 Species interaction effects

Herring are an important prey species in the ecosystem and are also one of the dominant planktivorous fish.

1.10.7 North Sea sprat

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 90s followed by a sharp decline. It is likely that the abundance of North Sea sprat is now is at the level of last year's biomass.

1.10.7.1 Stock status and catch options

Precautionary reference points have not been defined for this stock and the available information is inadequate to estimate the absolute stock size. However, relative trends in biomass from an exploratory assessment indicate that the stock has fluctuated around a median level for the past 10 years

1.10.7.2 Mixed fisheries considerations

Sprat has recently been fished with a 10% bycatch of juvenile herring. The bycatch of juvenile herring was taken from a North Sea herring stock that is experiencing severe recruitment failures. Although the bycatch of juvenile herring (8 000 tonnes) was much lower than the bycatch ceiling (31 900 t), the poor recruitment of herring warrants that the bycatch be constrained even further.

1.10.7.3 Ecosystem effects of fisheries

Multispecies investigations have demonstrated that sprat is one of the important prey species in the North Sea ecosystem. Many of the plankton-feeding fish have recruited poorly in recent years (e.g. herring, sandeel, Norway pout) changing availability of prey. The influence of the sprat fishery for other fish species and sea birds, are at present unknown.

1.10.7.4 Regulatory changes in the fisheries which have consequences for the assessment or projections

No recent changes in the fishery have taken place.

1.10.7.5 Agreed or proposed management plans

There are no management plans for this stock.

1.10.7.6 Species interaction effects

Sprat is an important prey species in the ecosystem and is also one of the dominant planktivorous fish.

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 analyses are given in chapters for each of the seven major stocks considered by HAWG. Despite this structure, it is important to realise that there are many links between the stocks and/or areas (e.g. North Sea and herring caught in IIIa, VIaN herring and the North Sea (and likely VIaS, VIIbc and Irish Sea), Celtic Sea and Irish Sea herring).

In 2008 HAWG carried out one benchmark assessment: western Baltic spring spawning herring. North Sea herring and VIaN herring were update assessments in 2008. Celtic Sea herring, VIaS and Irish Sea herring and North Sea sprat were all exploratory assessments. One stock with poor data (IIIa sprat) is described in Section 9. Two stocks, with very poor data (no catch at age sampling) and no current ongoing research are described in 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 2008. X: Multiple spreadsheets (usually .xls); W: WG-data national input spreadsheets (xls); D: Disfad inputs and Alloc-outputs (ascii/txt); I: Intercatch input

Stock	Catchyear	Format				Comments
		X	W	D	I	
Western Baltic Sea: IIIa and SD 22-24						
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			(I)	provided by Mikael van Deurs, Mar. 2007
	2007	X	W		I	provided by Lotte Worsøe Clausen, Mar. 2008
Celtic Sea and VIIj						
her_irls	1999	X				provided by Ciarán Kelly, Mar. 2000
	2000	X				provided by Ciarán Kelly, Mar. 2001
	2001			D		provided by Ciarán Kelly, Mar. 2002
	2002			D		provided by Ciarán Kelly, Mar. 2003
	2003			D		provided by Maurice Clarke, Mar. 2004
	2004			D		provided by Maurice Clarke, Mar. 2005
	2005			D		provided by Maurice Clarke, Mar. 2006
	2006			D	I	provided by Maurice Clarke, Mar. 2007
	2007		W		I	provided by Afra Egan, Mar. 2008
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			I	provided by Steven Beggs, Mar. 2006
	2007	X	W		I	provided by Steven Beggs, Mar. 2007
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	I	provided by Norbert Rohlf, Mar. 2007
	2007		W	D	I	provided by Norbert Rohlf, Mar. 2008
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
	2007		W	D		provided by Emma Hatfield, Mar. 2008, 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	I	provided by Afra Egan, Mar. 2007
	2007		W		I	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
	2007	X	(W)	D		provided by Lotte Worsøe Clausen, Mar. 2008
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
	2007	X	(W)	D	I	provided by Lotte Worsøe Clausen, Mar. 2008
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
	2007	X	(W)	D	I	provided by Else Torstensen, Mar. 2008
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

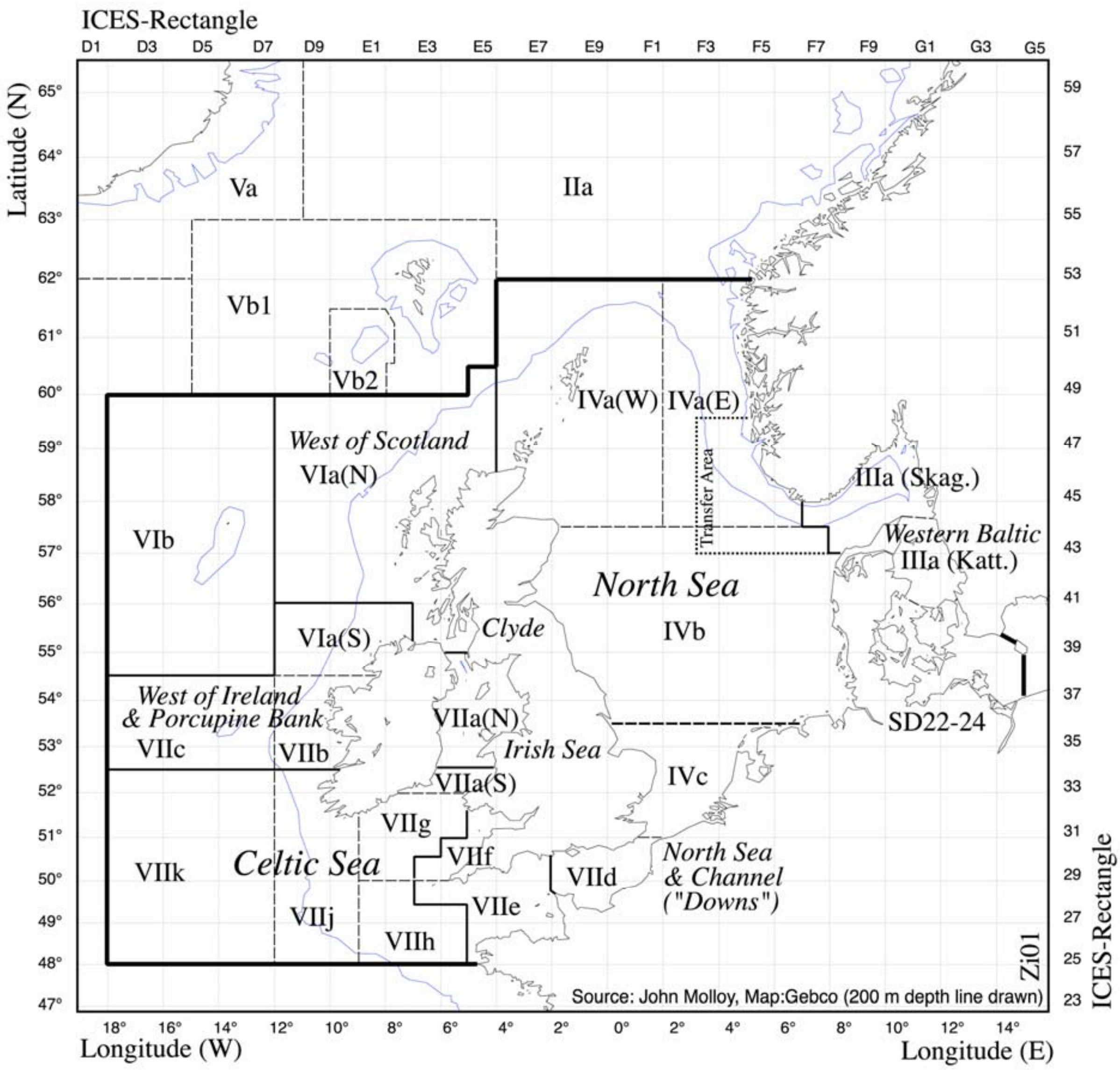


Figure 1.5.1 ICES areas as used for the assessment of herring stocks south of 62°N. Area names in italics indicate the area separation applied to the commercial catch and sampling data kept in long term storage. "Transfer area" refers to the transfer of Western Baltic Spring Spawners caught in the North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

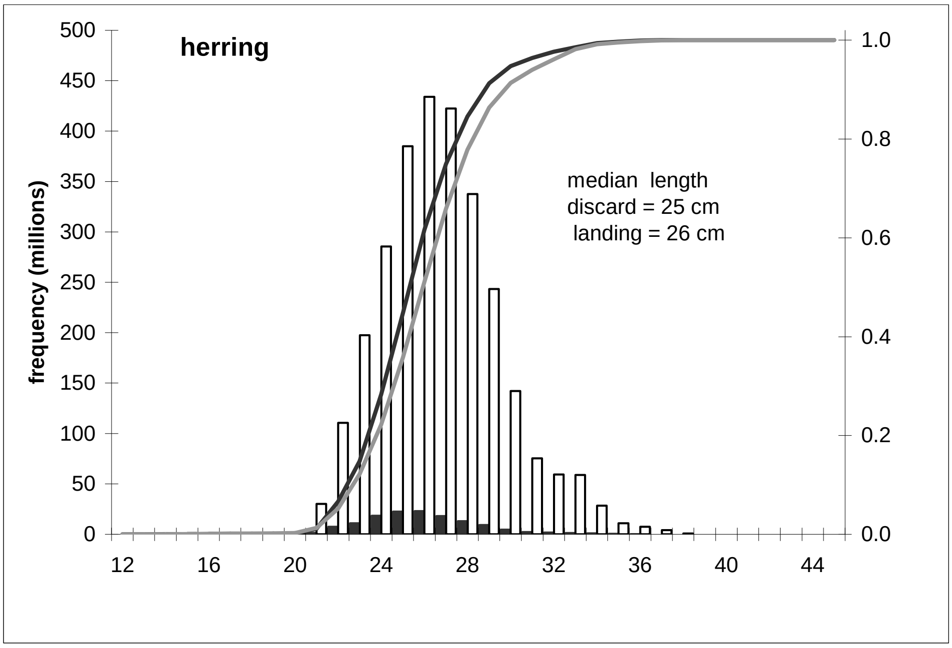


Figure 1.7.1 Length frequencies of discarded (filled) and landed herring (empty) by the Dutch pelagic freezer trawler fleet between 2002 and 2005 (summed over years and all areas). Cumulative frequencies and median lengths are also shown. X axis is length (cm).

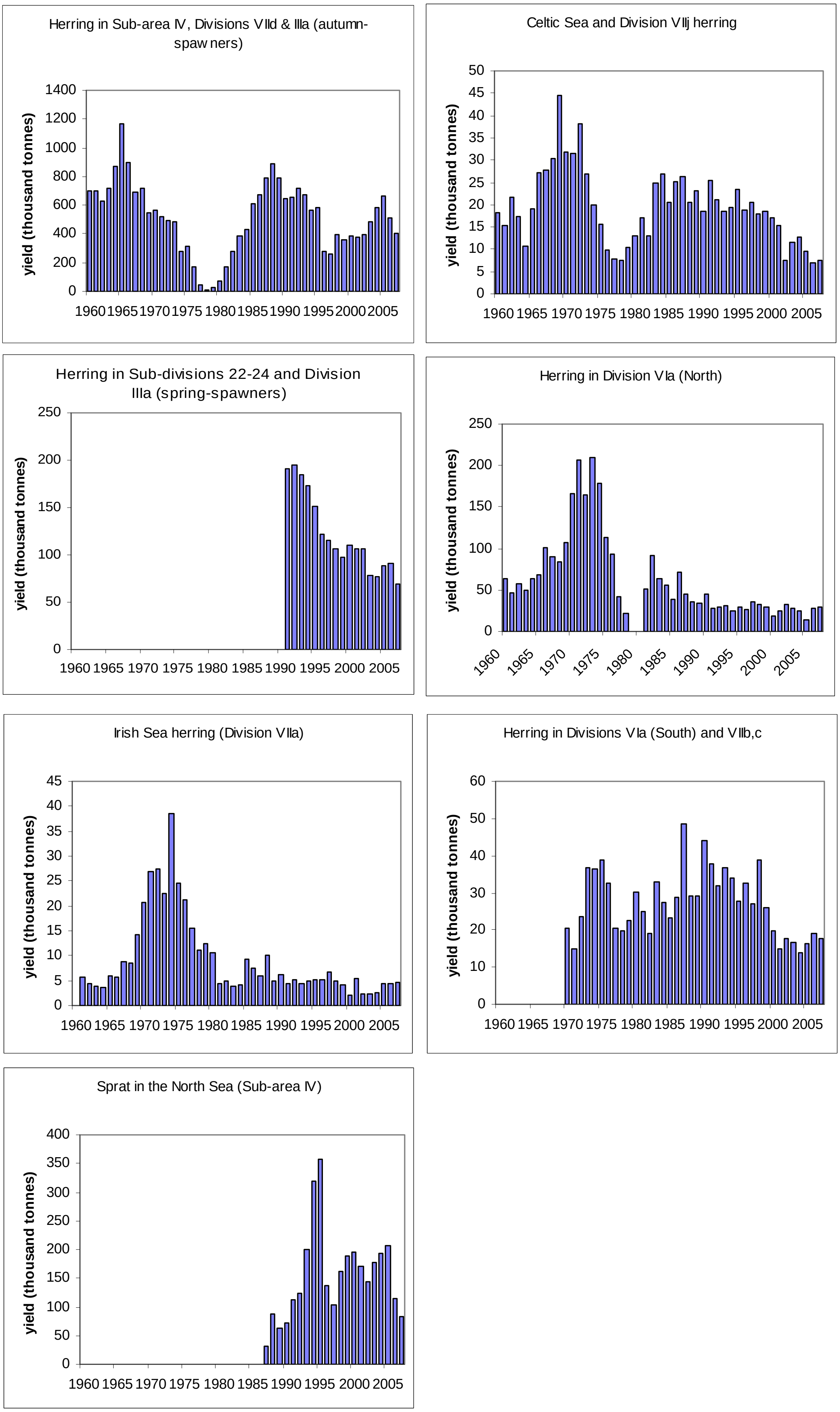
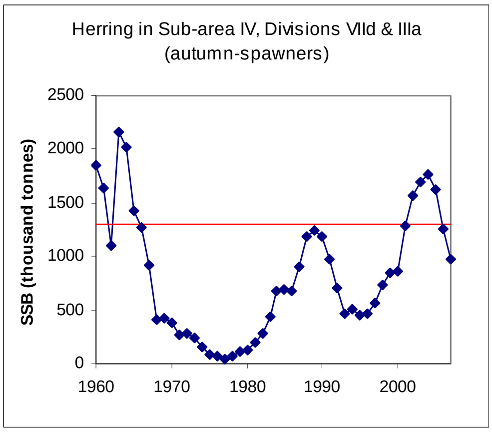
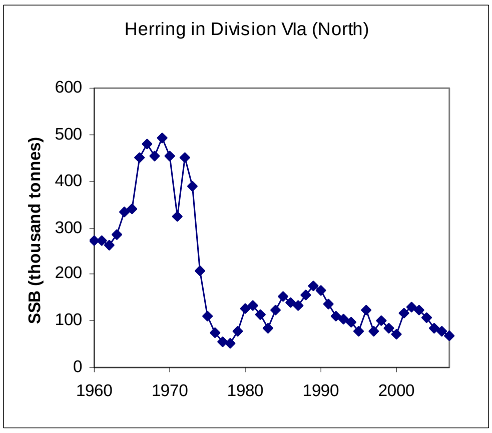


Figure 1.10.1 WG estimates of catch (yield) of the stocks presented in HAWG 2008.





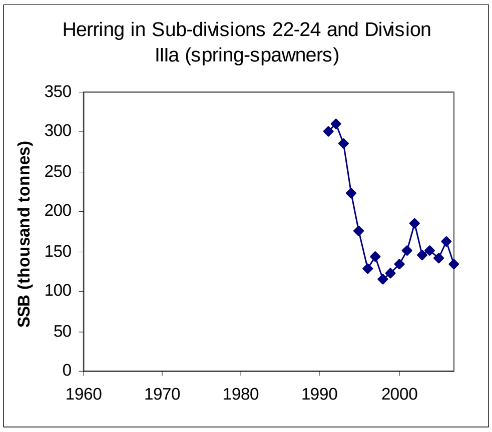


Figure 1.10.2 Spawning stock biomass estimates of the 3 herring stocks for which assessments were presented in HAWG 2008. The B_{pa} level (if defined) is indicated in the graphs.

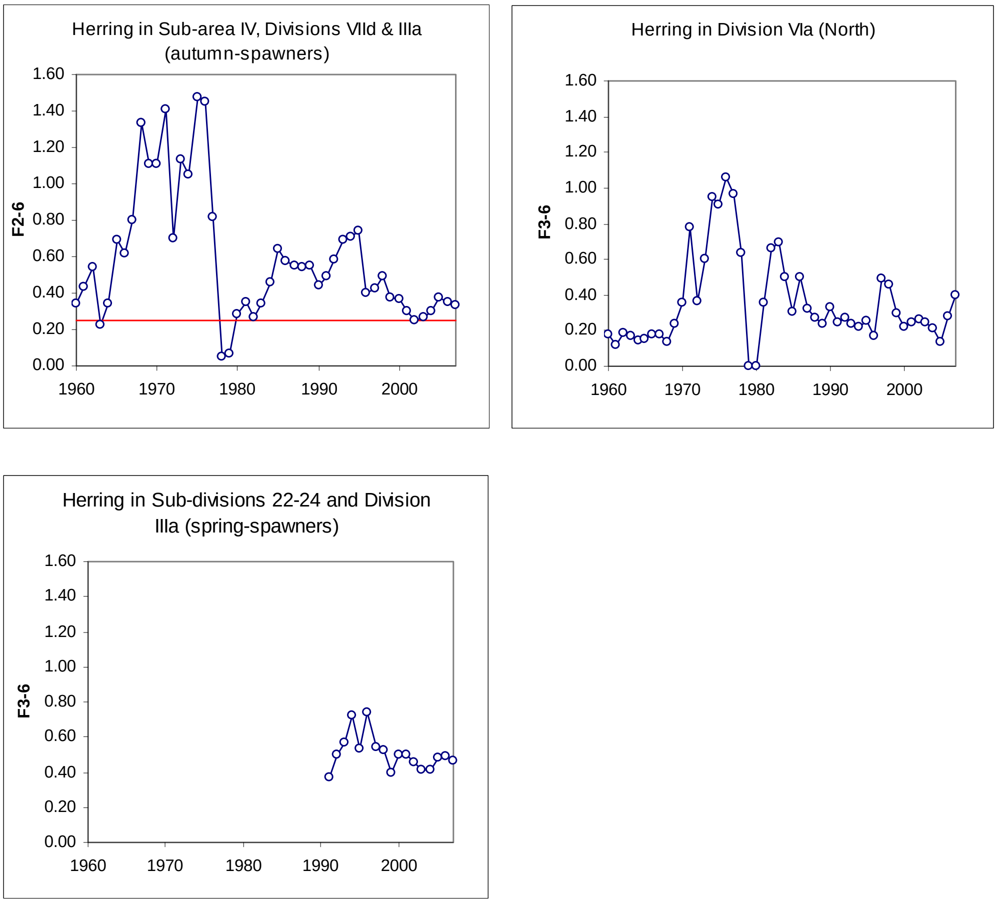


Figure 1.10.3 Estimates of mean F of the 3 herring stocks for which analytical assessments were presented in HAWG 2008. The F_{pa} level (if defined) is indicated in the graphs.

2 North Sea Herring

2.1 The Fishery

2.1.1 ICES advice and management applicable to 2007 and 2008

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

The management plan is given in Stock Annex 3 and is currently under the evaluation of WKHMP (ICES 2008/ACOM:27)

The final TAC adopted by the management bodies for 2007 was 341 100 t for Area IV and Division VIId, whereof not more than 37 517 t should be caught in Division IVc and VIId. For 2008, the TAC was reduced by 41% to 201 227 t, including a TAC of 26 661 t for Division IVc and VIId.

The by-catch ceiling set for fleet B in the North Sea was 31 900 t for 2007 and was decreased by 41% to 18 800 t for 2008. As North Sea autumn spawners are also caught in Division IIIa, regulations for the fleets operating in this area have to be taken into account for the management of the WBSS stock (see Section 3). Catches of herring in the Thames estuary are not included in the TAC. For a definition of the different fleets harvesting North Sea herring see Stock Annex 3 and Section 2.7.2.

2.1.2 Catches in 2007

Total landings and estimated catches are given in the Table 2.1.1 for the North Sea and for each Division in Tables 2.1.2 to 2.1.5. Total working group catches per statistical rectangle and quarter are shown in Figures 2.1.1 (a – d), the total for the year in Figure 2.1.1(e). Each nation provided most of their catch data (either official landings or working group catch) by statistical rectangle.

The catch figures in Tables 2.1.1 - 2.1.5 are mostly provided by WG members and may or may not reflect national catch statistics. These figures can therefore **not** be used for legal purposes. Denmark and Norway provided information on by-catches of herring in the industrial fishery. These are taken in the small-meshed fishery (B-fleet) under an EU quota by Denmark and are included in the A-fleet figures for Norway. Catch estimates of herring taken as by-catch by other small-mesh fisheries in the North Sea may be an underestimate. The total Working Group catch of all herring caught in the North Sea in 2007 amounted to 387 800 t.

Landings of herring taken as by-catch in the Danish small-meshed fishery in the North Sea have decreased by 40 % to 7 097 t as compared to last year (Table 2.1.6). This figure includes 6 596 t of herring taken as by-catch in the Danish sprat fishery (herring by-catch 8 %; 2006: 7 %). These industrial herring catches were much lower than the by-catch ceiling set by the EU (31 900 t).

In the Norwegian industrial fishery, herring by-catch has decreased in 2007 (345 t), compared to 961 t last year.

Official catches by the human consumption fishery were 353 900 t in 2007 (4 % above the TAC). Working group catches in the human consumption fishery were 380 700 t in 2007 (decreased by 24 % from last year). The excess over the TAC for the human consumption fishery amounted to 39 600 t (12 %) in the most recent year.

In southern North Sea and the Eastern Channel an over catch of 6 600 t was observed in 2006. In 2007, the total catch of 39 000 t was slightly higher than the TAC set to 37 500 t.

The total North Sea TAC and catch estimates for the years 1997 to 2007 are shown in the table below (adapted from Table 2.1.6). Since the introduction of yearly by-catch ceilings in 1996, these ceilings have never been exceeded.

YEAR	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
TAC HC ('000 t)	159	254	265	265	265	265	400	460	535	455	341
"Official" landings HC ('000 t)[1]	162	253	275	267	275	282	414	484	547	478	354
Working Group catch HC ('000 t)	226	324	318	328	303	331	438	537	617	498	381
Excess of landings over TAC HC ('000 t)	67	70	53	63	38	66	38	77	83	43	40
By-catch ceiling ('000 t) [2]	24	22	30	36	36	36	52	38	50	42	32
Reported by-catches ('000 t) [3]	13	14	15	18	20	22	12	14	22	12	7
Working Group catch North Sea ('000 t)	238	338	333	346	323	353	450	550	639	511	388

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

[3] provided by Denmark only.

2.1.3 Regulations and their effects

Landings taken in the North Sea but reported from other areas such as Divisions IIa and IIIa and from Division VIaN have increased in 2007 compared to 2006 (from 19 000 t to 26 000 t). The estimates of the total amount of catch in excess of the TAC in the human consumption fishery (excluding within-area misreporting) was about 40 000t which is similar to last year (roughly 12% of the TAC for human consumption).

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. This percentage was reduced to 40 % in 2007 and 30 % in 2008.

2.1.4 Changes in fishing technology and fishing patterns.

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

2.2 Biological composition of the catch

Biological information (numbers, weight, catch (SOP) at age and relative age composition) on the catch as obtained by sampling of commercial catches is given in

Tables 2.2.1 to 2.2.5. Data are given for the whole year and by quarter. Except in cases where the necessary data are missing, data are displayed separately by area for herring caught in the North Sea, Western Baltic spring spawners (only in IVaE), and the total NSAS stock, including catches in Division IIIa.

Biological information on the NSAS caught in Division IIIa was obtained using splitting procedures described in Sec. 3.2 and in Stock Annex 3. 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 1992-2007 (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 1997 – 2007.

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 27 % (to 2.7 billion fish) and by 22 % (to 3.0 billion fish), respectively, as compared to last year. 0- and 1-ringers contributed 22 % of the total catch in numbers of NSAS in 2007 (Table 2.2.7). 0- and 1-ringer catch has decreased by 35 % as compared to 2006. More than 57 % of the catch consist of the age group 4+ winter ringers. This is consistent in all areas in the North Sea.

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 1992-2007. After splitting the herring caught in the North Sea and IIIa between stocks, the total catch of North Sea Autumn spawners was 406 000 tonnes.

AREA	ALLOCATED	UNALLOCATED	DISCARDS	TOTAL
IVa West	198 766	22 215	93	221 074
IVa East	58 550	-96	-	58 454
IVb	69 436	-203	-	69 233
IVc/VIId	34 276	4 725	-	39 001
	Total catch in the North Sea			387 762
	Autumn Spawners caught in Division IIIa (SOP)			19 788
	Baltic Spring Spawners caught in the North Sea (SOP)			-1 070
	Blackwater Spring Spawning herring			-2
	Other Spring Spawners			0
	Total Catch NSAS used for the assessment			**406 478**

2.2.2 Other Spring-spawning herring in the North Sea

Norwegian Spring-spawners and local fjord-type spring spawning herring are taken in Division IVa (East) close to the Norwegian coast under a separate TAC. These catches are not included in the Norwegian North Sea catch figures given in Tables 2.1.1 to 2.1.6, but are listed separately in the respective catch tables. Catches were 685 t in 2007.

Blackwater herring are caught in the Thames estuary under a separate quota and included in the catch figure for England & Wales. Catches were only 2 t in 2007.

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

2.2.3 Data revisions

No data revisions were applied in this year's assessment. However, the result of the splitting procedure in 2006 for the transfer area is known to contain a small bug in terms of tonnage. This was estimate to be below 0.5 %, therefore the table was not updated. This has to be done in next year assessment.

2.2.4 Quality of catch and biological data, discards

As in previous years, some nations provided information on misreported and unallocated catches of herring in the North Sea and adjacent areas. The **Working Group catch**, which include estimates of discards and misreported or unallocated catches (see Section 1.5), was estimated to exceed the official catch by 7 %.

Information on discards is rare in 2007. The final figure for discards as used in the assessment was only 93 t, based on the raised discards for one fleet. As discards are likely to occur in all national fisheries, this figure is 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 6 000 t per year, but can't be split between area IV and VIaN. These are not included in the assessment (see section 1.7).

The European Union implemented a new sampling regime in 2002, obliging member states to meet specified overall sampling levels. In 2007, the sampling of commercial landings covers 86 % of the total catch (2006: 79 %). However, the number of herring length and weight measured has decreased by 16 % when compared to 2006, and the number of age readings has decreased by more than 50 % (Table 2.2.12). It should be observed that "sampled catch" in Table 2.2.12 refers to the proportion of the reported catch to which sampling was applied. This figure is limited to 100 % but might in fact exceed the official landings due to sampling of discards, unallocated and misreported catches.

More important than a sufficient overall sampling level is an appropriate spread of sampling effort over the different metiers (each combination of fleet/nation/area and quarter). Of 100 different *reported* metiers, only 30 were sampled in 2007. The recommended sampling level of more than 1 sample per 1 000 t catch has been met only for 17 metiers (2006: 19). For age readings (recommended level >25 fish aged per 1 000 t catch) this is also worse: only 16 metiers appear to be sampled sufficiently (2006: 21).

On the other hand, some of them yielded very little catch. In 55 metiers the catch is below 1000 t. The total catch in these metiers sums to 10 937 t, so the remaining 45 metiers represents 350 177 t of the official catch (97 %). Of these 45 metiers, 25 were sampled and 12 of them fulfil the recommended level of more than 1 sample per 1 000 t catch. Also 12 metiers have more than 25 age readings per 1 000 t catch and 9 metiers fulfil both criteria.

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

The WG recommends that all metiers with substantial catch should be sampled (including by-catches in the industrial fisheries), and that catches landed abroad should be sampled 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 2007

Six surveys were carried out in the North Sea during late June and July 2007. The individual surveys and the survey methods are given in the report of the Planning Group for Herring surveys (ICES, 2008/LRC:01). The vessels, areas and dates of cruises are given in Table 2.3.1.1 and in Figure 2.3.1.1.

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

The estimate of North Sea autumn spawning herring spawning stock is lower than the previous year, at 1.2 million tonnes and 7 096 million herring (Table 2.3.1.2). The survey shows only one particularly strong year class of herring (2000), followed by smaller year classes. Growth of this 2000 year class seems still to be slower than average: individuals of this year class were almost the same size and weights as the younger 2001 year class.

The spatial distribution of mature and immature autumn spawning herring is shown in Figures 2.3.1.2 & 2.3.1.3 respectively.

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

2.3.2 Larvae surveys

2.3.2.1 The MLAI and survey 2008

The larvae survey in 2007/08 covered six out of ten periods (Table 2.3.2.1) and the effort in samples taken and vessel days were comparable to previous years (Table 2.3.2.2).

The abundance trend in the four areas showed a decrease for the Orkney/Shetland, the Central and the Southern North Sea. Only in the Buchan area a slight increase of the LAI can be observed (Table 2.3.2.3, Figure. 2.3.2.1). However the LAI in the Southern North Sea area is still on a high level and the highest of all four areas.

Despite the decrease of the LAI for three areas and only a slight increase in one (Buchan) the MLAI from the larvae surveys in period 2007/2008 indicate that the SSB has increased considerably when compared to last year's WG estimate (Figure 2.3.2.2). The updated MLAI time-series is shown in Table 2.3.2.3

Detailed information on the extension and the effort of the larvae surveys in the North Sea are presented in Schmidt et al. (WD 3).

2.3.2.2 Considerations on the MLAI/IHLS design and potential issues arising

Given the construction of the MLAI and in the light that potential shifts in the stock components may have occurred, it is considered necessary to study potential effects originating from this on the MLAI estimates or the IHLS design.

The ICES International Herring Larvae Survey Program (IHLS) has been regularly carried out since 1972 in the North Sea and adjacent areas focusing on the spawning sites of various North Sea herring (sub)populations (stock components). The survey design was originally developed by an ICES working group between 1968 and 1972 (Saville 1968). Based on this a series of surveys are carried out each year during autumn and winter, following the spawning activities of herring from north to south. A specific combination of time periods (fortnights) and areas create the so called sampling units (= fortnights × areas). Survey results are archived in an IHLS database and reported to ICES. The main purposes of the program are to provide quantitative estimates of the abundance of herring larvae produced in the individual spawning areas of the North Sea. These estimates are used by the ICES Herring Assessment Working Group for assessing the state of the (adult) herring stock in the North Sea. Survey design and calculation procedure have been revised several times due to changes in the influencing factors and parameters. In year 2000 it was necessary to adapt the IHLS survey design and the related procedure for calculating larval abundance indices (LAI) as major constraints related to the timing and spatial coverage were strongly violated due to a dramatic reduction in ships and ship time, respectively. Accordingly, the MLAI approach (Multiplicative Larval Abundance Index) that was introduced in 1994 by Patterson and Beveridge (Patterson and Beveridge 1994, 1995a, b, 1996; Patterson et al. 1997) needed to be modified by introducing a weighting factor per sampling unit (Gröger *et al*. 2001). This weighting factor takes into account a reduction in the sampling effort which strongly affects the spatial coverage as well as the high variation among stations within the sampling units.

The MLAI is a linearized, i.e., log-transformed multiplicative, model similar to a 2-factor ANOVA. The model assumes that the abundance of larvae in each of the sampling units is proportional to the spawning stock size. Thus, the basic idea is to estimate year effects that are separated from sampling unit effects based on LAI calculations for the individual sampling units. Philosophically, this index can be considered an estimate of the average herring larval abundance for the entire North Sea. The model parameter estimates are given by:

$$\hat{\beta}_{weighted} = \begin{bmatrix} con\hat{s}tant \\ ML\hat{A}I_{year} \\ ML\hat{A}I_{unit} \end{bmatrix}_{weighted} = (X' W\ X\ )^{-1}\ X' W\ \ln(\ LAI_{year \times unit}\ )$$

Where, $MLAI_{year}$ is a column vector containing a subset of the estimated regression parameters that refer to years as factor levels (the year effects), $MLAI_{unit}$ is a column vector containing a subset of the estimated regression parameters that refer to the sampling units as factor levels (sampling unit effects) and *W* is a weight matrix containing the combined weights. As $MLAI_{year}$ and $MLAI_{unit}$ are estimated together, $MLAI_{year}$ can be thought of representing an abundance index that is corrected for potential sampling effects. *W* is a weight matrix containing the combined weights that take into account the degree of coverage and the uncertainty of the individual sampling units: a low coverage and/or a high uncertainty lead(s) to a down weighing of the sampling units associated and a high coverage and/or low uncertainty *vice versa* to an up weighing of the sampling units associated (for more details see Gröger *et al*., 2001). This design was *inter alia* chosen for the sake of objectivity i.e. to reduce distorting effects that may arise when arbitrarily excluding extreme values in some subjective manner. *X* is the matrix of effect coded factor levels (i.e. the codes are 0, 1, –1). The constant term is the intercept of the model. For convenience, the intercept will usually be added to $MLAI_{year}$ giving the actual multiplicative larval abundance index (MLAI). The term $\ln(LAI)_{year \times unit}$ represents the corresponding LAI values of which the logarithms have been taken.

What are the issues now? Given the construction of the MLAI, this index is directly influenced by the following input quantities:

1) Size of the larval abundance estimates (LAI values) by sampling unit

2) The degree of coverage per sampling unit

3) The uncertainty per sampling unit.

Furthermore, $MLAI_{year}$ may be influenced by hidden effects as it depends on the spatial and temporal definition of the sampling units (= fortnights × areas) and thus on the survey design. Apart from this, also technical changes in the sampling gear may influence the size of the $MLAI_{year}$ values more or less strongly, either directly or via affecting the $MLAI_{units}$ values. The latter may be specifically the case when national research vessels using modified gear prefer to concentrate on particular sampling areas, for instance, the southern or the northern part of the North Sea.

Given these dependencies it seems important to study the effect of potential violations with regard to the influencing factors above. We however need to distinguish between violations and required actions that relate to the IHLS survey design and those that relate to the MLAI calculations. Having said this, prospective studies should consider/diagnose the following aspects:

1) It needs to be tested whether and how potential shifts in time and space will influence the MLAI (variance inflation, distortions ?). And if yes, we need to answer the question whether it will affect significantly only the $MLAI_{unit}$ effects or also the $MLAI_{year}$ effects. In case it significantly influences the $MLAI_{year}$ pattern due to inflated variances or biases a remedy could be to adjust the survey design by re-allocating sampling positions in the area definition file and/or by adjusting the timing of the fortnights

2) Given potential changes in the proportionality of the stock components, individualising either all or splitting off particular stock components may be possible in theory; but considering them separately will create serious difficulties in practice as explained below:

- Changes in the proportions of larvae abundance happened and happens all the time in various areas of the North Sea; this means it will be difficult to set up a criterion that can be used to do this split on an objective basis
- Taking all components separately causes a big problem as we cannot distinguish between herring individuals originating from different herring stock components in commercial catches; given this, we need one single index for the entire North Sea
- Furthermore, temporal or spatial effects due to potential shifts in the proportionality of the larval production of the individual stock components are anticipated
    - to be partly balanced out by the fact that the $MLAI_{year}$ and $MLAI_{unit}$ values are not estimated independently of each other and that the sampling error is considered a part of the $MLAI_{unit}$ effects; consequently, estimating and then “trashing” the $MLAI_{unit}$ effects leads to year effects that may be considered corrected for potential sampling unit effects
    - to be partly balanced out by the weighing procedure, specifically if these are associated with changes in the sampling effort and/or LAI variability.

Having said this, it is nevertheless strongly recommended to investigate the potential and performance of the MLAI concept to balancing out those violations. All prospective tests may be performed based on controlled numerical simulations/experiments/scenarios.

2.3.3 International Bottom Trawl Survey (IBTS)

The International Bottom Trawl Survey (IBTS) started out as a young herring fish survey in 1966 with the objective of obtaining annual recruitment indices (abundance of 1-ringers in 1st quarter) for the combined North Sea herring stock. The survey has been carried out every year since, and presently it provides recruitment indices not only for herring, but for demersal species as well. Examinations of the catch of adult herring during the 1st quarter IBTS have shown that this catch also indicates abundances of 2-5+ herring. Further, sampling for herring larvae (0-ringers) is carried out at night-time during the IBTS 1st quarter. From 1977 to 1991 the used gear for larval sampling was a small mid-water trawl (IKMT), but due to poor catchability of this gear, the standard gear was changed in 1991 to a fine-meshed 2 metre ring net (MIK). The total abundance of herring larvae in the survey area is used as an estimate of 0-ringer abundance of the stock. Hence, the sampling during IBTS affords an extended series of herring abundance indices (0 to 5+ ringers).

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. The series of indices from 1983 is subsequently used in North Sea herring assessment. Note that the abundances in Division IIIa are not included in these 2-5+ ringer indices. Table 2.3.3.1 shows the time-series of abundance estimates of 2-5+ ringers from the 1st quarter IBTS for the period 1983-2008. As mentioned in last years report, the WG investigated the reasons for the outstandingly low estimates from the 2007 survey, but did not find any other indications than low abundances in the survey. The present 2008 indices for 2 and 3 ringers are low (approx. 30% and 50% of long term mean, respectively), while indices of 4 and 5+ ringers are higher than the long term mean of these ages.

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 for year classes 1977 to 2005 are shown in Table 2.3.3.2. This year's estimate of the 2006 year class strength indicates an increase in recruitment from the low recruitments estimated for the year classes 2002-2005. However, it should be noted that the index is strongly influenced by a single, outstandingly high trawl catch, which account for approx. 50% of the estimate.

Figure 2.3.3.1 illustrates the spatial distribution of 1-ringers as estimated by trawling in February 2006, 2007 and 2008. The illustrated distribution pattern for 2008 is dominated by the high catch retrieved off the Danish coast, other concentrations of 1-ringers were found in the coastal areas off the Dutch coast.

The Downs herring hatch later than the autumn spawned herring and generally appears as a smaller sized group during the 1st quarter IBTS. A recruitment index of smaller sized 1-ringers is calculated based on abundance estimates of herring <13 cm (ICES CM 2000/ ACFM:12, and ICES CM 2001/ ACFM:12).

Table 2.3.3.2 includes abundance estimates of 1-ringer herring smaller than 13 cm, calculated as the standard index but is in this case for herring <13 cm only. Indices for these small 1-ringers are given either for the total area or the area excluding division IIIa, and their relative proportions are also shown. In the time-series, the proportion of 1-ringers smaller than 13 cm (of total catches) is in the order of 20%, and the contribution from division IIIa to the overall abundance of <13 cm herring varies markedly during the period (Table 2.3.3.2). 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 2.3.3.2).

2.3.3.3 The MIK index of 0-ringer recruitment

This year's 0-ringer index is based on 648 depth-integrated hauls with a 2 metre ring-net (MIK). Index values are calculated as described in the WG report of 1996 (ICES 1996/ACFM:10). The series of estimates is shown in Table 2.3.3.3, the new index value of 0-ringer abundance of the 2007 year class is estimated at 27.8.

The index is the lowest since the estimate of the 1989 year class strength, and indicates a recruitment which is only 25% of the long term mean. It adds to a 5 year long series of low recruitment estimates. The 0-ringers included in the index were predominantly distributed off the Scottish coast, in the central-western area (Figure 2.3.3.2). Compared to the preceding two year classes, the 0-ringers from this year class is further restricted in distribution, without significant concentrations in other areas. Concentrations of Downs herring larvae were apparent from MIK catches in the area of the English Channel, however, due to their small size (mean sizes 11-17 mm) these will not represent recruitment at a scale comparable to estimates based on catches of larger larvae (> 20 mm), and they are not included in the standard procedure of index estimation (see ICES 1996 /ACFM:10). The WG investigated the potential increase in the present 0-ringer index, when including the Downs larvae, but accounting for 10% daily mortality of these until they reached the 20 mm length. This procedure only led to an approx. 15 % increase in index estimate, thus indicates a relatively minor bias when excluding this group from the index estimation. However, due to the apparent increasing importance of the Downs herring in the North Sea stock, the possibilities for inclusion of this component into the MIK-index will be investigated further and discussed at the 2009 meeting of the WG.

The long term trend in the distributional patterns of 0-ringers is apparent from the changes in absolute and relative abundance of 0-ringers in the western part of the North Sea, as illustrated in Figure 2.3.3.3. In this figure the relative abundance is given as the number of 0-ringers in the area west of 2°E relative to the total number of 0-ringers in the given year class. Since the year class 1982, when the relative abundance was 25%, a general increase in abundance has been seen for the western part. In the last decade, the majority of 0-ringers has been distributed in this area, and the calculated relative abundance of 70% 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 (winter ringers, wr) in the North Sea stock during the 3rd quarter in Divisions IV and IIIa (acoustic survey) as well as the mean weights-in-the-catch from 1996 to 2007, for comparison. The data for 2007 are taken from Table 2.3.1.2. In the third 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 2.3.1.4. This spatial variability of mean weight is considerable but is not unusual. While the catch and acoustic survey mean weights of 1-ringers in 2007 are at time series' (1996-2007) highs, the mean weights for 2007 for 3-ringers and older are close to the time series' lows. Since 1996, there has been a decline in mean weights in the older fish (4+wr), although the rate of decline has reduced to almost zero in recent years. For 6-ring herring, the acoustic survey shows mean weights that are the lowest for the last 12 years and are similar to herring a year younger, 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. In the short-term projections for this stock, the mean weights at age for the last 3 years was used except for the cohort coming from the 2000 yearclass; which had its weight at age modelled separately using the von Bertalanffy growth equation.

2.4.2 Maturity ogive

The percentages of North Sea autumn-spawning herring (at age) that are considered mature in 2007 were estimated from the acoustic survey (Table 2.4.2.1). The method and justification for the use of values derived from a single year's data was described fully in ICES (1996/ACFM:10). For 2-ringers, 3-ringers and 4-ringers, the proportions mature are 71%, 92% and 93%, respectively (Table2.4.2.1). For 2- and 3-ringers, these are above the time series averages but are not exceptional. Mean weight for the 3-ringers in the 2007 acoustic survey (Table 2.4.1.1) is below the historical average but this has not led to a decrease in the maturity ogive. The 2000 year class, which matured more slowly, became fully mature in 2006.

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 2006 year class was somewhat lower than indicated from this year's IBTS 1-ringer index of the year class (black square in the figure). Generally, there is a good agreement between the indices in their description of temporal trends in recruitment (Figure 2.5.2), but for the 2006 year class they show opposite trends.

2.5.2 Trends in recruitment from the assessment

Abundances of recruiting North Sea herring are estimated from the assessment (see the figure of temporal trend of recruitment in the assessment section of this report). 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 2002-2006 year classes are low, and the MIK index of 0-ringer recruitment for the present year indicates a very small 2007 year class. The present assessment estimates of 1-ringer recruitment are 8.7 and 7.3 no 10^9 for year classes 2005 and 2006 respectively, while the estimates for 0-ringers are 20.9 and 9.2 no 10^9 for year classes 2006 and 2007 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 was on the AFCM observation list, but was classed as an update assessment in 2008 by ACFM. The choice of assessment model, catch and survey weightings and the length of separable period were not explored in 2008, and for justification of the approach refer to the benchmark assessment (HAWG 2006) and Simmonds (2003). Following the benchmark investigation in 2006, the tool for the assessment of North Sea herring is ICA. However, the environment to execute the ICA has changed from the original ICA software into FLR (now called FLICA). This change in software has been tested with the new relaise of FLICA, and no differences were found. Therefore the WG assumes there are no differences between the old ICA and FLICA.

Since last year's WG, historical IBTS indices have been updated from 2004 onwards.

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. Following the WG examination in 2003 on variance and structural errors, 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 reviewers of the assessment in 2007 questioned the weightings of the ages and surveys in the stock assessment. The methods used to determine the weights are described in Simmonds 2003 and the method has been internationally reviewed and accepted by ICES for the last 7 years (ICES 2001, SGEHAP ACFM 22) (see Stock Annex 3). The WG still shares the opinion that the assessment is best executed including all surveys.

This year's assessment is an update assessment, therefore the performance of the assessment has been carefully scrutinised to check for potential problems, but no changes to the methods or development of the model took place in 2008. The diagnostics do not indicate any significant pattern or unreliable data points (Figure 2.6.1 to Figure 2.6.16) other than those minor issues previously described in 2006 and 2007. There is no evidence of cohort effects across the full selection pattern. Overall the catch residuals are small. There has been no major change in the patterns in the residuals for the surveys by adding the extra year of data (Figures 2.6.17 and 2.6.18).

In previous assessments it has been noted that in recent years the MLAI has positive residuals (Figure 2.6.16) and the acoustic survey has a block of negative residuals at older ages. The current assessment shows that this pattern has been maintained, and in the terminal year does not appear to be better than that seen within the last 5 years (Figure 2.6.16). However, in 2006 the residual from the MLAI is small. In the 2006 benchmark assessment it was concluded that one of the reasons for the relatively stable assessment was the balance of the major sources of information, with each potentially delivering short periods with bias but in combination providing a balance of errors.

Figure 2.6.19 shows retrospective estimates of SSB, mean $F_{2\text{-}6}$ and recruitment, by removing one year of data at a time. The estimation of F shows considerable consistency over the last 6 years, with underestimation during the period immediately following the management changes of 1996-7. SSB is reasonable stable over the last 6 years showing small upward and downward revision. The SSB has the same period of bias following the 1996-7 management changes as F. The retrospective estimates for recruitment in especially the last 5 years deviate from each other in a larger extend than observed within the SSB and $F_{2\text{-}6}$ retrospectives. However, for all three historical retrospective estimates it can be concluded that the patterns are stable. The recruitment estimate for 2008 should however be treated with care, considering the larger revision for recruits in 2007 as was estimated in the 2007 assessment. The selectivity pattern has not changed greatly over the recent period (Figure 2.6.20).

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, in the FLR environment - version 1.2-6 - (Fri Mar 16 21:21:37 2007)) with a separable constraint over a five-year period, tuned with the Acoustic survey (1989-2007), MLAI SSB index (1973-2007), IBTS (1984-2008) and the MIK survey (1992-2008) time series. The model settings are shown in Table 2.6.2.1, the ICA output is presented in Table 2.6.2.2 – Table 2.6.2.18, the stock summary in Table 2.6.2.10 and Figure 2.6.21 and model fit and parameter estimates in Table 2.6.2.18. Diagnostics of the catch for the separable period are shown in Figure 2.6.22.

The spawning stock at spawning time in 2007 is estimated at approximately 0.98 million tonnes, declining from 1.25 million tonnes in 2006. The abundance of 0-wr fish in 2008 (2007 year class) is low, which means the sixth consecutive year of poor recruitment (Figure 2.6.23). The strong 1998 and 2000 year classes are still evident in the population, with the 2000 year class at 6-wr in 2007 and the 1998 year class at 8-wr. Mean $F_{2\text{-}6}$ in 2007 is estimated at around 0.33, which is above the management agreement target F of 0.25, while mean $F_{0\text{-}1}$ is 0.06, below the agreed $F_{0\text{-}1}$ of 0.12, and lower than 2006. The 2007 recruitment (0-group in 2008) is estimated at 9 222 million, which is 22% of the geometric mean of recruitment since 1981.

2.6.3 State of the Stock

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

Based on the most recent estimates of SSB and fishing mortality, ICES classifies the stock as being at risk of having reduced reproductive capacity and at risk of being harvested unsustainably. SSB in 2007 was estimated at 0.98 million t, and is expected to remain below $\mathbf{B}_{pa}$ (1.3 million t) in 2008. All year classes since 2001 are estimated to be among the weakest since the late 1970s.

2.7 Short term predictions 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 2008 the stock numbers at age were taken from ICA (Table 2.6.2.12).

Recruitment: For 2009 and 2010, the recruitment was set to 22 558 million which is the geometric mean of the recruitments of the year classes 2002-2007 as estimated in this year's assessment. This is less than half the mean recruitment prior to 2006, but quite similar to the recruitment assumed last year. 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 adapted to the current recruitment regime.

Fishing Mortalities: Selection by fleet at age was calculated by splitting the total fishing mortality in 2007 at each age proportional to the catches by fleets at that age (Table 2.6.2.11). These selections at age were used for all years in the prediction.

Mean weights in the catch by fleet: The mean weight by fleet over the years 2005 – 2007, excluding the 2000 year class, were used for all prediction years. For the 2000 year class, the weights at age in the catches by the A fleet have been in the order of 10-15% below the average of the adjacent year classes. Assuming that the 2000 year class will continue to have reduced weights at age, the weights at age for this year class were reduced by 14% in the prediction years. 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 and the actual ages are hardly represented in the catches for these fleets.

Mean Weights at age in the stock: The mean over the last 3 years of the observed weights at age excluding the 2000 year class was used. For the 2000 year class the weights at age were predicted assuming growth according to the von Bertalanffy growth equation. This calculation differs from the procedure used to derive stock weights in the assessment, where the weights are smoothed as 3-year running means including the 2000 year class.

Maturity at age: The average maturity at age for 2005 to 2007 was used (Table 2.6.2.9). 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 2008 and management option tables for 2009

Assumptions for 2008

After the TACs were increased in 2003, the TAC for the A fleet has been over-fished by 9 – 16%, while the other fleets caught less than half their TAC or by-catch ceiling. Catches in 2008 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 2008.

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, 12% in 2007). Therefore, it is assumed that the agreed TAC of 201 227 tonnes for 2008 for the A-fleet will be overshot by 10%.

The utilisation of the by-catch quota by the B-fleet has fluctuated between 23% and 44% since 2003, and was 22% in 2007. For the prediction, it is assumed that the fishing mortality by the B fleet in 2008 will be equal to that in 2007 (0.027). For the C and D fleet, it was assumed that 20% of the TACs would be taken in 2008, which is approximately the fraction that was taken in the last two years. The fishing mortalities resulting from these assumed catches were well below those for 2007 which is due to the reduced TACs agreed for 2008.

Management Option Tables for 2009

The EU-Norway agreement on management of North Sea herring was updated in 2007. The revised rule specifies fishing mortalities for juveniles ($F_{0\text{-}1}$) and for adults ($F_{2\text{-}6}$) 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:

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

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

This rule is currently under evaluation by ICES (see section 1.3).

Points of interpretation:

- The $F_{0\text{-}1}$ and $F_{2\text{-}6}$ stated in the rule are assumed to apply to the total F summed over all fleets.
- The SSB referred to is taken to be the SSB in the prediction year, i.e. the fishing mortalities for 2009 should reflect its consequence for SSB in 2009.
- For 2008, Norway is allowed to transfer 30% (1 170 tonnes) of its quota in IIIa to IV. This transfer is assumed in the predictions.

- For F_{0-1}, a fishing mortality of 0.05 is assumed in the scenarios presented. This is in accordance with the fishing mortalities in recent years, and with the observation by WKHMP that increasing the F_{0-1} to 0.12 would increase the risk to B_{lim} substantially.
- Catches of North Sea autumn spawners by the C and D fleets were calculated assuming a TAC on Western Baltic Spring spawners of 33 000 tonnes (See Section 3).

Five different options were considered according to the agreed harvest rule (Table 2.7.2):

a) *Applying the harvest rule with F_{2-6} = 0.25 above the trigger biomass*

b) *Applying the harvest rule with F_{2-6} = 0.20 above the trigger biomass (as suggested by WKHMP 2008).*

c) *15% reduction in TAC by Fleet A*

d) *Catches in 2009 maintained as assumed for 2008*

e) *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 2008 as derived from the assessment, and by assuming 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 harvest rule with a reference F value = 0.25 will imply a 15% reduction in the TAC from 2008 to 2009.

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

The predictions this year are well in line with those obtained last year. The predicted catch according to the rule with F_{2-6} = 0.25 above the trigger biomass implies less reduction than 15%. Hence, the 15% constraint on TAC variation would only apply if a lower F above the rigger biomass would be adopted.

2.8 Medium term predictions and HCR simulations

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

2.9 Precautionary and Limit Reference Points

There appears to be controversy regarding whether or not the management of North Sea herring is precautionary. The existing management plan was instigated in 1996 and has been classified by ICES as precautionary because when implemented there is only a small risk of falling below Blim (800 000 tonnes). The precautionary reference points for this stock were adopted in 1998. The situation has now arisen that North Sea herring is nominally being managed by a precautionary management plan, although the SSB is now below the precautionary biomass reference point. We consider that the critical issue is identifying the risk of SSB falling below Blim. The following section is adapted from ICES WKHMP (ICES CM 2008 (ACOM:27)) and explores and discusses the issues about precautionary status of the management of North Sea herring.

The Blim

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

Fpa and Bpa

The target and trigger points used in the management plan (which began in 1997) were recommended by the Study Group on Precautionary Approach to Fisheries Management and adopted by ACFM as the precautionary reference points. This means that the precautionary reference points were taken from the already existing management plan. In the management plan, the target fishing mortalities were intended as targets and not as bounds. The inflection point (B trigger) in the rule (1.3 million tonnes) was derived largely as a compromise, allowing higher exploitation at higher biomass but reflecting an ambition to maintain the stock at a high level, by reducing the fishing mortality at an early stage of decline. WKHMP investigated B trigger and suggested that 1.3 million tonnes was appropriate and any reduction would increase the risk of the management rule resulting in SSBs below 800 000 tonnes.

Concept of a management plan (harvest control rule)

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

Concept of precautionary reference points

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

Conclusion

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

2.10 Quality of the Assessment

2.10.1 Precision of the estimates

The precision of the assessment derived from the FLICA model is based on a parametric variance covariance bootstrap of the parameters that influence the estimates of terminal F and SSB. The estimated precision expressed as a percentile contour plot is shown in Figure 2.10.1. The 95% intervals are given for F and SSB in combination and separately.

2.10.2 Comparison with earlier assessments

The data from the stock summary table is compared with the stock summary from the 2007 assessment and the first year (intermediate year) of the 2007 short term prediction. With the exception of the estimate of recruitment age 0 in 2007 the 2008 assessment is in good agreement with the assessment carried out last year, see text table below.

	2007 Assessment				2008 Assessment				Percentage change in estimate 2007-2008			
Year	**Rec**	**SSB**	**Catch**	**F_{2-6}**	**Rec**	**SSB**	**Catch**	**F_{2-6}**	**Rec**	**SSB**	**Catch**	**F_{2-6}**
2005	17505	1593	NA	0.37	16347	1621	NA	0.37	-6.6	1.7	NA	0.3
2006	27777	1208	NA	0.35	25024	1252	NA	0.35	-9.9	3.6	NA	-2.1
2007	11900	987*	400*	0.34*	20853	977	406	0.33	75.2	-1.0	1.5	-1.5

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

The revision on F and SSB are all negligible. The revision of recruitment at +75% is more important. In 2007 the recruitment (age 0) was only estimated by one survey (MIK), this year that cohort has additional estimates from 1 year of catch and the IBTS survey. This magnitude of revision is one of the larger revisions but is not outside the precision of the survey seen in earlier years (see Table 2.6.2.18). It must be remembered that this estimate may be revised again (in either direction) once more data become available in years to come. Even with this revision the recent recruitment is still one of the lowest since the 1970s.

The cohort retrospective evaluations suggest the WG is providing a very consistent evaluation of most year classes (Figure 2.10.2). The exceptions are the 2001, 2004 and 2006 year classes which are more variable in the first two years of observations. In particular the large 2000 year class has been estimated consistently since it was first seen in 2001.

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

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

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

Historically, the TAC for herring in IVc and VIId has been set as a proportion of the total North Sea TAC and this has varied between 6 and 16% since 1986. The proportion has been relatively high, particularly between 2002 and 2005. However, 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 cut by 33% in 2006, the proportion was still kept to 11% of the human consumption TAC. For 2007, it was set at 37 517 tonnes and at 26 771 tonnes for 2008. A comparison in percentage between TACs in the North Sea and in Divisions IVc and VIId are shown 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 2007 amounted to 39 000 tonnes.

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/ACFM:20) based on population profiles suggested that total mortality (*Z*) was significantly higher for the 1998 and 1999 year classes of Downs herring compared to herring caught in the northern part of the North Sea.

Downs herring is also taken in other herring fisheries in the North Sea. Downs herring mixes with other components of North Sea herring in the summer whilst feeding, 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.

The proportion of the autumn and winter spawning components in recruiting year classes of North Sea herring has been traditionally monitored through the abundance of different sized fish in the IBTS. The 1-ring fish from Downs spawning sites (winter) are thought to be smaller (<13 cm) than those from the more northern, autumn spawning sites (>13 cm). Both the total abundance and the proportion of Downs herring have, on average, been comparatively higher since the early 1990s, although there is considerable variation between year classes (Figure 2.11.3, Table 2.3.3.2). 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 2006 year class is about the same as the long-term average = 25% and appears to be slightly higher than the 2005 year class (Figure 2.11.3).

As mentioned in section 2.3.3.3, the MIK hauls for 0-ringers in this area might indicate the abundance of recruiting herring from the Downs stock component. However, due to their relatively small lengths and patchy distribution, the catches of this stock component cannot be included in the estimation. The possibilities for inclusion of this component in the recruitment estimation for 0-ringers will be investigated further and discussed at the 2009 meeting of the WG.

Last year the EU 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.

IBTS in the Eastern part of the English Channel.

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

In addition the RV "Thalassa" recorded acoustic data in the same way as in 2007. The most important marks were recorded along French coasts and the catch composition of pelagics hauls consisted of herring of 27.6 cm mean length fish (26 cm in 2007) belonging to age-groups 4 – 7. (Figure 2.11.4). Large and continuous shoals of herring were found at the same time in a restricted area, but less concentrated than in 2007. Mean density could be estimated around 1 000 tonnes per nautical mile square (less than half that in 2007) but it could not be raised to the whole area due to the spatial heterogeneity and the sampling protocol used. Nevertheless, this survey gives more information on herring shoals observed, their evolution and the possible change in behaviour in relation to herring spawning area.

Due to the findings of the survey in the eastern part of the Channel, an increase in survey effort (MIK and GOV) and in area coverage is recommended.

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 0.98 million t in 2007 and is expected to remain at this biomass in 2008. F in 2007 was 0.33 and expected to be significantly reduced at F=0.21 in 2008. While this reduction is very encouraging, at SSB=0.98Mt the management rule (see below) would have been expected to give an F=0.15. So F is still greater than the management plan originally envisaged.

The stock is managed according to the EU-Norway Management agreement which was updated on 26 November 2004 (Table 2.12.1).

WKHMP examined the performance of this harvest control rule in February 2008 (see Section 1.3) and considered:

- the rule was at best marginal overall (risk to being below Blim is 5%)
- the 15% year to year limit on TAC change does not increase risk at present (assuming the rule is applied)
- the management plan should be revised with F target reduced from 0.25 to 0.2.

There is a currently considerably increased uncertainty about the future for North Sea herring. Firstly, herring recruitment and growth is unusually reduced due to environmental effects. This recruitment level has reduced catch potential to less than 40% of the long term average, a situation that cannot be avoided by managers. Secondly, due to a combination of various enforcement issues and a decision to allow exploitation above the precautionary harvest rule as advised by ICES, there are 4 years of exploitation above the recommended harvest rate (2005-2008). Failure to bring the fishery inside the harvest rule for a fifth year combined with the poor recruitment will risk further stock decline. Given the current levels of recruitment, recovery from such a depleted state is likely to be slow. Therefore it would be particularly risky to bring SSB down to a level where recruitment might be expected to decline further (below Blim). If managers wish to avoid these risks it should be regarded as a matter of very high priority to get management targets back to the ICES recommended exploitation rate immediately (F 2009= 0.15).

Taking the above considerations together, this leads to a number of clear management recommendations

- As a first priority F needs to be reduced to at least the levels in the agreed management plan

- Managers should consider a revision of the management plan along the lines recommended by WKHMP such as a reduction in target F from 0.25 to 0.20.
- Once the F has reached the level envisaged in the management plan the 15% rule could be considered.

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. The WG considers that stock management is precautionary if a precautionary plan is being followed (Section 2.9).

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

North Sea herring and Western Baltic Spring Spawning herring are managed under mixed quotas in some areas of North Sea, Skagerrak and Kattegat. The management of these mixed components was discussed in detail last year (ICES CM 2007 ACFM:11). With the decline of both the WBSS herring the NS herring, conservation of both stock needs to be considered when setting TACs. The rate of reduction in F 2009 relative to F 2008 recommended for WBSS herring exceeds that recommended for NS herring. Under these circumstances primacy of consideration should be given to protection of WBSS herring.

2.13 Ecosystem considerations

2.13.1 Ecosystem considerations

Herring is considered to have a major impact on most other fish stocks as prey and predator and is itself prey for seabirds and sea mammals in that area. Herring spawning and nursery areas, being near the coasts, are particularly sensitive and vulnerable to anthropogenic influences. The most serious of these is the ever-increasing extraction of marine sand and gravel.

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

2.13.2 Changes in the environment

This stock has recently produced five poor year classes in a row, which has never been observed before. Larval surveys show a large abundance of larvae in recent years. However, survival of these larvae seems to be very poor. The specific reasons for this are not known. An ICES study group has reviewed the hypotheses for the serial poor recruitment in North Sea herring (SGRECVAP 2007) and commented that trends in herring recruitment are similar to the warming of the water on the spawning grounds and changes in the hydrography. These hydrographic changes may be linked to the AMO (Atlantic Multidecadal Oscillation) and are also associated with changes in the zooplankton community. Further investigation of the causes of the poor recruitment will require targeted research projects.

Table 2.1.1: Herring caught in the North Sea (Sub-area IV and Division VIId). Catch in tonnes by country, 1998 – 2007. These figures do not in all cases correspond to the official statistics and cannot be used for legal purposes.

Country	**1998** [9]	**1999** [9]	**2000** [9]	**2001** [9]	**2002**
Belgium	-	2	-	-	23
Denmark	58924	61268	64123	67096	70825
Faroe Islands	1246	1977	915	1082	1413
France	20784	26962	20952	24880 [14]	25422
Germany, Fed.Rep	22259	26764	26687	29779	27213
Netherlands	49933	54467	54341	51293	55257
Norway [4]	70981	74071	72072	75886	74974
Poland				-	-
Sweden	3221	3241	3046	3695	3418
USSR/Russia	452	-	-	-	-
UK (England)	7635	11434	11179	14582	13757
UK (Scotland)	31313	29911	30033	26719	30926
UK (N.Ireland)	1015	-	996	1018	944
Unallocated landings	70329 [12]	43327 [12]	61673 [12]	27362 [12]	31552
Total landings	338092	333424	346017	323392 [14]	335724
Discards	-	-	-	-	17093
Total catch	**338092**	**333424**	**346017**	**323392** [14]	**352817**
Estimates of the parts of the catches which have been allocated to spring spawning stocks					
IIIa type (WBSS)	7833	4732	6649	6449	6652
Thames estuary [5]	88	88	76	107	60
Others [11]	-	-	378	1097	0
Norw. Spring Spawners [13]	29220	32106	25678	7108	4069

Country	**2003**	**2004**	**2005**	**2006**	**2007**
Belgium	5	8	6	3	1
Denmark [7]	78606	99037	128380	102322	84697
Faroe Islands	627	402	738	1785	2891
France	31544	34521	38829	49475	24909
Germany	43953	41858	46555	40414	14893
Netherlands	81108	96162	81531	76315	66393
Norway [4]	112481	137638	156802	135361	100050
Poland	-	-	458	-	-
Sweden	4781	5692	13464	10529	15448
Russia	-	-	99	-	-
UK (England)	18639	20855	25311	22198	15993
UK (Scotland)	40292	45331	73227	48428	35115
UK (N.Ireland)	2010	2656	2912	3531	638
Unallocated landings	31875 [12]	48898 [12]	57788	18764	26641
Total landings	445921	533058	626101	509125	387669
Discards	4125	17059	12824	1492	93
Total catch	**450046**	**550117**	**638925**	**510617**	**387762**
Estimates of the parts of the catches which have been allocated to spring spawning stocks					
IIIa type (WBSS)	2821	7079	7039	10954	1070
Thames estuary [5]	84	62	74	65	2
Others [11]	308	0	0	0	0
Norw. Spring Spawners [13]	979	452	417	626	685

[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 UK (England). [7]Including any bycatches 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 VIaN 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	1998 [11]	1999 [11]	2000 [11]	2001 [11]	2002
Denmark	4634	15359	25530	17770	26422
Faroe Islands	1246	1977	205	192	-
France	4758	6369	3210	8164	10522
Germany	7753	11206	5811	17753	15189
Netherlands	10917	21552	15117	17503 #	18289
Norway	27290	31395	33164	11653	10836
Sweden	315	859	1479	-	-
Poland				1418	2397
Russia	452	-	-	-	-
UK (England)	4306	7999	8859	12283	10142
UK (Scotland)	29462	28537	29055	25105	30014
UK (N. Ireland)	1015	-	996	1018	944
Unallocated landings	56058 [8]	25469 [8]	44334 [8]	24725 [8]	14201
Misreporting from VIa North					
Total Landings	148206	150722	167760	137584	138956
Discards					17093
Total catch	**148206**	**150722**	**167760**	**137584**	**156049**

Country	2003	2004	2005	2006	2007
Denmark [7]	48358	48128	80990	60462	45948
Faroe Islands	95	-		580	1118
France	11237	10941	13474	18453	8570
Germany	25796	17559	22278	18605	4985
Netherlands	25045	43876	36619	39209	42622
Norway	34443	36119	66232	38363	40279
Poland	-	-	458	-	-
Sweden	2647	2178	8261	4957	7658
Russia	-	-	99	-	-
UK (England)	12030	13480	15523	12031	11833
UK (Scotland)	39970	43490	71941	47368	35115
UK (N. Ireland)	2010	2656	2912	3531	638
Unallocated landings	14115 [8]	28631 [8]	39324 [8]	10981 [8]	22215
Misreporting from VIa North					
Total Landings	215746	247058	358111	253048	220981
Discards	4125	15794	10861	1492	93
Total catch	**219871**	**262852**	**368972**	**254540**	**221074**

[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	1998 [7]	1999 [7]	2000 [7]	2001 [7]	2002
Denmark [5]	25750	18259	11300	18466	17846
Faroe Islands	-	-	710	890	1365
France	-	115	-	-	-
Germany	-	-	29	-	81
Netherlands	301	-	38	-	-
Norway [2]	43646	39977	38655	56904	63482
Sweden	1189	772	1177	517	568
Unallocated landings	-292 [4]	-	338	o	3959
Total landings	70594	59123	52247	76777	89303
Discards	-	-	-	-	-
Total catch	**70594**	**59123**	**52247**	**76777**	**89303**
Norw. Spring Spawners [6]	29220	32106	25678	7108	4069

Country	2003	2004	2005	2006	2007
Denmark [5]	7401	16278	5761	8614	2646
Faroe Islands	359	-	738	975	577
France	-	-		-	-
Germany	54	888		34	-
Netherlands	-	-		-	263
Norway [2]	62306	100443	89925	90065	54424
UK (Scotland)	-	-	-	83	-
Sweden	1529	1720	3510	2857	640
Unallocated landings	11991	0	0	0	-96
Total landings	83640	119329	99934	102628	58454
Discards	-	-	-	-	-
Total catch	**83640**	**119329**	**99934**	**102628**	**58454**
Norw. Spring Spawners [6]	979	452	417	626	685

[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	1998 [6]	1999 [6]	2000 [6]	2001 [6]	2002
Belgium	-	1	-	-	-
Denmark [4]	26667	26211	26825	30277	26387
Faroe Islands	-	-	-	-	48
France	8945	7634	10863	7796 [14]	4214
Germany	13590	13529	18818	8340	7577
Netherlands	27468	22343	26839	24160	13154
Norway	45	2699	253	7329	656
Sweden	1717	1610	390	1760	453
UK (England)	1767	1641	669	814	317
UK (Scotland)	1851	1374	978	1614	289
Unallocated landings	-12138 [5]	-3794 [5]	-9820 [5]	-22885 [5]	4052
Total landings	69912	73248	75815	59205	57147
Discards [2]					
Total catch	**69912**	**73248**	**75815**	**59205** [14]	**57147**

Country	2003	2004	2005	2006	2007
Belgium	-	-	-	-	-
Denmark [4]	22574	33857	41423	32277	35990
Faroe Islands	173	402	-	200	1196
France	7918	10592	10205	17385	8421
Germany	12116	13823	14381	14222	2205
Netherlands	19115	23649	10038	13363	8550
Norway	15732	1076	645	6933	5347
Sweden	605	1794	1694	2715	7150
UK (England)	2632	2864	3869	4924	577
UK (Scotland)	322	1841	1286	977	-
Unallocated landings	-2401	8300	10233	2364	-203
Total landings	78786	98198	93774	95360	69233
Discards [2]		1265	1963		
Total catch	**78786**	**99463**	**95737**	**95360**	**69233**

[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	1998 [9]	1999 [9]	2000 [9]	2001 [9]	2002
Belgium	-	1	1	-	23
Denmark	1873	1439	468	583	170
France	7081	12844	6879	8750	10686
Germany	916	2029	2029	3686	4366
Netherlands	11247	10572	12348	9630	23814
UK (England)	1562	1794	1651	1485	3298
UK (Scotland)	-	-	-	-	623
Unallocated landings	26701 [4]	21652 [4]	26822 [4]	25522 [4]	5336
Total landings	49380	50331	50198	49656	50318
Discards [3]					-
Total catch	**49380**	**50331**	**50198**	**49656**	**50318**
Coastal spring spawners included above [2]	88	88	76	147 [11]	60

Country	2003	2004	2005	2006	2007
Belgium	5	8	6	3	1
Denmark	273	774	206	969	113
Faroe Islands	-	-	-	30	-
France	12389	12988	15150	13637	7918
Germany	5987	9588	9896	7553	7703
Netherlands	36948	28637	34874	23743	14958
UK (England)	3977	4511	5919	5243	3583
UK (Scotland)	-	-	-	-	-
Unallocated landings	8170	11967	8231	5419	4725
Total landings	67749	68473	74282	56597	39001
Discards [3]	-	-	-	-	
Total catch	**67749**	**68473**	**74282**	**56597**	**39001**
Coastal spring spawners included above [2]	84	62	74	65	2

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

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 and Div IIIa in 2007. 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	67.7	2.3	0.0	2.3	0.0	543.2	7.9	0.0	545.5	7.9	621.0	553.4
1	189.3	0.1	0.0	0.1	1.7	44.4	0.0	0.0	46.2	0.0	235.6	46.2
2	76.9	12.5	0.1	12.4	90.0	35.5	0.1	4.0	138.0	4.1	219.0	142.1
3	2.1	66.9	2.6	64.2	238.3	50.5	1.4	55.7	353.1	57.1	412.2	412.8
4	0.4	51.1	1.3	49.9	151.0	32.5	1.4	48.1	233.4	49.4	283.2	284.0
5	1.4	33.8	0.6	33.2	179.8	73.7	0.5	19.5	286.8	20.0	308.3	307.4
6	0.3	119.4	0.8	118.6	339.3	91.1	2.0	76.3	549.0	78.3	627.6	628.1
7	0.6	19.2	0.4	18.8	88.2	22.7	0.5	16.2	129.7	16.7	147.1	146.8
8	0.0	22.9	0.5	22.4	86.4	11.2	0.3	12.0	120.1	12.4	132.5	132.9
9+	0.0	5.5	0.2	5.4	14.6	0.5	0.0	2.6	20.5	2.6	23.1	23.2
Sum	338.7	333.7	6.3	327.4	1189.4	905.4	14.1	234.4	2422.2	248.5	3009.4	2677.0
Quarter: 1												
0	0.0	0.7	0.0	0.7	0.0	0.0	0.0	0.0	0.7	0.0	0.7	0.7
1	46.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	46.9	0.1
2	54.4	0.8	0.0	0.8	5.5	0.1	0.0	0.0	6.4	0.0	60.8	6.4
3	0.6	4.5	0.0	4.5	26.6	0.4	0.6	14.6	31.6	15.2	47.5	46.8
4	0.4	3.6	0.0	3.6	17.7	0.3	0.5	7.8	21.6	8.3	30.3	29.9
5	0.3	2.7	0.0	2.7	28.6	0.4	0.2	4.9	31.8	5.1	37.1	36.8
6	0.2	7.7	0.0	7.7	39.0	0.6	0.6	10.4	47.3	11.0	58.6	58.3
7	0.1	1.2	0.0	1.2	12.3	0.2	0.2	1.3	13.7	1.5	15.2	15.2
8	0.0	1.3	0.0	1.3	19.3	0.3	0.1	1.3	20.9	1.4	22.3	22.3
9+	0.0	0.1	0.0	0.1	0.0	0.0	0.0	0.3	0.1	0.3	0.4	0.4
Sum	103.0	22.6	0.0	22.6	149.2	2.4	2.2	40.6	174.1	42.8	319.9	216.9
Quarter: 2												
0	0.0	0.0	0.0	0.0	0.0	17.3	0.3	0.0	17.3	0.3	17.6	17.6
1	11.2	0.0	0.0	0.0	0.5	0.4	0.0	0.0	0.8	0.0	12.1	0.8
2	12.4	7.1	0.0	7.1	29.2	0.9	0.0	0.0	37.2	0.0	49.6	37.2
3	0.6	45.8	1.1	44.6	97.5	3.1	0.0	0.0	145.2	0.1	145.8	146.4
4	0.0	37.9	0.6	37.2	62.0	1.5	0.0	0.0	100.7	0.0	100.8	101.4
5	1.1	20.9	0.3	20.7	46.1	1.6	0.0	0.0	68.3	0.0	69.4	68.6
6	0.0	82.7	0.3	82.3	105.1	3.4	0.0	0.0	190.8	0.0	190.9	191.2
7	0.6	9.5	0.2	9.3	13.6	0.6	0.0	0.0	23.6	0.0	24.2	23.8
8	0.0	7.8	0.1	7.7	8.7	0.4	0.0	0.0	16.9	0.0	16.9	17.0
9+	0.0	1.2	0.0	1.2	2.1	0.0	0.0	0.0	3.2	0.0	3.2	3.3
Sum	25.9	212.9	2.8	210.2	364.8	29.2	0.3	0.1	604.1	0.5	630.5	607.4
Quarter: 3												
0	35.5	0.0	0.0	0.0	0.0	190.1	0.0	0.0	190.1	0.0	225.7	190.1
1	85.5	0.0	0.0	0.0	0.3	5.7	0.0	0.0	6.0	0.0	91.5	6.0
2	9.5	3.5	0.0	3.5	48.4	14.8	0.0	0.0	66.7	0.0	76.2	66.7
3	0.7	13.8	1.5	12.4	107.4	25.3	0.0	0.1	145.1	0.1	145.8	146.6
4	0.0	8.1	0.6	7.5	68.8	17.1	0.0	0.1	93.4	0.1	93.5	94.1
5	0.1	4.6	0.3	4.4	92.5	44.7	0.0	0.0	141.6	0.0	141.7	141.9
6	0.0	17.2	0.3	16.9	175.5	49.5	0.0	0.2	241.9	0.2	242.1	242.4
7	0.0	0.9	0.1	0.9	46.1	14.0	0.0	0.0	61.0	0.1	61.0	61.1
8	0.0	2.2	0.2	2.1	43.4	3.5	0.0	0.0	49.0	0.0	49.0	49.2
9+	0.0	1.0	0.1	0.9	9.5	0.0	0.0	0.0	10.4	0.0	10.4	10.5
Sum	131.3	51.5	3.0	48.5	591.8	364.8	0.0	0.5	1005.1	0.5	1136.9	1008.6
Quarter: 4												
0	32.1	1.6	0.0	1.6	0.0	335.8	7.6	0.0	337.4	7.6	377.1	345.0
1	45.7	0.1	0.0	0.1	0.9	38.3	0.0	0.0	39.3	0.0	85.0	39.3
2	0.5	1.0	0.0	1.0	6.9	19.8	0.1	4.0	27.7	4.1	32.3	31.8
3	0.2	2.8	0.0	2.7	6.8	21.7	0.7	40.9	31.2	41.7	73.1	72.9
4	0.0	1.6	0.0	1.6	2.5	13.6	0.9	40.1	17.7	41.0	58.7	58.7
5	0.0	5.5	0.1	5.5	12.6	27.0	0.3	14.6	45.1	14.9	60.0	60.1
6	0.0	11.8	0.2	11.7	19.7	37.6	1.4	65.7	69.0	67.1	136.1	136.2
7	0.0	7.6	0.1	7.5	16.2	7.8	0.4	14.8	31.4	15.2	46.6	46.7
8	0.0	11.5	0.2	11.3	14.9	7.0	0.3	10.7	33.3	11.0	44.2	44.4
9+	0.0	3.2	0.0	3.2	3.1	0.5	0.0	2.2	6.7	2.3	9.0	9.0
Sum	78.5	46.7	0.6	46.1	83.6	509.1	11.6	193.2	638.8	204.8	922.1	844.2

Table 2.2.2: North Sea autumn spawning herring (NSAS), and western Baltic spring spawners (WBSS) caught in the North Sea and Div IIIa in 2007. 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	**0.027**	**0.011**	**0.000**	**0.000**	**0.011**	**0.007**	**0.000**	**0.011**	**-**	**0.012**	**0.011**
1	**0.062**	**0.047**	**0.000**	**0.108**	**0.068**	**0.099**	**0.000**	**0.070**	**0.099**	**0.064**	**0.070**
2	**0.071**	**0.156**	**0.157**	**0.150**	**0.145**	**0.135**	**0.129**	**0.149**	**0.129**	**0.121**	**0.149**
3	**0.108**	**0.148**	**0.148**	**0.156**	**0.160**	**0.123**	**0.131**	**0.155**	**0.131**	**0.151**	**0.152**
4	**0.125**	**0.156**	**0.156**	**0.166**	**0.180**	**0.142**	**0.154**	**0.165**	**0.154**	**0.163**	**0.164**
5	**0.152**	**0.186**	**0.185**	**0.196**	**0.201**	**0.151**	**0.159**	**0.196**	**0.158**	**0.193**	**0.194**
6	**0.184**	**0.184**	**0.186**	**0.191**	**0.210**	**0.164**	**0.173**	**0.192**	**0.173**	**0.190**	**0.190**
7	**0.175**	**0.204**	**0.199**	**0.227**	**0.246**	**0.177**	**0.196**	**0.227**	**0.196**	**0.223**	**0.224**
8	**0.154**	**0.226**	**0.221**	**0.241**	**0.234**	**0.203**	**0.209**	**0.238**	**0.209**	**0.235**	**0.235**
9+	**0.000**	**0.239**	**0.237**	**0.264**	**0.252**	**0.217**	**0.218**	**0.257**	**0.218**	**0.252**	**0.252**
Quarter: 1											
0	0.000	0.007	0.000	0.000	0.000	0.000	0.000	-	-	**0.007**	**0.007**
1	0.024	0.041	0.000	0.115	0.072	0.000	0.000	0.098	-	**0.024**	**0.098**
2	0.061	0.140	0.000	0.108	0.104	0.000	0.000	0.112	-	**0.066**	**0.112**
3	0.091	0.140	0.000	0.124	0.124	0.089	0.081	0.126	0.081	**0.111**	**0.112**
4	0.125	0.151	0.000	0.147	0.145	0.105	0.114	0.147	0.113	**0.138**	**0.138**
5	0.148	0.168	0.000	0.148	0.147	0.120	0.132	0.150	0.132	**0.147**	**0.147**
6	0.188	0.177	0.000	0.158	0.157	0.126	0.149	0.161	0.148	**0.159**	**0.158**
7	0.172	0.185	0.000	0.176	0.175	0.119	0.161	0.176	0.156	**0.175**	**0.175**
8	0.144	0.209	0.000	0.205	0.204	0.144	0.155	0.205	0.154	**0.202**	**0.202**
9+	0.000	0.249	0.000	0.207	0.000	0.230	0.230	0.238	-	**0.232**	**0.232**
Quarter: 2											
0	0.000	0.000	0.000	0.000	0.007	0.007	0.000	-	-	**0.007**	**0.007**
1	0.051	0.100	0.000	0.117	0.048	0.072	0.000	0.086	0.072	**0.053**	**0.086**
2	0.082	0.157	0.158	0.135	0.131	0.089	0.000	0.139	0.089	**0.125**	**0.139**
3	0.099	0.146	0.146	0.141	0.140	0.104	0.081	0.142	0.086	**0.142**	**0.142**
4	0.115	0.152	0.152	0.150	0.142	0.114	0.114	0.151	0.114	**0.151**	**0.151**
5	0.151	0.180	0.181	0.177	0.186	0.130	0.132	0.178	0.132	**0.178**	**0.178**
6	0.146	0.181	0.182	0.166	0.167	0.141	0.149	0.173	0.147	**0.173**	**0.173**
7	0.175	0.189	0.190	0.181	0.189	0.116	0.161	0.184	0.146	**0.184**	**0.184**
8	0.164	0.211	0.213	0.194	0.224	0.143	0.155	0.202	0.153	**0.202**	**0.202**
9+	0.000	0.248	0.248	0.223	0.000	0.000	0.230	0.232	-	**0.232**	**0.232**
Quarter: 3											
0	0.030	0.000	0.000	0.000	0.007	0.000	0.000	0.007	-	**0.011**	**0.007**
1	0.076	0.000	0.000	0.104	0.064	0.000	0.000	0.066	-	**0.075**	**0.066**
2	0.111	0.154	0.153	0.164	0.146	0.128	0.129	0.159	0.129	**0.153**	**0.159**
3	0.127	0.150	0.149	0.176	0.164	0.000	0.151	0.171	0.151	**0.171**	**0.171**
4	0.000	0.158	0.157	0.184	0.192	0.218	0.164	0.183	0.166	**0.183**	**0.183**
5	0.181	0.181	0.178	0.218	0.211	0.213	0.168	0.215	0.180	**0.215**	**0.215**
6	0.000	0.180	0.179	0.210	0.225	0.244	0.181	0.211	0.184	**0.211**	**0.211**
7	0.000	0.200	0.190	0.252	0.256	0.276	0.200	0.252	0.204	**0.252**	**0.252**
8	0.000	0.213	0.209	0.266	0.263	0.000	0.226	0.263	0.226	**0.263**	**0.263**
9+	0.000	0.234	0.234	0.277	0.000	0.000	0.216	0.273	0.216	**0.272**	**0.273**
Quarter: 4											
0	0.023	0.013	0.000	0.000	0.013	0.007	0.000	0.013	-	**0.014**	**0.013**
1	0.079	0.047	0.000	0.104	0.069	0.100	0.000	0.070	0.100	**0.075**	**0.070**
2	0.093	0.166	0.167	0.153	0.145	0.138	0.129	0.148	0.129	**0.144**	**0.145**
3	0.125	0.184	0.185	0.177	0.159	0.151	0.149	0.165	0.149	**0.156**	**0.156**
4	0.000	0.263	0.263	0.184	0.170	0.164	0.162	0.180	0.162	**0.168**	**0.168**
5	0.000	0.221	0.224	0.209	0.185	0.170	0.167	0.196	0.167	**0.189**	**0.189**
6	0.000	0.208	0.207	0.219	0.195	0.180	0.177	0.204	0.177	**0.191**	**0.191**
7	0.000	0.227	0.226	0.235	0.236	0.201	0.199	0.233	0.199	**0.222**	**0.222**
8	0.000	0.241	0.240	0.245	0.222	0.222	0.216	0.239	0.216	**0.233**	**0.233**
9+	0.000	0.236	0.236	0.252	0.252	0.216	0.216	0.245	0.216	**0.237**	**0.237**

Table 2.2.3: North Sea autumn spawning herring (NSAS), and western Baltic spring spawners (WBSS) caught in the North Sea in 2007. Mean length-at-age (cm) in the catch, by quarter and division.

WR	IIIa NSAS	IVa(E) all	IVa(E) WBSS	IVa(W)	IVb	IVc	VIId	IVa & IVb all	IVc & VIId	Herring caught in the North Sea
Quarters: 1-4										
0	**n.d.**	**12.2**	**n.d.**	**0.0**	**12.1**	**10.5**	**0.0**	**12.1**	**-**	**12.0**
1	**n.d.**	**18.9**	**n.d.**	**23.3**	**20.4**	**22.9**	**0.0**	**20.5**	**22.9**	**20.5**
2	**n.d.**	**25.6**	**n.d.**	**25.8**	**25.1**	**24.8**	**24.7**	**25.6**	**24.7**	**25.6**
3	**n.d.**	**25.5**	**n.d.**	**26.2**	**25.9**	**24.9**	**25.0**	**26.0**	**25.0**	**25.9**
4	**n.d.**	**25.9**	**n.d.**	**26.8**	**26.9**	**26.0**	**26.3**	**26.6**	**26.3**	**26.5**
5	**n.d.**	**27.5**	**n.d.**	**28.1**	**27.8**	**26.3**	**26.4**	**28.0**	**26.4**	**27.9**
6	**n.d.**	**27.2**	**n.d.**	**27.9**	**28.3**	**27.1**	**27.1**	**27.8**	**27.1**	**27.7**
7	**n.d.**	**28.7**	**n.d.**	**29.6**	**29.9**	**27.8**	**28.2**	**29.5**	**28.2**	**29.4**
8	**n.d.**	**29.8**	**n.d.**	**30.3**	**29.8**	**28.9**	**28.8**	**30.2**	**28.8**	**30.0**
9+	**n.d.**	**30.7**	**n.d.**	**30.8**	**31.5**	**29.0**	**29.0**	**30.7**	**29.0**	**30.6**
Quarter: 1										
0	n.d.	10.5	n.d.	0.0	0.0	0.0	0.0	-	-	**10.5**
1	n.d.	16.8	n.d.	25.8	20.3	0.0	0.0	23.7	-	**23.7**
2	n.d.	25.2	n.d.	24.6	24.2	0.0	0.0	24.6	-	**24.6**
3	n.d.	25.5	n.d.	25.9	25.8	23.9	23.2	25.8	23.2	**25.0**
4	n.d.	26.1	n.d.	27.4	27.1	24.9	25.0	27.2	25.0	**26.6**
5	n.d.	27.3	n.d.	27.5	27.5	25.8	26.0	27.5	26.0	**27.3**
6	n.d.	27.2	n.d.	28.1	27.9	26.2	26.7	27.9	26.7	**27.7**
7	n.d.	28.0	n.d.	29.1	29.0	26.4	27.6	29.0	27.5	**28.9**
8	n.d.	29.5	n.d.	30.7	30.7	27.8	27.6	30.6	27.6	**30.4**
9+	n.d.	28.9	n.d.	30.1	0.0	29.3	29.3	29.2	-	**29.3**
Quarter: 2										
0	n.d.	0.0	n.d.	0.0	10.5	10.5	0.0	-	-	**10.5**
1	n.d.	23.0	n.d.	24.0	17.4	20.3	0.0	21.0	20.3	**21.0**
2	n.d.	25.6	n.d.	24.9	24.3	21.6	0.0	25.0	21.6	**25.0**
3	n.d.	25.3	n.d.	25.4	25.1	23.9	23.2	25.3	23.4	**25.3**
4	n.d.	25.7	n.d.	25.9	25.3	24.8	25.0	25.8	24.9	**25.8**
5	n.d.	27.0	n.d.	27.2	27.5	25.8	26.0	27.2	26.0	**27.2**
6	n.d.	26.9	n.d.	26.6	26.6	26.3	26.7	26.7	26.6	**26.7**
7	n.d.	27.2	n.d.	27.5	27.6	26.3	27.6	27.4	27.2	**27.4**
8	n.d.	28.0	n.d.	28.3	29.4	27.8	27.6	28.2	27.6	**28.2**
9+	n.d.	28.8	n.d.	29.2	0.0	0.0	29.3	29.1	-	**29.1**
Quarter: 3										
0	n.d.	0.0	n.d.	0.0	10.5	0.0	0.0	10.5	-	**10.5**
1	n.d.	0.0	n.d.	23.0	18.9	0.0	0.0	19.1	-	**19.1**
2	n.d.	25.0	n.d.	26.4	25.0	24.8	24.7	26.0	24.7	**26.0**
3	n.d.	25.5	n.d.	26.9	25.9	0.0	25.7	26.6	25.7	**26.6**
4	n.d.	25.8	n.d.	27.3	27.3	28.6	26.7	27.2	26.8	**27.2**
5	n.d.	26.9	n.d.	28.6	28.2	28.3	26.4	28.4	26.9	**28.4**
6	n.d.	26.8	n.d.	28.3	28.7	29.6	27.5	28.3	27.6	**28.3**
7	n.d.	27.7	n.d.	30.0	29.9	30.6	28.3	29.9	28.4	**29.9**
8	n.d.	27.7	n.d.	30.2	30.3	0.0	29.3	30.1	29.3	**30.1**
9+	n.d.	29.4	n.d.	30.9	0.0	0.0	29.0	30.7	29.0	**30.7**
Quarter: 4										
0	n.d.	13.0	n.d.	0.0	13.0	10.5	0.0	13.0	-	**13.0**
1	n.d.	19.0	n.d.	23.0	20.7	23.0	0.0	20.7	23.0	**20.7**
2	n.d.	28.1	n.d.	26.6	25.3	25.0	24.7	25.8	24.7	**25.6**
3	n.d.	29.0	n.d.	28.1	26.0	25.7	25.6	26.7	25.6	**26.1**
4	n.d.	30.5	n.d.	28.0	26.5	26.6	26.5	27.1	26.5	**26.7**
5	n.d.	30.1	n.d.	29.4	27.2	26.5	26.5	28.2	26.5	**27.8**
6	n.d.	30.1	n.d.	30.1	27.9	27.4	27.2	28.9	27.2	**28.1**
7	n.d.	30.8	n.d.	30.8	30.1	28.4	28.3	30.6	28.3	**29.9**
8	n.d.	31.4	n.d.	31.4	29.5	29.2	28.9	31.0	28.9	**30.5**
9+	n.d.	31.8	n.d.	31.5	31.5	29.0	29.0	31.6	29.0	**31.0**

Table 2.2.4: North Sea autumn spawning herring (NSAS), and western Baltic spring spawners (WBSS) caught in the North Sea and Div IIIa in 2007. Catches (tonnes) at-age (SOP figures), by quarter and division.

WR	IIIa NSAS	IVa(E) all	IVa(E) WBSS	IVa(E) NSAS only	IVa(W)	IVb	IVc	VIId	IVa & IVb NSAS	IVc & VIId	Total NSAS	Herring caught in the North Sea
Quarters: 1-4												
0	**1.8**	**0.0**	**0.0**	**0.0**	**0.0**	**5.9**	**0.1**	**0.0**	**5.9**	**0.1**	**7.8**	**5.9**
1	**11.8**	**0.0**	**0.0**	**0.0**	**0.2**	**3.0**	**0.0**	**0.0**	**3.2**	**0.0**	**15.0**	**3.2**
2	**5.4**	**1.9**	**0.0**	**1.9**	**13.5**	**5.1**	**0.0**	**0.5**	**20.6**	**0.5**	**26.6**	**21.1**
3	**0.2**	**9.9**	**0.4**	**9.5**	**37.1**	**8.1**	**0.2**	**7.3**	**54.7**	**7.5**	**62.4**	**62.5**
4	**0.1**	**8.0**	**0.2**	**7.8**	**25.0**	**5.8**	**0.2**	**7.4**	**38.6**	**7.6**	**46.3**	**46.4**
5	**0.2**	**6.3**	**0.1**	**6.2**	**35.2**	**14.8**	**0.1**	**3.1**	**56.2**	**3.2**	**59.6**	**59.5**
6	**0.0**	**21.9**	**0.1**	**21.8**	**64.8**	**19.1**	**0.3**	**13.2**	**105.7**	**13.5**	**119.2**	**119.3**
7	**0.1**	**3.9**	**0.1**	**3.8**	**20.0**	**5.6**	**0.1**	**3.2**	**29.5**	**3.3**	**32.8**	**32.8**
8	**0.0**	**5.2**	**0.1**	**5.1**	**20.8**	**2.6**	**0.1**	**2.5**	**28.5**	**2.6**	**31.1**	**31.2**
9+	**0.0**	**1.3**	**0.0**	**1.3**	**3.9**	**0.1**	**0.0**	**0.6**	**5.3**	**0.6**	**5.8**	**5.9**
Sum	**19.7**	**58.5**	**1.1**	**57.4**	**220.5**	**70.2**	**1.0**	**37.8**	**348.2**	**38.8**	**406.6**	**388.0**
Quarter: 1												
0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	**0.0**
1	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**1.1**	**0.0**
2	3.3	0.1	0.0	0.1	0.6	0.0	0.0	0.0	0.7	0.0	**4.0**	**0.7**
3	0.1	0.6	0.0	0.6	3.3	0.1	0.1	1.2	4.0	1.2	**5.3**	**5.2**
4	0.1	0.5	0.0	0.5	2.6	0.0	0.1	0.9	3.2	0.9	**4.2**	**4.1**
5	0.0	0.5	0.0	0.5	4.2	0.1	0.0	0.6	4.8	0.7	**5.5**	**5.4**
6	0.0	1.4	0.0	1.4	6.2	0.1	0.1	1.5	7.6	1.6	**9.3**	**9.2**
7	0.0	0.2	0.0	0.2	2.2	0.0	0.0	0.2	2.4	0.2	**2.7**	**2.6**
8	0.0	0.3	0.0	0.3	3.9	0.1	0.0	0.2	4.3	0.2	**4.5**	**4.5**
9+	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.1	**0.1**	**0.1**
Sum	**4.7**	**3.6**	**0.0**	**3.6**	**23.0**	**0.4**	**0.2**	**4.8**	**27.0**	**5.0**	**36.6**	**32.0**
Quarter: 2												
0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.0	**0.1**	**0.1**
1	0.6	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.1	0.0	**0.6**	**0.1**
2	1.0	1.1	0.0	1.1	3.9	0.1	0.0	0.0	5.2	0.0	**6.2**	**5.2**
3	0.1	6.7	0.2	6.5	13.7	0.4	0.0	0.0	20.7	0.0	**20.7**	**20.8**
4	0.0	5.8	0.1	5.7	9.3	0.2	0.0	0.0	15.2	0.0	**15.2**	**15.3**
5	0.2	3.8	0.0	3.7	8.2	0.3	0.0	0.0	12.2	0.0	**12.3**	**12.2**
6	0.0	15.0	0.1	14.9	17.4	0.6	0.0	0.0	32.9	0.0	**32.9**	**33.0**
7	0.1	1.8	0.0	1.8	2.5	0.1	0.0	0.0	4.3	0.0	**4.4**	**4.4**
8	0.0	1.7	0.0	1.6	1.7	0.1	0.0	0.0	3.4	0.0	**3.4**	**3.4**
9+	0.0	0.3	0.0	0.3	0.5	0.0	0.0	0.0	0.8	0.0	**0.8**	**0.8**
Sum	**1.9**	**36.1**	**0.5**	**35.6**	**57.2**	**2.0**	**0.0**	**0.0**	**94.8**	**0.0**	**96.7**	**95.3**
Quarter: 3												
0	1.1	0.0	0.0	0.0	0.0	1.3	0.0	0.0	1.3	0.0	**2.4**	**1.3**
1	6.5	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.4	0.0	**6.9**	**0.4**
2	1.1	0.5	0.0	0.5	7.9	2.2	0.0	0.0	10.6	0.0	**11.7**	**10.6**
3	0.1	2.1	0.2	1.8	18.9	4.2	0.0	0.0	24.9	0.0	**25.0**	**25.1**
4	0.0	1.3	0.1	1.2	12.6	3.3	0.0	0.0	17.1	0.0	**17.1**	**17.2**
5	0.0	0.8	0.0	0.8	20.2	9.5	0.0	0.0	30.5	0.0	**30.5**	**30.5**
6	0.0	3.1	0.1	3.0	36.9	11.1	0.0	0.0	51.1	0.0	**51.1**	**51.2**
7	0.0	0.2	0.0	0.2	11.6	3.6	0.0	0.0	15.4	0.0	**15.4**	**15.4**
8	0.0	0.5	0.0	0.4	11.5	0.9	0.0	0.0	12.9	0.0	**12.9**	**12.9**
9+	0.0	0.2	0.0	0.2	2.6	0.0	0.0	0.0	2.8	0.0	**2.8**	**2.9**
Sum	**8.7**	**8.7**	**0.5**	**8.3**	**122.3**	**36.4**	**0.0**	**0.1**	**167.0**	**0.1**	**175.8**	**167.6**
Quarter: 4												
0	0.7	0.0	0.0	0.0	0.0	4.4	0.1	0.0	4.4	0.1	**5.2**	**4.5**
1	3.6	0.0	0.0	0.0	0.1	2.6	0.0	0.0	2.7	0.0	**6.4**	**2.7**
2	0.0	0.2	0.0	0.2	1.1	2.9	0.0	0.5	4.1	0.5	**4.7**	**4.6**
3	0.0	0.5	0.0	0.5	1.2	3.4	0.1	6.1	5.1	6.2	**11.4**	**11.3**
4	0.0	0.4	0.0	0.4	0.5	2.3	0.1	6.5	3.2	6.6	**9.8**	**9.8**
5	0.0	1.2	0.0	1.2	2.6	5.0	0.0	2.4	8.8	2.5	**11.3**	**11.3**
6	0.0	2.5	0.0	2.4	4.3	7.3	0.2	11.6	14.1	11.9	**25.9**	**26.0**
7	0.0	1.7	0.0	1.7	3.8	1.8	0.1	3.0	7.3	3.0	**10.4**	**10.4**
8	0.0	2.8	0.0	2.7	3.7	1.6	0.1	2.3	7.9	2.4	**10.3**	**10.3**
9+	0.0	0.8	0.0	0.7	0.8	0.1	0.0	0.5	1.6	0.5	**2.1**	**2.1**
Sum	**4.4**	**10.0**	**0.1**	**9.9**	**18.0**	**31.5**	**0.8**	**32.9**	**59.4**	**33.7**	**97.5**	**93.2**

Table 2.2.5: North Sea autumn spawning herring (NSAS), and western Baltic spring spawners (WBSS) caught in the North Sea in 2007. 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	**20.0%**	**0.7%**	**0.0%**	**0.7%**	**0.0%**	**60.0%**	**55.6%**	**0.0%**	**22.5%**	**3.2%**	**20.6%**	**20.7%**
1	**55.9%**	**0.0%**	**0.0%**	**0.0%**	**0.1%**	**4.9%**	**0.3%**	**0.0%**	**1.9%**	**0.0%**	**7.8%**	**1.7%**
2	**22.7%**	**3.8%**	**1.2%**	**3.8%**	**7.6%**	**3.9%**	**0.7%**	**1.7%**	**5.7%**	**1.6%**	**7.3%**	**5.3%**
3	**0.6%**	**20.0%**	**41.4%**	**19.6%**	**20.0%**	**5.6%**	**9.8%**	**23.8%**	**14.6%**	**23.0%**	**13.7%**	**15.4%**
4	**0.1%**	**15.3%**	**19.7%**	**15.2%**	**12.7%**	**3.6%**	**9.8%**	**20.5%**	**9.6%**	**19.9%**	**9.4%**	**10.6%**
5	**0.4%**	**10.1%**	**9.4%**	**10.1%**	**15.1%**	**8.1%**	**3.3%**	**8.3%**	**11.8%**	**8.1%**	**10.2%**	**11.5%**
6	**0.1%**	**35.8%**	**12.7%**	**36.2%**	**28.5%**	**10.1%**	**14.1%**	**32.6%**	**22.7%**	**31.5%**	**20.9%**	**23.5%**
7	**0.2%**	**5.8%**	**5.9%**	**5.8%**	**7.4%**	**2.5%**	**3.8%**	**6.9%**	**5.4%**	**6.7%**	**4.9%**	**5.5%**
8	**0.0%**	**6.9%**	**7.2%**	**6.9%**	**7.3%**	**1.2%**	**2.5%**	**5.1%**	**5.0%**	**5.0%**	**4.4%**	**5.0%**
9+	**0.0%**	**1.7%**	**2.4%**	**1.6%**	**1.2%**	**0.1%**	**0.2%**	**1.1%**	**0.8%**	**1.0%**	**0.8%**	**0.9%**
Sum 3+	**1.4%**	**95.5%**	**98.8%**	**95.5%**	**92.3%**	**31.2%**	**43.4%**	**98.3%**	**69.9%**	**95.2%**	**64.3%**	**72.3%**
Quarter: 1												
0	0.0%	3.0%	-	3.0%	0.0%	0.0%	0.0%	0.0%	0.4%	0.0%	**0.2%**	**0.3%**
1	45.5%	0.1%	-	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	**14.7%**	**0.0%**
2	52.9%	3.5%	-	3.5%	3.7%	3.4%	0.0%	0.0%	3.7%	0.0%	**19.0%**	**2.9%**
3	0.6%	20.0%	-	20.0%	17.9%	18.4%	28.8%	36.0%	18.1%	35.6%	**14.8%**	**21.6%**
4	0.4%	15.9%	-	15.9%	11.9%	12.4%	23.6%	19.2%	12.4%	19.4%	**9.5%**	**13.8%**
5	0.3%	11.9%	-	11.9%	19.2%	18.3%	8.4%	12.0%	18.2%	11.8%	**11.6%**	**17.0%**
6	0.2%	34.0%	-	34.0%	26.2%	26.9%	27.8%	25.6%	27.2%	25.7%	**18.3%**	**26.9%**
7	0.1%	5.2%	-	5.2%	8.3%	8.1%	7.5%	3.2%	7.9%	3.4%	**4.8%**	**7.0%**
8	0.0%	5.9%	-	5.9%	12.9%	12.4%	3.9%	3.2%	12.0%	3.2%	**7.0%**	**10.3%**
9+	0.0%	0.4%	-	0.4%	0.0%	0.0%	0.1%	0.8%	0.1%	0.8%	**0.1%**	**0.2%**
Sum 3+	**1.6%**	**93.4%**	-	**93.4%**	**96.3%**	**96.6%**	**100.0%**	**100.0%**	**95.9%**	**100.0%**	**66.1%**	**96.7%**
Quarter: 2												
0	0.0%	0.0%	0.0%	0.0%	0.0%	59.2%	84.4%	0.0%	2.9%	60.2%	**2.8%**	**2.9%**
1	43.4%	0.0%	0.0%	0.0%	0.1%	1.3%	0.3%	0.0%	0.1%	0.2%	**1.9%**	**0.1%**
2	47.9%	3.3%	0.7%	3.4%	8.0%	3.1%	1.7%	0.0%	6.2%	1.2%	**7.9%**	**6.1%**
3	2.1%	21.5%	40.6%	21.2%	26.7%	10.6%	4.5%	36.0%	24.0%	13.6%	**23.1%**	**24.1%**
4	0.1%	17.8%	23.4%	17.7%	17.0%	5.1%	4.0%	19.2%	16.7%	8.4%	**16.0%**	**16.7%**
5	4.2%	9.8%	9.7%	9.8%	12.6%	5.3%	0.8%	12.0%	11.3%	4.0%	**11.0%**	**11.3%**
6	0.1%	38.8%	12.5%	39.2%	28.8%	11.7%	3.3%	25.6%	31.6%	9.7%	**30.3%**	**31.5%**
7	2.2%	4.5%	7.3%	4.4%	3.7%	2.2%	0.6%	3.2%	3.9%	1.4%	**3.8%**	**3.9%**
8	0.0%	3.7%	4.9%	3.7%	2.4%	1.5%	0.3%	3.2%	2.8%	1.2%	**2.7%**	**2.8%**
9+	0.0%	0.6%	0.8%	0.6%	0.6%	0.0%	0.0%	0.8%	0.5%	0.2%	**0.5%**	**0.5%**
Sum 3+	**8.7%**	**96.7%**	**99.3%**	**96.6%**	**91.9%**	**36.4%**	**13.7%**	**100.0%**	**90.8%**	**38.5%**	**87.4%**	**90.8%**
Quarter: 3												
0	27.1%	0.0%	0.0%	0.0%	0.0%	52.1%	0.0%	0.0%	18.9%	0.0%	**19.8%**	**18.8%**
1	65.1%	0.0%	0.0%	0.0%	0.0%	1.6%	0.0%	0.0%	0.6%	0.0%	**8.1%**	**0.6%**
2	7.3%	6.9%	1.4%	7.2%	8.2%	4.1%	4.0%	0.7%	6.6%	0.9%	**6.7%**	**6.6%**
3	0.5%	26.9%	49.4%	25.5%	18.2%	6.9%	0.0%	17.7%	14.4%	16.8%	**12.8%**	**14.5%**
4	0.0%	15.7%	19.5%	15.5%	11.6%	4.7%	12.0%	22.9%	9.3%	22.3%	**8.2%**	**9.3%**
5	0.0%	9.0%	8.6%	9.1%	15.6%	12.3%	36.0%	5.2%	14.1%	6.8%	**12.5%**	**14.1%**
6	0.0%	33.4%	10.1%	34.8%	29.6%	13.6%	36.0%	35.3%	24.1%	35.4%	**21.3%**	**24.0%**
7	0.0%	1.8%	2.6%	1.8%	7.8%	3.8%	12.0%	10.5%	6.1%	10.6%	**5.4%**	**6.1%**
8	0.0%	4.4%	5.5%	4.3%	7.3%	1.0%	0.0%	7.2%	4.9%	6.8%	**4.3%**	**4.9%**
9+	0.0%	2.0%	2.8%	1.9%	1.6%	0.0%	0.0%	0.4%	1.0%	0.4%	**0.9%**	**1.0%**
Sum 3+	**0.5%**	**93.1%**	**98.6%**	**92.8%**	**91.8%**	**42.3%**	**96.0%**	**99.3%**	**73.9%**	**99.1%**	**65.4%**	**73.9%**
Quarter: 4												
0	40.9%	3.4%	0.0%	3.5%	0.0%	66.0%	65.2%	0.0%	52.8%	3.7%	**40.9%**	**40.9%**
1	58.2%	0.2%	0.0%	0.2%	1.0%	7.5%	0.4%	0.0%	6.2%	0.0%	**9.2%**	**4.7%**
2	0.6%	2.2%	2.0%	2.2%	8.3%	3.9%	0.8%	2.1%	4.3%	2.0%	**3.5%**	**3.8%**
3	0.3%	5.9%	6.0%	5.9%	8.1%	4.3%	6.4%	21.2%	4.9%	20.4%	**7.9%**	**8.6%**
4	0.0%	3.4%	4.0%	3.4%	3.0%	2.7%	7.4%	20.8%	2.8%	20.0%	**6.4%**	**7.0%**
5	0.0%	11.8%	12.0%	11.8%	15.1%	5.3%	2.4%	7.6%	7.1%	7.3%	**6.5%**	**7.1%**
6	0.0%	25.3%	26.0%	25.3%	23.6%	7.4%	11.9%	34.0%	10.8%	32.8%	**14.8%**	**16.1%**
7	0.0%	16.2%	16.0%	16.2%	19.3%	1.5%	3.2%	7.7%	4.9%	7.4%	**5.1%**	**5.5%**
8	0.0%	24.6%	26.0%	24.5%	17.9%	1.4%	2.3%	5.5%	5.2%	5.4%	**4.8%**	**5.3%**
9+	0.0%	6.9%	8.0%	6.9%	3.7%	0.1%	0.2%	1.2%	1.0%	1.1%	**1.0%**	**1.1%**
Sum 3+	**0.3%**	**94.1%**	**98.0%**	**94.1%**	**90.7%**	**22.6%**	**33.7%**	**97.9%**	**36.7%**	**94.3%**	**46.4%**	**50.7%**

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

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

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

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

Table 2.2.7: Catch at age (numbers in millions) of herring caught in the North Sea, 1992-2007. SG Rednose's revisions for 1995-2001 are included.

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
2007	553	46	142	413	284	307	628	147	133	23	2677

Table 2.2.8: Catch at age (numbers in millions) of Baltic spring spawning herring taken in the North Sea, and transferred to the assessment of the spring spawning stock in IIIa, 1992-2007.

Year/rings	0	1	2	3	4	5	6	7	8	9+	Total
1992	0.0	0.0	0.3	9.9	11.1	8.4	8.6	2.5	0.7	0.6	42.1
1993	0.0	0.0	4.2	10.8	12.3	8.4	5.9	4.7	1.7	1.0	49.0
1994	0.0	0.0	8.8	28.2	16.3	11.0	8.6	3.4	3.2	0.7	80.2
1995	0.0	0.0	22.4	11.0	14.9	4.0	2.9	1.9	0.7	0.0	57.8
1996	0.0	0.0	0.0	2.8	0.8	0.4	0.1	0.1	0.3	0.0	4.5
1997	0.0	0.0	2.2	1.3	1.5	0.4	0.2	0.1	0.2	0.0	5.9
1998	0.0	5.1	9.5	12.0	10.1	6.0	3.0	0.4	0.9	0.0	47.0
1999	0.0	0.0	3.3	14.3	5.6	3.6	1.4	0.6	0.4	0.0	29.3
2000	0.0	0.0	8.2	9.8	10.2	5.7	2.5	0.6	0.7	0.1	37.6
2001	0.0	0.0	11.3	10.2	6.1	7.2	2.7	1.6	0.4	0.0	39.9
2002	0.0	0.0	7.6	14.8	10.6	3.3	2.9	1.0	0.5	0.1	40.8
2003	0.0	0.0	0.0	3.1	6.0	3.5	1.2	1.3	0.5	0.1	15.7
2004	0.0	0.0	15.1	27.9	3.5	4.1	1.0	0.5	0.1	0.0	52.3
2005	0.0	0.0	6.6	17.4	12.7	2.6	3.8	1.1	0.4	0.3	44.8
2006	0.0	0.1	3.5	8.8	14.0	22.4	5.1	5.3	2.1	1.0	62.2
2007	0.0	0.0	0.1	2.6	1.3	0.6	0.8	0.4	0.5	0.2	6.3

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 - 2007. 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.

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
2007	68	189	77	2	0	1	0	1	0	339

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.

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
2007	621	236	219	412	283	308	628	147	132	23	3009

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 1997 – 2007. SG Rednose's revisions are included.

		Age (Rings)							
Div.	Year	2	3	4	5	6	7	8	9+
IIIa	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	-
	2007	0.071	0.108	0.125	0.152	0.184	0.175	0.154	-
IVa(E)	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
	2007	0.156	0.148	0.156	0.186	0.184	0.204	0.226	0.239
IVa(W)	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
	2007	0.150	0.156	0.166	0.196	0.191	0.227	0.241	0.264
IVb	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
	2007	0.145	0.160	0.180	0.201	0.210	0.246	0.234	0.252
IVa & IVb	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
	2007	0.149	0.155	0.165	0.196	0.192	0.227	0.238	0.257
IVc & VIId	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
	2007	0.129	0.131	0.154	0.158	0.173	0.196	0.209	0.218
Total North Sea Catch	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
	2007	0.149	0.152	0.164	0.194	0.190	0.224	0.235	0.252

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 2007 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%	1	0	0	0	n
total		**1**	**0**	**0%**	**1**	**0**	**0**	**0**	**n**
Denmark (A)	1	3	1	95%	22707	8	214	995	n
	2	3	1	89%	4384	2	26	280	n
	3	3	2	99%	27895	29	416	2985	y
	4	4	2	95%	22614	13	284	1706	n
total		**13**	**6**	**96%**	**77600**	**52**	**940**	**5966**	**n**
Denmark (B)	1	3	0	0%	29	0	0	0	n
	2	2	0	0%	128	0	0	0	n
	3	1	1	100%	1385	4	66	70	y
	4	3	2	100%	5555	13	82	259	y
total		**9**	**3**	**97%**	**7097**	**17**	**148**	**329**	**y**
England	1	1	0	0%	37	0	0	0	n
and Wales*	2	3	1	100%	3210	7	175	1079	y
	3	3	1	100%	7507	9	225	1065	y
	4	4	0	0%	5239	0	0	0	n
total		**11**	**2**	**100%**	**15992**	**16**	**400**	**2144**	**y**
Faroe	1	2	0	0%	676	0	0	0	n
Island	2	1	0	0%	170	0	0	0	n
	4	3	0	0%	2045	0	0	0	n
total		**6**	**0**	**0%**	**2891**	**0**	**0**	**0**	**n**
France	1	4	0	0%	638	0	0	0	n
	2	4	0	0%	1623	0	0	0	n
	3	4	0	0%	13277	0	0	0	n
	4	3	0	0%	9368	0	0	0	n
total		**15**	**0**	**0%**	**24906**	**0**	**0**	**0**	**n**
Germany	2	1	0	0%	1600	0	0	0	n
	3	2	1	79%	4010	28	1201	13379	y
	4	3	1	83%	9282	2	269	932	n
total		**6**	**2**	**73%**	**14892**	**30**	**1470**	**14311**	**y**
Netherlands	1	3	3	100%	3266	8	200	1564	y
	2	3	2	100%	12038	89	2225	13218	y
	3	5	2	100%	39399	33	825	3803	n
	4	3	1	67%	11687	1	25	129	n
total		**14**	**8**	**100%**	**66391**	**131**	**3275**	**18714**	**y**
Northern	3	1	0	0%	618	0	0	0	n
Ireland	4	1	0	0%	20	0	0	0	n
total		**2**	**0**	**0%**	**638**	**0**	**0**	**0**	**n**
Norway	1	3	0	0%	2388	0	0	0	n
	2	3	3	100%	59465	15	682	1326	n
	3	3	1	47%	17675	5	244	490	n
	4	3	2	91%	20522	9	382	795	n
total		**12**	**6**	**86%**	**100050**	**29**	**1308**	**2611**	**n**
Scotland	1	1	0	0%	943	0	0	0	n
	2	1	1	100%	3992	17	904	3661	y
	3	2	2	100%	29778	43	1897	6903	y
	4	1	0	0%	494	0	0	0	n
total		**5**	**3**	**96%**	**35208**	**60**	**2801**	**10564**	**y**
Sweden	2	3	0	0%	4548	0	0	0	n
	3	2	0	0%	6460	0	0	0	n
	4	1	0	0%	4440	0	0	0	n
total		**6**	**0**	**0%**	**15448**	**0**	**0**	**0**	**n**
grand total		**100**	**30**	**86%**	**361114**	**335**	**10342**	**54639**	**n**
Period total	**1**	20	4	85%	30684	16	414	2559	n
Period total	**2**	24	8	95%	91158	130	4012	19564	y
Period total	**3**	26	10	91%	148005	151	4874	28695	y
Period total	**4**	30	8	67%	91266	38	1042	3821	n
Total for stock 2007		**100**	**30**	**86%**	**361114**	**335**	**10342**	**54639**	**n**
Human Cons. only		91	27	85%	354017	318	10194	54310	n
Total for stock 2005		102	39	95%	568312	438	15499	89011	n
Total for stock 2006		107	39	79%	490362	404	23581	65536	n
Human Cons. only 2006		96	33	79%	478461	375	22823	64727	n

* majority of catches landed to Ijmuiden, the Netherlands

Table 2.3.1.1: Vessels, areas and cruise dates during the 2007 herring acoustic surveys.

VESSEL	PERIOD	AREA	RECTANGLES
FV Prowess (SCO)	30 June – 19 July	56°- 60°30′ N, 3° - 10° W	41E0-E3, 42E0-E3, 43E0-E3, 44E0-E3, 45E0-E4, 46E2-E5, 47E2-E5, 48E4-E5, 49E5
Johan Hjort (NOR)	21 June – 19 July	56°30′ N - 62° N, 2°-6°E	42F2-F5, 43F2-F5, 44F2-F5, 45F2-F5, 46F2- F5, 47F2-F5, 48F2-F4, 49F2-F4, 50F2-F4, 51F2-F4, 52F2-F4, plus overlap area A
Scotia (SCO)	29 June – 18 July	57° - 62° N, 2/4°W - 2°E	43E8-F1, 44E6-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	36F0-F3, 38F2-F7, 40E8-F5, 41E7-F5, 42E7- F1, 45E6-F1
Solea (GER)	28 June – 17 July	52° - 56°30′ N, Eng to Den/Ger coasts	33F1-F4, 34F2-F4, 35F2-F4, 36F4-F7, 37E9- F8, 38E8-F1, 39E8-F7, 40F6-F7
Dana (DEN)	28 June – 10 July	Kattegat north of 56° + Skagerrak and North Sea north of 56°30′ N, east of 6° E	41F6-F7, 41G1-G2, 42F6-F7, 42G0-G3, 43F6-G1, 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 2007, with mean weights and mean lengths by age ring.

AGE (RING)	NUMBERS	BIOMASS	MATURITY	WEIGHT(G)	LENGTH (CM)
0	**28907**	**180**	**0.00**	**6.2**	**9.5**
1	**6261**	**412**	**0.01**	**65.9**	**20.2**
2	**2750**	**339**	**0.71**	**123.2**	**24.0**
3	**1848**	**286**	**0.92**	**154.8**	**25.7**
4	**898**	**153**	**0.93**	**170.5**	**26.6**
5	**806**	**164**	**0.99**	**203.5**	**27.9**
6	**1323**	**262**	**0.99**	**198.4**	**27.7**
7	**243**	**53**	**0.99**	**217.8**	**28.4**
8	**152**	**38**	**1.00**	**246.8**	**29.5**
9+	**65**	**15**	**1.00**	**233.1**	**28.8**
Immature	**36157**	**698**		**19.3**	**11.7**
Mature	**7096**	**1203**		**169.6**	**26.3**
Total	**43254**	**1902**		**44.0**	**14.1**

Table 2.3.1.3: Estimates of North Sea autumn spawners (millions) at age from acoustic surveys, 1984-2007. 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 2007 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	2007
1	6,198	9,416	4,449	5,087	24,735	6,837	23,055	9,829	5,183	3,113	6,823	6,261
2	4,557	6,363	5,747	3,078	2,922	12,290	4,875	18,949	3,415	1,890	3,772	2,750
3	2,824	3,287	2,520	4,725	2,156	3,083	8,220	3,081	9,191	3,436	1,997	1,848
4	1,087	1,696	1,625	1,116	3,139	1,462	1,390	4,189	2,167	5,609	2,098	898
5	311	692	982	506	1,006	1,676	795	675	2,590	1,211	4,175	806
6	99	259	445	314	483	450	1,031	495	317	1,172	618	1,323
7	83	79	170	139	266	170	244	568	328	140	562	243
8	133	78	45	54	120	98	121	146	342	127	84	152
9+	206	158	121	87	97	59	150	178	186	107	70	65
Total	18,786	22,028	16,104	15,107	34,928	26,124	39,881	38,110	23,722	16,805	20,199	14,346
SSB ('000t)	1,446	1,780	1,792	1,534	1,833	2,622	2,948	2,999	2,584	1,868	2,130	1,203

Table 2.3.2.1: North Sea autumn spawners. Fortnightly time periods sampled and survey effort in 2007/2008.

NL – Netherlands, FRG – Federal Republic of Germany

Area	Time period	Samples available	Vessel days	Nation	Coverage
Orkney/Shetland	01-15 Sep.	None			
	16-30 Sep.	45	4	GER	Partly
Buchan	01-15 Sep.	None			
	16-30 Sep.	77/30	7/3	GER/NL	Total
Central North	01-15 Sep.	None			
Sea	16-30 Sep.	116	7	NL	Total
	01-15 Oct.	None			
Southern North	16-31 Dec.	77	4	NL	Total
Sea	01-15 Jan.	86	5	GER	Partly
	16-31 Jan.	64	4	NL	Partly

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
2007/08	495	34

Table 2.3.2.3: North Sea autumn spawners. Estimated abundances of herring larvae <10 mm long (<11 mm for the SNS), by standard sampling area and time periods. The number of larvae are expressed as mean number per ICES rectangle * 10^9

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

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
2008	253	155	255	200

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

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

Table 2.3.3.3 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 m² x 10⁹	83	34	86	102	37	93	31	31	
Year class									no. in 10⁹
1976	0.054	0.014	0.122	0.005	0.008	0.002	0.002	0.016	17.1
1977	0.024	0.024	0.05	0.015	0.056	0.013	0.006	0.034	13.1
1978	0.176	0.031	0.061	0.02	0.01	0.005	0.074	0	52.1
1979	0.061	0.195	0.262	0.408	0.226	0.143	0.099	0.053	101.1
1980	0.052	0.001	0.145	0.115	0.089	0.339	0.248	0.187	76.7
1981	0.197	0	0.289	0.199	0.215	0.645	0.109	0.036	133.9
1982	0.025	0.011	0.068	0.248	0.29	0.309	0.47	0.14	91.8
1983	0.019	0.007	0.114	0.268	0.271	0.473	0.339	0.377	115
1984	0.083	0.019	0.303	0.259	0.996	0.718	0.277	0.298	181.3
1985	0.116	0.057	0.421	0.344	0.464	0.777	0.085	0.084	177.4
1986	0.317	0.029	0.73	0.557	0.83	0.933	0.048	0.244	270.9
1987	0.078	0.031	0.417	0.314	0.159	0.618	0.483	0.495	168.9
1988	0.036	0.02	0.095	0.096	0.151	0.411	0.181	0.016	71.4
1989	0.083	0.03	0.04	0.094	0.013	0.035	0.041	0	25.9
1990	0.075	0.053	0.202	0.158	0.121	0.198	0.086	0.196	69.9
1991	0.255	0.39	0.431	0.539	0.5	0.369	0.298	0.395	200.7
1992	0.168	0.039	0.672	0.444	0.734	0.268	0.345	0.285	190.1
1993	0.358	0.212	0.26	0.187	0.12	0.119	0.223	0.028	101.7
1994	0.148	0.024	0.417	0.381	0.332	0.148	0.252	0.169	126.9
1995	0.26	0.086	0.699	0.092	0.266	0.018	0.001	0.02	106.2
1996	0.003	0.004	0.935	0.135	0.436	0.379	0.039	0.032	148.1
1997	0.042	0.021	0.338	0.064	0.178	0.035	0.023	0.083	53.1
1998	0.1	0.056	1.15	0.592	0.998	0.265	0.28	0.127	244.0
1999	0.045	0.011	0.799	0.2	0.514	0.22	0.107	0.026	137.1
2000	0.284	0.011	1.052	0.197	1.156	0.376	0.063	0.006	214.8
2001	0.08	0.019	0.566	0.473	0.567	0.247	0.209	0.226	161.8
2002	0.141	0.04	0.287	0.028	0.121	0.045	0.003	0.157	54.4
2003	0.045	0.005	0.284	0.074	0.106	0.021	0.022	0.154	47.3
2004	0.017	0.010	0.189	0.089	0.268	0.187	0.027	0.198	61.3
2005	0.013	0.018	0.327	0.081	0.633	0.184	0.007	0.131	83.1
2006	0.004	0.001	0.240	0.025	0.098	0.018	0.040	0.228	37.2
2007	0.013	0.009	0.184	0.029	0.067	0.047	0.018	0.007	**27.8**

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

YEAR/RINGS	1		2		3		4		5		6		7		8		9+	
	AS	3Q	AS	3Q	AS	3Q	AS	3Q	AS	3Q	AS	3Qh	AS	3Q	AS	3Q	AS	3Q
1996	45	75	119	135	196	186	253	224	262	229	299	253	306	292	325	300	335	302
1997	45	43	120	129	168	175	233	220	256	247	245	255	265	278	269	295	329	295
1998	52	54	109	131	198	172	238	209	275	237	307	263	289	269	308	313	363	298
1999	52	62	118	128	171	163	207	193	236	228	267	252	272	263	230	275	260	306
2000	46	54	118	123	180	172	218	201	232	228	261	241	295	266	300	286	280	271
2001	50	69	127	136	162	167	204	199	228	218	237	237	255	262	286	288	294	298
2002	45	50	138	140	172	177	194	200	224	224	247	244	261	252	280	281	249	298
2003	46	65	104	119	185	177	209	198	214	210	243	236	281	247	290	272	307	282
2004	35	45	116	125	139	159	206	203	231	234	253	250	262	264	279	262	270	299
2005	43	53	135	124	171	177	181	201	229	234	248	249	253	261	274	287	295	270
2006	45	61	127	139	158	163	188	192	188	205	225	242	243	257	244	260	265	285
2007	66	75	123	153	155	171	171	183	204	215	198	211	218	252	247	263	233	273

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

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

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	1972-2007	1973-2007
IBTS 1st Quarter (Trawl survey)	1-5wr	1971-2008	1984-2008
Acoustic (+trawl)	1wr	1995-2007	1997-2007
	2-9+wr	1984-2007	1989-2007
MIK net	0wr	1977-2008	1992-2008

Table 2.6.2.1 FLICA CONFIGURATION SETTINGS

```
sep.2       : NA
sep.gradual : TRUE
sr          : TRUE
sr.age      : 0
lambda.age  : 0.1 0.1 3.67 2.87 2.23 1.74 1.37 1.04 0.94 0
lambda.yr   : 1 1 1 1 1
lambda.sr   : 0.1
index.model : power linear linear linear
index.cor   : -9.25596313493178e+61 0 0 0
sep.nyr     : 5
sep.age     : 4
sep.sel     : 1
```

Table 2.6.2.2 STOCK OBJECT CONFIGURATION

```
      min       max plusgroup   minyear   maxyear
        0         9         9      1960      2008
```

Table 2.6.2.3 INDEX OBJECTS CONFIGURATION

```
MLAI
"SSB:" "MLAI1:" "MLAI" "<" "10" "mm"
      min       max plusgroup   minyear   maxyear    startf      endf
       NA        NA        NA      1973      2007        NA        NA

MIK 0-wr
"Herring in Sub-area IV, Divisions VIId & IIIa (autumn-spawners) . Imported
from VPA file."
      min       max plusgroup   minyear   maxyear    startf      endf
     0.00      0.00        NA   1992.00   2008.00      0.08      0.17

IBTS1: 1-5+ wr
"Herring in Sub-area IV, Divisions VIId & IIIa (autumn-spawners) . Imported
from VPA file."
      min       max plusgroup   minyear   maxyear    startf      endf
     1.00      5.00      5.00   1984.00   2008.00      0.08      0.17

Acoustic survey 1-9+ wr
"Herring in Sub-area IV, Divisions VIId & IIIa (autumn-spawners) . Imported
from VPA file."
      min       max plusgroup   minyear   maxyear    startf      endf
     1.00      9.00      9.00   1989.00   2007.00      0.54      0.56
```

Table 2.6.2.4 CATCH IN NUMBER

Units : thousands

year

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

year

age	1968	1969	1970	1971	1972	1973	1974	1975	1976
0	839300	112000	898100	684000	750400	289400	996100	263800	238200
1	2425000	2503300	1196200	4378500	3340600	2368000	846100	2460500	126600
2	1795200	1883000	2002800	1146800	1440500	1344200	772600	541700	901500
3	1494300	296300	883600	662500	343800	659200	362000	259600	117300
4	621400	133100	125200	208300	130600	150200	126000	140500	52000
5	157100	190800	50300	26900	32900	59300	56100	57200	34500
6	145000	49900	61000	30500	5000	30600	22300	16100	6100
7	163400	42700	7900	26800	200	3700	5000	9100	4400
8	13700	27400	12000	100	1100	1400	2000	3400	1000
9	91800	25100	12200	12400	400	600	1100	1400	400

year

age	1977	1978	1979	1980	1981	1982	1983	1984	1985
0	256800	130000	542000	1262700	9519700	11956700	13296900	6973300	4211000
1	144300	168600	159200	245100	872000	1116400	2448600	1818400	3253000
2	44700	4900	34100	134000	284300	299400	573800	1146200	1326300
3	186400	5700	10000	91800	56900	230100	216400	441400	1182400
4	10800	5000	10100	32200	39500	33700	105100	201500	368500
5	7000	300	2100	21700	28500	14400	26200	81100	124500
6	4100	200	200	2300	22700	6800	22800	22600	43600
7	1500	200	800	1400	18700	7800	12800	25200	20200
8	700	200	600	400	5500	3600	11000	11100	13100
9	0	300	100	100	1100	1100	12100	18600	16100

year

age	1986	1987	1988	1989	1990	1991	1992	1993
0	3724700	8229200	3164800	3057800	1302800	2386600	10331300	10265400
1	4801400	6836300	7867000	3145900	3020000	2138900	2303100	3826800
2	1266700	2137200	2232500	1593700	899300	1132800	1284900	1176300
3	840800	667900	1090700	1363800	779100	556700	442700	609000
4	465900	467100	383700	809300	861000	548900	361500	305500
5	129800	245800	255800	211800	387500	501200	360500	215600
6	62100	74700	128100	123700	80200	205300	375600	226000
7	20500	23800	38000	61000	54400	39300	152400	188000
8	13600	8000	15300	19500	28800	25600	39200	87300
9	14800	8200	8500	8700	11900	13000	23300	41700

year

age	1994	1995	1996	1997	1998	1999	2000	2001	2002
0	4498900	7438469	2311226	431175	259526	1566349	1105085	1832691	730279
1	1785200	1664874	1606393	479702	977680	303520	1171677	614469	837557
2	1783200	1444061	642084	687920	1220105	616354	622853	842635	579592
3	489100	816703	525601	446909	537932	1058716	463170	485628	970577
4	347600	231794	172099	284920	276333	294066	646814	278884	292205
5	109000	118536	57586	109178	175817	135648	213466	321743	140701
6	91800	55128	22534	31389	88927	69299	82481	90918	174570
7	76400	41409	9264	11832	15232	27998	35706	38252	48908
8	70000	68955	17195	18770	16766	10174	14624	17910	34620
9	46600	29245	3948	5697	3784	2054	2463	2692	8702

year

age	2003	2004	2005	2006	2007	2008
0	369074	715597	1015554	878637	621005	NA
1	617021	206648	715547	222111	235553	NA
2	1221992	447918	355453	401087	219115	NA
3	529386	1366155	485746	310602	417452	NA
4	835552	543376	1318647	464620	285746	NA
5	244780	753231	479961	997782	309454	NA
6	107751	169324	576154	252150	629187	NA
7	123291	104945	115212	247042	147830	NA
8	37671	65341	88311	63035	133388	NA
9	9044	31801	58497	43377	23362	NA

Table 2.6.2.5 WEIGHTS AT AGE IN THE CATCH

Units : kg

age	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
0	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015
1	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
2	0.126	0.126	0.126	0.126	0.126	0.126	0.126	0.126	0.126	0.126	0.126
3	0.176	0.176	0.176	0.176	0.176	0.176	0.176	0.176	0.176	0.176	0.176
4	0.211	0.211	0.211	0.211	0.211	0.211	0.211	0.211	0.211	0.211	0.211
5	0.243	0.243	0.243	0.243	0.243	0.243	0.243	0.243	0.243	0.243	0.243
6	0.251	0.251	0.251	0.251	0.251	0.251	0.251	0.251	0.251	0.251	0.251
7	0.267	0.267	0.267	0.267	0.267	0.267	0.267	0.267	0.267	0.267	0.267
8	0.271	0.271	0.271	0.271	0.271	0.271	0.271	0.271	0.271	0.271	0.271
9	0.271	0.271	0.271	0.271	0.271	0.271	0.271	0.271	0.271	0.271	0.271

age	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
0	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.007
1	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.049
2	0.126	0.126	0.126	0.126	0.126	0.126	0.126	0.126	0.126	0.126	0.118
3	0.176	0.176	0.176	0.176	0.176	0.176	0.176	0.176	0.176	0.176	0.142
4	0.211	0.211	0.211	0.211	0.211	0.211	0.211	0.211	0.211	0.211	0.189
5	0.243	0.243	0.243	0.243	0.243	0.243	0.243	0.243	0.243	0.243	0.211
6	0.251	0.251	0.251	0.251	0.251	0.251	0.251	0.251	0.251	0.251	0.222
7	0.267	0.267	0.267	0.267	0.267	0.267	0.267	0.267	0.267	0.267	0.267
8	0.271	0.271	0.271	0.271	0.271	0.271	0.271	0.271	0.271	0.271	0.271
9	0.271	0.271	0.271	0.271	0.271	0.271	0.271	0.271	0.271	0.271	0.271

age	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
0	0.010	0.010	0.010	0.009	0.006	0.011	0.011	0.017	0.019	0.017	0.010
1	0.059	0.059	0.059	0.036	0.067	0.035	0.055	0.043	0.055	0.058	0.053
2	0.118	0.118	0.118	0.128	0.121	0.099	0.111	0.115	0.114	0.130	0.102
3	0.149	0.149	0.149	0.164	0.153	0.150	0.145	0.153	0.149	0.166	0.175
4	0.179	0.179	0.179	0.194	0.182	0.180	0.174	0.173	0.177	0.184	0.189
5	0.217	0.217	0.217	0.211	0.208	0.211	0.197	0.208	0.193	0.203	0.207
6	0.238	0.238	0.238	0.220	0.221	0.234	0.216	0.231	0.229	0.217	0.223
7	0.265	0.265	0.265	0.258	0.238	0.258	0.237	0.247	0.236	0.235	0.237
8	0.274	0.274	0.274	0.270	0.252	0.277	0.253	0.265	0.250	0.259	0.249
9	0.275	0.275	0.275	0.292	0.262	0.299	0.263	0.259	0.287	0.271	0.287

age	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
0	0.010	0.006	0.009	0.015	0.015	0.021	0.009	0.015	0.012	0.012	0.014
1	0.033	0.056	0.042	0.018	0.044	0.051	0.045	0.033	0.048	0.037	0.037
2	0.115	0.130	0.130	0.112	0.108	0.114	0.115	0.113	0.118	0.118	0.104
3	0.145	0.159	0.169	0.156	0.148	0.145	0.151	0.157	0.149	0.153	0.158
4	0.189	0.181	0.198	0.188	0.195	0.183	0.171	0.179	0.177	0.170	0.174
5	0.204	0.214	0.207	0.204	0.227	0.219	0.207	0.201	0.198	0.199	0.184
6	0.228	0.240	0.243	0.212	0.226	0.238	0.233	0.216	0.213	0.214	0.205
7	0.244	0.255	0.247	0.261	0.235	0.247	0.245	0.246	0.238	0.228	0.222
8	0.256	0.273	0.283	0.280	0.244	0.289	0.261	0.275	0.267	0.250	0.232
9	0.310	0.281	0.276	0.288	0.291	0.283	0.301	0.262	0.288	0.252	0.256

age	2004	2005	2006	2007	2008
0	0.014	0.011	0.010	0.0124	NA
1	0.036	0.044	0.049	0.0638	NA
2	0.100	0.099	0.117	0.1214	NA
3	0.138	0.153	0.144	0.1513	NA
4	0.183	0.166	0.172	0.1634	NA
5	0.201	0.208	0.181	0.1933	NA
6	0.216	0.223	0.220	0.1900	NA
7	0.228	0.240	0.237	0.2232	NA
8	0.246	0.257	0.235	0.2349	NA
9	0.272	0.278	0.262	0.2523	NA

Table 2.6.2.6 WEIGHTS AT AGE IN THE STOCK

Units : kg

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

age \ year	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
0	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015
1	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
2	0.155	0.155	0.155	0.155	0.155	0.155	0.155	0.155	0.155	0.155	0.155
3	0.187	0.187	0.187	0.187	0.187	0.187	0.187	0.187	0.187	0.187	0.187
4	0.223	0.223	0.223	0.223	0.223	0.223	0.223	0.223	0.223	0.223	0.223
5	0.239	0.239	0.239	0.239	0.239	0.239	0.239	0.239	0.239	0.239	0.239
6	0.276	0.276	0.276	0.276	0.276	0.276	0.276	0.276	0.276	0.276	0.276
7	0.299	0.299	0.299	0.299	0.299	0.299	0.299	0.299	0.299	0.299	0.299
8	0.306	0.306	0.306	0.306	0.306	0.306	0.306	0.306	0.306	0.306	0.306
9	0.312	0.312	0.312	0.312	0.312	0.312	0.312	0.312	0.312	0.312	0.312

age \ year	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
0	0.015	0.017	0.016	0.014	0.009	0.008	0.009	0.012	0.011	0.010	0.006
1	0.050	0.057	0.056	0.061	0.050	0.048	0.044	0.052	0.059	0.064	0.061
2	0.155	0.150	0.138	0.130	0.122	0.123	0.122	0.126	0.139	0.137	0.134
3	0.187	0.190	0.187	0.183	0.170	0.166	0.165	0.174	0.184	0.194	0.184
4	0.223	0.230	0.232	0.232	0.212	0.208	0.205	0.212	0.212	0.214	0.213
5	0.239	0.243	0.247	0.252	0.230	0.229	0.228	0.244	0.239	0.234	0.234
6	0.276	0.282	0.275	0.273	0.242	0.248	0.252	0.271	0.265	0.253	0.262
7	0.299	0.311	0.321	0.315	0.275	0.259	0.261	0.284	0.280	0.272	0.273
8	0.306	0.338	0.341	0.331	0.268	0.263	0.277	0.298	0.300	0.291	0.302
9	0.312	0.347	0.365	0.392	0.343	0.325	0.315	0.331	0.328	0.312	0.320

age \ year	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
0	0.007	0.006	0.006	0.005	0.006	0.006	0.006	0.006	0.006	0.007	0.007
1	0.060	0.057	0.054	0.049	0.047	0.051	0.051	0.051	0.047	0.047	0.042
2	0.126	0.129	0.130	0.123	0.116	0.116	0.116	0.122	0.128	0.123	0.119
3	0.192	0.186	0.199	0.183	0.187	0.179	0.184	0.172	0.172	0.173	0.165
4	0.214	0.211	0.227	0.230	0.241	0.226	0.221	0.210	0.205	0.202	0.203
5	0.240	0.224	0.234	0.237	0.264	0.256	0.248	0.233	0.228	0.222	0.223
6	0.275	0.268	0.274	0.257	0.284	0.273	0.279	0.255	0.248	0.242	0.248
7	0.291	0.293	0.301	0.280	0.287	0.276	0.286	0.275	0.270	0.266	0.268
8	0.309	0.318	0.323	0.303	0.301	0.270	0.281	0.274	0.289	0.285	0.283
9	0.337	0.345	0.343	0.334	0.342	0.318	0.303	0.280	0.275	0.283	0.275

age \ year	2004	2005	2006	2007	2008
0	0.006	0.007	0.006	0.008	NA
1	0.041	0.041	0.051	0.055	NA
2	0.118	0.126	0.128	0.125	NA
3	0.164	0.155	0.161	0.156	NA
4	0.198	0.191	0.180	0.180	NA
5	0.225	0.216	0.207	0.196	NA
6	0.248	0.242	0.224	0.212	NA
7	0.265	0.252	0.238	0.230	NA
8	0.281	0.266	0.255	0.245	NA
9	0.291	0.277	0.264	0.249	NA

Table 2.6.2.7 NATURAL MORTALITY

Units : NA

year

age	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973
0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
4	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
5	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
6	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
7	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
8	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
9	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1

year

age	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
4	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
5	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
6	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
7	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
8	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
9	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1

year

age	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
4	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
5	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
6	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
7	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
8	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
9	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1

year

age	2002	2003	2004	2005	2006	2007	2008
0	1.0	1.0	1.0	1.0	1.0	1.0	NA
1	1.0	1.0	1.0	1.0	1.0	1.0	NA
2	0.3	0.3	0.3	0.3	0.3	0.3	NA
3	0.2	0.2	0.2	0.2	0.2	0.2	NA
4	0.1	0.1	0.1	0.1	0.1	0.1	NA
5	0.1	0.1	0.1	0.1	0.1	0.1	NA
6	0.1	0.1	0.1	0.1	0.1	0.1	NA
7	0.1	0.1	0.1	0.1	0.1	0.1	NA
8	0.1	0.1	0.1	0.1	0.1	0.1	NA
9	0.1	0.1	0.1	0.1	0.1	0.1	NA

Table 2.6.2.8 PROPORTION MATURE

Units : NA

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

age	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	0.0
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	0.0
2	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.7	0.75	0.8
3	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.0	1.00	1.0
4	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.0	1.00	1.0
5	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.0	1.00	1.0
6	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.0	1.00	1.0
7	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.0	1.00	1.0
8	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.0	1.00	1.0
9	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.0	1.00	1.0

age	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.85	0.82	0.91	0.86	0.50	0.47	0.73	0.67	0.61	0.64	0.64	0.69	0.67	0.77
3	0.93	0.94	0.97	0.99	0.99	0.61	0.93	0.95	0.98	0.94	0.89	0.91	0.96	0.92
4	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
5	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
6	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
7	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
8	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
9	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

age	2002	2003	2004	2005	2006	2007	2008
0	0.00	0.00	0.00	0.00	0.00	0.00	NA
1	0.00	0.00	0.00	0.00	0.00	0.00	NA
2	0.87	0.43	0.70	0.76	0.66	0.71	NA
3	0.97	0.93	0.65	0.96	0.88	0.92	NA
4	1.00	1.00	1.00	0.96	0.98	0.93	NA
5	1.00	1.00	1.00	1.00	1.00	1.00	NA
6	1.00	1.00	1.00	1.00	1.00	1.00	NA
7	1.00	1.00	1.00	1.00	1.00	1.00	NA
8	1.00	1.00	1.00	1.00	1.00	1.00	NA
9	1.00	1.00	1.00	1.00	1.00	1.00	NA

Table 2.6.2.9 SURVEY INDICES

MLAI - Index Value

Units : NA

age \ year	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
all	13.2	7.94	2.82	2.49	6.15	7.43	14.4	9.77	14.3	20.9	26.8	48.4	73.8

age \ year	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
all	38.4	67.7	134	132	172	90.3	42.1	30.1	20.8	22.4	44	56.5	72.9

age \ year	1999	2000	2001	2002	2003	2004	2005	2006	2007
all	60.5	40.4	130	110	268	322	192	118	173

MLAI - Index Variance (Inverse Weights)

Units : NA

age \ year	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
all	1.67	1.67	1.67	1.67	1.67	1.67	1.67	1.67	1.67	1.67	1.67	1.67	1.67

age \ year	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
all	1.67	1.67	1.67	1.67	1.67	1.67	1.67	1.67	1.67	1.67	1.67	1.67	1.67

age \ year	1999	2000	2001	2002	2003	2004	2005	2006	2007
all	1.67	1.67	1.67	1.67	1.67	1.67	1.67	1.67	1.67

MIK 0-wr - Index Value

Units : NA

age \ year	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
0	201	190	102	127	107	148	53.1	244	137	215	162	54.4	47.3	61.3

age \ year	2006	2007	2008
0	83.1	37.2	27.8

MIK 0-wr - Index Variance (Inverse Weights)

Units : NA

age \ year	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
0	1.59	1.59	1.59	1.59	1.59	1.59	1.59	1.59	1.59	1.59	1.59	1.59	1.59	1.59

age \ year	2006	2007	2008
0	1.59	1.59	1.59

IBTS1: 1-5+ wr - Index Value

Units : NA

age \ year	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
1	1515.6	2097.3	2662.8	3693.0	4394.2	2331.57	1061.6	1287	1268.1	2794.0
2	161.5	721.6	782.1	917.5	4163.4	875.34	462.1	693	436.6	787.4
3	61.4	282.0	276.0	116.3	791.5	338.51	279.8	259	193.1	222.6
4	26.9	42.1	79.0	59.4	58.0	89.38	269.1	222	54.8	45.0
5	10.2	27.9	28.1	48.8	25.1	8.52	71.3	146	92.3	65.5

age \ year	1994	1995	1996	1997	1998	1999	2000	2001	2002
1	1752.1	1345.75	1890.87	4404.6	2275.8	752.9	3725.13	2499.4	4064.8
2	1167.2	1392.86	197.52	506.5	791.6	450.6	199.37	1129.3	658.2
3	213.1	278.54	32.88	162.7	95.7	501.3	154.69	317.1	338.2
4	69.0	36.67	10.19	30.5	20.8	98.2	58.84	93.9	25.0
5	42.5	6.55	8.08	19.9	17.8	35.6	8.95	68.3	19.9

age \ year	2003	2004	2005	2006	2007	2008
1	2765.1	979	1002	911	1321.01	1901
2	1556.1	437	214	1481	50.00	253
3	611.9	766	356	335	18.25	155
4	360.0	112	389	241	7.94	255
5	53.2	171	131	328	41.28	200

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

Units : NA

age	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
1	2.13	2.13	2.13	2.13	2.13	2.13	2.13	2.13	2.13	2.13
2	3.57	3.57	3.57	3.57	3.57	3.57	3.57	3.57	3.57	3.57
3	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
4	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
5	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

age	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
1	2.13	2.13	2.13	2.13	2.13	2.13	2.13	2.13	2.13	2.13
2	3.57	3.57	3.57	3.57	3.57	3.57	3.57	3.57	3.57	3.57
3	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
4	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
5	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

age	2004	2005	2006	2007	2008
1	2.13	2.13	2.13	2.13	2.13
2	3.57	3.57	3.57	3.57	3.57
3	100.00	100.00	100.00	100.00	100.00
4	100.00	100.00	100.00	100.00	100.00
5	100.00	100.00	100.00	100.00	100.00

Acoustic survey 1-9+ wr - Index Value

Units : NA

age	1989	1990	1991	1992	1993	1994	1995	1996
1	-1	-1	-1	-1	-1	-1	-1	-1
2	4090000	3306000	2634000	3734000	2984000	3185000	3849000	4497000
3	3903000	3521000	1700000	1378000	1637000	839000	2041000	2824000
4	1633000	3414000	1959000	1147000	902000	399000	672000	1087000
5	492000	1366000	1849000	1134000	741000	381000	299000	311000
6	283000	392000	644000	1246000	777000	321000	203000	99000
7	120000	210000	228000	395000	551000	326000	138000	83000
8	44000	133000	94000	114000	180000	219000	119000	133000
9	22000	43000	51000	104000	116000	131000	93000	206000

age	1997	1998	1999	2000	2001	2002	2003	2004
1	9361000	4449000	5087000	24736000	6837000	23055000	9829400	5183700
2	5960000	5747000	3078000	2923000	12290000	4875000	18949400	3415900
3	2935000	2520000	4725000	2156000	3083000	8220000	3081000	9191800
4	1441000	1625000	1116000	3140000	1462000	1390000	4188900	2167300
5	601000	982000	506000	1007000	1676000	794600	675100	2590700
6	215000	445000	314000	483000	450000	1031000	494800	317100
7	46000	170000	139000	266000	170000	244400	568300	327600
8	78000	45000	54000	120000	98000	121000	145500	342050
9	159000	121000	87000	97000	59000	149500	177700	185600

age	2005	2006	2007
1	3114100	6822800	6261000
2	2055100	3772300	2750000
3	3648500	1997200	1848000
4	5789600	2097500	898000
5	1212900	4175100	806000
6	1174900	618200	1323000
7	139900	562100	243000
8	126500	84300	152000
9	106700	70400	65000

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

Units : NA

age	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
1	1.59	1.59	1.59	1.59	1.59	1.59	1.59	1.59	1.59	1.59	1.59
2	1.61	1.61	1.61	1.61	1.61	1.61	1.61	1.61	1.61	1.61	1.61
3	5.88	5.88	5.88	5.88	5.88	5.88	5.88	5.88	5.88	5.88	5.88
4	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
5	11.11	11.11	11.11	11.11	11.11	11.11	11.11	11.11	11.11	11.11	11.11
6	12.50	12.50	12.50	12.50	12.50	12.50	12.50	12.50	12.50	12.50	12.50
7	14.29	14.29	14.29	14.29	14.29	14.29	14.29	14.29	14.29	14.29	14.29
8	14.29	14.29	14.29	14.29	14.29	14.29	14.29	14.29	14.29	14.29	14.29

9	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00

	year							
age	2000	2001	2002	2003	2004	2005	2006	2007
1	1.59	1.59	1.59	1.59	1.59	1.59	1.59	1.59
2	1.61	1.61	1.61	1.61	1.61	1.61	1.61	1.61
3	5.88	5.88	5.88	5.88	5.88	5.88	5.88	5.88
4	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
5	11.11	11.11	11.11	11.11	11.11	11.11	11.11	11.11
6	12.50	12.50	12.50	12.50	12.50	12.50	12.50	12.50
7	14.29	14.29	14.29	14.29	14.29	14.29	14.29	14.29
8	14.29	14.29	14.29	14.29	14.29	14.29	14.29	14.29
9	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00

Table 2.6.2.10 STOCK SUMMARY

Year	Recruitment Age 0 [thousands]	TSB [tonnes]	SSB [tonnes]	Catches	Fbar (Age 0-1)	Fbar (Age 2-6)	Landings SOP
1960	1.21e+07	3714688	1853214	696200	0.1408	0.3398	1.183
1961	1.09e+08	4334760	1634912	696700	0.0740	0.4370	1.135
1962	4.63e+07	4378217	1096255	627800	0.0473	0.5376	1.171
1963	4.77e+07	4604975	2166573	716000	0.0694	0.2280	0.860
1964	6.28e+07	4778295	2013447	871200	0.1605	0.3445	1.066
1965	3.49e+07	4327785	1433137	1168800	0.1266	0.6946	1.150
1966	2.79e+07	3307122	1271486	895500	0.1033	0.6197	1.071
1967	4.03e+07	2816267	921580	695500	0.1618	0.7979	1.176
1968	3.87e+07	2520392	411810	717800	0.1675	1.3359	1.255
1969	2.16e+07	1905213	423982	546700	0.1687	1.1055	0.967
1970	4.11e+07	1921911	374684	563100	0.1516	1.1061	0.966
1971	3.23e+07	1849379	265989	520100	0.3181	1.4094	1.075
1972	2.09e+07	1549393	288246	497500	0.3183	0.6970	0.920
1973	1.01e+07	1155889	233324	484000	0.3601	1.1356	0.958
1974	2.17e+07	911723	161924	275100	0.2635	1.0528	0.968
1975	2.81e+06	679873	81560	312800	0.4235	1.4729	0.934
1976	2.72e+06	358038	77664	174800	0.1993	1.4495	0.953
1977	4.32e+06	209802	47137	46000	0.1982	0.8159	1.198
1978	4.59e+06	224198	64373	11000	0.1232	0.0542	1.215
1979	1.06e+07	381367	106555	25100	0.1254	0.0646	1.006
1980	1.67e+07	629703	130364	70764	0.1196	0.2849	1.094
1981	3.79e+07	1157875	194940	174879	0.3840	0.3534	1.008
1982	6.47e+07	1842235	277794	275079	0.2799	0.2644	0.979
1983	6.18e+07	2717507	431815	387202	0.3259	0.3386	1.077
1984	5.34e+07	2863083	678474	428631	0.2159	0.4558	1.054
1985	8.09e+07	3460052	698364	613780	0.2343	0.6445	1.042
1986	9.76e+07	3469993	678170	671488	0.1890	0.5731	1.137
1987	8.62e+07	3932969	898839	792058	0.2671	0.5536	1.017
1988	4.23e+07	3617108	1191784	887686	0.3527	0.5389	1.164
1989	3.91e+07	3305285	1246228	787899	0.2808	0.5483	1.034
1990	3.59e+07	2971149	1180937	645229	0.2560	0.4440	1.052
1991	3.36e+07	2709596	975990	658008	0.2131	0.4918	1.020
1992	6.21e+07	2431328	699157	716799	0.3421	0.5851	0.995
1993	5.02e+07	2512706	468597	671397	0.3993	0.6944	1.023
1994	3.44e+07	2018727	505921	568234	0.2365	0.7115	1.050
1995	4.17e+07	1838511	458732	579371	0.3077	0.7431	1.008
1996	4.99e+07	1622365	460013	275098	0.1646	0.4041	0.999
1997	2.80e+07	1942731	558390	264313	0.0350	0.4230	1.001
1998	2.72e+07	2052508	733735	391628	0.0900	0.4881	1.002
1999	6.78e+07	2319160	852645	363163	0.0434	0.3723	1.000
2000	3.99e+07	2842111	854701	388157	0.0622	0.3645	1.000
2001	9.30e+07	3224923	1290083	374065	0.0515	0.2970	0.990
2002	3.11e+07	3952853	1567010	394709	0.0392	0.2484	0.997
2003	1.96e+07	3675106	1700059	482281	0.0515	0.2637	1.015
2004	2.53e+07	3394187	1759662	587698	0.0587	0.3004	0.999
2005	1.63e+07	2919877	1620899	663813	0.0730	0.3733	1.003
2006	2.50e+07	2375848	1251675	514597	0.0677	0.3464	0.995
2007	2.09e+07	2112075	976663	406482	0.0648	0.3315	1.006
2008	9.22e+06	NA	NA	NA	NA	NA	NA

Table 2.6.2.11 ESTIMATED POPULATION ABUNDANCE

Units : thousands

age	1960	1961	1962	1963	1964	1965	1966
0	12084931	1.09e+08	46276439	47657595	62784623	34894548	27857691
1	16416655	4.33e+06	39307428	16941659	17274862	22808286	12745612
2	3684035	4.68e+06	1400454	13220079	5505326	4668403	6560013
3	7662362	1.76e+06	1868113	807739	7273200	2764234	1592762
4	602099	4.51e+06	1010240	816584	501982	3942335	1081062
5	740429	3.88e+05	2698121	596605	588643	313542	1640406
6	434518	5.11e+05	233124	1417370	463291	391315	146490
7	280970	2.86e+05	312606	91108	1064422	329056	210267
8	297500	1.35e+05	200619	145646	61192	720019	186357
9	328499	2.11e+05	201781	176856	134250	136682	461113

age	1967	1968	1969	1970	1971	1972	1973
0	40255632	38698257	21581359	41072900	32307387	20857867	10103030
1	10030704	14434400	13749231	7874201	14588703	11488258	7238545
2	3895987	2739005	3932843	3639605	2215613	2939019	2370465
3	2688291	1892139	538069	1329690	1019201	679023	966448
4	642255	984385	238216	176842	306621	247632	249431
5	552236	230568	305002	89896	42242	81343	100703
6	644036	218445	60737	96113	33857	12870	42462
7	89616	212051	61095	8212	29476	2199	6912
8	128842	17318	38481	15104	120	1702	1800
9	272842	116044	35251	15356	14924	619	771

age	1974	1975	1976	1977	1978	1979	1980	1981
0	21686358	2812384	2719123	4324058	4593004	10599415	16718132	37860480
1	3548909	7401803	883065	863339	1442471	1614297	3586029	5422913
2	1357194	830822	1367778	252675	235638	434127	502471	1177899
3	631793	359331	165432	264765	149073	170366	292438	258374
4	208422	195417	65255	31906	52186	116905	130461	157080
5	84029	69754	44700	10280	18638	42470	96185	87505
6	35173	23202	9528	8061	2712	16579	36433	66445
7	9648	10808	5843	2873	3420	2264	14811	30780
8	2760	4006	1263	1154	1183	2904	1291	12072
9	1518	1650	505	287	1774	484	323	2414

age	1982	1983	1984	1985	1986	1987	1988
0	64741164	61784996	53432433	80878731	97550103	86155223	42252368
1	8599363	17044832	15237519	15672587	27319965	33729957	26968244
2	1499148	2525621	4874330	4564871	3930329	7326966	8548367
3	630784	855526	1382686	2635802	2255824	1837798	3613735
4	160375	310329	506017	736150	1101680	1093941	906365
5	104669	113136	181227	267123	317844	555983	547873
6	52173	81034	77516	87270	123975	164747	270555
7	38617	40750	51707	48715	37760	53490	78418
8	10215	27540	24742	22965	24963	14808	25886
9	3121	30294	41459	28225	27165	15178	14381

age	1989	1990	1991	1992	1993	1994	1995
0	39148538	35859469	33621594	62122960	50221899	34447716	41677349
1	13720618	12641231	12437409	10993067	16984487	12680856	10102254
2	5551457	3279448	2956072	3361470	2745187	4095945	3646703
3	4435306	2759509	1665531	1232259	1403951	1041526	1530844
4	1979952	2407721	1559822	864518	612274	605119	416096
5	457039	1025570	1363106	891458	440154	265287	219493
6	253853	213258	561059	758747	465406	194476	136881
7	123691	112766	117022	313241	331546	207479	89171
8	35034	54264	50608	68652	139371	122547	115384
9	15630	22422	25699	40806	66573	81581	48936

age	1996	1997	1998	1999	2000	2001	2002
0	49881185	27979179	27189043	67808406	39882934	92955975	31112265
1	11114838	17013481	10042537	9851440	24036507	14031325	33132766
2	2770356	3173132	5980772	3133058	3448219	8165080	4806312
3	1481519	1505972	1765020	3391374	1795873	2023503	5328570
4	526014	742019	831904	962409	1826864	1054245	1220243
5	157672	312888	401646	490921	592110	1040359	689462
6	86663	88131	179694	197095	315591	333588	636425
7	71675	57047	50014	78544	112698	207341	215637
8	41528	56056	40390	30817	44551	68136	151304
9	9535	17014	9116	6222	7503	10241	38031

age \ year	2003	2004	2005	2006	2007	2008
0	19612864	25315355	16346727	25023741	20853003	9222947
1	11021868	6912867	8869756	5660016	8702427	7269545
2	11703046	3817527	2374314	2996068	1923691	2967820
3	3065461	7644764	2450386	1471898	1881398	1216613
4	3489162	2054482	4982643	1511081	926452	1197674
5	826951	2339153	1320983	2948748	922117	575017
6	490336	528167	1423231	729922	1688458	538503
7	410341	314479	322884	791067	420245	991205
8	148718	262391	191599	178712	453670	245782
9	36590	115144	177059	139544	77925	329943

Table 2.6.2.12 ESTIMATED FISHING MORTALITY

Units : f

year

age	1960	1961	1962	1963	1964	1965	1966	1967	1968
0	0.0257	0.0186	0.00486	0.0148	0.0126	0.00714	0.0215	0.0256	0.0348
1	0.2559	0.1294	0.08968	0.1241	0.3084	0.24613	0.1852	0.2981	0.3003
2	0.4385	0.6174	0.25031	0.2975	0.3890	0.77535	0.5921	0.4222	1.3274
3	0.3308	0.3553	0.62755	0.2757	0.4124	0.73882	0.7082	0.8046	1.8723
4	0.3407	0.4130	0.42669	0.2273	0.3706	0.77683	0.5717	0.9244	1.0717
5	0.2711	0.4082	0.54375	0.1529	0.3083	0.66098	0.8349	0.8274	1.2340
6	0.3179	0.3912	0.83952	0.1864	0.2421	0.52114	0.3914	1.0109	1.1741
7	0.6312	0.2549	0.66376	0.2980	0.2909	0.46856	0.3898	1.5438	1.6067
8	0.6015	0.5676	0.59749	0.3597	0.5968	0.91196	0.7660	1.0779	1.7152
9	0.6015	0.5676	0.59749	0.3597	0.5968	0.91196	0.7660	1.0779	1.7152

year

age	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978
0	0.00824	0.0351	0.034	0.0583	0.0462	0.075	0.158	0.147	0.0978	0.0456
1	0.32911	0.2681	0.602	0.5782	0.6740	0.452	0.689	0.251	0.2985	0.2008
2	0.78442	0.9729	0.883	0.8122	1.0223	1.029	1.314	1.342	0.2277	0.0243
3	0.91273	1.2671	1.215	0.8015	1.3341	0.973	1.506	1.446	1.4240	0.0431
4	0.87452	1.3318	1.227	0.7998	0.9880	0.995	1.375	1.748	0.4376	0.1060
5	1.05479	0.8765	1.088	0.5501	0.9519	1.187	1.891	1.613	1.2325	0.0171
6	1.90096	1.0820	2.634	0.5217	1.3819	1.080	1.279	1.099	0.7575	0.0806
7	1.29746	4.1229	2.752	0.1004	0.8181	0.779	2.046	1.522	0.7876	0.0634
8	1.34766	1.7344	1.965	1.1182	1.6437	1.398	2.100	1.718	1.0000	0.1953
9	1.34766	1.7344	1.965	1.1182	1.6437	1.398	2.100	1.718	1.0000	0.1953

year

age	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
0	0.0838	0.1259	0.482	0.335	0.400	0.227	0.0853	0.062	0.161	0.125	0.130
1	0.1671	0.1133	0.286	0.225	0.252	0.205	0.3832	0.316	0.373	0.581	0.431
2	0.0951	0.3651	0.325	0.261	0.302	0.315	0.4049	0.460	0.407	0.356	0.399
3	0.0669	0.4215	0.277	0.509	0.325	0.430	0.6724	0.524	0.507	0.402	0.411
4	0.0951	0.2994	0.306	0.249	0.438	0.539	0.7399	0.584	0.591	0.585	0.558
5	0.0533	0.2699	0.417	0.156	0.278	0.631	0.6676	0.557	0.620	0.669	0.662
6	0.0128	0.0686	0.443	0.147	0.349	0.364	0.7378	0.741	0.642	0.683	0.711
7	0.4619	0.1045	1.003	0.238	0.399	0.712	0.5686	0.836	0.626	0.706	0.724
8	0.2442	0.3924	0.647	0.460	0.541	0.633	0.9039	0.841	0.830	0.958	0.869
9	0.2442	0.3924	0.647	0.460	0.541	0.633	0.9039	0.841	0.830	0.958	0.869

year

age	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
0	0.0589	0.118	0.297	0.376	0.227	0.322	0.0756	0.0246	0.0152	0.0371
1	0.4531	0.308	0.387	0.422	0.246	0.294	0.2536	0.0455	0.1648	0.0498
2	0.3775	0.575	0.573	0.669	0.684	0.601	0.3095	0.2866	0.2673	0.2565
3	0.3705	0.456	0.499	0.642	0.718	0.868	0.4914	0.3935	0.4065	0.4186
4	0.4689	0.459	0.575	0.736	0.914	0.870	0.4195	0.5138	0.4274	0.3857
5	0.5032	0.486	0.550	0.717	0.562	0.829	0.4817	0.4546	0.6119	0.3418
6	0.5001	0.483	0.728	0.708	0.680	0.547	0.3182	0.4665	0.7276	0.4590
7	0.7012	0.433	0.710	0.895	0.487	0.664	0.1458	0.2453	0.3842	0.4670
8	0.8075	0.751	0.905	1.057	0.906	0.976	0.5675	0.4317	0.5694	0.4242
9	0.8075	0.751	0.905	1.057	0.906	0.976	0.5675	0.4317	0.5694	0.4242

year

age	2000	2001	2002	2003	2004	2005	2006	2007	2008
0	0.0447	0.0316	0.0377	0.0428	0.0488	0.0606	0.0562	0.0538	NA
1	0.0797	0.0714	0.0407	0.0603	0.0687	0.0853	0.0792	0.0758	NA
2	0.2330	0.1268	0.1497	0.1258	0.1434	0.1782	0.1653	0.1582	NA
3	0.3327	0.3058	0.2234	0.2002	0.2281	0.2834	0.2629	0.2516	NA
4	0.4630	0.3247	0.2891	0.2999	0.3416	0.4246	0.3939	0.3770	NA
5	0.4738	0.3915	0.2408	0.3483	0.3969	0.4932	0.4576	0.4379	NA
6	0.3201	0.3363	0.3389	0.3442	0.3921	0.4873	0.4521	0.4326	NA
7	0.4032	0.2151	0.2715	0.3472	0.3955	0.4915	0.4560	0.4364	NA
8	0.4212	0.3222	0.2743	0.2999	0.3416	0.4246	0.3939	0.3770	NA
9	0.4212	0.3222	0.2743	0.2999	0.3416	0.4246	0.3939	0.3770	NA

Table 2.6.2.13 FITTED SELECTION PATTERN

Units : f

age	2003	2004	2005	2006	2007
0	0.143	0.143	0.143	0.143	0.143
1	0.201	0.201	0.201	0.201	0.201
2	0.420	0.420	0.420	0.420	0.420
3	0.668	0.668	0.668	0.668	0.668
4	1.000	1.000	1.000	1.000	1.000
5	1.162	1.162	1.162	1.162	1.162
6	1.148	1.148	1.148	1.148	1.148
7	1.158	1.158	1.158	1.158	1.158
8	1.000	1.000	1.000	1.000	1.000
9	1.000	1.000	1.000	1.000	1.000

Table 2.6.2.14 PREDICTED INDEX VALUES

MLAI

Units : NA

age	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
all	17.0	11.2	5.08	4.8	2.70	3.87	6.91	8.72	13.8	20.8	34.6	58.2	60.2

age	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
all	58.2	80.4	111	117	110	88.4	60.2	38	41.5	37.1	37.2	46.5	63.7

age	1999	2000	2001	2002	2003	2004	2005	2006	2007
all	75.7	75.9	122	152	167	174	159	118	88.5

MIK 0-wr

Units : NA

age	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
0	182	145	102	121	150	84.6	82.4	205	120	281	94	59.2	76.4	49.2

age	2006	2007	2008
0	75.4	62.9	27.8

IBTS1: 1-5+ wr

Units : NA

age	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
1	2186.4	2199.4	3866.3	4739.8	3692.4	1914.0	1758.6	1761.8	1541.9	2371.9
2	685.8	635.1	543.0	1019.1	1196.5	772.9	457.8	402.6	457.9	369.5
3	139.2	257.4	224.4	183.2	365.0	447.5	279.8	167.1	122.9	137.6
4	30.6	43.4	66.3	65.8	54.5	119.5	147.0	95.3	52.1	36.1
5	12.1	14.4	17.0	25.7	29.8	28.1	46.2	68.9	66.1	45.2

age	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
1	1810.3	1433.6	1585.3	2490.6	1448.3	1441.3	3503.6	2047.4	4853.1	1610.5
2	550.3	495.1	390.0	448.0	846.5	444.0	490.1	1176.1	690.3	1685.9
3	101.1	145.9	148.0	152.3	178.2	341.8	183.0	206.8	550.3	317.5
4	34.9	24.2	32.3	45.0	51.0	59.4	111.6	65.5	76.2	217.5
5	27.8	19.1	12.1	17.4	21.8	26.5	35.2	55.0	57.8	63.4

age	2004	2005	2006	2007	2008
1	1009	1292	825.1	1269.1	1060.1
2	549	340	429.5	276.0	425.8
3	789	251	151.3	193.6	125.2
4	127	306	93.1	57.2	74.0
5	117	112	156.6	116.9	88.1

Acoustic survey 1-9+ wr

Units : NA

age \ year	1989	1990	1991	1992	1993	1994	1995	1996
1	NA	NA	NA	NA	NA	NA	NA	NA
2	5848689	3496087	2826999	3218100	2492837	3688835	3438444	3065901
3	5579370	3549374	2044140	1476462	1555632	1106864	1497454	1782924
4	2477637	3163925	2060399	1071625	694515	622475	438444	710272
5	558275	1367292	1834693	1158310	521760	342479	244579	212707
6	297487	280713	745583	881153	546473	231911	175596	126084
7	132827	122617	147446	338994	324013	253846	98955	105781
8	37766	60519	58209	72555	135489	129474	117324	52849
9	40764	60497	71513	104334	156572	208526	120383	29356

age \ year	1997	1998	1999	2000	2001	2002	2003	2004
1	11259692	6223938	6504368	15610738	9154699	21985353	7235159	4516950
2	3556312	6774313	3569894	3980088	9991621	5807723	14328562	4629124
3	1912687	2225724	4248089	2358457	2696985	7431177	4330076	10634152
4	951290	1118412	1323870	2408412	1499742	1770218	5031749	2895487
5	428440	504398	715230	802267	1474909	1061874	1200499	3306357
6	118172	208719	265379	458661	480508	915428	703244	737786
7	79709	64741	97146	144368	294563	296979	542111	404561
8	76870	51347	42435	61448	99233	226247	219274	378090
9	56445	28037	20726	25038	36085	137583	130521	401400

age \ year	2005	2006	2007
1	5742709	3677016	5664113
2	2824508	3589471	2313730
3	3306359	2008555	2583383
4	6709185	2069303	1280581
5	1770833	4031145	1274321
6	1886685	986527	2306581
7	394009	984360	528603
8	263773	250216	641137
9	589717	472676	266426

Table 2.6.2.15 INDEX RESIDUALS

MLAI

Units : NA

age \ year	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
all	-0.256	-0.342	-0.589	-0.655	0.822	0.652	0.732	0.114	0.0346	0.00341

age \ year	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
all	-0.255	-0.185	0.205	-0.414	-0.172	0.189	0.117	0.444	0.0214	-0.357

age \ year	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
all	-0.234	-0.691	-0.506	0.167	0.194	0.135	-0.223	-0.63	0.0609	-0.328

age \ year	2003	2004	2005	2006	2007
all	0.469	0.613	0.193	0.000997	0.67

MIK 0-wr

Units : NA

age \ year	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
0	0.0997	0.268	0.000853	0.0444	-0.342	0.559	-0.439	0.175	0.130	-0.269

age \ year	2002	2003	2004	2005	2006	2007	2008
0	0.543	-0.0845	-0.479	0.219	0.0972	-0.525	-5.2e-14

IBTS1: 1-5+ wr

Units : NA

age \ year	1984	1985	1986	1987	1988	1989	1990	1991	1992
1	-0.366	-0.0476	-0.373	-0.250	0.1740	0.197	-5.05e-01	-0.314	-0.1955
2	-1.446	0.1278	0.365	-0.105	1.2469	0.124	9.34e-03	0.543	-0.0478
3	-0.818	0.0914	0.207	-0.454	0.7741	-0.279	-9.45e-05	0.437	0.4514
4	-0.130	-0.0317	0.175	-0.103	0.0609	-0.291	6.05e-01	0.843	0.0511

```
  5 -0.168  0.6619  0.503  0.640 -0.1722 -1.193  4.33e-01  0.751  0.3337
   year
age  1993    1994    1995   1996   1997   1998    1999    2000    2001
  1 0.164 -0.0327 -0.0633  0.176  0.570  0.452 -0.6495  0.0613  0.1995
  2 0.757  0.7520  1.0344 -0.680  0.123 -0.067  0.0147 -0.8995 -0.0406
  3 0.481  0.7452  0.6469 -1.504  0.066 -0.622  0.3830 -0.1678  0.4272
  4 0.220  0.6805  0.4174 -1.154 -0.389 -0.897  0.5031 -0.6402  0.3596
  5 0.372  0.4242 -1.0727 -0.404  0.135 -0.201  0.2941 -1.3700  0.2172
   year
age    2002    2003    2004   2005   2006    2007   2008
  1 -0.1772  0.5405 -0.0301 -0.255 0.0993  0.0401  0.584
  2 -0.0477 -0.0801 -0.2288 -0.462 1.2381 -1.7083 -0.522
  3 -0.4870  0.6560 -0.0296  0.349 0.7943 -2.3618  0.215
  4 -1.1124  0.5037 -0.1257  0.240 0.9515 -1.9752  1.237
  5 -1.0648 -0.1767  0.3766  0.161 0.7405 -1.0409  0.821
```

Acoustic survey 1-9+ wr

```
Units   :       NA
   year
age    1989      1990     1991     1992   1993   1994    1995   1996
  1      NA        NA       NA       NA     NA     NA      NA     NA
  2 -0.3577 -0.055905 -0.07071  0.14869  0.180 -0.147  0.1128  0.383
  3 -0.3573 -0.008026 -0.18435 -0.06902  0.051 -0.277  0.3097  0.460
  4 -0.4169  0.076071 -0.05047  0.06797  0.261 -0.445  0.4270  0.426
  5 -0.1264 -0.000945  0.00777 -0.02121  0.351  0.107  0.2009  0.380
  6 -0.0499  0.333929 -0.14647  0.34646  0.352  0.325  0.1450 -0.242
  7 -0.1016  0.538045  0.43589  0.15290  0.531  0.250  0.3326 -0.243
  8  0.1528  0.787395  0.47925  0.45186  0.284  0.526  0.0142  0.923
  9 -0.6168 -0.341397 -0.33805 -0.00321 -0.300 -0.465 -0.2581  1.948
   year
age    1997   1998   1999    2000    2001    2002    2003   2004    2005
  1 -0.1847 -0.336 -0.246  0.4603 -0.2919  0.0475  0.3064  0.138 -0.6120
  2  0.5163 -0.164 -0.148 -0.3087  0.2070 -0.1751  0.2795 -0.304 -0.3180
  3  0.4282  0.124  0.106 -0.0898  0.1338  0.1009 -0.3403 -0.146  0.0985
  4  0.4153  0.374 -0.171  0.2653 -0.0255 -0.2418 -0.1833 -0.290 -0.1474
  5  0.3384  0.666 -0.346  0.2273  0.1278 -0.2900 -0.5756 -0.244 -0.3784
  6  0.5985  0.757  0.168  0.0517 -0.0656  0.1189 -0.3516 -0.844 -0.4736
  7 -0.5497  0.965  0.358  0.6111 -0.5497 -0.1949  0.0472 -0.211 -1.0354
  8  0.0146 -0.132  0.241  0.6693 -0.0125 -0.6258 -0.4101 -0.100 -0.7348
  9  1.0356  1.462  1.435  1.3543  0.4917  0.0831  0.3086 -0.771 -1.7096
   year
age     2006   2007
  1  0.61817  0.100
  2  0.04968  0.173
  3 -0.00567 -0.335
  4  0.01353 -0.355
  5  0.03509 -0.458
  6 -0.46738 -0.556
  7 -0.56031 -0.777
  8 -1.08794 -1.439
  9 -1.90422 -1.411
```

Table 2.6.2.16 PREDICTED CATCH IN NUMBER

Units : thousands

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

age	1968	1969	1970	1971	1972	1973	1974	1975	1976
0	839300	112000	898100	684000	750400	289400	996100	263800	238200
1	2425000	2503300	1196200	4378500	3340600	2368000	846100	2460500	126600
2	1795200	1883000	2002800	1146800	1440500	1344200	772600	541700	901500
3	1494300	296300	883600	662500	343800	659200	362000	259600	117300
4	621400	133100	125200	208300	130600	150200	126000	140500	52000
5	157100	190800	50300	26900	32900	59300	56100	57200	34500
6	145000	49900	61000	30500	5000	30600	22300	16100	6100
7	163400	42700	7900	26800	200	3700	5000	9100	4400
8	13700	27400	12000	100	1100	1400	2000	3400	1000
9	91800	25100	12200	12400	400	600	1100	1400	400

age	1977	1978	1979	1980	1981	1982	1983	1984	1985
0	256800	130000	542000	1262700	9519700	11956700	13296900	6973300	4211000
1	144300	168600	159200	245100	872000	1116400	2448600	1818400	3253000
2	44700	4900	34100	134000	284300	299400	573800	1146200	1326300
3	186400	5700	10000	91800	56900	230100	216400	441400	1182400
4	10800	5000	10100	32200	39500	33700	105100	201500	368500
5	7000	300	2100	21700	28500	14400	26200	81100	124500
6	4100	200	200	2300	22700	6800	22800	22600	43600
7	1500	200	800	1400	18700	7800	12800	25200	20200
8	700	200	600	400	5500	3600	11000	11100	13100
9	0	300	100	100	1100	1100	12100	18600	16100

age	1986	1987	1988	1989	1990	1991	1992	1993
0	3724700	8229200	3164800	3057800	1302800	2386600	10331300	10265400
1	4801400	6836300	7867000	3145900	3020000	2138900	2303100	3826800
2	1266700	2137200	2232500	1593700	899300	1132800	1284900	1176300
3	840800	667900	1090700	1363800	779100	556700	442700	609000
4	465900	467100	383700	809300	861000	548900	361500	305500
5	129800	245800	255800	211800	387500	501200	360500	215600
6	62100	74700	128100	123700	80200	205300	375600	226000
7	20500	23800	38000	61000	54400	39300	152400	188000
8	13600	8000	15300	19500	28800	25600	39200	87300
9	14800	8200	8500	8700	11900	13000	23300	41700

age	1994	1995	1996	1997	1998	1999	2000	2001	2002
0	4498900	7438469	2311226	431175	259526	1566349	1105085	1832691	730279
1	1785200	1664874	1606393	479702	977680	303520	1171677	614469	837557
2	1783200	1444061	642084	687920	1220105	616354	622853	842635	579592
3	489100	816703	525601	446909	537932	1058716	463170	485628	970577
4	347600	231794	172099	284920	276333	294066	646814	278884	292205
5	109000	118536	57586	109178	175817	135648	213466	321743	140701
6	91800	55128	22534	31389	88927	69299	82481	90918	174570
7	76400	41409	9264	11832	15232	27998	35706	38252	48908
8	70000	68955	17195	18770	16766	10174	14624	17910	34620
9	46600	29245	3948	5697	3784	2054	2463	2692	8702

age	2003	2004	2005	2006	2007
0	521265	764663	610620	868788	693533
1	409578	291659	461878	274139	403929
2	1199184	442058	336231	395970	244103
3	505710	1418315	550697	309805	380945
4	862415	567417	1646177	469718	277752
5	232141	731580	491420	1034255	312295
6	136265	163569	524526	253586	566350
7	114862	98081	119799	276715	141938
8	36759	72469	63301	55552	136011
9	9044	31801	58497	43377	23362

Table 2.6.2.17 CATCH RESIDUALS

Units : NA

age \ year	2003	2004	2005	2006	2007
0	-0.3453	-0.0663	5.09e-01	0.01127	-0.11046
1	0.4098	-0.3446	4.38e-01	-0.21046	-0.53930
2	0.0188	0.0132	5.56e-02	0.01284	-0.10800
3	0.0458	-0.0375	-1.25e-01	0.00257	0.09151
4	-0.0316	-0.0433	-2.22e-01	-0.01091	0.02837
5	0.0530	0.0292	-2.36e-02	-0.03590	-0.00914
6	-0.2348	0.0346	9.39e-02	-0.00568	0.10522
7	0.0708	0.0676	-3.90e-02	-0.11343	0.04067
8	0.0245	-0.1035	3.33e-01	0.12636	-0.01948
9	0.0000	0.0000	-1.11e-16	0.00000	0.00000

Table 2.6.2.18 FIT PARAMETERS

	Value	CV (%)	Lower 95 pct CL	Upper 95 pct CL
F, 2003	3.00e-01	7.3	2.52e-01	3.56e-01
F, 2004	3.42e-01	8.1	2.88e-01	4.05e-01
F, 2005	4.25e-01	10.6	3.56e-01	5.07e-01
F, 2006	3.94e-01	10.6	3.25e-01	4.78e-01
F, 2007	3.77e-01	11.5	3.03e-01	4.70e-01
Selectivity at age 0	1.43e-01	15.2	7.98e-02	2.55e-01
Selectivity at age 1	2.01e-01	18.1	1.14e-01	3.55e-01
Selectivity at age 2	4.20e-01	10.1	3.53e-01	4.98e-01
Selectivity at age 3	6.68e-01	21.5	5.63e-01	7.91e-01
Selectivity at age 5	1.16e+00	60.8	9.72e-01	1.39e+00
Selectivity at age 6	1.15e+00	70.6	9.49e-01	1.39e+00
Selectivity at age 7	1.16e+00	75.3	9.33e-01	1.44e+00
Terminal year pop, age 0	2.09e+07	1.1	1.45e+07	3.00e+07
Terminal year pop, age 1	8.70e+06	0.9	6.59e+06	1.15e+07
Terminal year pop, age 2	1.92e+06	0.7	1.57e+06	2.36e+06
Terminal year pop, age 3	1.88e+06	0.6	1.57e+06	2.26e+06
Terminal year pop, age 4	9.26e+05	0.7	7.76e+05	1.11e+06
Terminal year pop, age 5	9.22e+05	0.7	7.65e+05	1.11e+06
Terminal year pop, age 6	1.69e+06	0.7	1.38e+06	2.07e+06
Terminal year pop, age 7	4.20e+05	1.0	3.28e+05	5.39e+05
Terminal year pop, age 8	4.54e+05	1.1	3.39e+05	6.06e+05
Last true age pop, 2003	1.49e+05	1.8	9.74e+04	2.27e+05
Last true age pop, 2004	2.62e+05	1.3	1.89e+05	3.65e+05
Last true age pop, 2005	1.92e+05	1.2	1.44e+05	2.56e+05
Last true age pop, 2006	1.79e+05	1.2	1.35e+05	2.37e+05
Recruitment prediction	9.22e+06	1.7	5.46e+06	1.56e+07
Index 1, biomass, K	1.15e+00	3.9	1.06e+00	1.24e+00
Index 1, biomass, Q	1.13e-05	5.2	3.56e-06	3.59e-05
Index 2, age 0 numbers, Q	3.44e-06	0.5	3.01e-06	3.93e-06
Index 3, age 1 numbers, Q	1.67e-04	0.7	1.48e-04	1.88e-04
Index 3, age 2 numbers, Q	1.52e-04	0.9	1.30e-04	1.77e-04
Index 3, age 3 numbers, Q	1.09e-04	4.5	4.87e-05	2.43e-04
Index 3, age 4 numbers, Q	6.55e-05	4.3	2.93e-05	1.46e-04
Index 3, age 5 numbers, Q	3.50e-05	4.0	1.57e-05	7.84e-05
Index 4, age 1 numbers, Q	1.18e+00	50.4	1.00e+00	1.38e+00
Index 4, age 2 numbers, Q	1.55e+00	14.0	1.37e+00	1.75e+00
Index 4, age 3 numbers, Q	1.76e+00	20.3	1.41e+00	2.20e+00
Index 4, age 4 numbers, Q	1.80e+00	25.5	1.34e+00	2.41e+00
Index 4, age 5 numbers, Q	1.86e+00	25.5	1.36e+00	2.53e+00
Index 4, age 6 numbers, Q	1.83e+00	27.7	1.32e+00	2.54e+00
Index 4, age 7 numbers, Q	1.69e+00	34.3	1.19e+00	2.40e+00
Index 4, age 8 numbers, Q	1.84e+00	29.7	1.29e+00	2.62e+00
Index 4, age 9 numbers, Q	4.44e+00	14.2	2.94e+00	6.73e+00
SRR, a	5.91e+07	1.2	3.86e+07	9.04e+07
SRR, b	4.40e+05	3.4	1.83e+05	1.06e+06

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

```
North sea herring 2008                    F ref. age for each fleet
2008                                      1 2 6
0 9                                       2 0 1
4                                         3 0 1
                                          4 0 1
Two age ranges for overall F
0 1
2 6

Init numbers by start of 2008
       0        9222.947
       1        7269.545
       2        2967.824
       3        1216.614
       4        1197.675
       5         575.016
       6         538.503
       7         991.205
       8         245.782
       9         329.943
recruitments
22558
22558
selection by age and fleet
                0            0.0018      0.0463      0.0012      0.0046
                1            0.0068      0.0081      0.0485      0.0126
                2            0.1025      0.0000      0.0429      0.0125
                3            0.2507      0.0000      0.0011      0.0001
                4            0.3764      0.0000      0.0005      0.0001
                5            0.4360      0.0000      0.0019      0.0001
                6            0.4328      0.0000      0.0001      0.0001
                7            0.4341      0.0000      0.0018      0.0000
                8            0.3769      0.0000      0.0000      0.0000
                9            0.3770      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 2008
               0            0.0640      0.0103      0.0318      0.0164
               1            0.0994      0.0335      0.0679      0.0308
               2            0.1325      0.0000      0.0760      0.0653
               3            0.1504      0.0000      0.1120      0.1065
               4            0.1679      0.0000      0.1436      0.1489
               5            0.2009      0.0000      0.1706      0.1630
               6            0.2211      0.0000      0.1852      0.1829
               7            0.2006      0.0000      0.2014      0.1893
               8            0.2454      0.0000      0.1864      0.2122
               9            0.2600      0.0000      0.0000      0.0000
weca 2009
                0            0.0640      0.0103      0.0318      0.0164
                1            0.0994      0.0335      0.0679      0.0308
                2            0.1325      0.0000      0.0760      0.0653
                3            0.1504      0.0000      0.1120      0.1065
                4            0.1679      0.0000      0.1436      0.1489
                5            0.2009      0.0000      0.1706      0.1630
                6            0.2211      0.0000      0.1852      0.1829
                7            0.2334      0.0000      0.2014      0.1893
                8            0.2109      0.0000      0.1864      0.2122
                9            0.2600      0.0000      0.0000      0.0000
```

```
west  2008
               0            0.006
               1            0.051
               2            0.128
               3            0.161
               4            0.180
               5            0.216
               6            0.236
               7            0.196
               8            0.255
               9            0.264
west  2009
               0            0.006
               1            0.051
               2            0.128
               3            0.161
               4            0.180
               5            0.216
               6            0.236
               7            0.238
               8            0.197
               9            0.264
west  2010
               0            0.006
               1            0.051
               2            0.128
               3            0.161
               4            0.180
               5            0.216
               6            0.236
               7            0.238
               8            0.255
               9            0.198
maturity 2008
              0              0.00
              1              0.00
              2              0.71
              3              0.92
              4              0.96
              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              0.92
              4              0.96
              5             1.00
              6             1.00
              7             1.00
              8             1.00
              9             1.00
maturity 2010
              0              0.00
              1              0.00
              2              0.71
              3              0.92
              4              0.96
              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 (2008) with catch constraint

F fleet A	F fleet B	F fleet C	F fleet D	F0-1	F2-6	Catch fleet a	Catch fleet b	Catch fleet c	Catch fleet d	SSB 2008
0.206	0.048	0.011	0.005	0.066	0.211	220.9	6.9	10.3	2.3	977.7

Prediction year (2009)

F-values by fleet and total						Catches by fleet					
F Fleet A	F fleet B	F fleet C	F fleet D	F0-1	F2-6	Catch fleet a	Catch fleet b	Catch fleet c	Catch fleet d	SSB 2009	SSB 2010
a) Following the management rule with $F_{2\text{-}6}$ = 0.25 above trigger											
0.163	0.030	0.014	0.004	0.050	0.169	179.1	8.0	7.9	1.7	1030.3	959.5
b) Following the revised management rule with $F_{2\text{-}6}$ = 0.20 above trigger											
0.143	0.031	0.014	0.004	0.050	0.149	158.8	8.0	7.9	1.7	1044.0	990.4
c) 15% reduction in TAC by fleet A											
0.155	0.050	0.014	0.004	0.070	0.161	171.0	13.0	7.9	1.7	1035.8	971.3
d) Catches in 2009 maintained as assumed for 2008(status quo catch)											
0.205	0.026	0.018	0.006	0.052	0.214	221.1	6.9	10.3	2.3	1000.3	893.9
e) No fishing											
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1152.6	1260.7

Table 2.12.1. North Sea Herring. Selected sections on the EU-Norway management agreement for North Sea herring.

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 toset 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 thepreceding 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.*

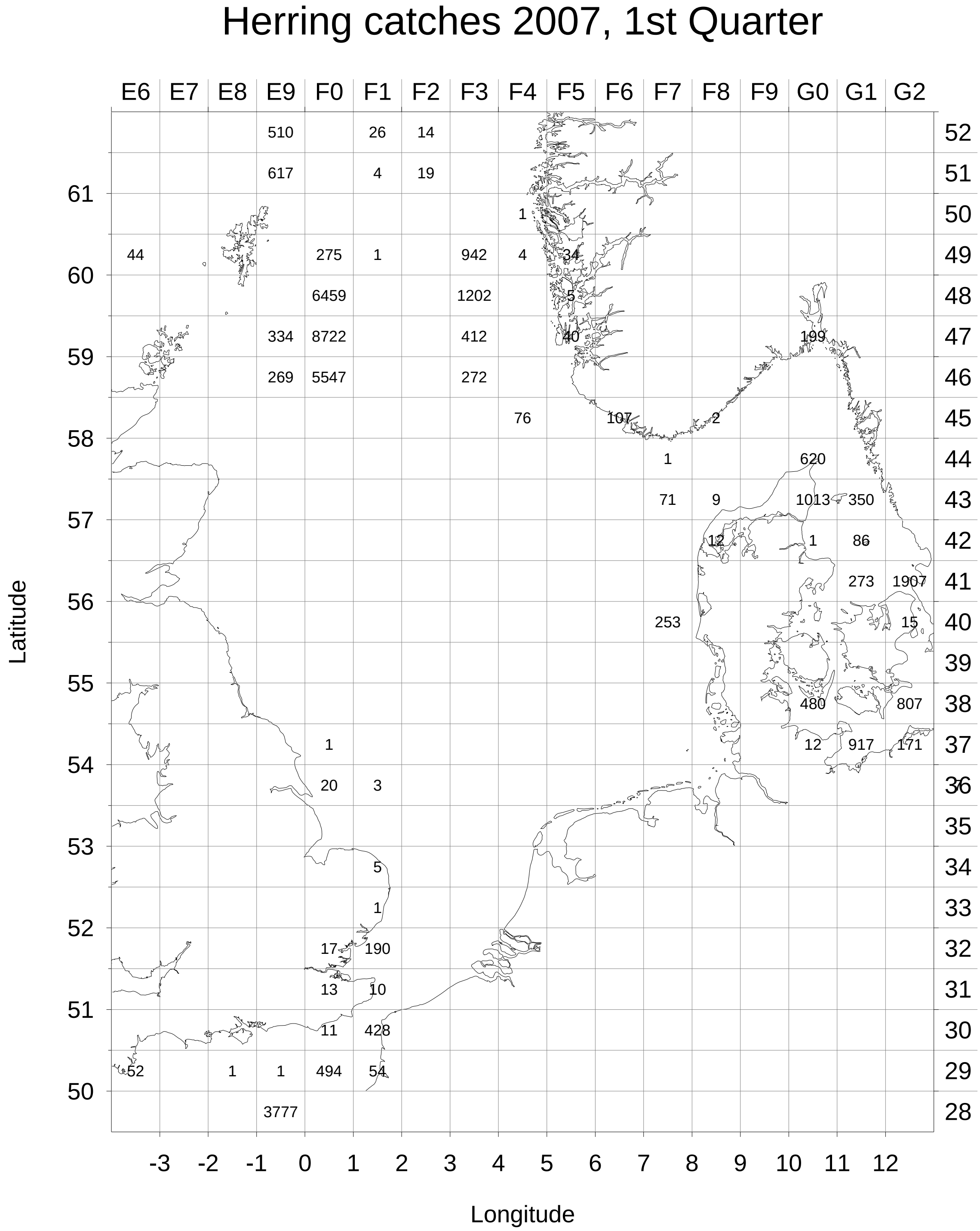


Figure 2.1.1a: Herring catches in the 1st quarter in the North Sea, in Div VIId, Div IIIa, SD 22 and SD 24 (in tonnes) in 2007 by statistical rectangle. Working group estimates (if available).

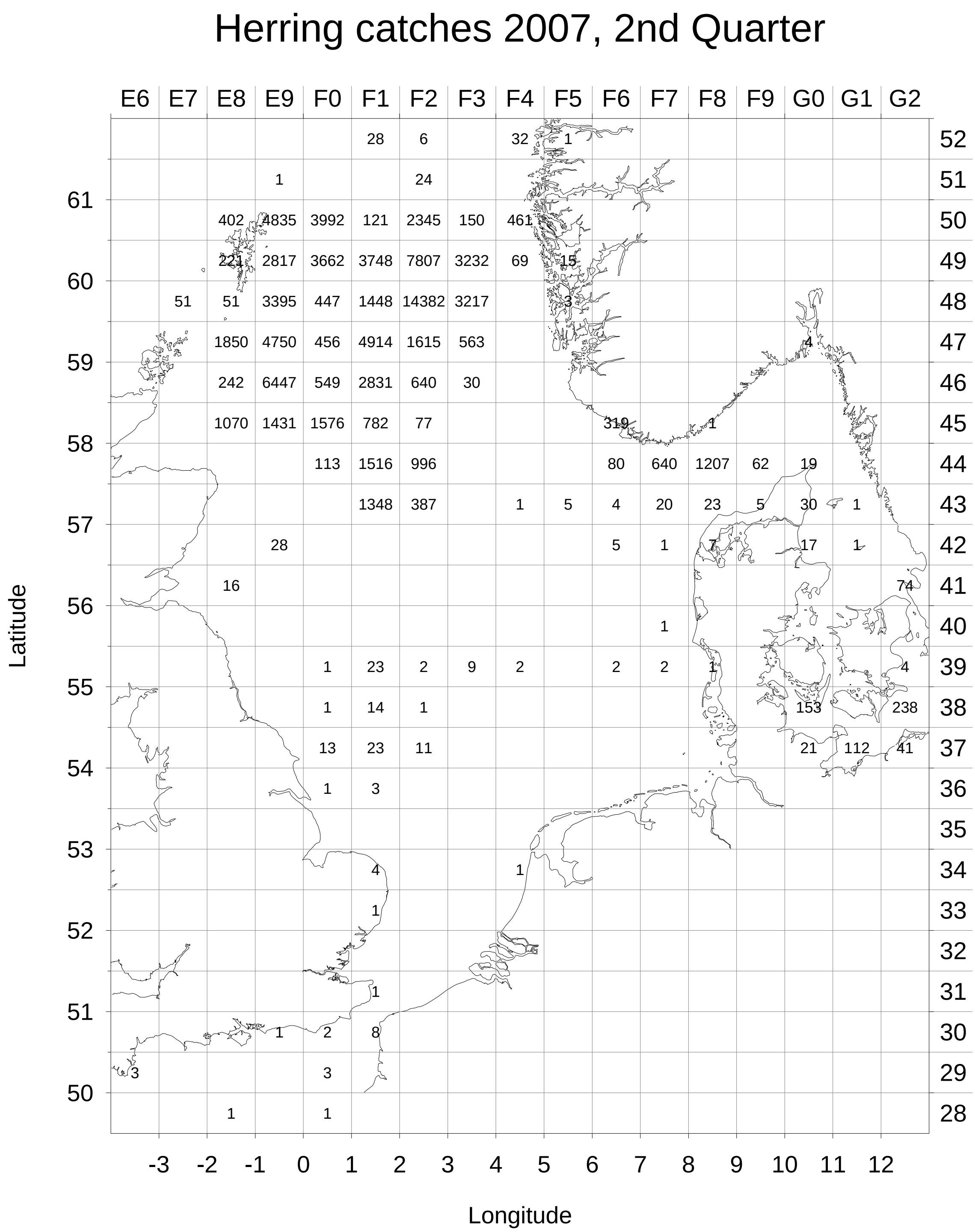


Figure 2.1.1b: Herring catches in the 2nd quarter in the North Sea, in Div VIId, Div IIIa, SD 22 and SD 24 (in tonnes) in 2007 by statistical rectangle. Working group estimates (if available).

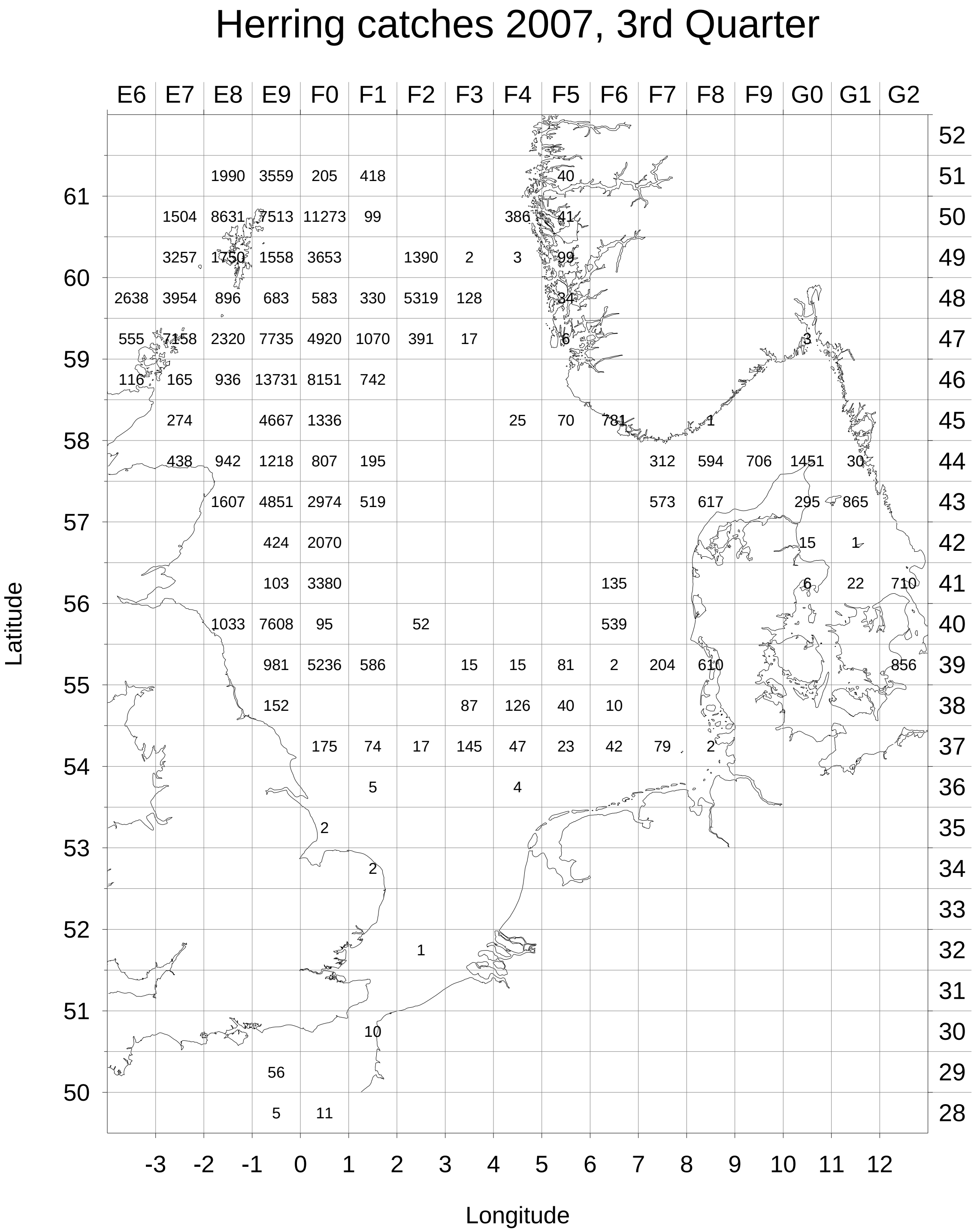


Figure 2.1.1c: Herring catches in the 3rd quarter in the North Sea, in Div VIId, Div IIIa, SD 22 and SD 24 (in tonnes) in 2007 by statistical rectangle. Working group estimates (if available).

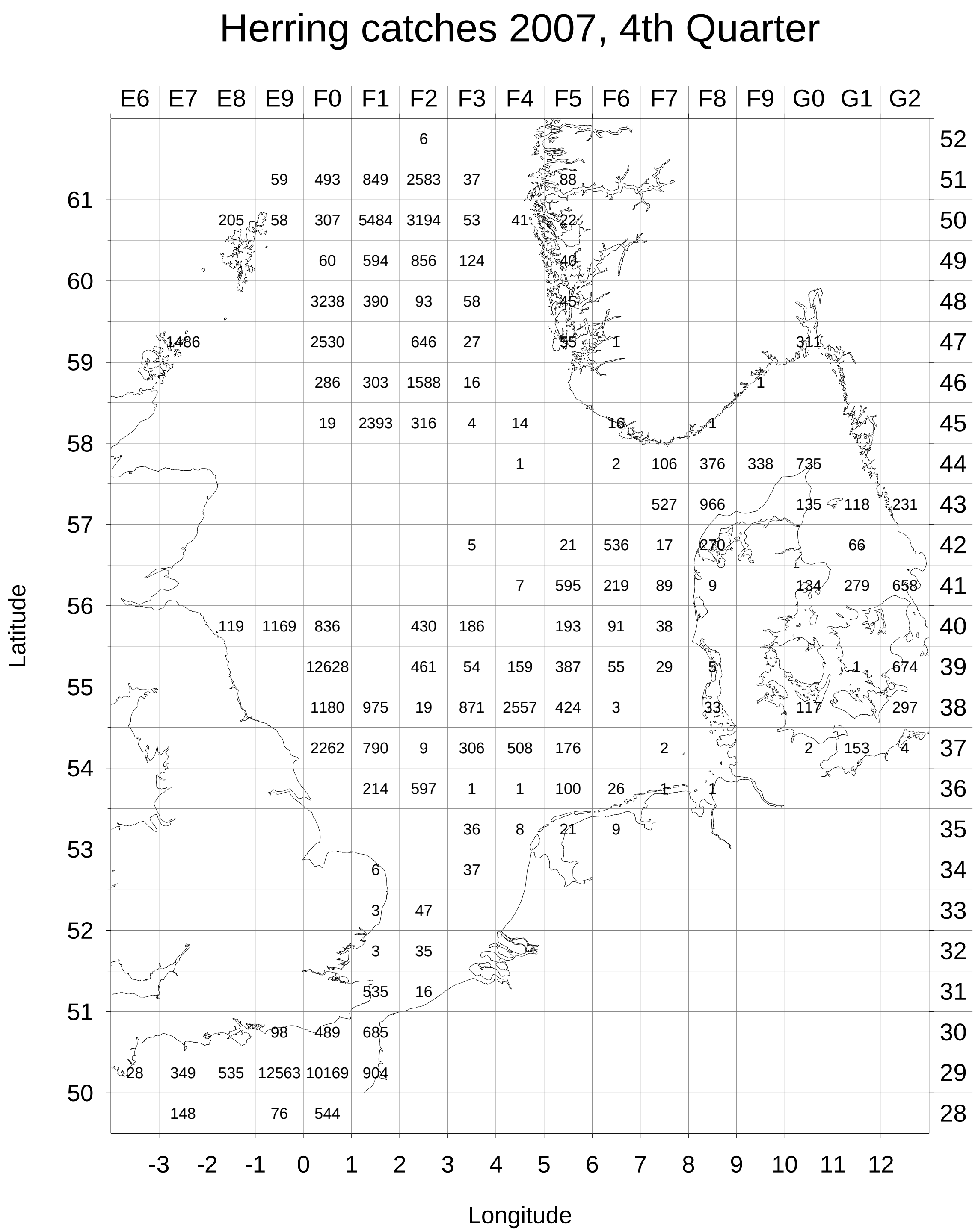


Figure 2.1.1d: Herring catches in the 4th quarter in the North Sea, in Div VIId, Div IIIa, SD 22 and SD 24 (in tonnes) in 2007 by statistical rectangle. Working group estimates (if available).

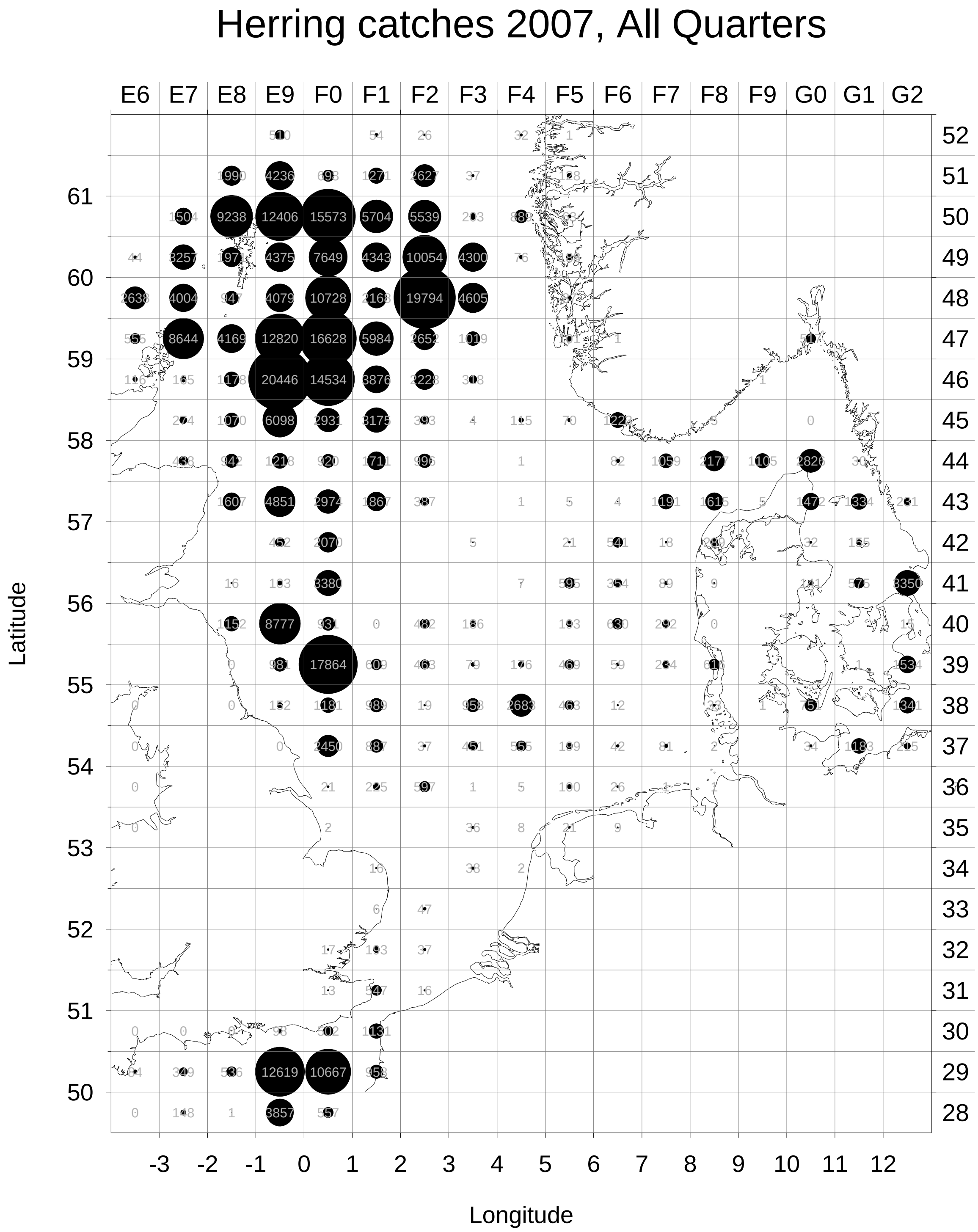


Figure 2.1.1e: Herring catches in all quarters in the North Sea, in Div VIId, Div IIIa, SD 22 and SD 24 (in tonnes) in 2007 by statistical rectangle. Working group estimates (if available).

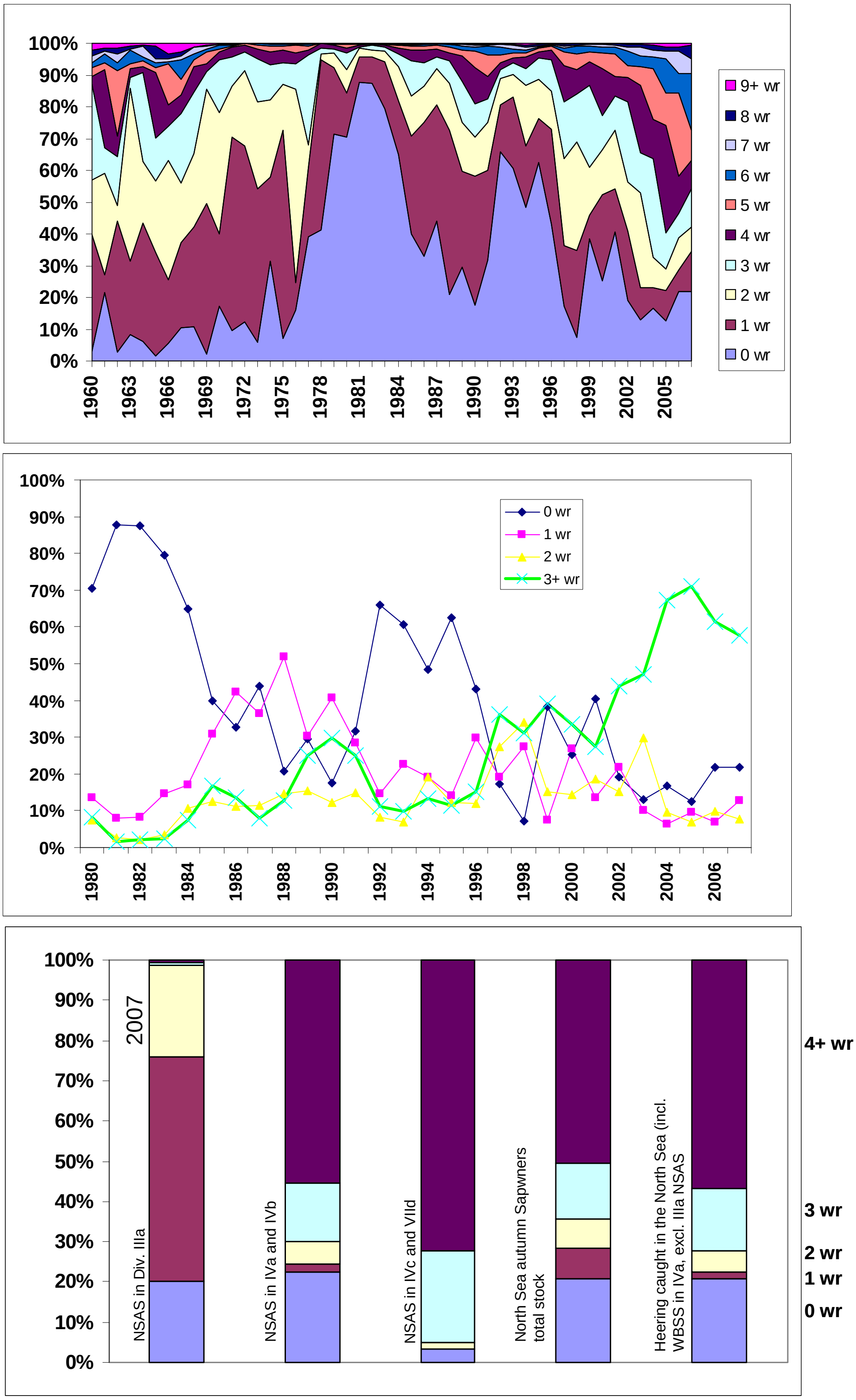


Figure 2.2.1: Proportions of age groups (numbers) in the total catch of herring in the North Sea (upper, 1960-2007, and middle panel, 1980-2007), and in the total catch of North Sea autumn spawners in 2007 (lower panel).

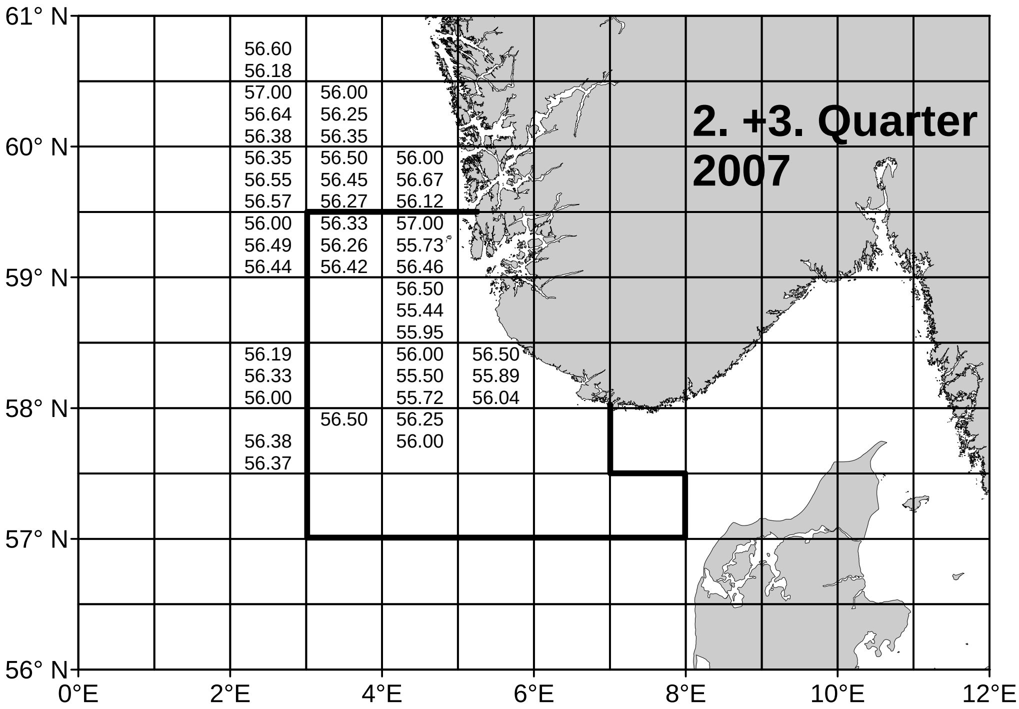


Figure 2.2.2: Mean vertebrae counts of 2 (upper number), 3 (middle) and 4+ herring (lower) in the North Sea and Div. IIIa as obtained by Norwegian sampling in the 2nd and 3rd quarter 2007. The transfer area (Western Baltic spring spawners transferred to the assessment of IIIa herring) is indicated.

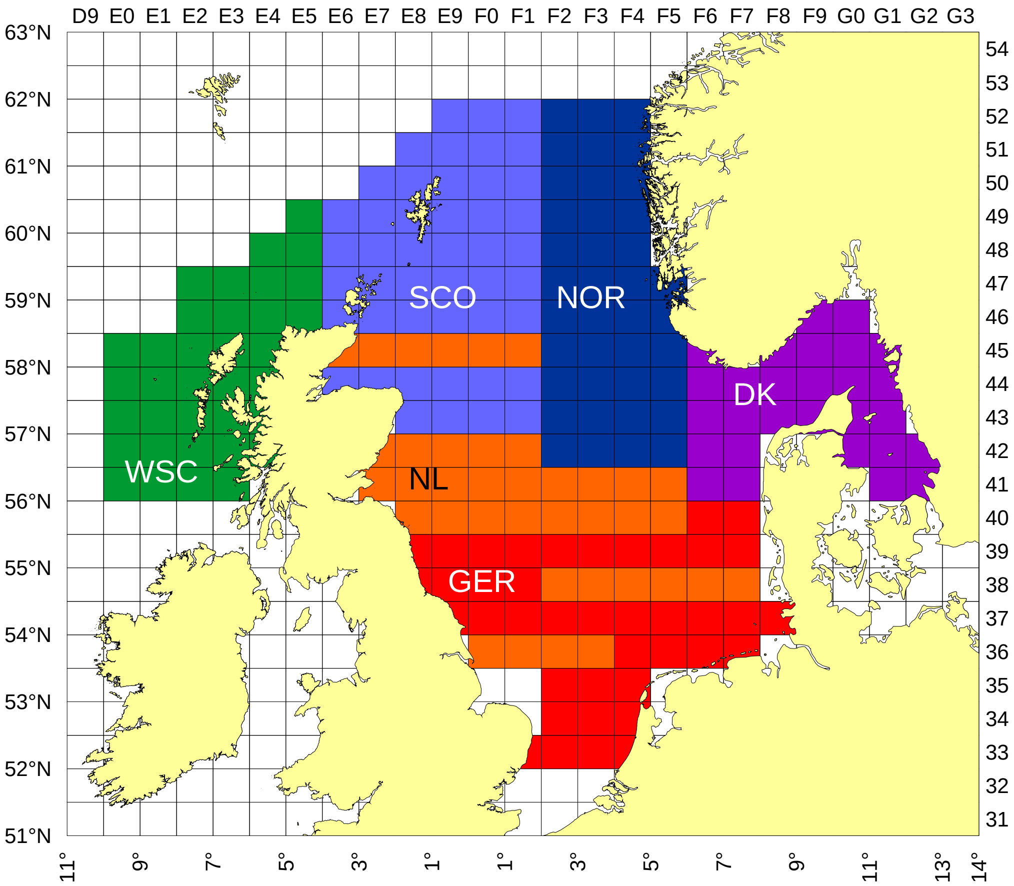


Figure 2.3.1.1: Survey area coverage in the herring acoustic surveys in 2007, by rectangle and nation (WSC = West of Scotland charter vessel; SCO = Scotia; NOR = Johan Hjort; DK = Dana; NL = Tridens; GER = Solea).

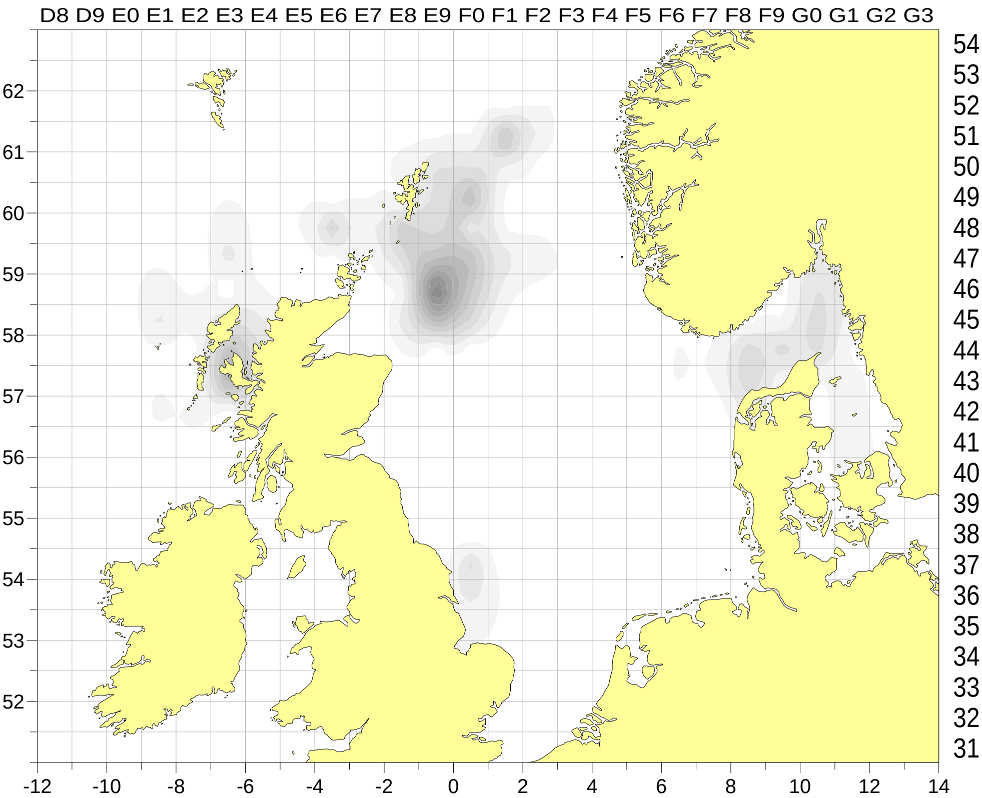


Figure 2.3.1.2: Biomass of mature autumn spawning herring from the combined acoustic survey in June – July 2007.

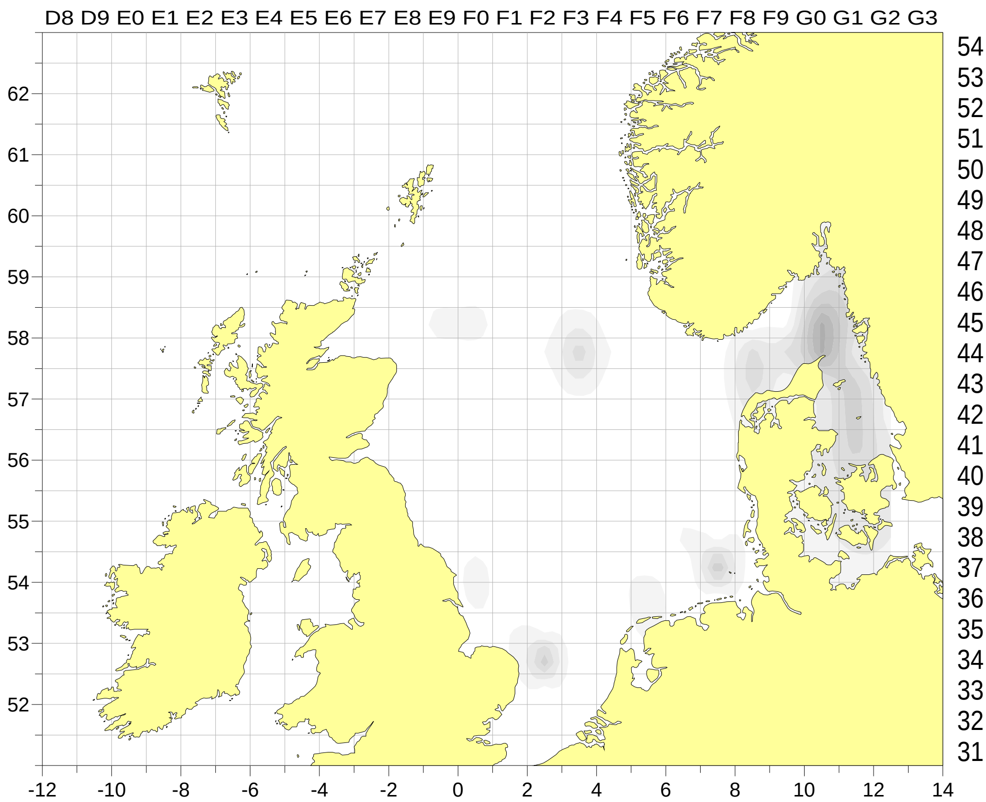


Figure 2.3.1.3: Biomass of immature autumn spawning herring from the combined acoustic survey in June – July 2007.

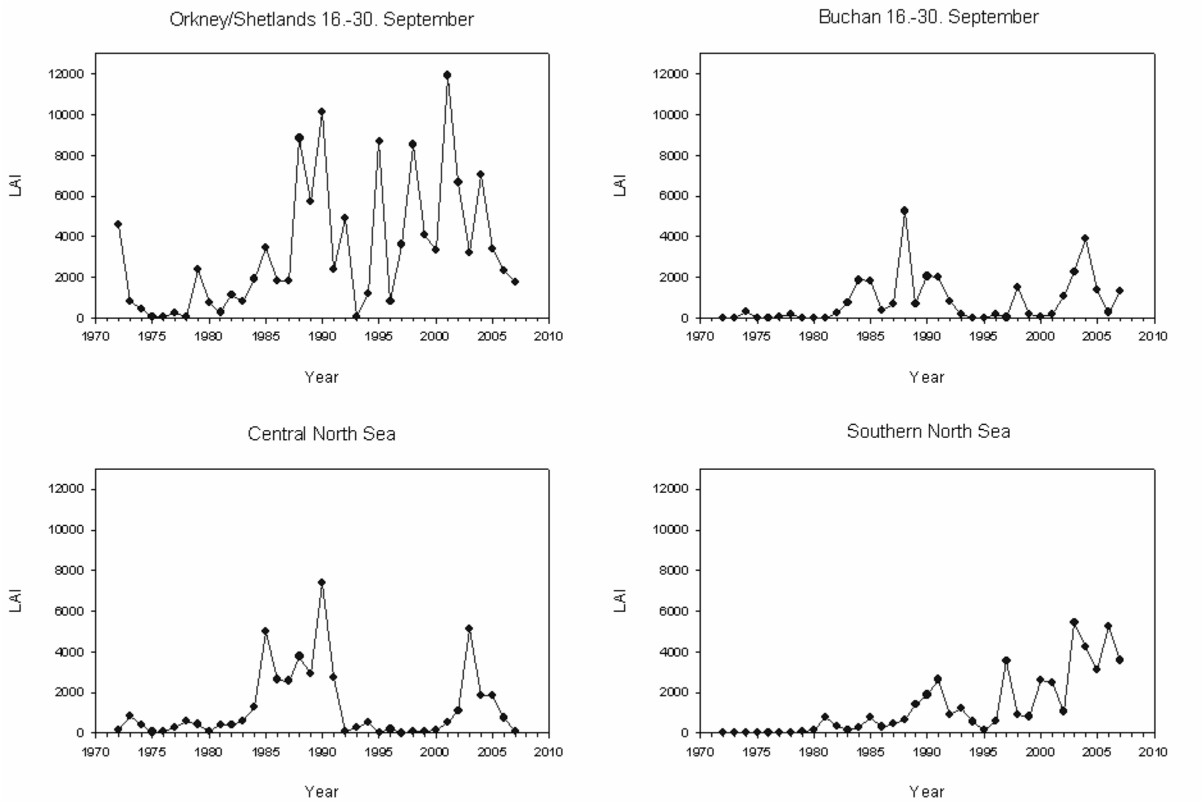


Figure 2.3.2.1: North Sea autumn spawners. Larval Abundance Index time-series for a collection of areas and sampling periods (Orkney/Shetlands 2nd half of September top left panel, Buchan 2nd half of September top right, central North Sea lower left, southern North Sea lower right. For the CNS and the SNS the abundance is the average of the three surveys).

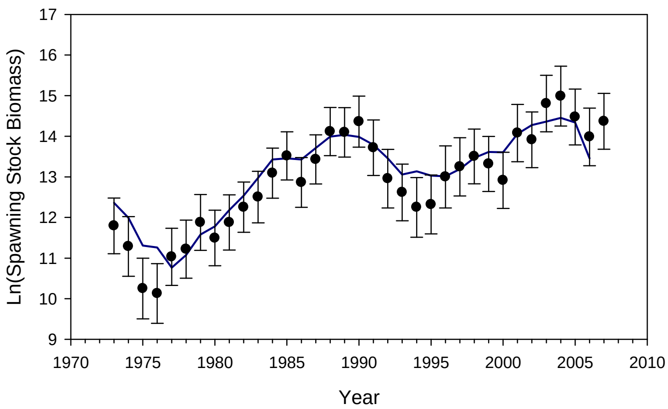


Figure 2.3.2.2: North Sea autumn spawners. Comparison of spawning stock size estimates from the Herring Assessment Working Group (ICES, 2007; bold line) and the year effects fitted to the larval abundances in the multiplicative model (symbols with error bars). The MLAI estimates have been rescaled to the mean of the WG estimates. Error bars indicate +/- one standard error of larval survey abundance estimates. Note the log y axis.

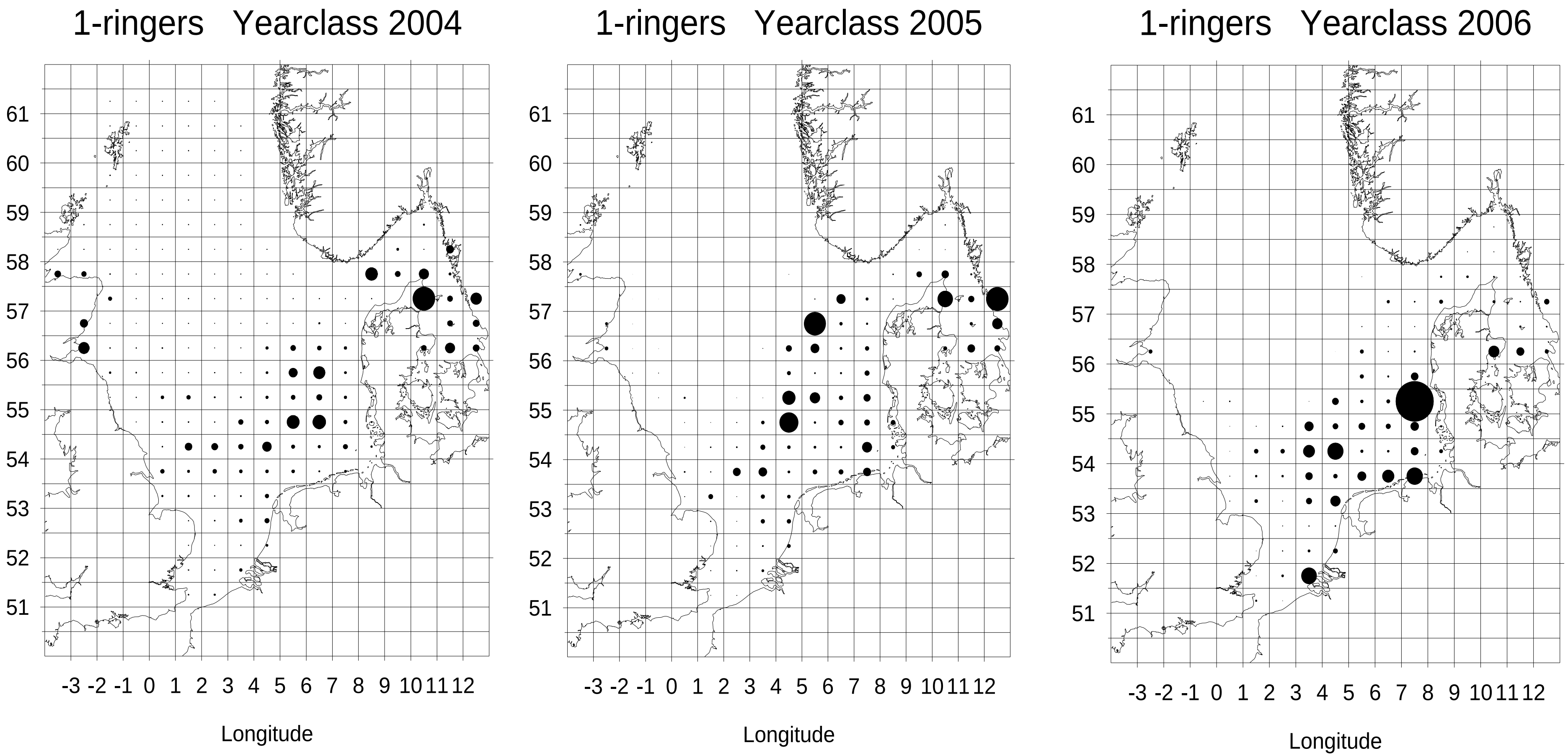


Figure 2.3.3.1. North Sea herring. Distribution of 1-ringer herring, year classes 2004-2006. Abundance estimates of 1-ringers within each statistical rectangle are based on
GOV catches during IBTS in February 2005-2007. Areas of filled circles illustrate numbers per hour, the area of a circle extending to the border of a rectangle represents 45000 h^{-1}.

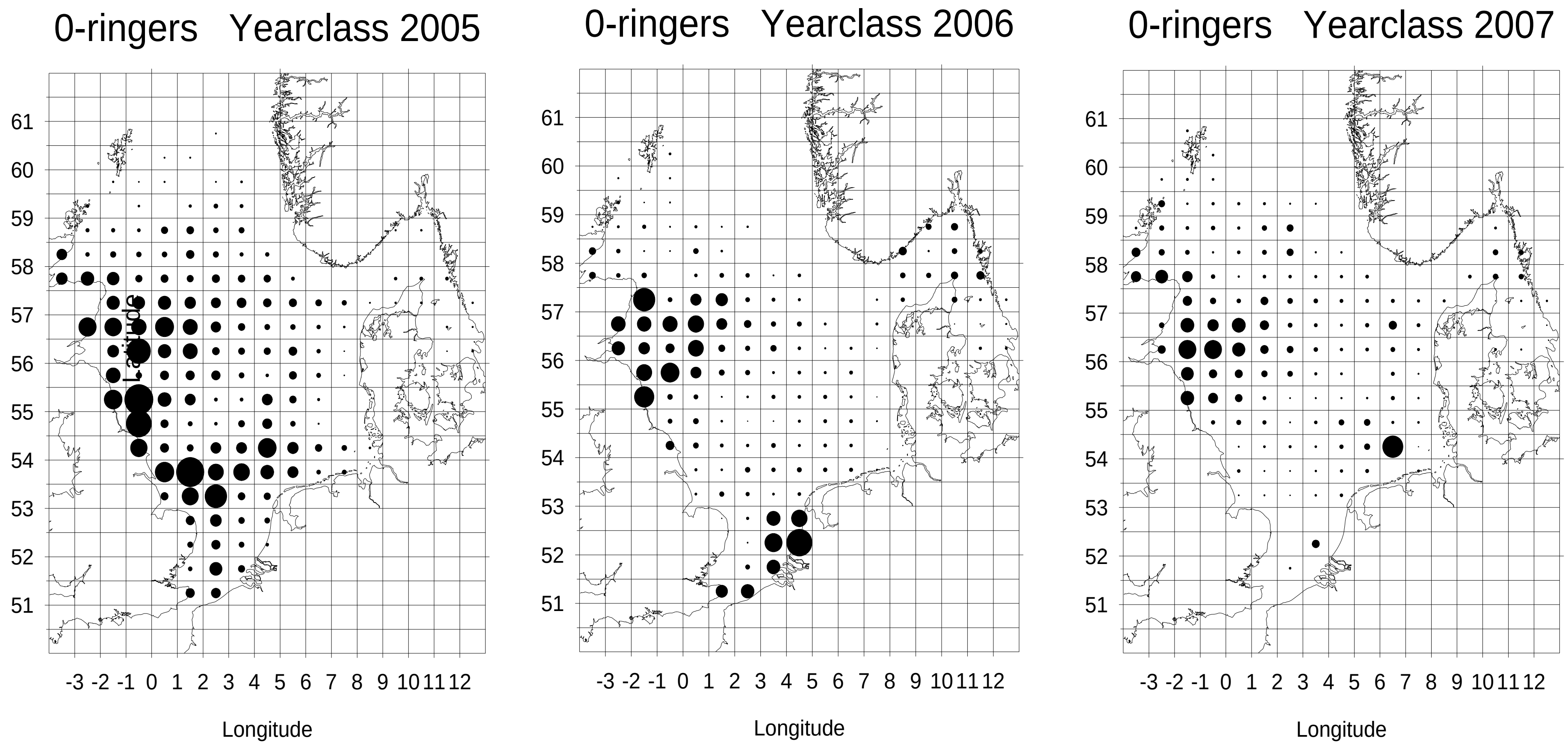


Figure 2.3.3.2. North Sea herring. Distribution of 0-ringer herring, year classes 2005-2007. Abundance estimates of 0-ringers within each statistical rectangle are based on MIK catches during IBTS in February 2006-2008 . Areas of filled circles illustrate densities in no m^{-2}, the area of a circle extending to the border of a rectangle represents 1 m^{-2}

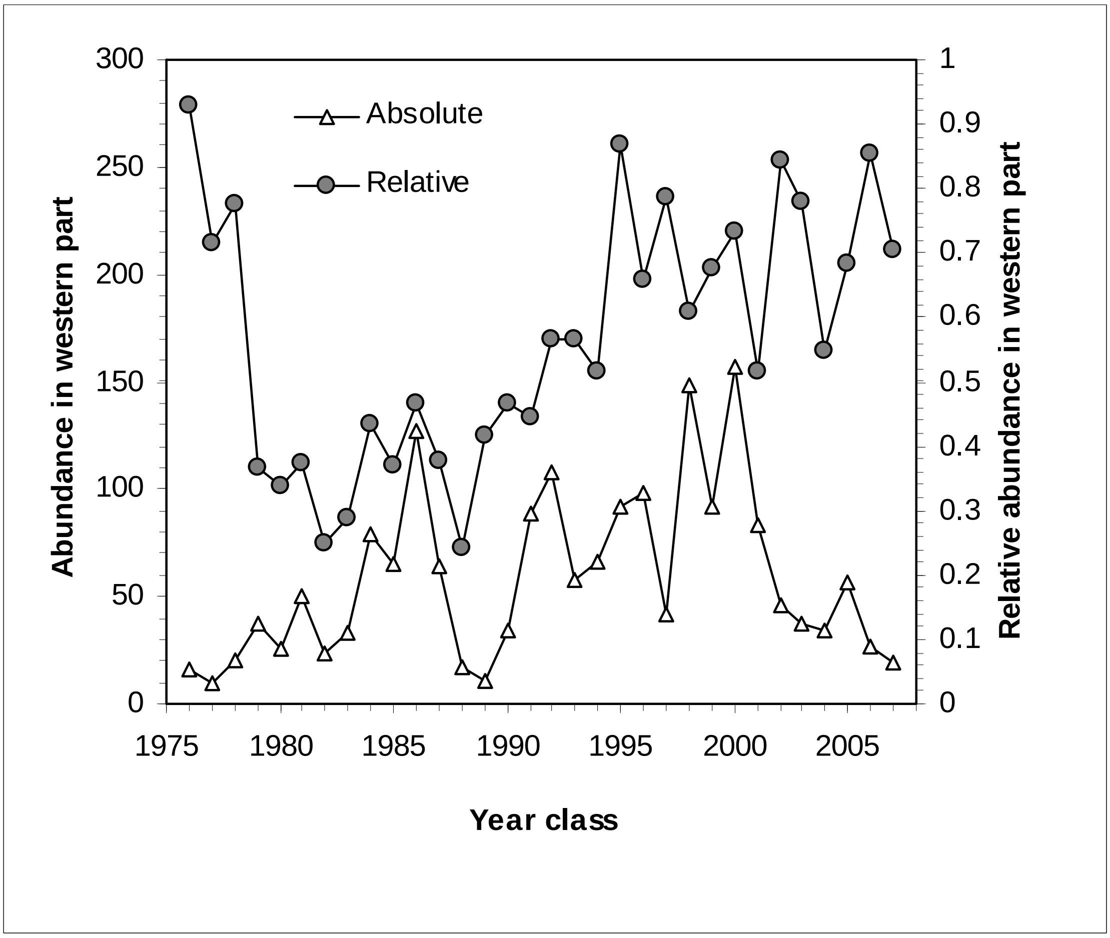


Figure 2.3.3.3 North Sea herring. Absolute (no * 10^9) and relative abundance of 0-ringers in the area west of 2°E in the North Sea. Abundances are based on MIK sampling during IBTS,the relative abundance in the western part is estimated as the number of 0-ringers west of 2°E relative to total number of 0-ringers.

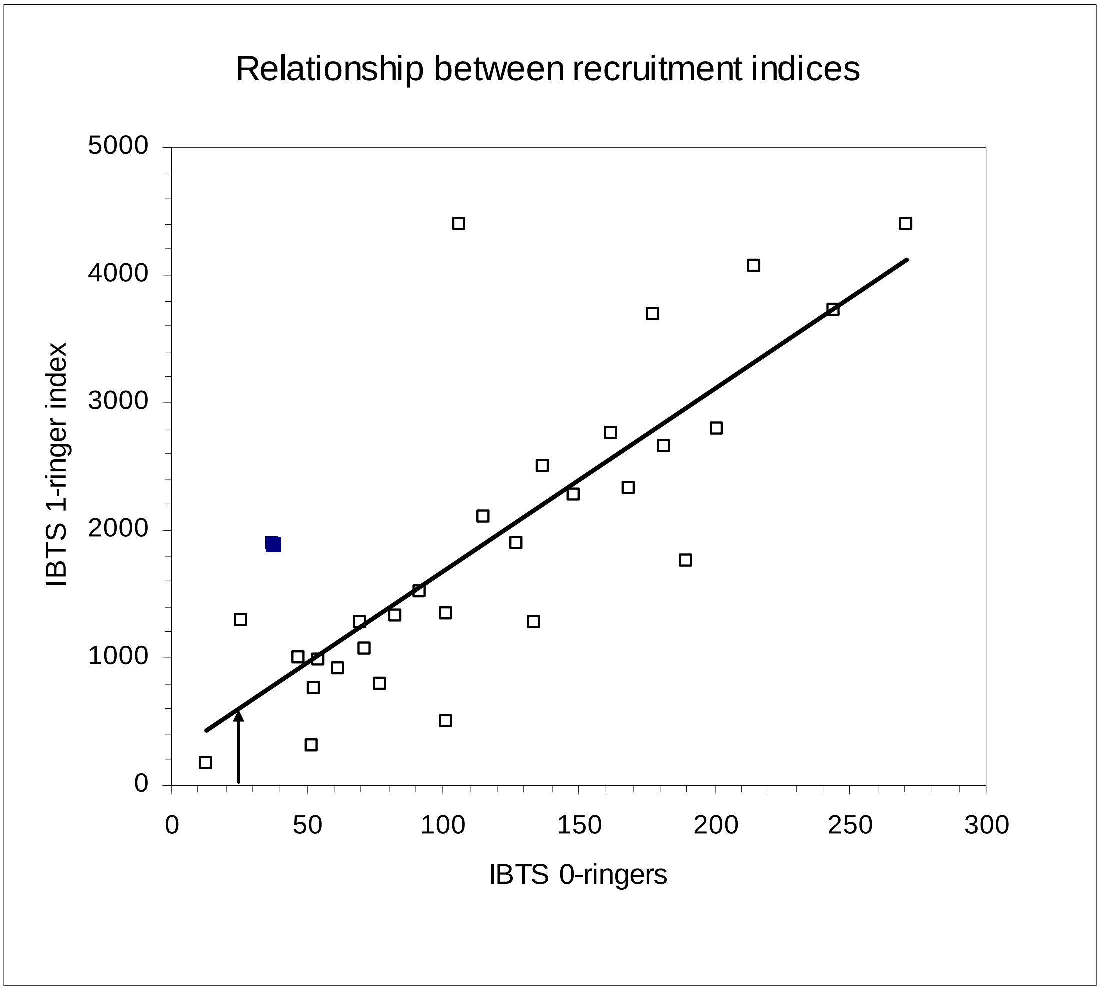


Figure 2.5.1 North Sea herring. Relationship between indices of 0-ringers and 1-ringers for year classes 1977 to 2006. The 2006 relation is shown as a filled square, the present 0-ringer index for year class 2007 is indicated by an arrow.

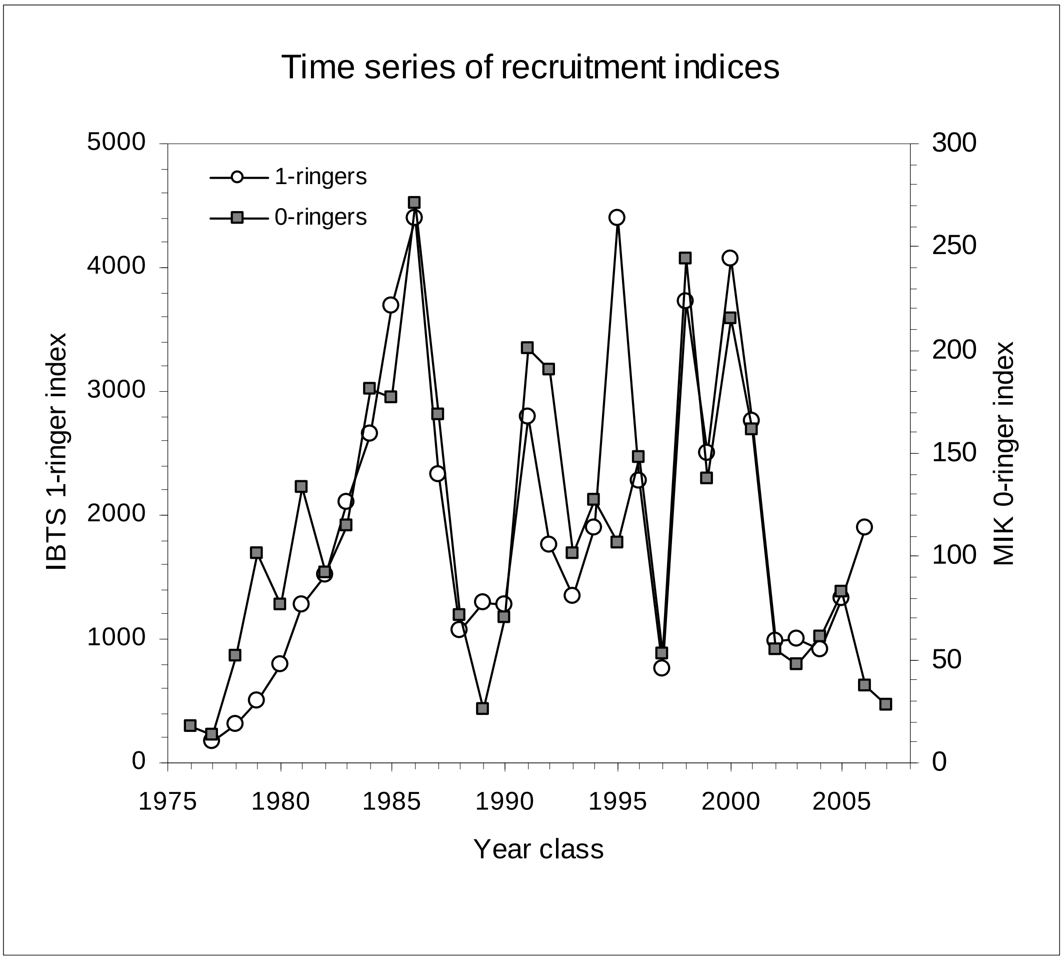


Figure 2.5.2 North Sea herring. Time series of 0-ringer and 1-ringer indices. Year classes 1976 to 2007 for 0-ringers, year classes 1977-2006 for 1-ringers.

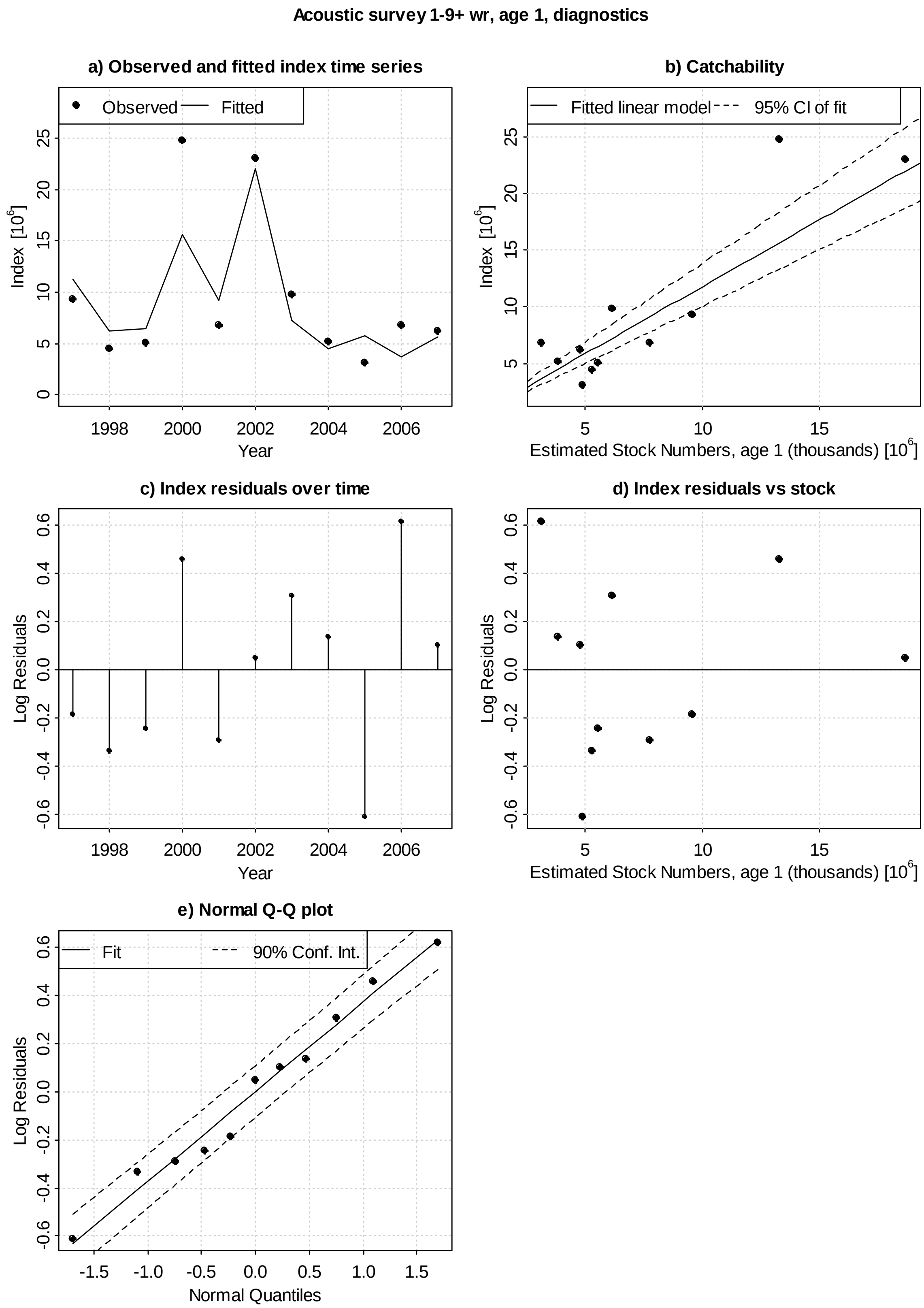


Figure 2.6.1. North Sea herring. Diagnostics of Acoustic survey catchability at 1 wr from the final ICA assessment. Top left: VPA estimates of numbers at 1 wr (line) and numbers predicted from index abundance at 1 wr. Top right: scatterplot of index observations versus VPA estimates of numbers at 1 wr with the best-fit catchability model (linear function). Middle right: log residuals of catchability model by VPA estimate of numbers at 1 wr. Middle left: log residuals of catchability model by year. Bottom left: normal Q-Q plot of log residuals.

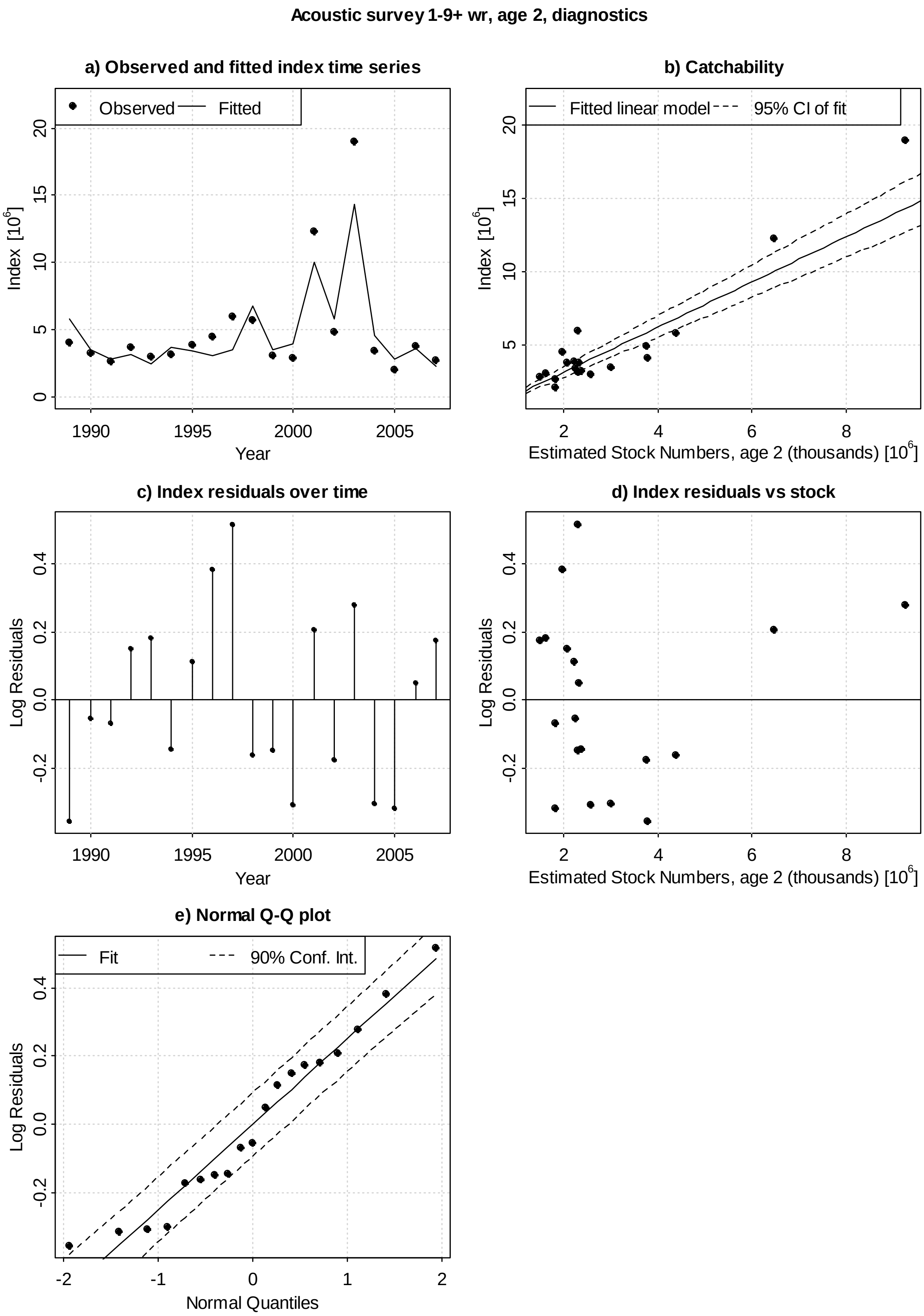


Figure 2.6.2. North Sea herring. Diagnostics of Acoustic survey catchability at 2 wr from the final ICA assessment. Top left: VPA estimates of numbers at 2 wr (line) and numbers predicted from index abundance at 2 wr. Top right: scatterplot of index observations versus VPA estimates of numbers at 2 wr with the best-fit catchability model (linear function). Middle right: log residuals of catchability model by VPA estimate of numbers at 2 wr. Middle left: log residuals of catchability model by year. Bottom left: normal Q-Q plot of log residuals.

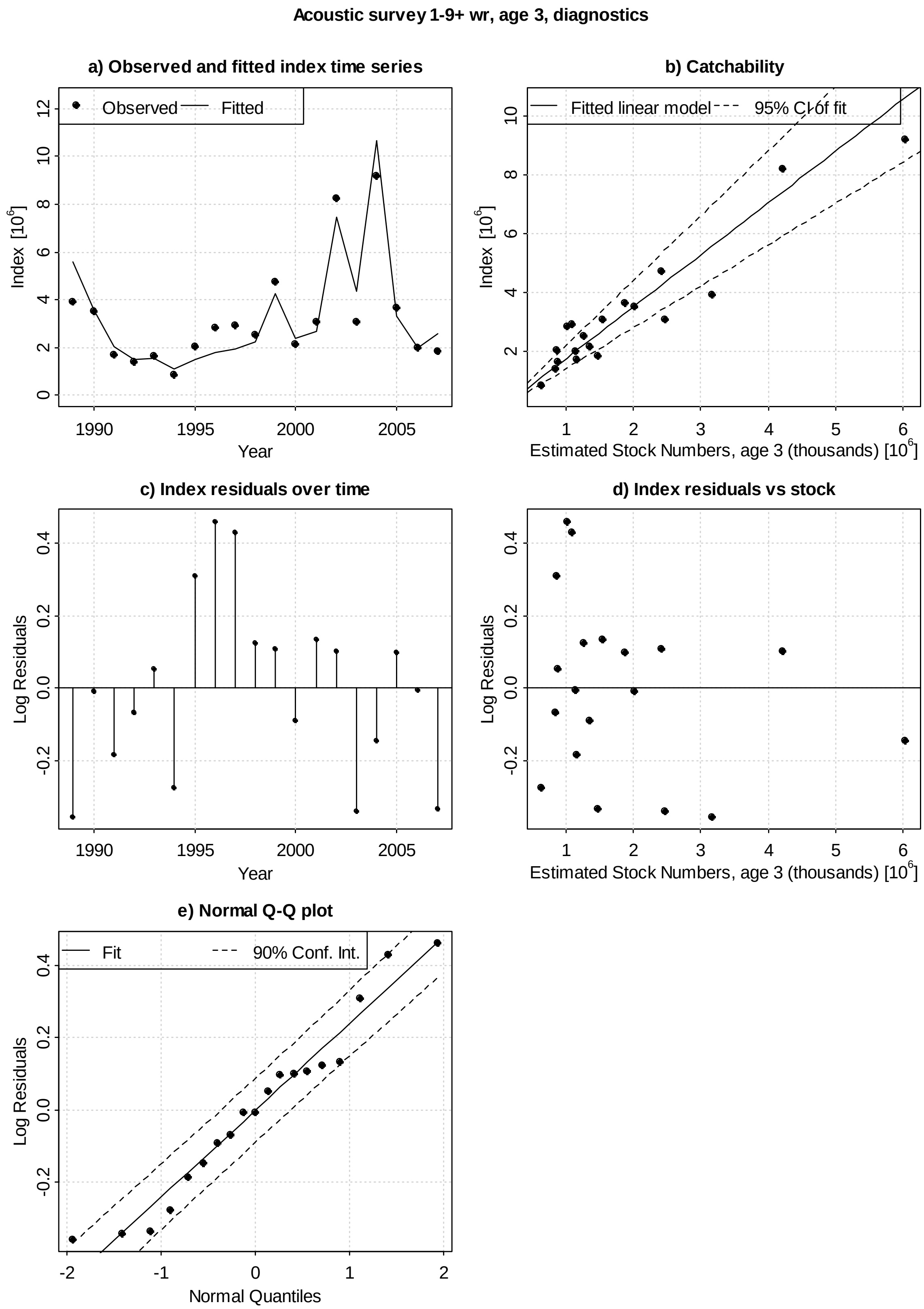


Figure 2.6.3. North Sea herring. Diagnostics of Acoustic survey catchability at 3 wr from the final ICA assessment. Top left: VPA estimates of numbers at 3 wr (line) and numbers predicted from index abundance at 3 wr . Top right: scatterplot of index observations versus VPA estimates of numbers at 3 wr with the best-fit catchability model (linear function). Middle right: log residuals of catchability model by VPA estimate of numbers at 3 wr. Middle left: log residuals of catchability model by year. Bottom left: normal Q-Q plot of log residuals.

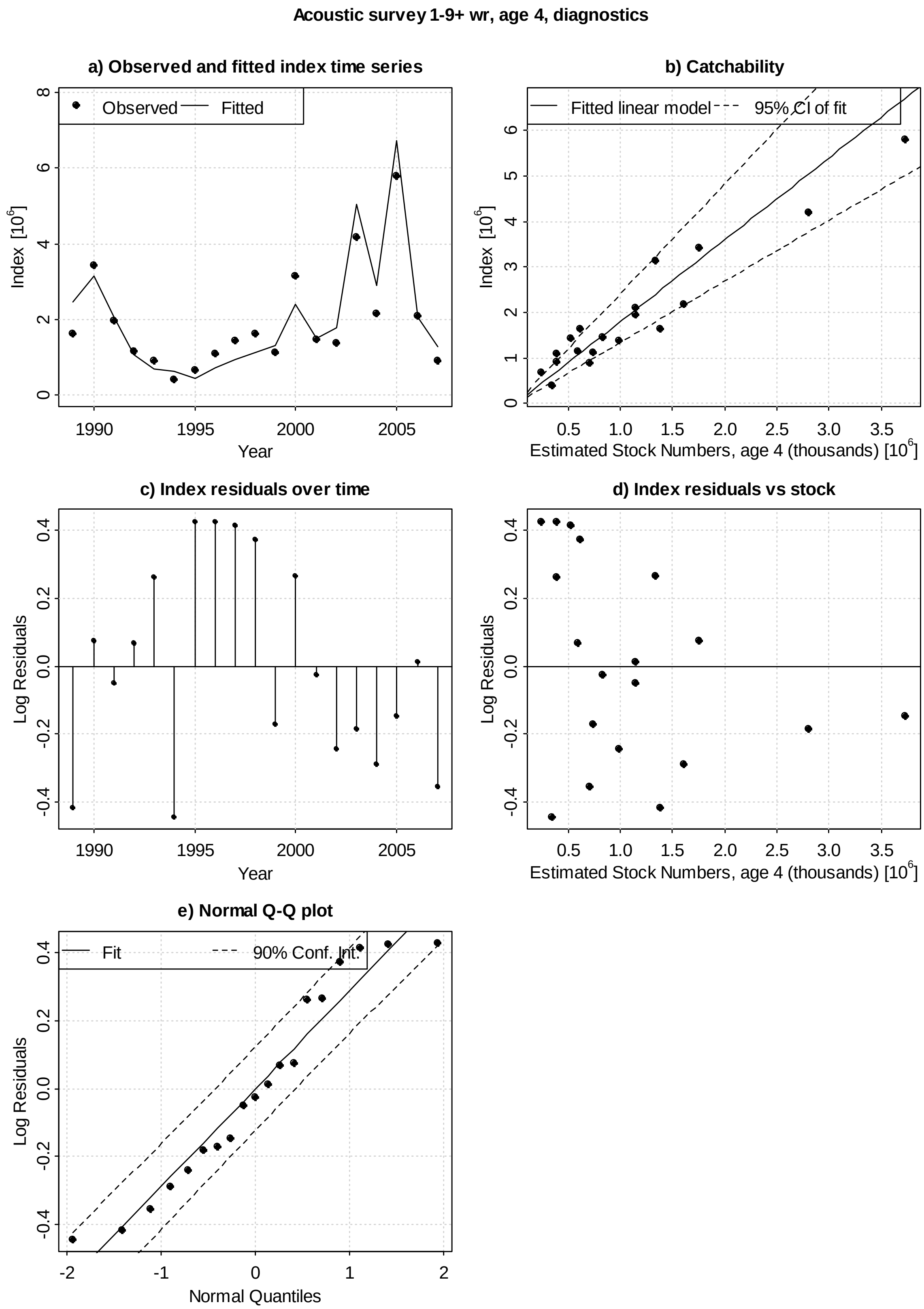


Figure 2.6.4. North Sea herring. Diagnostics of Acoustic survey catchability at 4 wr from the final ICA assessment. Top left: VPA estimates of numbers at 4 wr (line) and numbers predicted from index abundance at 4 wr. Top right: scatterplot of index observations versus VPA estimates of numbers at 4 wr with the best-fit catchability model (linear function). Middle right: log residuals of catchability model by VPA estimate of numbers at 4 wr. Middle left: log residuals of catchability model by year. Bottom left: normal Q-Q plot of log residuals.

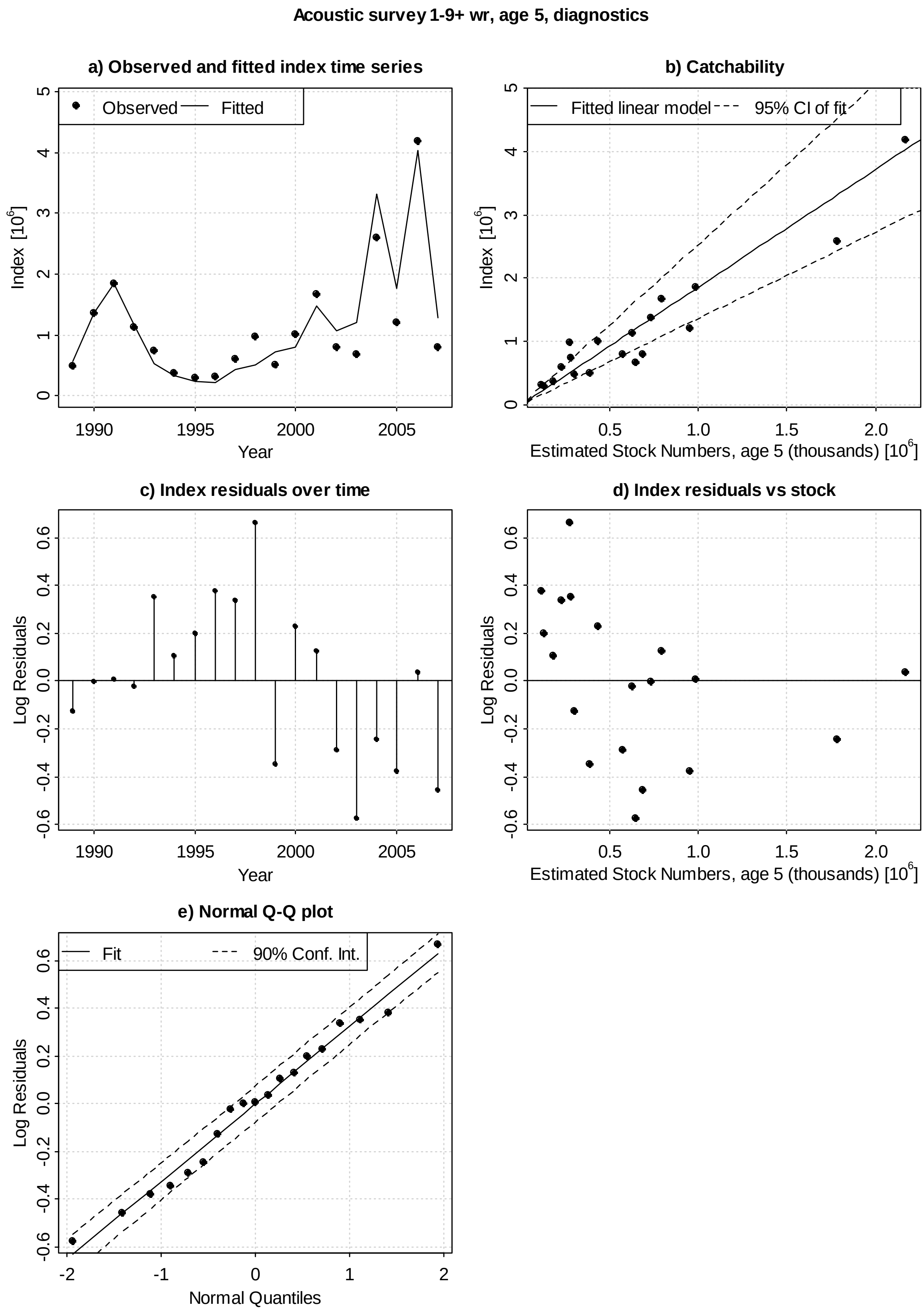


Figure 2.6.5. North Sea herring. Diagnostics of Acoustic survey catchability at 5 wr from the final ICA assessment. Top left: VPA estimates of numbers at 5 wr (line) and numbers predicted from index abundance at 5 wr. Top right: scatterplot of index observations versus VPA estimates of numbers at 5 wr with the best-fit catchability model (linear function). Middle right: log residuals of catchability model by VPA estimate of numbers at 5 wr. Middle left: log residuals of catchability model by year. Bottom left: normal Q-Q plot of log residuals.

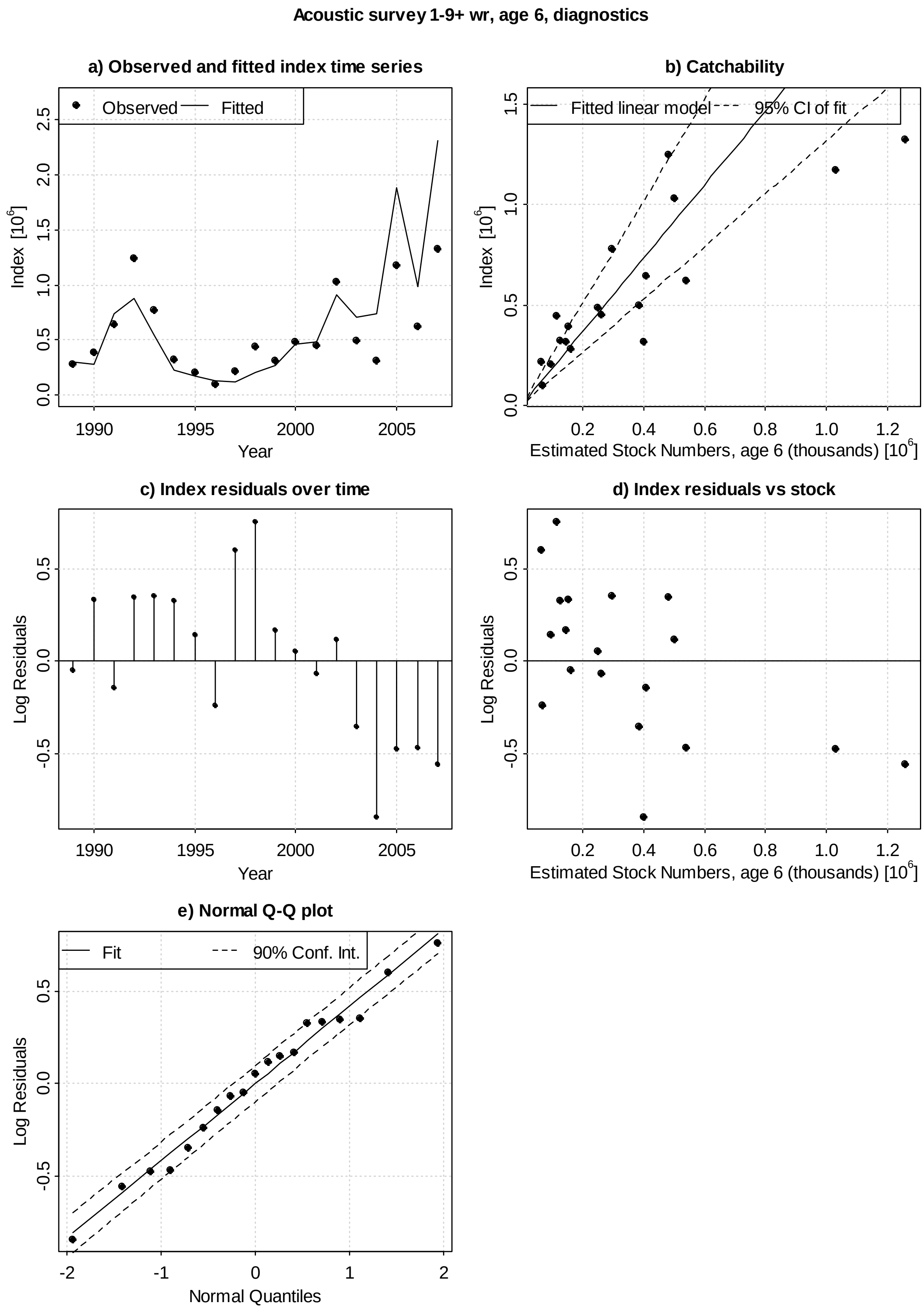


Figure 2.6.6. North Sea herring. Diagnostics of Acoustic survey catchability at 6 wr from the final ICA assessment. Top left: VPA estimates of numbers at 6 wr (line) and numbers predicted from index abundance at 6 wr. Top right: scatterplot of index observations versus VPA estimates of numbers at 6 wr with the best-fit catchability model (linear function). Middle right: log residuals of catchability model by VPA estimate of numbers at 6 wr. Middle left: log residuals of catchability model by year. Bottom left: normal Q-Q plot of log residuals.

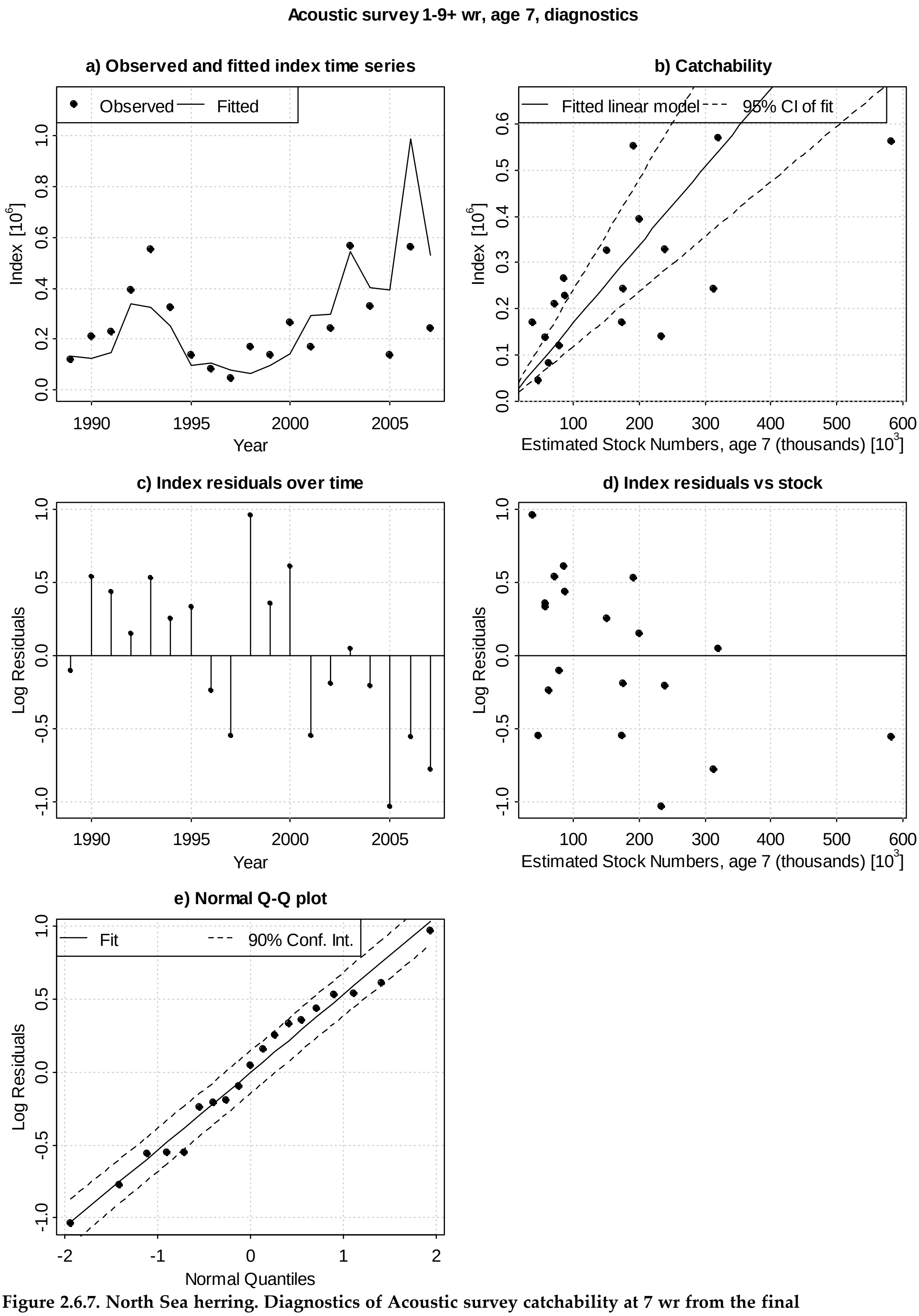


Figure 2.6.7. North Sea herring. Diagnostics of Acoustic survey catchability at 7 wr from the final ICA assessment. Top left: VPA estimates of numbers at 7 wr (line) and numbers predicted from index abundance at 7 wr. Top right: scatterplot of index observations versus VPA estimates of numbers at 7 wr with the best-fit catchability model (linear function). Middle right: log residuals of catchability model by VPA estimate of numbers at 7 wr. Middle left: log residuals of catchability model by year. Bottom left: normal Q-Q plot of log residuals.

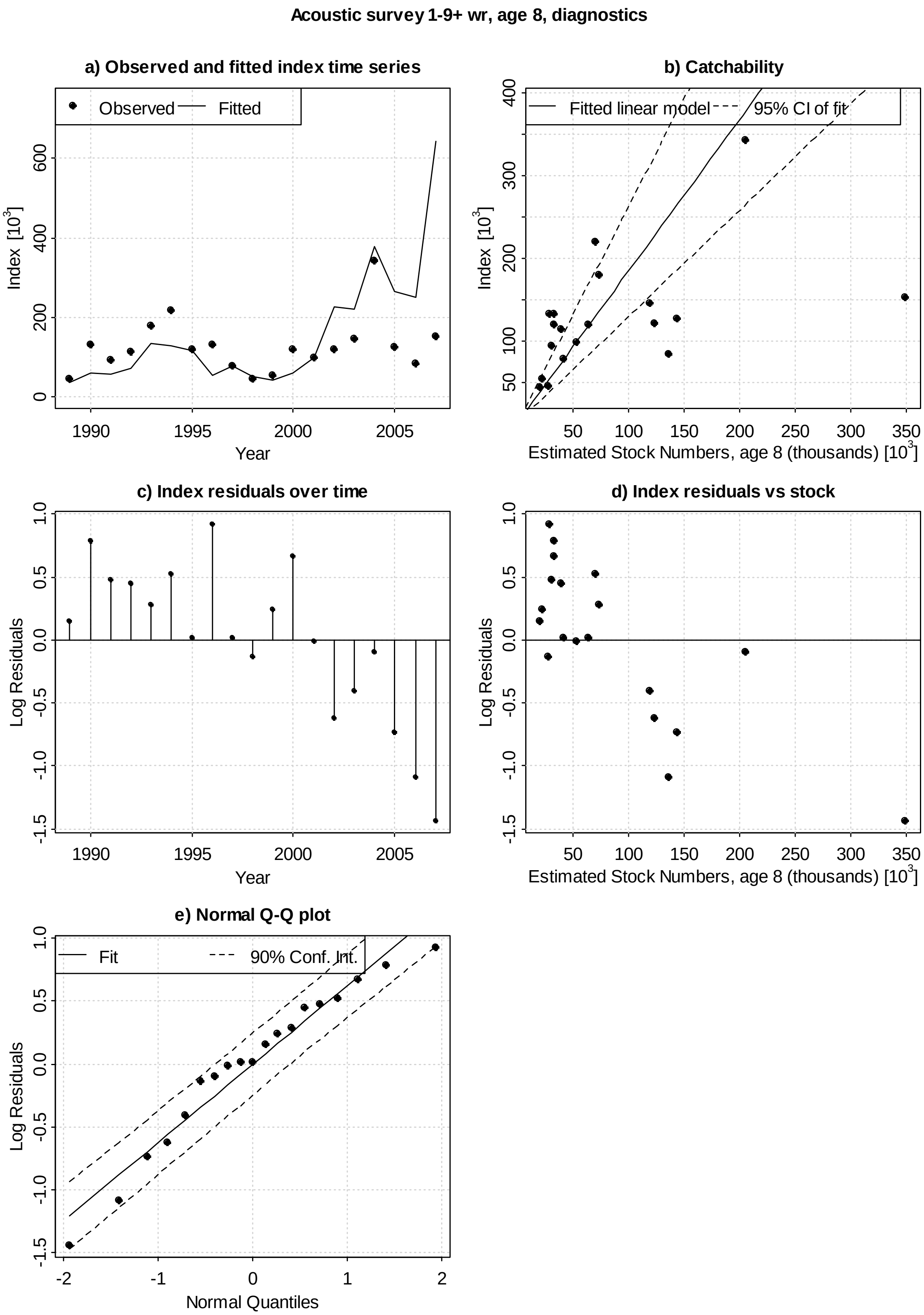


Figure 2.6.8. North Sea herring. Diagnostics of Acoustic survey catchability at 8 wr from the final ICA assessment. Top left: VPA estimates of numbers at 8 wr (line) and numbers predicted from index abundance at 8 wr. Top right: scatterplot of index observations versus VPA estimates of numbers at 8 wr with the best-fit catchability model (linear function). Middle right: log residuals of catchability model by VPA estimate of numbers at 8 wr. Middle left: log residuals of catchability model by year. Bottom left: normal Q-Q plot of log residuals.

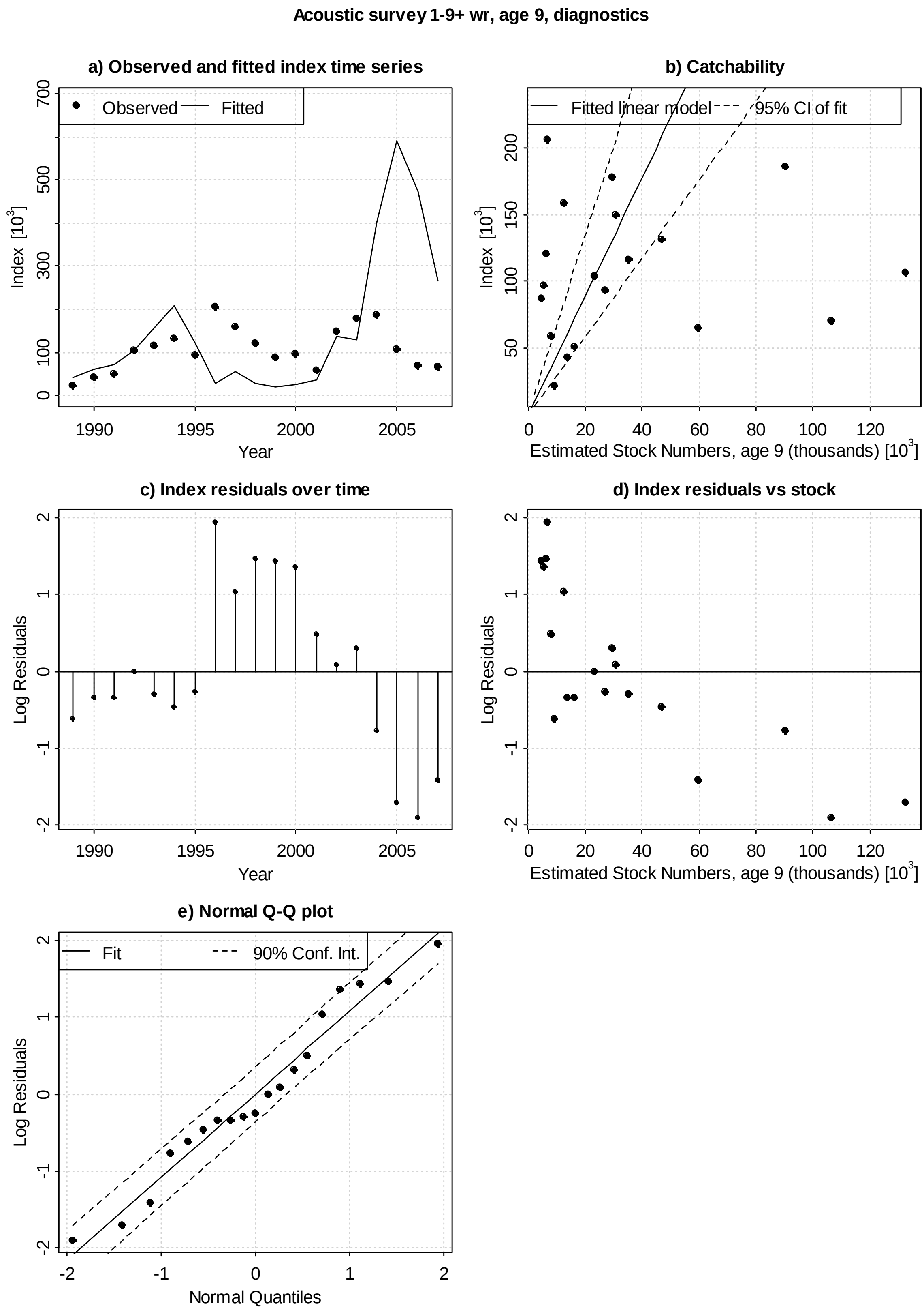


Figure 2.6.9. North Sea herring. Diagnostics of Acoustic survey catchability at 9+ wr from the final ICA assessment. Top left: VPA estimates of numbers at 9+ wr (line) and numbers predicted from index abundance at 9+ wr. Top right: scatterplot of index observations versus VPA estimates of numbers at 9+ wr with the best-fit catchability model (linear function). Middle right: log residuals of catchability model by VPA estimate of numbers at 9+ wr. Middle left: log residuals of catchability model by year. Bottom left: normal Q-Q plot of log residuals.

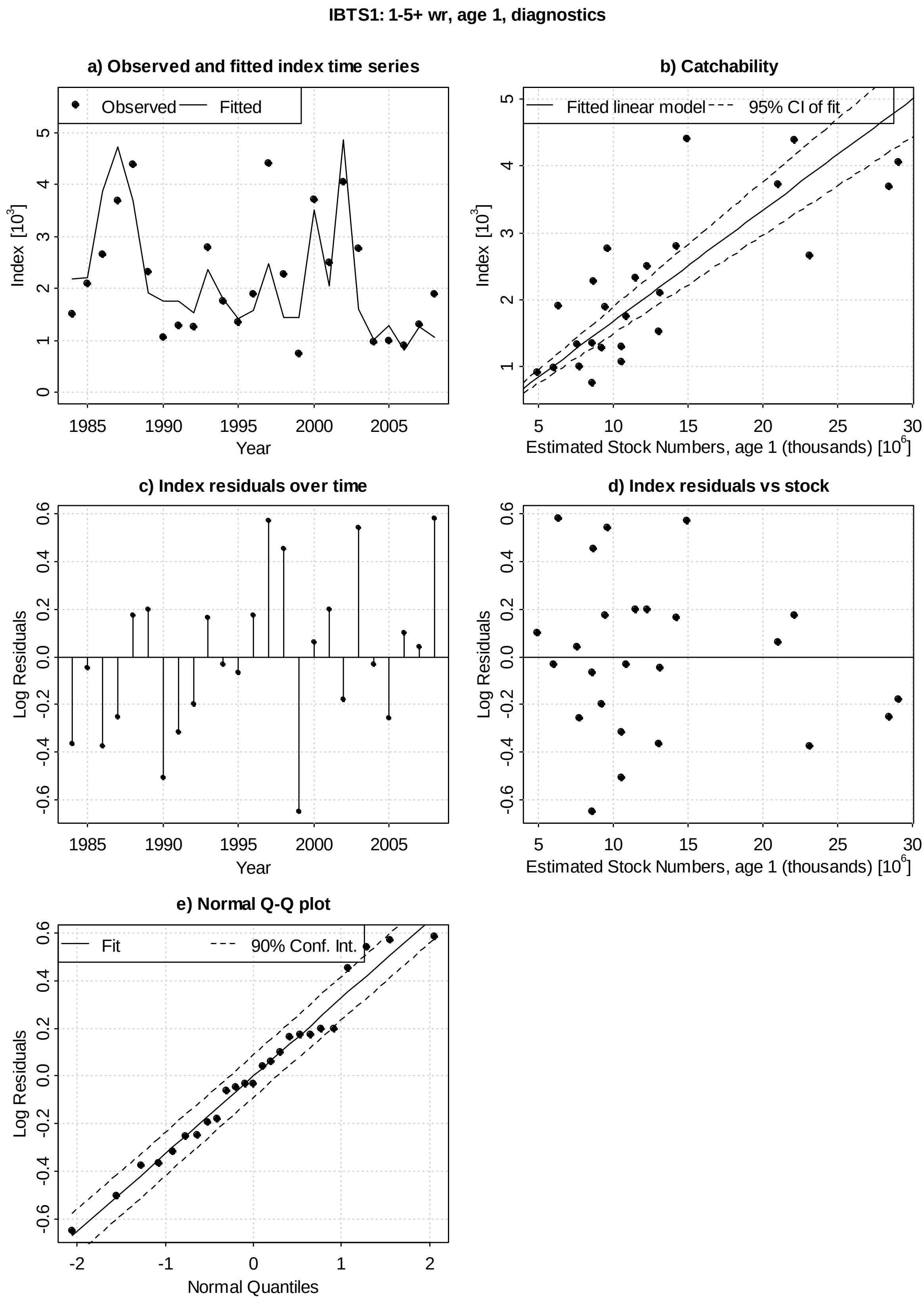


Figure 2.6.10. North Sea herring. Diagnostics of IBTS survey catchability at 1 wr from the final ICA assessment. Top left: VPA estimates of numbers at 1 wr (line) and numbers predicted from index abundance at 1 wr. Top right: scatterplot of index observations versus VPA estimates of numbers at 1 wr with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

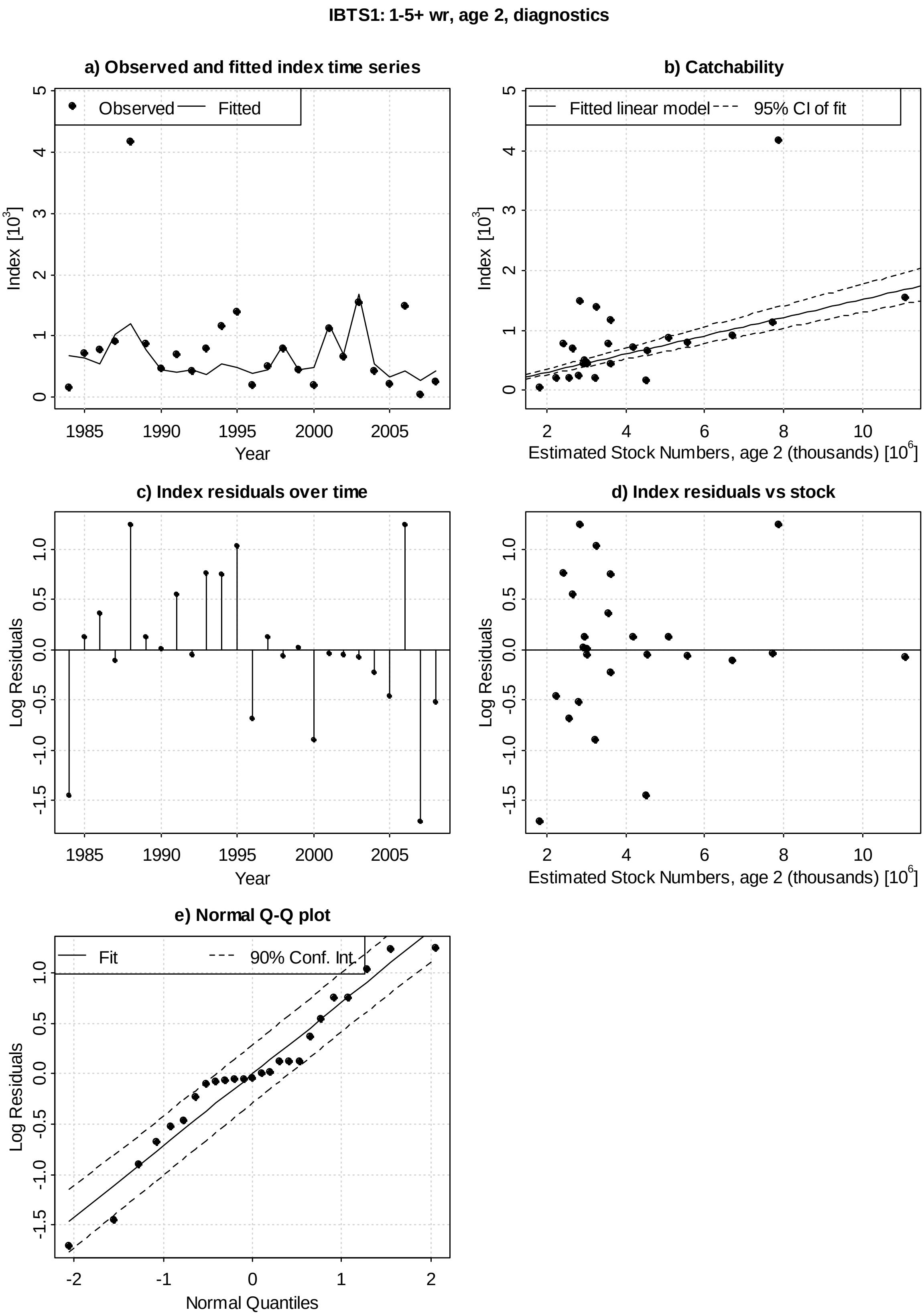


Figure 2.6.11. North Sea herring. Diagnostics of IBTS survey catchability at 2 wr from the final ICA assessment. Top left: VPA estimates of numbers at 2 wr (line) and numbers predicted from index abundance at 2 wr. Top right: scatterplot of index observations versus VPA estimates of numbers at 2 wr with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

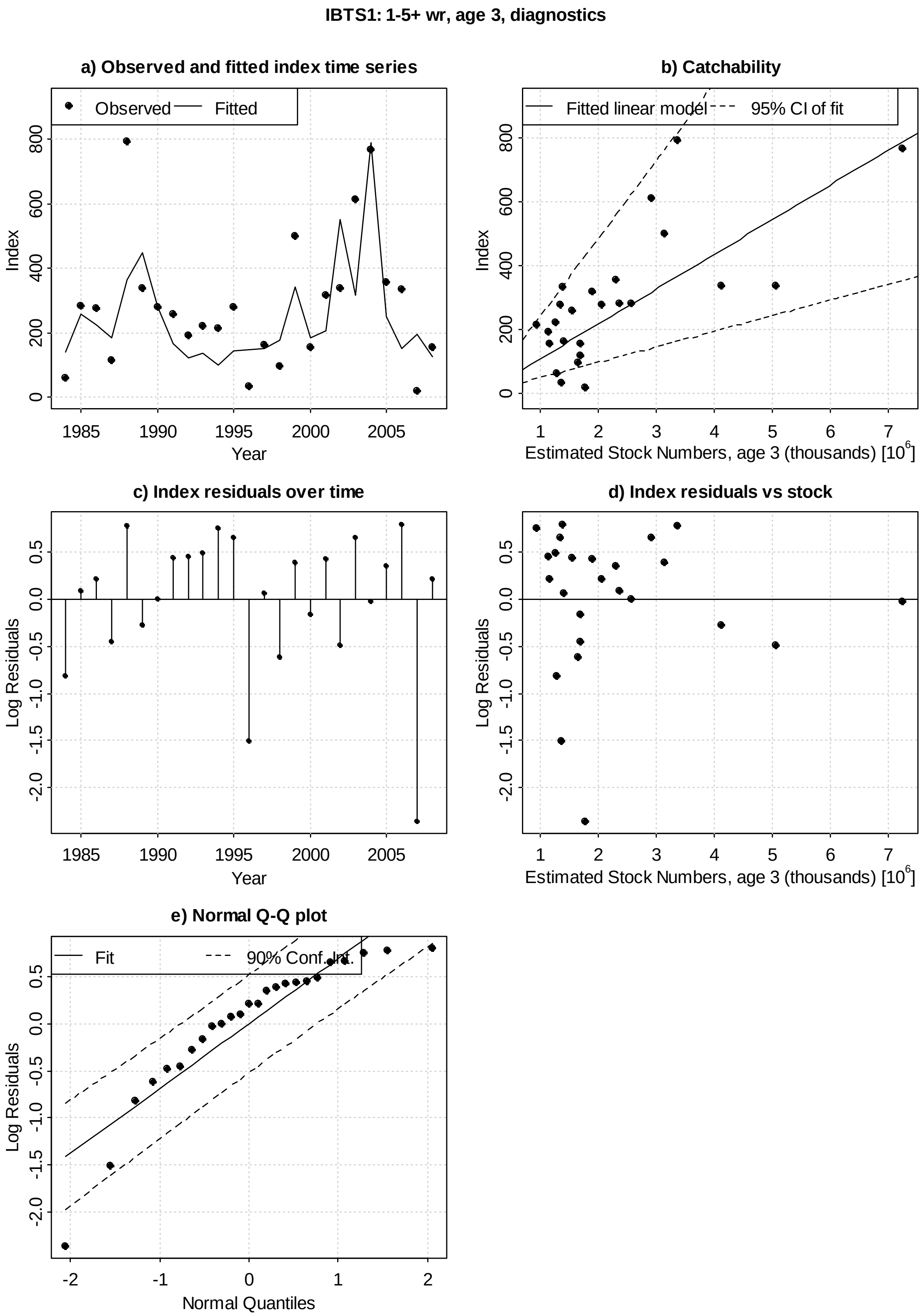


Figure 2.6.12. North Sea herring. Diagnostics of IBTS survey catchability at 3 wr from the final ICA assessment. Top left: VPA estimates of numbers at 3 wr (line) and numbers predicted from index abundance at 3 wr. Top right: scatterplot of index observations versus VPA estimates of numbers at 3 wr with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

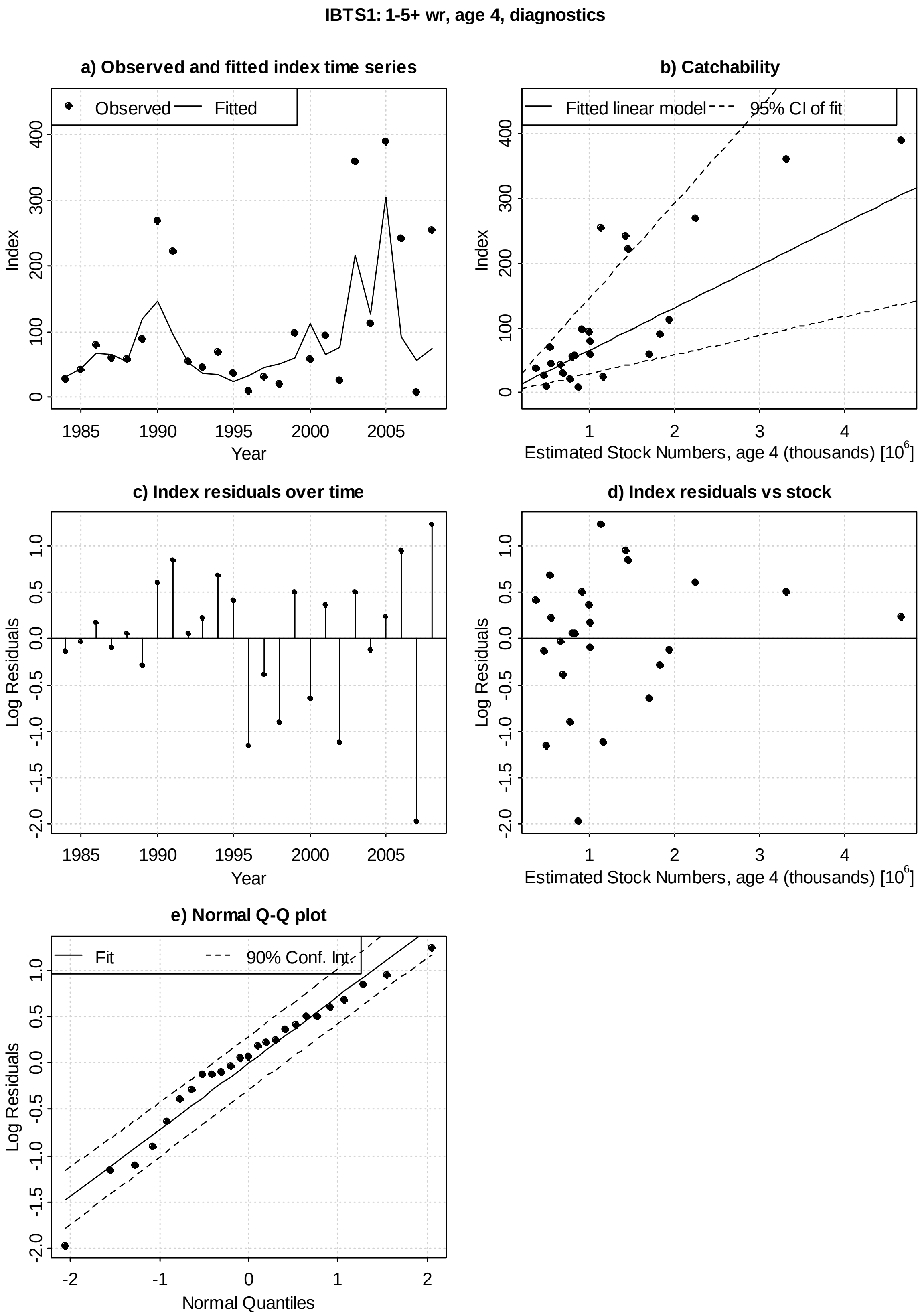


Figure 2.6.13. North Sea herring. Diagnostics of IBTS survey catchability at 4 wr from the final ICA assessment. Top left: VPA estimates of numbers at 4 wr (line) and numbers predicted from index abundance at 4 wr. Top right: scatterplot of index observations versus VPA estimates of numbers at 4 wr with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

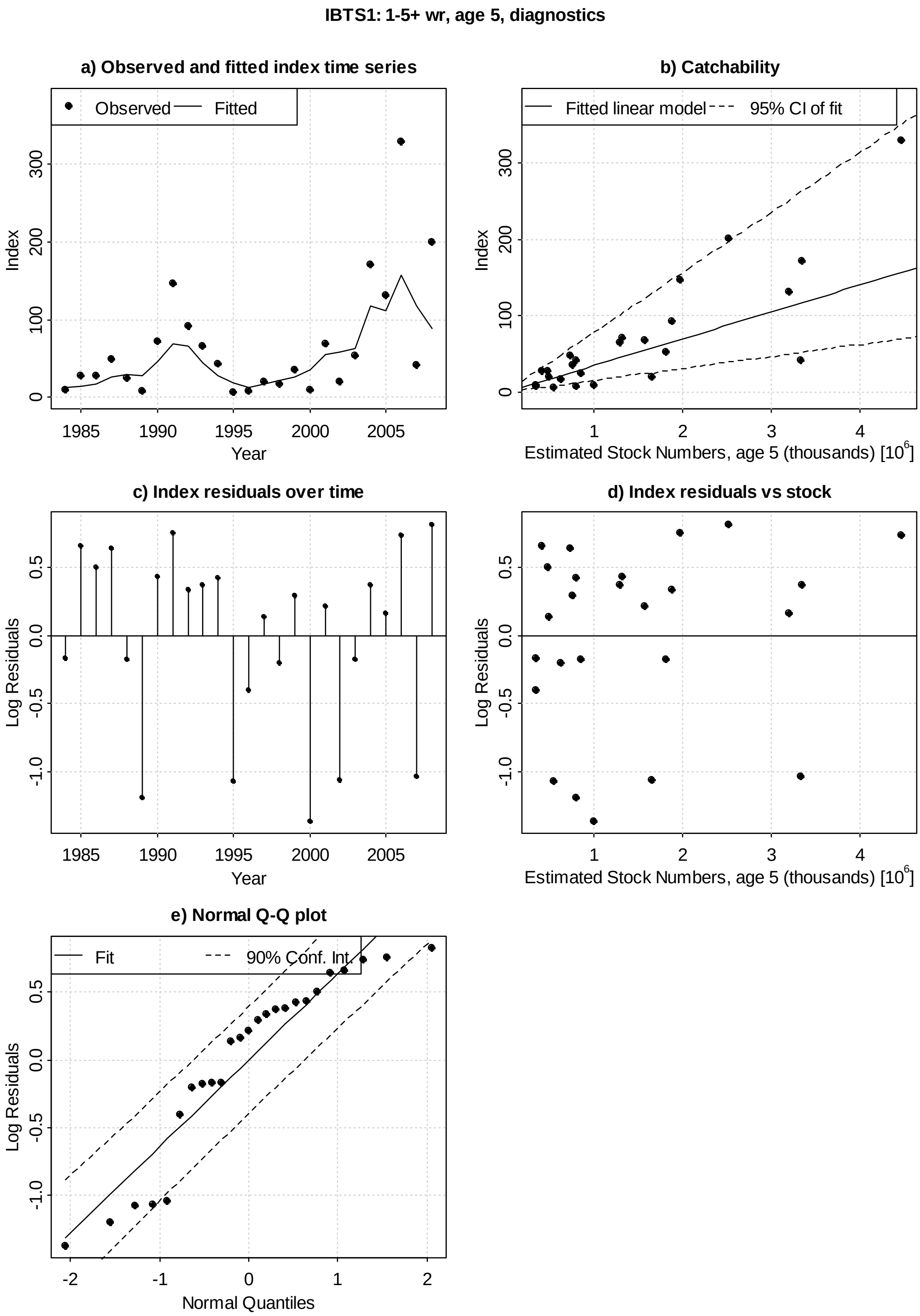


Figure 2.6.14. North Sea herring. Diagnostics of IBTS survey catchability at 5+ wr from the final ICA assessment. Top left: VPA estimates of numbers at 5+ wr (line) and numbers predicted from index abundance at 5+ wr. Top right: scatterplot of index observations versus VPA estimates of numbers at 5+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

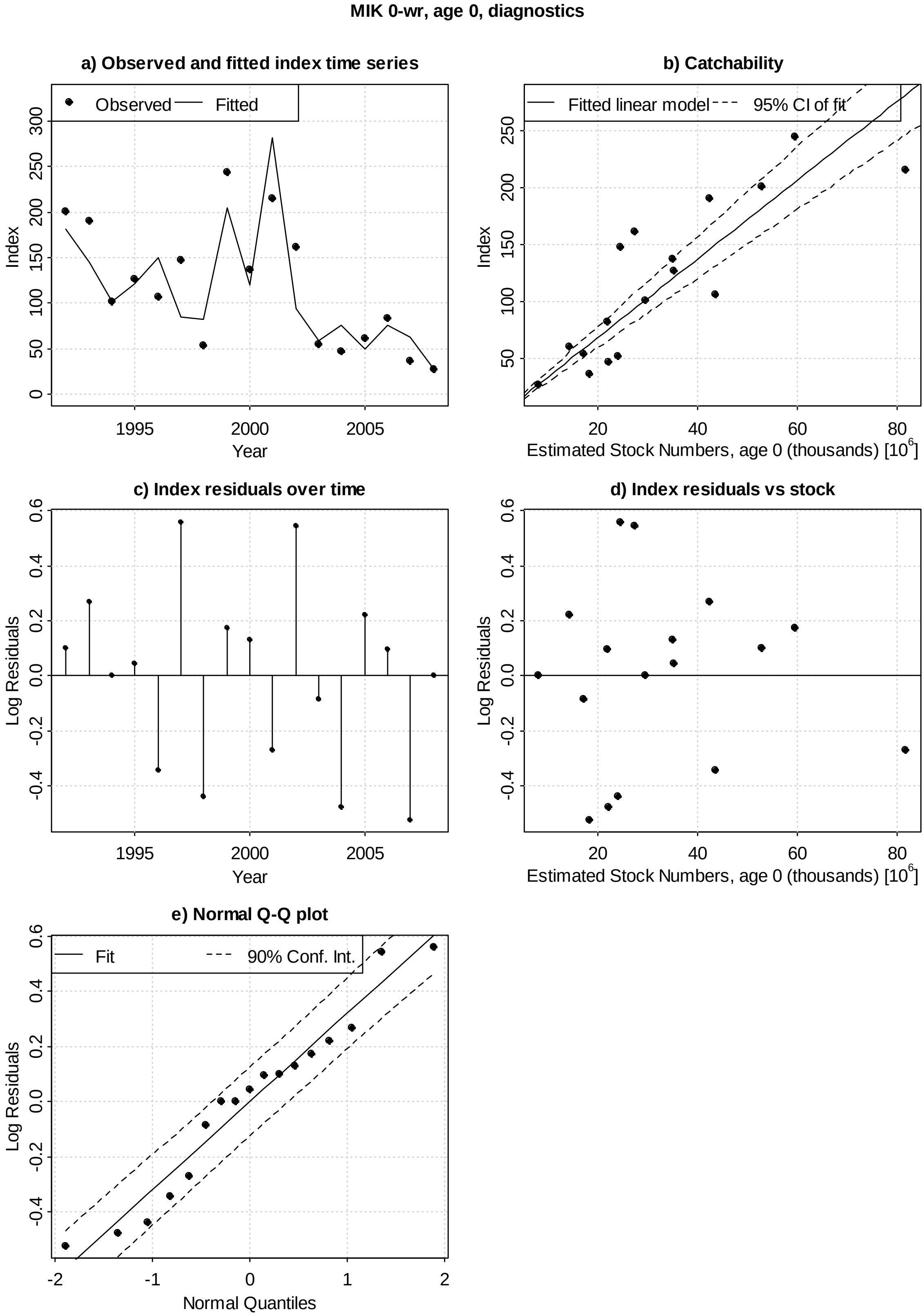


Figure 2.6.15. North Sea herring. Diagnostics of MIK survey catchability at 0 wr from the final ICA assessment. Top left: VPA estimates of numbers at 0 wr (line) and numbers predicted from index abundance at 0 wr. Top right: scatterplot of index observations versus VPA estimates of numbers at 0 wr with the best-fit catchability model (linear function). Middle right: log residuals of catchability model by VPA estimate of numbers at 0 wr. Middle left: log residuals of catchability model by year. Bottom left: normal Q-Q plot of log residuals.

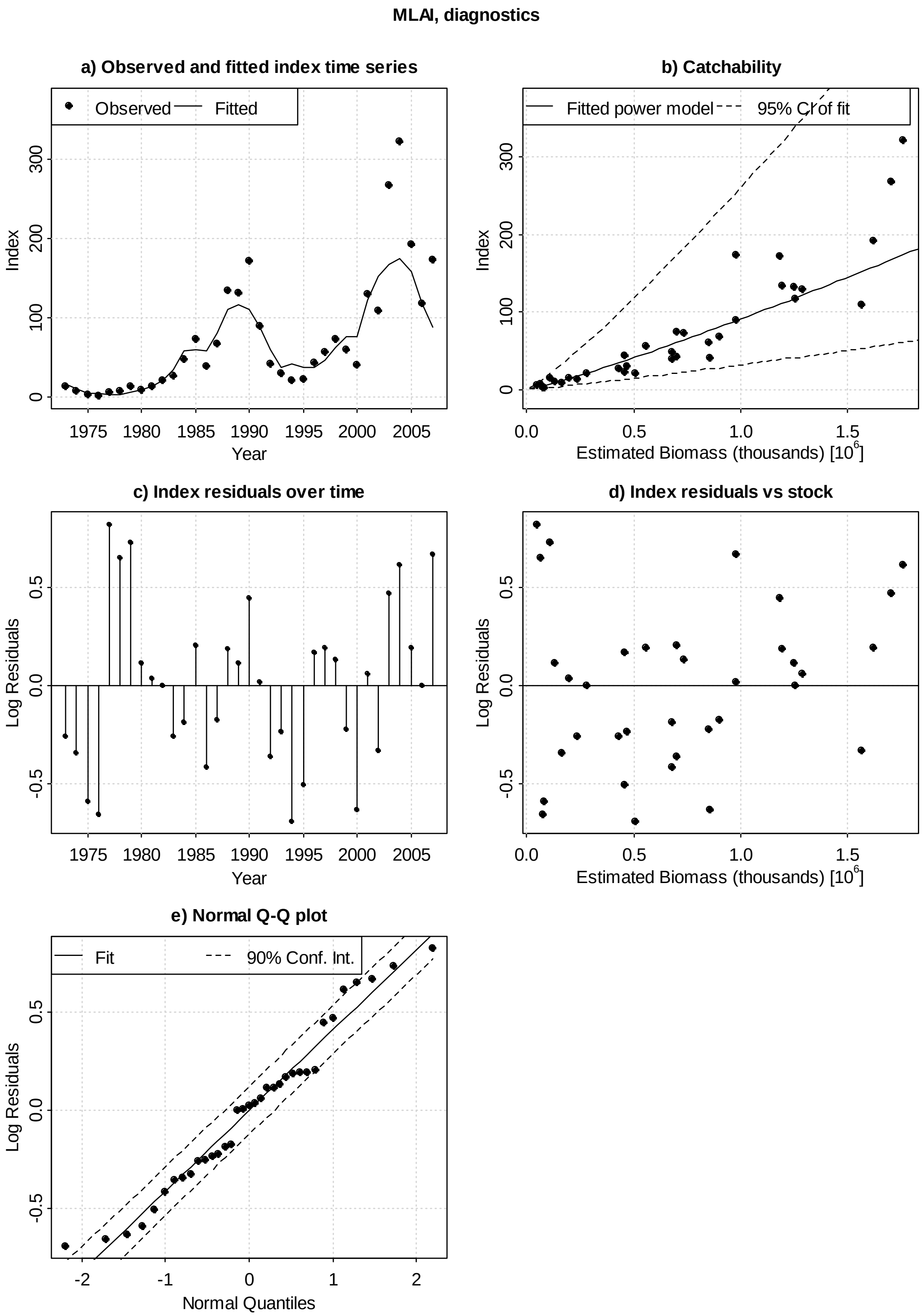


Figure 2.6.16. North Sea herring. Diagnostics of MLAI survey catchability at all ages from the final ICA assessment. Top left: VPA estimates of biomass of all ages and biomass predicted from index abundance for all ages. Top right: scatterplot of index observations versus VPA estimates of all ages with the best-fit catchability model (power function). Middle left: log residuals of catchability model by VPA estimate of numbers at 0 wr. Middle right: log residuals of catchability model by year. Bottom left: normal Q-Q plot of log residuals.

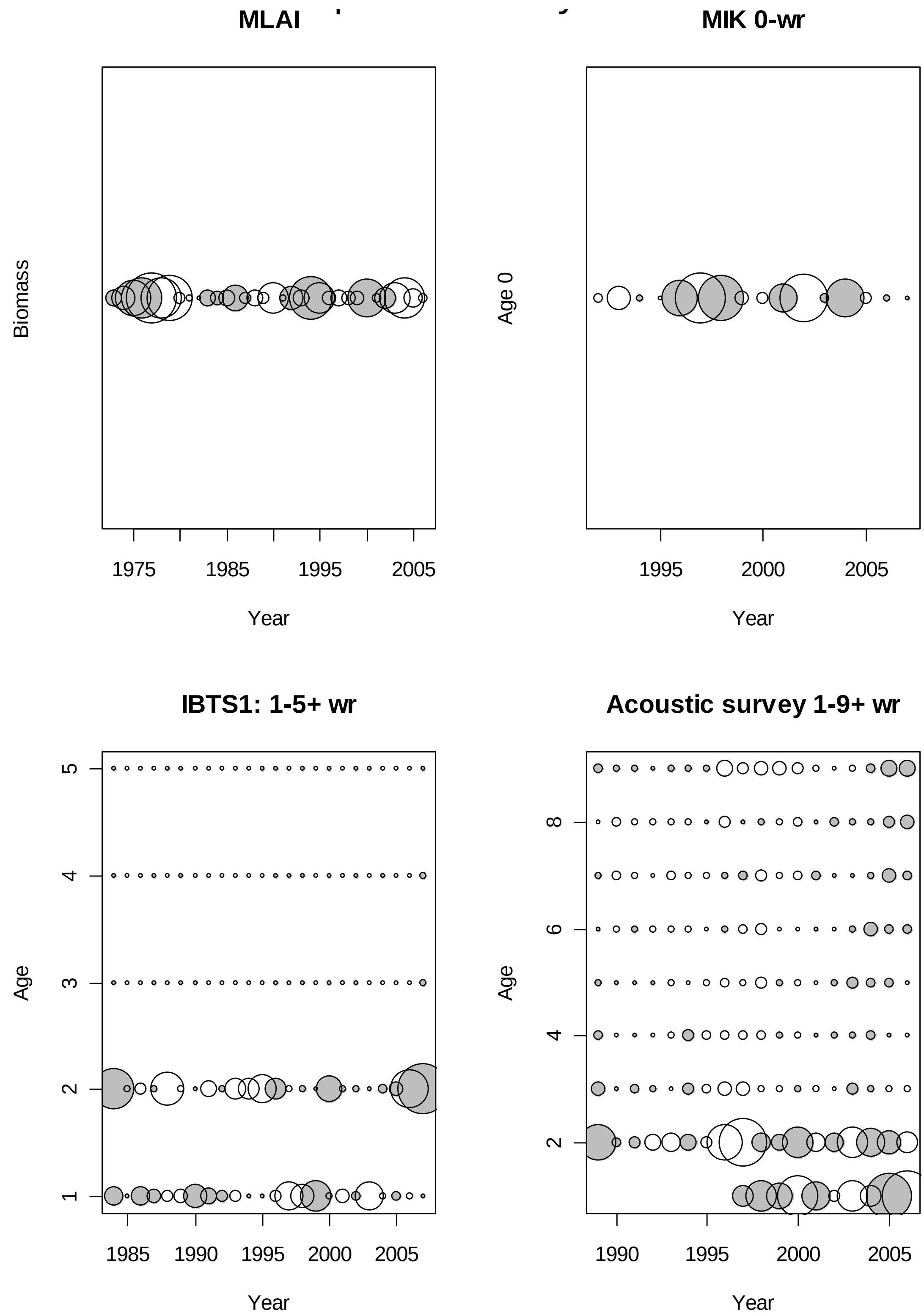


Figure 2.6.17. North Sea herring. Residuals of surveys for the assessment up to 2007.

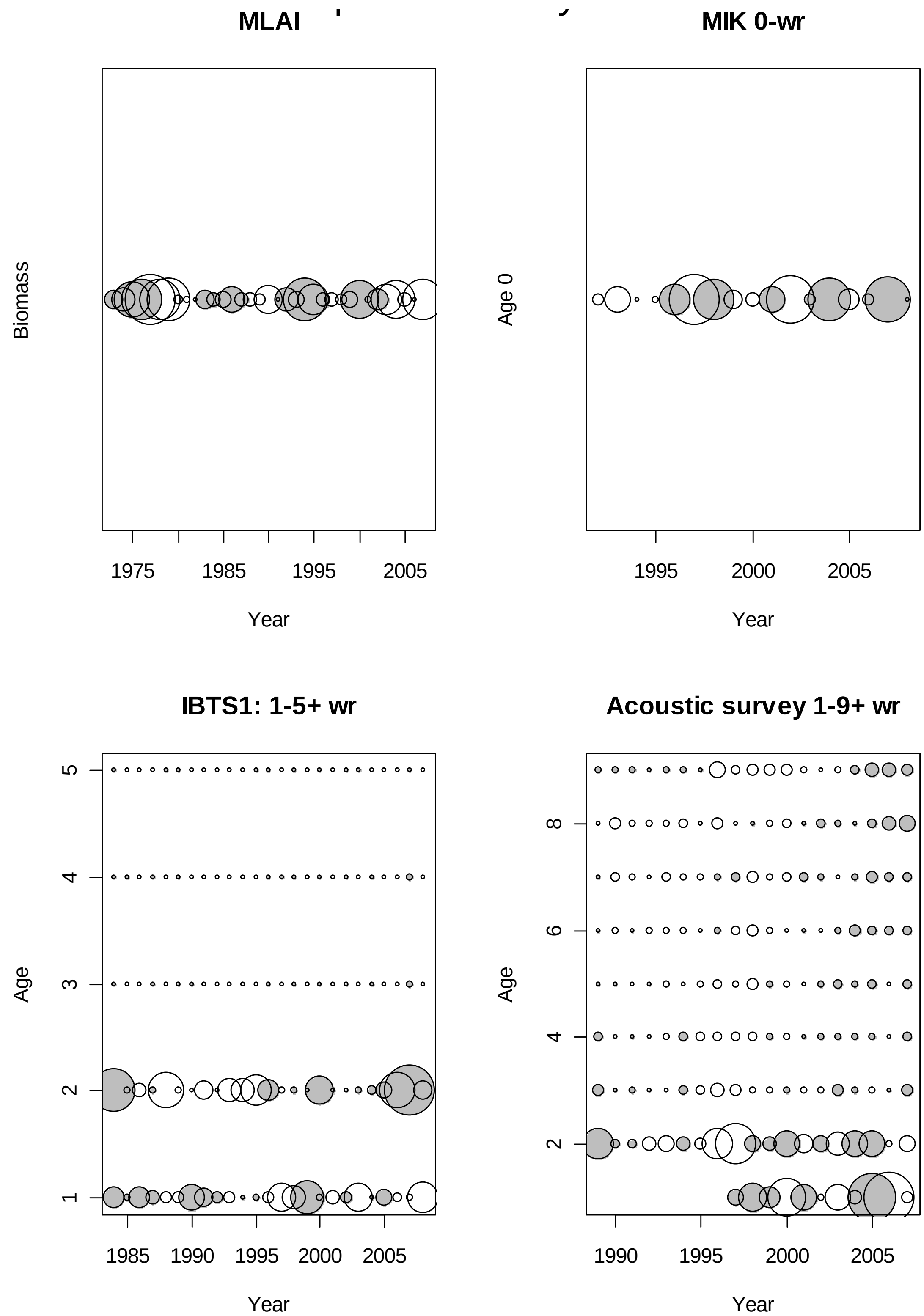


Figure 2.6.18. North Sea herring. Residuals of surveys for the assessment up to 2008.

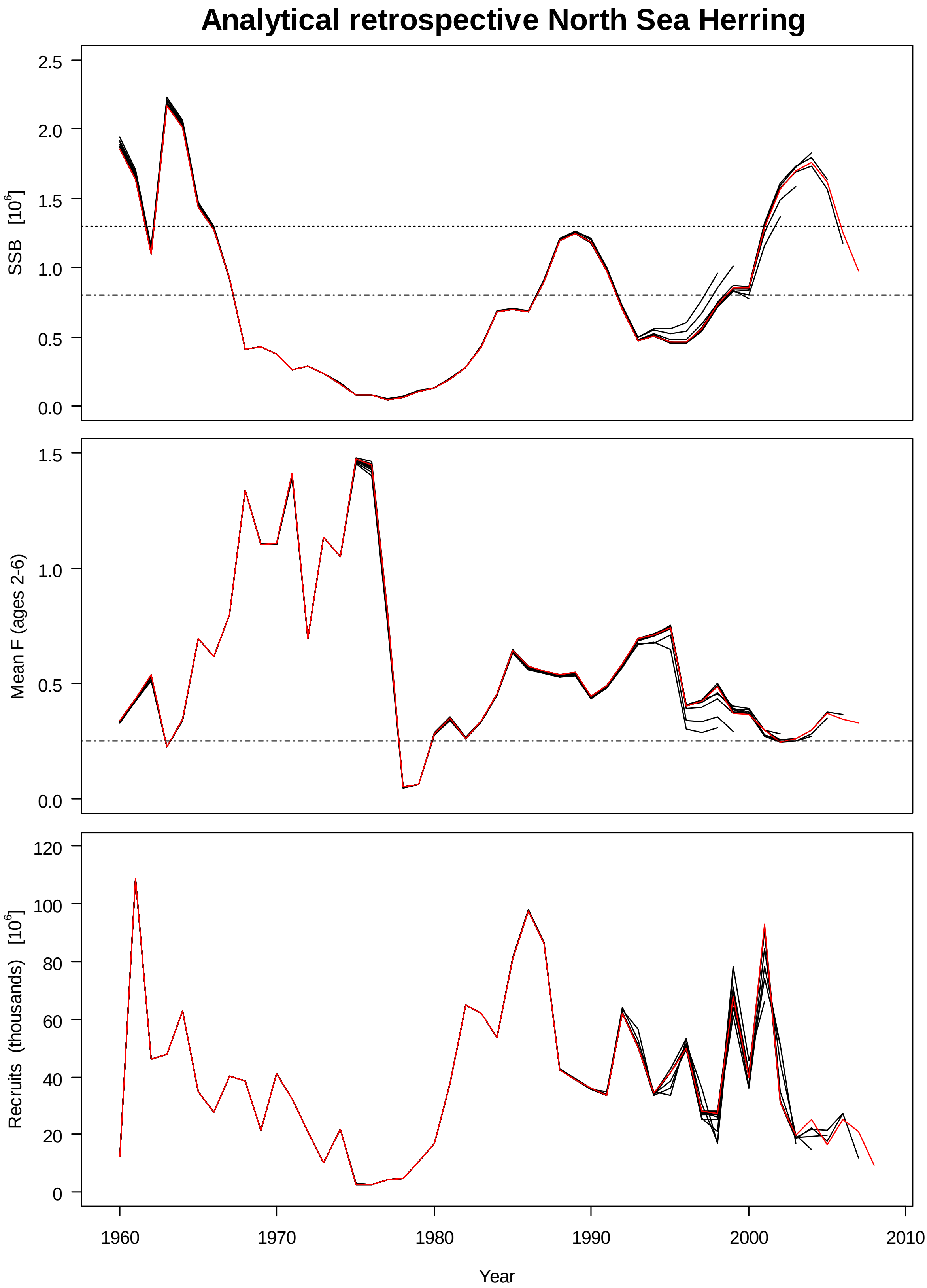


Figure 2.6.19. North Sea herring. Retrospective ICA plots for SSB, mean F on ages 2-6, and recruitment.

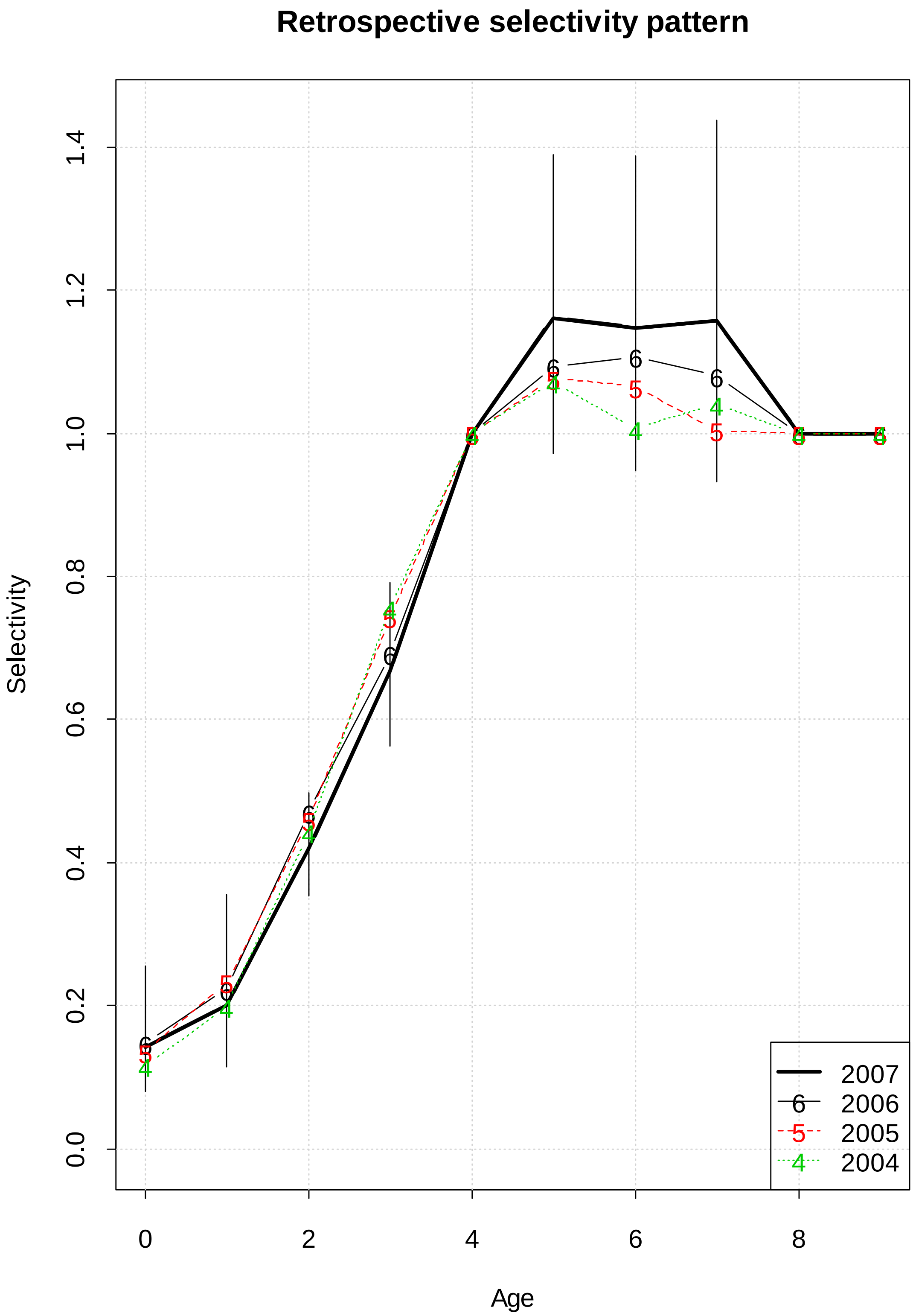


Figure 2.6.20. North Sea herring. Retrospective selection pattern from the ICA assessment model.

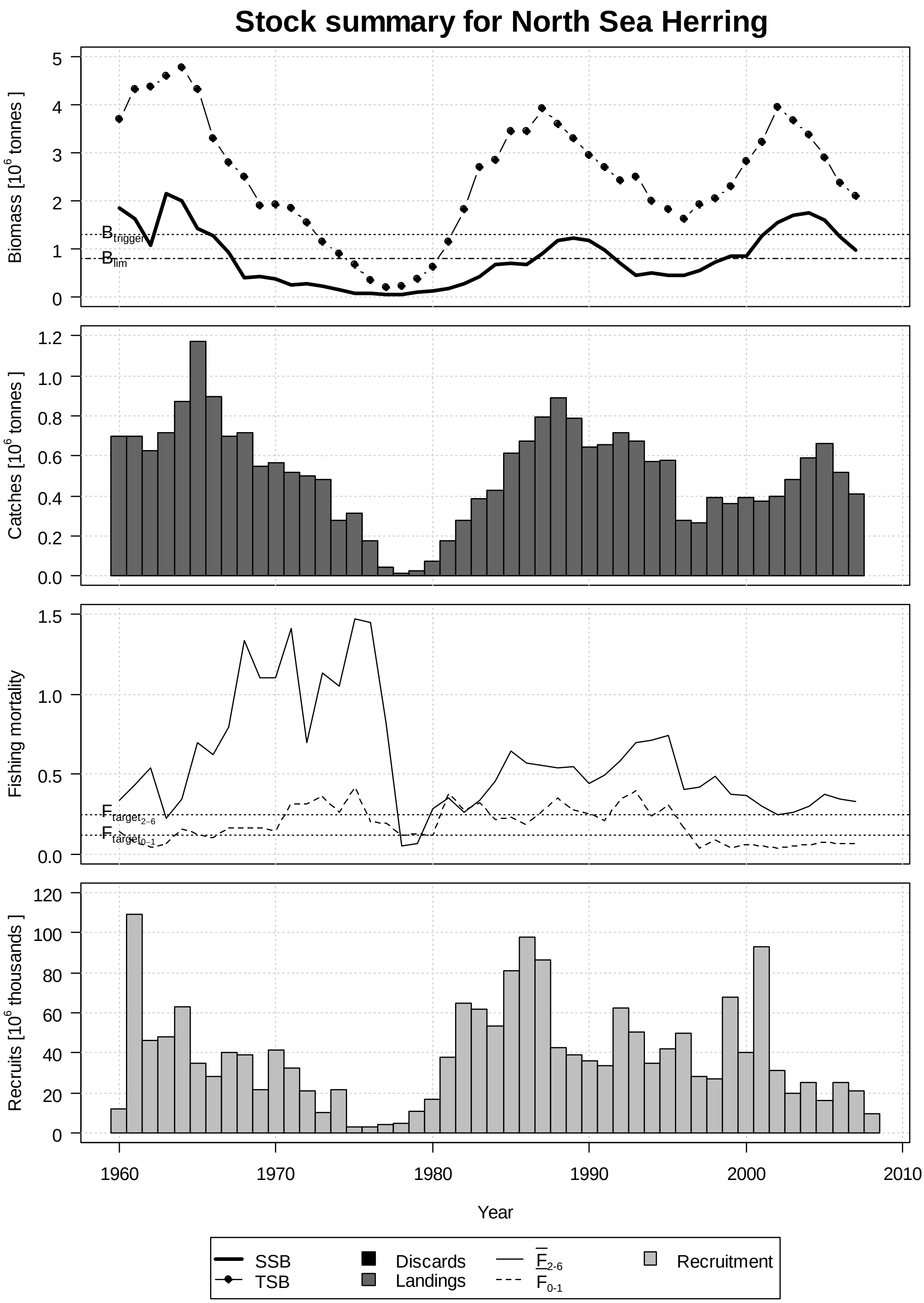


Figure 2.6.21. North Sea herring. Stock summary plot for SSB and TSB, catches, mean F on ages 2-6 and 0-1, and recruitment.

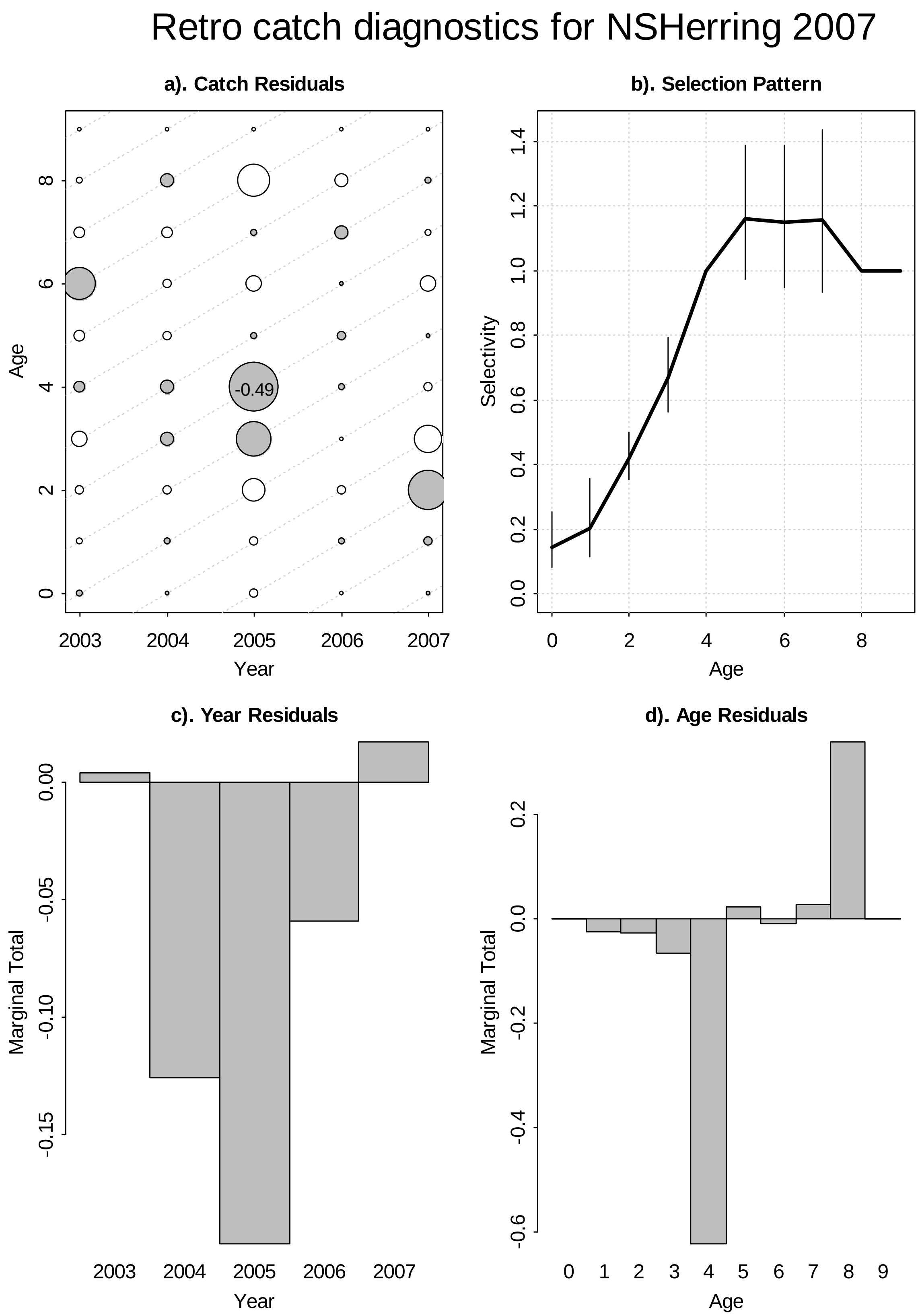


Figure 2.6.22. North Sea herring. Diagnostics of selection pattern from the final ICA assessment. Top left: bubbles plot of log catch residuals by age (weighting applied) and year (5 yr separable period). Top right: estimated selection parameters (relative to 4 wr) with 95% confidence intervals. Bottom left: marginal totals of log residuals by year. Bottom right: marginal totals of log residuals by age (wr).

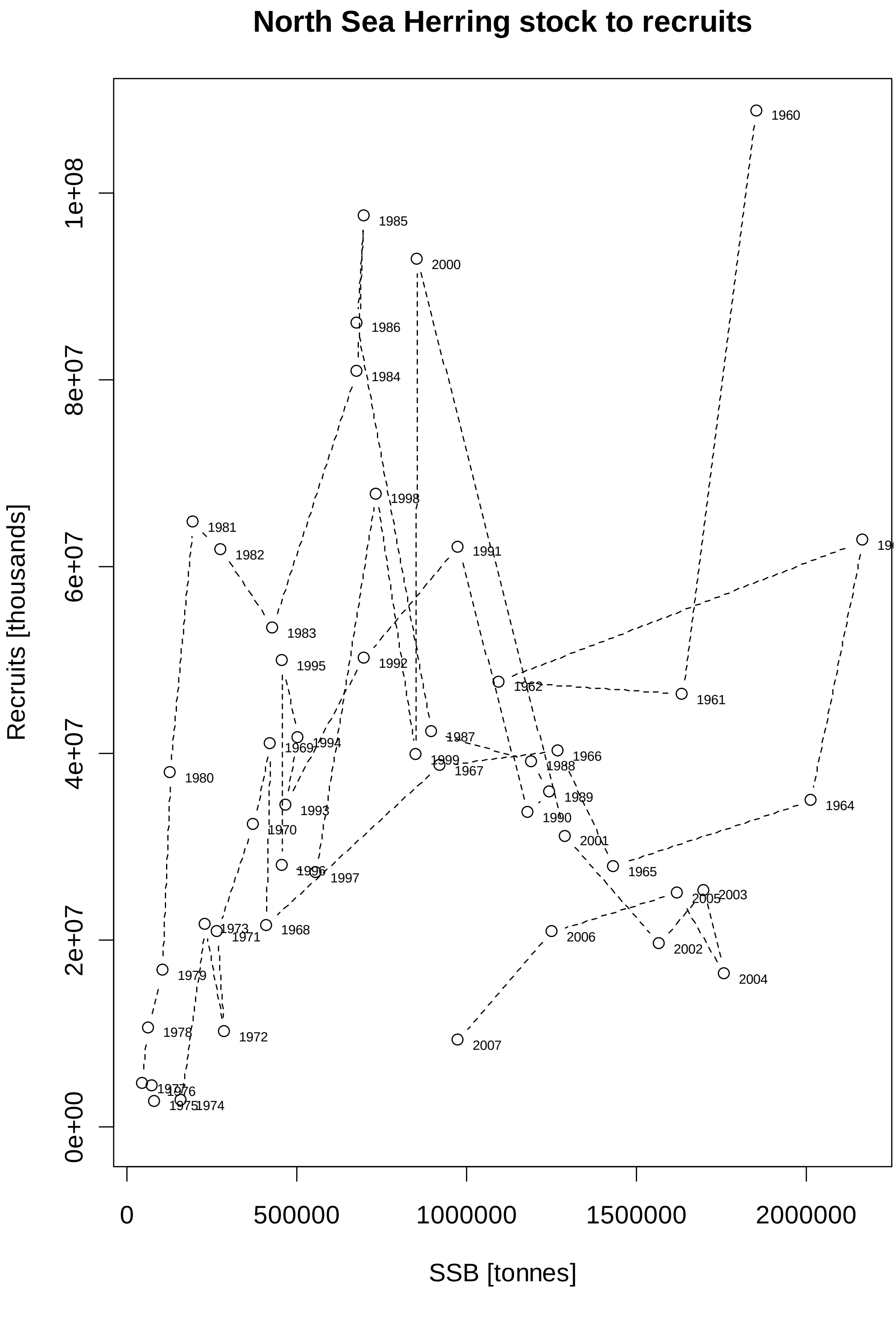


Figure 2.6.23. North Sea herring. Stock and recruit plot. Each point labelled by year class.

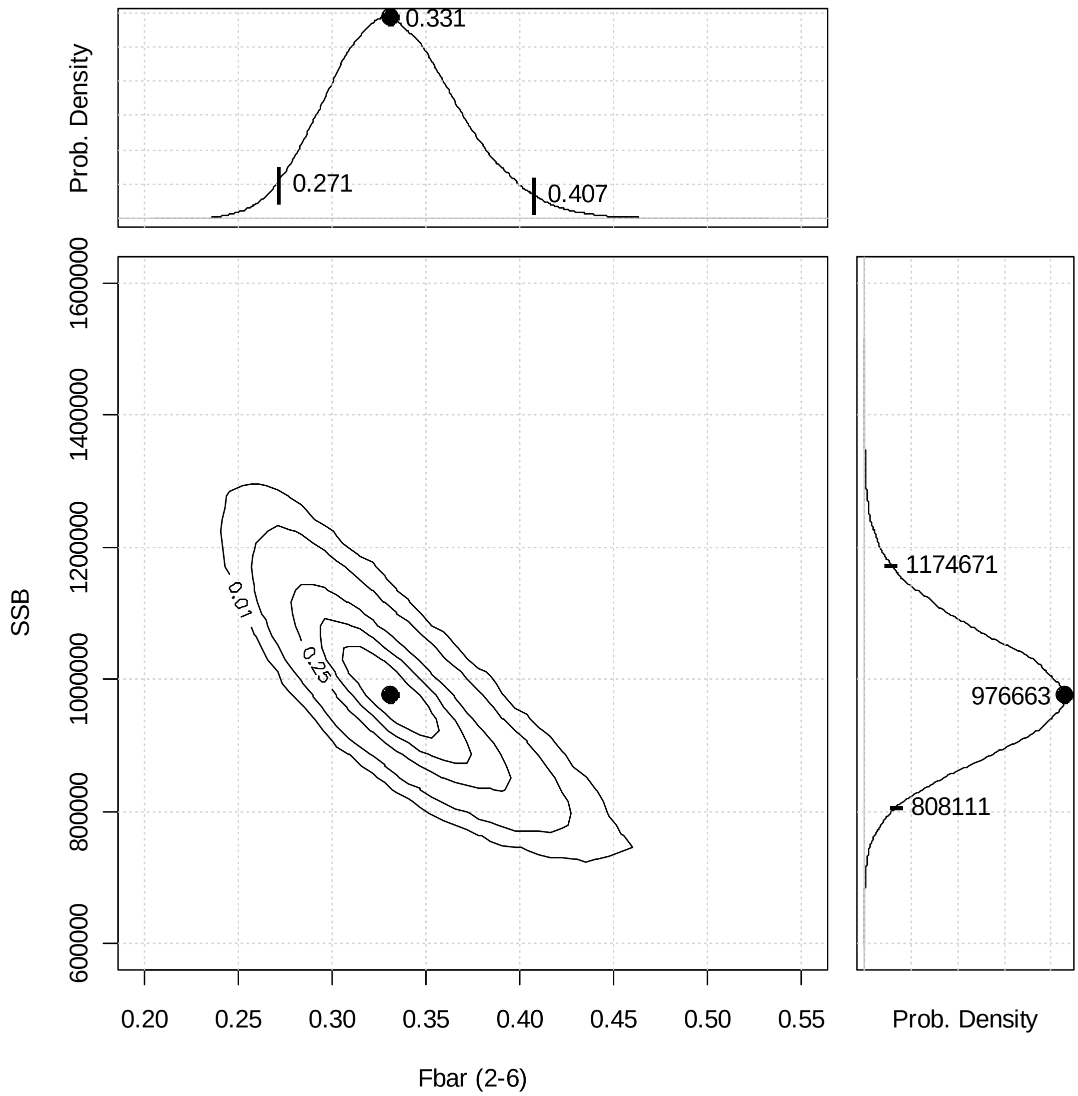


Figure 2.10.1. Model uncertainty; distribution and quantiles of estimated SSB and F2-6 in the terminal year of the assessment. Estimates of precision are based on a parametric bootstrap from the FLICA estimated variance/covariance estimates from the model.

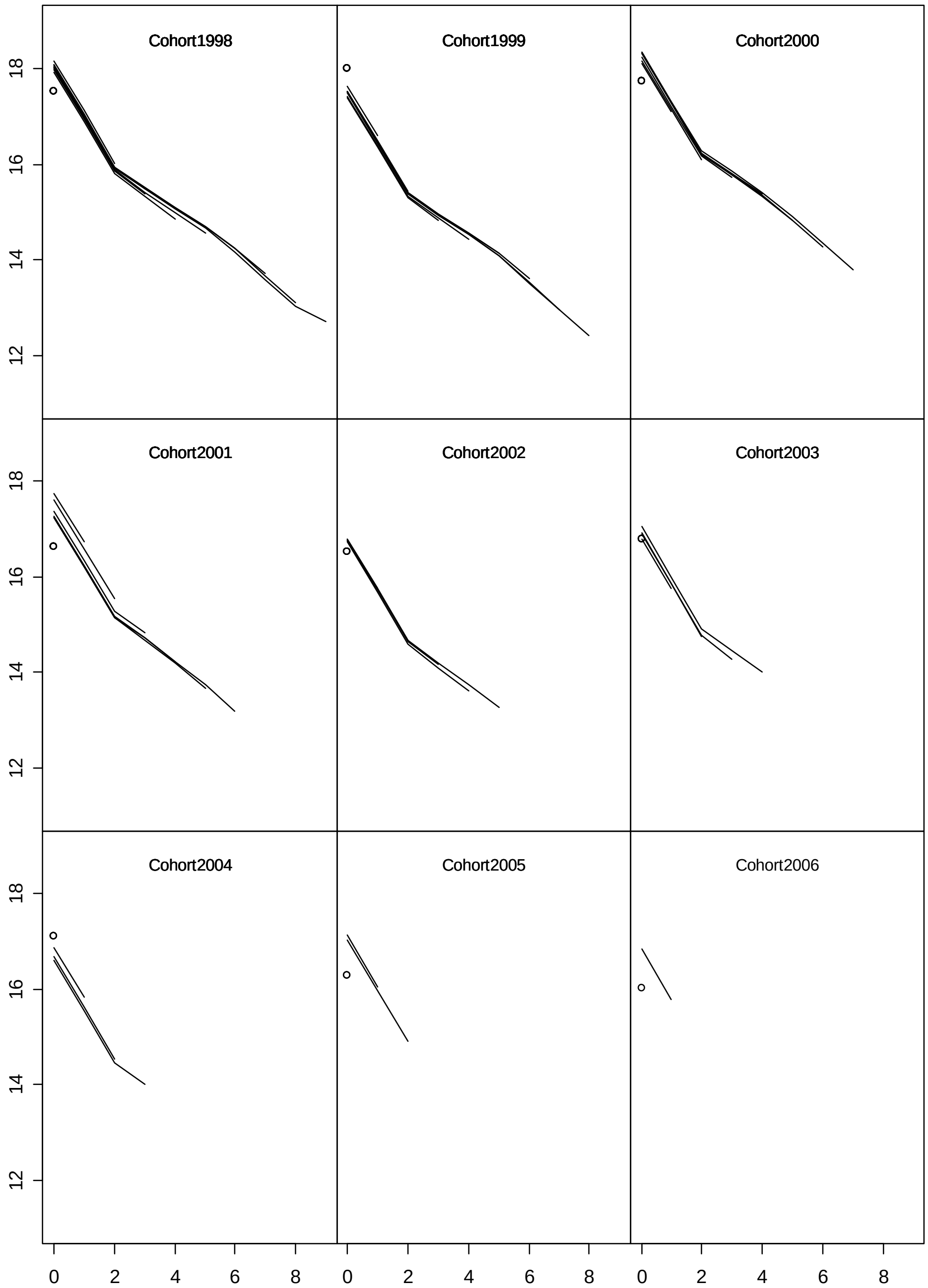


Figure 2.10.2 Cohort retrospectives for cohorts that contribute the current stock of North Sea herring.

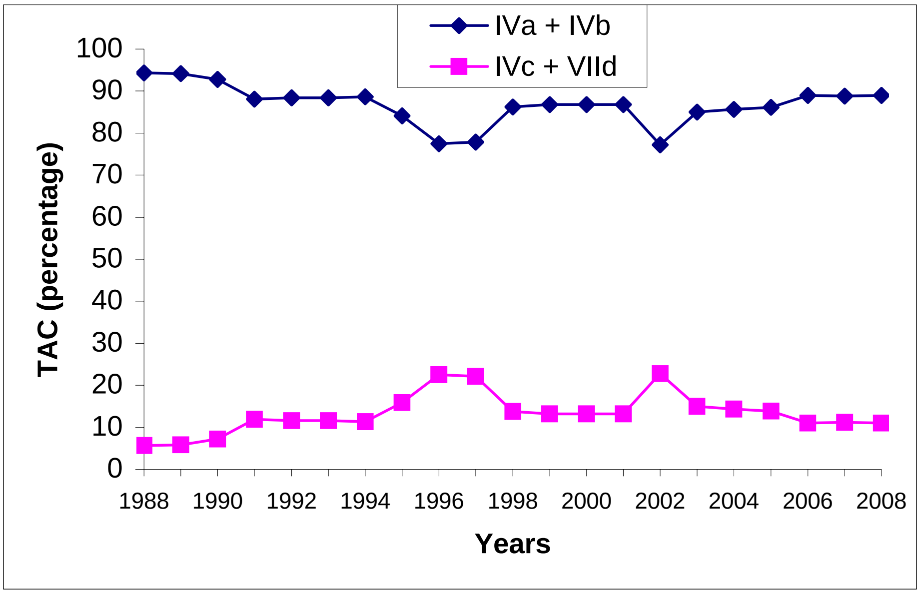


Figure 2.11.1. North Sea herring. Comparison of TACs for total North Sea and IVc and VIId

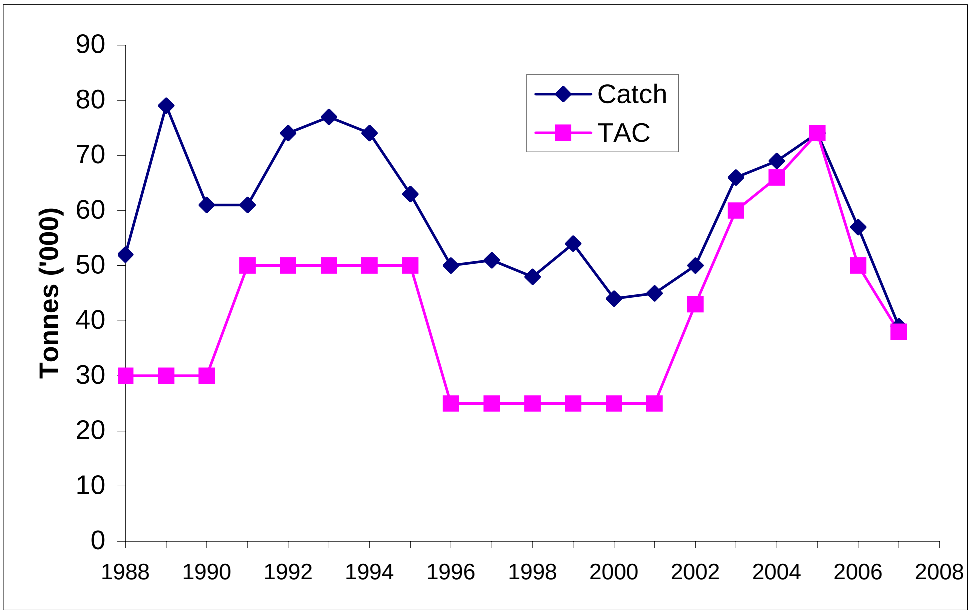


Figure 2.11.2. Herring in IVc and VIId. Comparison of historical catches and TACs

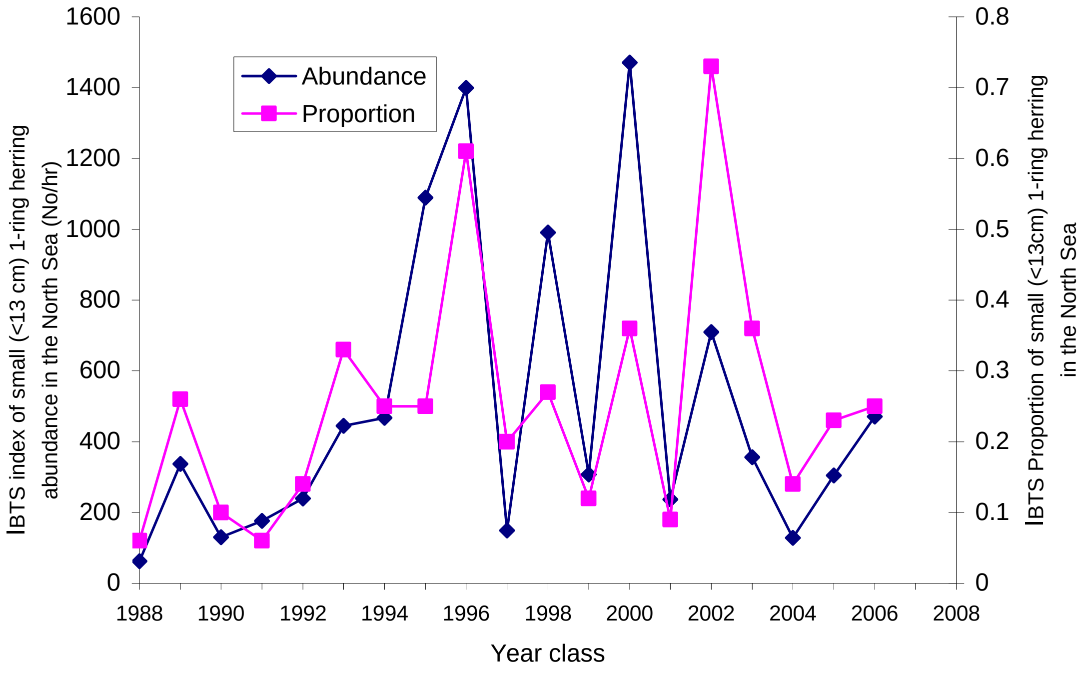


Figure 2.11.3. Downs herring. Index (Nos per hr) of small (<13cm) 1-ringers in the North sea and proportion of small 1-ringers versus all sizes in the North sea (from table 2.3.3.2).

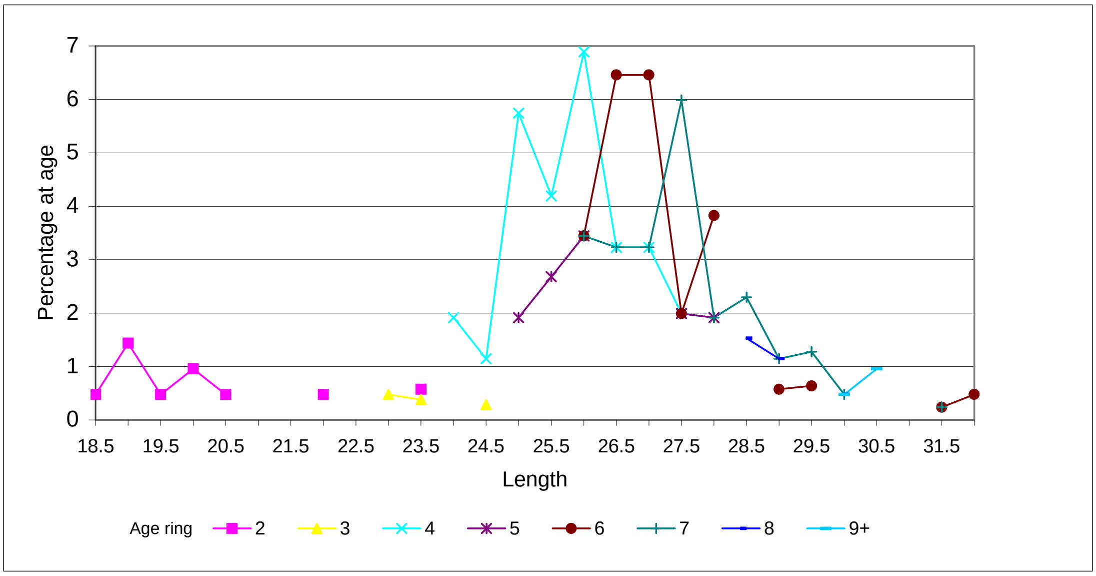


Figure 2.11.4. Downs herring. IBTS 08. Catch composition by age from pelagics hauls in the eastern Channel. Age 4, 5, 6 and 7 represent respectively 30%, 12%, 24% and 23 % of the total.

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

3.1 The Fishery

3.1.1 ACFM advice and management applicable to 2007 and 2008

At the ACFM (May) meeting in 2007, 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 over a number of years. Fishing mortality estimates for 2007 are 0.49 for adults and 0.22 for the juveniles (1-ringers) and the recruitment has declined since 2003.

The recruitment has shown a declining trend in recent years and fishing mortality is estimated at a stable high level compared to other herring stocks. ACFM recommended in 2007 that, since the current fishing mortality will likely lead to a decline in the stock if not reduced, the fishing mortality should be reduced towards F0.1 within 3 to 5 years. This would correspond to a 20% reduction of F and a TAC of less than 71 000 t in 2008. 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 2007 was 69 360 t in Division IIIa for the human consumption fleet and a by-catch ceiling of 15 396 t to be taken in the small mesh fishery. For 2008, the EU and Norway agreement on herring TACs in Division IIIa was 63 143 t.

Previous to 2006 no special TAC for Subdivisions 22-24 was set. In 2007, a TAC (49 500 t) was set on the Western Baltic stock component. The TAC for 2008 was set at 44 550 t.

3.1.2 Catches in 2007

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

Landings from 1986 to 2007 are given in Table 3.1.1. In 2007 the total landings in Division IIIa and Subdivisions 22–24 have decreased to 87 700 t, which is the lowest value of the time series (1986-2007). The decrease in landings is particularly evident in the Skagerrak. The German landings have increased slightly for the last three years in Subdivision 22-24, but are still diminutive in Division IIIa. As in previous years the 2007 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 2007 in thousands of tonnes by fleet (as defined by HAWG) and quarter.

Selection by fleet is done disregarding the nationality of the fleets assuming that the fleets target the same part of the population regardless of national flag. However, on analysis of the age distribution in the catches of the Danish and Swedish Fleet D in Sub.Div. 20 and 21 it became apparent that the Swedish Fleet D targets a larger part of the population as the landings of fish older than 3 years are higher than what is observed in the Danish catches of the same fleet. Thus the selection by fleet is not identical between the two countries. The Danish fleet definition follows the definition set by HAWG, where Fleet D (or so called Industrial fleet) is defined as all fisheries in which trawlers (with mesh sizes less than 32 mm) and small purse seiners, fish for sprat. For most of the landings taken by this fleet, herring is landed as by-catch from the sprat fishery and the Norway pout and blue whiting fisheries. The Swedish fleet definition is based on mesh size of the gear, as for the Danish fleet. However, a recent change in the Swedish industrial fishery (see section 3.1.3.1) implies that there is no difference in age structure of the landings between vessels using different mesh sizes since both are basically targeting herring for human consumption. Thus Swedish age-length keys cannot be used to raise Danish catches and vice versa.

3.1.3 Regulations and their effects

Corrections for misreporting by area have been incorporated in the assessment. In recent years, ICES has calculated that a substantial part of the catch reported as taken in Division IIIa by fleet C was actually taken in Subarea IV. These catches have been allocated to the North Sea stock and accounted for under the A fleet. Regulations allowing quota transfers from Division IIIa to the North Sea were introduced as an incentive to decrease misreporting for the Norwegian part of the fishery. Recent Working Group estimates of 28% misreporting may be underestimating the problem since not all countries supply this information to ICES.

The quota for the C fleet and the bycatch quota for the D fleet (see above) are set for the NSAS and the WBSS stocks together. The implication for the catch of NSAS must also be taken into account when setting quotas for the fleets that exploit these stocks.

3.1.3.1 Changes in fishing technology and fishing patterns

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

Since 2001, the fishing pattern has changed in the German fleet. In former years, the main catch of herring was taken in the passive gears, bottom-set gillnets and trapnets. Recently the landings by trawl have reached a level of more than 50% of the total landings (2003: 63%, 2004: 52%, 2005: 57% and 2006: 64%). This change is due to requirements from a new fish factory on the Rügen Island.

The Swedish industrial fishery rapidly declined during the 1990s and it is currently no longer operating in the area. Therefore, there is no difference in age structure of the landings between vessels using different mesh sizes since both are basically targeting herring for human consumption.

A descriptive analysis of the Danish fleet dynamics during the last decade, in terms of the distribution of herring catches over fleets and at the overall activity of the vessels targeting herring in IIIa, was performed in the IAMHERSKA (Improved Advice for the Mixed HERring stocks in the Skagerrak and KAttegat (ICES Division IIIa)) project (Ulrich-Rescan and Andersen 2006 WD 1 in ICES CM 2006/ACFM: 20). During the second half of the nineties, both the southern and northern trawling fleets extended their activity to the Baltic, and decreased meanwhile their industrial activities in the Kattegat and Skagerrak, which induced reduced by-catches of herring. In the same period, the large purse seiners (most of the vessels are polyvalent) increased significantly their geographical mobility, with a majority of their effort being spent outside the traditional Danish fishing grounds in the North Sea and Division IIIa as they participated in fisheries for blue whiting and Norwegian spring spawning herring.

The full consequence of the implementation of the ITQ system for herring is yet unknown as vessels still are changing status. However, a change in the behaviour in the Danish herring fishery indicates that vessels without an ITQ for herring are targeting a mixed sprat and herring fishery and land their catch for industrial purposes, whereas vessels with an ITQ for herring are primarily participating in the herring fishery for human consumption.

3.2 Biological composition of the catch

Table 3.2.1 and Table 3.2.2 show the total catch (autumn- and spring-spawners combined) in numbers and mean weight-at-age in the catch for herring by quarter and fleet landed from Skagerrak and Kattegat, respectively. The total catch in numbers and mean weights-at-age for herring landed from Subdivisions 22 - 24 are shown in Table 3.2.3.

The level of sampling of the commercial landings was generally acceptable (Table 3.2.4). In the cases of missing samples the corresponding landings were minor. Where sampling was missing in areas and quarters on national landings, sampling from either other nations or adjacent areas and quarters were used to estimate catch in numbers and mean weight-at-age (Table 3.2.5).

Based on the proportions of spring- and autumn-spawners in the landings, catches were split between NSAS and WBSS (Table 3.2.6 and see Section 3.2.2 for more details)

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

The total catch expressed as SOP of the WBSS taken in the North Sea + Div. IIIa in 2007 was estimated to be 28 600 t, and has thereby decreased to below the levels observed in 2003 (38 000 t) and 2004 (35 000 t) from the somewhat high level in 2006 (48 700 t) (Table 3.2.13).

Total catches (SOP) of WBSS from the North Sea, Div. IIIa, and Subdivisions 22-24 respectively, by quarter, was estimated for 2007 (Table 3.2.14). Additionally, the total catches of WBSS in numbers and tonnes (SOP), divided between the North Sea and Division IIIa and Subdivisions 22–24 respectively for 1991–2007, 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 around 40 000 t, which also is the lowest level found in the time series (1991-2007) (Table 3.2.16).

The total catch (SOP) of NSAS in Div. IIIa amounted to 19 788 t in 2007, which is slightly higher than the lowest value observed in the time series (15 015 t in 2006). The increase relative to 2006 was mainly due to a proportionally higher representation of the younger age classes in 2007 (Table 3.2.17).

3.2.1 Quality of Catch Data and Biological Sampling Data

The amount of discards for 2007 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 2007 more than meets the recommended level of one sample per 1 000 t landed per quarter and the coverage of areas, times of the year and gear (mesh size) was acceptable. One exception is the scarce sampling covering catches from Subdivision 23 comprising 2 072 t and scientific samples from the KASU survey in Subdivision 23 was applied to raise the catches. However, for some of the sampling unit (SD and quarter) sample size of ages was possibly lower (see HAWG WD Cardinale and Hansson 2006 for details) than the value necessary to reach ±5% precision level as established by the current European Data Regulation system.

As a part of the benchmark assessment process, the catch data were explored comparing the ratios between consecutive ages within each year class of the log catch numbers (log catch ratios) and performing cohort analysis. Please refer to section 3.6.1.1 for this exploration.

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 to 2-ringers from the North Sea Autumn Spawners (NSAS). The winter spawning Downs herring are included under NSAS (see Stock Annex 3). 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 4). 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 4). 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 4).

Different area-based TACs and by-catch ceilings are set for herring in Divisions IIIa and IV. However, during summer, feeding migration 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 (IAMHERSKA, Clausen et al. 2007). 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 (IAMHERSKA, Clausen et al. 2007). 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 2007 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. For the 2nd and 3rd quarters the split was calculated based on an average of samples from the two quarters due to scarce data in quarter 2. 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 (IBTS and landings)	DK & NOR samples (IBTS and landings)	DK samples (IBTS)	DK & NOR samples (IBTS and landings)
2nd quarter	DK samples (acoustic and landings)	DK & NOR samples (acoustic and landings)	DK & NOR samples (acoustic and landings)	DK & NOR samples (acoustic and landings)
3rd quarter	DK & NOR samples (acoustic and landings)	NOR samples (landings)	NOR samples (landings)	NOR samples (landings)
4th quarter	DK samples (landings)	DK samples (landings)	DK samples (landings)	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 2007 the split of the Swedish and Danish landings used 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 6 501 otolith microstructure analyses in 2007 (4 258 Danish and 2 243 Swedish). Data were disaggregated by area (Kattegat and Skagerrak), quarter (1–4) and age group (1-8+ ringer in 1st quarter and 0-8+ ringer in 2nd, 3rd and 4th quarters).

Generally, the sampling for split in 2007 covered younger age classes (0 to 2-ringers) well. In cases where sampling of older age-classes had fewer than 12 individuals per cell (area, quarter, and ring) 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 4).

3.2.2.3 Accuracy and precision in stock identification

The stock classification using visual inspection of otolith microstructure has been validated using 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 that counts 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 4.

3.3 Fishery Independent Information

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

A joint German-Danish acoustic survey was carried out with R/V "SOLEA" between 4th and 23rd October 2007 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 2008/LRC:01). The results for 2007 are presented in Table 3.3.1a. The time series has been revised to include the southern part SD 21 (see Table 3.3.1a and b for comparisons). The years 1991-1993 were excluded due to different recording methods at that time. The 2001 year was also excluded since SD 23 was not covered. The western Baltic spring spawning herring stock was estimated to be 3.7 x 10^9 fish or about 106 x 10^3 tonnes in Subdivisions 22–24. This is only half of the biomass when compared to last year (Table 3.3.1).

3.3.2 Danish Acoustic Survey in Division IIIa (Summer)

The Danish acoustic survey, from 26th June to 7th July 2007, 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 2008/LRC:01). 1999 was excluded due to different survey area coverage. The estimates of western Baltic spring spawning herring SSB are 644 700 tonnes and 9 199 million herring, which is similar to last year's estimate. The stock is once again dominated by 1 and 2 ringer fish. The results from this survey are summarised in Table 3.3.2. The two first years of the time series were erroneously excluded but this error will not affect the assessment. Thus, the time series used was 1993-2007.

3.3.3 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 3.3.3 and Table 3.3.4. The estimated mean value of abundance for 1-ringers in 2008 1st quarter is the lowest observed during the time series. The older age classes show also a clear decrease with among the lowest observed values for all age classes. For 3rd quarter survey indices, the value for 1-ringers in 2007 is around the average of the time-series and similar to last year's estimates. However, the abundance of 3+-ringers is the lowest on record.

3.3.4 Larvae Surveys

Herring larvae surveys in the western Baltic were conducted in weekly intervals during the 2007 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 has failed to predict year classes of intermediate strength. The main reason was that during the sampling period the water temperature increased from about 5 °C to more than 20.5 °C with high variability from year to year, which potentially affects growth of the larvae during the sampling period. This strong increase of the temperature results in increasing mean daily growth of larvae which was not taken into account by the estimation of the former presented larvae index N30. A new index was defined as the total number of larvae that reach the length of 20 mm (N20; Table 3.3.5). There was a high correlation between the indices N20 and the 1-ringer index in the German Acoustic Survey which are based on significantly different methods, areas and periods. Thus, results suggest that the index N20 is a suitable estimator of the new year class of the spring spawning herring in ICES subdivision 22 – 24 (Oeberst et al, 2007, WD 7 to this report).

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

The weight in catch is estimated from the catch data prior to splitting into spawning types and thus represents a mix of NSAS, WBSS and local spawning stocks, which potentially may give a biased mean weight at age for WBSS. Initial comparisons of the mean weight at age for age groups 1-7 by spawning type, year and subdivision in the catch based on DIFRES data only showed a significant difference in mean weight at age between spring and winter/autumn spawners. Autumn spawners were larger than spring spawners with the largest differences in the young ages 1- to 2-ringer. For mature ages there was a clear seasonal difference in the signal reflecting the spawning cycle of the two stocks. Both stocks appear to have a similar declining trend in mean weight for mature herring during recent years. Preliminary comparison of available data sampled from Swedish and Danish fisheries also indicated a significant difference between country effects. Due to unresolved large differences in SOP estimates and weight of landings in a number of instances it was determined to continue the exploration of the mean weight at age for the time series 1991-2007, including estimates from all fisheries. The current assessment was performed using the status-quo raising method.

Mean weights at age in the catch in the 1st quarter were used as stock weights (Table 3.2.14). In order to check if this is a valid assumption and represents the actual weights in the stock, the index was compared to the average weights in the catch by age during the whole year. The relationship followed the expected pattern where the weight of the younger age classes in the catch are somewhat higher than in the stock as these are taken as an average over the whole year allowing for growth. From age-class 4 the relation between weight in catch and weight in stock followed a 1:1 line as expected. Thus the use of weight in the catch in quarter 1 is a sound indicator for the weight in the stock and does not give a biased representation of the stock.

A revision of the mean weights at age for the WBSS in catch and stock will have no influence on numbers at age and will therefore only have marginal influence on the assessment. Due to the potential change in SOP a weight revision will have some, although minor, influences on the catch options in the management considerations for the catches of the two stocks in Division IIIa.

The maturity ogive of WBSS applied in HAWG has been assumed constant between years and thus been the same since 1991 (ICES CM 1992/Assess:13), although large year-to-year variations in the percentage mature have been observed (Gröhsler and Müller, 2004). To check if the robustness of the maturity ogive has changed since 2003, the year-to-year variation in percentage mature at age 3 and 4 in quarter 1 was examined and revealed some variation within those age-groups, though with an average not diverging alarmingly from the ogives used by HAWG.

The same maturity ogive was used as in the HAWG 2007:

W-RINGS	0	1	2	3	4	5	6	7	8+
Maturity	0.00	0.00	0.20	0.75	0.90	1.00	1.00	1.00	1.00

3.5 Recruitment

Indices of recruitment of 0-ringer western Baltic spring spawning herring (WBSS) in Subdivisions 22-24 for 2007 were available from the revised larval survey and are described in Section 3.3.4 and Oeberst et al., 2007 (WD 7 to the present report).

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

3.6.1 Input data

3.6.1.1 Catch data

Catch in numbers at age from 1991 to 2007 were available for Subdivision IVa (East), Division IIIa and Subdivisions 22-24 (Table 3.6.1) and as proportion at age (Figure 3.6.1.1). 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. Exploring the cohort dynamics by log catch indices gives an indication of total mortality and catchability in successive cohorts from year classes 1991-2004 (Figures 3.6.1.3a). The slopes of log catches clearly indicate a continuous decreasing trend in total mortality over the time series. All estimated slopes have r^2>0.9.

Mean weights at age in the catch are found in Table 3.6.2 and in Figure 3.6.1.2. The proportions of F (0.1) and M (0.25) before spawning were assumed constant between years. The difference between these two values arises due to the fact that the fishery is prosecuted in the latter half of the year. Natural mortality was assumed constant over time and equal to 0.3, 0.5, and 0.2 for 0-ringers, 1-ringers, and 2+ -ringers respectively (Table 3.6.4). The estimates of natural mortality were derived as a mean for the years 1977–1995 from the Baltic MSVPA (ICES 1997/J:2).

3.6.1.2 Data exploration of surveys

3.6.1.2.1 German Acoustic Survey in Subdivisions 21-24

Comparing old and new survey time series

The German acoustic survey time series was revised in 2007, including the inclusion of SD 21 to improve the coverage of the stock at this time of the year. Trends in number of individuals per age classes are very similar when comparing the German acoustic survey with (i.e. new survey time series) or without the inclusion of the SD 21 (i.e. old survey time series after data revision) although the total numbers are obviously larger when SD 21 is included. The same applies for trends in weight at age. No long term trend in weight at age is observed, except for a drop in weight at age for age 7 and, to a minor extent, for age 6 in recent years.

Internal consistency

When the survey is checked for internal consistency by tracking year classes, the revised time series is generally slightly better at tracking year classes than the previous series although the differences were not large (Figure 3.6.1.2.1a and b). However, both the old and new surveys are able to consistently follow only the first year classes (1-3).

Mortality signal

In terms of total fishing mortality estimates, revised and new acoustic time series are showing similar values when some year or age classes are excluded (based on trend in residuals and different survey methods). The SD22-24 survey estimates slightly larger fishing mortality (0.4 to 0.5) compared to SD21-24 (0.3) survey.

Conclusions

The German acoustic survey in SD 21-24 tuning fleet is generally able to track age classes 1-3 of the western Baltic herring stock and the inclusion of the southern Kattegat slightly improves the quality of the results. However acoustic estimates in this area have not yet been split into autumn and spring spawning herring.

3.6.1.2.2 Danish Acoustic Survey in Division IIIa

Internal consistency

The survey has a reduced internal consistency in tracking younger (<2 years old) and older year classes (7+) (Figure 3.6.1.2.2).

Conclusions

The Danish Acoustic Survey in Division IIIa is generally able to track age classes 3-6 of the western Baltic herring stock.

3.6.1.2.3 International bottom trawl surveys Q1 and Q3 in division IIIa

For the two IBTS indices, is instead clear that those fleets are in general more noisy than acoustic surveys and possibly able to track the age 1 and 2 in the western Baltic herring stock only for IBTS Q3 (Figure 3.6.1.2.3). However, a major concern is raised in the way the indices are derived, as well as the exclusion of Skagerrak area from index estimation. Analysis is ongoing to test the use of zeros inflated distributions and inclusion of the Skaggerak area for estimating catch at age from IBTS surveys.

Conclusions

In light of the considerations expressed above, IBTS surveys were not used into assessment.

3.6.1.2.4 Merged German Acoustic Survey in Subdivisions 22-24 and Danish Acoustic Survey in Division IIIa

Internal consistency

An attempt has been made also in merging the German and Danish acoustic surveys in a single tuning fleet. However, the internal consistency of the combined German and Danish acoustic tuning fleet was found to be poor. Furthermore, the current level of biological understanding of this stock is poor as the migration patterns are seasonally variable and thus difficult to cover in a reliable manner.

Conclusions

From this analysis, it was evident that pooling of the Danish and German Acoustic surveys was not considered as satisfactory and therefore should be discarded.

3.6.1.2.5 Larvae Surveys (N20)

New survey time series

The German larval survey is conducted in the Greifswalder Bodden at spawning time. This area is usually the main spawning area of WBBS herring. Data revision was made in 2007 with a new method in calculating number at 20mm (the N20 index - for further details see chapter 3.3.4). The time series now covers the period 1992-2007.

Conclusions

The new index covers the main spawning area of the stock and correlates well with the juvenile abundances (age 1) observed in the German acoustic survey. This survey time series should therefore be used in the assessment as recruitment index.

3.6.1.3 Overall trends in the age structured survey data

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 1991-2004 (Figures 3.6.1.3b-d). The slopes of both acoustic surveys indicate a continuous decreasing trend in total mortality. Slopes from the IBTS surveys in the Kattegat are more fluctuating, with a tendency for IBTS q1 to an increasing trend in total mortality. Most of the estimated slopes have the r^2 between 0.7 and 0.9. There is no general indication of a long term increase in total mortality based on these indices and most of the surveys are indeed showing a stable or decreased total mortality in the latest years.

Thus the final choice of survey indices for the assessment of WBSS (Table 3.3.6) was:

FLT1: Danish Hydroacoustic survey in Division IIIa & Sub-division IVa East, July 1993–2007, 3- to 6- ringers (“Danish acoustic survey”)

FLT2: German Hydroacoustic survey in Subdivisions 21, 22, 23 and 24, Oct. 1994–2007, 1- to 3-ringers (“German acoustic survey”)

FLT3: N20 larval abundance index, 1992-2007.

The choice of age groups included in FLT1 and FLT2 respectively are made on the basis of existing knowledge of migration patterns and the analysis of the internal consistency of the surveys by age. Survey ages with poor internal consistency were omitted.

All fleets are age-structured number 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	-	-	FLT1	-
Subdivisions 21, 22-24	-	FLT3	FLT3	FLT2

3.6.2 Assessment method

As a part of the benchmark assessment process, the choice of assessment model was examined. Previous assessments of this stock were based on the ICA method, and therefore this method makes a suitable first candidate. Here we have tested the assumptions underpinning this method to test its appropriateness for this stock. This has been achieved using the FLICA implementation of the ICA method, with support from AMCI as a complementary exploration tool.

The ICA method is based on three fundamental assumptions. Firstly, it is assumed that the most recent period of the fishery is characterised by a stable relative selectivity in the most recent years, and therefore can be modelled as the product of a selection pattern at age, and a year term (the "separability" assumption). Secondly, ICA requires that the catchability of the survey indices employed is stable in time, allowing for a single catchability model to be fitted across the entire time series of survey values. Finally, there is a requirement to fix the selection pattern at some age (referred to as the "reference" age) relative to the last ages considered by the model. The choice of this age has important implications for the shape and structure of the fitted selection pattern. Each of these requirements is tested in turn here.

A second assessment tool, AMCI, was used in an exploratory manner to complement the investigations performed with FLICA, and to provide an independent "second opinion" regarding the appropriateness of these assumptions. AMCI is somewhat more flexible than FLICA, and allows for time-varying selection patterns and catchabilities – it is therefore an excellent tool for investigating the stability of these parameters over time.

F_{bar}, the mean fishing mortality, was defined as ages 3- to 6-ringers. The use of a separable model in this assessment means that the effect of changing this definition will only scale the value of fishing mortality The consequences of changing this definition on the perception of the stock were therefore not explored.

3.6.2.1 Separability assumption

Exploratory runs were performed examining the validity of the separability assumption in recent years. The selection patterns calculated in a retrospective manner agree closely, indicating a stable selection in recent years and a separable period in the range of 5-7 years. (Figure 3.6.2.1.). An appreciable change in the mean selection pattern does appear to take place for assessments based on data prior to 2001 and 2002 – however, the pattern appears to be more stable in recent times.

AMCI was also used to test the assumption of stable selection in recent years. AMCI was set up with a slowly changing selection at age over the whole time period, but with equal selection at age from age 4 and upwards. Figure 3.6.2.2 shows the resulting annual fishing mortalities at age, normalized to the average F over ages 3-6. There appear to be 3 periods with different selection. The first (until the mid 1990s) and the last (from 2002 onwards) are quite similar, while the selection at young age was higher in the intermediate period. Hence, the observation in FLICA of constant selection from 2003 onwards is supported by this analysis.

Varying the length of the separable period in FLICA between three and five years did not have strong consequences for the selection pattern for assessments based on the full data set from 1991 to 2007 (Figure 3.6.2.3). The fishing mortality in the reference age, and its associated uncertainty, did not show any trend with changes in the length of the separable period between three and seven years, suggesting that that the tightness of the fit to the data was not strongly influenced by the length of the separable period (Figure 3.6.2.4).

These explorations suggest that the assumption of separability is valid, and that the choice of the length of the separable period does not have a strong bearing on the results.

3.6.2.2 Stable catchability in the indices

FLICA assumes a constant catchability in the surveys. The validity of this assumption was explored by examining the catchability of each survey for each age estimated in a retrospective manner. The catchabilities for all surveys were seen to be relatively constant over that time period, with only weak trends being observed in a subset of the indices examined (Figure 3.6.2.5).

The stability of the index catchabilities were also explored with AMCI by allowing the catchabilities to change gradually over time (Figure 3.6.2.6). A gradual change in the selection at age was permitted, but with a flat selection from age 4 upwards, as described in Section 3.1.1.1. Assuming a constant selection from 2002 onwards, (analogous to the structure of the FLICA model) made virtually no difference to the results. A downward trend was seen in the selection at age 6, and to some extent age 5 in the Danish acoustic survey, and a similar trend at age 3 in the German acoustic survey. Assuming fixed catchabilities leads to lower estimates of fishing mortalities and higher estimates of SSB for the recent years.

The two methods used to explore the stability of the survey catchabilities gave complementary results. While some trends are seen, they are generally weak and are not reflected uniformly within the surveys. The assumption of a relatively stable survey catchability therefore appears to be valid.

3.6.2.3 Choice of Reference Age

The choice of reference age for the separable model in FLICA was explored, with ages in the range from three to six years old being examined. It appeared that the fishing mortality-at-age in the terminal year increases almost linearly up to the reference age (Figure 3.6.2.7). The uncertainty in the fishing mortality on the reference age in the terminal year increased strongly as the reference age was increased from three to six years (Figure 3.6.2.8), suggesting that the choice of reference age does have a strong effect on the quality of the fit. However, such a conclusion could not be verified from the residuals in the catch data, which showed virtually no effect on either the mean or distribution (standard deviation) (Figure 3.6.2.9).

Further exploration of this phenomenon was performed using the AMCI assessment tool. The effect of fixing the reference age effect was reproduced in AMCI by assuming a constant selection at age for a range of age spans 4 - 8 to 7 – 8 (Figure 3.6.2.10). The strong "hockey-stick" mortality-at-age seen in FLICA is reproduced here, with an almost linear increase in fishing mortality up to the point of inflexion at the reference age, and then a subsequent plateau at ages older than the reference age. The fit of the model to the catch data improves appreciably as the reference age is increased from four to five, but is relatively constant thereafter (Figure 3.6.2.11). The fit to the survey data is virtually unchanged.

The shape of the selection at age and the sensitivity to the reference age remains an unresolved problem. The better fit of the catch data with a high reference age suggests that the source of the linear rise in the selection with age may be in the catch data. However, knowledge of the way the fishery is carried out makes it very unlikely that the selection should rise steeply towards high ages, and a plateau in the mortality seems reasonable. It was therefore decided to choose age 4 as the reference age.

3.6.2.4 Conclusive choice of assessment model

The underlying assumptions in the FLICA appear to be valid and match the development in catch and survey indices over time for the WBSS stock. FLICA was therefore chosen as the main assessment model for the stock.

3.6.3 Choice of FLICA configuration

3.6.3.1 Length of the separable period

Exploratory work performed above in relation to the validity of the separability assumption showed that both the selection pattern and the terminal results were independent of the length of the separable period. In the absence of any obvious problems with the historic choice of a five year separable period, and the relative insensitivity of the results to this value, a separable period of five years was chosen.

3.6.3.2 Inclusion of the N20 larval index

In previous sections, the quality of the individual survey indices was assessed by examining the internal consistency i.e. the way the index perceives the subsequent ages in a cohort. It was not, however, possible to make such an analysis directly for the N20 larval index, as it is only an index of one age group (i.e. 0-ringers). Preliminary runs in FLICA including the new larval index, N20, showed that the inclusion of the larval index gives a firmer estimate of the recruitment of the stock (Section 3.3.4). Here we explore the consequences for the quality of the assessment of including or omitting this index in more detail, and also examine the appropriate choice of catchability model.

Including the N20 index in the assessment appeared to increase the uncertainty in the estimation of the fishing mortality on the reference age in the terminal year (Figure 3.6.3.1). However, the increase in the uncertainty was relatively small, and improvements were seen elsewhere in the model, particularly in the retrospective patterns in the assessment. The decision was therefore made to include the N20 index in the final assessment.

Two different models for the catchability of this index were considered – a power law and a linear model. The power law model appears to give a slightly tighter fit to the data, as measured by the uncertainty in the fishing mortality in the reference age in the terminal year (Figure 3.6.3.1). Furthermore, an appreciable improvement could be seen in the residuals to the catchability model, with a subtle reduction in the magnitude of some of the outlying values, especially at high stock sizes (Figure 3.6.3.2). However, problems became apparent with the fit of the power law model when the uncertainty of the estimated parameters was examined – the estimates of the parameters in the power law model were unrealistically high (e.g. a confidence interval for the N20 catchability from $1x10^{-12}$ to $1x10^{-3}$). Such a result suggests that the model may have become or is approaching over-parameterisation, and therefore may be unstable – however, the current understanding of this problem and its consequences for the quality of the assessment is poor and requires further investigation. Therefore, given that the perceived improvement in the fit is small, and that the addition of extra parameters may destabilise the fit, the application of Occam's razor and the use of the simplest model (i.e. the linear catchability model) appears to be appropriate.

3.6.3.3 Exploration of 0-group weighting

Historic experience has shown that the catch of 0-group individuals is poorly reported and the quality of these data is generally poor. Past assessments of this stock have downweighted this information in the fit. Here, we examine the application of three different weights to this age-group: 0.01, 0.1, and 1, relative to the weight given to the remainder of the catch data.

The different weightings gave no change in the selection patterns (Figure 3.6.3.3). Increasing the weighting of the 0-group catch to place it on an even level with the other catch information in the assessment appeared to improve the quality of the fit, as judged by the uncertainty in the fishing mortality on the reference age in the terminal year (Figure 3.6.3.4). However, given the uncertain quality of this information, the practice of downweighting it appears judicious.

3.6.3.4 Exploration by individual survey indices

The influence of the individual survey indices was explored by performing runs in FLICA using the catch data and each individual index in turn (Figure 3.6.3.5). There was no difference in the uncertainty of the estimation of terminal F applying the two acoustic surveys individually compared to the baseline setting using all three indices. The N20 index gave a significantly higher uncertainty in the estimation of terminal fishing mortality. However, this is not a surprisingly result considering that this index only contains information on one age group (the recruits), compared to the three to four age groups contained in the other indices.

The terminal estimates of SSB and mean F from assessments performed in this manner were compared to the range of likely values (i.e. the estimated confidence intervals for the SSB and mean F) (Figure 3.6.3.6). The SSB and mean F estimated from the two acoustic surveys agree closely with the baseline scenario. The estimate from the N20 index is somewhat different, but importantly the result lies within the 95% confidence interval estimated from the use of all three indices. We therefore conclude that the information contained in the surveys does not conflict in a significant manner.

The perception of the historic development of the stock is not altered greatly by the individual survey indices either (Figure 3.6.3.7). The SSB and mean fishing mortality trajectories from the two acoustic surveys follow the trend from the baseline scenario very closely, and are virtually indistinguishable. Using just the catch data and the N20 index in the assessment gives a higher SSB and a lower mean fishing mortality than in the other cases; as noted above, this is not surprising given the smaller amount of information that this survey contains. The general trends in the development of the stock agree between all survey combinations.

Given the close agreement between the indices, the final combination of tuning fleets was to include the N20 index as a recruitment index and apply the two acoustic surveys each covering a separate part of the age classes. 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- to 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.

3.6.3.5 Conclusion

Significant changes have been made to the manner in which this stock is assessed. There are some issues which require more detailed examination: specifically the incomplete understanding of the way the model responds to the choice of reference age, the issues relating to the choice of catchability model for the N20 index, and the weak trends in catchability all require further investigation. However, the assessment group considers that the assessment provides a suitable basis for providing advice.

3.6.4 Key Run

The following settings (Tables 3.6.7-9) were used in 2008:

- The period for the separable constraint: 5 years (2003-2007)
- The weighing factor to all indices (lambda = 1)
- A linear catchability model for all indices
- The reference F set at age 4 and the selection=1 for the oldest age
- The catch data were down-weighted to 0.1 for 0-ringer herring

3.6.5 Final Assessment

The input data (years 1991-2007, Ages 0- to 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 (Table 3.6.5)

The following surveys were included (Tables 3.6.6):

- FLT 1: DK Hydroacoustic survey in Division IIIa+ SD IVaE, July 1993–2007, excl. 1999, 3–6 ringers
- FLT 2: GER Hydroacoustic survey in Subdivisions 21, 22, 23 and 24, Oct 1994–2007, excl. 2001, 1–3 ringers
- FLT 3: N20 larval survey, Greifswalder botten 1992-2007

The final model settings are shown in Tables 3.6.7-9. The output data are given in Tables 3.6.10-3.6.18. The estimated SSB for 2007 is 133 503 tonnes with a mean fishing mortality (ages 3-6) of 0.46 (Table 3.6.10, Figure 3.6.5.1). Parametric bootstrapping of the parameters estimated by the model gives 95% confidence limits of [99 235, 180 170] tonnes for the SSB and [0.300, 0.724] for the mean fishing mortality (Figure 3.6.3.6).

After a period of fluctuating high fishing mortality in the mid 1990s, the $F_{3\text{-}6}$ value has slightly declined and stabilised around 0.4 to 0.5 (Figure 3.6.5.1). 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 3.6.10), though the SSB observed for 2007 is continuing the downward trend started in 2005.

The need for a good indicator of recruitment has been previously advocated and this year's assessment has included a recruitment index in form of the N20 survey. The quality of the recruitment estimate, as judged by the retrospective pattern, has improved as a result, and the residuals around this index are relatively low, especially in the most recent years (Figure 3.6.5.2). The use of the estimate of 0-ringers from the N20 directly should be done with caution if the index is high, as this may give an overestimation of the recruitment

Recruitment in 2007 is estimated at approximately 1.0 billion individuals. This is the lowest value observed in the 17 years covered by the assessment, and represents the continuation of a trend of decreasing recruitment from prior to 2000.

Retrospective analysis suggests the assessment method gives a consistent perception of the stock, with no historic bias in the terminal SSB, and a weak tendency to over-estimate the terminal fishing mortality (Figure 3.6.5.2). The retrospective pattern in recruitment shows some variability, but is generally free from bias.

Some patterns are apparent in the index residuals (Figure 3.6.5.3). The Danish acoustic survey shows appreciable year effects across all ages. The German acoustic survey appears to give a more random pattern. The residuals are generally small (e.g. less than 0.5), but are dominated by a few outlying points. No cohort or age effects are apparent.

The catch residuals are generally free from patterns (Figure 3.6.5.4). There does appear, however, to be a clustering of residuals within a year, which may be indicative of aging or sampling issues. The marginal totals of residuals between the catch and the separable model are small overall, although there does appear to be a trend in the age residuals on either side of the reference age – this may be related to the issues discussed with respect to the choice of reference age discussed above in Section 3.6.3.2.

The individual diagnostics for the three surveys generally show good quality fits (Figures 3.6.5.5 – 3.6.5.12). Outliers are present in some of surveys, but seem to be scattered at random, with no clear pattern. The residuals appear to be distributed randomly, and the assumption of their being distributed normally is generally held up, especially once the obvious outliers are ignored. The year effects in the Danish acoustic survey noted previously are also apparent in the diagnostics, especially in age 5 and 6. Generally, however, the agreement between the data and the fitted model appears good through all data sources.

Changing the age-range of the German acoustic and including the southern part of Sub.div 21 has improved the performance of this index, showing a closer fit to all included age classes (Figures 3.6.5.9-11).

3.6.6 State of the stock

In the absence of defined reference points, the state of the stock cannot be evaluated. An analytical assessment demonstrates that the SBB has been stable over a number of years but now approaches the lowest level since the beginning of the time series. The spawning stock at spawning time in 2007 is estimated at approximately 133 000 tonnes, declining from approximately 150 000 tonnes in 2006. Fishing mortality has also been stable in the same period but larger than any proxy of F_{msy}. Recruitment has declined since 2003 and the estimated number of the 0-ringers in 2007 is 1.01 billion, the lowest observed level.

3.6.7 Comparison with previous years perception of the stock

This year's assessment is a benchmark assessment and the perception of the stock has changed.

The SSB decrease predicted in this year's assessment is significantly lower compared with the predictions made in former years. The main reason for this difference is the changes made to the choice of survey data feed to the model. However, the general quality of the assessment has improved as a result and it would therefore appear that the changes are believable.

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

Category	Parameter	Assessment in 2007	Assessment in 2008	Diff. 07-06 (+/-) %
ICA input	No. of years for separable constraints	5	5	No
	Reference age for separable constraint	4	4	No
	Selection to be fixed on last age	1	1	No
	Weighting factor to all indices	1	1	No
	Catch down-weighted to 0.1 for 0-ringer	Yes	Yes	No
	Tuning data	Acoustic Surv. Div. IIIa 2-8+ wr	Acoustic Surv. Div. IIIa 3-6 wr	Yes
		Acoustic Surv. SDs 22-24 0-5 wr	Acoustic Surv. SDs 21-24 1-3 wr	Yes
		IBTS Surv. Quarter 3 1-5 wr	Larvae Index 0 wr	Yes
ICA results	SSB 2005	155 248	142 785	-8.0
	F(3-6) 2005	0.49	0.48	-2.0
	SSB 2006	184 516	162 978	-11.7
	F(3-6) 2006	0.52	0.49	-5.8

3.7 Short term predictions

Short-term projections 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 2008-2010, where the geometric mean of the recruitment over the period 2002–2006 was taken, the numbers of 1-ringers in 2008 was taken as the projected recruitment in 2007.

Mean weights-at-age in the catch and in the stock were taken as a mean for the years 2005–2007. When predicting catch levels for 2008 we considered two options either assuming *status quo* fishing mortality or assuming a TAC constraint and that the TAC will be taken. In the case of 2008 WBSS herring catches, the two options will result in the same fishing mortality.

The total 2008 TAC for herring in Division IIIa + SD22-24 is 96 223 t with a likely 30% transfer of the Norwegian quotas in Division IIIa to the North Sea; the possible total TAC ends at 93 886 t. This will, with the 2007 year's share of C-, D- and F-fleets as well as the proportion of spring spawners in Division IIIa, amount to a TAC-based catch of WBSS herring of 79 294 t. The total amount is, however, assumed not to be taken due to the expected misreporting. We cannot predict the level of misreporting in 2008 but the level has apparently been declining from 2004-2007: 48%, 45%, 36%, and 28% and with a similar decline in 2008 we may predict a catch in 2008 of WBSS that is at the same level as the catch at *status quo* fishing mortality. A *status quo* fishing pattern equal to the last 3 years average (2005-2007) for 2008 onwards was assumed. Input data for catch predictions are presented in Table 3.7.1.

Short-term predictions were carried out assuming a *status quo* fishing mortality for 2008. The single option table is available for 2008 to 2010 for the following two scenarios: 1) *Status quo* F and 2) F_{msy} = 0.25.

	CURRENT YEAR	ADVICE YEAR	TERMINAL YEAR
SCENARIO	2008	2009	2010
1) *status quo* F	F_{2008}= F_{2007} = 0.478 *Status quo* F Catch = 63 700 t	F_{2009}= F_{2008} = 0.478 *Status quo* F Catch = 57 400 t	F_{2010}= F_{2009} = 0.478 *Status quo* F Catch = 58 000 t
2) $F_{msy'}$	F_{2008}= F_{2007} = 0. 478 *Status quo* F Catch = 63 700 t	F_{2009} = 0.25 F_{msy} Catch = 32 800 t	F_{2010} = 0.25 F_{msy} Catch = 38 200 t

The results of the short-term predictions are given in Tables 3.7.2 – 3.7.4. Table 3.7.2 shows single *status quo* option predictions for 2008-2010. The catches for 2009 and 2010 at *status quo* fishing mortality were predicted to be 57 400 t and 58 000 t, respectively, which is an overall decrease in relation to the current catch level of 69 000 t. At this scenario SSB is predicted to decline from 122 700 t to 104 600 t in 2009 and further down to 89 000 t in 2010, which is considerably lower than the lowest values observed during the late 1990s.

Table 3.7.3 shows multiple options for 2009 at *status quo* fishing mortality in 2008, and for 2010 based on F_{msy} (0.25) in 2009. Based on F_{msy} (0.25) in both years, SSB in 2009 and 2010 are predicted to be 107 000 t and 110 900 t, thus impeding the otherwise subsequent decline in SSB. This scenario corresponds to landings of 32 800 t in 2009 and 38 200 t in 2010.

3.8 Medium term explorations

Medium term exploration was conducted in WKHMP. The same analysis was repeated in HAWG 2008 using the updated data after the benchmark assessment. There were no large differences between the two analyses. The major factor scaling the simulation output is the level of the expected mean recruitment under various circumstances and as the recruitment estimation for WBSS is not well established, the prediction of recruitment is based on quite sensitive assumptions. The introduction of a recruitment index in the assessment has given more confidence in the short to medium term predictions; however, there is no basis for estimation of a stock-recruit relationship. Therefore a breakpoint cannot be firmly defined where a decreasing spawning stock influences recruitment negatively. The two parameters that are most influential on estimates of sustainable exploitation are target F and selection pattern. Risks to the spawning stock being below the breakpoint were further influenced by increasing uncertainty in the assessment combined with a relaxation of the TAC maximum inter-annual variation. The main outcome of the analysis was that, provided recruitment does not further decline below the average in recent years, a fishing mortality of 0.25 could be a proxy for F_{msy}.

3.9 Precautionary and yield based reference points

There are no precautionary approach reference points for this stock.

A good understanding of the stock-recruitment relationship is a prerequisite for a robust simulation of a long term management plan. For WBSS such a relationship between stock and recruitment is not well established, and it is unknown where the breakpoint is. However this year's assessment has initiated the development of a stock-recruitment relationship in accepting the N20 as a recruitment index and the current understanding of the stock-recruitment relationship will potentially improve in a longer perspective.

Based on yield per recruit analysis and simulation carried out during HAWG (2007) and WKHMP (2008), a proxy for long term maximum sustainable exploitation rate should be a level of fishing mortality that should not exceed F = 0.25.

3.10 Quality of the Assessment

Overall the assessment is recommended as suitable for the provision of advice. The details of the assessment have been discussed in great detail in the benchmark analysis presented in Section 3.1. The conclusions are discussed below, indicating where there are firm conclusions and where more work is required in the future.

3.10.1 Catch data

A clear mortality signal can be detected in the catch data suggesting a decreasing trend in total mortality over the time series.

3.10.2 Weighing of indices and catch in the assessment

The weight of the 0-group in the catch was examined in the context of reducing the variability and retrospective performance. The analysis suggested that down-weighting the 0-group to 0.1 was appropriate.

3.10.3 Mean weights-at-age and maturity-at-age

The weight in catch is estimated from the catch data prior to splitting into spawning types. Initial comparisons of mean weight-at-age by spawning type suggested that the differences did not follow a clear pattern and therefore may not result in substantial bias in quantities such as SSB. This needs further investigation.

Mean weights-at-age in the catch in the 1st quarter were used as stock weights. This assumption was investigated and the conclusion was that the use of weight in the catch in quarter 1 is a sound indicator for the weight in the stock and does not give a biased representation of the stock. This may need to be re-examined if catch weights are found to change when examined further.

The maturity ogive appears to be relatively stable over time. However, some inter-annual variation in percentage mature in some ages was observed, though with an average not diverging from the fixed ogives used by HAWG. Therefore the same fixed natural mortality was used in 2008 as in former years.

3.10.4 Sensitivity to model configuration

Two assessment methods were considered. The current procedure, Integrated Catch Analysis (ICA) implemented with FLICA, has provided consistent results with respect to fishing mortality, spawning biomass and recruitment for several years. On that basis, FLICA was used as a baseline method but AMCI was used to further investigate sensitivity of the results to the choice of settings. AMCI, which allows the selectivity in the fishery to be flexible, supported the choice of the length of the separable period.

The results are sensitive to the choice of reference age. This issue was investigated with both AMCI and FLICA but the results were not conclusive. However, the perception of the fishery selectivity is that it is stable for fish age 4 and older, as the signal in the log catch ratios is stable over these ages. On that basis, age 4 was chosen as reference age.

3.10.5 Use of tuning indices in the 2008 assessment

All survey indices available were examined for internal consistency and for consistency between surveys and catch-at-age. As a result of the analysis three survey indices, including a larval index of age-0, were selected as tuning indices. Examination of index catch curves and index log-catch ratios was the basis for the exclusion of some of the survey youngest and oldest age groups from the analysis. Examination of ICA diagnostics indicated the best approach to model the catchabilities for each of the indices with linear models. After careful examination of the uncertainty introduced by fitting the catchability of the larval index with a power model it was concluded that a linear model was more appropriate as there were indications that the power model may result in over-parameterisation.

Although none of the surveys cover the entire distribution of the stock, each of them covers areas where it is likely that a subset of ages are well represented at survey time. Therefore, the surveys can be considered complementary.

3.10.6 Comparison with the 2007 assessment

The 2008 assessment shows differences in the SSB and fishing mortality in the range of 2 – 12% compared with last years assessment, see text table in section 3.6.7. This is magnitude of change is acceptable because although the model settings are similar the tuning indices have been changed.

3.10.7 Uncertainty in the 2008 assessment

An “otolith” plot showing the correlation and uncertainties in the estimates of terminal F and SSB resulting from taking into account the historic uncertainty in the assessment is shown in Figure 3.6.3.6. The plot suggests reasonably tight confidence intervals with the position of the 95th and 5th percentiles corresponding to 156% and 65% respectively of the point estimate of F. The assessment was run with one survey at a time. The resulting point estimates of F and SSB in the terminal year from each acoustic survey lie close to the final estimate from the full assessment and within the 25% confidence limit. This is an indication of consistent signals between these surveys and catch. The use of the larval survey as the only tuning index results in estimates that differ much more from the full assessment lying between the 95th and 75th percentile confidence limits: however, this is not unexpected as this index is only indicative of age 0.

3.10.8 Reliability of the assessment

Because the use of tuning indices has changed this year it is not possible to provide a historic retrospective. However, analytical retrospectives are shown in Figure 3.6.5.2 for SSB, F and recruitment showing no strong evidence of retrospective bias. There are indications that high values of recruitment can be overestimated.

3.10.9 Predictions

The larval index appears to overestimate recruitment particularly when it is above average. Therefore, caution should be exercised when using the assessment estimate of age 1 in the predictions.

3.10.10 Comparison of FLICA and ICA

The FLICA implementation of the ICA method was used for the first time in this stock. For comparison with previous work, the key run was also run in the “standard” ICA package. The two different methods gave results that agreed to within better than 1%.

3.11 Management Considerations

Catch options for mixed stocks in Division IIIa based on short term predictions for WBSS

There is strong evidence of a declining recruitment over the last 5 years in the WBSS herring stock. The present state of a declined NSAS stock with poor recruitment in the last 6 years strongly suggests 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 out-take of WBSS has to be considered. Furthermore the implication for the out-take of NSAS has to be taken into account when setting fleet wise quotas for that stock (see Section 2.7).

For ***2007 the agreed TAC*** for the directed fishery in Division IIIa (C-fleet) was 69 360 t. The TAC was divided into quotas, 500 t for the Faeroes and 9 251 t for Norway, of which 40% could be taken in the North Sea. For the EU a total quota of 59 609 t was agreed of which all had to be taken in Division IIIa; this was 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) was set at 15 396 t and divided between Denmark 13 160 t, Germany 117 t and Sweden 2 119 t.

For ***2008 the agreed TAC*** for the directed fishery in Division IIIa (C-fleet) is 51 673 t. The TAC is divided into quotas, 500 t for the Faeroes and 6 892 t for Norway, of which 30% can be taken in the North Sea. For the EU a total quota of 44 281 t is agreed of which all has to be taken in Division IIIa; this is divided between Denmark 21 474 t, Germany 344 t and Sweden 22 463 t. A by-catch quota for Division IIIa herring in the small meshed fishery (fleet-D) is set at 11 470 t and divided between Denmark 9 805 t, Germany 87 t and Sweden 1 578 t.

It must also be noted that a slightly variable and small amount (around 1 100 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%, 36% and 28% are misreported in 2003, 2004, 2005, 2006 and 2007 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.

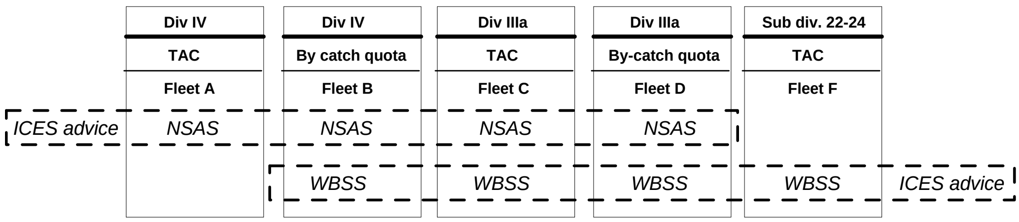
TAC in Subdivisions 22–24

For ***2007 the agreed TAC*** for the herring fishery in Subdivisions 22-24 (Fleet F) was 49 500 t. The TAC was 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.

For ***2008 the agreed TAC*** for the herring fishery in Subdivisions 22-24 (Fleet F) is 44 550 t. The TAC is divided into quotas, 6 245 t for Denmark, 24 579 t for Germany, 3 t for Finland, 5 797 t for Poland and 7 926 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.

Text table **A** showing the 2007 **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
2007 catch in t	25 300	2 300	61 100	88 700
2007share in %	29%	3%	69%	100%

*A constant catch of 1100 t of WBSS caught in Subarea IV is accounted for in the calculations.

Text table **B** showing the 2007 **proportion** of WBSS in catches by fleet (the split).

WBSS	Fleet C	Fleet D	Fleet F (SD22-24) + Fleet A (IV)
2007 proportions	0.61	0.40	1.00

The catch option for 2009 is based on the share by fleet and stock composition in catches for the most recent year 2007. The ratio by fleet and stock composition is given in the following text table A and B, respectively:

Exploring a range of total WBSS catches

The settings of F in the stock short term projections considered the strong declining recruitment in the WBSS stock as well as the present low level of the NSAS stock with very low recruitment in the recent 6 years. Catch options were explored for the two stocks in Division IIIa at total catches set for the entire WBSS stock. The focus was on an urgent reduction in fishing mortality to avoid a rapid stock depletion in the short term, and that in the long term would give maximum sustainable yields.

The projected stock composition in 2009 is assumed to equal the 2007 proportions of the NSAS and WBSS in each of the C and D fleets (in Division IIIa). Further the 2007 catch of 1 100 t of WBSS is assumed taken in Subarea IV.

The stock assessment shows a recent decrease in SSB from 163 000 in 2006 to 133 500 t in 2007 likely driven by a high fishing mortality and no strong year class entering the spawning stock. Short-term projections calculate that the assumed catch in 2008 (in total 63 700 t with status quo fishing mortality) will lead to a decrease in SSB in 2008 to 122 700 t. With catch options for 2009 and 2010 assuming *status quo* fishing mortality (F_{sq}) will further decrease SSB in 2009 to about 104 600 t and in 2010 to 89 000 t (Table 3.7.2). The setting of a restrictive fishing mortality of 0.25 (proxy for F_{msy}) will to some degree arrest the fast decline and lead to a decrease in SSB to 107 000 t in 2009 with a subsequent small increase to 110 900 t in 2010 (Table 3.7.3).

The text table below gives catch options based on the F levels above and two other scenarios derived from the HAWG 2008 short-term projections for the WBSS in Division IIIa, in SDs 22-24 and in Subarea IV.

In the text table below the option 1 ≈ F_{msy}, in bold, corresponds to a fishing mortality of 0.25 suggested by WKHMP as a level for long term maximum sustainable yield. Options 2 and 3 of intermediate catches, as well as the option of a *status quo* fishing mortality 4 ≈ F_{sq}, are also given (catch values are rounded to the nearest 100 t).

Management considerations for Division IIIa + SD 22-24 based on short term predictions (HAWG 2008)										
Catch option for the WBSS herring stock in 2009		WBSS herring				NSAS herring		Total catches of both stocks in Division IIIa and Sub-division 22-24		
Option	Total catches of WBSS herring*	Fleet A*	Fleet C	Fleet D	Fleet F	Fleet C	Fleet D	Fleet C	Fleet D	Fleet F
1 F_{msy}=0.25	**32,800**	**1,100**	**12,200**	**1,100**	**18,400**	**7,900**	**1,600**	**20,000**	**2,800**	**18,400**
2 F=0.31	40,000	1,100	14,800	1,400	22,700	9,600	2,000	24,400	3,400	22,700
3 F=0.40	50,000	1,100	18,600	1,700	28,700	12,000	2,500	30,600	4,200	28,700
4 F_{stq}=0.48	56,700	1,100	21,000	1,900	32,600	13,600	2,800	34,700	4,800	32,600
*A catch of 1100 t of WBSS herring taken in the Eastern North Sea is assumed.										

Short term projections show that recent catch levels will lead to a drastic decline in SSB, indicating that fishing mortality should urgently be reduced. Catches based on F_{msy} for the advice year, 2009, will halt this development in 2010.

The catches of WBSS in the C- and D-fleets comprise 31% of the total out-take of the WBSS stock, whereas the catches of NSAS in the same fleets only comprise 5% of the total out-take of the NSAS stock. Due to the state of the WBSS stock exhibiting a drastic decline in recruitment and negative development of the spawning stock biomass both stocks now have equal priority in calculations of catch options for the combined stocks of NSAS and WBSS herring in Division IIIa. Thus the resulting catch options were also used as constraints for short term predictions for the NSAS herring (section 2.7).

Development of a management plan for WBSS herring

Work in ICES has explored management options for exploitation of the western Baltic spring spawning herring under different assumptions of production and recruitment. Variations in target F and breakpoint for linear reduction in F at low SSB were investigated by stochastic simulation with and without TAC constraints and including changes in selection pattern as well as different levels of uncertainty in the assessment.

Provided recruitment does not further decline below the average in recent years a fishing mortality of 0.25 could be a target in the development of a management plan for the western Baltic spring spawning herring stock. Changes in environmental conditions may influence development of recruitment in an unforeseeable way and change the basis for the production of the stock; this will also affect the optimum target F.

3.12 Ecosystem considerations

3.12.1 Impacts of the fisheries on the ecosystem

Herring is considered to have a major impact on most other fish stocks as prey and predator and is itself prey for seabirds and sea mammals. Herring spawning and nursery areas, being near the coasts, are particularly sensitive and vulnerable to anthropogenic influences. The most serious of these is the increasing rate of extraction of marine sand and gravel.

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

3.12.2 Changes in the environment with potential influence on the stock

By comparing five different Baltic herring stocks, temperature and SSB were shown as the main predictors contributing to explain recruitment in the whole Baltic Sea, (Cardinale et al. 2008) except for western Baltic herring where the Baltic Sea Index (BSI) was the selected proxy in the final model. However, the Baltic Sea Index is known to be a proxy for SST in the area.

3.12.3 Considerations for biodiversity

To ensure conservation of herring population diversity in an area, all stock components and their natural migration patterns must be considered in the compilation of scientific advice on the fishery (Stephenson 2001). Recent results from the HERGEN research-project on herring (HERGEN, EU project QLRT 200-01370, final report) reveal 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 reaches 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 "strays" 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). Thus, obtaining high levels of precision in the input data in terms of stock affiliation and geographical origin of catch to the assessment of mixed stocks is highly warranted. If the fishery is conducted exclusively on parts of the mixed population and this is not reported properly this potentially can drive parts of the stock components extinct.

Table 3.1.1 WESTERN BALTIC HERRING.

Total landings in 1986-2007 in thousands of tonnes.

(Data provided by Working Group members 2008).

Year	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
Skagerrak											
Denmark	94.0	105.0	144.4	47.4	62.3	58.7	64.7	87.8	44.9	43.7	28.7
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	9.4
Sweden	43.0	51.2	57.2	47.9	56.5	54.7	88.0	56.4	66.4	48.5	32.7
Total	139.1	157.4	207.3	96.9	124.4	121.5	166.6	168.4	129.0	108.9	70.8
Kattegat											
Denmark	37.4	46.6	76.2	57.1	32.2	29.7	33.5	28.7	23.6	16.9	17.2
Sweden	35.9	29.8	49.7	37.9	45.2	36.7	26.4	16.7	15.4	30.8	27.0
Total	73.3	76.4	125.9	95.0	77.4	66.4	59.9	45.4	39.0	47.7	44.2
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	34.4
Germany	60.0	53.1	54.7	56.4	45.5	15.8	15.6	11.1	11.4	13.4	7.3
Poland	12.3	8.0	6.6	8.5	9.7	5.6	15.5	11.8	6.3	7.3	6.0
Sweden	5.9	7.8	4.6	6.3	8.1	19.3	22.3	16.2	7.4	15.8	9.0
Total	92.2	101.4	99.0	92.9	76.9	65.9	80.3	77.1	64.6	73.3	56.7
Sub. Div. 23											
Denmark	1.5	0.8	0.1	1.5	1.1	1.7	2.9	3.3	1.5	0.9	0.7
Sweden	1.4	0.2	0.1	0.1	0.1	2.3	1.7	0.7	0.3	0.2	0.3
Total	2.9	1.0	0.2	1.6	1.2	4.0	4.6	4.0	1.8	1.1	1.0
Grand Total	307.5	336.2	432.4	286.4	279.9	257.8	311.4	294.9	234.4	231.0	172.7

Year	1997	1998 [2]	1999 [2]	2000	2001 [5]	2002 [4]	2003	2004	2005	2006 [1,3]	2007 [1]
Skagerrak											
Denmark	14.3	10.3	10.1	16.0	16.2	26.0	15.5	11.8	14.8	5.2	3.6
Faroe Islands									0.4		
Germany							0.7	0.5	0.8	0.6	0.5
Norway	8.8	8.0	7.4	9.7							3.5
Sweden	32.9	46.9	36.4	45.8	30.8	26.4	25.8	21.8	32.5	26.0	19.4
Total	56.0	65.2	53.9	71.5	47.0	52.3	42.0	34.1	48.5	31.8	26.9
Kattegat											
Denmark	8.8	23.7	17.9	18.9	18.8	18.6	16.0	7.6	11.1	8.6	9.2
Sweden	18.0	29.9	14.6	17.3	16.2	7.2	10.2	9.6	10.0	10.8	11.2
Total	26.8	53.6	32.5	36.2	35.0	25.9	26.2	17.2	21.1	19.4	20.3
Sub. Div. 22+24											
Denmark	30.5	30.1	32.5	32.6	28.3	13.1	6.1	7.3	5.3	1.4	2.8
Germany	12.8	9.0	9.8	9.3	**11.4**	22.4	18.8	18.5	21.0	22.9	24.6
Poland	6.9	6.5	5.3	6.6	9.3	-	4.4	5.5	6.3	5.5	2.9
Sweden	14.5	4.3	2.6	4.8	13.9	10.7	9.4	9.9	9.2	9.6	7.2
Total	64.7	49.9	50.2	53.3	62.9	46.2	38.7	41.2	41.8	39.4	37.6
Sub. Div. 23											
Denmark	2.2	0.4	0.5	0.9	0.6	4.6	2.3	0.1	1.8	1.8	2.9
Sweden	0.1	0.3	0.1	0.1	0.2	-	0.2	0.3	0.4	0.7	
Total	2.3	0.7	0.6	1.0	0.8	4.6	2.6	0.4	2.2	2.5	2.9
Grand Total	149.8	169.4	137.2	162.0	145.7	128.9	109.5	92.8	113.6	93.0	87.7

[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 2001-2007 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
2007	1	7.7	3.0	18.8	29.5
	2	3.8	0.1	10.5	14.4
	3	22.4	0.8	1.7	24.9
	4	7.7	1.8	9.5	18.9
	Total	41.6	5.7	40.5	87.7

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: 2007 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	1.33	36.45	2.87	34.56	4.20	35.16
	2	4.08	69.97	7.64	64.66	11.72	66.51
	3	0.69	102.85	1.27	100.07	1.97	101.05
	4	0.94	130.62	2.11	130.62	3.04	130.62
	5	0.62	149.04	0.76	144.79	1.38	146.69
	6	0.40	191.74	0.90	191.74	1.30	191.74
	7	0.48	174.47	0.12	166.00	0.59	172.82
	8+	0.01	215.00	0.02	215.00	0.03	215.00
	Total	8.55		15.70		24.24	
	SOP		782		1304		2086
2	1	4.53	52.74	0.46	49.10	4.99	52.40
	2	9.49	89.40	1.05	35.13	10.55	83.99
	3	1.82	108.31	0.41	62.65	2.22	99.96
	4	0.43	114.97	0.05	114.97	0.48	114.97
	5	2.73	152.27	0.02	115.73	2.74	152.05
	6	0.10	150.38	0.01	150.38	0.12	150.38
	7	4.03	175.40	0.00	165.33	4.04	175.39
	8+	0.01	226.00	0.00	226.00	0.01	226.00
	Total	23.15		2.00		25.15	
	SOP		2475		95		2570
3	0	0.20	30.00	2.87	20.89	3.07	21.49
	1	97.48	82.53	1.71	44.05	99.19	81.86
	2	31.12	112.62	0.11	62.28	31.24	112.43
	3	12.20	126.70	0.00	128.09	12.20	126.70
	4	10.95	149.53	0.00	148.84	10.95	149.53
	5	3.59	180.64	0.00	183.19	3.59	180.64
	6	2.28	219.26	0.00	220.09	2.28	219.26
	7	0.62	202.59	0.00	203.67	0.62	202.59
	8+	1.03	236.72	0.00	237.00	1.03	236.72
	Total	159.47		4.69		164.16	
	SOP		16257		142		16399
4	0	0.08	45.50	3.71	22.58	3.78	23.06
	1	32.40	87.60	7.38	84.87	39.77	87.10
	2	9.07	107.29	0.93	101.20	10.00	106.73
	3	3.71	129.09	0.36	145.04	4.07	130.50
	4	3.00	155.85	0.54	158.64	3.53	156.27
	5	0.55	162.08	0.14	164.90	0.69	162.64
	6	0.08	215.00	0.03	215.00	0.11	215.00
	7	0.12	182.33	0.04	182.33	0.16	182.33
	8+	0.32	209.75	0.11	209.75	0.43	209.75
	Total	49.32		13.23		62.55	
	SOP		4956		1001		5956
Total	0	0.28	34.33	6.57	21.84	6.85	22.36
	1	135.73	82.29	12.42	66.30	148.15	80.95
	2	53.77	104.38	9.73	64.92	63.50	98.33
	3	18.42	124.47	2.04	100.54	20.46	122.09
	4	15.31	148.63	2.69	135.94	18.00	146.73
	5	7.49	166.34	0.92	147.31	8.41	164.26
	6	2.86	212.77	0.94	191.91	3.80	207.60
	7	5.25	178.70	0.16	170.18	5.41	178.45
	8+	1.37	230.24	0.14	210.84	1.50	228.50
	Total	240.49		35.61		276.10	
	SOP		24469		2542		27011

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: 2007 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	24.05	31	27.32	17	51.36	23
	2	59.03	61	17.53	57	76.56	60
	3	6.85	89	0.50	90	7.35	89
	4	6.44	122	0.36	131	6.80	122
	5	2.77	148	0.16	165	2.93	149
	6	3.86	182	0.43	190	4.29	183
	7	0.37	171	0.01	139	0.38	170
	8+	0.24	103			0.24	103
	Total	103.61		46.31		149.91	
	SOP		6969		1659		8627
2	1	5.07	59	1.18	15	6.25	51
	2	6.62	80	0.57	56	7.18	78
	3	1.17	95			1.17	95
	4	0.89	109			0.89	109
	5	0.94	129			0.94	129
	6	0.27	140			0.27	140
	7	0.65	165			0.65	165
	8+	0.19	148			0.19	148
	Total	15.78		1.75		17.53	
	SOP		1328		50		1378
3	0	13.61	49	19.44	19	33.05	31
	1	41.14	67	10.22	28	51.35	59
	2	13.60	86	0.21	76	13.80	86
	3	5.93	115			5.93	115
	4	3.97	128			3.97	128
	5	1.23	153			1.23	153
	6	0.54	162			0.54	162
	7	0.06	218			0.06	218
	8+	0.15	240			0.15	240
	Total	80.22		29.87		110.09	
	SOP		6123		662		6785
4	0	0.53	29	28.84	22	29.37	23
	1	34.38	59	1.67	43	36.05	59
	2	6.04	86	0.61	63	6.65	84
	3	1.43	107	0.01	116	1.44	107
	4	0.34	130	0.01	130	0.34	130
	5	0.12	146	0.00	146	0.12	146
	6						
	7						
	8+						
	Total	42.83		31.14		73.97	
	SOP		2790		759		3549
Total	0	14.14	49	48.29	21	62.42	27
	1	104.63	56	40.38	20	145.01	46
	2	85.28	68	18.92	58	104.20	67
	3	15.38	101	0.52	91	15.89	101
	4	11.63	123	0.36	131	12.00	124
	5	5.06	146	0.16	165	5.22	146
	6	4.67	178	0.43	190	5.10	179
	7	1.07	170	0.01	139	1.08	170
	8+	0.58	153			0.58	153
	Total	242.43		109.07		351.50	
	SOP		17209		3130		20340

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: 2007 Country: ALL

Quarter	W-rings	Sub-division 22 Numbers	Sub-division 22 Mean W.	Sub-division 23 Numbers	Sub-division 23 Mean W.	Sub-division 24 Numbers	Sub-division 24 Mean W.	Total Numbers	Total Mean W.
1	1	18.69	10	2.35	20	8.92	16	29.96	12
	2	7.25	44	3.67	64	28.51	50	39.44	51
	3	6.31	69	3.92	87	33.25	78	43.49	77
	4	3.69	90	3.09	126	40.07	112	46.85	112
	5	1.22	111	2.01	152	16.73	143	19.97	142
	6	1.15	125	0.96	169	6.96	169	9.07	163
	7	0.45	105	0.77	167	7.04	181	8.27	175
	8+	0.33	156			6.76	193	7.08	191
	Total	39.10		16.77		148.26		204.13	
	SOP		1656		1607		14815		18078
2	1	4.16	15	0.00	20	0.49	21	4.64	16
	2	3.47	45	0.00	64	14.27	40	17.75	41
	3	0.64	66	0.00	87	37.64	54	38.28	54
	4	0.11	91	0.00	126	30.08	80	30.18	80
	5	0.13	147	0.00	152	17.56	106	17.68	107
	6	0.16	149	0.00	169	6.15	121	6.31	121
	7	0.07	164	0.00	167	3.44	134	3.52	135
	8+	0.06	177			2.58	165	2.64	166
	Total	8.79		0.00		112.21		121.00	
	SOP		336		0		8492		8828
3	0	0.08	13	2.11	11			2.19	12
	1	0.00	49	8.28	42	0.63	61	8.91	43
	2			0.78	55	2.45	102	3.23	91
	3					1.25	131	1.25	131
	4					1.19	134	1.19	134
	5					0.63	141	0.63	141
	6								
	7								
	8+								
	Total	0.08		11.17		6.14		17.40	
	SOP		1		416		700		1117
4	0	2.38	13	4.30	11	0.23	16	6.91	12
	1	0.12	49	16.86	42	4.84	44	21.82	42
	2			1.59	55	16.50	67	18.09	66
	3					11.32	86	11.32	86
	4					4.57	106	4.57	106
	5					3.39	88	3.39	88
	6					1.28	77	1.28	77
	7					0.47	116	0.47	116
	8+					0.14	155	0.14	155
	Total	2.50		22.76		42.73		67.99	
	SOP		36		847		3251		4133
Total	0	2.46	13	6.41	11	0.23	16	9.10	12
	1	22.97	11	27.49	40	14.88	27	65.34	27
	2	10.72	44	6.05	61	61.73	55	78.50	54
	3	6.95	69	3.92	87	83.46	69	94.34	69
	4	3.79	90	3.09	126	75.91	99	82.79	100
	5	1.35	115	2.01	152	38.31	121	41.67	123
	6	1.31	128	0.96	169	14.39	140	16.66	141
	7	0.53	113	0.77	167	10.96	163	12.25	161
	8+	0.39	159			9.48	185	9.86	184
	Total	50.47		50.70		309.34		410.51	
	SOP		2028		2870		27258		32156

Table 3.2.4 WESTERN BALTIC HERRING.
Samples of commercial landings by quarter and area for 2007 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**				
		2	0	2	150	100
		3	2	7	518	256
		4	2	0		
	Total		4	9	668	356
	Germany	**1**				
		2				
		3	0	1	332	332
		4				
	Total		0	1	332	332
	Norway	**1**	0			
		2	2	No data available		
		3	1			
		4	1			
	Total		3	0	0	0
	Sweden	**1**	2	10	679	678
		2	1	6	650	649
		3	12	13	650	649
		4	4	8	673	673
	Total		19	37	2652	2649
Kattegat	**Denmark**	**1**	4	13	1554	547
		2	0			
		3	3	28	1612	356
		4	2	11	939	214
	Total		9	52	4105	1117
	Sweden	**1**	4	14	700	699
		2	0	12	687	683
		3	6	14	705	702
		4	1	7	675	673
	Total		11	47	2767	2757
Sub-Division 22	**Denmark**	**1**	0	3	274	103
		2	0	5	127	126
		3	0			
		4	0	1	43	43
	Total		0	9	444	272
	Germany	**1**	2	1	387	151
		2	0	2	1229	209
		3	0	0	0	0
		4	0	0	0	0
	Total		2	3	1616	360
Sub-Division 23	**Denmark**	**1**	2	2	247	100
		2	0			
		3	0			
		4	1			
	Total		2	12	2060	632
Sub-Division 24	**Denmark**	**1**	1	3	375	312
		2	0	1	5	5
		3	0			
		4	1	1	98	98
	Total		3	5	478	415
	Germany	**1**	10	29	10563	2349
		2	7	15	7053	1200
		3	0	0	0	0
		4	5	4	1275	262
	Total		23	48	18891	3811
	Poland	**1**	1	3	492	120
		2	2	2	294	96
		3	0	1	306	111
		4	0	2	310	158
	Total		3	8	1402	485
	Sweden	**1**	3	7	650	648
		2	1	1	100	98
		3	0	0	0	0
		4	3	3	300	300
	Total		7	11	1050	1046

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 2007.

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

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

continued

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 2007

	Country	Quarter	Fleet	Sampling
Sub-Division 22	Denmark	1	F	Danish sampling in Q1
		2	F	Danish sampling in Q2
		3	F	No landings
		4	F	Danish sampling in Q4
	Germany	1	F	German sampling in Q1
		2	F	German sampling in Q2
		3	F	No landings
		4	F	Danish sampling in Q4
Sub-Division 23	Denmark	1	F	Danish sampling in Q1
		2	F	Danish sampling in Q1
		3	F	KASU scientific sampling in Q4
		4	F	KASU scientific sampling in Q4
Sub-Division 24	Denmark	1	F	Danish sampling Q1
		2	F	Danish sampling Q2
		3	F	Danish sampling Q4
		4	F	Danish sampling Q4
	Germany	1	F	German sampling Q1
		2	F	German sampling Q2
		3	F	Danish sampling Q4
		4	F	German sampling Q1
	Poland	1	F	Polish sampling Q1
		2	F	Polish sampling Q2
		3	F	Polish sampling Q3
		4	F	Polish sampling Q4
	Sweden	1	F	Swedish sampling Q1
		2	F	Swedish sampling Q2
		3	F	Swedish sampling Q4
		4	F	Swedish sampling 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	98.0%	2.0%	50		83.2%	16.8%	298	
	2	74.0%	26.0%	50		59.8%	40.2%	174	
	3	**5.5%**	**94.5%**	*55*		7.4%	92.6%	68	
1	4	**3.8%**	**96.2%**	*26*		4.6%	95.4%	65	
	5	**8.3%**	**91.7%**	*12*		6.1%	93.9%	33	
	6	**10.0%**	**90.0%**	*30*	a (6-8+)	**2.4%**	**97.6%**	*41*	(6-8+)
	7	**10.0%**	**90.0%**	*30*	a	**2.4%**	**97.6%**	*41*	
	8+	**10.0%**	**90.0%**	**30**	a	**2.4%**	**97.6%**	**41**	
	0	100.0%	0.0%	54	a	100.0%	0.0%	0	Sk
	1	100.0%	0.0%	49		100.0%	0.0%	48	
	2	78.3%	21.7%	106		58.0%	42.0%	50	
	3	21.8%	78.2%	55		6.0%	94.0%	50	
2	4	3.0%	97.0%	33		0.0%	100.0%	25	
	5	38.5%	61.5%	13		**4.0%**	**96.0%**	*25*	(5-8+)
	6	13.3%	86.7%	15	(6-8+)	**4.0%**	**96.0%**	*25*	
	7	**13.3%**	**86.7%**	*15*	a	**4.0%**	**96.0%**	*25*	
	8+	**13.3%**	**86.7%**	**15**		**4.0%**	**96.0%**	**25**	
	0	97.5%	2.5%	81		98.5%	1.5%	66	
	1	65.4%	34.6%	156		40.2%	59.8%	179	
	2	28.8%	71.3%	80		4.0%	96.0%	99	
	3	5.5%	94.5%	55		0.0%	100.0%	70	
3	4	0.0%	100.0%	34		0.0%	100.0%	54	
	5	1.6%	98.4%	63	a	0.0%	100.0%	15	
	6	0.0%	100.0%	21	a	**0.0%**	**100.0%**	12	a
	7	**0.0%**	**100.0%**	*20*	a (7-8+)	**0.0%**	**100.0%**	12	a (7-8+)
	8+	**0.0%**	**100.0%**	**20**	a	**0.0%**	**100.0%**	**12**	a
	0	100.0%	0.0%	2		96.4%	3.6%	84	
	1	81.3%	18.8%	48		37.1%	62.9%	132	
	2	**2.0%**	**98.0%**	*50*		4.5%	95.5%	67	
	3	**3.8%**	**96.2%**	*26*		3.2%	96.8%	31	
4	4	**0.0%**	**100.0%**	*39*		0.0%	100.0%	15	(4-8+)
	5	**0.0%**	**100.0%**	*23*	(5-8+)	0.0%	100.0%	15	
	6	**0.0%**	**100.0%**	*23*		**0.0%**	**100.0%**	*15*	
	7	**0.0%**	**100.0%**	*23*		**0.0%**	**100.0%**	*15*	
	8+	**0.0%**	**100.0%**	**23**		**0.0%**	**100.0%**	**15**	

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: 2007 Country: All

		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
1	1	20.01	31	22.73	17	42.75	23
	2	35.28	61	10.48	57	45.76	60
	3	0.50	89	0.04	90	0.54	89
	4	0.30	122	0.02	131	0.31	122
	5	0.17	148	0.01	165	0.18	149
	6	0.09	182	0.01	190	0.10	183
	7	0.01	171	0.00	139	0.01	170
	8+	0.01	103			0.01	103
	Total	56.37		33.28		89.66	
	SOP		2914		986		3900
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
2	1	5.07	59	1.18	15	6.25	51
	2	3.84	80	0.33	56	4.17	78
	3	0.07	95			0.07	95
	4						
	5	0.04	129			0.04	129
	6	0.01	140			0.01	140
	7	0.03	165			0.03	165
	8+	0.01	148			0.01	148
	Total	9.06		1.51		10.57	
	SOP		623		37		660
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
3	0	13.40	49	19.15	19	32.55	31
	1	16.55	67	4.11	28	20.66	59
	2	0.55	86	0.01	76	0.56	86
	3						
	4						
	5						
	6						
	7						
	8+						
	Total	30.50		23.27		53.76	
	SOP		1819		472		2291
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
4	0	0.51	29	27.81	22	28.32	23
	1	12.76	59	0.62	43	13.38	59
	2	0.27	86	0.03	63	0.30	84
	3	0.05	107	0.00	116	0.05	107
	4						
	5						
	6						
	7						
	8+						
	Total	13.59		28.46		42.05	
	SOP		801		652		1453
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
Total	0	13.91	49	46.96	21	60.87	27
	1	54.39	51	28.65	19	83.03	40
	2	39.94	64	10.84	57	50.78	62
	3	0.62	91	0.04	90	0.66	91
	4	0.30	122	0.02	131	0.31	122
	5	0.21	144	0.01	165	0.21	145
	6	0.10	178	0.01	190	0.12	179
	7	0.03	167	0.00	139	0.04	166
	8+	0.01	128			0.01	128
	Total	109.51		86.53		196.04	
	SOP		6157		2147		8304

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: 2007 Country: All

		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
1	1	1.30	36	2.81	35	4.12	35
	2	3.02	70	5.65	65	8.67	67
	3	0.04	103	0.07	100	0.11	101
	4	0.04	131	0.08	131	0.12	131
	5	0.05	149	0.06	145	0.11	147
	6	0.04	192	0.09	192	0.13	192
	7	0.05	174	0.01	166	0.06	173
	8+	0.00	215	0.00	215	0.00	215
	Total	4.54		8.78		13.32	
	SOP		291		509		801
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
2	1	4.53	53	0.46	49	4.99	52
	2	7.43	89	0.82	35	8.26	84
	3	0.40	108	0.09	63	0.49	100
	4	0.01	115	0.00	115	0.01	115
	5	1.05	152	0.01	116	1.05	152
	6	0.01	150	0.00	150	0.02	150
	7	0.54	175	0.00	165	0.54	175
	8+	0.00	226	0.00	226	0.00	226
	Total	13.98		1.38		15.36	
	SOP		1204		58		1263
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
3	0	0.20	30	2.80	21	2.99	21
	1	63.73	83	1.12	44	64.85	82
	2	8.95	113	0.03	62	8.98	112
	3	0.67	127	0.00	128	0.67	127
	4						
	5	0.06	181	0.00	183	0.06	181
	6						
	7						
	8+						
	Total	73.60		3.95		77.55	
	SOP		6368		110		6478
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
4	0	0.08	46	3.71	23	3.78	23
	1	26.32	88	6.00	85	32.32	87
	2	0.18	107	0.02	101	0.20	107
	3	0.14	129	0.01	145	0.16	130
	4						
	5						
	6						
	7						
	8+						
	Total	26.72		9.73		36.46	
	SOP		2347		596		2944
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
Total	0	0.28	34	6.50	22	6.78	22
	1	95.89	82	10.38	65	106.27	80
	2	19.58	97	6.53	61	26.11	88
	3	1.24	120	0.17	84	1.41	116
	4	0.05	126	0.08	130	0.13	129
	5	1.16	154	0.07	142	1.23	153
	6	0.05	181	0.09	191	0.15	187
	7	0.59	175	0.01	166	0.60	175
	8+	0.00	222	0.00	216	0.01	219
	Total	118.84		23.84		142.68	
	SOP		10211		1274		11485

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: 2007 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	4.04	31	4.58	17	8.62	23
	2	23.75	61	7.05	57	30.80	60
	3	6.35	89	0.47	90	6.81	89
	4	6.14	122	0.34	131	6.48	122
	5	2.60	148	0.15	165	2.75	149
	6	3.76	182	0.42	190	4.18	183
	7	0.36	171	0.01	139	0.37	170
	8+	0.24	103			0.24	103
	Total	47.23		13.02		60.25	
	SOP		4055		672		4727
2	1						
	2	2.78	80	0.24	56	3.02	78
	3	1.10	95			1.10	95
	4	0.89	109			0.89	109
	5	0.90	129			0.90	129
	6	0.26	140			0.26	140
	7	0.62	165			0.62	165
	8+	0.18	148			0.18	148
	Total	6.72		0.24		6.96	
	SOP		705		13		718
3	0	0.21	49	0.29	19	0.50	31
	1	24.59	67	6.11	28	30.70	59
	2	13.05	86	0.20	76	13.25	86
	3	5.93	115			5.93	115
	4	3.97	128			3.97	128
	5	1.23	153			1.23	153
	6	0.54	162			0.54	162
	7	0.06	218			0.06	218
	8+	0.15	240			0.15	240
	Total	49.72		6.60		56.33	
	SOP		4304		190		4494
4	0	0.02	29	1.03	22	1.05	23
	1	21.62	59	1.05	43	22.67	59
	2	5.77	86	0.58	63	6.35	84
	3	1.38	107	0.01	116	1.39	107
	4	0.34	130	0.01	130	0.34	130
	5	0.12	146	0.00	146	0.12	146
	6						
	7						
	8+						
	Total	29.24		2.68		31.92	
	SOP		1989		108		2096
Total	0	0.23	48	1.32	22	1.55	25
	1	50.24	61	11.74	25	61.98	54
	2	45.34	73	8.07	58	53.41	71
	3	14.76	102	0.48	91	15.24	101
	4	11.33	123	0.35	131	11.68	124
	5	4.86	146	0.15	165	5.00	146
	6	4.56	178	0.42	190	4.98	179
	7	1.04	170	0.01	139	1.05	170
	8+	0.56	153			0.56	153
	Total	132.92		22.54		155.46	
	SOP		11052		984		12036

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: 2007 Country: All

		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
1	1	0.03	36	0.06	35	0.08	35
	2	1.06	70	1.99	65	3.05	67
	3	0.66	103	1.20	100	1.86	101
	4	0.90	131	2.03	131	2.93	131
	5	0.56	149	0.70	145	1.26	147
	6	0.36	192	0.81	192	1.17	192
	7	0.43	174	0.10	166	0.53	173
	8+	0.01	215	0.02	215	0.03	215
	Total	4.01		6.91		10.92	
	SOP		491		794		1285
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
2	1						
	2	2.06	89	0.23	35	2.29	84
	3	1.42	108	0.32	63	1.74	100
	4	0.42	115	0.05	115	0.46	115
	5	1.68	152	0.01	116	1.69	152
	6	0.09	150	0.01	150	0.10	150
	7	3.49	175	0.00	165	3.50	175
	8+	0.01	226	0.00	226	0.01	226
	Total	9.17		0.62		9.79	
	SOP		1271		37		1308
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
3	0	0.01	30	0.07	21	0.08	21
	1	33.74	83	0.59	44	34.33	82
	2	22.17	113	0.08	62	22.26	112
	3	11.53	127	0.00	128	11.53	127
	4	10.95	150	0.00	149	10.95	150
	5	3.54	181	0.00	183	3.54	181
	6	2.28	219	0.00	220	2.28	219
	7	0.62	203	0.00	204	0.62	203
	8+	1.03	237	0.00	237	1.03	237
	Total	85.87		0.74		86.62	
	SOP		9889		33		9922
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
4	0						
	1	6.07	88	1.38	85	7.46	87
	2	8.89	107	0.91	101	9.80	107
	3	3.57	129	0.35	145	3.92	130
	4	3.00	156	0.54	159	3.53	156
	5	0.55	162	0.14	165	0.69	163
	6	0.08	215	0.03	215	0.11	215
	7	0.12	182	0.04	182	0.16	182
	8+	0.32	210	0.11	210	0.43	210
	Total	22.60		3.49		26.09	
	SOP		2608		404		3013
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
Total	0	0.01	30	0.07	21	0.08	21
	1	39.84	83	2.03	72	41.88	83
	2	34.19	109	3.20	73	37.39	105
	3	17.18	125	1.87	102	19.05	123
	4	15.26	149	2.61	136	17.87	147
	5	6.33	169	0.85	148	7.18	166
	6	2.81	213	0.85	192	3.66	208
	7	4.66	179	0.15	171	4.81	179
	8+	1.37	230	0.13	211	1.50	229
	Total	121.65		11.77		133.42	
	SOP		14258		1269		15527

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**

Quarter	W-rings	Fleet C Numbers	Fleet C Mean W.	Fleet D Numbers	Fleet D Mean W.	Total Numbers	Total Mean W.
1	1	21.32	32	25.55	19	46.86	24
	2	38.30	62	16.13	60	54.44	61
	3	0.54	90	0.11	97	0.65	91
	4	0.33	123	0.10	131	0.43	125
	5	0.22	148	0.07	147	0.29	148
	6	0.13	185	0.10	192	0.24	188
	7	0.06	174	0.01	165	0.07	172
	8+	0.01	120	0.00	215	0.01	144
	Total	60.91		42.07		102.98	
	SOP		3205		1495		4701
2	1	9.60	56	1.64	25	11.24	51
	2	11.27	86	1.15	41	12.42	82
	3	0.47	106	0.09	63	0.56	99
	4	0.01	115	0.00	115	0.01	115
	5	1.09	151	0.01	116	1.09	151
	6	0.02	146	0.00	150	0.03	146
	7	0.56	175	0.00	165	0.56	175
	8+	0.01	162	0.00	226	0.01	164
	Total	23.03		2.89		25.93	
	SOP		1828		95		1922
3	0	13.60	49	21.95	19	35.55	30
	1	80.28	79	5.23	31	85.51	76
	2	9.50	111	0.04	65	9.54	111
	3	0.67	127	0.00	128	0.67	127
	4						
	5	0.06	181	0.00	183	0.06	181
	6						
	7						
	8+						
	Total	104.10		27.21		131.31	
	SOP		8187		582		8769
4	0	0.59	31	31.52	22	32.11	23
	1	39.08	78	6.62	81	45.70	79
	2	0.45	94	0.05	79	0.50	93
	3	0.19	124	0.01	144	0.20	125
	4						
	5						
	6						
	7						
	8+						
	Total	40.31		38.19		78.50	
	SOP		3148		1248		4397
Total	0	14.19	48	53.46	21	67.65	27
	1	150.28	71	39.03	31	189.31	63
	2	59.52	75	17.37	59	76.90	71
	3	1.86	111	0.21	85	2.07	108
	4	0.35	123	0.10	130	0.45	124
	5	1.36	152	0.08	145	1.44	152
	6	0.16	179	0.10	191	0.26	184
	7	0.62	175	0.01	165	0.63	175
	8+	0.02	144	0.00	216	0.02	154
	Total	228.36		110.37		338.72	
	SOP		16368		3420		19788

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: 2007** **Country: All**

		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
1	1	4.06	31	4.64	17	8.70	24
	2	24.81	62	9.04	59	33.85	61
	3	7.00	91	1.67	97	8.67	92
	4	7.04	123	2.37	131	9.41	125
	5	3.17	148	0.85	148	4.01	148
	6	4.13	183	1.23	191	5.36	185
	7	0.79	173	0.12	163	0.91	172
	8+	0.25	107	0.02	215	0.27	116
	Total	51.24		19.93		71.17	
	SOP		4546		1467		6012
		Fleet C		**Fleet D**		**Total**	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
2	1						
	2	4.84	84	0.47	46	5.31	81
	3	2.52	103	0.32	63	2.84	98
	4	1.30	111	0.05	115	1.35	111
	5	2.58	144	0.01	116	2.59	144
	6	0.35	142	0.01	150	0.36	143
	7	4.11	174	0.00	165	4.12	174
	8+	0.19	152	0.00	226	0.19	153
	Total	15.89		0.86		16.75	
	SOP		1975		50		2026
		Fleet C		**Fleet D**		**Total**	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
3	0	0.21	49	0.37	19	0.58	30
	1	58.33	76	6.70	29	65.03	71
	2	35.22	103	0.28	72	35.50	103
	3	17.47	123	0.00	128	17.47	123
	4	14.92	144	0.00	149	14.92	144
	5	4.77	174	0.00	183	4.77	174
	6	2.82	208	0.00	220	2.82	208
	7	0.68	204	0.00	204	0.68	204
	8+	1.18	237	0.00	237	1.18	237
	Total	135.59		7.35		142.94	
	SOP		14193		223		14416
		Fleet C		**Fleet D**		**Total**	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
4	0	0.02	29	1.03	22	1.05	23
	1	27.69	66	2.43	67	30.12	66
	2	14.66	99	1.49	86	16.15	98
	3	4.95	123	0.36	144	5.31	124
	4	3.33	153	0.54	158	3.88	154
	5	0.68	159	0.14	165	0.82	160
	6	0.08	215	0.03	215	0.11	215
	7	0.12	182	0.04	182	0.16	182
	8+	0.32	210	0.11	210	0.43	210
	Total	51.84		6.18		58.01	
	SOP		4597		512		5109
		Fleet C		**Fleet D**		**Total**	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
Total	0	0.23	47	1.40	22	1.63	25
	1	90.08	71	13.77	32	103.86	66
	2	79.53	88	11.28	62	90.80	85
	3	31.94	114	2.35	100	34.28	113
	4	26.60	138	2.96	136	29.56	138
	5	11.19	159	1.00	150	12.19	158
	6	7.37	191	1.27	191	8.64	191
	7	5.70	177	0.16	168	5.86	177
	8+	1.93	208	0.13	211	2.06	208
	Total	254.57		34.31		288.88	
	SOP		25311		2252		27563

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 1991-2007.

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	1346.77
	Mean W.	33.00	48.63	69.50	99.94	135.69	146.24	166.91	179.74	193.23	
	SOP	3299.87	7656.46	26613.62	39454.71	22657.27	16429.88	3647.95	1318.14	608.74	121686.63
1992	Numbers	109.08	246.00	321.85	174.02	154.47	78.33	55.83	17.91	8.53	1166.03
	Mean W.	13.90	44.07	86.95	112.93	136.18	166.35	183.49	194.35	203.57	
	SOP	1516.22	10840.58	27986.49	19653.18	21035.47	13029.76	10243.16	3480.89	1737.27	109523.02
1993	Numbers	161.25	371.50	315.82	219.05	94.08	59.43	40.97	21.71	8.22	1292.03
	Mean W.	15.10	25.87	81.36	127.53	150.09	171.08	195.93	209.13	239.04	
	SOP	2434.91	9611.56	25695.54	27935.64	14120.14	10166.57	8026.96	4540.63	1966.03	104497.98
1994	Numbers	60.62	153.11	261.14	221.64	130.97	77.30	44.40	14.39	8.62	972.19
	Mean W.	20.20	42.61	94.84	122.75	150.31	168.73	194.67	209.92	220.24	
	SOP	1224.56	6524.31	24766.99	27206.25	19686.09	13043.26	8642.46	3021.51	1897.96	106013.39
1995	Numbers	50.31	302.51	204.19	97.93	90.86	30.55	21.28	12.01	7.24	816.86
	Mean W.	17.92	41.49	97.80	138.03	163.14	198.51	206.99	228.79	234.35	
	SOP	901.66	12551.14	19969.61	13517.04	14822.87	6065.33	4404.12	2746.64	1695.68	76674.09
1996	Numbers	166.23	228.05	317.74	75.60	40.41	30.63	12.58	6.73	5.63	883.60
	Mean W.	10.52	27.61	90.07	134.89	164.94	186.57	204.05	208.47	220.25	
	SOP	1747.94	6296.43	28617.71	10196.93	6664.61	5714.08	2567.57	1402.34	1241.02	64448.62
1997	Numbers	25.97	73.43	158.71	180.06	30.15	14.15	4.77	1.75	2.31	491.31
	Mean W.	19.18	49.68	76.71	127.25	154.39	175.83	184.37	192.04	208.02	
	SOP	497.94	3648.03	12175.61	22912.70	4655.67	2488.87	879.10	336.83	480.33	48075.08
1998	Numbers	36.26	175.14	315.15	94.53	54.72	11.19	8.72	2.19	2.09	699.98
	Mean W.	27.81	51.27	71.53	108.82	142.63	171.74	194.44	184.16	230.00	
	SOP	1008.50	8979.66	22541.57	10286.89	7804.06	1921.99	1694.74	402.61	481.46	55121.49
1999	Numbers	41.34	190.29	155.67	122.26	43.16	22.21	4.42	3.02	2.40	584.77
	Mean W.	11.53	50.96	83.59	114.90	121.21	145.24	169.57	123.84	152.32	
	SOP	476.52	9697.90	13011.90	14047.56	5231.70	3225.44	748.67	373.38	366.22	47179.29
2000	Numbers	114.83	318.22	302.10	99.88	50.85	18.76	8.21	1.35	1.40	915.60
	Mean W.	22.65	31.88	67.39	107.68	140.25	169.95	156.95	184.97	210.10	
	SOP	2600.55	10145.19	20357.05	10755.90	7131.34	3188.81	1287.93	249.46	293.63	56009.87
2001	Numbers	121.68	36.63	208.10	111.08	32.06	19.67	9.84	4.17	2.42	545.65
	Mean W.	9.00	51.20	76.23	108.87	145.27	171.37	188.21	187.25	203.34	
	SOP	1095.59	1875.17	15863.43	12092.68	4657.21	3370.83	1852.00	780.09	492.37	42079.37
2002	Numbers	69.63	577.69	168.26	134.60	53.09	12.05	7.48	2.43	2.02	1027.26
	Mean W.	10.18	20.42	78.22	117.74	143.76	169.78	191.89	198.25	215.45	
	SOP	708.74	11795.44	13161.97	15848.04	7632.35	2045.85	1435.18	481.39	434.97	53543.92
2003	Numbers	52.11	63.02	182.53	65.45	64.37	21.47	6.26	4.35	1.81	461.38
	Mean W.	13.01	37.37	76.46	113.31	132.67	142.18	153.55	169.91	162.24	
	SOP	677.85	2355.21	13956.79	7416.46	8540.42	3052.62	961.14	739.80	294.20	37994.49
2004	Numbers	25.67	209.34	96.02	93.98	18.24	16.84	4.51	1.51	0.59	466.71
	Mean W.	27.07	43.22	81.94	117.10	145.41	157.41	170.71	184.38	187.07	
	SOP	694.94	9047.40	7868.58	11004.82	2652.45	2651.17	769.31	278.96	110.63	35078.25
2005	Numbers	95.32	96.87	203.33	75.35	46.93	9.33	11.50	3.46	1.41	543.51
	Mean W.	14.07	54.91	85.65	121.61	148.32	162.67	176.31	178.31	200.61	
	SOP	1341.03	5318.72	17414.88	9163.28	6960.95	1518.52	2027.61	617.71	282.14	44644.85
2006	Numbers	7.30	104.15	115.60	114.22	48.92	55.75	11.09	10.31	5.15	472.49
corrected	Mean W.	16.62	36.94	82.91	113.00	142.50	175.17	198.21	209.46	219.96	
	SOP	121.25	3846.70	9584.17	12906.53	6971.55	9765.29	2199.10	2159.24	1133.90	48687.73
2007	Numbers	1.63	103.86	90.88	36.91	30.81	12.78	9.45	6.24	2.68	295.22
	Mean W.	25.17	65.63	84.98	115.67	138.44	159.24	190.77	178.55	211.88	
	SOP	40.92	6815.63	7723.10	4269.33	4265.11	2035.14	1802.16	1113.94	567.07	28632.40

Data for 1995 to 2001 was revised in 2003.

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

Division: IV + IIIa + 22-24 **Year: 2007**

		Division IV		Division IIIa		Sub-division 22-24		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
1	1	0.00	24.00	8.70	23.55	29.96	12.48	38.66	15
	2	0.00	141.00	33.85	60.95	39.64	50.73	73.49	55
	3	0.00	165.00	8.67	91.83	44.49	77.58	53.16	80
	4	0.00	181.70	9.41	125.01	48.95	111.74	58.35	114
	5	0.00	202.50	4.01	148.02	21.22	141.63	25.23	143
	6	0.00	210.40	5.36	185.10	9.39	162.61	14.75	171
	7	0.00	235.50	0.91	171.51	8.33	175.31	9.24	175
	8+	0.00	244.70	0.27	115.83	7.10	191.08	7.37	188
	Total	0.00		71.17		209.08		280.25	
	SOP		0		6012.35		18655.38		24667.73
		Division IV		Division IIIa		Sub-division 22-24		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
2	1	0.00	0.00	0.00	0.00	4.64	16.04	4.64	16
	2	0.02	158.00	5.31	80.67	28.70	48.98	34.02	54
	3	1.12	146.00	2.84	98.16	43.09	56.51	47.05	61
	4	0.65	152.00	1.35	111.24	31.38	82.05	33.38	85
	5	0.27	181.00	2.59	143.93	19.83	109.61	22.69	114
	6	0.35	182.00	0.36	142.59	7.10	122.40	7.80	126
	7	0.20	190.00	4.12	173.88	3.64	136.21	7.96	157
	8+	0.16	218.00	0.19	152.73	2.89	159.75	3.24	162
	Total	2.77		16.75		141.27		160.78	
	SOP		450		2025.55		10488.69		12964.60
		Division IV		Division IIIa		Sub-division 22-24		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
3	0	0.00	0.00	0.58	29.98	2.19	11.51	2.76	15
	1	0.00	110.50	65.03	71.22	9.55	42.93	74.58	68
	2	0.04	153.00	35.50	102.62	4.03	82.62	39.57	101
	3	1.47	149.00	17.47	122.81	1.99	101.79	20.93	123
	4	0.58	157.00	14.92	143.83	3.09	79.27	18.59	134
	5	0.25	178.00	4.77	173.60	4.43	57.72	9.45	119
	6	0.30	179.00	2.82	208.19	1.00	49.00	4.12	167
	7	0.08	190.00	0.68	203.85	0.55	54.00	1.31	140
	8+	0.25	217.33	1.18	237.14	0.01	65.00	1.44	233
	Total	2.97		142.94		26.84		172.74	
	SOP		483		14415.63		1550.67		16449.72
		Division IV		Division IIIa		Sub-division 22-24		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
4	0	0.00	0.00	1.05	22.53	6.91	11.99	7.96	13
	1	0.00	141.00	30.12	65.71	24.03	43.07	54.16	56
	2	0.01	167.00	16.15	97.68	21.49	75.82	37.65	85
	3	0.04	185.00	5.31	124.36	17.43	110.65	22.77	114
	4	0.02	263.00	3.88	153.96	12.63	151.98	16.53	153
	5	0.07	224.00	0.82	160.15	6.74	133.77	7.62	137
	6	0.16	207.00	0.11	215.00	3.26	145.85	3.53	151
	7	0.10	226.00	0.16	182.33	2.50	183.05	2.76	185
	8+	0.21	239.06	0.43	209.75	2.08	202.82	2.72	207
	Total	0.61		58.01		97.08		155.70	
	SOP		136		5109.10		8853.02		14098.12
		Division IV		Division IIIa		Sub-division 22-24		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
Total	0	0.00	0.00	1.63	25.17	9.10	11.88	10.72	14
	1	0.00	0.00	103.86	65.63	68.19	27.77	172.04	51
	2	0.07	156.59	90.80	84.92	93.86	57.31	184.73	71
	3	2.63	148.22	34.28	113.17	106.99	74.93	143.90	85
	4	1.25	156.47	29.56	137.68	96.05	106.28	126.86	114
	5	0.60	185.00	12.19	157.98	52.22	121.34	65.00	129
	6	0.81	185.80	8.64	191.24	20.75	140.75	30.20	156
	7	0.38	199.32	5.86	177.22	15.02	162.69	21.26	167
	8+	0.61	224.85	2.06	208.02	12.08	185.52	14.76	190
	Total	6.34		288.88		474.26		769.48	
	SOP		1069.77		27562.63		39547.76		68180.17

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 1991-2007

Year	Area / W-rings	0	1	2	3	4	5	6	7	8+	Total
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	**[c]Div. IV+Div. III**	7.3	104.1	115.6	114.2	48.9	55.7	11.1	10.3	5.2	472.5
	Sub-div. 22-24	0.6	44.8	72.1	119.0	101.7	43.0	31.4	22.1	12.2	446.8
2007	**Div. IV+Div. IIIa**	1.6	103.9	90.9	36.9	30.8	12.8	9.4	6.2	2.7	295.2
	Sub-div. 22-24	9.1	68.2	93.9	107.0	96.1	52.2	20.8	15.0	12.1	474.3

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

[c] values have been corrected in 2007

Table 3.2.16 **WESTERN BALTIC HERRING.**
Mean weight (g) and SOP (tons) of *Western Baltic Spring Spawners* in Division IIIa and the North Sea + in Sub-Divisions 22-24 in the years 1991 - 2007

	W-rings	0	1	2	3	4	5	6	7	8+	SOP
Year	**Area**										
1991	**Div. IV+Div. IIIa**	33.0	48.6	69.5	99.9	135.7	146.2	166.9	179.7	193.2	121686.6
	Sub-div. 22-24	11.5	31.5	60.4	83.2	105.2	126.6	145.6	160.0	163.7	69886.5
1992	**Div. IV+Div. IIIa**	13.9	44.1	87.0	112.9	136.2	166.3	183.5	194.4	203.6	109523.0
	Sub-div. 22-24	19.1	23.3	44.8	77.4	99.2	123.3	152.9	166.2	184.2	84888.2
1993	**Div. IV+Div. IIIa**	15.1	25.9	81.4	127.5	150.1	171.1	195.9	209.1	239.0	104498.0
	Sub-div. 22-24	16.2	24.5	44.5	73.6	94.1	122.4	149.4	168.5	178.7	80511.9
1994	**Div. IV+Div. IIIa**	20.2	42.6	94.8	122.7	150.3	168.7	194.7	209.9	220.2	106013.4
	Sub-div. 22-24	12.9	28.2	54.2	76.4	95.0	117.7	133.6	154.3	173.9	66424.8
1995	**Div. IV+Div. IIIa**	17.9	41.5	97.8	138.0	163.1	198.5	207.0	228.8	234.3	76674.0
	Sub-div. 22-24	9.3	16.3	42.8	68.3	88.9	125.4	150.4	193.3	207.4	74156.8
1996	**Div. IV+Div. IIIa**	10.5	27.6	90.1	134.9	164.9	186.6	204.1	208.5	220.2	64449.0
	Sub-div. 22-24	12.1	22.9	45.8	74.0	92.1	116.3	120.8	139.0	182.5	56816.8
1997	**Div. IV+Div. IIIa**	19.2	49.7	76.7	127.2	154.4	175.8	184.4	192.0	208.0	48075.0
	Sub-div. 22-24	30.4	24.7	58.4	101.0	120.7	155.2	181.3	197.1	208.8	67512.8
1998	**Div. IV+Div. IIIa**	27.8	51.3	71.5	108.8	142.6	171.7	194.4	184.2	230.0	55121.0
	Sub-div. 22-24	13.3	26.3	52.2	78.6	103.0	125.2	150.0	162.1	179.5	51910.9
1999	**Div. IV+Div. IIIa**	11.5	51.0	83.6	114.9	121.2	145.2	169.6	123.8	152.3	47179.0
	Sub-div. 22-24	11.1	26.9	50.4	81.6	112.0	148.4	151.4	167.8	161.0	50060.3
2000	**Div. IV+Div. IIIa**	22.6	31.9	67.4	107.7	140.2	170.0	157.0	185.0	210.1	56010.0
	Sub-div. 22-24	16.5	22.2	42.8	80.4	123.5	133.2	143.4	155.4	151.4	53903.7
2001	**Div. IV+Div. IIIa**	9.0	51.2	76.2	108.9	145.3	171.4	188.2	187.2	203.3	42079.0
	Sub-div. 22-24	12.9	22.3	46.8	69.0	93.5	150.8	145.1	146.3	153.1	63723.8
2002	**Div. IV+Div. IIIa**	10.2	20.4	78.2	117.7	143.8	169.8	191.9	198.2	215.5	53543.9
	Sub-div. 22-24	10.8	27.3	57.8	81.7	108.8	132.1	186.6	177.8	157.7	52646.7
2003	**Div. IV+Div. IIIa**	13.0	37.4	76.5	112.7	132.1	140.8	151.9	167.4	158.2	37075.1
	Sub-div. 22-24	22.4	25.8	46.4	75.3	95.2	117.2	125.9	157.1	162.6	40315.0
2004	**Div. IV+Div. IIIa**	27.1	43.2	81.9	117.1	145.4	157.4	170.7	184.4	187.1	35078.3
	Sub-div. 22-24	3.7	14.3	47.4	77.7	96.4	125.5	150.4	165.8	151.0	41736.5
2005	**Div. IV+Div. IIIa**	14.1	54.9	85.6	121.6	148.3	162.7	176.3	178.3	200.6	44644.9
	Sub-div. 22-24	13.6	14.2	48.3	73.3	89.3	115.5	143.6	159.9	170.2	43724.8
2006	[c] **Div. IV+Div. IIIa**	16.6	36.9	82.9	113.0	142.5	175.2	198.2	209.5	220.0	48687.7
	Sub-div. 22-24	21.2	34.0	56.7	84.0	102.2	125.3	143.9	175.8	170.0	41861.2
2007	**Div. IV+Div. IIIa**	25.2	65.6	85.0	115.7	138.4	159.2	190.8	178.6	211.9	28632.4
	Sub-div. 22-24	11.9	27.8	57.3	74.9	106.3	121.3	140.8	162.7	185.5	39547.8

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

[c] values have been corrected in 2007

Table 3.2.17 WESTERN BALTIC HERRING.
Transfers of *North Sea autumn spawners* from Div. IIIa to the North Sea
Numbers ('000) and mean weight, SOP in (tonnes) 1991-2007.

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	1790.6
	Mean W.	25.6	40.5	72.9	97.2	135.8	149.7	155.7	159.8	176.8	
	SOP	17314.0	30335.8	21744.3	5098.0	1049.2	770.7	178.2	58.5	26.5	76575.3
1992	Number	2298.4	1408.8	220.3	22.1	10.4	6.6	2.9	1.0	0.4	3970.9
	Mean W.	12.3	51.8	84.2	131.4	162.0	173.4	185.3	198.4	201.2	
	SOP	28159.2	72985.2	18557.0	2907.1	1682.9	1143.0	532.7	200.4	83.7	126251.2
1993	Number	2795.4	2032.5	237.6	26.5	7.7	3.6	2.7	2.2	0.7	5109.0
	Mean W.	12.5	28.6	79.7	141.4	132.3	233.4	238.5	180.6	203.1	
	SOP	34903.1	58106.6	18939.3	3749.2	1016.2	850.1	646.9	389.8	133.1	118734.5
1994	Number	481.6	1086.5	201.4	26.9	6.0	2.9	1.6	0.4	0.2	1807.5
	Mean W.	16.0	42.9	83.4	110.7	138.3	158.6	184.6	199.1	213.9	
	SOP	7722.8	46630.2	16789.9	2979.5	830.8	459.6	286.8	74.9	36.8	75811.4
1995	Number	1144.5	1189.2	161.5	13.3	3.5	1.1	0.6	0.4	0.3	2514.4
	Mean W.	11.2	39.1	88.3	145.7	165.5	204.5	212.2	236.4	244.3	
	SOP	12836.7	46555.2	14266.5	1939.9	573.0	224.9	132.6	86.0	65.5	76680.2
1996	Number	516.1	961.1	161.4	17.0	3.4	1.6	0.7	0.4	0.3	1661.9
	Mean W.	11.0	23.4	80.2	126.6	165.0	186.5	216.1	216.3	239.1	
	SOP	5696.9	22448.3	12946.7	2151.4	564.8	307.1	144.7	76.7	66.4	44402.9
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	1304.4	14571.2	9025.3	2643.3	285.2	145.8	40.2	16.3	24.8	28056.6
1998	Number	51.3	745.1	161.5	26.6	19.2	3.0	3.1	1.2	0.5	1011.6
	Mean W.	27.4	56.4	79.8	117.8	162.9	179.7	197.2	178.9	226.3	
	SOP	1408.9	41993.8	12895.9	3137.2	3136.4	546.6	607.9	211.0	107.7	64045.4
1999	Number	598.8	303.0	148.6	47.2	13.4	6.2	1.2	0.5	0.5	1119.4
	Mean W.	10.4	50.5	87.7	113.7	137.4	156.5	188.1	187.3	198.8	
	SOP	6255.5	15297.0	13037.3	5368.6	1840.8	974.4	230.5	90.2	91.7	43186.1
2000	Number	235.3	984.3	116.0	21.9	22.9	7.5	3.3	0.6	0.1	1391.8
	Mean W.	21.3	28.5	76.1	108.8	163.1	190.3	183.9	189.4	200.2	
	SOP	5005.0	28011.8	8825.1	2377.5	3730.7	1436.0	601.0	114.2	13.4	50114.6
2001	Number	807.8	563.6	150.0	17.2	1.4	0.3	0.5	0.0	0.0	1540.8
	Mean W.	8.7	49.4	75.3	108.2	130.1	147.1	219.1	175.8	198.1	
	SOP	7029.0	27848.9	11299.8	1856.4	177.4	42.6	109.1	7.9	5.2	48376.4
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	5858.7	13790.3	5705.2	684.2	105.6	26.0	21.4	8.5	5.3	26205.1
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	441.6	14992.5	12218.7	1605.7	2435.7	292.8	213.1	264.4	33.4	32497.7
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	1993.4	3920.8	12638.3	2498.3	850.5	1479.1	312.3	366.5	154.5	24213.6
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	1595.0	15527.3	11303.6	1711.9	828.2	412.2	419.6	95.1	33.6	31926.5
2006	Number	35.1	150.1	50.2	10.2	3.3	3.3	0.6	0.4	0.2	253.3
	Mean W.	14.3	53.5	79.2	117.6	140.2	185.5	190.4	215.6	206.9	
	SOP	503.5	8034.7	3974.8	1199.6	456.3	620.5	107.4	81.5	37.1	15015.3
2007	Number	67.7	189.3	76.9	2.1	0.4	1.4	0.3	0.6	0.0	338.7
	Mean W.	26.7	62.6	71.1	108.1	124.4	151.7	183.7	174.7	153.8	
	SOP	1807.4	11857.5	5464.1	224.0	55.4	218.7	48.0	110.5	2.9	19788.4

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

Table 3.3.1a WESTERN BALTIC HERRING. Acoustic survey on the Spring Spawning Herring in Sub-divisions 21-24 in autumn 1993-2007 (September/October).

Year	1993	1994	1995	1996	1997	1998	1999	2000	2001*	2002**	2003	2004	2005	2006	2007
Numbers in millions															
W-rings															
0	893	5475	5108	1833	2859	2490	5994	1009	2478	4103	3777	2555	3055	4159	2591
1	492	416	1675	1439	1955	801	1339	1430	1126	838	1238	969	753	950	560
2	437	884	329	590	738	679	287	454	1227	421	223	592	640	274	278
3	530	560	358	434	395	394	233	329	845	575	217	346	401	376	149
4	403	444	354	295	162	237	156	202	367	341	260	163	192	353	136
5	125	189	254	306	119	100	52	79	132	64	97	143	105	183	88
6	55	60	127	119	99	51	8	39	86	25	38	79	90	131	25
7	28	24	46	47	33	24	1	6	20	10	9	23	26	85	23
8+	13	2	27	19	48	9	2	4	10	13	10	12	17	30	11
Total	2976	8053	8277	5083	6409	4785	8072	3551	6290	6389	5869	4882	5279	6542	3860
3+ group	1154	1279	1166	1220	856	815	452	658	1459	1028	631	766	830	1159	432
Biomass ('000 tonnnes)															
W-rings															
0	12.8	66.9	58.5	16.6	28.5	23.8	71.8	13.8	31.2	38.2	33.9	23.1	33.1	43.9	25.8
1	19.5	14.5	58.6	46.6	76.4	39.9	51.1	57.5	48.2	34.2	44.8	35.9	30.1	38.8	23.0
2	21.7	41.0	20.9	29.1	43.5	50.1	22.0	28.4	75.9	30.0	16.1	34.5	48.6	19.7	20.8
3	33.8	40.7	30.1	31.0	35.9	35.3	27.5	27.7	77.2	56.8	22.0	27.7	36.2	35.9	12.6
4	25.7	43.0	40.1	21.2	22.3	28.0	16.7	24.1	38.0	40.4	34.2	18.4	22.7	37.4	12.5
5	12.7	24.2	27.3	37.1	16.7	11.4	6.8	9.3	18.5	9.0	14.6	17.3	14.4	27.2	8.9
6	7.1	12.3	14.9	16.1	14.0	6.2	0.9	5.6	13.3	3.5	5.7	12.2	14.5	19.9	2.9
7	2.3	5.3	9.3	6.1	5.3	3.7	0.3	1.2	3.9	1.1	1.3	3.4	5.2	14.6	2.6
8+	1.8	0.6	6.6	2.9	10.6	2.2	0.5	0.8	2.1	1.9	1.6	2.0	3.6	6.5	1.9
Total	137.3	248.5	266.3	206.8	253.3	200.5	197.5	168.4	308.1	215.0	174.2	174.6	208.3	243.9	111.0
3+ group	83.3	126.2	128.2	114.4	104.9	86.8	52.6	68.7	152.9	112.6	79.4	81.1	96.5	141.5	41.4
Mean weight (g)															
W-rings															
0	14.3	12.2	11.5	9.0	10.0	9.5	12.0	13.7	12.6	9.3	9.0	9.0	10.8	10.5	10.0
1	39.7	34.8	35.0	32.4	39.1	49.8	38.2	40.2	42.8	40.8	36.2	37.0	40.0	40.8	41.0
2	49.7	46.4	63.7	49.4	58.9	73.8	76.6	62.6	61.8	71.1	72.3	58.3	76.0	71.9	74.8
3	63.9	72.8	84.1	71.5	91.1	89.5	118.2	84.3	91.4	98.7	101.3	80.1	90.2	95.3	84.6
4	63.6	97.0	113.3	71.7	137.2	118.4	106.9	119.4	103.4	118.3	131.2	112.6	118.3	106.2	92.0
5	101.4	127.7	107.6	121.6	140.8	114.1	130.3	117.3	140.4	141.8	150.2	121.0	136.7	148.9	100.9
6	127.7	203.9	117.7	134.6	141.0	120.8	106.6	145.5	154.8	142.6	150.2	154.7	161.3	151.7	116.8
7	81.0	225.2	199.6	129.9	160.2	157.2	237.9	204.5	198.5	110.9	156.6	151.0	201.8	171.5	109.3
8+	137.7	269.1	241.2	154.9	222.3	232.6	218.5	180.7	217.0	142.6	163.3	169.2	213.4	213.9	176.0
Total	46.1	30.9	32.2	40.7	39.5	41.9	24.5	47.4	49.0	33.6	29.7	35.8	39.5	37.3	28.7

*incl. mean for Sub-division 23, which was not covered by RV SOLEA

**incl. mean for Sub-division 2!, which was not covered by RV SOLEA

Table 3.3.1b **WESTERN BALTIC HERRING. Acoustic survey on the Spring Spawning Herring in Sub-divisions 22-24 in autumn 1993-2007 (September/October).**

Year	1993	1994	1995	1996	1997	1998	1999	2000	2001*	2002	2003	2004	2005	2006	2007
Numbers in millions															
W-rings															
0	799	4,461	4,294	1,515	2,707	2,430	5,023	886	1,789	3,680	3,517	2,496	2,910	3,694	2,473
1	356	408	1,208	1,121	1,465	455	1,208	1,100	1,107	593	753	917	684	726	491
2	360	816	311	554	524	564	276	443	1,225	368	189	582	591	203	276
3	484	542	333	430	364	368	233	328	844	562	217	345	391	330	149
4	380	444	345	295	161	235	154	201	367	338	260	162	190	343	136
5	120	189	249	306	119	100	52	79	132	62	97	142	105	181	88
6	51	60	127	119	99	51	8	39	86	24	38	79	90	130	25
7	27	24	39	47	33	24	1	6	20	3	9	23	26	85	23
8+	13	2	27	19	48	9	2	4	10	13	10	12	17	30	11
Total	2,589	6,946	6,934	4,406	5,521	4,235	6,958	3,086	5,580	5,643	5,090	4,757	5,004	5,722	3,671
3+ group	1,075	1,261	1,121	1,216	824	786	450	656	1,458	1,002	630	762	819	1,099	432
Biomass ('000 tonnnes)															
W-rings															
0	11.5	49.9	44.9	13.3	26.7	22.9	56.6	11.2	19.2	31.3	30.3	21.5	30.4	37.1	23.8
1	12.7	14.2	41.0	34.2	52.2	18.3	45.1	43.4	47.4	23.2	23.8	34.1	26.7	26.9	20.0
2	15.9	37.8	20.1	27.4	31.1	41.9	21.3	27.7	75.8	26.8	14.1	34.1	45.2	14.4	20.7
3	29.6	39.6	28.5	30.7	33.8	33.3	27.5	27.6	77.1	55.8	22.0	27.7	35.5	31.8	12.6
4	23.3	43.0	39.5	21.2	22.2	27.8	16.4	24.0	38.0	40.0	34.2	18.3	22.5	36.3	12.5
5	12.0	24.2	26.9	37.1	16.7	11.3	6.8	9.2	18.5	8.8	14.6	17.3	14.4	27.0	8.9
6	6.6	12.3	14.9	16.1	14.0	6.1	0.9	5.6	13.3	3.4	5.7	12.2	14.5	19.9	2.9
7	2.2	5.3	8.7	6.1	5.3	3.7	0.3	1.2	3.9	0.5	1.3	3.4	5.2	14.6	2.6
8+	1.8	0.6	6.6	2.9	10.6	2.2	0.5	0.8	2.1	1.9	1.6	2.0	3.6	6.5	1.9
Total	115.6	226.9	231.2	189.0	212.7	167.5	175.3	150.9	295.2	191.8	147.6	170.6	198.0	214.5	105.8
3+ group	75.5	125.1	125.2	114.1	102.7	84.4	52.3	68.5	152.8	110.5	79.4	80.9	95.6	136.1	41.3
Mean weight (g)															
W-rings															
0	14.4	11.2	10.5	8.8	9.9	9.4	11.3	12.7	10.7	8.5	8.6	8.6	10.5	10.0	9.6
1	35.7	34.8	33.9	30.5	35.6	40.3	37.3	39.5	42.8	39.2	31.6	37.2	39.1	37.0	40.7
2	44.3	46.3	64.5	49.6	59.3	74.3	77.0	62.6	61.8	72.9	74.4	58.6	76.4	71.0	74.9
3	61.1	73.0	85.8	71.3	92.8	90.4	118.2	84.3	91.4	99.3	101.4	80.2	90.8	96.4	84.6
4	61.5	97.0	114.5	71.7	137.8	118.4	106.4	119.4	103.4	118.4	131.2	113.0	118.2	106.1	92.1
5	100.6	127.7	108.1	121.6	140.8	113.7	130.3	117.3	140.4	143.0	150.2	122.1	136.7	149.3	100.9
6	129.0	203.9	117.7	134.6	141.0	120.4	106.6	145.5	154.8	143.5	150.2	154.7	161.3	152.6	116.8
7	79.7	225.2	221.9	129.9	160.2	157.2	237.9	204.5	198.5	204.9	156.6	151.0	201.8	171.5	109.3
8+	137.0	269.1	241.2	154.9	222.3	232.6	218.5	180.7	217.0	142.6	163.3	169.2	213.4	213.9	176.0
Total	44.7	32.7	33.3	42.9	38.5	39.5	25.2	48.9	52.9	34.0	29.0	35.9	39.6	37.5	28.8

* incl. mean for Sub-division 23, which was not covered by RV SOLEA

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

Year	1991	1992*	1993*	1994*	1995*	1996*	1997	1998	1999**	2000	2001	2002	2003	2004	2005	2006	2007
Numbers in millions																	
W-rings																	
0		3853	372	964													
1		277	103	5	2199	1091	128	138	1367	1509	66	3346	1833	1669	2687	2081	3918
2	1864	2092	2768	413	1887	1005	715	1682	1143	1891	641	1577	1110	930	1342	2217	3621
3	1927	1799	1274	935	1022	247	787	901	523	674	452	1393	395	726	464	1780	933
4	866	1593	598	501	1270	141	166	282	135	364	153	524	323	307	201	490	499
5	350	556	434	239	255	119	67	111	28	186	96	88	103	184	103	180	154
6	88	197	154	186	174	37	69	51	3	56	38	40	25	72	84	27	34
7	72	122	63	62	39	20	80	31	2	7	23	18	12	22	37	10	26
8+	10	20	13	34	21	13	77	53	1	10	12	17	5	18	21	0	14
Total	**5177**	**10509**	**5779**	**3339**	**6867**	**2673**	**2088**	**3248**	**3201**	**4696**	**1481**	**7002**	**3807**	**3926**	**4939**	**6786**	**9199**
3+ group	**5177**	**4287**	**2536**	**1957**	**2781**	**577**	**1245**	**1428**	**691**	**1295**	**774**	**2079**	**864**	**1328**	**910**	**2487**	**1660**
Biomass ('000 tonnnes)																	
W-rings																	
0		34.3	1	8.7													
1		26.8	7	0.4	77.4	52.9	4.7	7.1	74.8	61.4	3.5	137.2	79.0	63.9	105.9	112.6	193.2
2	177.1	169.0	139	33.2	108.9	87.0	52.2	136.1	101.6	138.1	55.8	107.2	91.5	75.6	100.1	160.5	273.4
3	219.7	206.3	112	114.7	102.6	27.6	81.0	84.8	59.5	68.8	51.2	126.9	41.4	89.4	46.6	158.6	90.9
4	116.0	204.7	69	76.7	145.5	17.9	21.5	35.2	14.7	45.3	21.5	55.9	41.7	41.5	28.9	56.3	59.6
5	51.1	83.3	65	41.8	33.9	17.8	9.8	13.1	3.4	25.1	17.9	12.8	13.9	29.3	16.5	23.7	18.5
6	19.0	36.6	26	38.1	27.4	5.8	9.8	6.9	0.5	10.0	6.9	7.4	4.2	11.7	14.9	4.1	4.6
7	13.0	24.4	16	13.1	6.7	3.3	14.9	4.8	0.3	1.4	4.7	3.5	2.0	4.1	7.5	1.6	2.6
8+	2.0	5.0	2	7.8	3.8	2.7	13.6	9.0	0.1	1.3	2.7	3.1	0.9	3.2	4.9	0.02	1.94
Total	597.9	756.1	436.5	325.8	506.2	215.1	207.5	297.0	254.9	351.4	164.2	454.0	274.5	318.8	325.3	517.5	644.7
3+ group	420.9	560.3	291.0	292.3	319.9	75.2	150.6	153.7	78.5	151.9	104.9	209.6	104.0	179.3	119.3	244.4	178.2
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	49.3
2	95.0	80.8	50.1	80.3	57.7	86.6	73.0	80.9	88.9	73.1	87.0	68.0	82.5	81.3	74.6	72.4	75.5
3	114.0	114.7	87.9	122.7	100.4	111.9	103.0	94.1	113.8	102.2	113.2	91.1	104.9	123.2	100.5	89.1	97.4
4	134.0	128.5	116.2	153.0	114.6	126.8	129.6	124.7	109.1	124.4	140.5	106.6	128.8	135.2	143.7	114.8	119.5
5	146.0	149.8	149.9	175.1	132.9	149.4	145.0	118.7	120.0	135.4	185.2	145.8	134.2	159.4	160.9	131.6	120.0
6	216.0	185.7	169.6	205.0	157.2	157.3	143.1	135.8	179.9	179.2	182.6	186.5	165.4	162.9	177.7	153.2	136.6
7	181.0	199.7	256.9	212.0	172.9	166.8	185.6	156.4	179.9	208.8	206.3	198.7	167.2	191.6	202.3	169.2	101.5
8+	200.0	252.0	164.2	230.3	183.1	212.9	178.0	168.0	181.7	135.2	226.9	183.4	170.3	178.0	229.2	178.0	138.3
Total	115.6	123.9	75.8	100.2	73.7	80.5	99.4	91.4	78.5	74.8	110.9	64.8	72.1	81.2	65.9	76.3	70.1

* revised in 1997

**the survey only covered the Skagerrak area by Norway. Additional estimates for the Kattegat area were added (see ICES 2000/ACFM:10, Table 3.5.8)

Table 3.3.3 International Bottom Trawl Survey 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
2008	142	48	15	12	3

* = no data available

Table 3.3.4 International Bottom Trawl Survey 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
2007	582	139	22	18	15

* = no survey was carried out in 2000

Table 3.3.5 N20 Larval abundance index. Estimation of the herring 0-Group reaching 20mm in length in Greifswalder Bodden and adjacent waters (March/April to June).

Year	N20 (millions)
1992	1060
1993	3044
1994	12515
1995	7930
1996	21012
1997	4872
1998	16743
1999	20364
2000	3026
2001	4845
2002	11324
2003	5507
2004	5640
2005	3887
2006	3774
2007	1900

TABLE 3.6.1 WESTERN BALTIC HERRING. CATCH IN NUMBER

Units : thousands

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

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

TABLE 3.6.2 WESTERN BALTIC HERRING. WEIGHTS AT AGE IN THE CATCH

Units : kg

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

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

TABLE 3.6.3 WESTERN BALTIC HERRING. WEIGHTS AT AGE IN THE STOCK

Units : kg

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

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

TABLE 3.6.4 WESTERN BALTIC HERRING. NATURAL MORTALITY

Units : NA

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

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

TABLE 3.6.5 WESTERN BALTIC HERRING. PROPORTION MATURE

Units : NA

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

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

TABLE 3.6.6 WESTERN BALTIC HERRING. SURVEY INDICES

DK AS 3-6 wr - Index Value

Units : NA

age \ year	1993	1994	1995	1996	1997	1998	1999	2000
3	1.27e+09	9.35e+08	1.02e+09	2.47e+08	7.87e+08	9.01e+08	NA	6.74e+08
4	5.98e+08	5.01e+08	1.27e+09	1.41e+08	1.66e+08	2.82e+08	NA	3.64e+08
5	4.34e+08	2.39e+08	2.55e+08	1.19e+08	6.70e+07	1.11e+08	NA	1.86e+08
6	1.54e+08	1.86e+08	1.74e+08	3.70e+07	6.90e+07	5.10e+07	NA	5.56e+07

age \ year	2001	2002	2003	2004	2005	2006	2007
3	4.52e+08	1.39e+09	3.95e+08	7.26e+08	4.64e+08	1.78e+09	9.33e+08
4	1.53e+08	5.24e+08	3.23e+08	3.07e+08	2.01e+08	4.90e+08	4.99e+08
5	9.64e+07	8.75e+07	1.03e+08	1.84e+08	1.02e+08	1.80e+08	1.54e+08
6	3.76e+07	3.95e+07	2.52e+07	7.21e+07	8.36e+07	2.70e+07	3.40e+07

DK AS 3-6 wr - Index Variance (Inverse Weights)

Units : NA

age \ year	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
4	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
5	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
6	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Ger AS 1-3 wr - Index Value

Units : NA

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

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

Ger AS 1-3 wr - Index Variance (Inverse Weights)

Units : NA

age \ year	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
2	1	1	1	1	1	1	1	1	1	1	1	1	1	1
3	1	1	1	1	1	1	1	1	1	1	1	1	1	1

N20 - Index Value

Units : NA

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

age \ year	2006	2007
0	3774	1900

N20 - Index Variance (Inverse Weights)

Units : NA

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

age \ year	2007
0	1

TABLE 3.6.7 WESTERN BALTIC HERRING. FLICA CONFIGURATION SETTINGS

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

TABLE 3.6.8 WESTERN BALTIC HERRING. STOCK OBJECT CONFIGURATION

min	max	plusgroup	minyear	maxyear
0	8	8	1991	2007

TABLE 3.6.9 INDEX OBJECTS CONFIGURATION

DK AS 3-6 wr
"Herring in Sub-division 22-24 and Division IIIa (spring-spawners) . Imported from VPA file."

min	max	plusgroup	minyear	maxyear	startf	endf
3.00	6.00	NA	1993.00	2007.00	0.58	0.67

Ger AS 1-3 wr
"Herring in Sub-division 22-24 and Division IIIa (spring-spawners) . Imported from VPA file."

min	max	plusgroup	minyear	maxyear	startf	endf
1.00	3.00	NA	1994.00	2007.00	0.77	0.83

N20
"Herring in Sub-division 22-24 and Division IIIa (spring-spawners) . Imported from VPA file."

min	max	plusgroup	minyear	maxyear	startf	endf
0.0	0.0	NA	1992.0	2007.0	0.3	0.5

TABLE 3.6.10 WESTERN BALTIC HERRING. STOCK SUMMARY

Year	Recruitment Age 0 [000's]	SSB	Catches [tonnes]	Fbar (Age 0-1)	Fbar (Age 3-6)	Landings SOP
1991	4973141	301075	191573	0.1446	0.372	1.000
1992	3628435	311020	194411	0.1113	0.497	1.000
1993	3078526	285122	185010	0.1907	0.564	1.000
1994	6136242	223336	172438	0.1065	0.723	1.000
1995	4011494	175388	150831	0.4074	0.535	1.000
1996	4426373	128943	121266	0.2145	0.737	1.000
1997	3909206	142964	115588	0.2148	0.542	1.000
1998	5434000	115736	107032	0.2426	0.527	1.000
1999	6290720	122457	97240	0.1781	0.398	1.000
2000	3312213	133861	109914	0.1921	0.502	1.000
2001	4268308	151672	105803	0.2799	0.498	1.000
2002	2752233	185828	106191	0.2309	0.455	1.000
2003	3693719	146445	78309	0.0855	0.409	1.000
2004	2591517	151364	76815	0.0870	0.417	1.000
2005	2064024	142785	88406	0.0999	0.478	1.000
2006	1845079	162978	90549	0.1025	0.491	1.000
2007	1001595	133503	68997	0.0972	0.465	0.988

TABLE 3.6.11 WESTERN BALTIC HERRING. ESTIMATED POPULATION ABUNDANCE

Units : 000's

age	1991	1992	1993	1994	1995	1996	1997	1998	1999
0	4973141	3628435	3078526	6136242	4011494	4426373	3909206	5434000	6290720
1	4518893	3582259	2563744	2104252	4320433	2509579	3132551	2573862	3555638
2	2153245	2111064	1823290	1150997	1085356	1373859	1037440	1391240	1087990
3	1781318	1276617	1187403	1047402	614982	496617	765263	589596	752468
4	915475	952143	717661	600165	514786	300363	227934	378473	318670
5	602260	498508	480251	353817	252782	246988	117273	119115	178564
6	221642	333794	244055	205078	139606	131538	86334	57395	56945
7	37932	139654	148239	107921	62641	60578	49479	35041	25741
8	14132	59866	56898	72133	38980	49542	56297	32110	16523

age	2000	2001	2002	2003	2004	2005	2006	2007
0	3312213	4268308	2752233	3693719	2591517	2064024	1845079	1001595
1	4173198	2323089	2517207	1910258	2678186	1878283	1491141	1332074
2	1686528	1820599	1011278	1026970	997800	1395123	956705	755987
3	590801	935290	1051567	574905	647422	626052	841624	572464
4	395287	316314	534225	572655	343050	384106	354181	471470
5	179873	208288	162083	282876	305554	181623	190685	173500
6	96033	83084	109220	81483	148801	159443	88677	91827
7	32720	44387	33126	54894	42533	77039	77149	42310
8	25386	16213	19932	27740	34141	35080	47150	41903

TABLE 3.6.12 WESTERN BALTIC HERRING. ESTIMATED FISHING MORTALITY

Units : f

age	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
0	0.0281	0.0473	0.0805	0.0509	0.169	0.0457	0.118	0.124	0.110	0.0547	0.228
1	0.2611	0.1754	0.3008	0.1621	0.646	0.3834	0.312	0.361	0.246	0.3295	0.332
2	0.3228	0.3754	0.3543	0.4268	0.582	0.3852	0.365	0.415	0.411	0.3896	0.349
3	0.4264	0.3760	0.4823	0.5103	0.517	0.5788	0.504	0.415	0.444	0.4247	0.360
4	0.4078	0.4844	0.5072	0.6647	0.534	0.7405	0.449	0.551	0.372	0.4407	0.469
5	0.3902	0.5142	0.6509	0.7300	0.453	0.8511	0.515	0.538	0.420	0.5724	0.446
6	0.2619	0.6117	0.6160	0.9860	0.635	0.7778	0.702	0.602	0.354	0.5718	0.720
7	0.4814	0.5317	0.6364	0.6939	0.847	0.8028	0.631	0.653	0.516	0.6159	0.599
8	0.4814	0.5317	0.6364	0.6939	0.847	0.8028	0.631	0.653	0.516	0.6159	0.599

age	2002	2003	2004	2005	2006	2007
0	0.0652	0.0215	0.0219	0.0251	0.0258	0.0244
1	0.3965	0.1494	0.1522	0.1746	0.1793	0.1700
2	0.3648	0.2614	0.2661	0.3054	0.3135	0.2972
3	0.4078	0.3163	0.3221	0.3696	0.3795	0.3598
4	0.4358	0.4282	0.4359	0.5003	0.5136	0.4869
5	0.4877	0.4424	0.4504	0.5169	0.5307	0.5031
6	0.4880	0.4501	0.4583	0.5259	0.5400	0.5119
7	0.6096	0.4282	0.4359	0.5003	0.5136	0.4869
8	0.6096	0.4282	0.4359	0.5003	0.5136	0.4869

TABLE 3.6.13 WESTERN BALTIC HERRING. FITTED SELECTION PATTERN

Units : f

age	2003	2004	2005	2006	2007
0	0.0502	0.0502	0.0502	0.0502	0.0502
1	0.3490	0.3490	0.3490	0.3490	0.3490
2	0.6104	0.6104	0.6104	0.6104	0.6104
3	0.7388	0.7388	0.7388	0.7388	0.7388
4	1.0000	1.0000	1.0000	1.0000	1.0000
5	1.0333	1.0333	1.0333	1.0333	1.0333
6	1.0513	1.0513	1.0513	1.0513	1.0513
7	1.0000	1.0000	1.0000	1.0000	1.0000
8	1.0000	1.0000	1.0000	1.0000	1.0000

TABLE 3.6.14 WESTERN BALTIC HERRING. PREDICTED INDEX VALUES

DK AS 3-6 wr

Units : NA

age \ year	1993	1994	1995	1996	1997	1998	1999	2000
3	1.19e+09	1.03e+09	6.05e+08	4.70e+08	7.59e+08	6.18e+08	NA	6.16e+08
4	5.97e+08	4.53e+08	4.21e+08	2.16e+08	1.97e+08	3.07e+08	NA	3.43e+08
5	3.05e+08	2.14e+08	1.82e+08	1.38e+08	8.11e+07	8.12e+07	NA	1.20e+08
6	1.28e+08	8.52e+07	7.22e+07	6.23e+07	4.29e+07	3.03e+07	NA	5.17e+07

age \ year	2001	2002	2003	2004	2005	2006	2007
3	1.02e+09	1.11e+09	6.41e+08	7.20e+08	6.75e+08	9.02e+08	6.21e+08
4	2.70e+08	4.65e+08	5.01e+08	2.99e+08	3.21e+08	2.94e+08	3.97e+08
5	1.50e+08	1.14e+08	2.05e+08	2.20e+08	1.25e+08	1.31e+08	1.21e+08
6	4.08e+07	6.20e+07	4.73e+07	8.60e+07	8.83e+07	4.87e+07	5.13e+07

Ger AS 1-3 wr

Units : NA

age \ year	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
1	949232	1323592	948387	1253708	990175	1499939	1646495	NA	941293	870459
2	437532	364449	539936	414325	534043	418970	660482	NA	403977	445622
3	493086	288064	221335	362066	299490	373616	297839	NA	537379	316084

age \ year	2004	2005	2006	2007
1	1217736	838822	663453	597114
2	431323	584416	398162	318756
3	354321	329838	439932	303996

N20

Units : NA

age \ year	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
0	6380	5341	10774	6718	7788	6682	9265	10785	5806	6981	4805	6562	4603	3661

age \ year	2006	2007
0	3272	1777

TABLE 3.6.15 WESTERN BALTIC HERRING. INDEX RESIDUALS

DK AS 3-6 wr

Units : NA

age \ year	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
3	0.064957	-0.101	0.524	-0.644	0.0362	0.3767	NA	0.0897	-0.8084	0.229
4	0.000964	0.101	1.103	-0.427	-0.1701	-0.0834	NA	0.0591	-0.5664	0.120
5	0.352559	0.111	0.339	-0.151	-0.1912	0.3127	NA	0.4366	-0.4449	-0.265
6	0.186454	0.780	0.879	-0.520	0.4764	0.5199	NA	0.0727	-0.0812	-0.450

age \ year	2003	2004	2005	2006	2007
3	-0.486	0.00896	-0.376	0.680	0.406
4	-0.437	0.02747	-0.467	0.512	0.227
5	-0.683	-0.18030	-0.202	0.323	0.242
6	-0.630	-0.17623	-0.055	-0.590	-0.412

Ger AS 1-3 wr

Units : NA

age \ year	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
1	-0.826	0.236	0.4173	0.4445	-0.212	-0.114	-0.1411	NA	-0.1168	0.353
2	0.703	-0.104	0.0887	0.5775	0.239	-0.377	-0.3749	NA	0.0422	-0.694
3	0.127	0.217	0.6736	0.0859	0.274	-0.474	0.0994	NA	0.0683	-0.375

age \ year	2004	2005	2006	2007
1	-0.2286	-0.108	0.359	-0.0642
2	0.3173	0.091	-0.372	-0.1368
3	-0.0231	0.196	-0.156	-0.7131

N20

Units : NA

age \ year	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
0	-1.79	-0.562	0.150	0.166	0.993	-0.316	0.592	0.636	-0.652	-0.365	0.857

age \ year	2003	2004	2005	2006	2007
0	-0.175	0.203	0.0598	0.143	0.0668

TABLE 3.6.16 WESTERN BALTIC HERRING. PREDICTED CATCH IN NUMBER

Units : NA

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

age	2001	2002	2003	2004	2005	2006	2007
0	756285	150271	67896	48493	44256	40603	20909
1	523163	659130	209963	299355	238542	194021	164997
2	488816	281840	215017	212240	334467	234598	177061
3	257837	321311	142047	162444	176415	242400	157711
4	108097	172285	182059	110658	138181	130044	166060
5	68376	57160	92333	101184	67018	71800	62691
6	39092	38532	26967	49959	59622	33834	33628
7	18307	13842	17452	13720	27715	28327	14902
8	6687	8329	8819	11013	12620	17312	14759

TABLE 3.6.17 WESTERN BALTIC HERRING. CATCH RESIDUALS

Units : thousands

age \ year	2003	2004	2005	2006	2007
0	-2.39e-01	1.61e+00	8.82e-01	-1.63e+00	-6.68e-01
1	-5.04e-01	4.25e-01	2.46e-01	-2.65e-01	4.18e-02
2	2.08e-01	-7.04e-02	-4.66e-02	-2.23e-01	4.24e-02
3	1.27e-01	1.42e-02	8.01e-03	-3.86e-02	-9.16e-02
4	3.97e-02	-1.72e-01	-5.80e-02	1.47e-01	-2.69e-01
5	1.16e-01	-1.03e-01	-1.00e-01	3.19e-01	3.61e-02
6	7.67e-02	-2.03e-02	9.70e-02	2.27e-01	-1.08e-01
7	-4.17e-09	8.09e-02	1.19e-01	1.35e-01	3.55e-01
8	0.00e+00	2.22e-16	2.22e-16	-2.22e-16	-1.11e-16

TABLE 3.6.18 WESTERN BALTIC HERRING. FIT PARAMETERS

	Value	CV.pct	Lower.95.pct.CL	Upper.95.pct.CL
F, 2003	4.28e-01	23.1	2.91e-01	6.29e-01
F, 2004	4.36e-01	23.3	2.99e-01	6.37e-01
F, 2005	5.00e-01	28.2	3.41e-01	7.33e-01
F, 2006	5.14e-01	31.8	3.39e-01	7.78e-01
F, 2007	4.87e-01	33.8	3.02e-01	7.85e-01
Selectivity at age 0	5.02e-02	16.6	1.90e-02	1.33e-01
Selectivity at age 1	3.49e-01	21.3	2.25e-01	5.41e-01
Selectivity at age 2	6.10e-01	43.7	4.00e-01	9.32e-01
Selectivity at age 3	7.39e-01	69.6	4.89e-01	1.12e+00
Selectivity at age 5	1.03e+00	570.2	7.17e-01	1.49e+00
Selectivity at age 6	1.05e+00	357.0	7.41e-01	1.49e+00
Terminal year pop, age 0	1.00e+06	2.4	5.28e+05	1.90e+06
Terminal year pop, age 1	1.33e+06	1.7	8.32e+05	2.13e+06
Terminal year pop, age 2	7.56e+05	1.5	5.06e+05	1.13e+06
Terminal year pop, age 3	5.72e+05	1.4	3.99e+05	8.21e+05
Terminal year pop, age 4	4.71e+05	1.4	3.31e+05	6.72e+05
Terminal year pop, age 5	1.73e+05	1.7	1.17e+05	2.57e+05
Terminal year pop, age 6	9.18e+04	2.0	5.93e+04	1.42e+05
Terminal year pop, age 7	4.23e+04	2.5	2.53e+04	7.08e+04
Last true age pop, 2003	5.49e+04	3.3	2.69e+04	1.12e+05
Last true age pop, 2004	4.25e+04	2.6	2.48e+04	7.28e+04
Last true age pop, 2005	7.70e+04	2.2	4.78e+04	1.24e+05
Last true age pop, 2006	7.71e+04	2.2	4.71e+04	1.26e+05
Index 1, age 3 numbers, Q	1.54e+03	2.4	1.09e+03	2.18e+03
Index 1, age 4 numbers, Q	1.30e+03	2.5	9.11e+02	1.84e+03
Index 1, age 5 numbers, Q	1.08e+03	2.6	7.57e+02	1.54e+03
Index 1, age 6 numbers, Q	8.72e+02	2.8	6.05e+02	1.26e+03
Index 2, age 1 numbers, Q	7.66e-01	61.0	5.57e-01	1.05e+00
Index 2, age 2 numbers, Q	6.28e-01	34.8	4.57e-01	8.62e-01
Index 2, age 3 numbers, Q	8.31e-01	87.6	6.05e-01	1.14e+00
Index 3, age 0 numbers, Q	2.02e-03	1.4	1.70e-03	2.41e-03

Table 3.7.1 WESTERN BALTIC HERRING. Input table for short term predictions

MFDP version 1a
Run: WBSS_F0.25
Time and date: 17:59 03/04/2008
Fbar age range: 3-6

2008

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
0	2513544	0.3	0.00	0.1	0.25	0.000	0.025	0.015
1	724081	0.5	0.00	0.1	0.25	0.015	0.175	0.038
2	681664	0.2	0.20	0.1	0.25	0.056	0.305	0.072
3	459792	0.2	0.75	0.1	0.25	0.085	0.370	0.092
4	327077	0.2	0.90	0.1	0.25	0.113	0.500	0.113
5	237204	0.2	1.00	0.1	0.25	0.147	0.517	0.135
6	85888	0.2	1.00	0.1	0.25	0.166	0.526	0.155
7	45061	0.2	1.00	0.1	0.25	0.176	0.500	0.172
8	42369	0.2	1.00	0.1	0.25	0.186	0.500	0.183

2009

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
0	2513544	0.3	0.00	0.1	0.25	0.000	0.025	0.015
1	.	0.5	0.00	0.1	0.25	0.015	0.175	0.038
2	.	0.2	0.20	0.1	0.25	0.056	0.305	0.072
3	.	0.2	0.75	0.1	0.25	0.085	0.370	0.092
4	.	0.2	0.90	0.1	0.25	0.113	0.500	0.113
5	.	0.2	1.00	0.1	0.25	0.147	0.517	0.135
6	.	0.2	1.00	0.1	0.25	0.166	0.526	0.155
7	.	0.2	1.00	0.1	0.25	0.176	0.500	0.172
8	.	0.2	1.00	0.1	0.25	0.186	0.500	0.183

2010

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
0	2513544	0.3	0.00	0.1	0.25	0.000	0.025	0.015
1	.	0.5	0.00	0.1	0.25	0.015	0.175	0.038
2	.	0.2	0.20	0.1	0.25	0.056	0.305	0.072
3	.	0.2	0.75	0.1	0.25	0.085	0.370	0.092
4	.	0.2	0.90	0.1	0.25	0.113	0.500	0.113
5	.	0.2	1.00	0.1	0.25	0.147	0.517	0.135
6	.	0.2	1.00	0.1	0.25	0.166	0.526	0.155
7	.	0.2	1.00	0.1	0.25	0.176	0.500	0.172
8	.	0.2	1.00	0.1	0.25	0.186	0.500	0.183

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)

$N_{2008,2009,2010}$ Age 0:	Geometric Mean from ICA of age 0 (Table 3.6.11) for the years 2002-2006
N_{2008} Age 1-8+:	Projected population numbers Jan 1st 2008 (FLSTF)
Natural Mortality (M):	Average for 2005-2007
Weight in the Catch/Stock (CWt/SWt):	Average for 2005-2007
Exploitation pattern (Sel):	Average for 2005-2007

Table 3.7.2 **WESTERN BALTIC HERRING.**
Short term prediction single option table
2008, 2009, and 2010: Status quo F: Fbar=0.4782

MFDP version 1a
Run: after_HAWG2008
Time and date: 16:26 03/04/2008
Fbar age range: 3-6

Year:	**2008**	**multiplier:**	**1**	**Fbar:**	**0.4782**				
Age	F	CatchNos	Yield	StockNos	Biomass	SSNos(Jan)	SSB(Jan)	SSNos(ST)	SSB(ST)
0	0.0251	53894	807	2513544	251	0	0	0	0
1	0.1746	91957	3490	724081	11117	0	0	0	0
2	0.3054	163420	11757	681664	38278	136333	7656	125783	7063
3	0.3696	129563	11978	459792	39124	344844	29343	316123	26899
4	0.5003	117663	13332	327077	36847	294369	33163	266348	30006
5	0.5169	87525	11817	237204	34880	237204	34880	214268	31507
6	0.5259	32116	4966	85888	14296	85888	14296	77514	12902
7	0.5003	16210	2787	45061	7938	45061	7938	40771	7183
8	0.5003	15242	2788	42369	7868	42369	7868	38336	7119
Total		707591	63721	5116681	190600	1186069	135144	1079144	122680

Year:	**2009**	**multiplier:**	**1**	**Fbar:**	**0.4782**				
Age	F	CatchNos	Yield	StockNos	Biomass	SSNos(Jan)	SSB(Jan)	SSNos(ST)	SSB(ST)
0	0.0251	53894	807	2513544	251	0	0	0	0
1	0.1746	230615	8753	1815895	27880	0	0	0	0
2	0.3054	88418	6361	368812	20710	73762	4142	68055	3821
3	0.3696	115877	10712	411224	34991	308418	26243	282730	24058
4	0.5003	93577	10603	260123	29305	234111	26374	211826	23864
5	0.5169	59914	8089	162375	23877	162375	23877	146675	21568
6	0.5259	43307	6696	115815	19277	115815	19277	104522	17398
7	0.5003	14950	2570	41559	7321	41559	7321	37603	6624
8	0.5003	15614	2856	43404	8061	43404	8061	39272	7293
Total		716167	57447	5732751	171673	979444	115295	890683	104626

Year:	**2010**	**multiplier:**	**1**	**Fbar:**	**0.4782**				
Age	F	CatchNos	Yield	StockNos	Biomass	SSNos(Jan)	SSB(Jan)	SSNos(ST)	SSB(ST)
0	0.0251	53894	807	2513544	251	0	0	0	0
1	0.1746	230615	8753	1815895	27880	0	0	0	0
2	0.3054	221740	15953	924930	51938	184986	10388	170671	9584
3	0.3696	62695	5796	222491	18932	166869	14199	152970	13016
4	0.5003	83693	9483	232646	26209	209381	23588	189451	21343
5	0.5169	47650	6433	129136	18989	129136	18989	116650	17153
6	0.5259	29645	4584	79280	13196	79280	13196	71549	11909
7	0.5003	20160	3466	56040	9872	56040	9872	50705	8933
8	0.5003	15174	2775	42179	7833	42179	7833	38164	7087
Total		765264	58049	6016141	175101	867871	98065	790161	89025

Input units are thousands and kg - output in tonnes

Table 3.7.3 **WESTERN BALTIC HERRING.**
Short term prediction single option table
2008: Status quo F and 2009/2010: Fbar = 0.25

MFDP version 1a
Run: WBSS_F0.25
Time and date: 17:59 03/04/2008
Fbar age range: 3-6

Year:	**2008**	**multiplier:**	**1**	**Fbar:**	**0.4782**				
Age	F	CatchNos	Yield	StockNos	Biomass	SSNos(Jan)	SSB(Jan)	SSNos(ST)	SSB(ST)
0	0.0251	53894	807	2513544	251	0	0	0	0
1	0.1746	91957	3490	724081	11117	0	0	0	0
2	0.3054	163420	11757	681664	38278	136333	7656	125783	7063
3	0.3696	129563	11978	459792	39124	344844	29343	316123	26899
4	0.5003	117663	13332	327077	36847	294369	33163	266348	30006
5	0.5169	87525	11817	237204	34880	237204	34880	214268	31507
6	0.5259	32116	4966	85888	14296	85888	14296	77514	12902
7	0.5003	16210	2787	45061	7938	45061	7938	40771	7183
8	0.5003	15242	2788	42369	7868	42369	7868	38336	7119
Total		707591	63721	5116681	190600	1186069	135144	1079144	122680

Year:	**2009**	**multiplier:**	**0.5228**	**Fbar:**	**0.25**				
Age	F	CatchNos	Yield	StockNos	Biomass	SSNos(Jan)	SSB(Jan)	SSNos(ST)	SSB(ST)
0	0.0131	28336	424	2513544	251	0	0	0	0
1	0.0913	125146	4750	1815895	27880	0	0	0	0
2	0.1597	49459	3558	368812	20710	73762	4142	69054	3878
3	0.1932	65700	6074	411224	34991	308418	26243	287761	24486
4	0.2615	54494	6175	260123	29305	234111	26374	216944	24440
5	0.2702	35007	4726	162375	23877	162375	23877	150338	22107
6	0.275	25350	3919	115815	19277	115815	19277	107179	17840
7	0.2615	8706	1497	41559	7321	41559	7321	38511	6784
8	0.2615	9093	1663	43404	8061	43404	8061	40221	7470
Total		401291	32786	5732751	171673	979444	115295	910009	107004

Year:	**2010**	**multiplier:**	**0.5228**	**Fbar:**	**0.25**				
Age	F	CatchNos	Yield	StockNos	Biomass	SSNos(Jan)	SSB(Jan)	SSNos(ST)	SSB(ST)
0	0.0131	28336	424	2513544	251	0	0	0	0
1	0.0913	126655	4807	1837790	28216	0	0	0	0
2	0.1597	134814	9699	1005304	56451	201061	11290	188226	10569
3	0.1932	41124	3802	257399	21902	193049	16427	180120	15326
4	0.2615	58140	6588	277523	31265	249770	28138	231455	26075
5	0.2702	35349	4773	163958	24109	163958	24109	151803	22322
6	0.275	22207	3434	101460	16888	101460	16888	93894	15629
7	0.2615	15089	2594	72027	12689	72027	12689	66745	11758
8	0.2615	11219	2052	53553	9945	53553	9945	49626	9216
Total		472933	38172	6282557	201717	1034877	119487	961869	110896

Input units are thousands and kg - output in tonnes

Table 3.7.4 **WESTERN BALTIC HERRING.**
Short-term prediction multiple option table, 2008 Status quo F.

MFDP version 1a
Run: after_HAWG2008
Western Baltic Herring (combined sex; plus group)
Time and date: 16:26 03/04/2008
Fbar age range: 3-6

2008 Biomass	SSB	FMult	FBar	Landings
190600	122680	1	0.4782	63721

2009 Biomass	SSB	FMult	FBar	Landings	2010 Biomass	SSB
171673	109672	0.000	0.0000	0	237378	141584
.	109157	0.100	0.0478	6802	229957	135082
.	108644	0.200	0.0956	13341	222834	128895
.	108133	0.300	0.1435	19629	215995	123008
.	107625	0.400	0.1913	25676	209427	117406
.	107119	0.500	0.2391	31492	203120	112075
.	106616	0.600	0.2869	37088	197061	107000
.	106115	0.700	0.3347	42472	191239	102170
.	105616	0.800	0.3826	47655	185645	97572
.	105120	0.900	0.4304	52644	180269	93194
.	104626	1.000	0.4782	57447	175101	89025
.	104135	1.100	0.5260	62074	170132	85056
.	103646	1.200	0.5738	66530	165354	81275
.	103159	1.300	0.6217	70824	160758	77674
.	102674	1.400	0.6695	74962	156337	74243
.	102192	1.500	0.7173	78950	152083	70975
.	101713	1.600	0.7651	82796	147989	67861
.	101235	1.700	0.8129	86504	144049	64894
.	100760	1.800	0.8607	90081	140255	62066
.	100287	1.900	0.9086	93532	136602	59371
.	99817	2.000	0.9564	96862	133084	56802

Input units are thousands and kg - output in tonnes

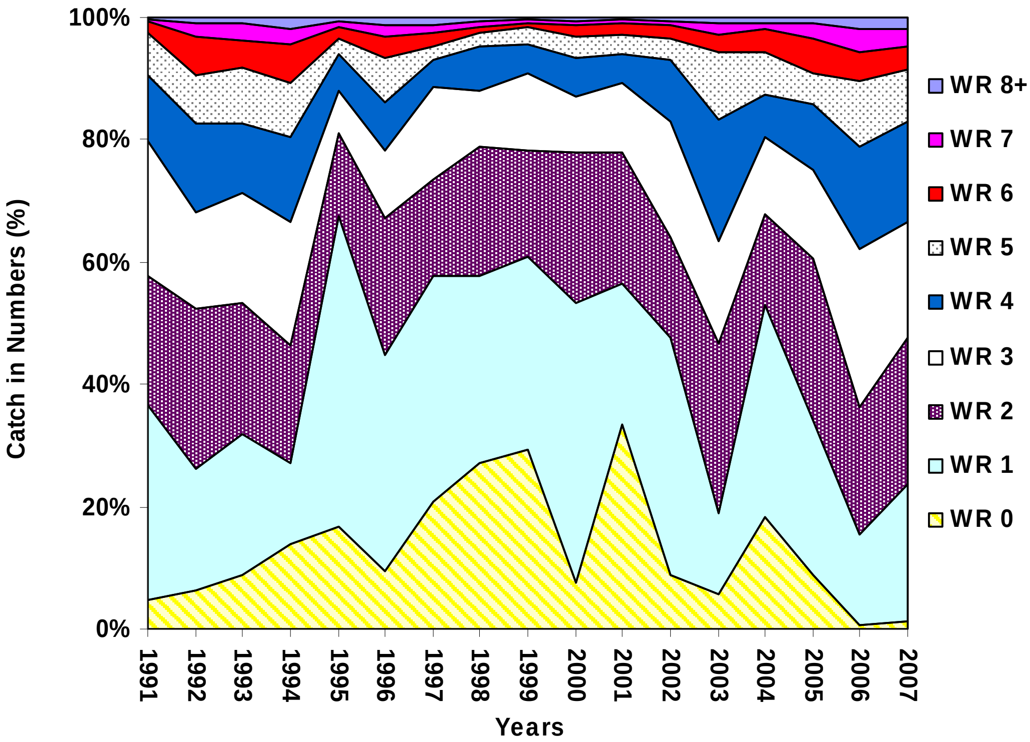


Figure 3.6.1.1 WESTERN BALTIC HERRING.
Proportions of age groups (numbers) in the total catch.

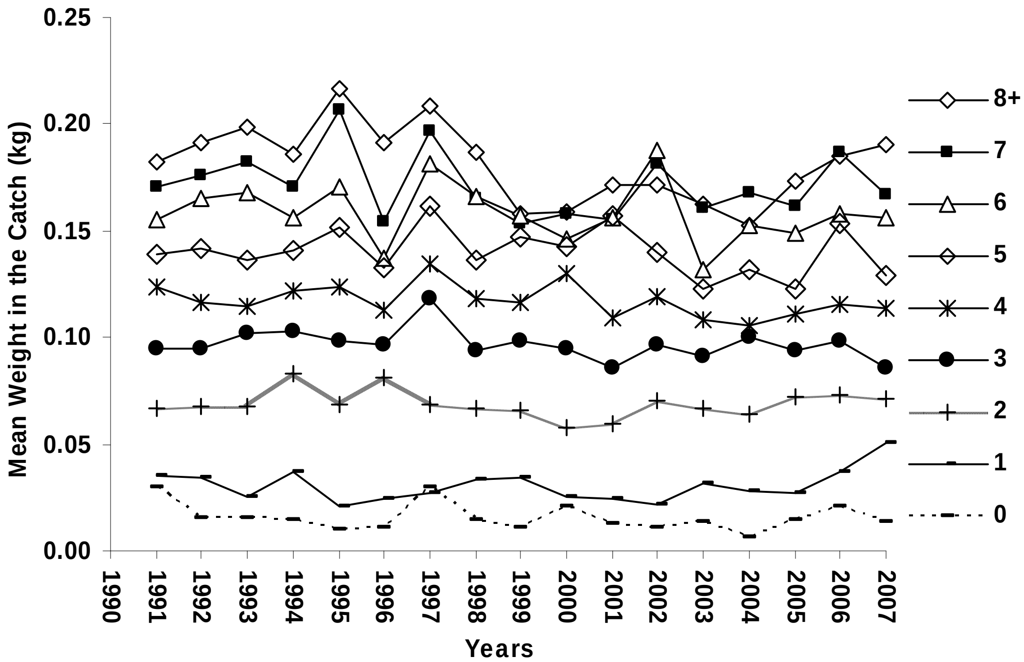


Figure 3.6.1.2 WESTERN BALTIC HERRING.
Mean weight in the catch (kg).

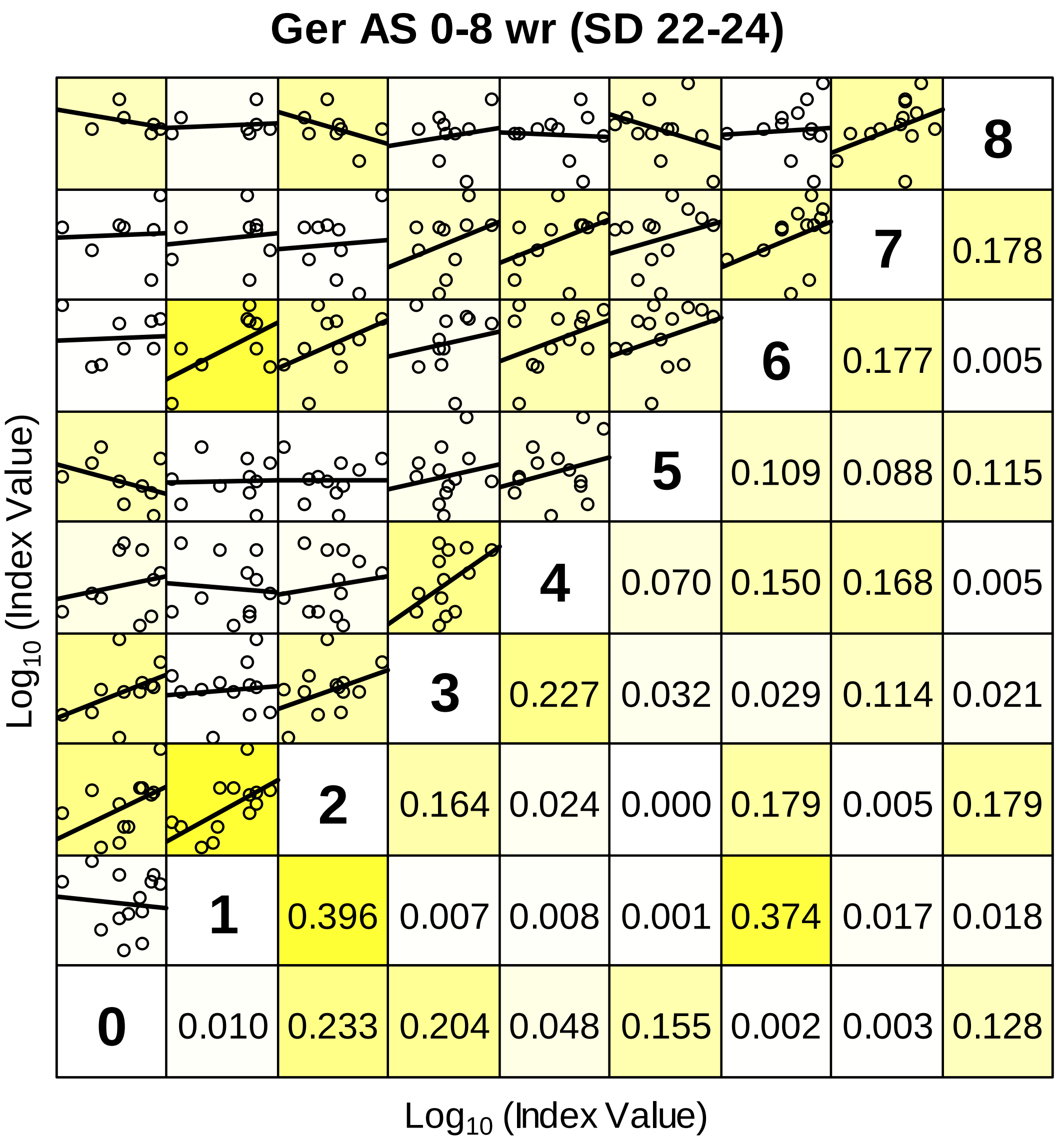


Figure 3.6.1.2.1.a WESTERN BALTIC HERRING. Internal consistency analysis (age 0-8) for the German Acoustic survey SD22-24.

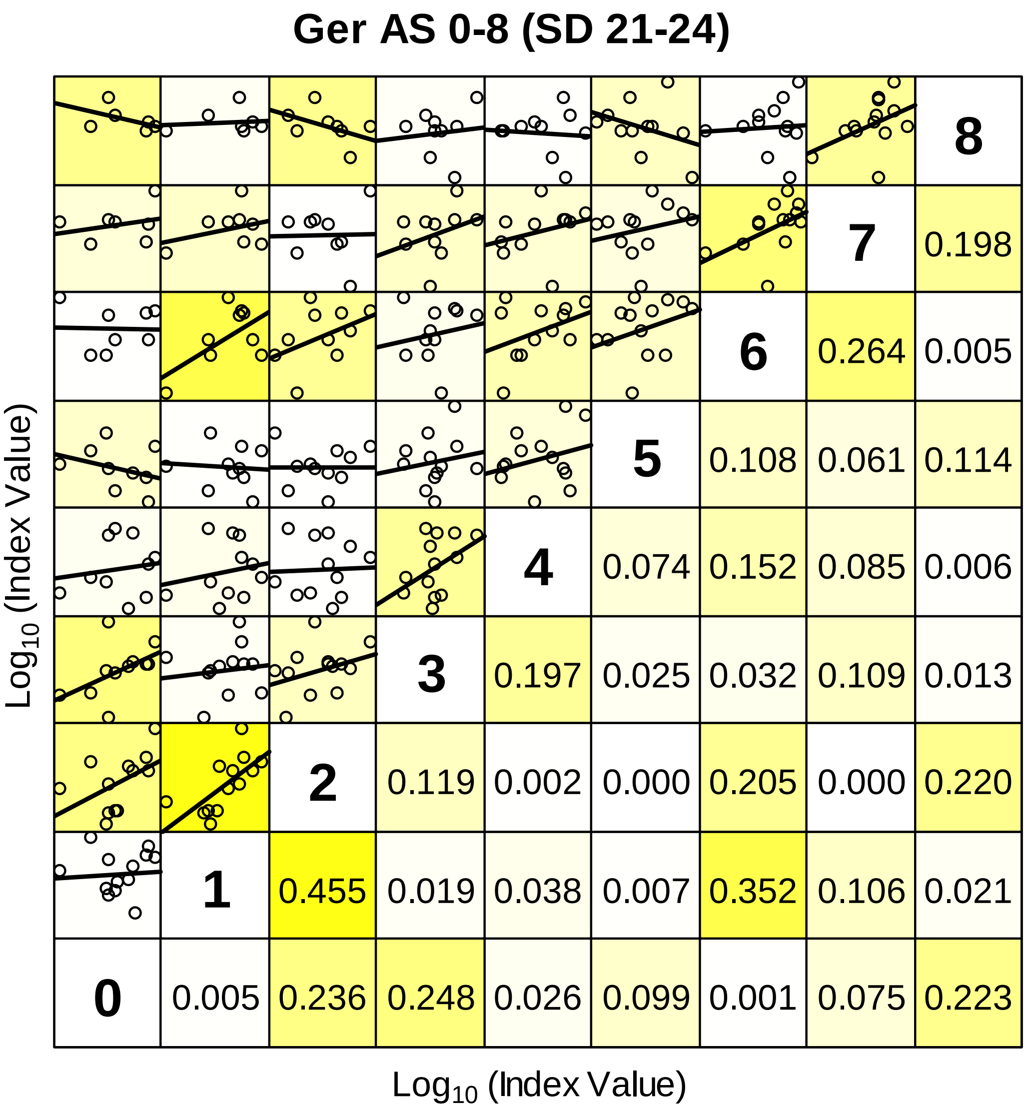


Figure 3.6.1.2.1.b WESTERN BALTIC HERRING. Internal consistency analysis (age 0-8+) for the German Acoustic survey SD21-24.

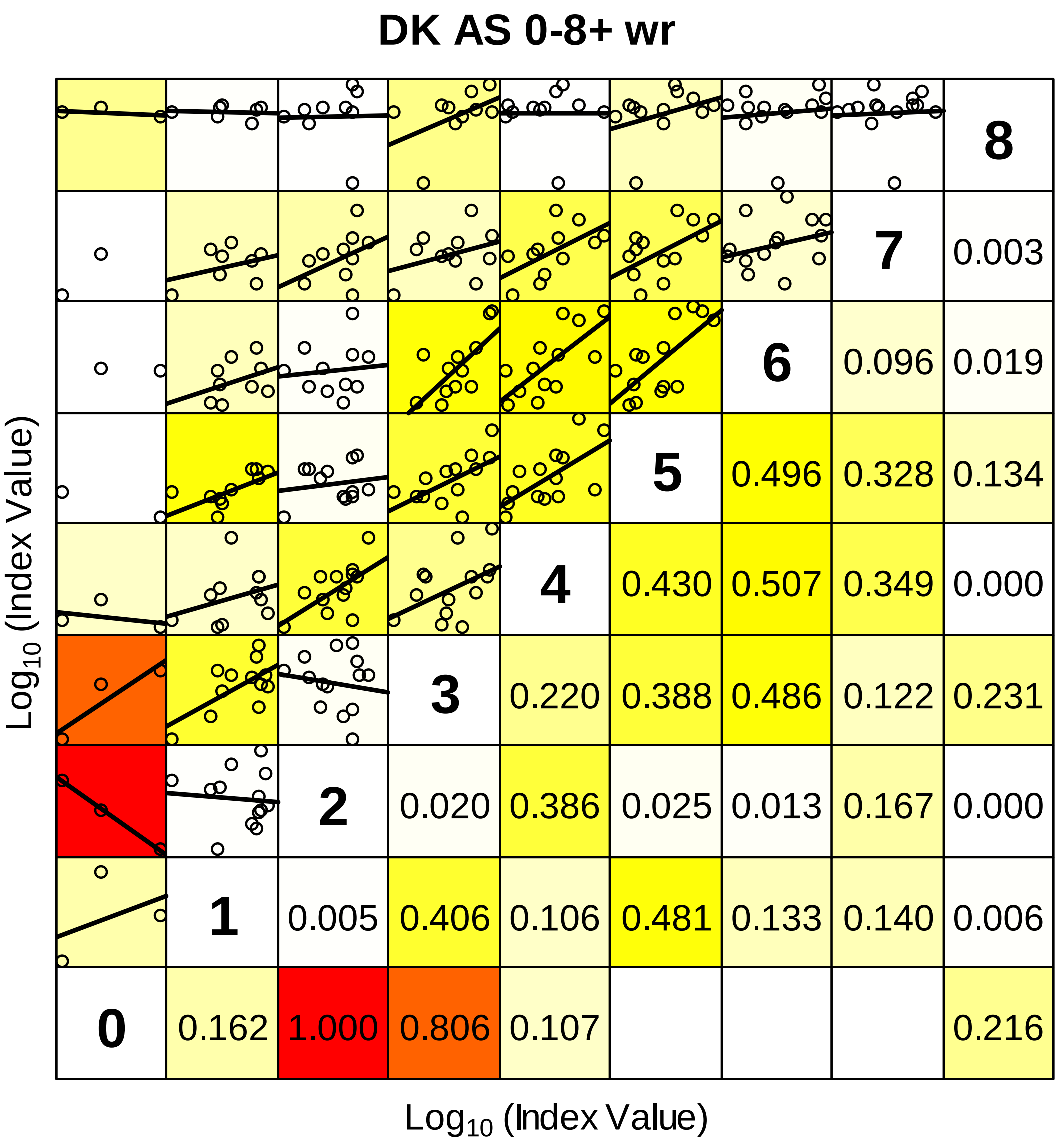


Figure 3.6.1.2.2. WESTERN BALTIC HERRING. Internal consistency analysis (age 0-8+) for the Danish Acoustic survey.

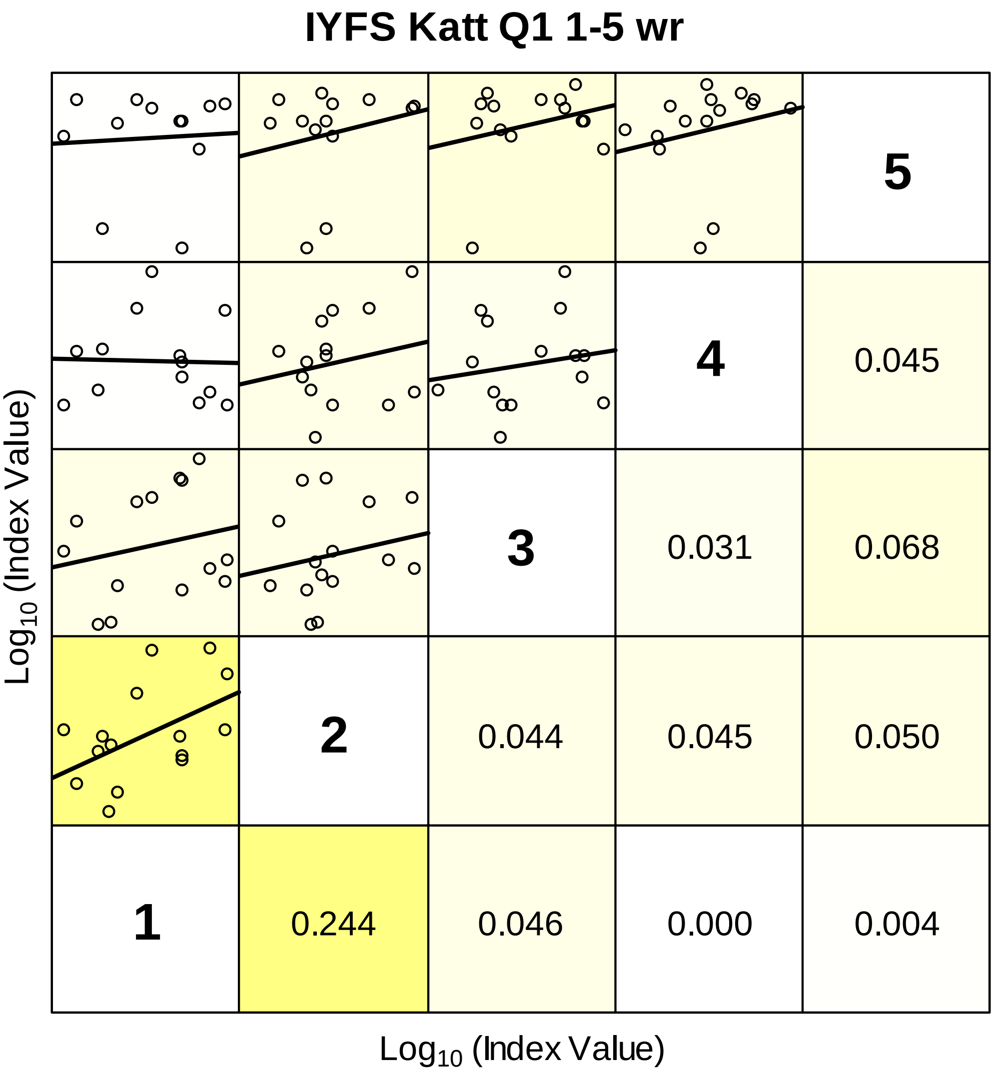


Figure 3.6.1.2.3.a WESTERN BALTIC HERRING. Internal consistency analysis (age 0-5+) for the IBTS Q1 survey in SD 21.

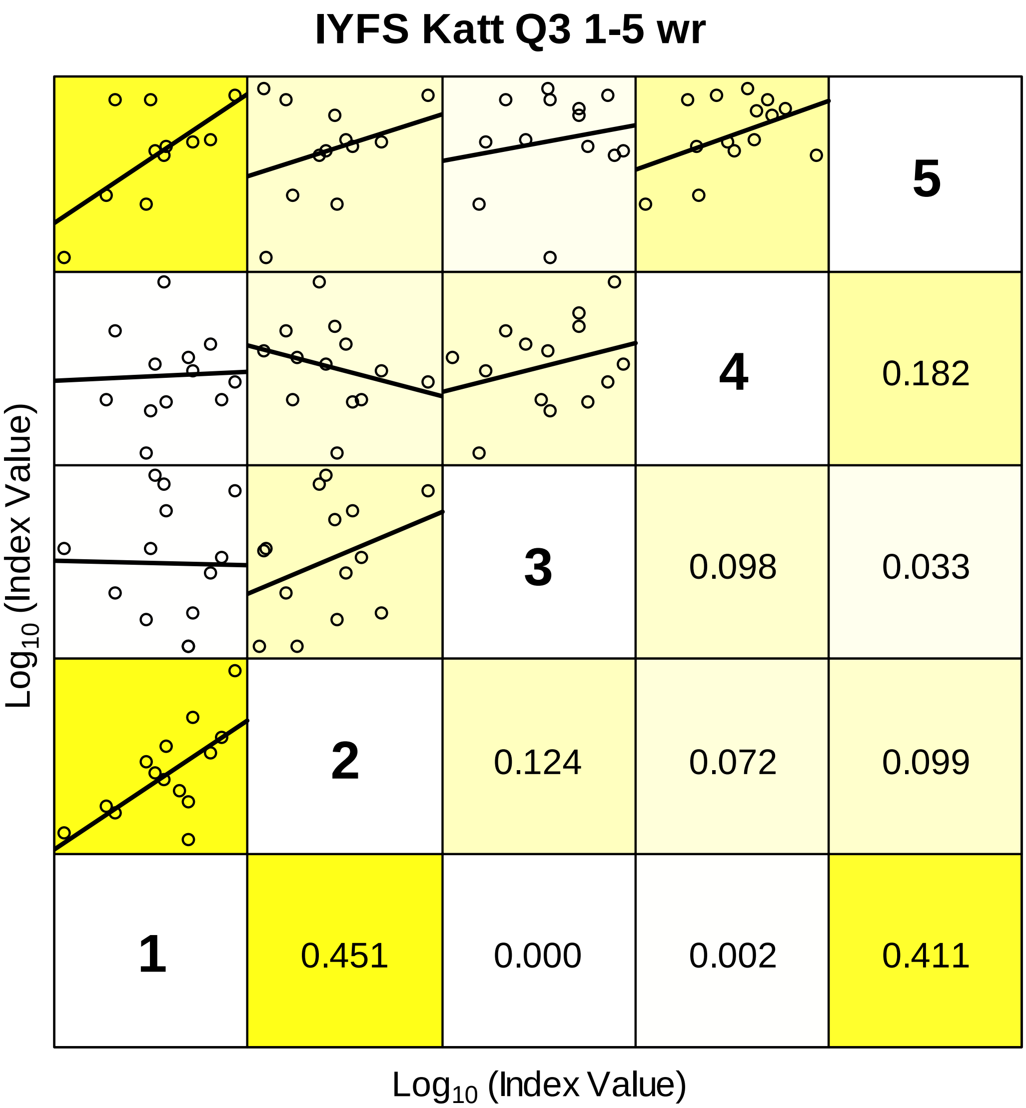


Figure 3.6.1.2.3.b WESTERN BALTIC HERRING. Internal consistency (age 0-5+) for the IBTS Q3 survey in SD 21.

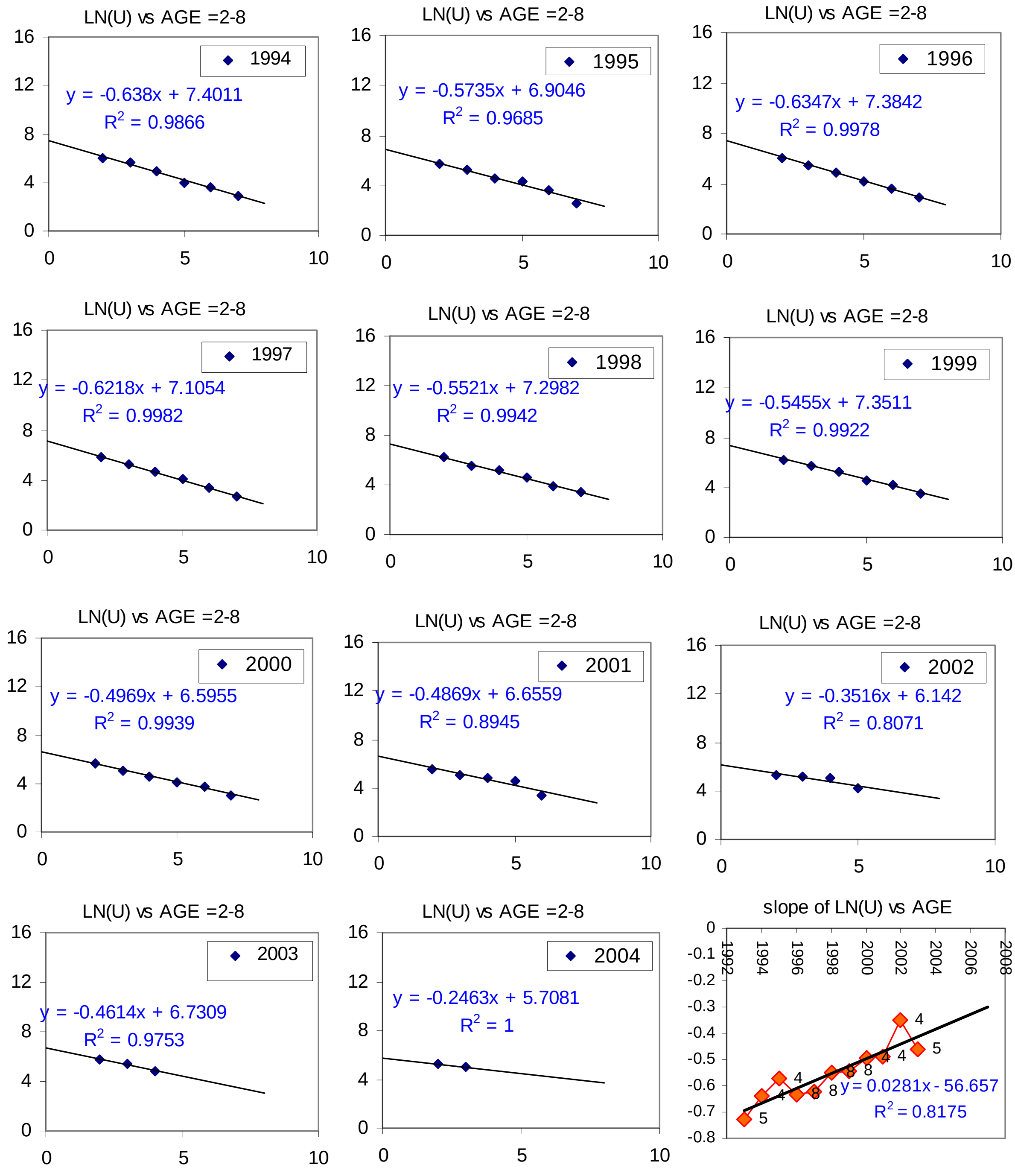


Figure 3.6.1.3.a WESTERN BALTIC HERRING. Log Catch vs Age for successive cohorts and thei

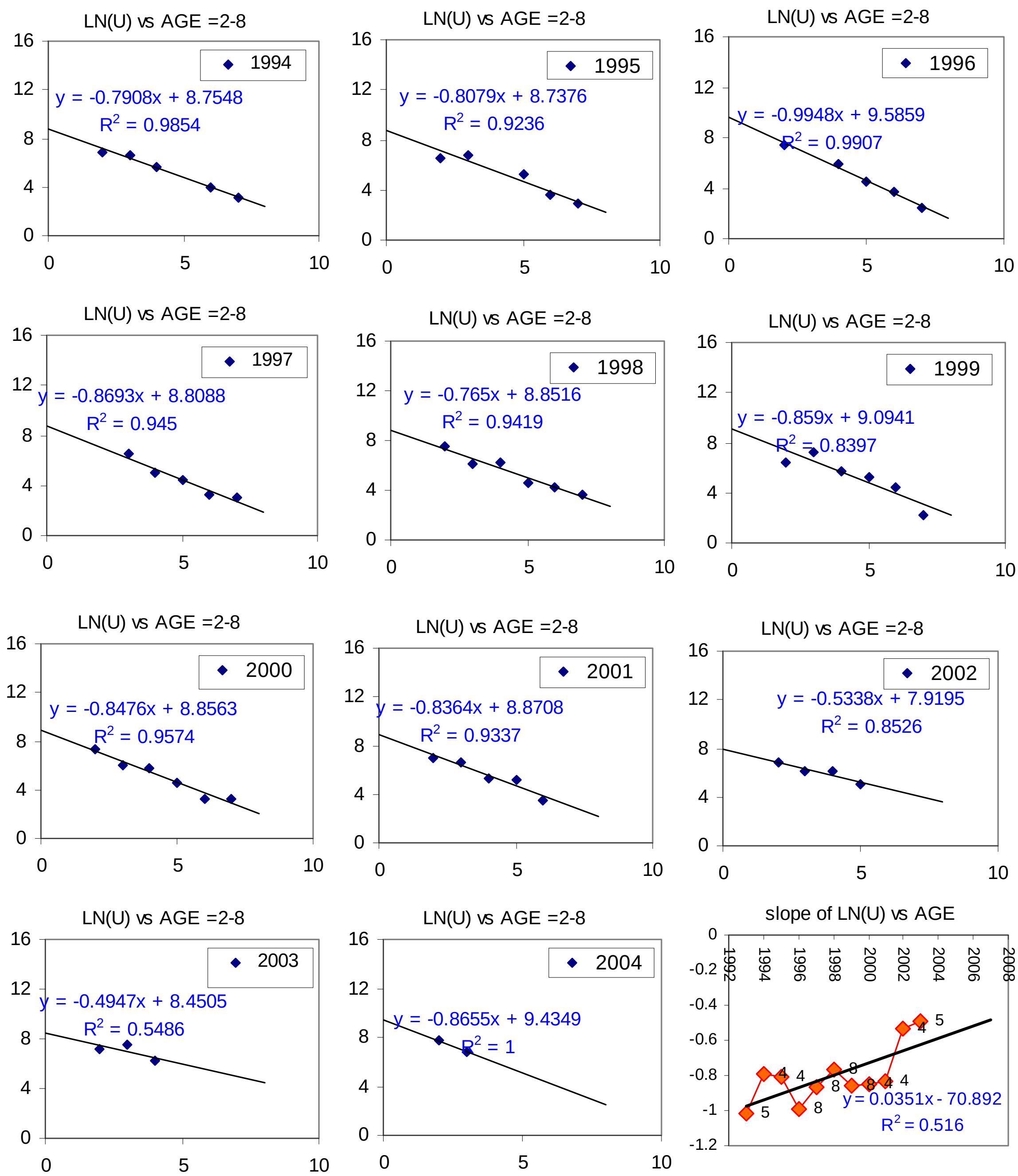


Figure 3.6.1.3.b WESTERN BALTIC HERRING. Log Catch vs Age for successive cohorts and thei

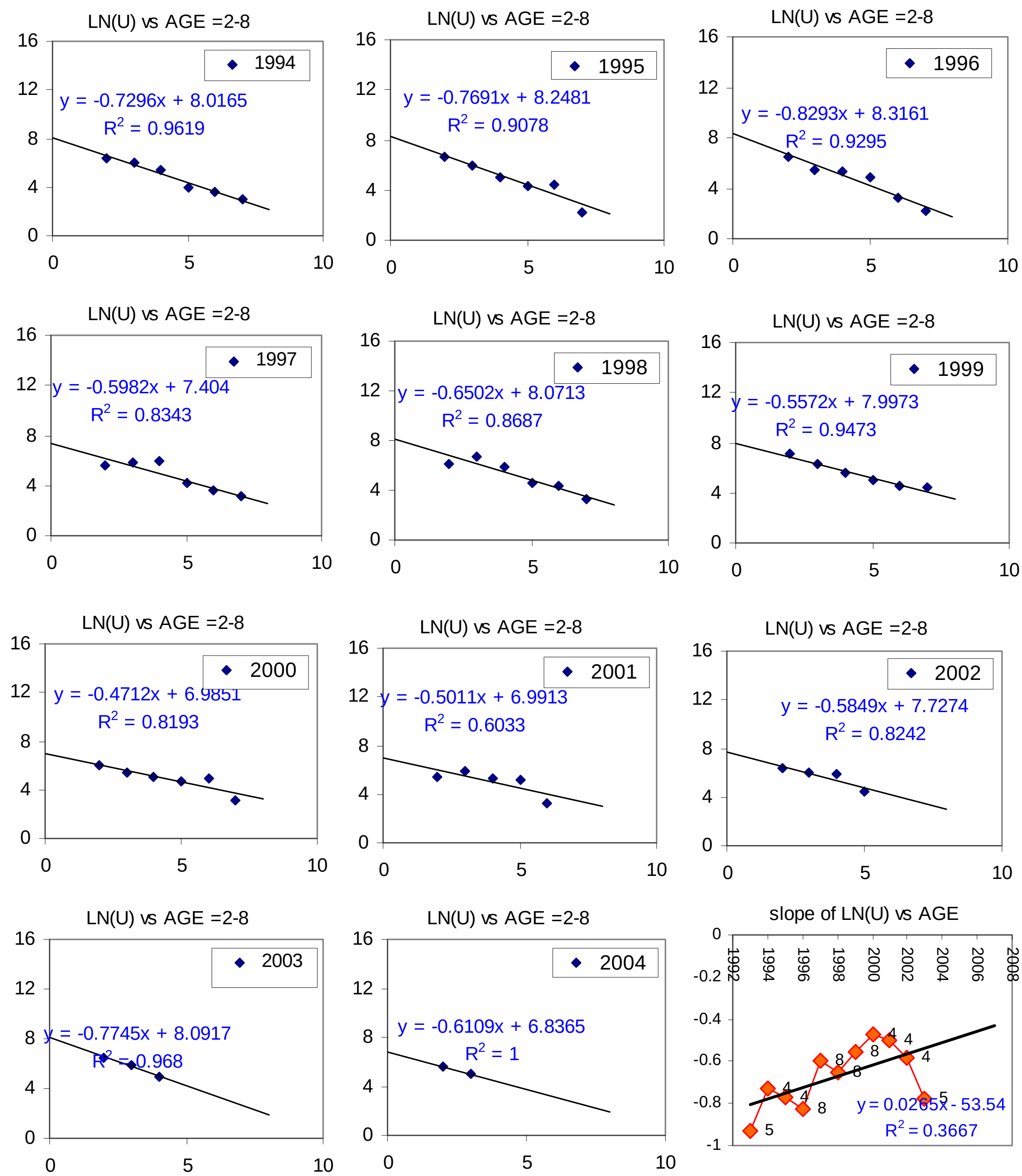


Figure 3.6.1.3.c WESTERN BALTIC HERRING. Log Catch vs Age for successive cohorts and thei

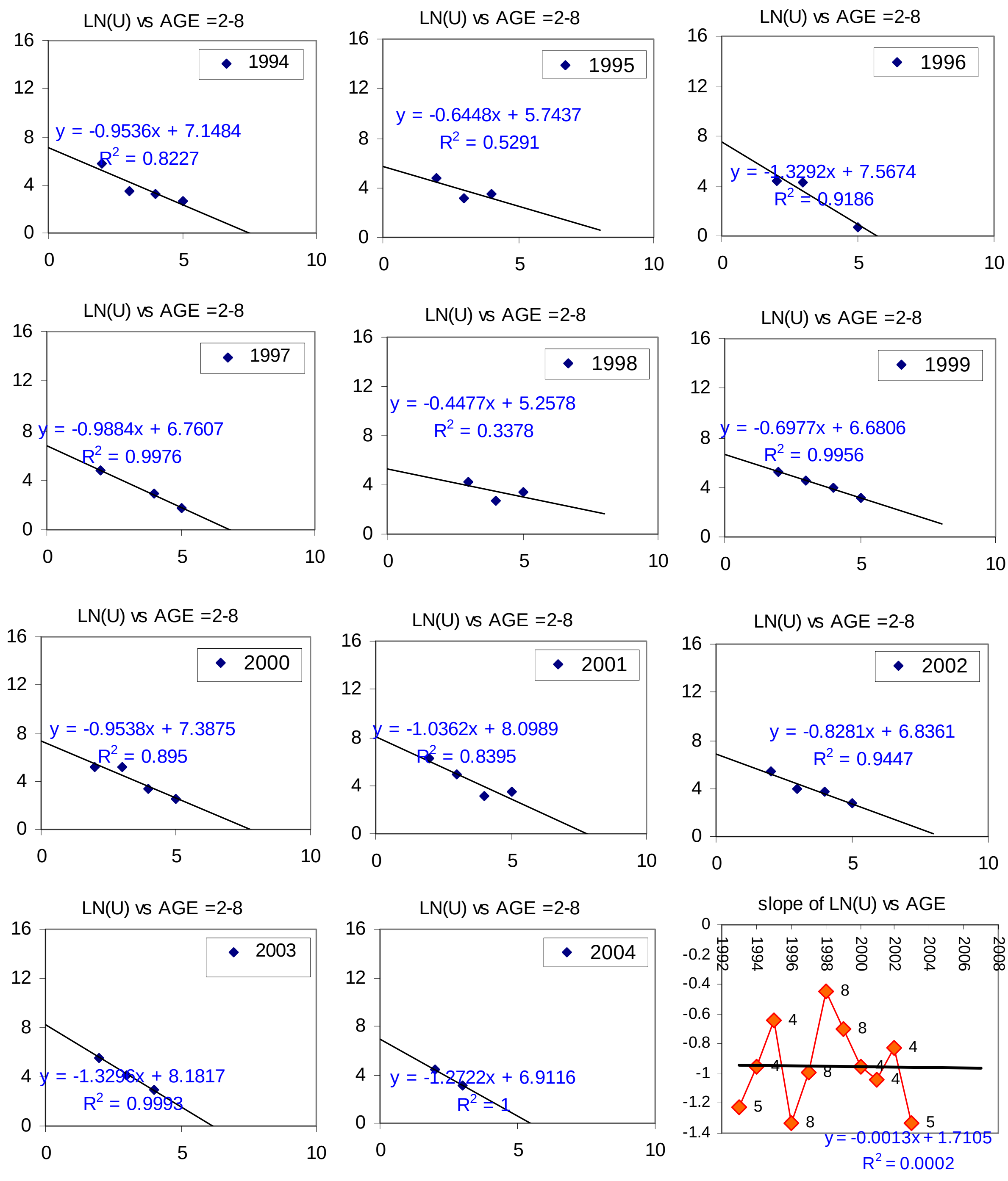


Figure 3.6.1.3.d WESTERN BALTIC HERRING. Log Catch vs Age for successive cohorts and thei

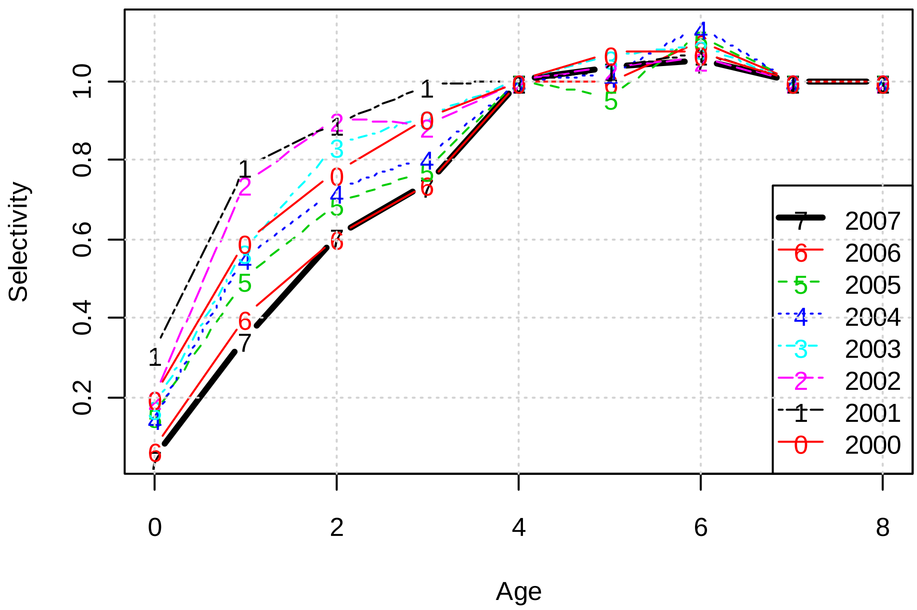


Figure 3.6.2.1 WESTERN BALTIC HERRING. Retrospective selection pattern by age for the baseline scenario. The selection pattern is estimated retrospectively using a truncated data series running from the start of the assessment period (1991) up to the final year indicated by the legend.

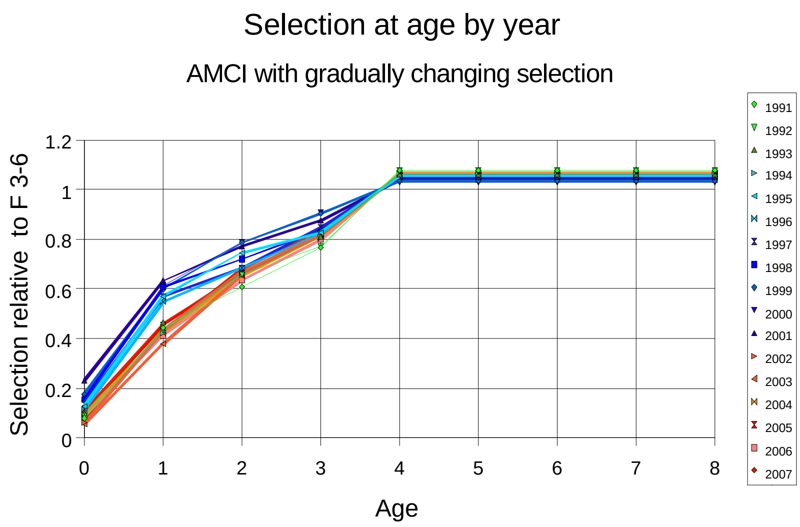


Figure 3.6.2.2. WESTERN BALTIC HERRING. Yearly selection at age as estimated by AMCI when allowing the selection to vary gradually over time.

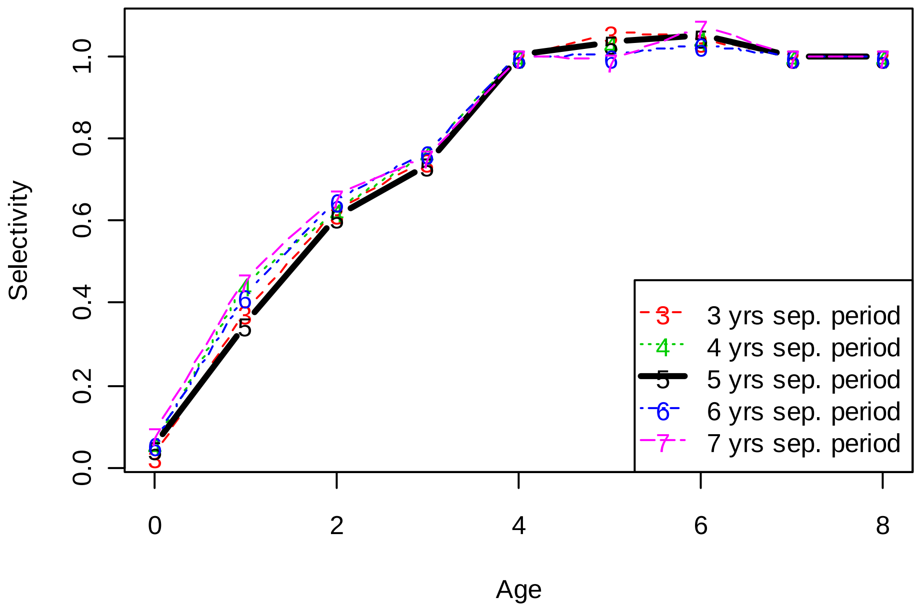


Figure 3.6.2.3. WESTERN BALTIC HERRING. Selectivity at age as a function of the length of the separable period in the FLICA assessment method. The baseline scenario uses a five year separable period.

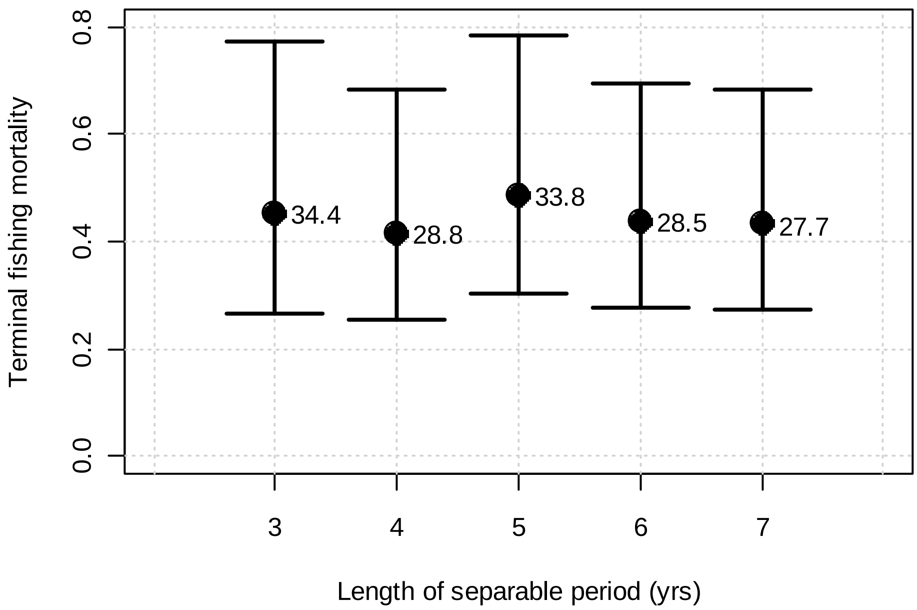


Figure 3.6.2.4.WESTERN BALTIC HERRING. Fishing mortality on the reference ages (with estimated uncertainty) as a function of the length of the separable period employed in FLICA. The numbers to the right of the data points give the percentage CV (coefficient of variance: the standard error in the estimate divided by the value of the estimated parameter) associated with each setting. The baseline scenario uses a five year separable period.

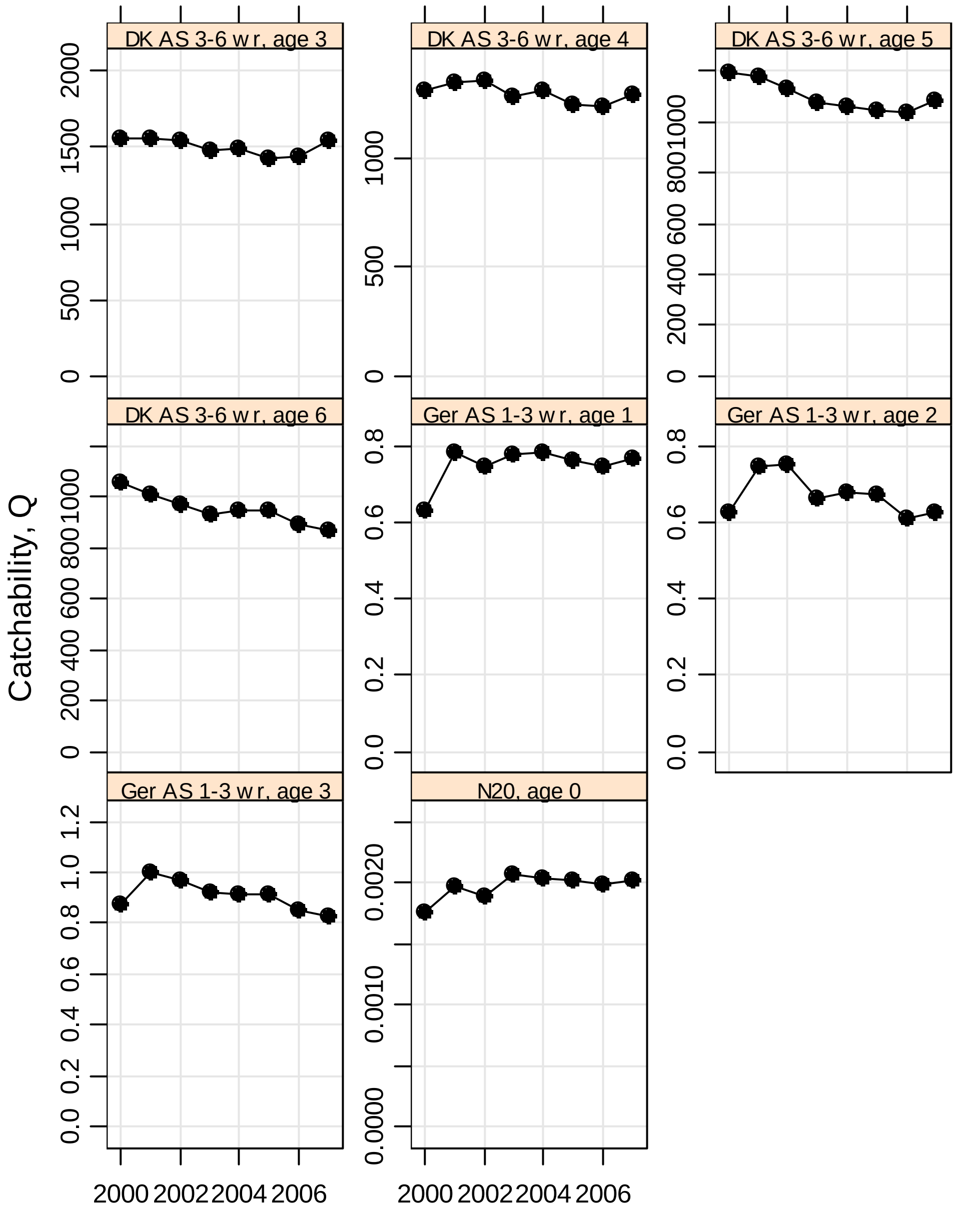


Figure 3.6.2.5. WESTERN BALTIC HERRING. Catchability of each survey at age, estimated retrospectively. The catchability is derived from an assessment using data from 1991 (the start of the assessment period) up to the point denominated on the x-axis.

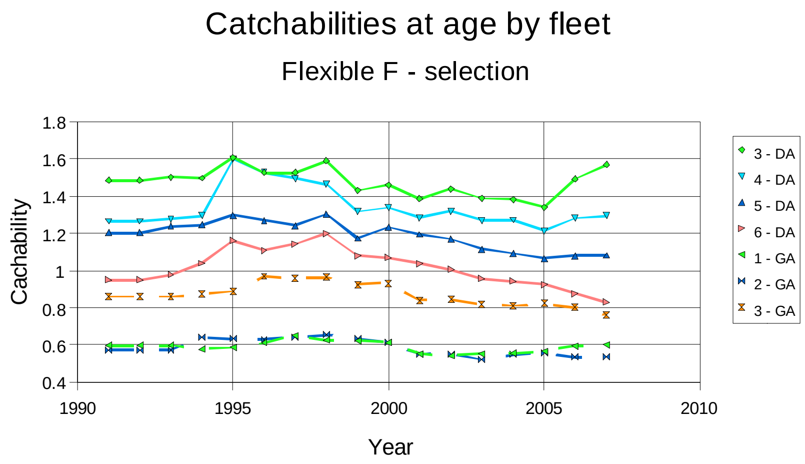


Figure 3.6.2.6. WESTERN BALTIC HERRING. Trends in catchabilities at age estimated with AMCI when catchabilities are allowed to change gradually over time. Numbers in the legend indicate age. DA: Danish acoustic survey (whole lines). GA: German acoustic survey (broken lines)

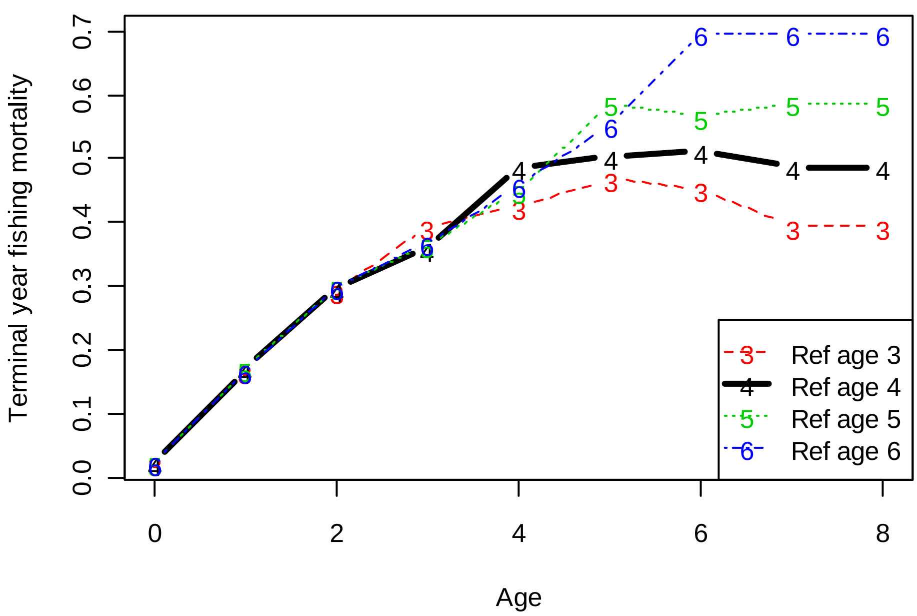


Figure 3.6.2.7. WESTERN BALTIC HERRING. Fishing mortality in the terminal year as a function of age for a set of different reference ages. The baseline scenario uses a reference age of four.

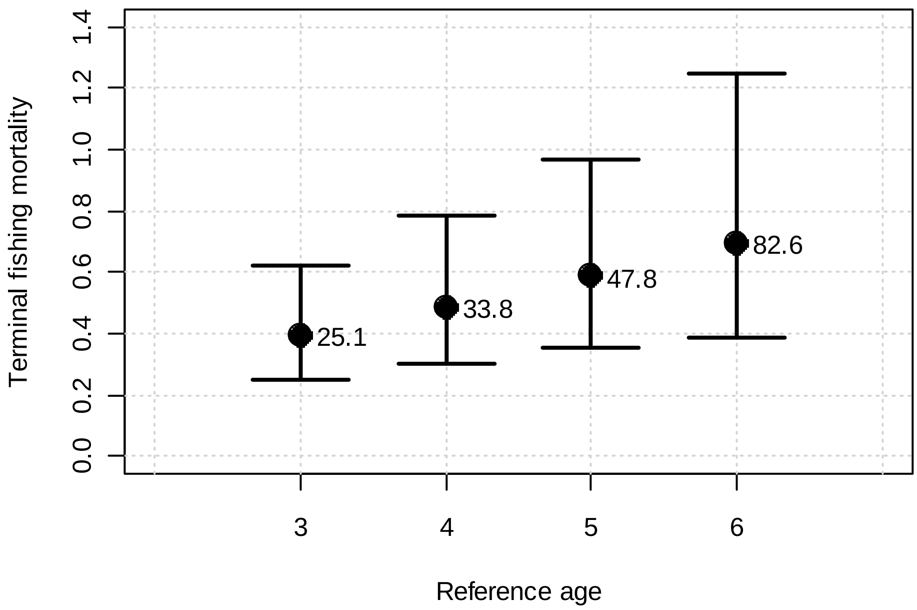


Figure 3.6.2.8. WESTERN BALTIC HERRING. Fishing mortality on the reference ages (with estimated uncertainty) as a function of the reference age employed in the FLICA model. The numbers to the right of the data points give the percentage CV (coefficient of variance: the standard error in the estimate divided by the value of the estimated parameter) associated with each setting. The baseline scenario uses a reference age of four.

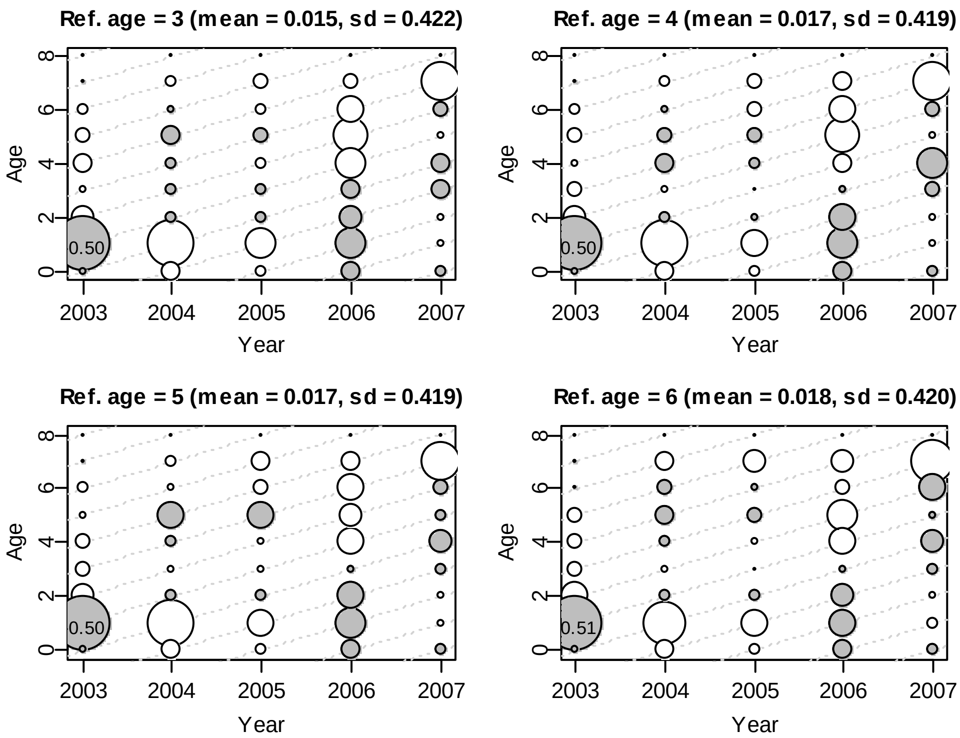


Figure 3.6.2.9. WESTERN BALTIC HERRING. Catch residual bubble plots, showing the value of the residual for each age and year during the separable period, for each of four different reference ages. The mean and standard deviation of the residuals is given in the titles. Negative residuals are coloured grey, whilst positive residuals are white. Diagonal lines link cohorts. The residual corresponding to the largest absolute value is labelled on the figure with that value. Bubble sizes between plots are comparable. The baseline scenario uses a reference age of four.

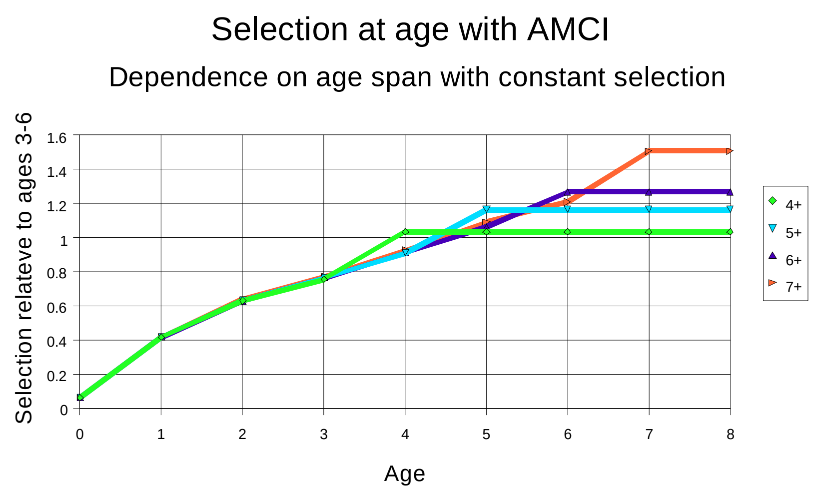


Figure 3.6.2.10. WESTERN BALTIC HERRING. Selection at age estimated with AMCI for a constant selection for 2002 - 2007, assuming constant selection above a range of ages.

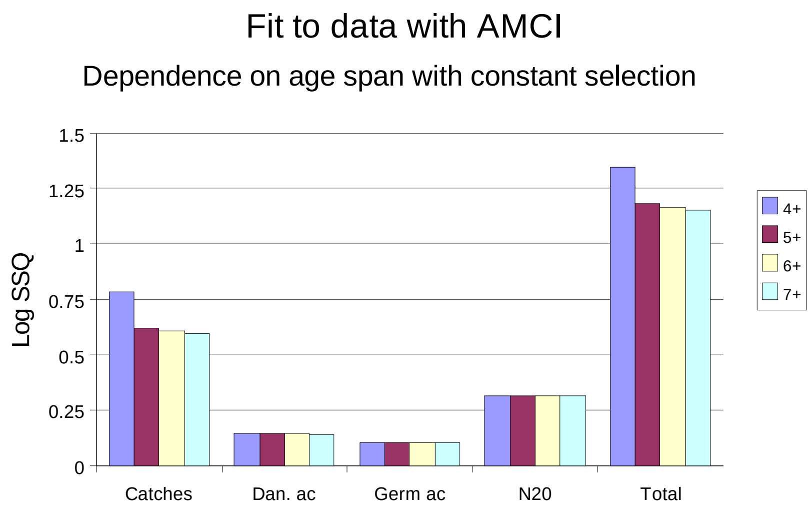


Figure 3.6.2.11. WESTERN BALTIC HERRING. The fit of the AMCI model, in terms of the partial sum of weighted squared log –residuals for each separate data source. The sums of squares are shown for a range of ages (indicated in the legend) above which a flat selection pattern was assumed.

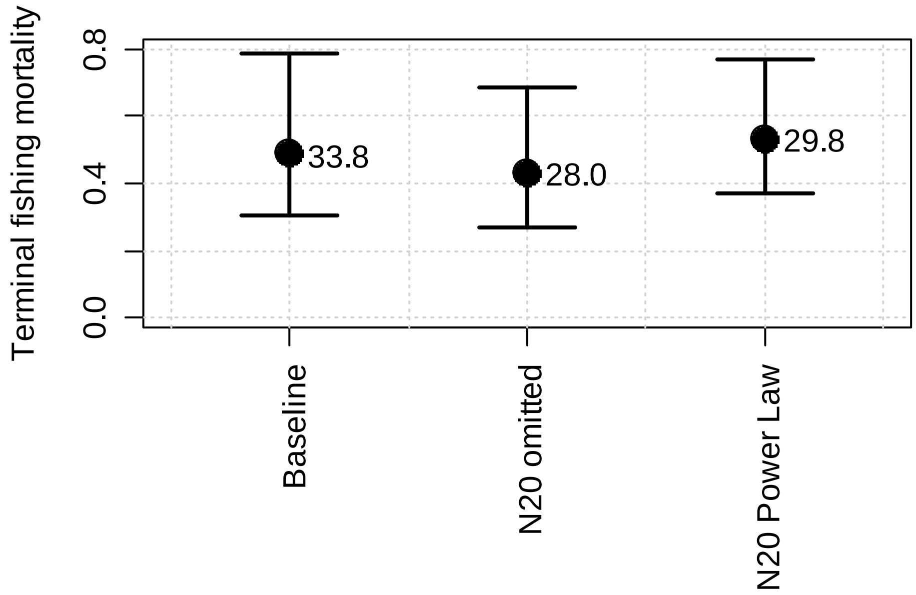


Figure 3.6.3.1. WESTERN BALTIC HERRING. Effect of different treatments of the N20 index on the fishing mortality on the reference ages (with estimated uncertainty) employed in FLICA. Treatments plotted here are including the N20 with a linear catchability model ("Baseline scenario"), omitting the N20 index from the assessment ("N20 omitted") and modelling the N20 index with a power-law catchablity model ("N20 power law"). The numbers to the right of the data points give the percentage CV (coefficient of variance: the standard error in the estimate divided by the value of the estimated parameter) associated with each setting.

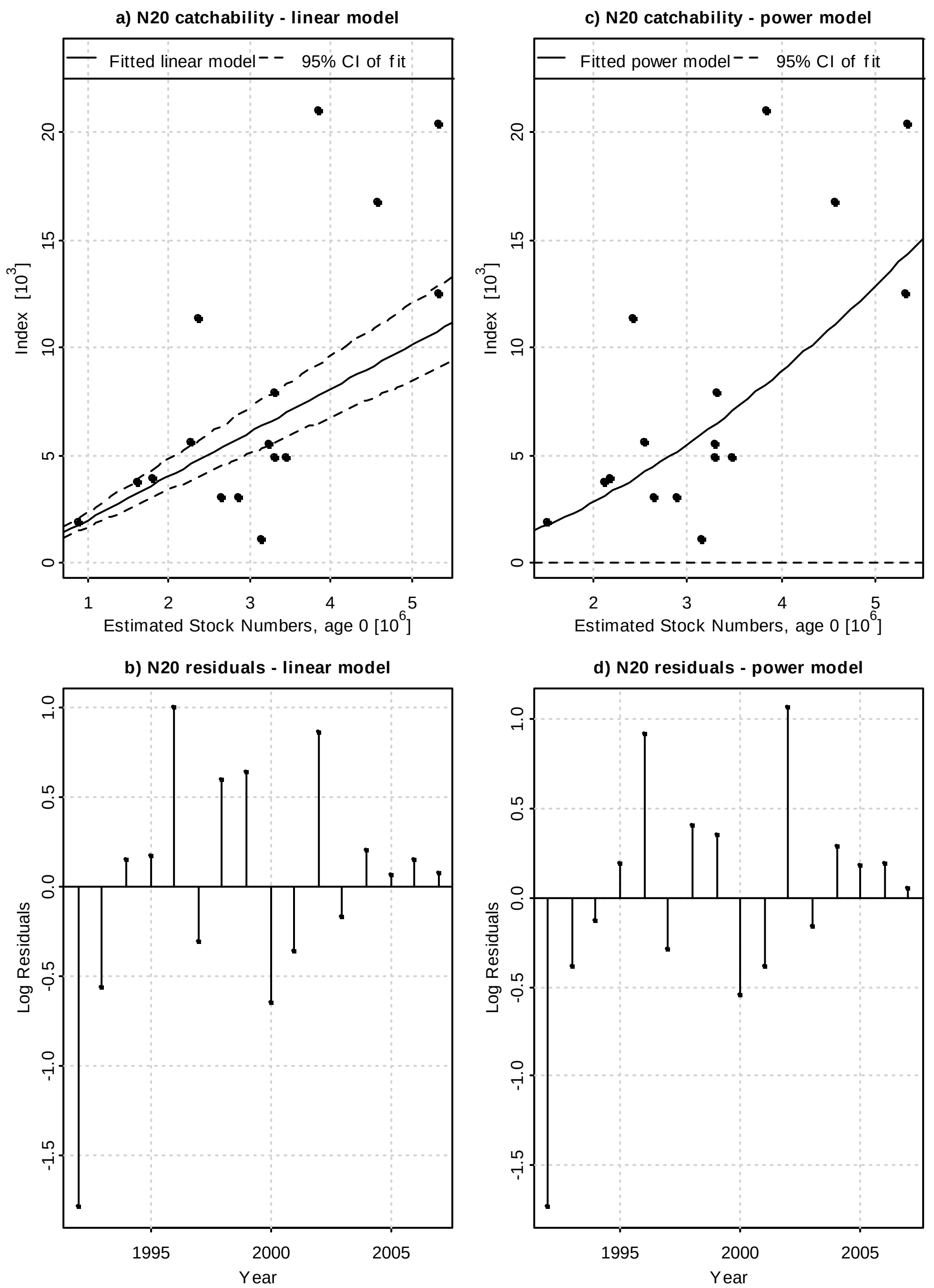


Figure 3.6.3.2. WESTERN BALTIC HERRING. Diagnostic plots for the choice of catchability model for the N20 index. a) Observed index value against stock numbers estimated by the FLICA method, with the linear catchability model, with 95% confidence limits. b) Residuals to the linear catchability model as a function of time. c) Observed index value against stock numbers estimated by the FLICA method using a power law catchability model, with 95% confidence limits. d) Residuals to the power-law catchability model as a function of time.

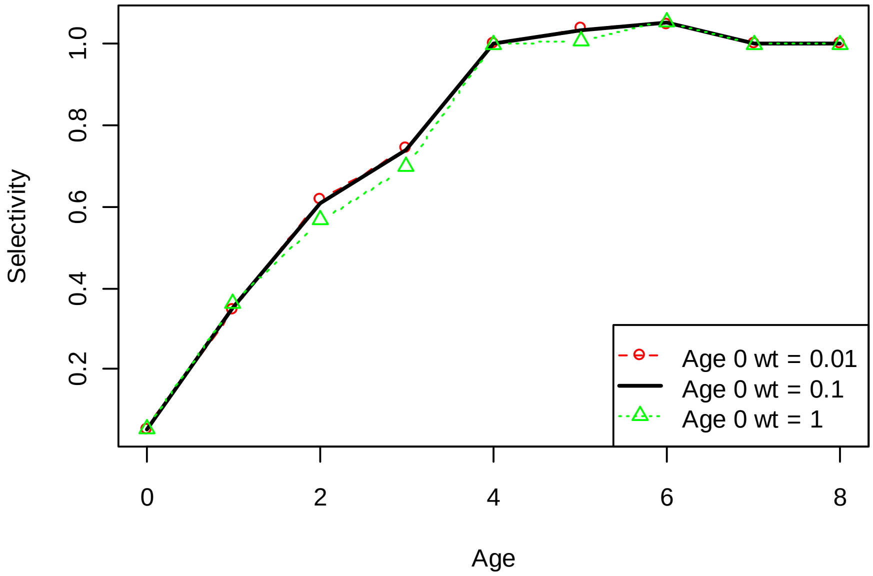


Figure 3.6.3.3. WESTERN BALTIC HERRING. Influence on estimated selection pattern of changing the weighting placed on 0-group (Age 0) catches.

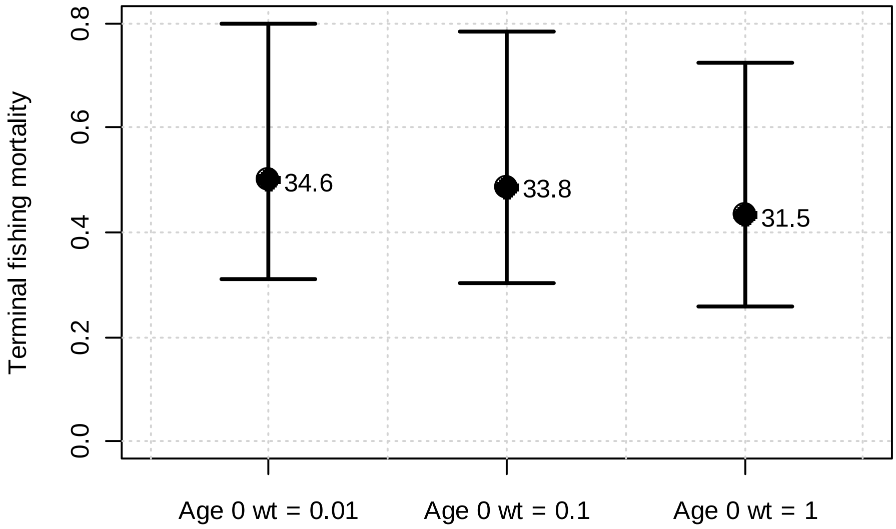


Figure 3.6.3.4. WESTERN BALTIC HERRING. Effect on the fishing mortality at the reference age in the terminal year of changing the weighting on 0-group.

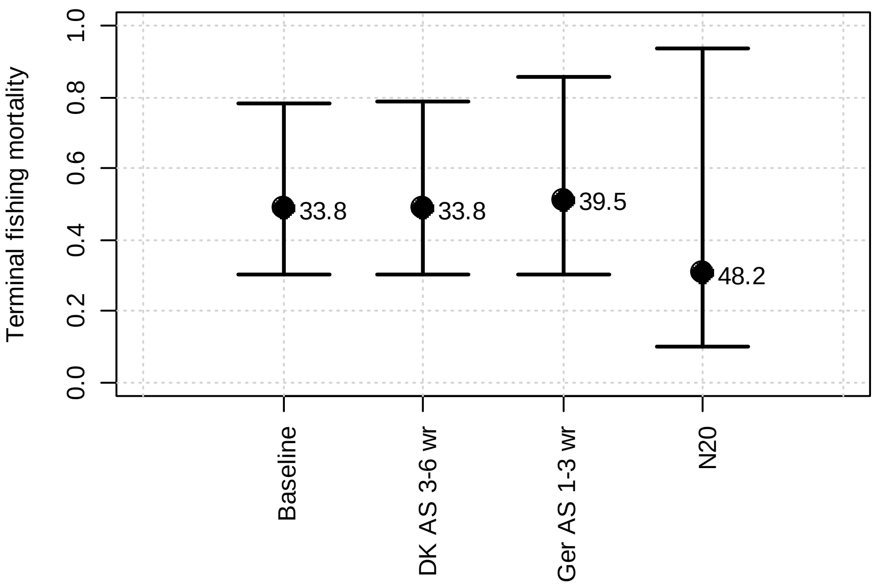


Figure 3.6.3.5. WESTERN BALTIC HERRING Fishing mortality on the reference ages (with estimated uncertainty) for assessments using catch data and a single survey index. Surveys considered here are the Danish acoustic survey with age 3-6 wr data ("DK AS 3-6 wr"), the German acoustic survey in subdivisions 21-24 with age 1-3 wr data ("Ger AS 1-3 wr"), and the N20 larval abundance index ("N20"). The baseline scenario ("Baseline") uses all three indices, in addition to the catch data. The numbers to the right of the data points give the percentage CV (coefficient of variance: the standard error in the estimate divided by the value of the estimated parameter) associated with each setting. All models are employed with a linear catchability model.

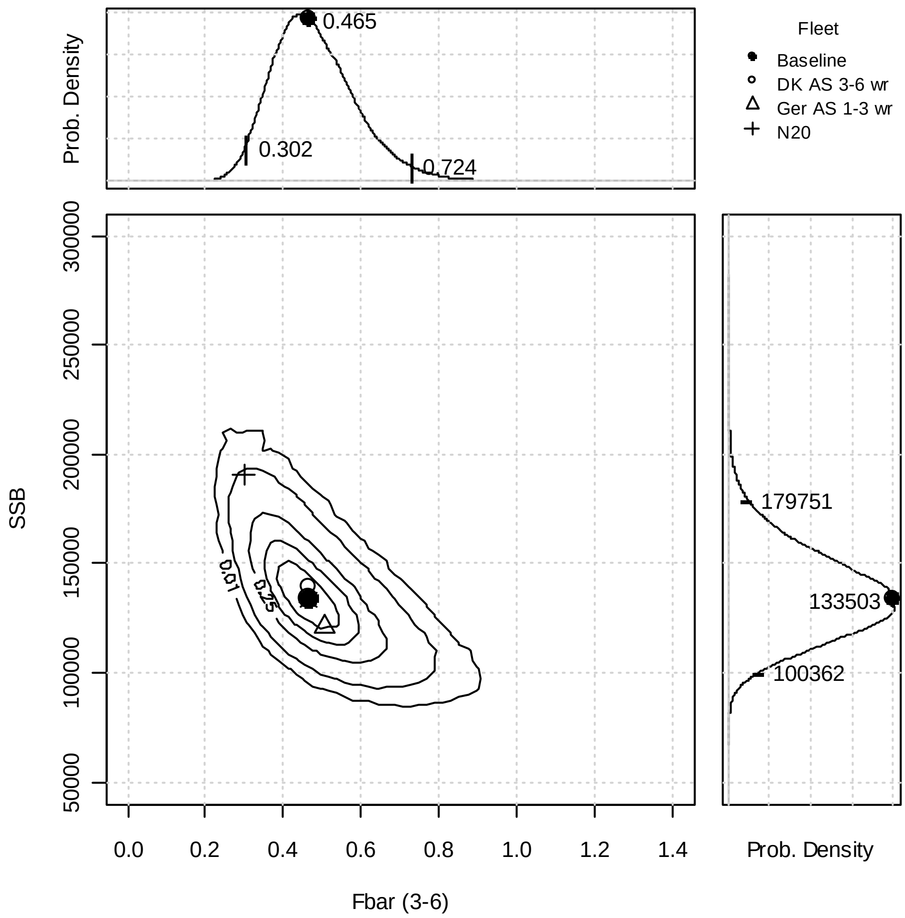


Figure 3.6.3.6. WESTERN BALTIC HERRING. "Otolith" plot. The main figure depicts the uncertainty in the estimated spawning stock biomass and average fishing mortality, and their correlation. Contour lines give the 1%, 5%, 25%, 50% and 75% confidence intervals for the two estimated parameters and are estimated from a parametric bootstrap based on the variance-covariance matrix in the parameters returned by FLICA. The plots to the right and top of the main plot give the probability distribution in the SSB and mean fishing mortality respectively. The SSB and fishing mortality estimated by the method is plotted on all three plots with a heavy dot. 95% confidence intervals, with their corresponding values, are given on the plots to the right and top of the main plot. The SSB and fishing mortality estimated by FLICA using catch data and a single survey index are also plotted on the main plot. The "baseline" scenario uses all three indices.

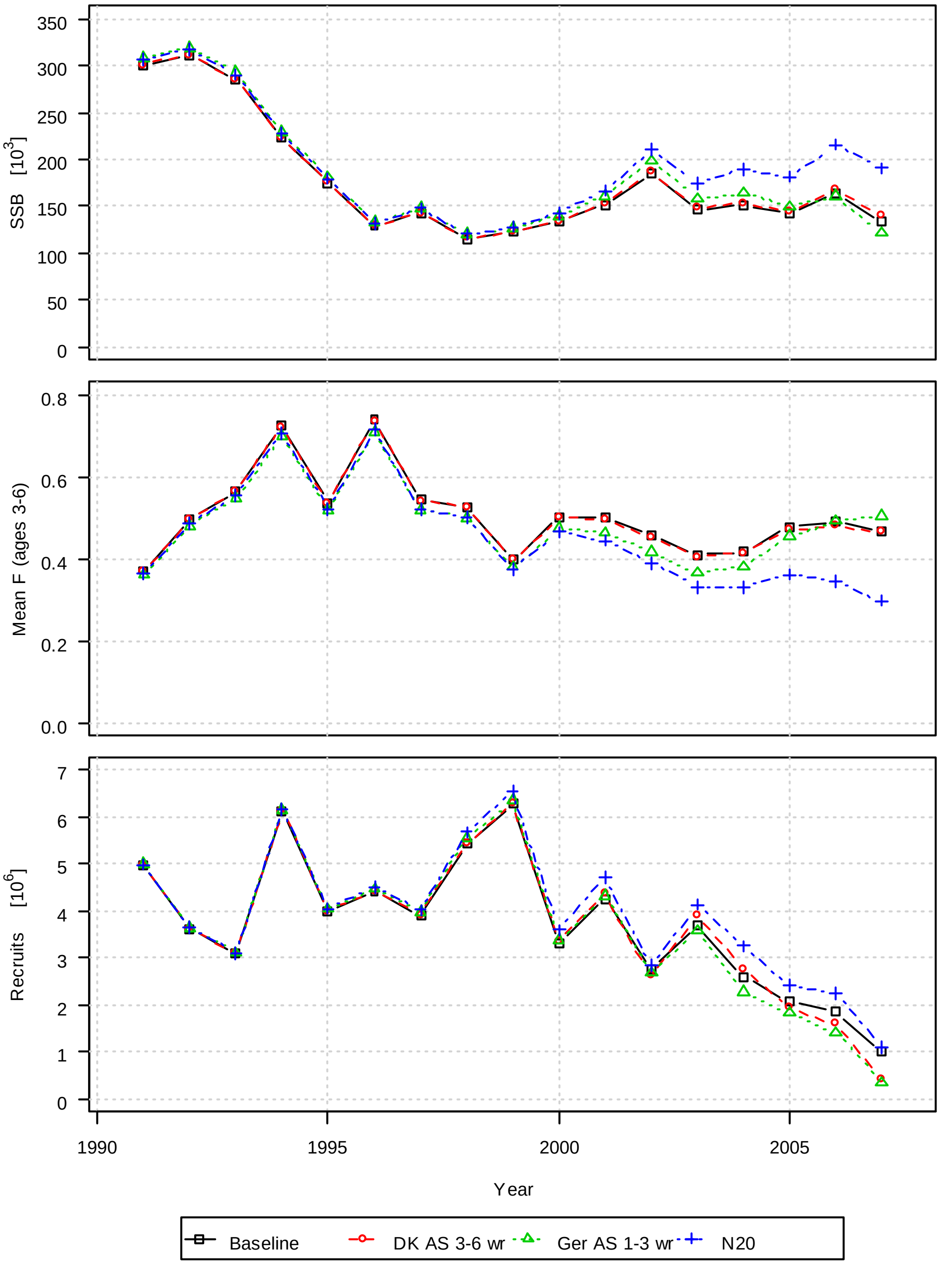


Figure 3.6.3.7. WESTERN BALTIC HERRING. Perception of spawning stock biomass, mean fishing mortality and recruitment based assessments performed using catch data and a single survey index as a tuning fleet. Surveys considered here are the Danish acoustic survey with age 3-6 wr data ("DK AS 3-6 wr"), the German acoustic survey in subdivisions 21-24 with age 1-3 wr data ("Ger AS 1-3 wr"), and the N20 larval abundance index ("N20"). The baseline scenario ("Baseline") uses all three indices, in addition to the catch data. All models are employed with a linear catchability model.

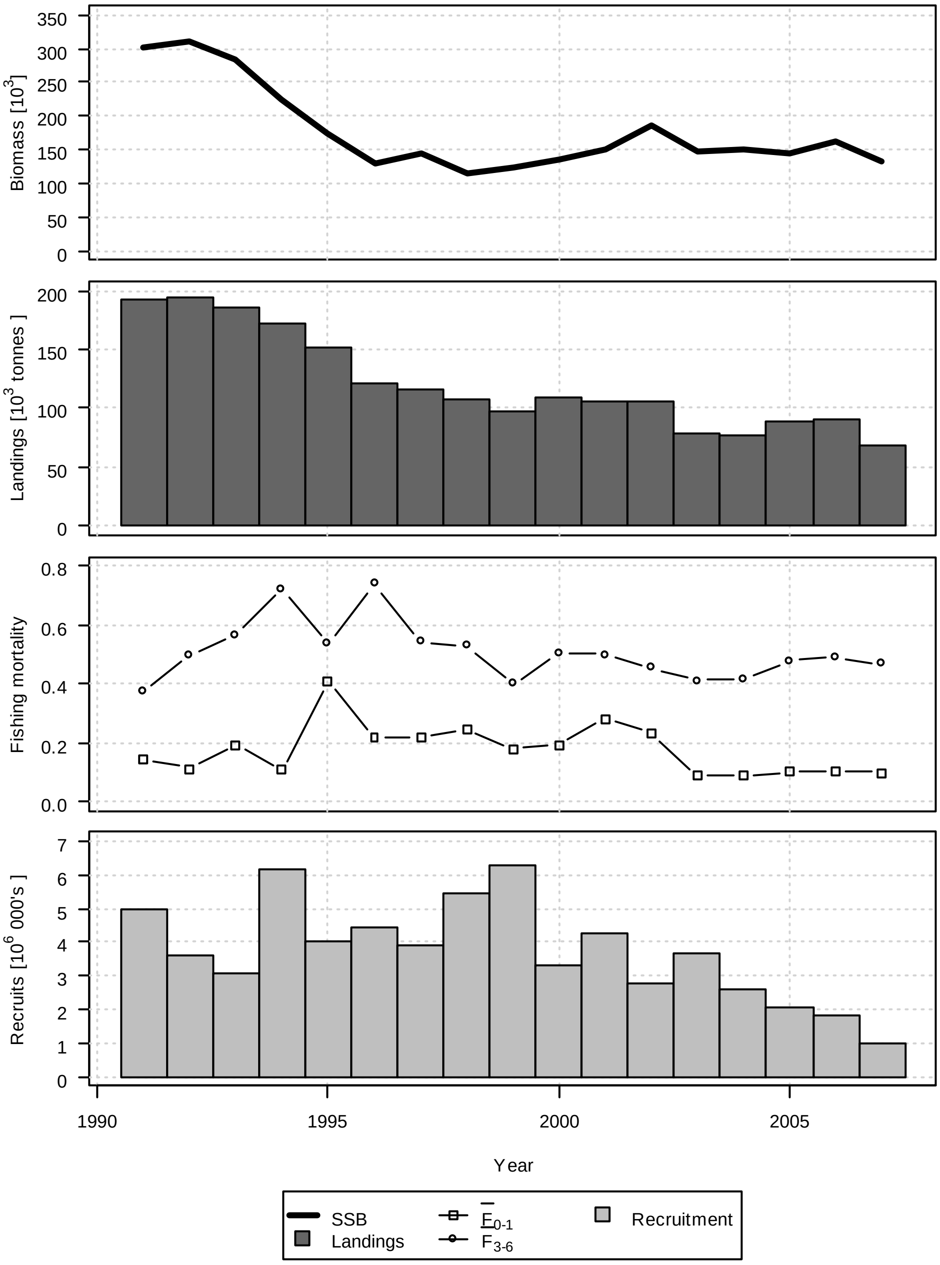


Figure 3.6.5.1. WESTERN BALTIC HERRING. Stock summary plot. Top panel) Spawning stock and total biomass. Second panel) Landings as a function of time. Third panel) Mean annual fishing mortality on ages 3-6 ringers and 0-1 ringers as a function of time. Bottom panel) Recruitment as a function of time.

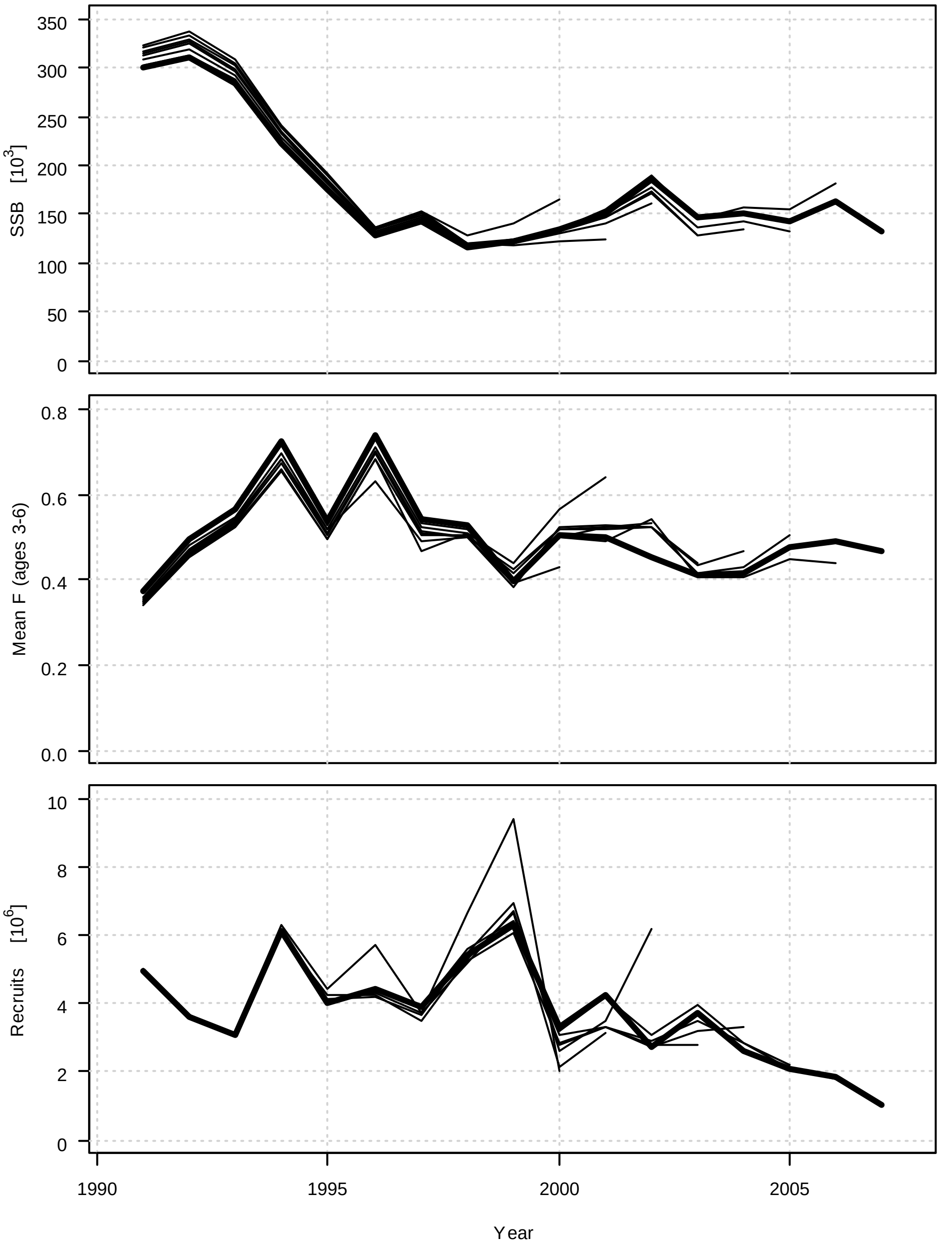


Figure 3.6.5.2. WESTERN BALTIC HERRING. Retrospective pattern in the assessment. Top panel) Spawning stock biomass. Middle panel) Mean fishing mortality in the ages 3-6 ringer. Bottom panel) Recruitment.

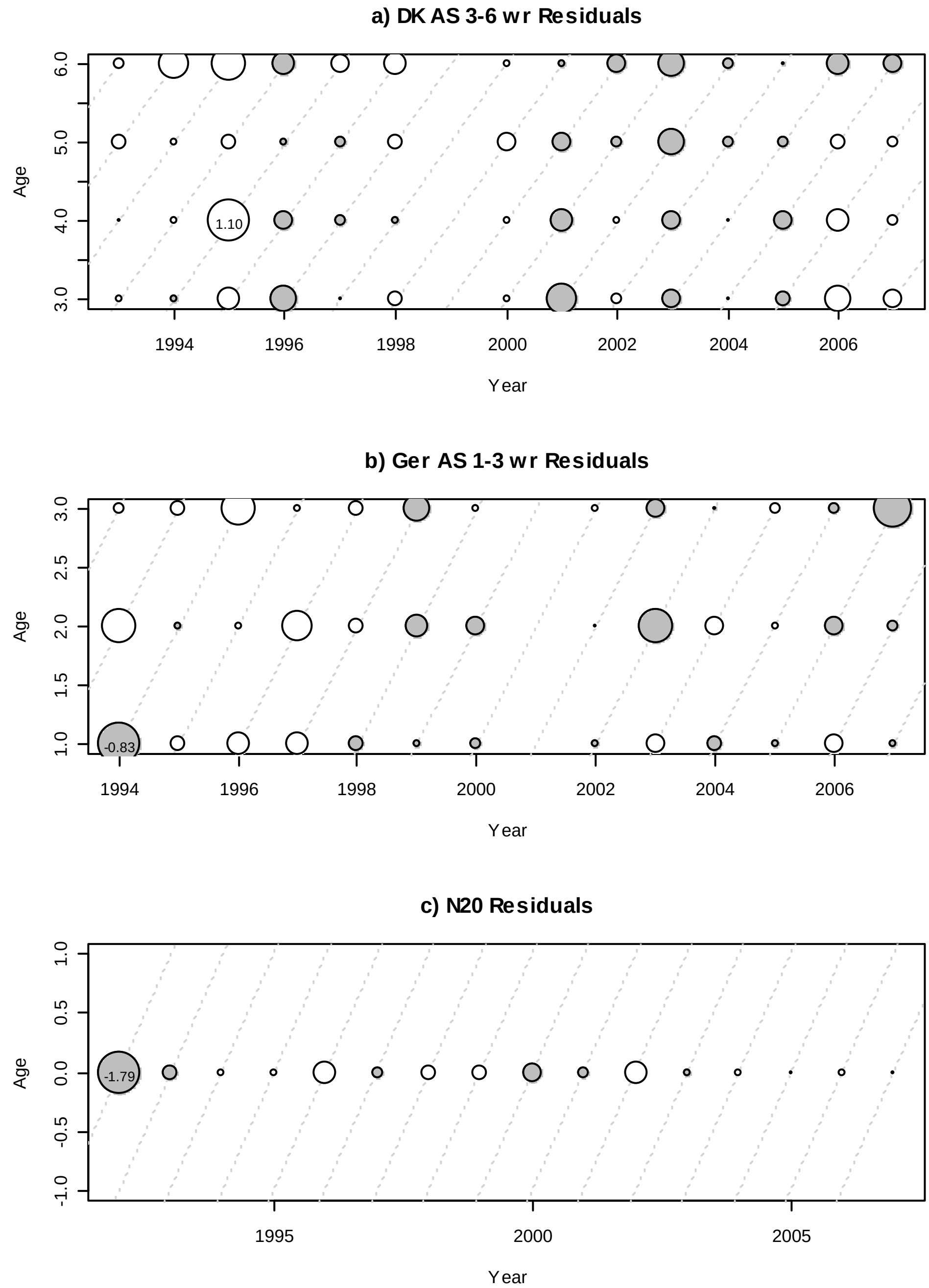


Figure 3.6.5.3. WESTERN BALTIC HERRING. Survey residual bubble plots, showing the value of the log-residual for each age and year, for each of the three surveys used in the assessment. Negative log-residuals are coloured grey, whilst positive residuals are white. Diagonal lines link cohorts. The residual corresponding to the largest absolute value is labelled on the figure with that value. Bubble sizes between plots are comparable. a) Residuals for the Danish acoustic survey ages 3-6 wr ("DK AS 3-6 wr"). b) Residuals for the German acoustic survey, ages 1-3 wr ("Ger AS 1-3 wr"). c) Residuals for the N20 larval abundance index ("N20").

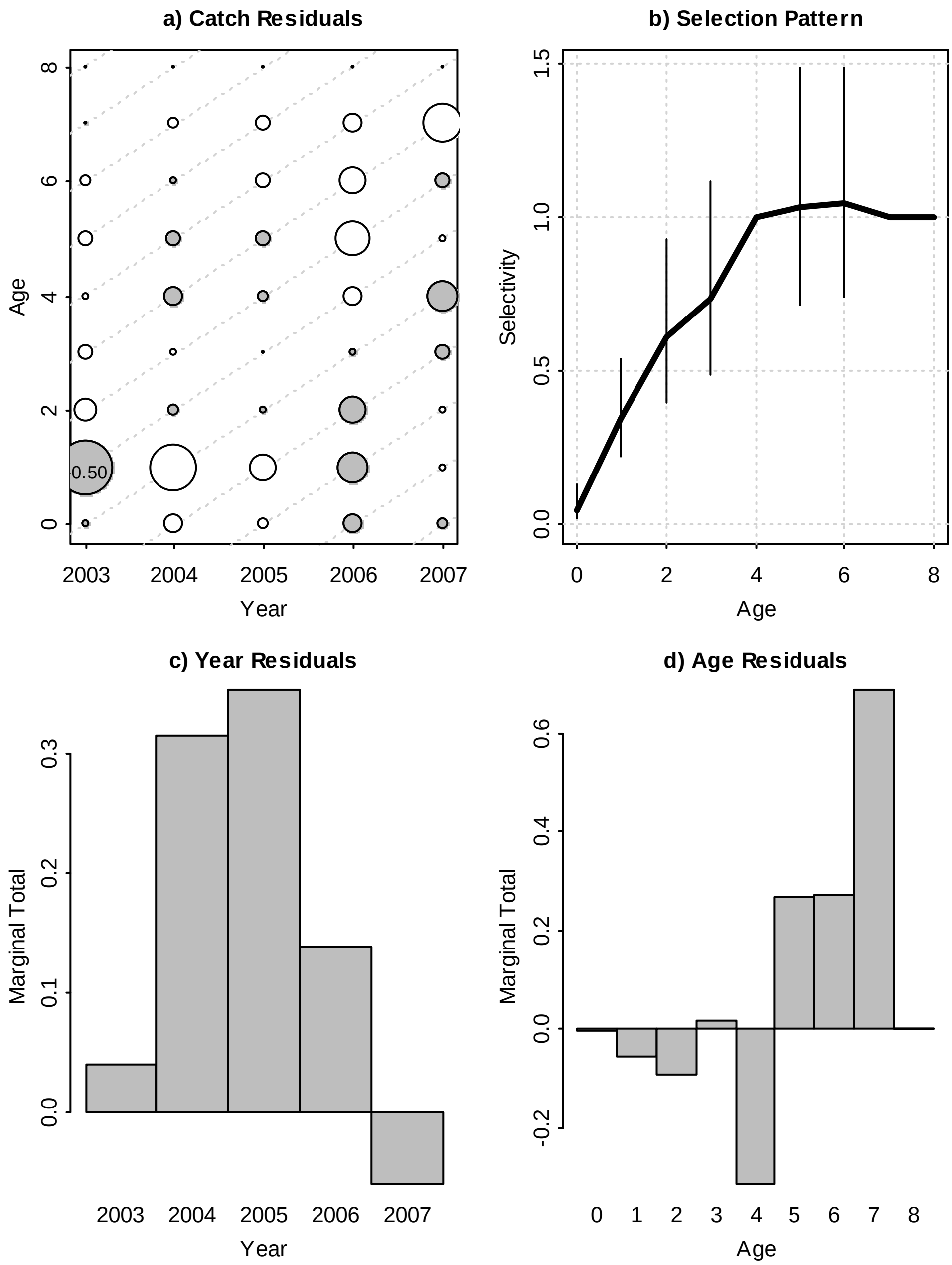


Figure 3.6.5.4. WESTERN BALTIC HERRING. Diagnostics of selection pattern from the final FLICA assessment. a) Bubbles plot of log catch residuals by age (weighting applied) and year. Grey bubbles correspond to negative log residuals. The largest residual is given. b) Estimated selection parameters (relative to 4 wr) with 95% confidence intervals. c): Marginal totals of residuals by year. d). Marginal totals of residuals by age (wr).

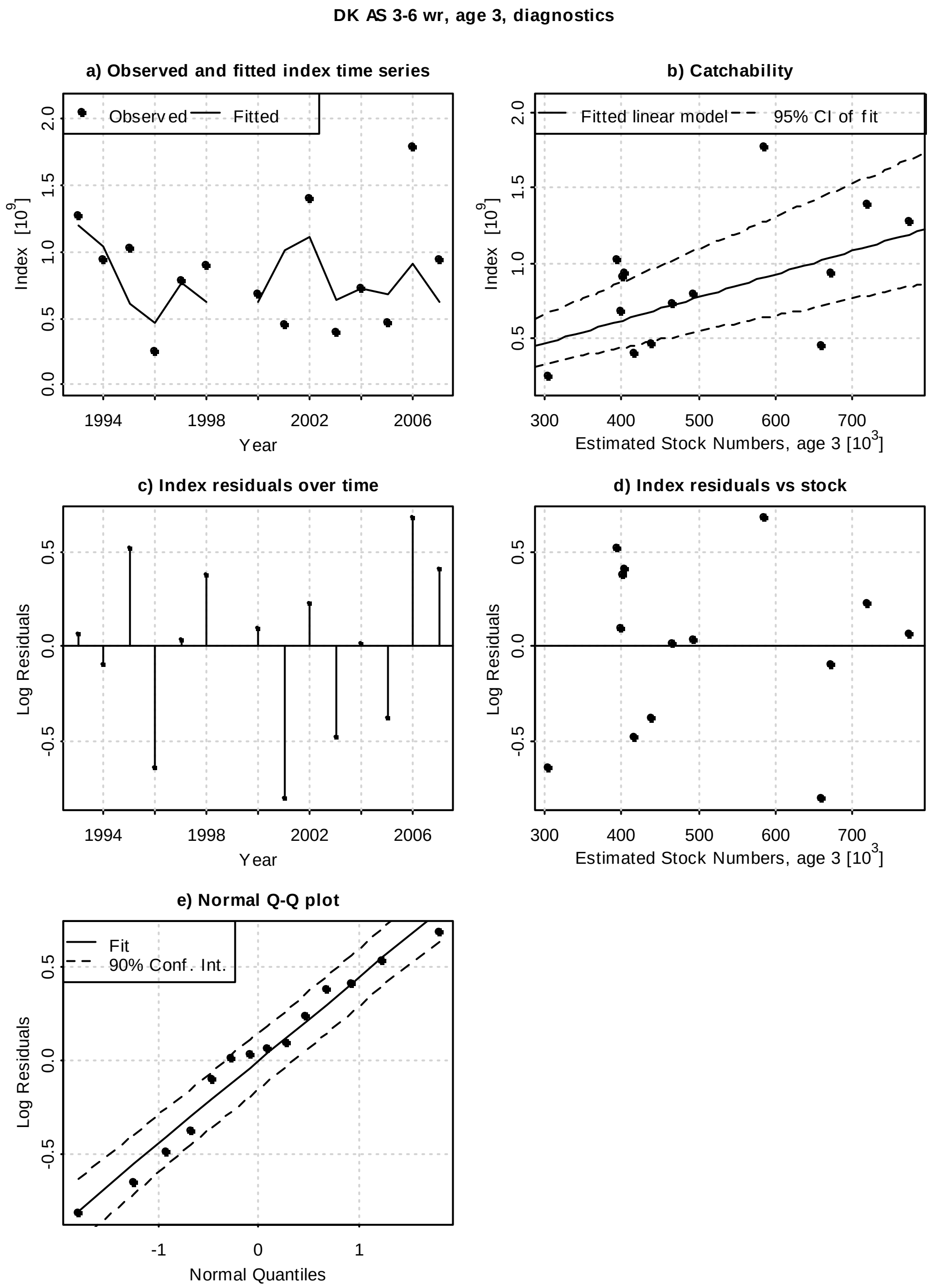


Figure 3.6.5.5. WESTERN BALTIC HERRING. Diagnostics of the Danish acoustic survey ("DK AS 3-6 wr") fit at 3 wr from the final FLICA assessment. a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus FLICA estimates of stock numbers at age. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log residuals of catchability model fitted by FLICA as a function of time. d). Log residuals from the catchability model against stock size at age estimated by the FLICA assessment method. e). Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line).

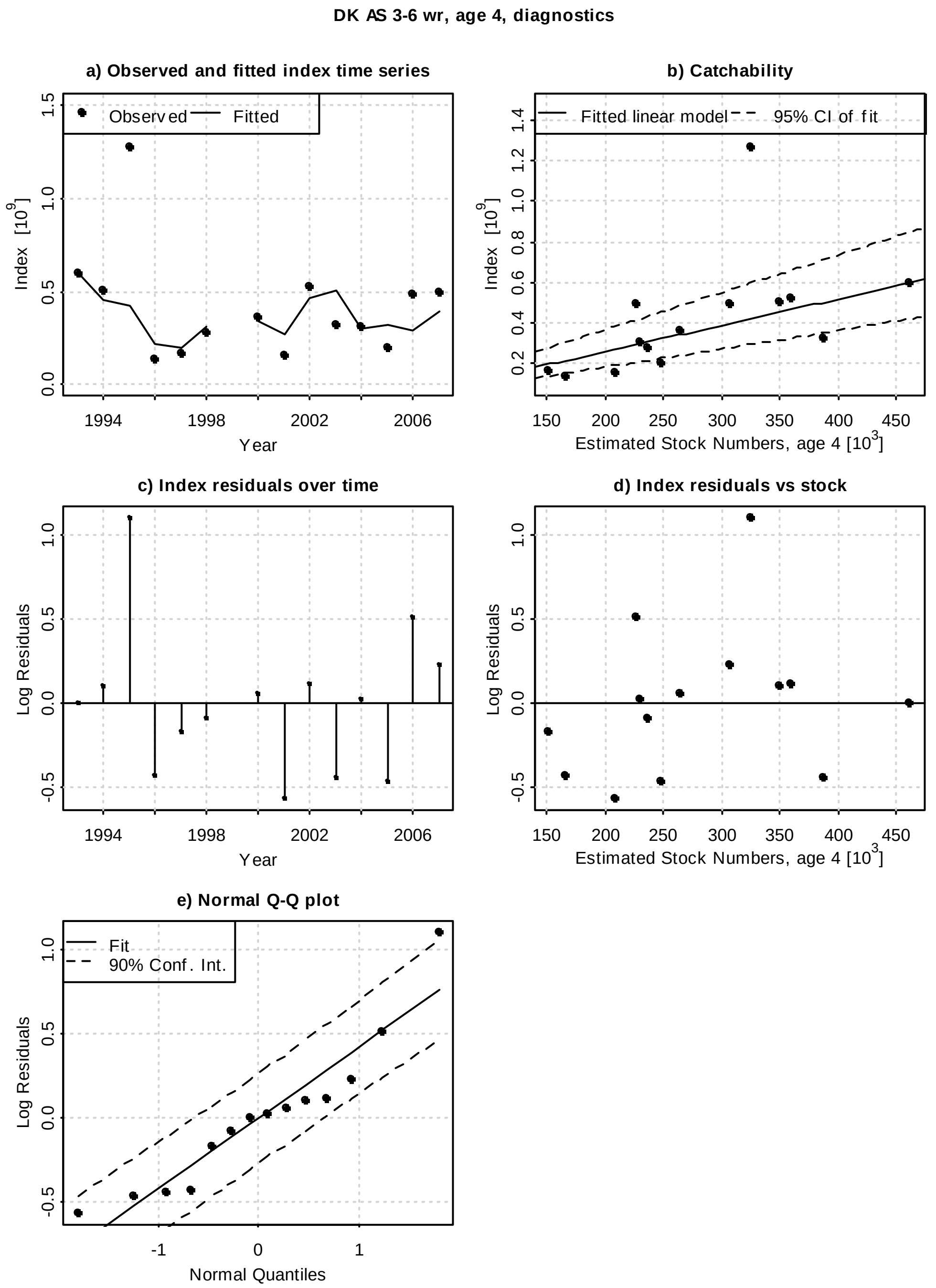


Figure 3.6.5.6. WESTERN BALTIC HERRING. Diagnostics of the Danish acoustic survey ("DK AS 3-6 wr") fit at 4 wr from the final FLICA assessment. a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus FLICA estimates of stock numbers at age. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log residuals of catchability model fitted by FLICA as a function of time. d). Log residuals from the catchability model against stock size at age estimated by the FLICA assessment method. e). Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line).

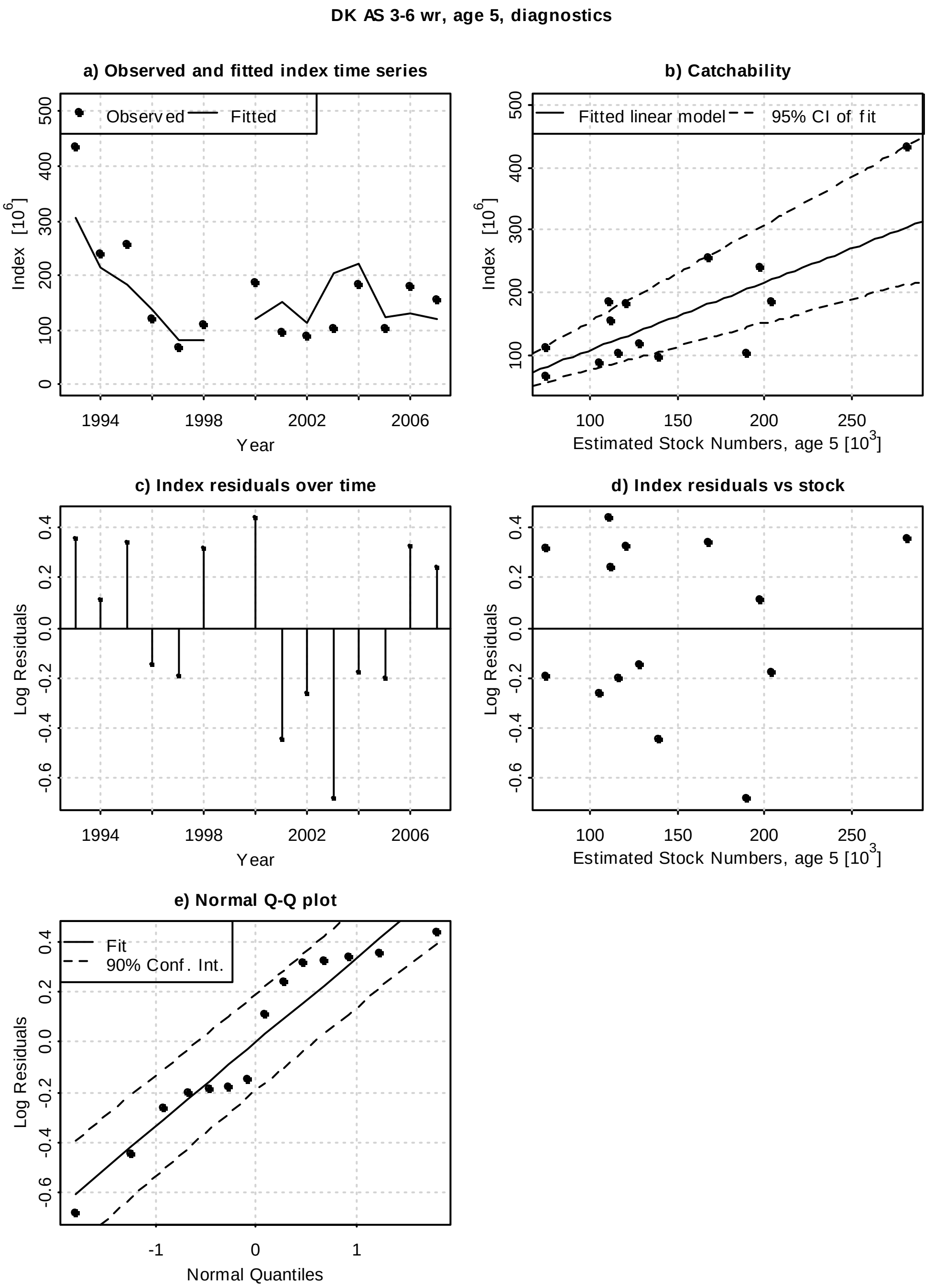


Figure 3.6.5.7. WESTERN BALTIC HERRING. Diagnostics of the Danish acoustic survey ("DK AS 3-6 wr") fit at 5 wr from the final FLICA assessment. a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus FLICA estimates of stock numbers at age. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log residuals of catchability model fitted by FLICA as a function of time. d). Log residuals from the catchability model against stock size at age estimated by the FLICA assessment method. e). Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line).

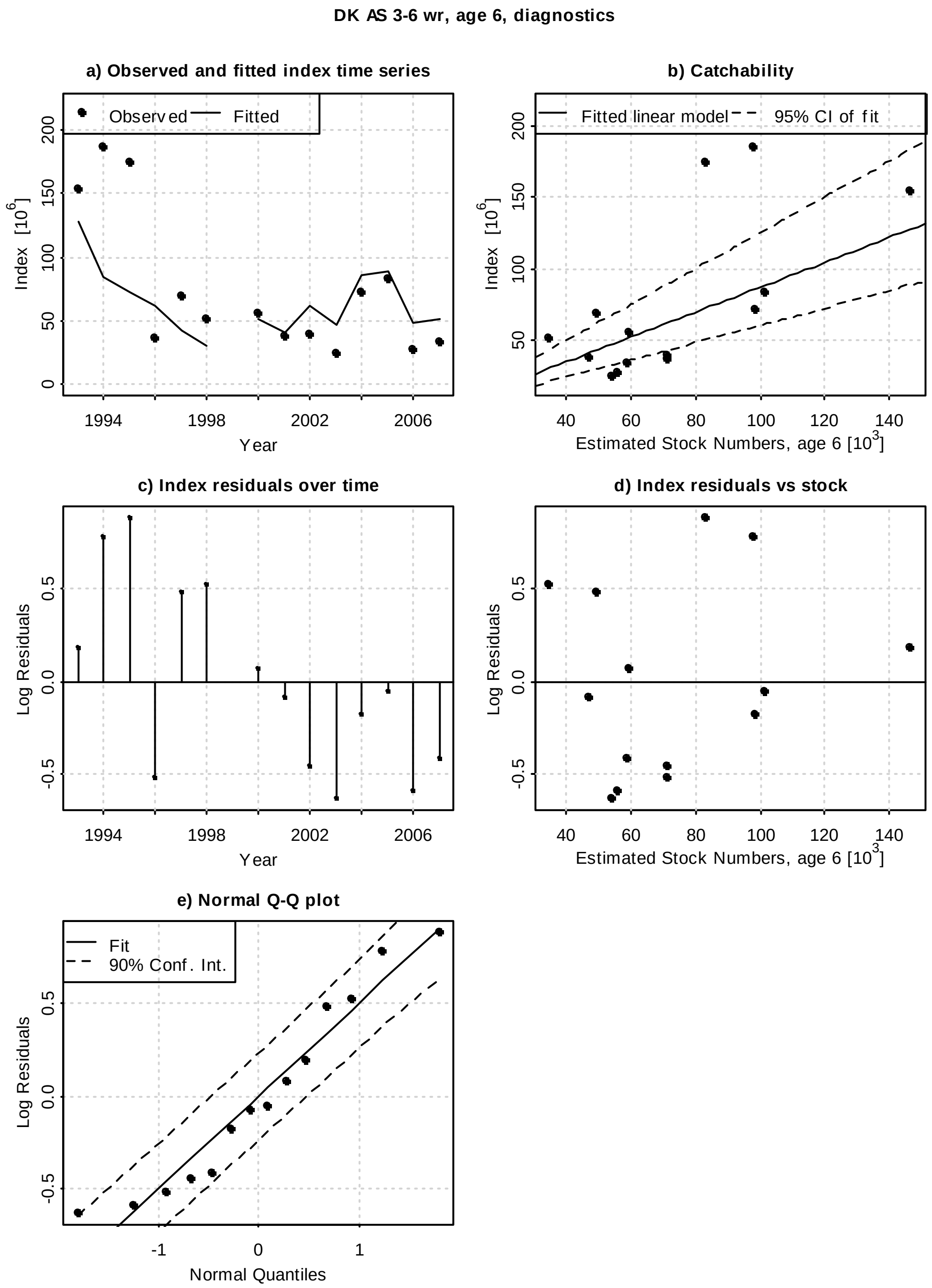


Figure 3.6.5.8. WESTERN BALTIC HERRING. Diagnostics of the Danish acoustic survey ("DK AS 3-6 wr") fit at 6 wr from the final FLICA assessment. a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus FLICA estimates of stock numbers at age. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log residuals of catchability model fitted by FLICA as a function of time. d). Log residuals from the catchability model against stock size at age estimated by the FLICA assessment method. e). Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line).

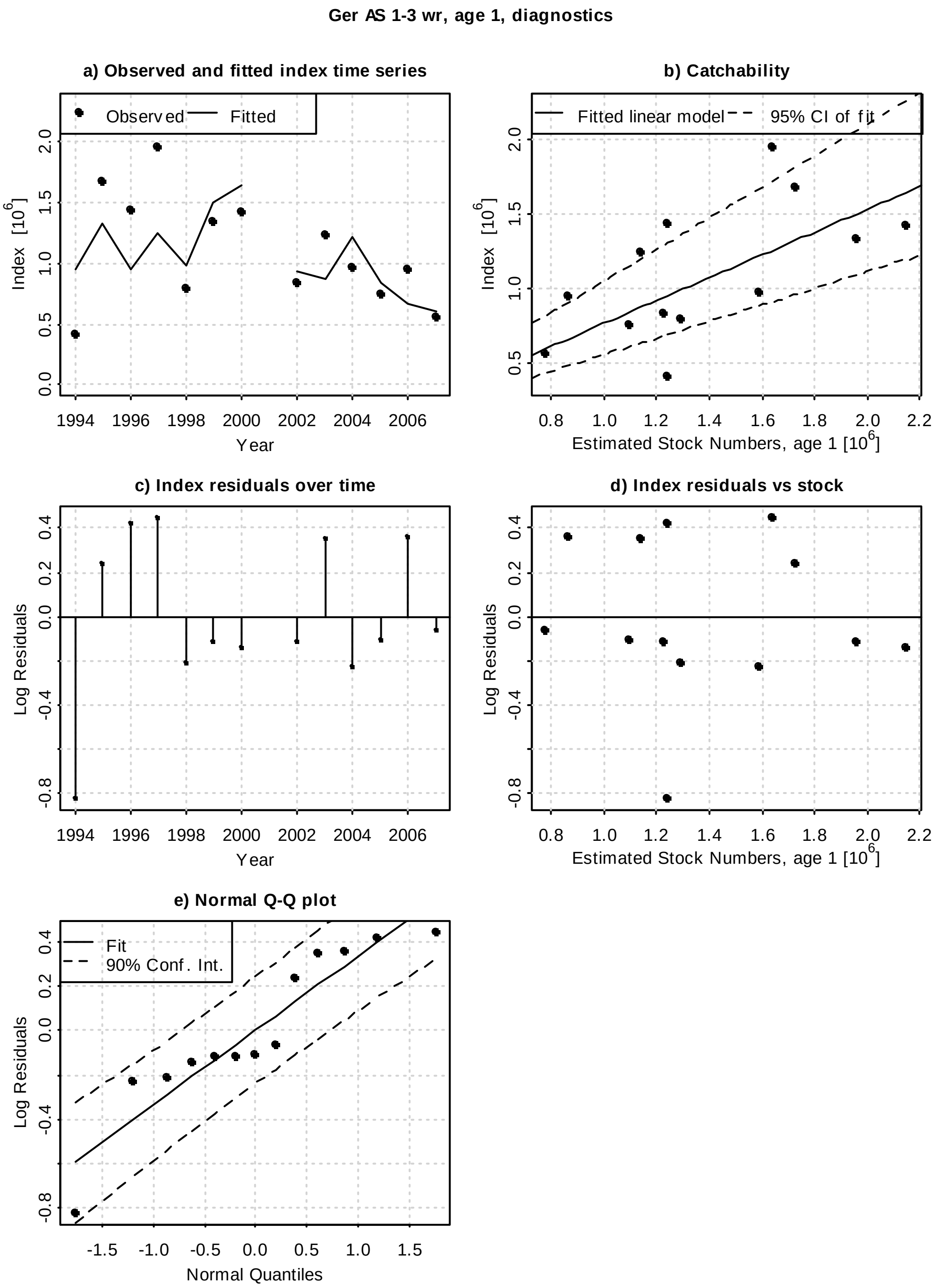


Figure 3.6.5.9. WESTERN BALTIC HERRING. Diagnostics of the German acoustic survey in subdivision 21-24 ("Ger AS 1-3 wr") fit at 1 wr from the final FLICA assessment. a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus FLICA estimates of stock numbers at age. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log residuals of catchability model fitted by FLICA as a function of time. d). Log residuals from the catchability model against stock size at age estimated by the FLICA assessment method. e). Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line).

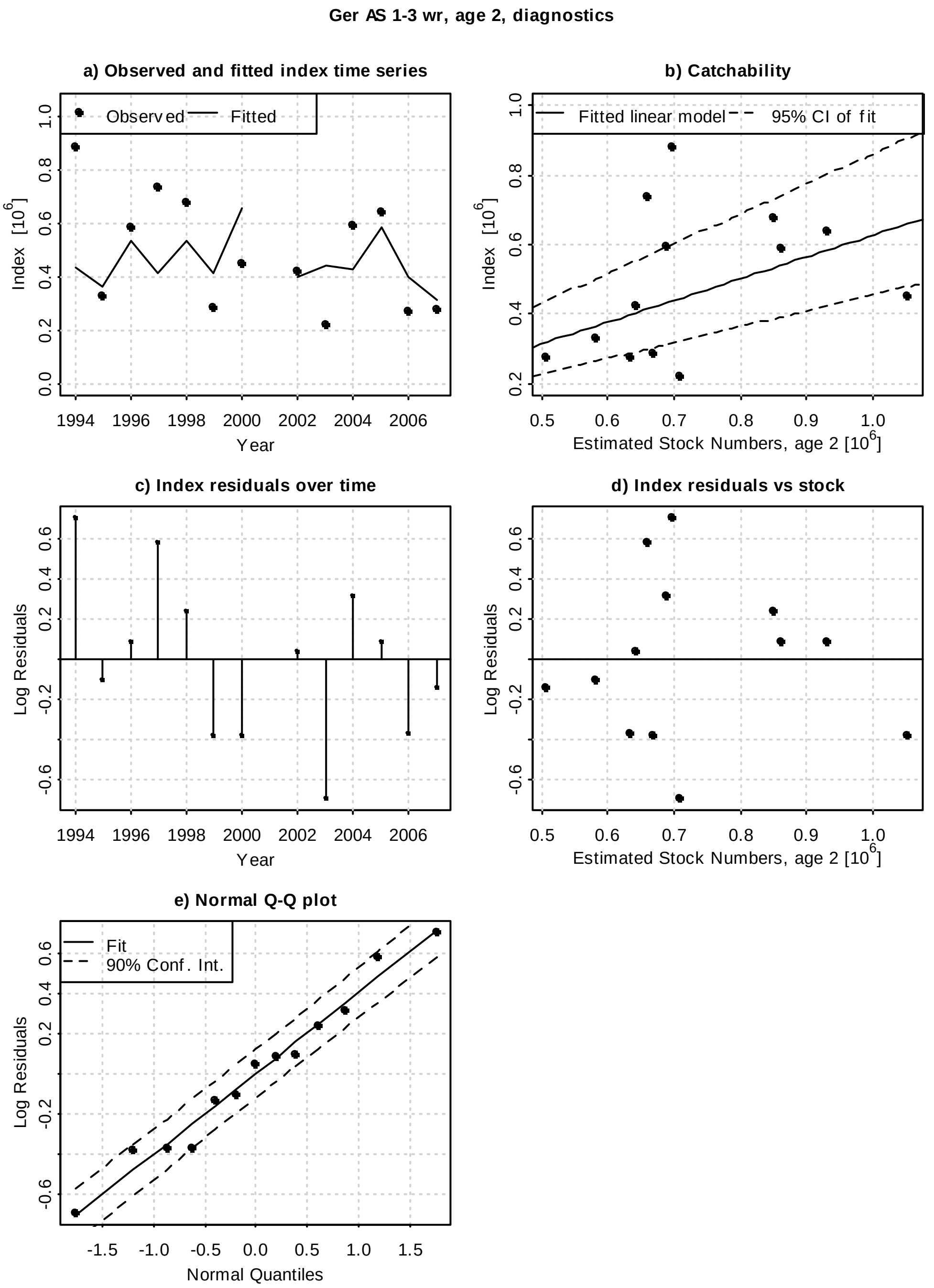


Figure 3.6.5.10. WESTERN BALTIC HERRING. Diagnostics of the German acoustic survey in subdivision 21-24 ("Ger AS 1-3 wr") fit at 2 wr from the final FLICA assessment. a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus FLICA estimates of stock numbers at age. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log residuals of catchability model fitted by FLICA as a function of time. d). Log residuals from the catchability model against stock size at age estimated by the FLICA assessment method. e). Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line).

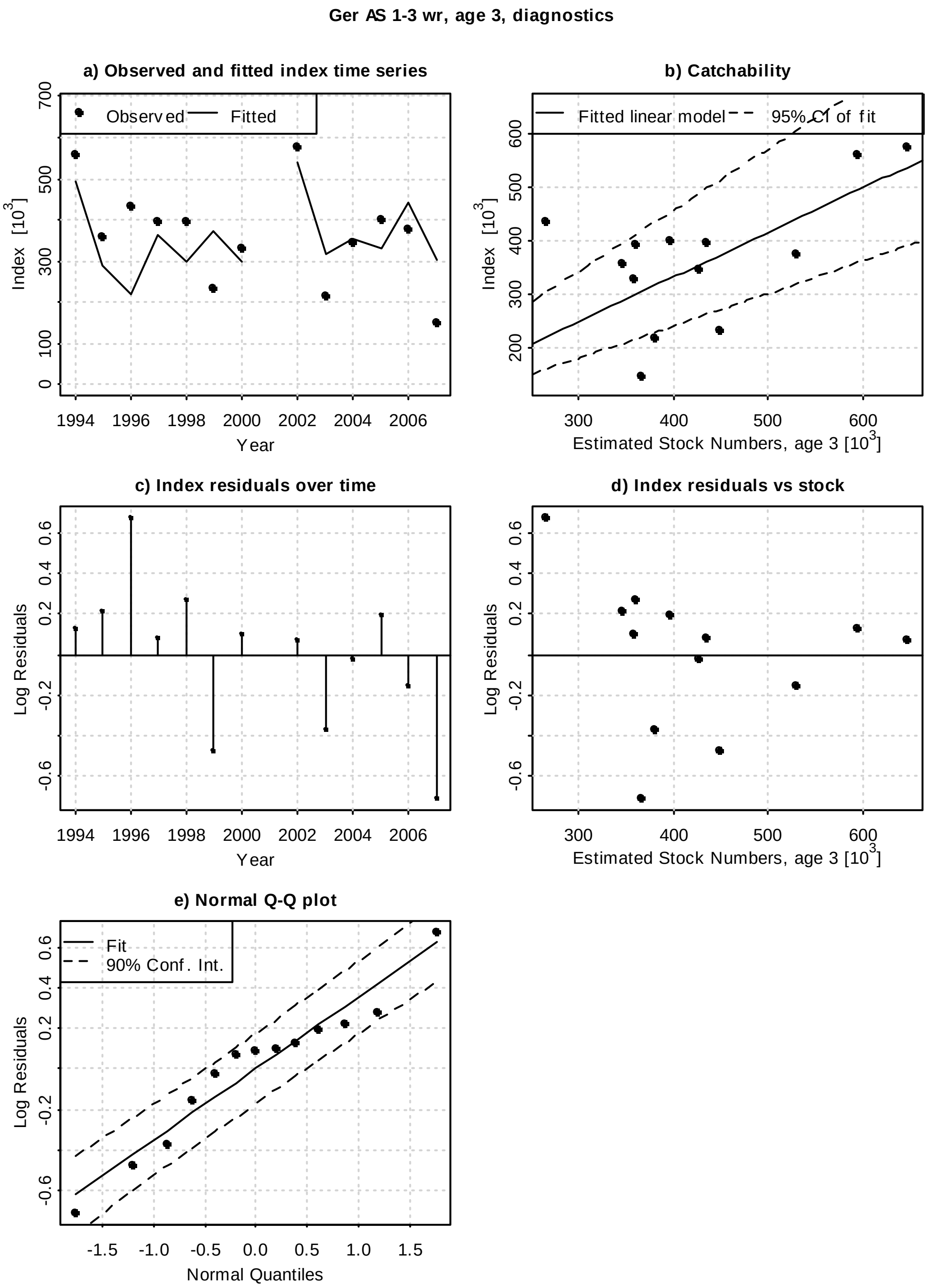


Figure 3.6.5.11.WESTERN BALTIC HERRING. Diagnostics of the German acoustic survey in subdivision 21-24 ("Ger AS 1-3 wr") fit at 3 wr from the final FLICA assessment. a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus FLICA estimates of stock numbers at age. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log residuals of catchability model fitted by FLICA as a function of time. d). Log residuals from the catchability model against stock size at age estimated by the FLICA assessment method. e). Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line).

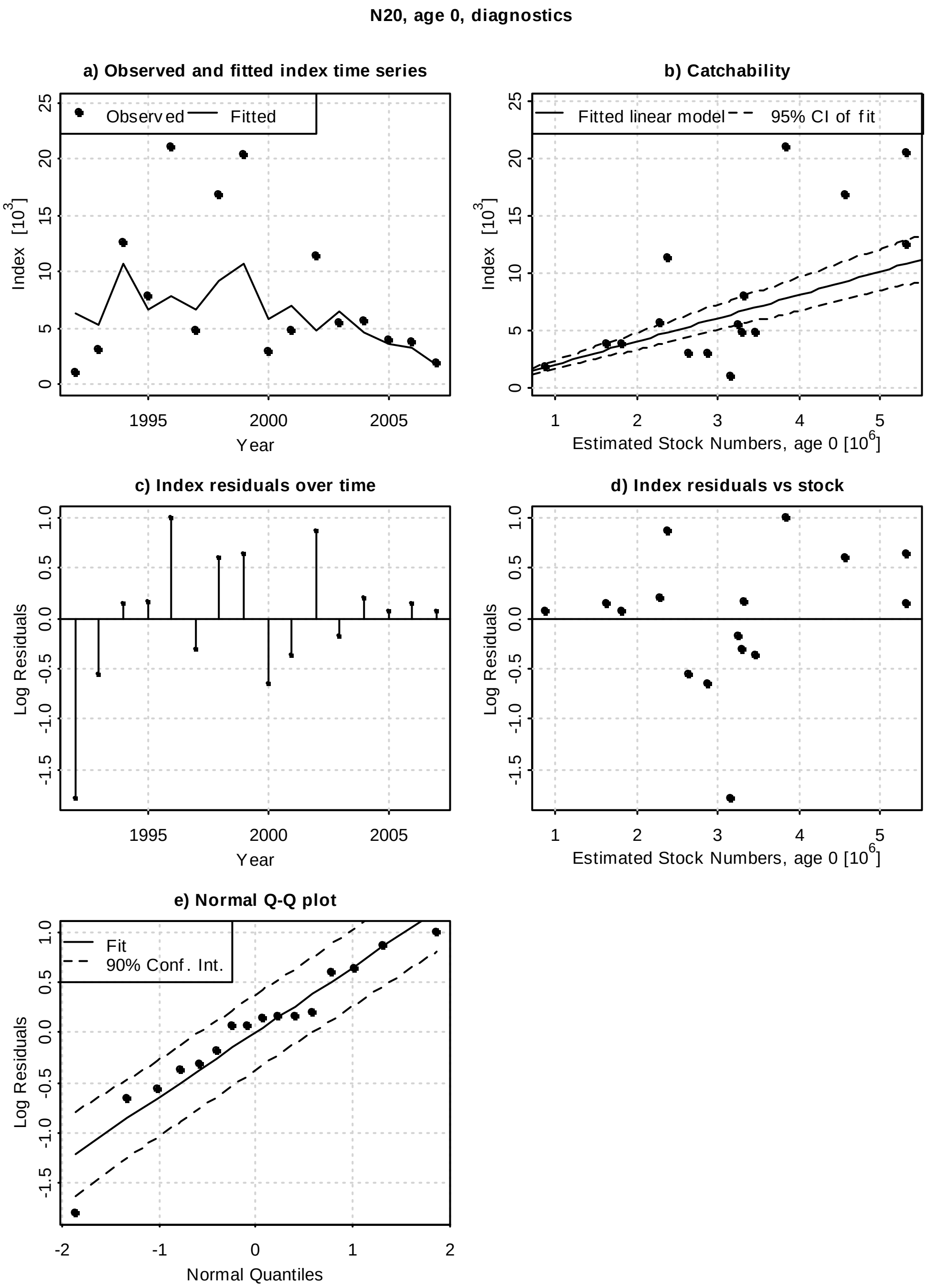
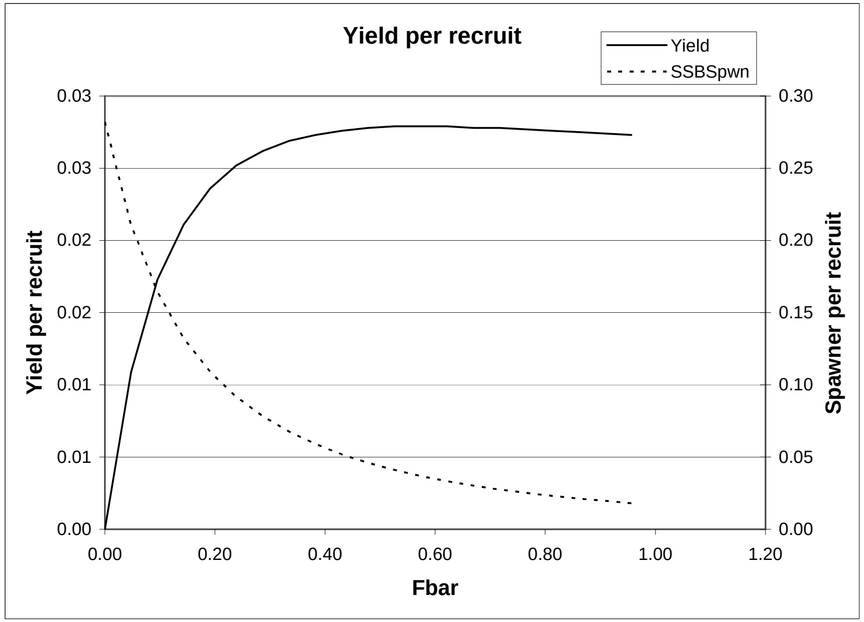
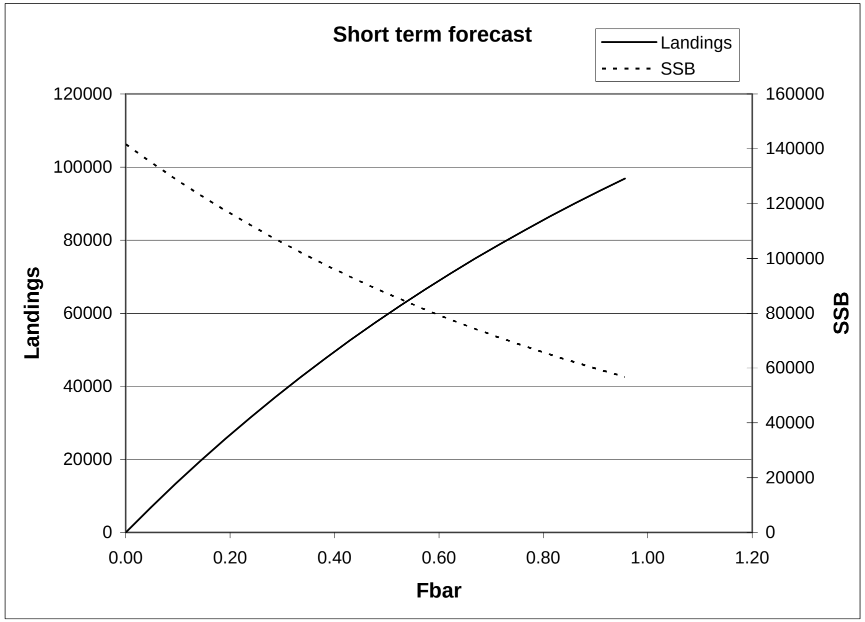


Figure 3.6.5.12. WESTERN BALTIC HERRING. Diagnostics of the N20 larval abundance indiex ("N20") fit at 0 wr from the final FLICA assessment. a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus FLICA estimates of stock numbers at age. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log residuals of catchability model fitted by FLICA as a function of time. d). Log residuals from the catchability model against stock size at age estimated by the FLICA assessment method. e). Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line).





MFYPR version 2a
Run: afterHAWG_______2
Time and date: 16:29 03/04/2008

Reference point	F multiplier	Absolute F
Fbar(3-6)	1.0000	0.4782
FMax	1.2051	0.5763
F0.1	0.4692	0.2244
F35%SPR	0.4556	0.2178

Weights in kilograms

MFDP version 1a
Run: after_HAWG2008
Western Baltic Herring (combined sex; plus group)
Time and date: 16:26 03/04/2008
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**

4 Celtic Sea and Division VIIj Herring

The herring fisheries to the south of Ireland in the Celtic Sea and in Division VIIj exploit herring that have a protracted spawning 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 The Fishery

4.1.1 Advice and management applicable to 2007 – 2008

The TAC in 2007 was 9 393 t, and in 2008 is 7 890 t. In 2007, ICES considered the current level of SSB to be uncertain, but may be below B_{pa} and possibly even below B_{lim}.. At that current level of SSB there was considered to be a risk of reduced recruitment. Currently F is uncertain but high and needs to be reduced. Under those circumstances ICES recommended that targeted fishing should not proceed without a rebuilding plan.

Each year, a rotational “spawning box” closure is implemented for a two week period (Fig 4.1.1.1a). In 2007/2008 Box B was closed, and in 2008/2009 Box C will be closed. It should be noted that Box C is closed under the terms of the plan outlined above.

Local Irish Management Plan

A committee was established in 2000 to manage the Irish fishery for this stock, on a local basis. The committee stated its intention to follow the objectives below:

- 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.

In 2007, the Irish fishing industry engaged in a process to develop a rebuilding plan in response to the ICES advice. The final plan was developed in late November 2007, just before the Fisheries Council meeting. This plan envisaged:

- 15 % reduction in TAC for 2008, with future adjustments being based on latest ICES advice.
- Closure of Sub-Division VIIaS (Fig 4.1.1.1) for three years. A small scale sentinel fishery for small vessels <50 feet and/or single trawlers up to a maximum of 8% of the Irish quota.

- Development of a recruit index to improve prediction of incoming year classes.
- Additional real-time closures, in anticipation of scientific advice on this subject.

The final Council decision was to reduce the TAC by 16%, rather than 15% envisaged by the industry plan. However, the closure of VIIaS was enshrined in Irish legislation for 2008.

4.1.2 The fishery in 2007/2008

The landings in this fishery since 1958 are shown in Figure 4.1.2.1.

In 2007-2008, 31 vessels took part in the Irish fishery. These are categorised as follows:

- 4 Polyvalent RSW trawlers 24 m to 33 m
- 21 Polyvalent trawlers up to 27m,
- 27 polyvalent vessels < 17m.

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 season while a number of RSW vessels reported combined 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, entitled to fish for any species 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 larger vessels at the end of September, landing a total of about 1 000 t (Figure 4.1.2.2). The fourth quarter fishery began on the 1st October, and lasted until the 2nd November. The fishery took place in two main areas: VIIj, off the south Irish coast, and further east in VIIg and between Cork and Capel Island. On the 22nd November the fishery reopened to small vessels from the Dunmore East area. About 400 t tonnes were landed during this period. 1 160 tonnes were landed in January, into Ringaskiddy and Dunmore East. The fishery closed on the 17th January.

Since 1st January 2008, VIIaS has been closed except for a sentinel fishery for vessels under 65 feet, with a quota of 530 t.

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.

4.1.3 The catches in 2007/2008

The estimated national catches from 1988–2007 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 2007/2008 season was over 7 600 t, an increase from 6 944 t in the previous season (Figure 4.1.2.1.). These data include discards, only until 1997. Some landings in 2007/2008 were unallocated and are subtracted from official catches to produce best estimates of catch.

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.

Discrepancies in landings and discards estimates between Tables 4.1.3.1 and 4.1.3.2 (ICES, HAWG 2007, Technical Minutes) are explained by distribution of catches in the first quarter of the succeeding years.

4.1.4 Regulations and their effects

The closure of VIIaS, except for a sentinel fishery, means that only small dry hold vessels using single trawls can fish in that area. It is considered that the catch in this fishery relates to a low partial F (F<0.02) if the stock was around $B_{lim,}$ and even lower if the stock is larger. It is difficult to predict the value of this closure. However, this box is the dominant spawning ground in recent years and it is known as an area for first time spawners. Diversion of effort to the western grounds is a cause for concern and this measure needs to be accompanied by catch reductions on the stock overall.

It is unclear if the timing of the rotating spawning box closures coincides with peak spawning at present.

It is thought that the low tolerance for water content in catches has improved data quality since 2004.

4.1.5 Changes in fishing technology and fishing patterns

The stock is exploited by two types of vessels, larger boats with RSW storage and smaller dry hold vessels. The smaller vessels are confined to the spawning grounds (VIIaS and VIIg) during the winter period. The refrigerated seawater (RSW) tank vessels target the stock inshore in winter and offshore during the summer feeding phase (VIIg). There has been little fishing in VIIj in recent seasons, and there is evidence that stock abundance in this area is currently low.

Since 2002 fishing has taken place in quarter 3, targeting fish during the feeding phase on the offshore grounds around the Kinsale Gas Fields. These fish tend to be fatter and in better condition than winter-caught fish. In 2003 the fishery opened in July on the Labadie Bank, and larger fish were caught than are normally found in the fishery. Only RSW and bulk storage vessels can prosecute this fishery. Traditional dry-hold boats are unable to participate.

In recent years, the targeting fleet has changed. The fleet size has reduced but an increasing proportion of the catch is taken by RSW and bulk storage vessels and less by dry hold vessels. There has been considerable efficiency creep in the fishery since the 1980s with greater ability to locate fish.

The collapse of the market for herring roe means that there is no longer the same incentive to discard (slip) catches.

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 2007/2008. In 2007/2008, there was a strong dominance of 3-ringers (2003/2004 year class). This cohort was strong the previous season also. The 5-ringers (2001/2002 year class) were weak as in previous seasons (Table 4.2.1.1). The yearly mean standardised plot (Figure 4.2.1.1.) shows that 2-ringers have been the dominant age in catches in general throughout the series with 3-ringers more dominant in 2007. 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. Three ringers dominate in all quarters and in all areas. In quarter four higher numbers of 1-ringers than 2-ringers were found both in VIIg and VIIaS. Table 4.2.1.2 shows that there were small-size fish recorded in VIIaS and that larger fish were caught in VIIg and VIIj.

4.2.2 Quality of catch and biological data

Biological sampling of the catches throughout the region was comprehensive throughout the area exploited by the Irish fishery (Table 4.2.3.1). However no samples accompanied reported landings from the Netherlands, Germany or France. Under the Data Collection Programme the sampling of this stock is well above that required by the Minimum Programme (Section 1.5). 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 (Section 1.5).

The quality of catch data has varied over time. A rudimentary history of the Irish fishery since 1958 is presented in the Stock Annex (Stock Annex 5). 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, and such biases need to be considered when examining long term stock dynamics.

Discarding was a major feature of the fishery from 1983 to 1997, when the fishery sought fish of a particular roe quality, discarding early stage, spent and young fish. Though discarding is thought to be lower in subsequent years, the tight quota situation coupled with market requirements are known to lead to some discarding, particularly of smaller fish. There is no information on misreporting in this fishery in recent years, but it is thought to have decreased.

4.3 Fishery Independent Information

4.3.1 Acoustic Surveys

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 has been conducted. The acoustic series was revised in 2006 (ICES HAWG, 2006) and in response to ICES HAWG (2007, Technical Minutes) this revision is explained in the Stock Annex 5. This series dates from 1995 and is presented in Table 4.3.1.1.

The acoustic survey of the 2007/2008 season was carried out in October 2007, on the *Celtic Explorer*. The survey track began at the northern boundary of VIIj, covering the SW bays in zig-zags and parallel transects. The survey was broken into two main components. The first, a broad scale survey was composed of 10 strata. The second component focused exclusively on spawning areas and was made up of 6 strata.

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 65 nmi offshore (Figure 4.3.1.1a). 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. A zigzag transect approach was used to maximise coverage in bays. In total the combined survey transect length was 3 159nmi.

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. In total the spawning areas contributed over 43% of the TSB by weight with small amounts of herring found in the offshore areas.

The age structured index of biomass and catch numbers from acoustic surveys in this area is shown in Table 4.3.1.2. It can be seen that the design of the acoustic surveys has changed since 2005. Before that time, a variety of survey tracks were implemented. In those years, the surveys were adaptive, with track being adapted to include areas of known fish abundance on an *ad hoc* basis. Since 2005, the survey track has been fixed in advance and no echo traces recorded off track are included in the estimate.

In 2007/2008 the SSB estimate was 46 445t. This is an increase of about 27% from the previous year. The current estimate is also much more precise, with a CV of 25 %, the most precise in the series. This precise estimate is associated with more even distribution of herring than in previous years.

The percentage age composition in the survey and the commercial fishery are compared in Figure 4.3.1.2. The survey displayed a slightly higher proportion of 1-ringers but the same age distribution as the commercial fishery across all other ages. Both the survey and the fishery showed a strong predominance of 3-ringers and low abundance of older age classes.

4.3.2 Other surveys

In 2008, a pair trawl survey was conducted, to find juvenile herring (Clarke et al. 2008). This was a scoping exercise, to map the distribution of juvenile herring in advance of developing a recruit index for this stock. A new Irish recruit survey is envisaged by the industry initiated plan for rebuilding the stock. It is envisaged that a combination of the Northern Ireland GFS and Irish survey of the Celtic Sea and VIIj could be used. GFS surveys could provide useful indices for the component of the stock, if the origin of herring in catches can be identified. Some progress has been made on this (Beggs, 2008 WD).

4.4 Mean weights-at-age and maturity-at-age

The mean weights in the catch and mean weight in the stock at spawning time are presented in Figure 4.4.1.1. There has been an overall downward trend in mean weights at age since the mid-1980s. The values for 2007/2008 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, for quarters 4 and 1 (Figure 4.4.1.2). The numbers of fish sampled for 7 to 9 ring were low.

The current maturity ogive considers 50% of 1-ringers to be mature, but the percentage is higher, at least in commercial catches.

4.5 Recruitment

At present there are no recruitment estimates for this stock that can be used for predictive purposes. The 2001/2002 year class recruitment is known now to have been very weak and the 2003/2004 is now known to be quite strong. The 2004/2005 appears quite weak in the catches. It is always difficult to assess the strength of the recruiting year class (2005/2006).

Contrary to ICES HAWG (2007, Technical Minutes), there is no discrepancy in recruitment as displayed in bubble plots and assessment outputs.

4.6 Assessment

4.6.1 Exploratory Assessments

This stock was classified as benchmark assessment in 2007. A number of different models were tried viz. ICA, XSA, CSA and Bayesian catch at age methods. In addition an analysis of long term dynamics of recruitment was conducted. Simulations of various fishing mortalities were conducted, based on stock productivity. The separability assumption may not be valid, and future benchmark work should consider models that allow for changes in selection pattern (ICES HAWG, 2007, Technical Minutes).

In 2008, exploratory update assessment runs were conducted using the ICA model (Table 4.6.2.1). These runs were to explore stock trends, with update of the new catch at age and tuning data. The base case run follows the procedures used for a number of years, and additional runs considered a reduced plus group and non-inclusion of the 2007 survey.

Residual pattern (Figure 4.6.2.1) improves somewhat with a reduction in the plus group to 7+ ringer. Future benchmark work should use 7+, as long as there is a truncation of older ages. Survey residuals (Figure 4.6.2.2) display a much improved pattern for 2005 onwards. This coincides with the adoption of a uniform randomised track design and fixing of the survey timing in October. Future benchmark work should consider only surveys since 2005 as directly comparable.

Exploratory assessments are only indicative of stock trends (Figure 4.6.2.3). The problems associated with this assessment remain: poor estimation of incoming year class. Therefore the assessment cannot be used as basis for advice in the usual way, by a short term forecast.

Exploratory runs suggest that the stock is just below B_{pa}. The exclusion of the acoustic survey 2007 scales down SSB a little. There is no reason to exclude this survey, however. This is because it is part of a revised survey design that has been uniform since 2005, and survey diagnostics have improved since that time. The exact value of SSB not reliably estimated.

The 2001/2002 year class was the lowest in the series. The 2004/2005 year class is now known to be quite poor, with two observations now available. The 2003/2004 was rather strong, the best since the mid 1990s.

F has declined steadily from a high of over 1.2 in 2003/2004 to about 0.3 in 2007/2008. Yield-per-recruit studies in 2007 suggest $F_{0.1} = 0.19$. Thus, current F is probably above $F_{0.1}$.

Uncertainty in the ICA SPALY run is presented in Figure 4.6.2.2. The SPALY run is much more precise than in the period 1997-2005. Uncertainty has increased somewhat in most recent years, but the improved coherence between the catch numbers at age and the survey is expected to yield improvements.

It is considered that no benchmark work be conducted for two or three years. By that time a series of 5 or 6 years of uniform design acoustic data and hopefully a recruit index will be available to tune the assessment. The time lag between the estimation of incoming year classes in the assessment, and their appearance in the fishery will hopefully be shortened. In the meantime, updates should be used to track stock trends, including the latest catch at age and survey data.

The stock may have increased in size since to around B_{pa}, though there is still considerable uncertainty in these estimates. F has declined from the peak in 2003, but is likely above $F_{0.1}$. $F_{0.1}$ = 0.19 and near F associated with reduced surplus production. Recruitment has varied with two very low values and one rather good one in the past five years. Overall recruitment is around long term mean and no exceptional year classes have entered the fishery in recent years. The stock may be showing signs of recovery to B_{pa}. However it is still very dependent on strength of incoming year classes, that cannot be assessed until fully recruited. Therefore poor future recruitments could lead to reduced stock sizes, even at current levels of catch.

4.6.2 Productivity analysis

To account for the influence of the ecosystem on the productivity of this herring stocks (ICES, 2007, Chapter 1) the methods of Nash and Dickey-Collas (2005) were applied.

The recruit per spawner ratio was calculated. These calculations formed the basis for the detection of periods of high and low production of the stock (Figure 4.6.2.1).

The next step was to calculate the net and surplus production of the whole stock, including the recruits and the growth of all non-recruits, the natural and the fishing mortality. To subtract the influence of the spawning stock biomass a hockey stick and a Ricker stock recruitment relationship were fitted to the data to obtain the residuals of the recruits of a given year. The residuals were used to remove the year effect from the estimation of the stock size and to gain the net production and the surplus production respectively without the effect of the SSB on the number of recruits. Contrary to ICES (2007, Technical Minutes) the stock recruit model is not presented. This is because the model is not considered a good fit to the data and because the aim of this analysis is to examine recruitment, having removed the effect of SSB.

The data used in this analysis was derived from the assessment outputs from the HAWG in 2006 (Table 1.8.3.1).

Calculation of the surplus production

$$Ps = Br + Bg - M$$

where Br is the biomass of the recruits, Bg the gain of biomass due to growth of all fish excluding the recruits and M the natural mortality. The net production equals the surplus production minus the fishing mortality (F).

The Celtic Sea herring stock had a low productivity throughout the whole time series, compared to other stocks (ICES, 2007). The net and surplus production is very noisy displaying neither clear trend. The impact of a varying F was tested using the Hockey Stick stock recruitment relationship. The stock showed variable production over time (Figure 4.6.2.2). It can be seen that $F_{0.1}$ is associated with high though variable surplus production over the series, whilst Fs greater than 0.4 are associated with reduced productivity in the most recent years. This analysis demonstrates the benefits of harvesting at F around $F_{0.1}$. Exploitation in the range of recent F (~0.7-1.2) is detrimental to stock productivity.

4.6.3 State of the stock

The stock size continues to be uncertain, with exploratory assessments suggesting that the SSB is probably below B_{pa}. The current stock size is likely a little higher than last year. In recent years SSB has been lower than B_{pa} and possible B_{lim}, and F has been high. The stock is currently composed mainly of younger fish.

4.7 Short term projections

None of the assessments were considered reliable enough to form the basis of short term projections.

4.8 Medium term projections

A yield per recruit was conducted in 2007, see Stock Annex. $F_{0.1}$ was estimated as 0.19. There is no basis to update this estimate at present.

In 2008, the WG conducted preliminary projections using FPRESS (ICES SGMAS, 2006). This was in order to test the medium term behaviour of the stock in a stochastic framework, using as inputs the characteristics of this stock. No explicit management plan nor HCR exists for this stock. So, as a first step a simple harvest control rule, adjusting succeeding TACs by the ratio of current stock size to $SSB_{trigger}$ was simulated. Two simulations were run, one from 2008 the other from 2001, using reported catches and the TAC for 2008. The HCR adjusted the starting TAC by a factor as follows:

$TAC_{mult} = SSB / SSB_{trigger}$

Where TAC_{mult} = TAC multiplier

SSB = SSB from terminal estimate

$SSB_{trigger}$ = Changepoint in Hockey Stick S/R function = 46,446 t.

The SSB relies on an estimate being available, but a high CV can be assumed in order to account for great assessment uncertainty.

The stock dynamics are modelled using as inputs the historic catches, weights at age and mortalities from the trial assessments. The stock recruitment function was Hockey Stick, fitted with Julio's algorithm. The GM recruitment from this relationship was used in simulations, in the starting vector.

To account for the large uncertainty in the initial population vector, CVs of 0.4 were assumed when building in stochastic. Only F was assigned a lower CV, assuming that F is better estimated than other parameters. The outputs are very sensitive to the levels of error assigned to these estimates.

Simple HCR simulations are presented in Figures 4.8.1 to 4.8.2 for the simulations from 2008 and 2001 respectively. These risk profiles show that risks of $SSB<B_{lim}$ are above acceptable levels even at current TAC starting point. Risks of being around B_{lim} of less than 5% seem to associated with only TACs of less than 5 000 t. There is slightly greater risk of being at B_{lim} in simulation starting from 2001, than that starting in 2008 simulation than in the one above.

More work is envisaged to develop and test by simulation, a management plan for this stock. A detailed study is being developed for possible inclusion in "Linking Herring" (Section 1.4.7). It is not considered possible to simulate the industry initiative at present.

4.9 Precautionary and yield based reference points

Biological reference points were discussed in detail at the working groups in the late 1990s (ICES SGPRP 1997; 1998). A summary of this discussion was presented in the 2002 HAWG report (ICES HAWG 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.

F0.1 was estimated to be F=0.19 (ICES HAWG, 2007). F associated with reduced surplus production is estimated as being > 0.4 (Section 4.6.2).

A recent management strategy simulation presented at the STECF plenary (STECF, 2006) estimates 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 B_{lim} 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.

The trial assessments conducted in 2008 are still noisy, though uncertainty is much lower than in previous years (Figure 4.6.1.4). There is improved coherence between the catch at age and the survey data. The survey itself is more stable since a uniform design was adopted in 2005, reflected in better tuning diagnostics. It is hoped that if the assessment continues to stabilise it may provide the basis for advice in a few years.

The WG welcomes the development of a recruit index and recommends a new Irish survey. In addition, Northern Ireland GFS data should be made available for 2009, in order to investigate its utility as a recruit index. Further work on splitting catches according to natal origin should continue.

In 2008, ICA was used for exploratory runs. In addition, FLICA was implemented for the first time. Figure 4.10.1 shows that both packages give the same outputs. FLICA will be used rather than ICA in future exploratory work.

4.11 Management Considerations

Fishing mortality of this stock has been high for many years, well above a long term sustainable level of $F_{0.1}$ = 0.18. From 1982 the stock was maintained with good recruitment up to the mid-1990s. SSB has declined steadily since 1990. In recent years, the fishery has relied on younger fish at 3, 4, and 5 years of age.

Exploratory assessments were conducted with no final assessment. The data are still not good enough to form the basis of short term advice. However, there are certain pieces of information that can be obtained from the available data, that can be used to help managers in their decision making process.

Catches in recent years have been much lower than in earlier years, with recent removals among the lowest in the series. However these catches have been associated with some high Fs. In the past 5 years there have been two very poor recruitments and one rather good one. F has declined from an all time high level to about 0.3, though it is still above $F_{0.1}$. Clearly, further reductions in F are required.

SSB has shown an overall downward trend since 1994. Recent SSB has been as low as when the stock previously collapsed. It is not possible to estimate current stock size, with precision, and this will be the case for the next three years. But this lack of 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.

The WG is aware of the rebuilding plan proposed by the Irish industry. This envisaged a 15% TAC reduction in 2008, with future catch levels based on ICES advice. ICES will not be able to give catch advice for 2009, in the traditional way, using a short term forecast. However the overall trend of low SSB needs to be reversed. Further reductions in F are required. Unless there is exceptional recruitment in the near future this cannot be achieved.

Reductions in F are related to recruitment. Poor recruitment, as in 2003, can lead to a sharp increase in F, at low stock size. With the truncation of age classes and lowest observed mean weights at age this affect is heightened. Therefore the current catch regime may not deliver sustained low F in the next years, with low risk.

The measures to protect first time spawners by closing the Dunmore East Box should continue. Though it may not be possible to predict the success of this measure, it should be maintained for the next three years until 2010.

A management plan should be developed with stakeholder consultation. However, the first priority is to rebuild the stock. A long term target is $F_{0.1}$, being a proxy for F_{MSY}. In order to reduce F to this level (F = 0.19) further reductions in catches are required. These catches are likely to be in the order of 5 000 t, rather than current catch (around 8 000 t).

4.12 Environment

Ecosystem considerations

Herring are an important prey species in the ecosystem and also one of the dominant planktivorous fish.

The spawning grounds for herring in the Celtic Sea are well known and are located inshore close to the coast. These spawning grounds may contain one or more spawning beds on which herring deposit their eggs. Individual spawning beds within the spawning grounds have been mapped and consist of either gravel or flat stone (Breslin, 1998). Spawning grounds tend to be vulnerable to anthropogenic influences such as dredging and sand and gravel extraction. There have been several proposals for extraction of gravel and to dump dredge spoil in recent years. Many of these proposals relate to known herring spawning grounds. ICES has consistently advised that activities that perturb herring spawning grounds should be avoided.

Herring fisheries tend to be clean with little bycatch of other fish. Mega fauna by-catch is unquantified.

Changes in the environment

Temperatures in this area have been increasing over the last number of decades. There are indications that salinity is also increasing (ICES 2006). It is considered that this could have implications for herring that is at the southern edge of its distribution in this area. It is known that similar environmental changes have affected the North Sea herring. There is no evidence that changes in the environmental regime in the Celtic Sea has had any effect on productivity of this stock.

Table 4.1.3.1. Celtic Sea and Division VIIj herring. Landings by quota year (t), 1988–2006. (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
1988	-	-	16,800	-	-	-	2,400	19,200
1989	+	-	16,000	1,900	-	1,300	3,500	22,700
1990	+	-	15,800	1,000	200	700	2,500	20,200
1991	+	100	19,400	1,600	-	600	1,900	23,600
1992	500	-	18,000	100	+	2,300	2,100	23,000
1993	-	-	19,000	1,300	+	-1,100	1,900	21,100
1994	+	200	17,400	1,300	+	-1,500	1,700	19,100
1995	200	200	18,000	100	+	-200	700	19,000
1996	1,000	0	18,600	1,000	-	-1,800	3,000	21,800
1997	1,300	0	18,000	1,400	-	-2,600	700	18,800
1998	+	-	19,300	1,200	-	-200	-	20,300
1999		200	17,900	1300	+	-1300	-	18,100
2000	573	228	18,038	44	1	-617	-	18,267
2001	1,359	219	17,729	-	-	-1578	-	17,729
2002	734	-	10,550	257	-	-991	-	10,550
2003	800	-	10,875	692	14	-1,506	-	10,875
2004	801	41	11,024	-	-	-801	-	11,065
2005	821	150	8452	799	-	-1770	-	8,452
2006	-	-	8,530	518	5	-523	-	8,530
2007	581	248	8,268	463	63	-1355	-	8,268

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
1988/1989	-	-	17,000	-	-	-	3,400	20,400
1989/1990	+	-	15,000	1,900	-	2,600	3,600	23,100
1990/1991	+	-	15,000	1,000	200	700	1,700	18,600
1991/1992	500	100	21,400	1,600	-	-100	2,100	25,600
1992/1993	-	-	18,000	1,300	-	-100	2,000	21,200
1993/1994	-	-	16,600	1,300	+	-1,100	1,800	18,600
1994/1995	+	200	17,400	1,300	+	-1,500	1,900	19,300
1995/1996	200	200	20,000	100	+	-200	3,000	23,300
1996/1997	1,000	-	17,900	1,000	-	-1,800	750	18,800
1997/1998	1,300	-	19,900	1,400	-	-2100	-	20,500
1998/1999	+	-	17,700	1,200	-	-700	-	18,200
1999/2000		200	18,300	1300	+	-1300	-	18,500
2000/2001	573	228	16,962	44	1	-617	-	17,191
2001/2002	-	-	15,236	-	-	-	-	15,236
2002/2003	734	-	7,465	257	-	-991	-	7,465
2003/2004	800	-	11,536	610	14	-1,424	-	11,536
2004/2005	801	41	12,702	-	-	-801	-	12,743
2005/2006	821	150	9,494	799	-	-1770	-	9,494
2006/2007	-	-	6,944	518	5	-523	-	6,944
2007/2008	379	248	7,636	327	-	-954	-	7,636

Table 4.2.1.1. Celtic Sea & Division VIIj herring. Comparison of age distributions (percentages) in the catches of Celtic Sea and VIIj herring over the time series.

	1	2	3	4	5	6	7	8	9
1958	1	3	25	20	10	18	12	7	4
1959	1	27	2	20	12	6	19	4	8
1960	2	53	18	3	10	3	4	3	3
1961	3	22	44	8	3	7	4	2	7
1962	1	16	17	41	7	3	7	3	5
1963	0	52	13	4	21	3	1	3	3
1964	12	25	28	11	3	14	2	1	4
1965	0	56	8	13	3	4	10	1	6
1966	5	15	46	8	10	4	3	7	3
1967	5	26	13	32	6	6	3	4	4
1968	8	35	25	7	14	3	3	1	3
1969	4	40	24	14	5	8	2	1	1
1970	1	24	33	17	12	5	4	1	2
1971	8	15	24	27	12	7	3	3	1
1972	4	67	9	8	7	2	1	1	0
1973	16	26	38	5	7	4	2	2	1
1974	5	43	17	22	4	4	3	1	1
1975	18	22	25	11	13	5	2	2	2
1976	26	22	14	14	6	9	4	2	3
1977	20	31	22	13	4	5	3	1	1
1978	7	35	31	14	4	4	1	2	1
1979	21	26	23	16	5	2	2	1	1
1980	11	47	18	10	4	3	2	2	1
1981	40	22	22	6	5	4	1	0	1
1982	20	55	11	6	2	2	2	0	1
1983	9	68	18	2	1	0	0	1	0
1984	11	53	24	9	1	1	0	0	0
1985	14	44	28	12	2	0	0	0	0
1986	3	39	29	22	6	1	0	0	0
1987	4	42	27	15	9	2	1	0	0
1988	2	61	23	7	4	2	1	0	0
1989	5	27	44	13	5	2	2	0	0
1990	2	35	21	30	7	3	1	1	0
1991	1	40	24	11	18	3	2	1	0
1992	8	19	25	20	7	13	2	5	0
1993	1	72	7	8	3	2	5	1	0
1994	10	29	50	3	2	4	1	1	0
1995	6	49	14	23	2	2	2	1	1
1996	3	46	29	6	12	2	1	1	1
1997	3	26	37	22	6	4	1	1	0
1998	5	34	22	23	11	3	2	0	0
1999	11	27	28	11	12	7	1	2	0
2000	7	58	14	9	4	5	2	0	0
2001	12	49	28	5	3	1	1	0	0
2002	6	46	32	9	2	2	1	0	0
2003	3	41	27	16	6	4	3	0	1
2004	5	10	50	24	9	2	1	0	0
2005	19	38	7	23	9	2	1	0	0
2006	3	58	19	4	11	4	1	0	0
2007	12	17	56	9	2	3	1	0	0

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.

	2007							2008		
	7aSQ4 CS	7aSQ4 Harbour	7g Q3	7g Q4	7k Q4	7j Q3	7j Q4	7aSQ1 Harbour	7g Q1	Total
16.5		2								2
17		2								2
17.5		0						2		2
18	2	4		14	0	5				25
18.5	1	28		7	0					36
19	14	81		106	0	5		5		211
19.5	37	191	23	283	2	45	1	24		607
20	74	318	31	545	4	125	2	45	11	1155
20.5	76	300	23	553	5	150	1	55	29	1192
21	121	369	31	907	10	264	2	50	55	1809
21.5	104	237	85	751	11	299	5	52	59	1603
22	138	191	155	956	13	364	10	26	221	2075
22.5	108	264	210	793	25	688	13	19	331	2452
23	171	306	358	1155	37	1027	23	45	559	3680
23.5	252	418	731	1693	57	1570	47	81	592	5440
24	454	507	1236	3173	97	2697	79	83	1033	9360
24.5	478	414	1438	3428	129	3584	92	83	1438	11086
25	414	316	1236	2982	98	2732	79	31	1295	9182
25.5	280	150	824	2005	59	1630	53	24	953	5977
26	144	101	505	1034	25	708	32	21	820	3392
26.5	80	69	233	581	16	439	15	14	625	2072
27	61	28	163	397	9	244	10	10	658	1580
27.5	34	24	187	227	3	85	12	5	346	921
28	7	10	210	57	1	25	13		166	489
28.5	3	8	101	21	0	5	6		33	178
29	2	2	70	14	0	5	4		4	101
29.5			23		0		1		7	32
30			16				1			17
30.5										
31									4	4

Table 4.2.3.1 Celtic Sea & Division VIIj (2006/2007). Sampling intensity of Irish commercial catches. Only Ireland provides samples of this stock.

ICES area	Year	Quarter	Landings (t)	No. Samples	No. aged	No. Measured	Aged/1000 t
VIIg	**2007**	**3**	**1034**	**4**	**298**	**1015**	**288**
VIIg	**2007**	**4**	**2473**	**11**	**749**	**3061**	**303**
VIIg	**2008**	**1**	**1131**	**8**	**589**	**2512**	**521**
Sub-total			**4638**	**23**	**1636**	**6588**	**1112**
VIIaS_inside harbour	**2007**	**4**	**419**	**16**	**1192**	**2199**	**2845**
VIIaS_outside harbour	**2007**	**4**	**353**	**1**	**75**	**241**	**212**
VIIaS_inside harbour	**2008**	**1**	**59**	**2**	**150**	**284**	**2542**
Sub-total			**831**	**19**	**1417**	**2724**	**5600**
VIIj	**2007**	**3**	**66**	**0**	**0**	**0**	**0**
VIIj	**2007**	**4**	**2027**	**12**	**885**	**3349**	**437**
Sub-total			**2093**	**12**	**885**	**3349**	**437**
Total Celtic Sea			**7562**	**54**	**3938**	**12661**	**521**

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 000s tonnes).

Season	1995 1996	1996 1997	1997 1998	1998 1999	1999 2000	2000 2001	2001 2002	2002 2003	2003 2004	2004 2005	2005 2006	2006 2007	2007 2008
0	**202**	**3**	**-**	**0**	**-**	**25**	**40**	**0**	**24**	**-**	**2**	**-**	**1**
1	**25**	**164**	**-**	**30**	**-**	**102**	**28**	**42**	**13**	**-**	**65**	**21**	**106**
2	**157**	**795**	**-**	**186**	**-**	**112**	**187**	**185**	**62**	**-**	**137**	**211**	**70**
3	**38**	**262**	**-**	**133**	**-**	**13**	**213**	**151**	**60**	**-**	**28**	**48**	**220**
4	**34**	**53**	**-**	**165**	**-**	**2**	**42**	**30**	**17**	**-**	**54**	**14**	**31**
5	**5**	**43**	**-**	**87**	**-**	**1**	**47**	**7**	**5**	**-**	**22**	**11**	**9**
6	**3**	**1**	**-**	**25**	**-**	**0**	**33**	**7**	**1**	**-**	**5**	**1**	**13**
7	**1**	**15**	**-**	**24**	**-**	**0**	**24**	**3**	**0**	**-**	**1**	**-**	**4**
8	**2**	**0**	**-**	**4**	**-**	**0**	**15**	**0**	**0**	**-**	**0**	**-**	**1**
9+	**2**	**2**	**-**	**2**	**-**	**0**	**52**	**0**	**0**	**-**	**0**	**-**	**0**
Abundance	**469**	**1338**	**-**	**656**	**-**	**256**	**681**	**423**	**183**	**-**	**312**	**305**	**454**
SSB	**36**	**151**	**-**	**100**	**-**	**20**	**95**	**41**	**20**	**-**	**33**	**36**	**46**
CV	**53**	**26**	**-**	**36**	**-**	**100**	**88**	**49**	**34**	**-**	**48**	**35**	**25**
Design*	**AR**	**AR**	**-**	**AR**	**-**	**AR**	**AR**	**AR**	**AR**	**-**	**R**	**R**	**R**

*AR Adaptive random; R random

Table 4.6.1.1. Celtic Sea and VIIj herring. Settings used in exploratory VPA type assessments.

Name	ICA Base case	ICA 7+	2007 survey removed
Separable period	**6**	**6**	**6**
Selection at oldest true age	**1**	**1**	**1**
Plus group	**9 ring**	**7 ring**	**9 ring**
Mean F age range	**2-7**	**2-5**	**2-7**
Shrinkage	**No**	**No**	**No**

Table 4.8.1. Celtic Sea and VIIj herring. Input settings for exploratory FPRESS runs.

	2008	2001
Simulations		
No. iterantions	**1000**	**1000**
Years	**2008-2018**	**2001-2018**
No. years	**10**	
TAC		
HCR factor	**SSB/SSBtrig**	**1**
TAC CV	**0.4**	**0.4**
TAC Bias	**1**	**1**
Miniumum TAC	**5390**	**5390**
Maximum TAC	**20390**	**20390**
Population		
Age range	**1-9**	**1-10**
Fbar range	**2-7**	**2-8**
Fbar CV	**0.2**	**0.2**
Hist Rec CV	**0.4**	**0.5**
Hist Catches	**0.4**	
Mean recruitment	**447,318**	**447,319**
S/R model		
Gradient	**9.66**	**9.66**
SSBtrig	**46,446**	**46,446**
Desciption	**Hockey**	**Hockey**
Assessment		
SSB CV	**1.2**	**1.2**
F CV	**0.2**	**0.2**
SSB HCR	**46,446**	**46,446**
F in final year	**From ICA**	**0.5 ~ long term mean**
SSB and population vectors	**From ICA**	**Recalc. From GM recruits**

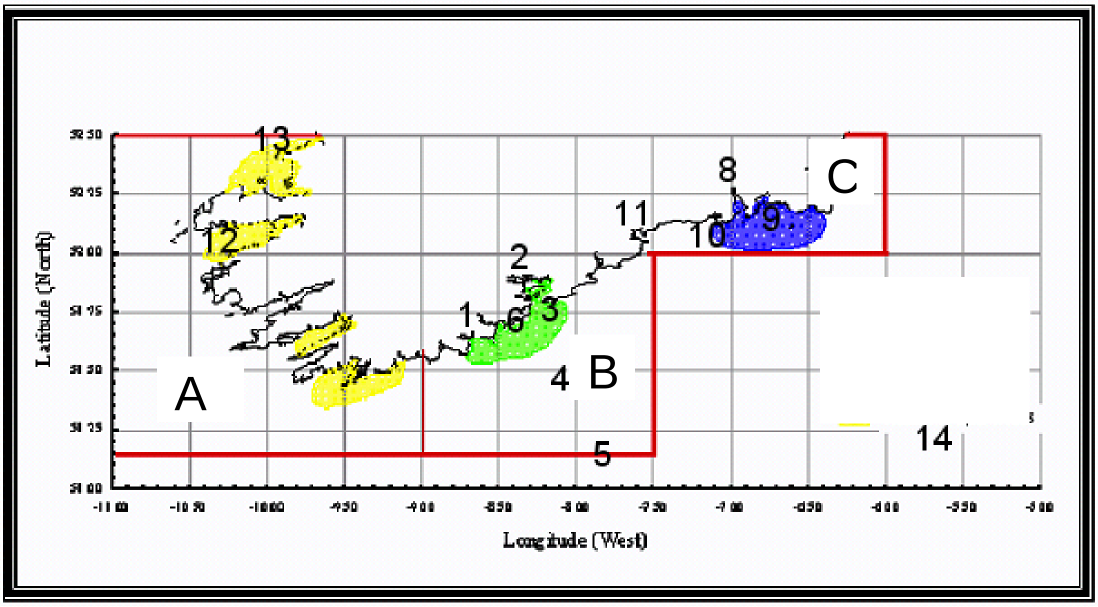


Figure 4.1.1.1. Celtic Sea and VIIj herring, areas mentioned in the text and spawning boxes A, B and C, south of Ireland. One of these boxes is closed each season, under EU legislation. 1 Courtmacsherry, 2 Cork Harbour, 3 Daunt Rock, 4 Kinsale Gas Field (Rigs), 5 Labadie Bank, 6 Kinsale, 8 Waterford 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.

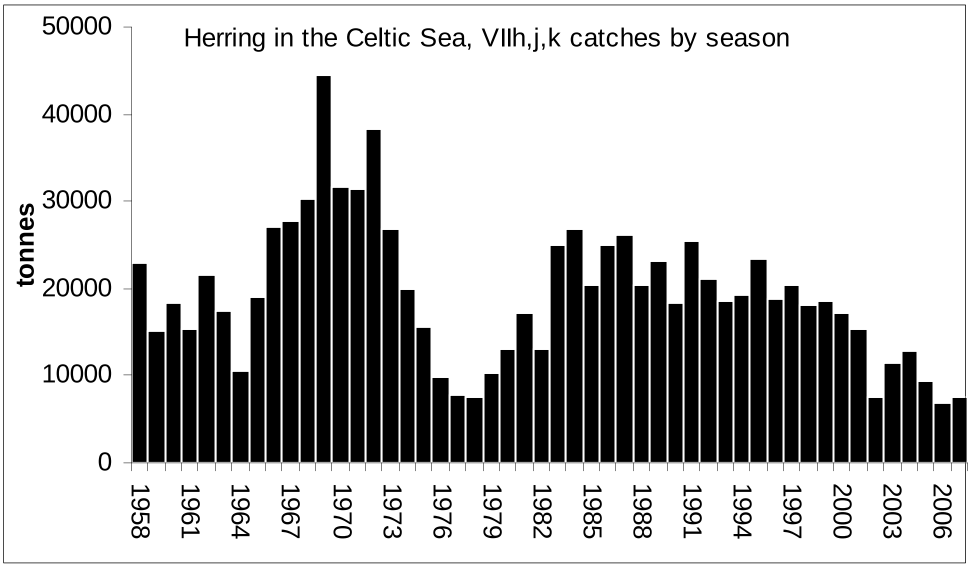


Figure 4.1.2.1 Celtic Sea and Division VIIj – working group estimates of herring landings per season.

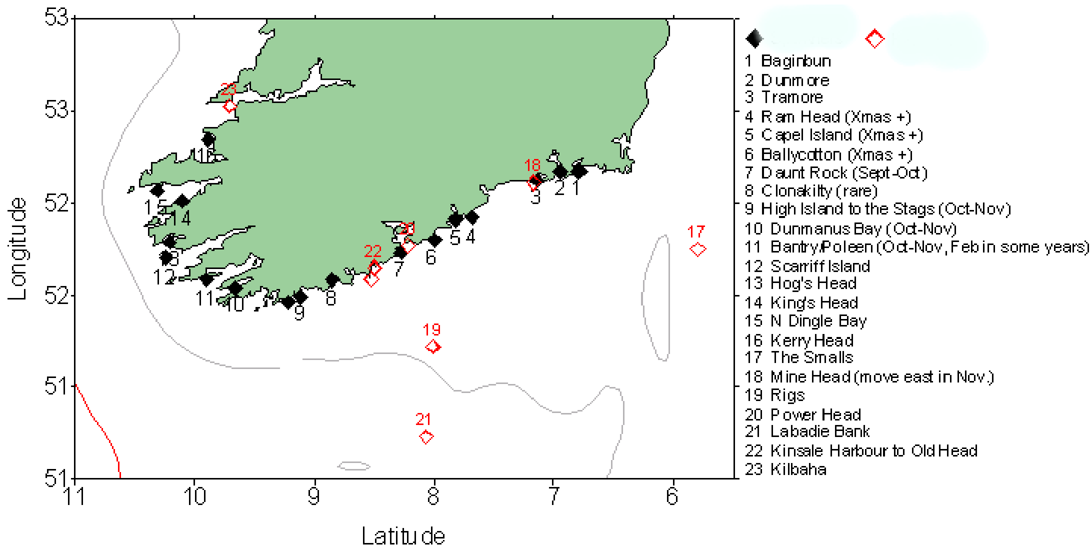


Figure 4.1.2.2 Celtic Sea and VIIj herring, Location of non-spawning (open symbol) and spawning (closed symbol) herring in the Celtic Sea and SW of Ireland. Based on expert fishermens' personal information.

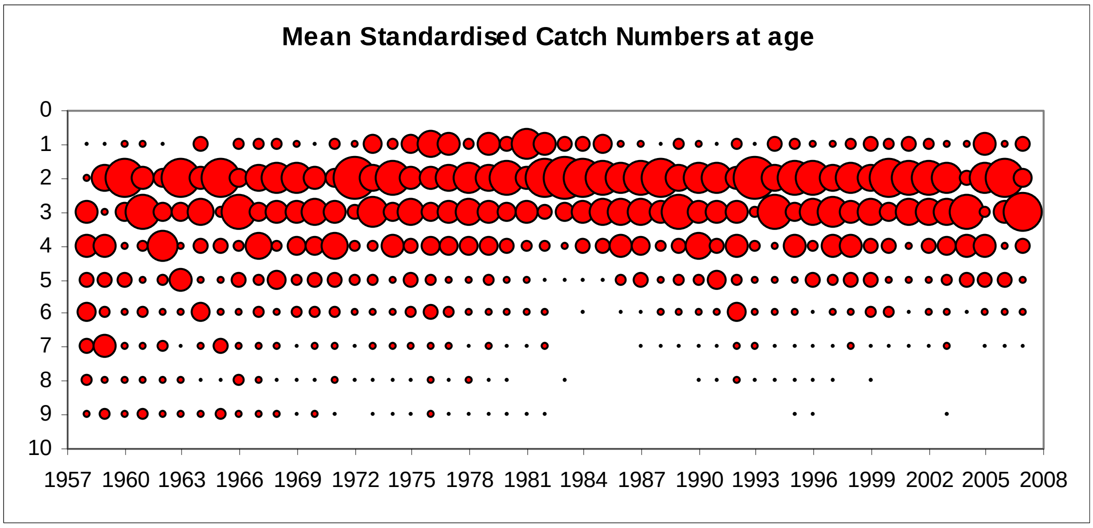


Figure 4.2.1.1. Celtic Sea and Division VIIj. Catch numbers at age standardised by yearly mean. 9-ringer is the plus group.

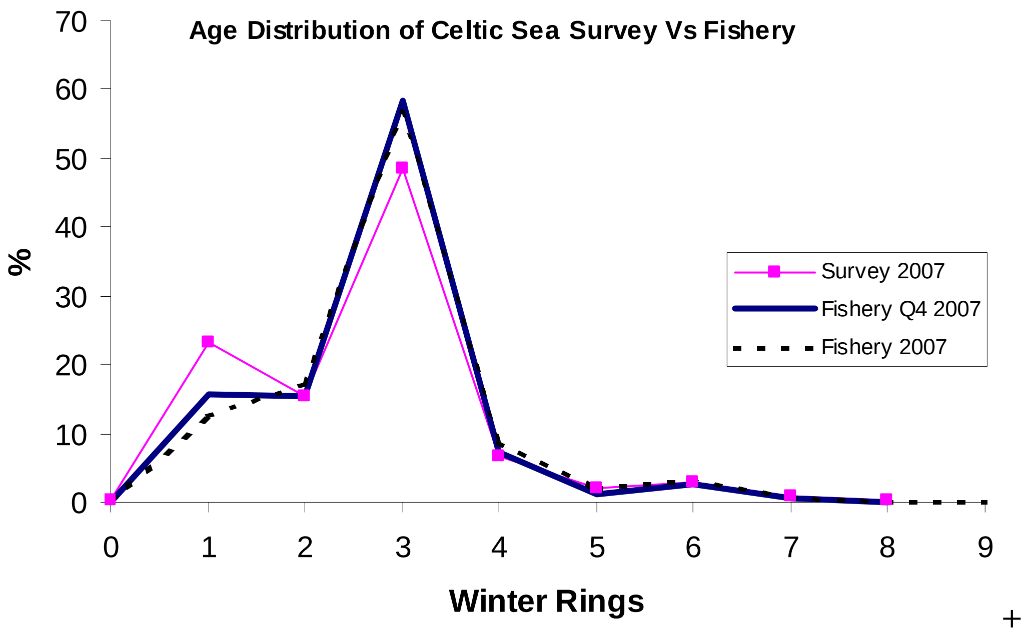


Figure 4.2.1.2 Celtic Sea and Division VIIj – percentage age composition by metier (ICES Division and quarter). 9-ringer is the plus group.

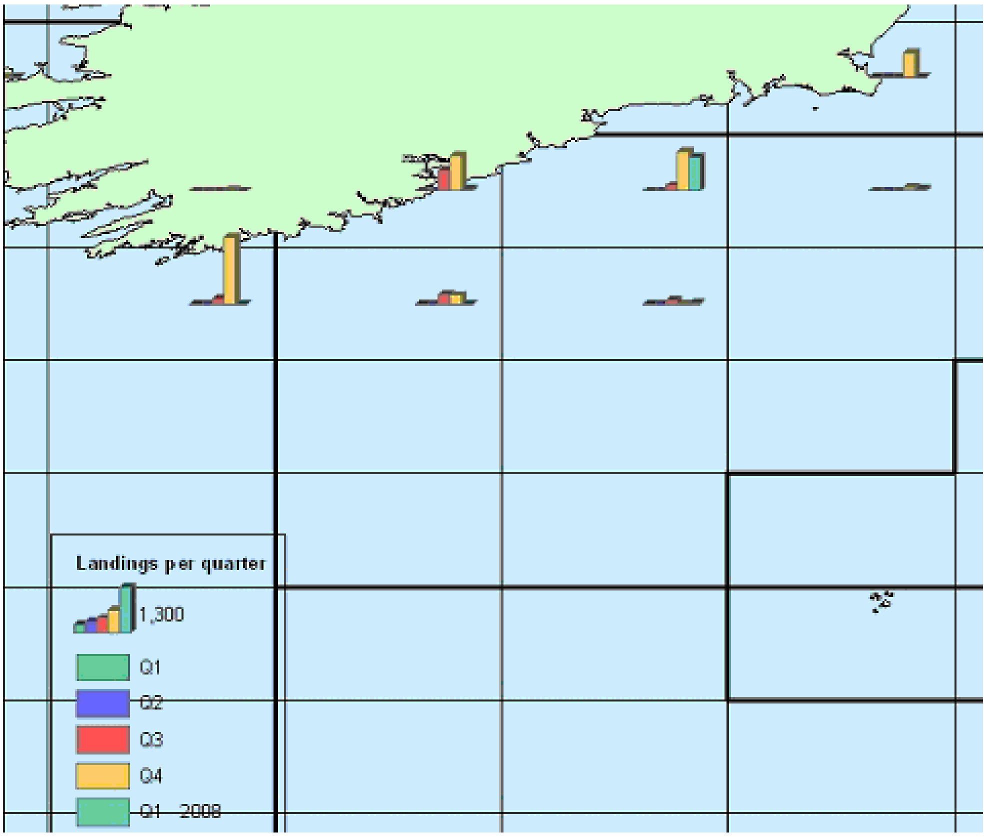


Figure 4.1.3.2 Celtic Sea and VIIj herring. Irish official herring catches by statistical rectangle in 2007/2008.

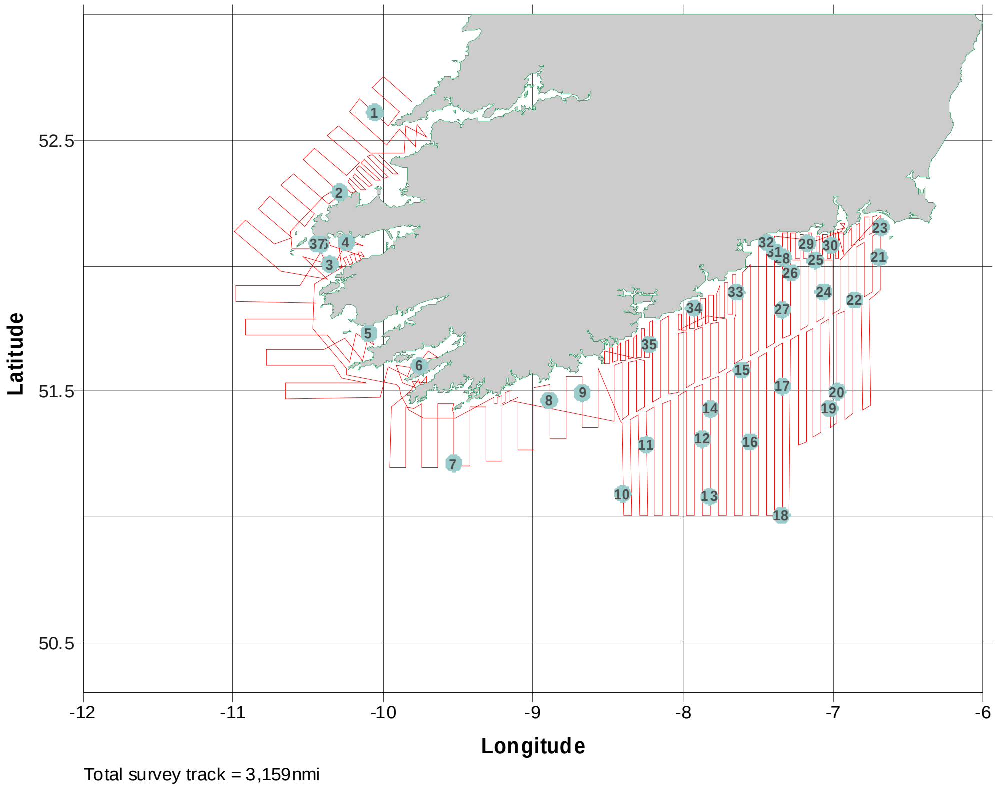


Figure 4.3.1.1a Celtic Sea and VIIj herring. Celtic Sea and Division VIIj acoustic survey 2007, survey track and haul positions from acoustic survey, October 2007.

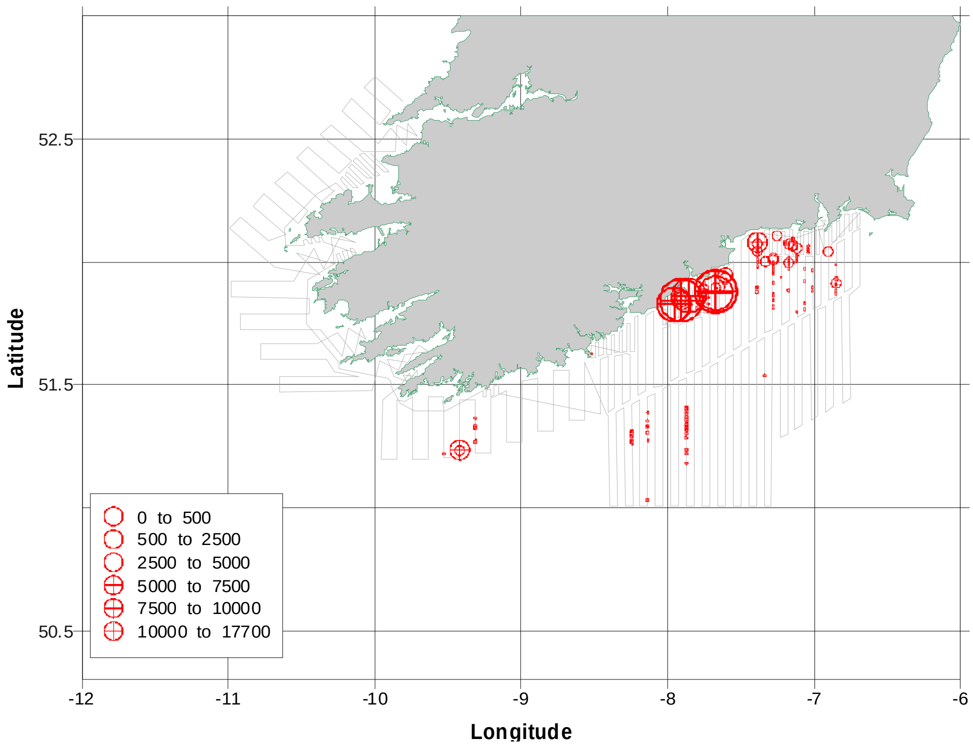


Figure 4.3.1.1b. Celtic Sea and VIIj herring. Celtic Sea and Division VIIj acoustic survey 2007, total Sa values attributed to herring.

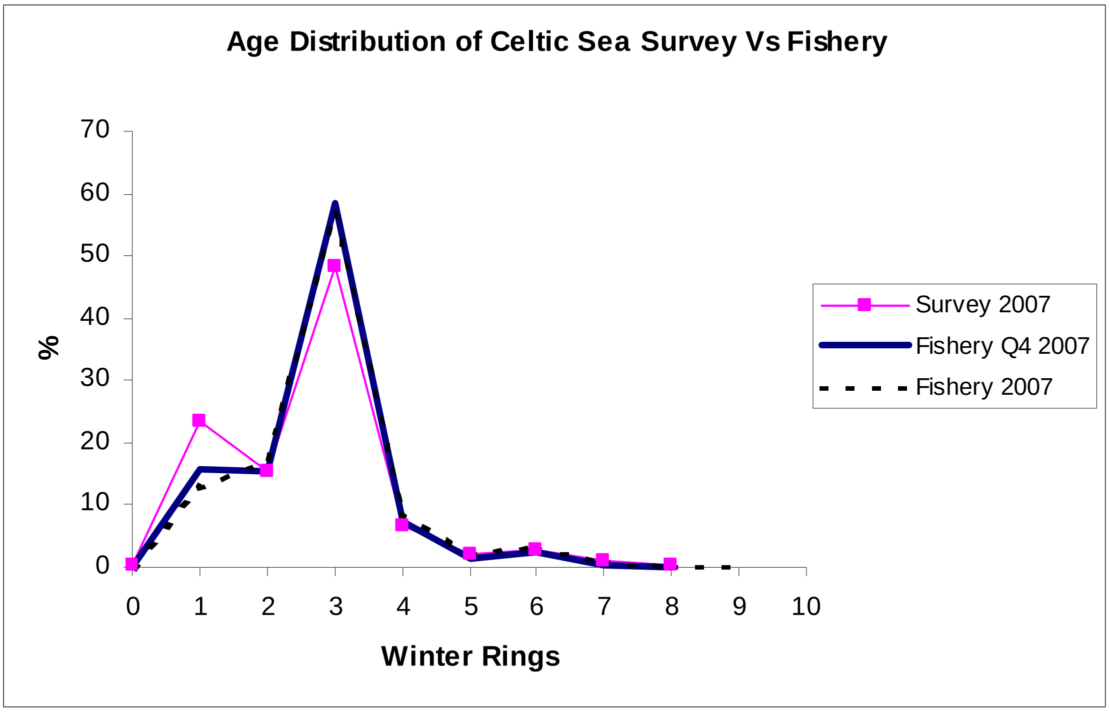
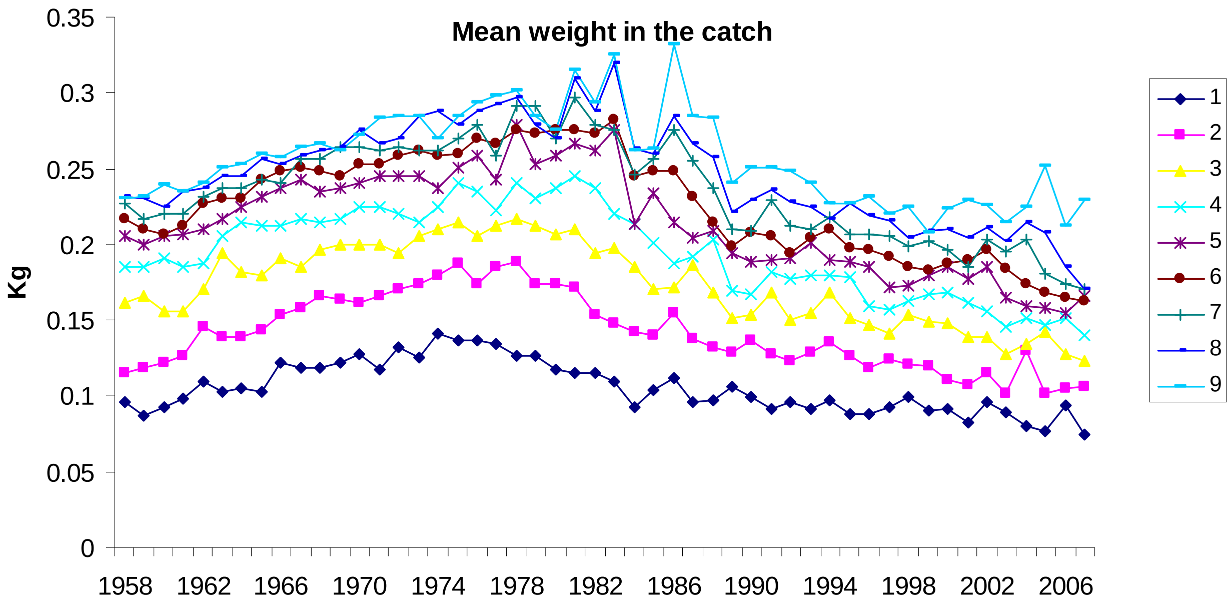


Figure 4.3.1.2 Celtic Sea and VIIj herring. The percentage age composition in the survey and the commercial fishery 2007/2008. 9-ringer is the plus group.



4.4.1.1 Celtic Sea and VIIj herring. Trends over time in mean weight at age in the catch. 9-ringer is the plus group.

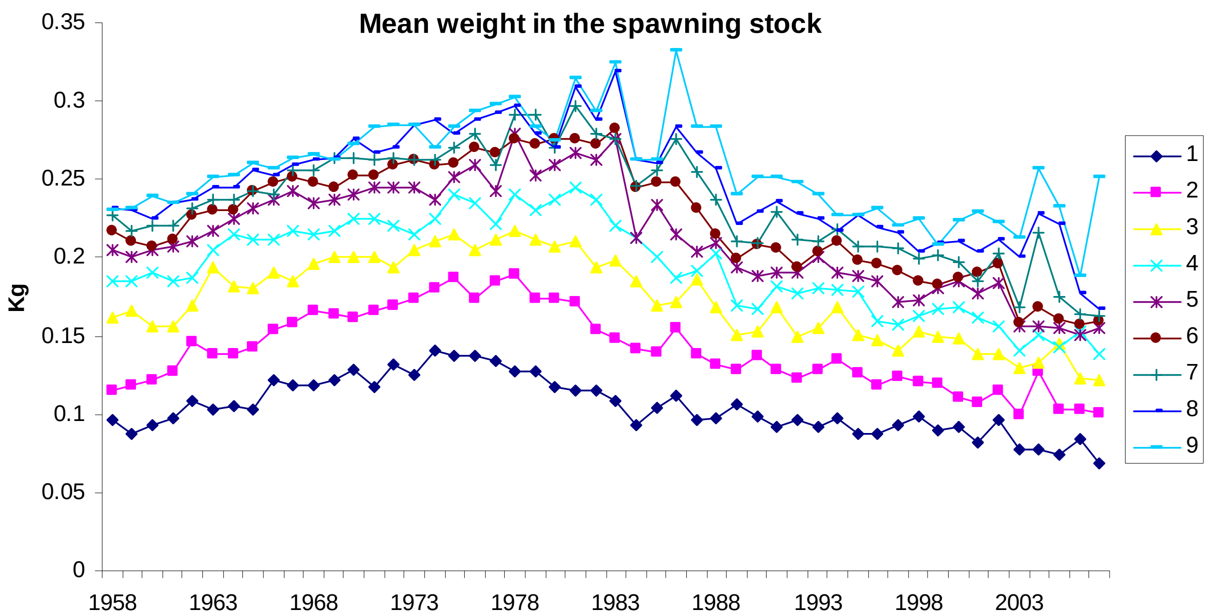


Figure.4.4.1.2 Celtic Sea and VIIj herring. Trends over time in mean weight at age in the stock at spawning time. 9-ringer is the plus group.

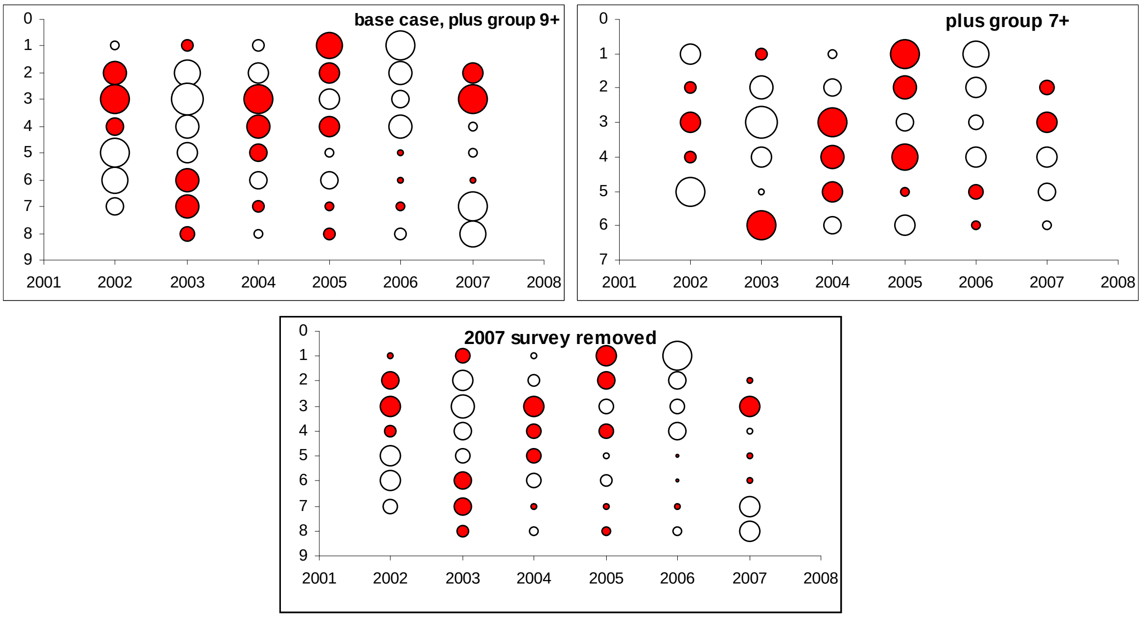


Figure 4.6.1.1 Celtic Sea and VIIj herring. Separable model residuals for four ICA exploratory assessments. 9-ringer is the plus group. 2007 survey estimates removed to test effect on final estimates.

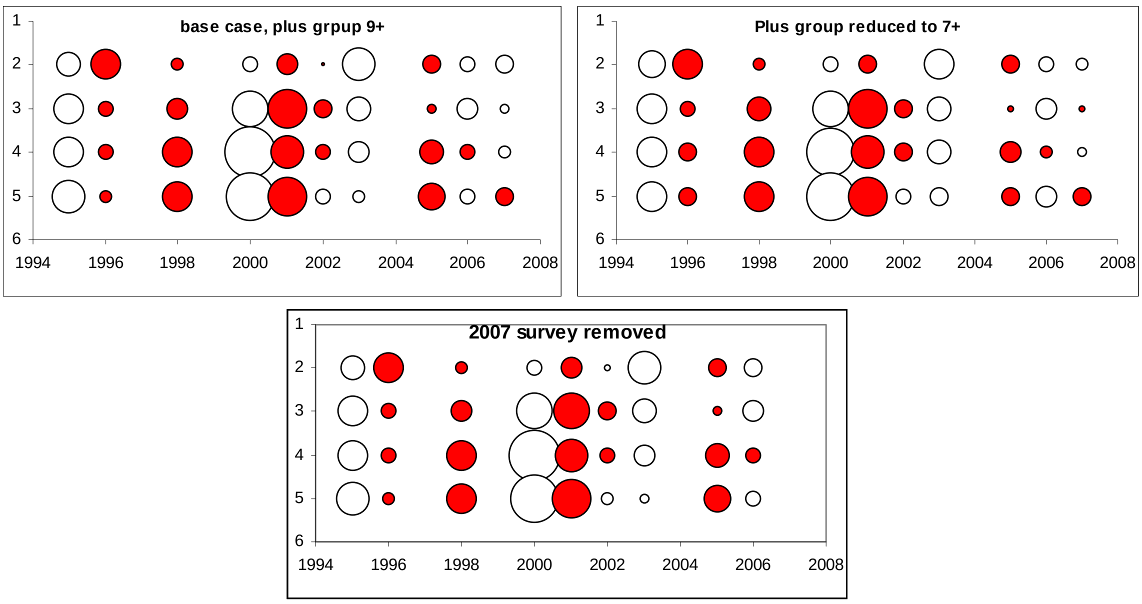


Figure 4.6.1.2 Celtic Sea and VIIj herring. Survey index residuals from four ICA exploratory runs. 9-ringer is the plus group in base case. 2007 survey estimates removed to test effect on final estimates.

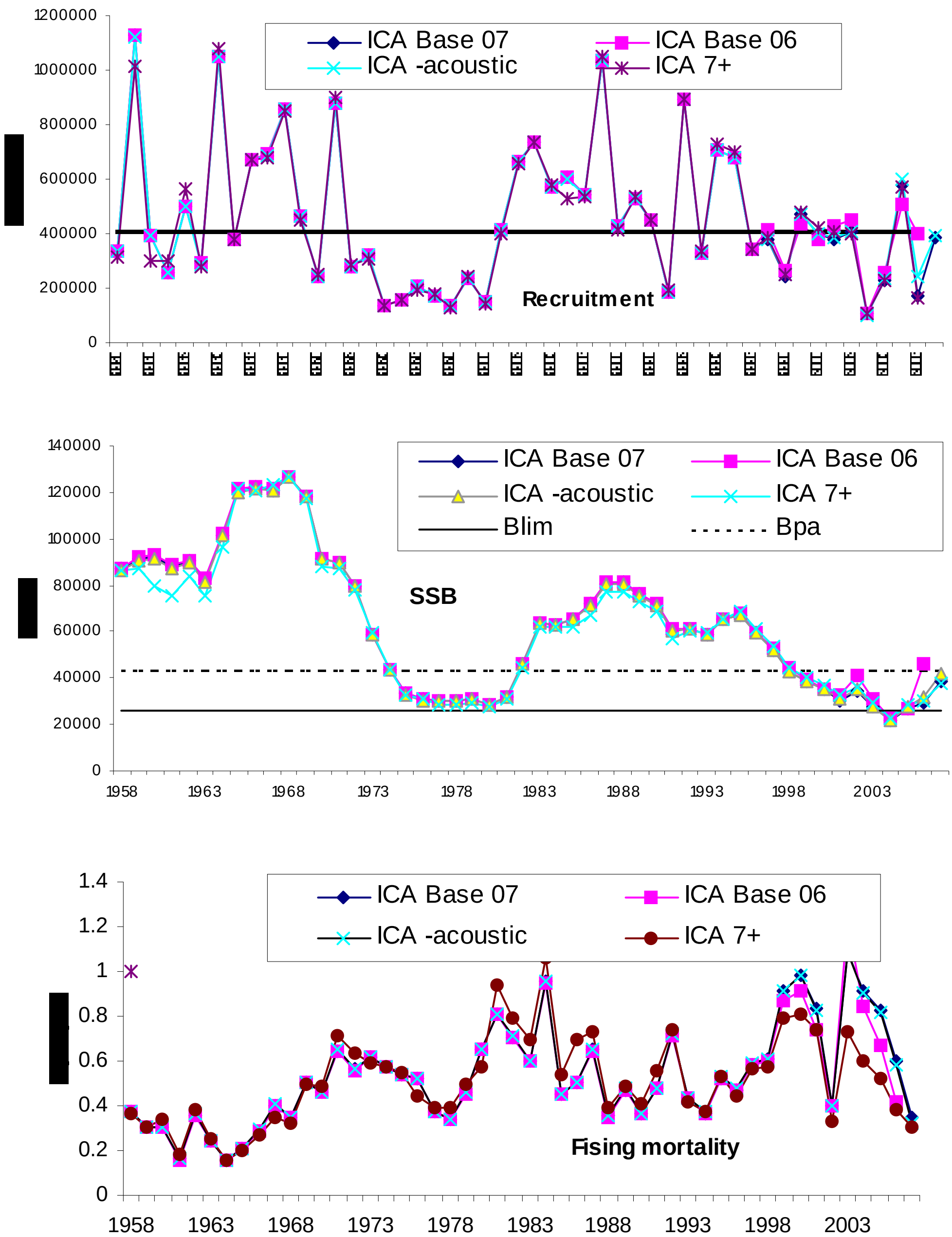


Figure 4.6.1.3 Celtic Sea and VIIj herring. Exploratory assessment using ICA. 2007 survey estimates removed to test effect on final estimates.

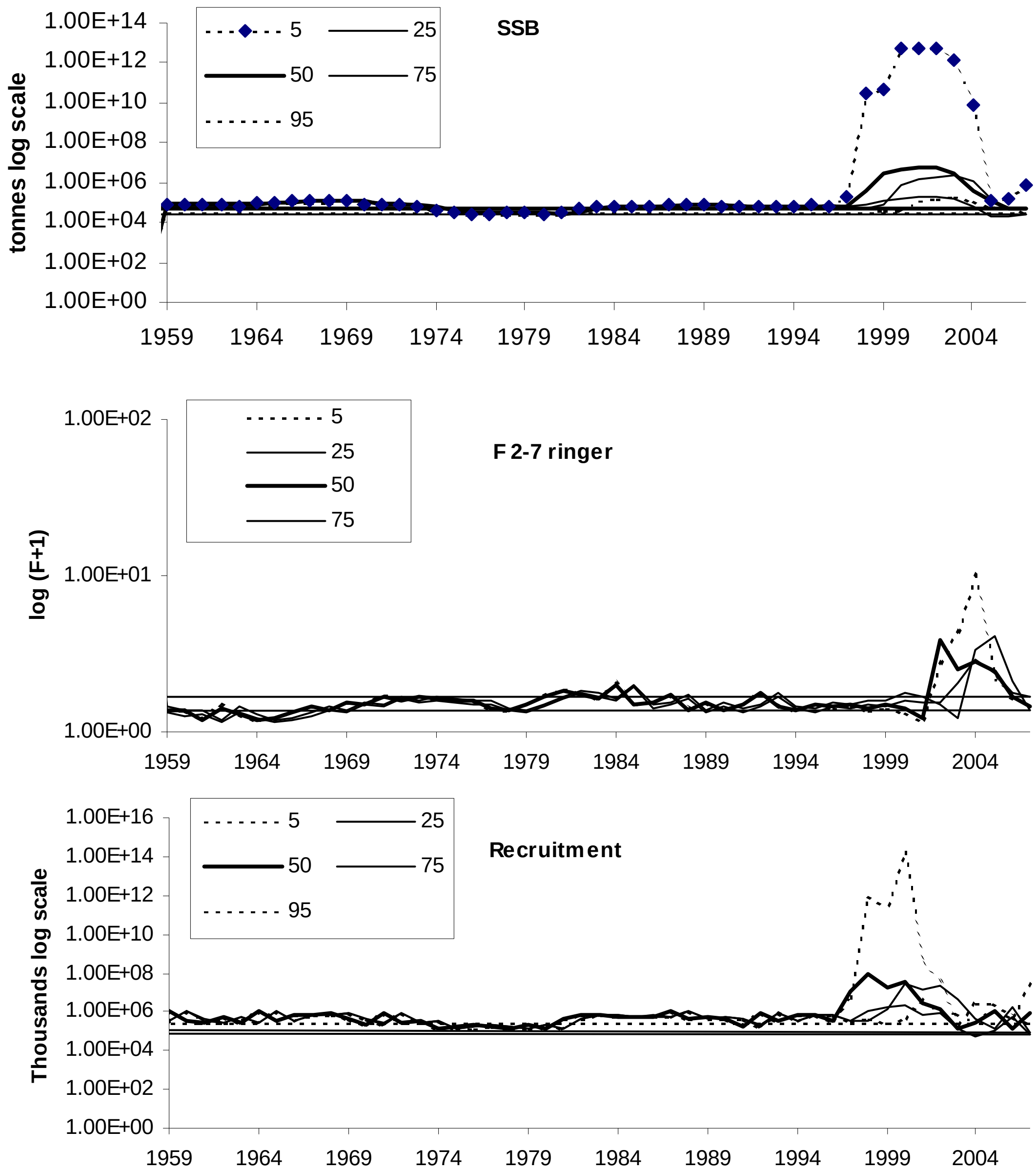


Figure 4.6.1.4 Celtic Sea and VIIj herring. Uncertainty in ICA base case run.

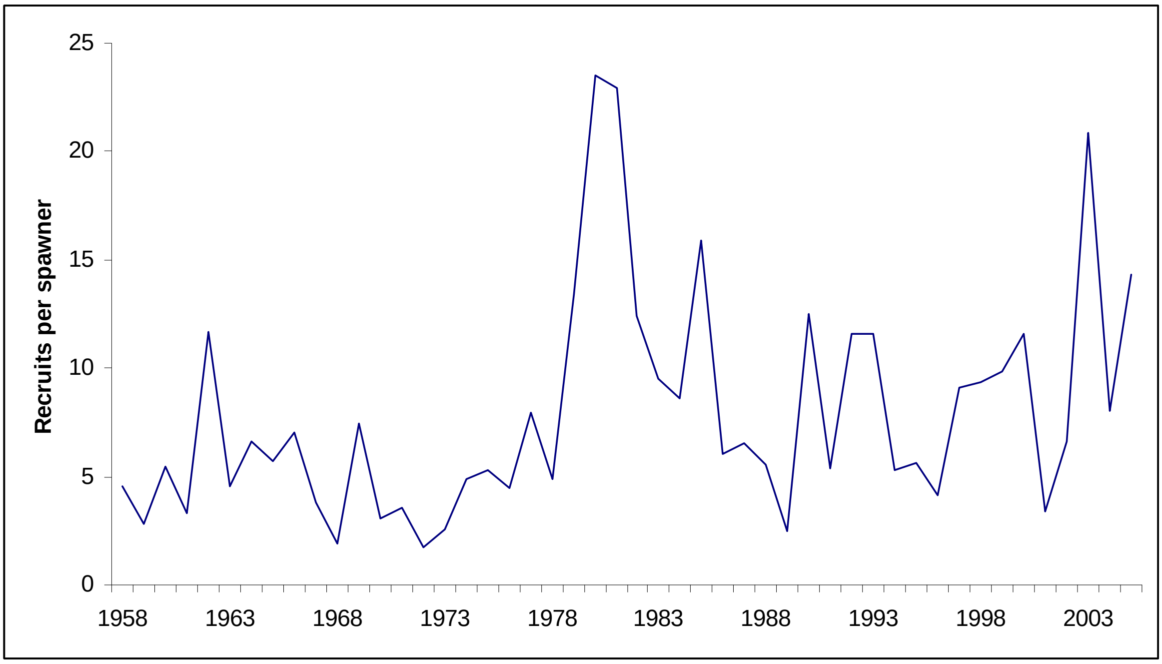


Figure 4.6.2.1 Celtic Sea and VIIj herring. Recruits per spawener, in '000s/tonnes.

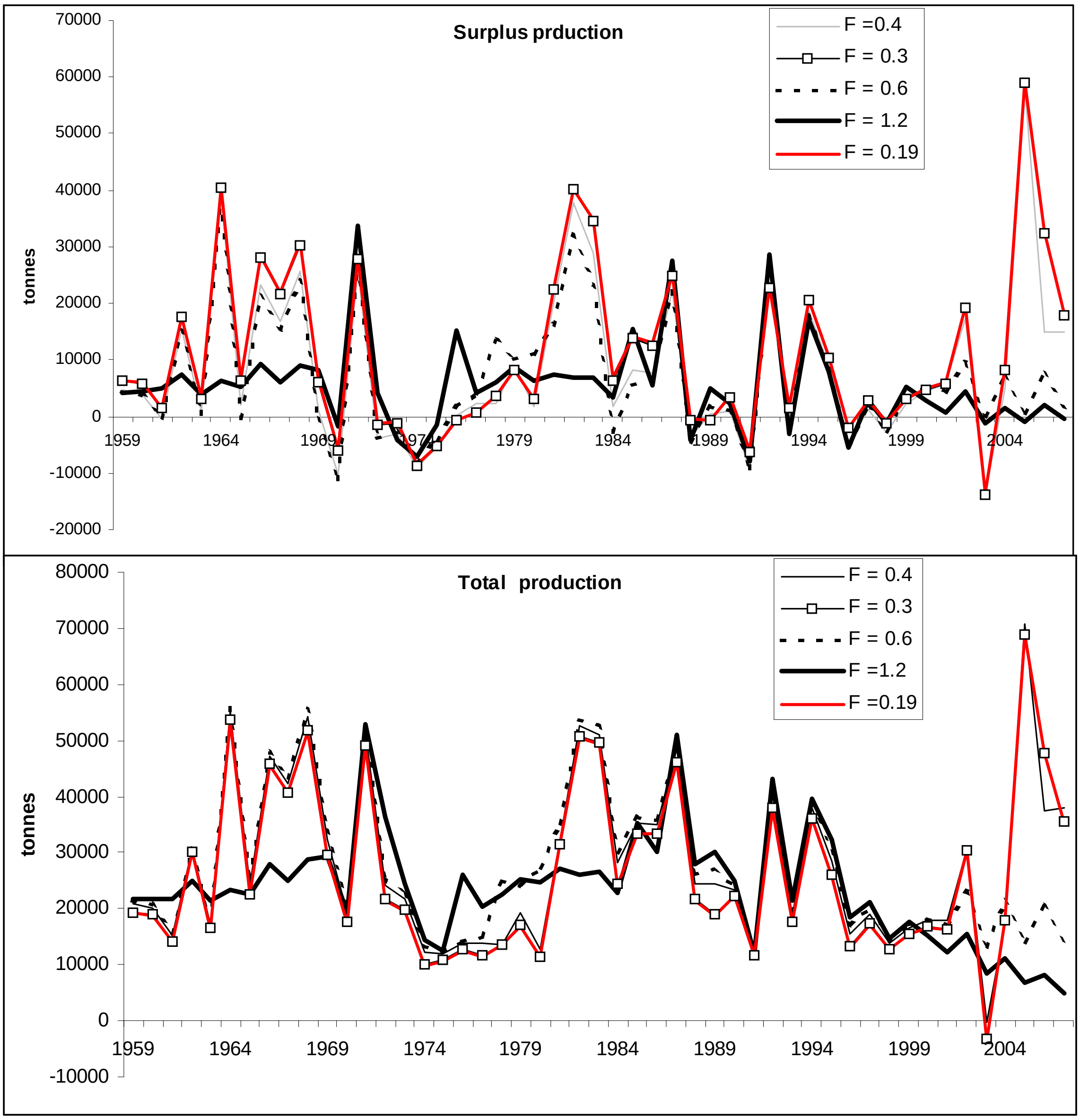


Figure 4.6.2.2 Celtic Sea and VIIj herring. Total and surplus production in the time series over a range of fishing mortalities.

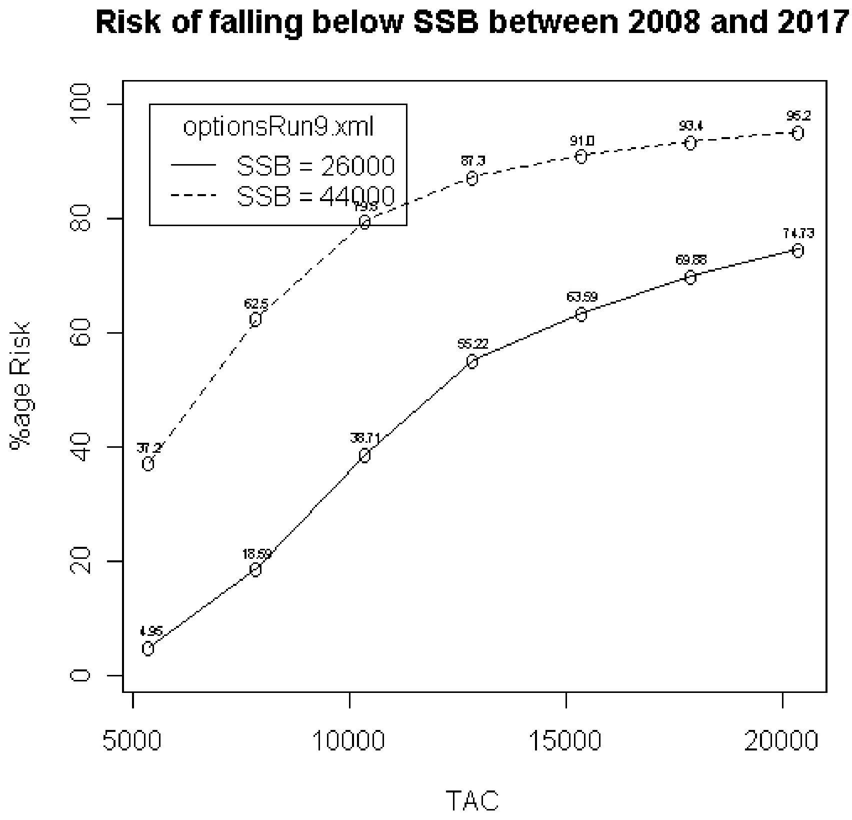


Figure 4.8.1 Celtic Sea and VIIj herring. Medium term simulations from 2008 of simple HCR using FPRESS. Risk of SSB<B_{pa} and B_{lim} for a variety of starting TACs.

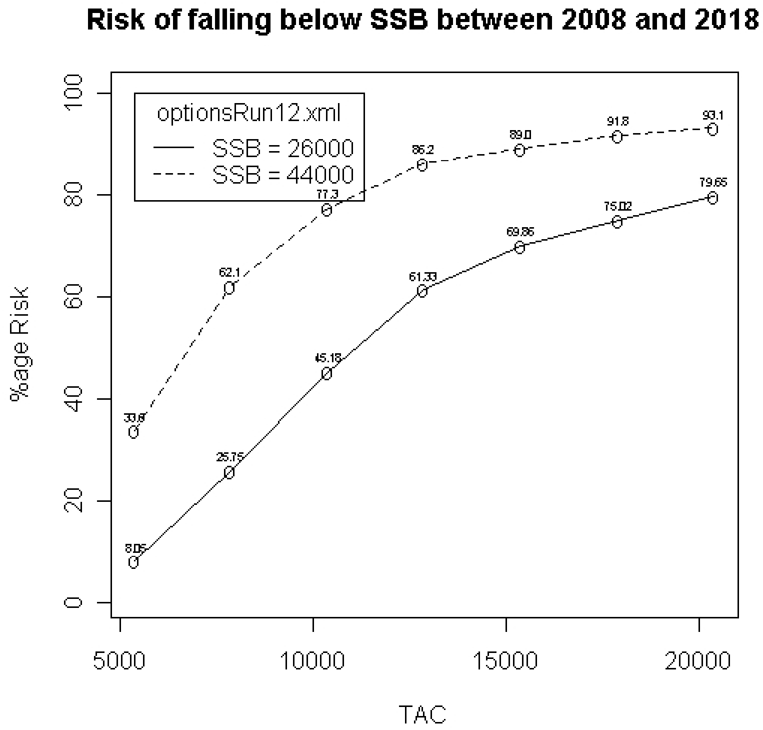


Figure 4.8.2 Celtic Sea and VIIj herring. Medium term simulations from 2001 of simple HCR using FPRESS. Risk of SSB<Bpa and Blim for a variety of starting TACs.

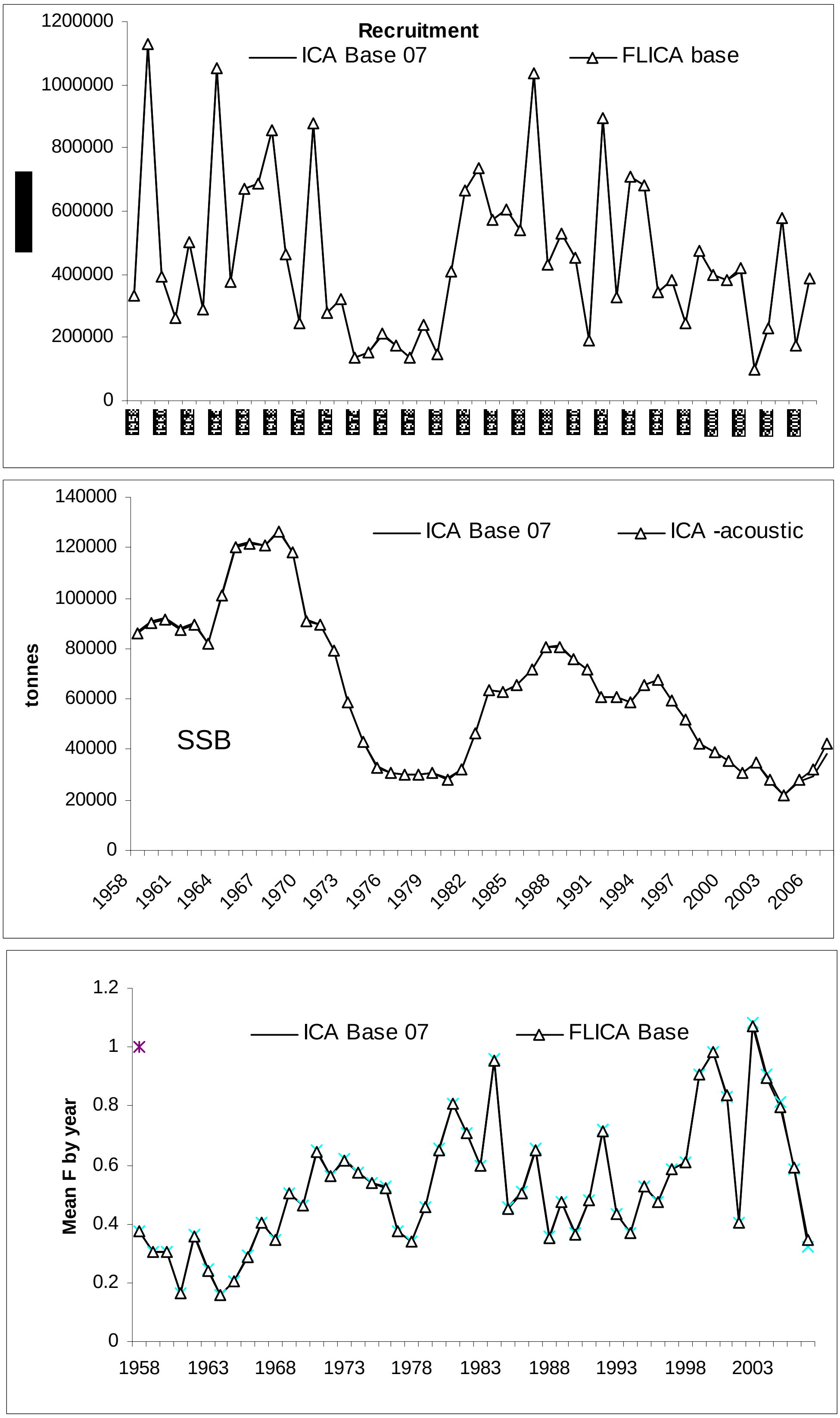


Figure 4.10.1 Celtic Sea and VIIj herring. Comparison of ICA and FLICA outputs using base case approach.

5 West of Scotland Herring

The location of the area occupied by the stock is shown in Figure 5.1. This is an update assessment.

5.1 The Fishery

5.1.1 ACFM Advice Applicable to 2007 and 2008

ACFM reported in 2007 that the stock was fluctuating at a low level and was being exploited slightly above $\mathbf{F_{msy}}$. The 2001 and 2002 year classes were very weak

There was an agreed assessment in 2007, with an improvement of the data basis from 2006. The basis for the advice has changed: in 2006 it was based on status quo TAC, in 2007 the advice was based on the proposed management plan. The assessment was considered to be noisy but unbiased. Medium-term evaluations of the management plan had been carried out assuming the same level of noise as seen in the assessment. In 2007 the assessment of the current biomass was more certain than in 2006. Fishing according to the proposed management plan would imply catches up to 15 000 tonnes in 2008.

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}.	

ICES has not provided recommendations on a year on year constraint. The 2005 WG considered the risks associated with optional TAC constraint and found that for the above rule constraints on variation of 15% did not increase risks importantly. Greater constraint increased risk and reduced catches.

The agreed TAC for 2008 is 27 200 t, which is not in accordance with the HCR above and is therefore not precautionary. The TAC in 2007 was 34 000 t.

5.1.2 Changes in the VIa (North) Fishery.

Historically, catches have been taken from this area by three fisheries.

i) A Scottish domestic pair trawl fleet and the Northern Irish fleet operated in shallower, coastal areas, principally fishing in the Minches and around the Island of Barra (Figure 5.1) in the south; younger herring are found in these areas. This fleet has reduced in recent years.

ii) The Scottish single boat trawl and purse seine fleets, with refrigerated seawater tanks, targeting herring mostly in the northern North Sea, but also operated in the northern part of VIa (N). This fleet now operates mostly with trawls but many vessels can deploy either gear.

iii) An international freezer-trawler fishery has historically operated in deeper water near the shelf edge where older fish are distributed. These vessels are mostly registered in the Netherlands, Germany, France and England but most are Dutch owned.

In recent years the catch of these last two fleets has become more similar

In 2007, the Scottish trawl fleet fished predominantly in areas similar to the freezer trawler fishery, and hardly in the coastal areas in the southern part of VIa (N). The Northern Irish fleet fished only in the north of VIa (N). In common with 2006, but in contrast to most of the previous years' fisheries, in 2007 90% of the fishery was prosecuted in quarter 3 and 97% of those catches were distributed in the northern part of the area. Prior to 2006 there was a much more even distribution of effort, both temporally and spatially.

5.1.3 Regulations and their affects

As a result of perceived problems of area misreporting of catch from IVa into VIa (N), Scotland introduced a fishery regulation in 1997 with the aim to improve reporting accuracy. Under this regulation, Scottish vessels fishing for herring were required to hold a license either to fish in the North Sea or in the west of Scotland area (VIa (N)). Only one licensed option could be held at any one time. However in 2004, the requirement to carry only a single licence was rescinded. Area misreporting of catch taken in area IVa into area VIa (N) then increased in 2004 and continued in 2005. It is possible, therefore, that the relaxation of this single area licence contributed to a resurgence in area misreporting. In 2007, as in 2006, there was no misreporting from IVa into VIa (N). New sources of information on catch misreporting from the UK became available in 2006 (see the 2007 HAWG report). This information was associated with a stricter enforcement regime that may be responsible for the lack of that area misreporting since 2006.

The Butt of Lewis box, (a seasonal closure to pelagic fishing of the spawning ground in the north west of the continental shelf in area VIa(North) since the late 1970s (Figure 5.1)) has been opened to fishing following a STECF review in 2007. It has not been possible to show either beneficial or deleterious effects from this closure.

5.1.4 Catches in 2007 and Allocation of Catches to Area for VIa (North)

For 2007 the preliminary report of official catches corresponding to the VIa (N) herring stock unit total 33 735 t, compared with the TAC of 34 000 t. The Working Group's estimates of area misreported and unallocated catches are 4 119 t. Discarding is not perceived to be a problem.

The Working Group's best estimate of removals from the stock in 2007 is 29 616 t (Table 5.1.1).

5.2 Biological composition of the catch

Catch and sample data, by country and by period (quarter), are detailed in Table 5.2.1. The number of samples used to allocate an age-distribution for the VIa (N) catches have continued at the low level seen over the last few years (except in 2006). There were 25 samples available in 2007, obtained from the Scottish, Dutch and Irish fleets. There was only one sample from the Dutch fleet, which took the second largest catches in the area. The samples available were used to allocate a mean age-structure (using the sample weighted mean) 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, 1998a). 23 of the 25 samples obtained came from only one of the major fisheries by fleet (Scotland), and season (quarter 3); it is likely that they are reasonably representative of the catches, but do not reflect the entire area of the fishery in that quarter.

Catch number and weight-at-age information is given in the ICA stock report section 5.6 (cf Table 5.6.1.4 and 5.6.1.5 respectively). Three relatively greater yearclasses can be seen clearly in the catch-at-age table: 1999 and 2000 at 7- and 6-ring respectively in 2007, recruitment of the 2004 yearclass, at 2-ring in 2007. The 2001, 2002 and 2003 yearclasses all appear relatively weak, with the 2002 yearclass the weakest. 1-ring herring in the catch are variable and are rarely representative of yearclass strength and are down-weighted in the assessment, see Section 5.6.

5.3 Fishery Independent Information

5.3.1 Acoustic Survey

The 2007 acoustic survey was carried out from the 29th June to the 19th July 2007 using a chartered commercial fishing vessel (MFV *Prowess*). Further details are available in the Report of the Planning Group for Herring Surveys (ICES 2008/LRC:01). The commercial vessel changes through the timeseries, though year effects seen in the series are not linked to vessel effects. The biomass estimate for VIa(N) from the acoustic survey has reduced by approximately 40% from 2006 (from 501 500 tonnes to 298 880 tonnes), similar to the low value seen in 2005 (231 300 tonnes). This year very few fish below 20cm or above 31cm were seen on this survey; the weight/length relationship has a shallower gradient than in previous years, possibly due to the restricted length range. This results in reduced numbers of immature fish, along with the larger fish being lighter than would be expected.

For ages 5-ring and older the same yearclass proportions seen in the catch can be seen clearly in the acoustic survey table (cf. Table 5.6.1.9); for the younger ages though, the pattern is different. The survey shows higher proportions of 3- and 4-ringers, whereas the catch shows higher proportions of 2-ring fish, which is the opposite of what would normally be expected. There is no basis for concluding which of the sources of data are more reliable, the catch is sparsely and partially sampled and the survey in 2007 appears to have some sampling problems (ICES 2008/LRC:01).

The 2005 yearclass (age 1) is not observed in the survey with zero catch. The survey always estimates age 1 poorly. However, zero is not a valid entry for the assessment modelling. The recruitment estimate is not used for projection (see Section 5.7.1) but it does influence the model fit slightly. The sensitivity of the assessment to this low value is discussed in Section 5.6.

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 5.3.1 and are used in the assessment. The weights-at-age in the catch (cf Table 5.6.1.5) are comparable to previous years for older ages, with slightly higher weights at younger ages. The weights-at-age in the stock are lower than normal for the older ages and in the high end of the range for the younger ages (cf. Table 5.6.1.6). This is likely a reflection of the reduced size and age range caught on the survey (ICES 2008/LRC:01).

5.4.2 Maturity Ogive

The maturity ogive is obtained from the acoustic survey (Table 5.3.1), the survey provides estimated values for the period 1992 to 2007 (cf. Table 5.6.1.8). In 2007, only a negligible proportion of the 2-ring fish caught were immature, this is unusually high. All other fish were mature and therefore, for the first time, 100% of each age class >1 are considered mature. The sensitivity of the assessed SSB to the estimated maturity is discussed in section 5.6.

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

Input data for the assessment are given in Tables 5.6.1.4 to 5.6.1.9. In the 2008 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, the reviewers commented, in 2007, that the data changes made to the stock from 2000 to 2005 were not sufficiently illustrated in the 2007 HAWG report. 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). As this is an update assessment the model and the model settings used below (Table 5.6.1.1) are the same as last year's assessment; these will not be explored in detail this year. All assessments of the stock were carried out by fitting an integrated catch-at-age model (ICA – Patterson 1998b) using FL ICA (FLR Project, http:/flr-project.org/doku.php). A single age-structured index was available from the acoustic survey from 1987- 2007 (Table 5.6.1.9).

In the 2007 HAWG there were several revisions to the historical data that were explored and reported but the effect of these changes not illustrated. Here results of exploratory assessments to investigate the effects of these revisions are provided to show how these influence our perception of the stock. Last year it was shown that the catch revision resulted in a slightly lower catch over the period 2000 – 2005 and this gave a small upward revision (10%) in terminal SSB and consequent decrease in F for the assessment with revised data. In contrast in 2007 the increased biomass in the 2006 survey resulted in upward revision of the SSB value for 2005 (by 27%) and a consequent decrease in F.

The three exploratory assessments performed here looked at the steps in the catch data revisions done last year:

1) the original data as used in the 2005 assessment, with the 2006 data as used last year and the new 2007 data
2) the original data with area misreporting revisions (see 2007 HAWG report for details), with the 2006 data as used last year and the new 2007 data
3) the fully revised data set incorporating both area and catch misreporting revisions, with the 2006 data as used last year and the new 2007 data

With the revised data set FLICA was run for the data time-series 1957-2007, to compare the model fits.

The separable model residual patterns for the three runs are, to all intents and purposes, identical (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 reasonably small and there are no trends with age.

Figure 5.6.2 shows the values for SSB and F produced by the three assessment runs. There is a minimal difference between the three trajectories for both SSB and F, as would be expected given the small percentage changes described above. These differences are within the bounds of the confidence intervals of the assessment. The difference in terminal SSB pre- and post-change is around 5%.

To test the effect of the high maturation at age 2 (Section 5.4.2) the assessment was re-run with fraction mature at age 2 taken from average maturity for the years 2004-2006. This resulted in a 4% reduction of SSB in 2007. This is considered negligible in the context of the final estimate of SSB.

To test the effect of the zero estimate of age 1 herring in the acoustic survey (Section 5.3.1), the model was run with age 1 set to 50% of lowest observed, lowest observed, and second lowest observed. This influenced the assessment of SSB and F by between -2% and +1% from allocating the survey as unknown. For the final assessment the unknown setting was used for this value. The recruitment estimated by this observation is replaced in the short term forecast (Section 2.7.1).

5.6.2 Stock Assessment

This is an update assessment using FLICA with the same settings as in 2007, with the 8 year separable period moved forward one year from 1999 - 2006 to 2000 – 2007, using the complete survey time series. This uses catch data from 1957 to 2007 giving an assessment of F from 1957 to 2007 and numbers at age from 1st Jan 1957 to 2008. The run settings are in Table 5.6.1.1-3, input data in Tables 5.6.1.4-9. The stock summary is given in Table 5.6.1.10 and Figure 5.6.3. The output data are in Tables 5.6.1.11-14. Run diagnostics are given in Tables 5.6.1.15–17 and Figures 5.6.4-13. The parameter estimates are given in Table 5.6.1.18.

The assessment results in an SSB for 2007 of 68 764 t and a mean fishing mortality (3 to 6-ringers) of 0.40, the summary is given in Figure 5.6.3 and Table 5.6.1.10 which illustrate the stock trends from the assessment. The separable model diagnostics (Tables 5.6.1.17 and Figure 5.6.4) show that the total residuals by age and year between the catch and separable model are reasonably trend-free. The 1999 and 2000 year classes are still reasonably abundant in the catch and survey data in 2007 (7- and 6-ringers respectively). There is conflicting information on recent recruitment in the catch and survey with the survey suggesting a slightly better recruitment of the 2003 year class (3-ringers in 2007) and the catch suggesting it is the 2004 year class (2-ringers in 2007) that is better. This year's estimate of SSB for 2006 is 76 700 t, compared with 77 800 t in last year's final assessment run. The assessment run shows a slightly increased catch, continuing low levels of recruitment (the 2001, 2002 and 2003 year classes are all weak and the apparent reasonable 2004 year class recruitment is being reduced by the survey), decreased SSB and a large increase in F since 2005.

The tuning diagnostic (Figures 5.6.4 to 5.6.13 and Table 5.6.1.15) show that the assessment is relatively well behaved and the analytical retrospective (Figure 5.6.14) plots show that the assessment is reasonably stable.

The outcome of the assessment this year suggests that because catch has remained at a similar level over the last 3 years this is no longer a fairly lightly exploited stock and

F has increased to F=0.40 (more than double the 2005 exploitation rate). Catch has increased only slightly since 2006 but recruitment for the 2001 year classes onwards shows the longest series of low recruitments in the time series (Table 5.6.12). The SSB has halved from its previous high value in 2002, likely a result of lower recruitment and an increased catch since 2005.

5.7 Short term projections

5.7.1 Deterministic short-term projections

In 2005 the Working Group tested a management agreement applicable to VIa (North) (ICES CM 2005/ACFM:16). To date this proposed agreement has not been implemented. However, the Working Group still recommends that the management agreement be applied to the VIa (North) stock. A deterministic short-term projection is presented, which provides options that include those based on the proposed management agreement.

Short-term projections were carried out using MFDP. Input data are stock numbers on 1st January in 2008 from the 2008 ICA assessments (Section 5.6.2, Tables 5.6.1), with geometric mean recruitment 1989-2005 replacing recruitment both 1- and 2-ring in 2008. For the selection of this period see productivity section in 2007 WG report. The retrospective assessment of recruitment estimates in the 2003 Working Group (ICES 2003/ACFM:17) showed the substantial revision of 1- and 2-ring herring abundance (1st January survivors) in subsequent assessments, justifying the use of geometric means for these ages. The selection pattern used is as estimated by ICA (Tables 5.6.1.12, and Figure 5.6.4). 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., 2005 - 2007). A TAC constraint of 27 300t in 2008 (F=0.4) is indistinguishable from *status quo* F in the intermediate year so this is used as the basis for projection. All the input values are summarised in Table 5.7.1.1.

The results of the short-term projection are given in Tables 5.7.1.2 – 5.7.1.3. For F in accordance with the proposed management plan (SSB2009 < 75 000t, F =0.2 in 2009) catches are projected to be 13 000 t, SSB rises from approximately 62 000 t in 2008 to 68 000 in 2009 and 77 000 t in 2010.

5.7.2 Yield-per-recruit

Yield-per-recruit analyses were carried out using MFYPR to provide yield-per-recruit (Figure 5.7.2.1). The value for $\mathbf{F}_{0.1}$ is 0.18.

5.8 Medium term projections and HCR performance

Medium term projections were used extensively in 2006 to evaluate HCRs for this area. There is no evidence that the stock diagnostics have changed, and that recruitment has departed from the two period evaluation already carried out, so the proposed rule should be adequate.

5.9 Precautionary and yield based reference points

B_{lim} is agreed at 50,000t (based on B_{loss}). There are no agreed precautionary reference points for this stock. The proposed management rule has a B_{trig} at 75 000 t.

5.10 Quality of the Assessment

The HAWG considers that this year's assessment is a reliable as last years. The precision of the assessment estimated through parametric bootstrap is shown in Figure 2.10.1. The influence of catch revisions have been explored and shown to make little difference to the assessment outcome. The assessment outcomes were very similar to those from last year. SSB, catch and F estimated in last year's assessment and short term forecast are compared with this year's assessment in the text table below.

	2007 REPORT					THIS YEAR			
	Year	SSB	Catch	F 3-6		Year	SSB	Catch	F 3-6
ASSESS 2007	2005	88261	14129	0.13	ASSESS 2008	2005	85097	14129	0.14
	2006	77787	27346	0.28		2006	76700	27346	0.28
STF* 2007	2007	66510*	34000*	0.46*		2007	68758	29616	0.40

* projected values from the intermediate year in the deterministic short term forecast assuming a catch constraint. STF refers to values estimated in the first year of the short term forecast in the 2007 report.

Retrospective analyses of the assessment from 2007 to 2002 (Figure 5.6.14) supports the perception of a noisy but fairly well balanced assessment. Catches remain at or below TACs; recruitment is low due to low productivity. These conditions have been assumed as one of the scenarios for the HCR considerations (Simmonds and Keltz 2007).

5.11 Management Considerations

In 2007, the stock was more heavily exploited than it has been since 1999. This recent increased F is associated with:

- Reduced area misreporting from area IVa (Section 5.1.2) due to improved enforcement,
- A roll-over TAC advised for 2007 due to some uncertainty with the assessment.
- Insufficient reduction in TAC for 2008 (-20%) with the ICES advice last year of 50% reduction
- The longest series of low recruitments in the time series (1999 to 2003 year classes (Table 5.6.10))

Although the 2004 and 2005 recruitment values are uncertain, there is no evidence of high values. Recruitment at 1-ring in 2006 and 2007 is uncertain. If the TAC of 27 200 t set for 2008 is taken, the SSB will decline further to 62 000; F is predicted to remain stable at F=0.4, well above the proposed management plan F of 0.2 for the current situation of SSB below B_{trig} and above candidates for F_{msy}. The short-term projections, which take into account 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 is reduced to a very low level F=0.025. If catches in 2009 were to return to the 2006 level of 34 000 t SSB is projected to be below B_{lim} in 2010. If F in 2009 is reduced to F=0.2, SSB would rise to B_{trig} in 2010 implying catches of 13 000 t.

5.12 Ecosystem Considerations

Herring are an important prey species in the ecosystem and also one of the dominant planktivorous fish.

Herring fisheries tend to be clean with little bycatch of other fish. Scottish discard observer programs since 1999 indicate that discarding of herring in these directed fisheries are at a low level. These discard observer programs have recorded occasional catches of seals and zero catches of cetaceans.

5.13 Changes in the environment

Temperatures in this area have been increasing over the last number of decades. There are indications that salinity is also increasing (ICES 2006). It is considered that this may have implications for herring. It is known that similar environmental changes have affected the North Sea herring. There is evidence that changes there have been recent changes of the productivity of this stock (ICES HAWG 2007).

Herring are thought to be a source of food for seals. Grey seals (*Halichoerus grypus*) are common in many parts of the Celtic Seas area. The majority of individuals are found in the Hebrides and in Orkney (SCOS 2005). A recent study (Hammond & Harris 2006) of seal diets off western Scotland revealed that grey seals may be an important predator for cod, herring and sandeels in this area. Common seals (*Phoca vitulina*) are also widespread in the northern part of the ecoregion with around 15,000 animals estimated (SCOS 2005). The numbers of seals in VIa North is thought to have increased over the last decades. The seal consumption of herring is estimated with great uncertainty and the impact of increased predation is not known, but there is a possibility that seal predation could influence natural mortality.

Table 5.1.1 Herring in VIa (N). Catch in tonnes by country, 1984-2007. These figures do not in all cases correspond to the official statistics and cannot be used for management purposes.

Country	1984	1985	1986	1987	1988	1989	1990	1991
Denmark	96							
Faroes	954	104	400				326	482
France		20	18	136	44	1342	1287	1168
Germany	5564	5937	2188	1711	1860	4290	7096	6450
Ireland			6000	6800	6740	8000	10000	8000
Netherlands	7729	5500	5160	5212	6131	5860	7693	7979
Norway	6669	4690	4799	4300	456		1607	3318
UK	37554	28065	25294	26810	26894	29874	38253	32628
Unallocated	16588	-502	37840	18038	5229	2123	2397	-10597
Discards						1550	1300	1180
Total	75154	43814	81699	63007	47354	53039	69959	50608
Area-	-19142	-4672	-10935	-18647	-11763	-19013	-25266	-22079
WG	56012	39142	70764	44360	35591	34026	44693	28529
Source (WG)	1986	1987	1988	1989	1990	1991	1993	1993

Country	1992	1993	1994	1995	1996	1997	1998	1999
France	119	818	274	3672	2297	3093	1903	463
Germany	5640	4693	5087	3733	7836	8873	8253	6752
Ireland	7985	8236	7938	3548	9721	1875	11199	7915
Netherlands	8000	6132	6093	7808	9396	9873	8483	7244
Norway	2389	7447	8183	4840	6223	4962	5317	2695
UK	32730	32602	30676	42661	46639	44273	42302	36446
Unallocated	-5485	-3753	-4287	-4541	-17753	-8015	-11748	-8155
Discards	200		700			62	90	
Total	51578	56175	54664	61271	64359	64995	65799	61514
Area-	-22593	-24397	-30234	-32146	-38254	-29766	-32446	-23623
WG	28985	31778	24430	29575	26105	35233*	33353	29736
Source (WG)	1994	1995	1996	1997	1997	1998	1999	2000

Country	2000	2001	2002	2003	2004	2005	2006	2007
France	870	760	1340	1370	625	613	701	703
Germany	4615	3944	3810	2935	1046	2691	3152	1749
Ireland	4841	4311	4239	3581	1894	2880	4352	5129
Netherlands	4647	4534	4612	3609	8232	5132	7008	8052
Norway								
UK	22816	21862	20604	16947	17706	17494	18284	17618
Unallocated			878	-7				
Discards					123	772	163	
Total	37789	35411	36283	28835	29854	31392	34230	33735
Area-	-19467	-11132	-8735	-3581	-7218	-17263	-6884	-4119
WG	18322[$]	24556[$]	32914[$]	28081$	25021[$]	14129[$]	27346	29616
Source (WG)	2001	2002	2003	2004	2005	2006	2007	2008

***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 2007.

PERIOD : 1

Country	Sampled Catch	Official Catch	No. of samples	No. measured	No. aged	SOP %
Ireland	0.00	2194.00	0	0	0	0.00
Netherlands	2327.00	851.00	1	150	25	100.04
Scotland	0.00	28.00	0	0	0	0.00
Period Total	2327.00	3073.00	1	150	25	100.04

Sum of Offical Catches : 3073.00
Unallocated Catch : -718.00
Working Group Catch : 2355.00

PERIOD : 2

Country	Sampled Catch	Official Catch	No. of samples	No. measured	No. aged	SOP %
France	0.00	215.00	0	0	0	0.00
Germany	0.00	303.00	0	0	0	0.00
Netherlands	0.00	187.00	0	0	0	0.00
Period Total	0.00	705.00	0	0	0	0.00

Sum of Offical Catches : 705.00
Unallocated Catch : -187.00
Working Group Catch : 518.00

PERIOD : 3

Country	Sampled Catch	Official Catch	No. of samples	No. measured	No. aged	SOP %
England & Wales	0.00	2926.00	0	0	0	0.00
Faroes	0.00	484.00	0	0	0	0.00
France	0.00	488.00	0	0	0	0.00
Germany	1375.00	1375.00	0	0	0	0.00
Ireland	0.00	1520.00	0	0	0	0.00
N. Ireland	2046.00	2046.00	1	208	77	100.00
Netherlands	0.00	6959.00	0	0	0	0.00
Scotland	12618.00	12618.00	23	3410	1094	100.08
Period Total	16039.00	28416.00	24	3618	1171	91.42

Sum of Offical Catches : 28416.00
Unallocated Catch : -1744.00
Working Group Catch : 26672.00

PERIOD : 4

Country	Sampled Catch	Official Catch	No. of samples	No. measured	No. aged	SOP %
Germany	0.00	71.00	0	0	0	0.00
Ireland	0.00	1415.00	0	0	0	0.00
Netherlands	0.00	55.00	0	0	0	0.00
Period Total	0.00	1541.00	0	0	0	0.00

Sum of Offical Catches : 1541.00
Unallocated Catch : -1470.00
Working Group Catch : 71.00

Total over all Areas and Periods

Country	Sampled Catch	Official Catch	No. of samples	No. measured	No. aged	SOP %
England & Wales	0.00	2926.00	0	0	0	0.00
Faroes	0.00	484.00	0	0	0	0.00
France	0.00	703.00	0	0	0	0.00
Germany	1375.00	1749.00	0	0	0	0.00
Ireland	0.00	5129.00	0	0	0	0.00
N. Ireland	2046.00	2046.00	1	208	77	100.00
Netherlands	2327.00	8052.00	1	150	25	100.04
Scotland	12618.00	12646.00	23	3410	1094	100.06
Total for Stock	18366.00	33735.00	25	3768	1196	92.52

Sum of Offical Catches : 33735.00
Unallocated Catch : -4119.00
Working Group Catch : 29616.00

Table 5.3.1 Herring in VIa (N). Estimates of abundance, biomass, maturity, weight- and length-at-age from Scottish acoustic surveys. Thousands of fish at age and spawning biomass (SSB, tonnes). N.B. In this table "age" refers to number of rings (winter rings in the otolith).

Age (ring)	Numbers	Biomass	Maturity	weight(g)	Length (cm)
0					
1					
2	126.0	21.10	1.00	167.5	26.3
3	294.4	53.86	1.00	183.0	27.2
4	202.5	38.74	1.00	191.4	27.7
5	145.3	28.33	1.00	195.1	27.8
6	346.9	67.67	1.00	195.1	27.9
7	242.9	49.09	1.00	202.1	28.2
8	163.5	33.23	1.00	203.4	28.3
9+	32.1	6.86	1.00	213.8	28.8
Immature	0.1	0.02		138.6	24.5
Mature	1,553.5	298.86		192.5	27.7
Total	1,553.6	298.88		192.4	27.7

Table 5.6.1.1 Herring in VIa (N). FLICA run settings, input data and results 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).

```
sep.2       : NA
sep.gradual : TRUE
sr          : FALSE
sr.age      : 1
lambda.age  : 0.1 1 1 1 1 1 1 1 0
lambda.yr   : 1 1 1 1 1 1 1 1
lambda.sr   : 0.01
index.model : linear
index.cor   : 1
sep.nyr     : 8
sep.age     : 4
sep.sel     : 1
```

Table 5.6.1.2 STOCK OBJECT CONFIGURATION

min	max	plusgroup	minyear	maxyear
1	9	9	1957	2008

Table 5.6.1.3 INDEX OBJECTS CONFIGURATION

FLT01:West Scotland Summer Acoustic Survey (Catch:Thousands)(Effort:Unknown)
"Herring in Division VIa (North)(runname:ICAPGF08) . Imported from VPA file."

min	max	plusgroup	minyear	maxyear	startf	endf
1.00	9.00	9.00	1987.00	2007.00	0.52	0.57

Table 5.6.1.4 CATCH IN NUMBER

Units : Thousands

year

age	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966
1	6496	15616	53092	3561	13081	55048	11796	26546	299483	211675
2	74622	30980	67972	102124	45195	92805	78247	82611	19767	500853
3	58086	145394	35263	60290	61619	22278	53455	70076	62642	33456
4	25762	39070	116390	22781	33125	67454	11859	26680	59375	60502
5	33979	24908	24946	48881	22501	44357	40517	7283	22265	40908
6	19890	27630	17332	11631	12412	19759	26170	24227	5120	19344
7	8885	17405	16999	10347	5345	24139	8687	18637	22891	5563
8	1427	9857	7372	6346	4814	6147	13662	8797	18925	17811
9	4423	7159	8595	4617	2582	7082	6088	15103	19531	27083

year

age	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
1	207947	220255	37706	238226	207711	534963	51170	309016	172879	69053
2	27416	94438	92561	99014	335083	621496	235627	124944	202087	319604
3	218689	20998	71907	253719	412816	175137	808267	151025	89066	101548
4	37069	159122	23314	111897	302208	54205	131484	519178	63701	35502
5	39246	13988	211243	27741	101957	66714	63071	82466	188202	25195
6	29793	23582	21011	142399	25557	25716	54642	49683	30601	76289
7	11770	15677	42762	21609	154424	10342	18242	34629	12297	10918
8	5533	6377	26031	27073	16818	55763	6506	22470	13121	3914
9	25799	10814	26207	24082	31999	16631	32223	21042	13698	12014

year

age	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
1	34836	22525	247	2692	36740	13304	81923	2207	40794	33768	19463
2	47739	46284	142	279	77961	250010	77810	188778	68845	154963	65954
3	95834	20587	77	95	105600	72179	92743	49828	148399	86072	45463
4	22117	40692	19	51	61341	93544	29262	35001	17214	118860	32025
5	10083	6879	13	13	21473	58452	42535	14948	15211	18836	50119
6	12211	3833	8	9	12623	23580	27318	11366	6631	18000	8429
7	20992	2100	4	8	11583	11516	14709	9300	6907	2578	7307
8	2758	6278	1	1	1309	13814	8437	4427	3323	1427	3508
9	1486	1544	0	0	1326	4027	8484	1959	2189	1971	5983

year

age	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
1	1708	6216	14294	26396	5253	17719	1728	266	1952	1193	9092
2	119376	36763	40867	23013	24469	95288	36554	82176	37854	55810	74167
3	41735	109501	40779	25229	24922	18710	40193	30398	30899	34966	34571
4	28421	18923	74279	28212	23733	10978	6007	21272	9219	31657	31905
5	19761	18109	26520	37517	21817	13269	7433	5376	7508	23118	22872
6	28555	7589	13305	13533	33869	14801	8101	4205	2501	17500	14372
7	3252	15012	9878	7581	6351	19186	10515	8805	4700	10331	8641
8	2222	1622	21456	6892	4317	4711	12158	7971	8458	5213	2825
9	2360	3505	5522	4456	5511	3740	10206	9787	31108	9883	3327

year

age	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
1	7635	3569	143	992	56.1	0	183	132	131	NA
2	35252	18162	81030	38482	33332.0	6844	9633	6691	34326	NA
3	93910	17264	14943	93975	46865.6	22223	23237	9186	17755	NA
4	25078	40674	9306	9014	53766.7	27815	20602	13645	6555	NA
5	13364	12264	24482	18114	7463.0	45782	10238	41068	14265	NA
6	7529	7121	9281	28016	4344.6	3916	9783	27782	30566	NA
7	3251	3083	6625	9040	12818.4	7642	1015	20973	21517	NA
8	1257	1452	4611	1548	9187.6	8481	1195	3042	13585	NA
9	1089	456	1001	1423	1408.0	4008	1431	5089	4243	NA

Table 5.6.1.5 WEIGHTS AT AGE IN THE CATCH

Units : Kg

age	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967
1	0.079	0.079	0.079	0.079	0.079	0.079	0.079	0.079	0.079	0.079	0.079
2	0.104	0.104	0.104	0.104	0.104	0.104	0.104	0.104	0.104	0.104	0.104
3	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130
4	0.158	0.158	0.158	0.158	0.158	0.158	0.158	0.158	0.158	0.158	0.158
5	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164
6	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170
7	0.180	0.180	0.180	0.180	0.180	0.180	0.180	0.180	0.180	0.180	0.180
8	0.183	0.183	0.183	0.183	0.183	0.183	0.183	0.183	0.183	0.183	0.183
9	0.185	0.185	0.185	0.185	0.185	0.185	0.185	0.185	0.185	0.185	0.185

age	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978
1	0.079	0.079	0.079	0.079	0.079	0.090	0.090	0.090	0.090	0.090	0.090
2	0.104	0.104	0.104	0.104	0.104	0.121	0.121	0.121	0.121	0.121	0.121
3	0.130	0.130	0.130	0.130	0.130	0.158	0.158	0.158	0.158	0.158	0.158
4	0.158	0.158	0.158	0.158	0.158	0.175	0.175	0.175	0.175	0.175	0.175
5	0.164	0.164	0.164	0.164	0.164	0.186	0.186	0.186	0.186	0.186	0.186
6	0.170	0.170	0.170	0.170	0.170	0.206	0.206	0.206	0.206	0.206	0.206
7	0.180	0.180	0.180	0.180	0.180	0.218	0.218	0.218	0.218	0.218	0.218
8	0.183	0.183	0.183	0.183	0.183	0.224	0.224	0.224	0.224	0.224	0.224
9	0.185	0.185	0.185	0.185	0.185	0.224	0.224	0.224	0.224	0.224	0.224

age	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
1	0.090	0.090	0.090	0.080	0.080	0.080	0.069	0.113	0.073	0.080	0.082
2	0.121	0.121	0.121	0.140	0.140	0.140	0.103	0.145	0.143	0.112	0.142
3	0.158	0.158	0.158	0.175	0.175	0.175	0.134	0.173	0.183	0.157	0.145
4	0.175	0.175	0.175	0.205	0.205	0.205	0.161	0.196	0.211	0.177	0.191
5	0.186	0.186	0.186	0.231	0.231	0.231	0.182	0.215	0.220	0.203	0.190
6	0.206	0.206	0.206	0.253	0.253	0.253	0.199	0.230	0.238	0.194	0.213
7	0.218	0.218	0.218	0.270	0.270	0.270	0.213	0.242	0.241	0.240	0.216
8	0.224	0.224	0.224	0.284	0.284	0.284	0.223	0.251	0.253	0.213	0.204
9	0.224	0.224	0.224	0.295	0.295	0.295	0.231	0.258	0.256	0.228	0.243

age	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
1	0.079	0.084	0.091	0.089	0.083	0.106	0.081	0.089	0.097	0.076	0.0834
2	0.129	0.118	0.119	0.128	0.142	0.142	0.134	0.136	0.138	0.130	0.1373
3	0.173	0.160	0.183	0.158	0.167	0.181	0.178	0.177	0.159	0.158	0.1637
4	0.182	0.203	0.196	0.197	0.190	0.191	0.210	0.205	0.182	0.175	0.1829
5	0.209	0.211	0.227	0.206	0.195	0.198	0.230	0.222	0.199	0.191	0.2014
6	0.224	0.229	0.219	0.228	0.201	0.214	0.233	0.223	0.218	0.210	0.2147
7	0.228	0.236	0.244	0.223	0.244	0.208	0.262	0.219	0.227	0.225	0.2394
8	0.237	0.261	0.256	0.262	0.234	0.227	0.247	0.238	0.212	0.223	0.2812
9	0.247	0.271	0.256	0.263	0.266	0.277	0.291	0.263	0.199	0.226	0.2526

age	2001	2002	2003	2004	2005	2006	2007	2008
1	0.049	0.107	0.060	0.000	0.108	0.0908	0.115	NA
2	0.140	0.146	0.145	0.154	0.133	0.1580	0.167	NA
3	0.163	0.163	0.160	0.173	0.163	0.1676	0.188	NA
4	0.183	0.173	0.169	0.195	0.184	0.1929	0.197	NA
5	0.192	0.160	0.186	0.216	0.211	0.2076	0.210	NA
6	0.196	0.179	0.200	0.220	0.226	0.2251	0.221	NA
7	0.205	0.187	0.194	0.199	0.234	0.2443	0.216	NA
8	0.225	0.245	0.186	0.190	0.256	0.2615	0.262	NA
9	0.272	0.281	0.294	0.311	0.250	0.2750	0.303	NA

Table 5.6.1.6 WEIGHTS AT AGE IN THE STOCK

Units : Kg

age \ year	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967
1	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090
2	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164
3	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208
4	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.233
5	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.246
6	0.252	0.252	0.252	0.252	0.252	0.252	0.252	0.252	0.252	0.252	0.252
7	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258
8	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269
9	0.292	0.292	0.292	0.292	0.292	0.292	0.292	0.292	0.292	0.292	0.292

age \ year	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978
1	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090
2	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164
3	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208
4	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.233
5	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.246
6	0.252	0.252	0.252	0.252	0.252	0.252	0.252	0.252	0.252	0.252	0.252
7	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258
8	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269
9	0.292	0.292	0.292	0.292	0.292	0.292	0.292	0.292	0.292	0.292	0.292

age \ year	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
1	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090
2	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164
3	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208
4	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.233
5	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.246
6	0.252	0.252	0.252	0.252	0.252	0.252	0.252	0.252	0.252	0.252	0.252
7	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258
8	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269
9	0.292	0.292	0.292	0.292	0.292	0.292	0.292	0.292	0.292	0.292	0.292

age \ year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
1	0.090	0.090	0.090	0.075	0.052	0.042	0.045	0.057	0.066	0.054	0.062
2	0.164	0.164	0.164	0.162	0.150	0.144	0.140	0.150	0.138	0.137	0.141
3	0.208	0.208	0.208	0.196	0.192	0.191	0.180	0.189	0.176	0.166	0.173
4	0.233	0.233	0.233	0.206	0.220	0.202	0.209	0.209	0.194	0.188	0.183
5	0.246	0.246	0.246	0.226	0.221	0.225	0.219	0.225	0.214	0.203	0.194
6	0.252	0.252	0.252	0.234	0.233	0.227	0.222	0.233	0.226	0.219	0.204
7	0.258	0.258	0.258	0.254	0.241	0.247	0.229	0.248	0.234	0.225	0.211
8	0.269	0.269	0.269	0.260	0.270	0.260	0.242	0.266	0.225	0.235	0.222
9	0.292	0.292	0.292	0.276	0.296	0.293	0.263	0.287	0.249	0.245	0.230

age \ year	2001	2002	2003	2004	2005	2006	2007	2008
1	0.062	0.062	0.064	0.059	0.0751	0.075	0.075	NA
2	0.132	0.153	0.138	0.138	0.1296	0.135	0.168	NA
3	0.170	0.177	0.176	0.159	0.1538	0.166	0.183	NA
4	0.190	0.198	0.190	0.180	0.1665	0.185	0.191	NA
5	0.198	0.212	0.204	0.189	0.1802	0.192	0.195	NA
6	0.212	0.215	0.213	0.202	0.1911	0.204	0.195	NA
7	0.220	0.225	0.217	0.213	0.2125	0.211	0.202	NA
8	0.236	0.243	0.223	0.214	0.2030	0.224	0.203	NA
9	0.254	0.259	0.228	0.206	0.2284	0.231	0.214	NA

Table 5.6.1.7 NATURAL MORTALITY

Units : NA

year

age	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
4	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
5	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
6	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
7	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
8	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
9	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1

year

age	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
4	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
5	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
6	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
7	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
8	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
9	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1

year

age	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
4	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
5	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
6	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
7	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
8	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
9	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1

year

age	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	NA
2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	NA
3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	NA
4	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	NA
5	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	NA
6	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	NA
7	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	NA
8	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	NA
9	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	NA

Table 5.6.1.8 PROPORTION MATURE

Units : NA

year

age	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57
3	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96
4	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
5	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
6	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
7	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
8	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
9	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

year

age	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57
3	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96
4	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
5	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
6	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
7	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
8	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
9	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

year

age	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.47	0.93	0.48	0.19	0.76	0.57	0.85
3	0.96	0.96	0.96	0.96	0.96	0.96	0.96	1.00	0.96	0.92	0.98	0.94	0.96	0.97
4	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
5	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
6	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
7	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
8	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
9	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

year

age	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000	0	NA
2	0.57	0.45	0.93	0.92	0.76	0.83	0.84	0.810	1	NA
3	0.98	0.92	0.99	1.00	1.00	0.97	1.00	0.965	1	NA
4	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.000	1	NA
5	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.000	1	NA
6	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.000	1	NA
7	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.000	1	NA
8	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.000	1	NA
9	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.000	1	NA

Table 5.6.1.9 SURVEY INDICES

FLT01:West Scotland Summer Acoustic Survey (Catch:Thousands)(Effort:Unknown) - Index Value

Units : NA

age	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
1	249100	-1	-1	-1	338312	74310	2760	494150	460630	41220
2	578400	-1	-1	-1	294484	503430	750270	542080	1085090	576460
3	551100	-1	-1	-1	327902	210980	681170	607720	472710	802530
4	353100	-1	-1	-1	367830	258090	653050	285610	450250	329110
5	752600	-1	-1	-1	488288	414750	544000	306760	153000	95360
6	111600	-1	-1	-1	176348	240110	865150	268130	187060	60600
7	48100	-1	-1	-1	98741	105670	284110	406840	169180	77380
8	15900	-1	-1	-1	89830	56710	151730	173740	236580	78190
9	6500	-1	-1	-1	58043	63440	156180	131880	201510	114810

age	1997	1998	1999	2000	2001	2002	2003	2004	2005
1	792320	1221700	534200	447600	313100	424700	438800	564000	50200
2	641860	794630	322400	316200	1062000	436000	1039400	274500	243400
3	286170	666780	1388000	337100	217700	1436900	932500	760200	230300
4	167040	471070	432000	899500	172800	199800	1471800	442300	423100
5	66100	179050	308000	393400	437500	161700	181300	577200	245100
6	49520	79270	138700	247600	132600	424300	129200	55700	152800
7	16280	28050	86500	199500	102800	152300	346700	61800	12600
8	28990	13850	27600	95000	52400	67500	114300	82200	39000
9	24440	36770	35400	65000	34700	59500	75200	76300	26800

age	2006	2007
1	112300	-1
2	835200	126000
3	387900	294400
4	284500	202500
5	582200	145300
6	414700	346900
7	227000	242900
8	21700	163500
9	59300	32100

FLT01:West Scotland Summer Acoustic Survey (Catch:Thousands)(Effort:Unknown) - Index Variance (Inverse Weights)

Units : NA

age	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
1	10	10	10	10	10	10	10	10	10	10	10	10	10	10
2	1	1	1	1	1	1	1	1	1	1	1	1	1	1
3	1	1	1	1	1	1	1	1	1	1	1	1	1	1
4	1	1	1	1	1	1	1	1	1	1	1	1	1	1
5	1	1	1	1	1	1	1	1	1	1	1	1	1	1
6	1	1	1	1	1	1	1	1	1	1	1	1	1	1
7	1	1	1	1	1	1	1	1	1	1	1	1	1	1
8	1	1	1	1	1	1	1	1	1	1	1	1	1	1
9	1	1	1	1	1	1	1	1	1	1	1	1	1	1

age	2001	2002	2003	2004	2005	2006	2007
1	10	10	10	10	10	10	10
2	1	1	1	1	1	1	1
3	1	1	1	1	1	1	1
4	1	1	1	1	1	1	1
5	1	1	1	1	1	1	1
6	1	1	1	1	1	1	1
7	1	1	1	1	1	1	1
8	1	1	1	1	1	1	1
9	1	1	1	1	1	1	1

Table 5.6.1.10 STOCK SUMMARY

Year	Recruitment Age 1 [Thousands]	TSB [Thousands]	SSB	Catches [Tonnes]	Fbar (Age 3-6)	Landings SOP
1957	1156075	429043	197471	43438	0.268	0.726
1958	2256921	530228	217271	59669	0.307	0.747
1959	2223173	568410	234603	65221	0.278	0.725
1960	655164	460122	271870	63759	0.177	0.568
1961	1325163	466079	271741	46353	0.120	0.585
1962	2400431	577304	261348	58195	0.188	0.773
1963	2179409	610096	286475	49030	0.168	0.697
1964	997559	556885	332796	64234	0.143	0.577
1965	7967406	1157812	339966	68669	0.150	0.859
1966	1074624	879267	451328	100619	0.180	1.014
1967	2515751	856891	480596	90400	0.180	0.807
1968	4109954	974795	454409	84614	0.138	0.796
1969	3001534	1001508	491623	107170	0.235	0.757
1970	3442450	1014535	455346	165930	0.352	0.734
1971	9580461	1525614	324469	207167	0.777	1.016
1972	2676797	1124779	450451	164756	0.362	1.024
1973	1075497	806260	388709	210270	0.603	1.044
1974	1675595	579266	206337	178160	0.953	1.125
1975	2119231	437963	108805	114001	0.902	1.011
1976	618256	266920	75191	93642	1.058	0.998
1977	629396	165990	53814	41341	0.970	0.915
1978	919314	173799	50705	22156	0.640	1.006
1979	1219817	221416	77061	60	0.000	1.001
1980	895139	258365	126990	306	0.000	1.001
1981	1669378	368161	134356	51420	0.355	0.970
1982	779065	309610	112506	92360	0.662	1.035
1983	3054354	436908	83804	63523	0.698	1.028
1984	1159832	362750	124083	56012	0.502	0.949
1985	1216972	358009	153601	39142	0.302	1.006
1986	904968	323828	140132	70764	0.503	1.048
1987	2153505	394361	131338	44360	0.323	0.973
1988	926242	347908	156819	35591	0.270	1.024
1989	883476	333918	174318	34026	0.237	1.020
1990	440702	284150	165829	44693	0.333	0.989
1991	385237	218832	134854	28529	0.245	1.069
1992	797238	226657	111317	28985	0.268	1.002
1993	600226	192362	105371	31778	0.237	0.991
1994	849893	186553	96745	24430	0.223	0.998
1995	652959	164774	76959	29575	0.258	1.000
1996	847295	202301	123121	26105	0.168	1.048
1997	1512594	220792	77857	35233	0.490	1.008
1998	485023	186601	101025	33353	0.458	0.999
1999	301944	143904	84392	29736	0.295	1.002
2000	1619398	200247	72317	18322	0.215	1.000
2001	983427	217130	115037	24556	0.247	1.005
2002	977738	240290	131339	32914	0.265	1.002
2003	361862	195643	124161	28081	0.247	1.007
2004	226438	153291	107306	25021	0.215	1.017
2005	218745	119302	85284	14129	0.133	1.002
2006	435783	134792	76813	27346	0.275	1.000
2007	596324	107734	68816	29616	0.395	1.000
2008	596324	NA	NA	NA	NA	NA

Table 5.6.1.11 ESTIMATED POPULATION ABUNDANCE

Units : Thousands

age	1957	1958	1959	1960	1961	1962	1963	1964	1965
1	1156075	2256921	2223173	655164	1325163	2400431	2179409	997559	7967406
2	954079	421519	821195	787058	238950	479897	851129	794900	351586
3	242182	642963	285762	550217	495850	138500	276434	563623	518263
4	148787	146077	395696	202185	396134	350441	93335	178229	398309
5	146424	110173	95128	247711	161307	326964	253075	73191	135936
6	86698	100256	76059	62419	177750	124590	253727	190526	59307
7	60933	59579	64518	52378	45440	149041	93975	204723	149386
8	8430	46698	37410	42259	37575	36039	111941	76779	167535
9	26128	33916	43616	30745	20153	41521	49883	131817	172899

age	1966	1967	1968	1969	1970	1971	1972	1973
1	1074624	2515751	4109954	3001534	3442450	9580461	2676797	1075497
2	2757621	275691	805834	1384703	1082295	1129059	3403916	682520
3	243540	1615920	180799	516289	946602	717116	552045	1991877
4	367866	169254	1125984	129101	357926	547140	220137	294885
5	304029	275422	117977	867736	94686	217819	209744	147776
6	101863	236249	211946	93465	584794	59379	100683	126563
7	48799	73810	185472	169378	64637	394077	29548	66713
8	113437	38871	55612	152928	112703	38013	210385	16939
9	172489	181247	94306	153962	100252	72326	62746	83898

age	1974	1975	1976	1977	1978	1979	1980	1981	1982
1	1675595	2119231	618256	629396	919314	1219817	895139	1669378	779065
2	366062	441387	680126	187878	211418	325130	448602	327737	592810
3	306072	165352	156806	234887	98597	117220	240741	332093	176471
4	907708	115883	56076	38422	106579	62208	95902	197016	177178
5	142451	331338	44709	17278	13894	57908	56270	86727	120133
6	74036	51076	122172	16671	6120	6070	52385	50903	58108
7	62821	20207	17351	38627	3607	1924	5485	47392	34086
8	43068	24147	6688	5409	15128	1282	1738	4955	31895
9	40331	25209	20528	2914	3721	9653	9886	5020	9298

age	1983	1984	1985	1986	1987	1988	1989	1990	1991
1	3054354	1159832	1216972	904968	2153505	926242	883476	440702	385237
2	278877	1076125	425394	424063	313364	780916	339752	321399	153842
3	228217	140511	636245	256409	183039	175979	476646	220275	203193
4	79915	103879	70394	387516	132766	109008	106568	291806	143648
5	71957	44598	60833	47368	237986	89755	71682	78465	193592
6	53447	24981	26192	40618	25030	167783	62465	47686	45873
7	30260	22549	11854	17411	19725	14662	124710	49313	30534
8	19932	13476	11602	4209	13306	10929	10182	98584	35246
9	20043	5963	7642	5814	22694	11607	22002	25372	22788

age	1992	1993	1994	1995	1996	1997	1998	1999	2000
1	797238	600226	849893	652959	847295	1512594	485023	301944	1619398
2	126501	290233	210539	311653	240055	310567	555758	173152	106650
3	94328	72863	134250	124800	161041	145540	182492	348382	98246
4	143626	54844	42847	73845	74860	104047	87732	118304	200892
5	103205	107428	39207	33065	46652	58980	64141	49167	83251
6	139564	72682	84603	28422	24815	35085	31482	36373	31817
7	28679	94157	51721	68856	21724	20078	15207	14894	25768
8	20438	19925	66991	36821	53941	15198	8406	5604	10392
9	26090	15818	56235	45209	198392	28812	9900	4855	2878

age	2001	2002	2003	2004	2005	2006	2007	2008
1	983427	977738	361862	226438	218745	435783	596324	596324
2	595306	361482	359365	133011	83242	80434	160164	160164
3	69777	383118	229891	231347	87184	57014	50768	50768
4	63987	44087	236829	145334	151186	61780	34756	34756
5	151561	47125	31910	174496	109941	121967	44223	44223
6	59016	104017	31596	21913	124146	85274	80570	80570
7	23362	42149	72821	22578	16140	98453	58944	58944
8	18916	16681	29500	52022	16626	12798	68034	68034
9	5641	7458	7953	25648	13854	25549	15672	15672

Table 5.6.1.12 ESTIMATED FISHING MORTALITY

Units : f

age	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
1	0.01	0.01	0.04	0.01	0.02	0.04	0.01	0.04	0.06	0.36	0.14	0.09	0.02	0.11
2	0.09	0.09	0.10	0.16	0.25	0.25	0.11	0.13	0.07	0.23	0.12	0.15	0.08	0.11
3	0.31	0.29	0.15	0.13	0.15	0.19	0.24	0.15	0.14	0.16	0.16	0.14	0.17	0.35
4	0.20	0.33	0.37	0.13	0.09	0.23	0.14	0.17	0.17	0.19	0.26	0.16	0.21	0.40
5	0.28	0.27	0.32	0.23	0.16	0.15	0.18	0.11	0.19	0.15	0.16	0.13	0.29	0.37
6	0.28	0.34	0.27	0.22	0.08	0.18	0.11	0.14	0.10	0.22	0.14	0.12	0.27	0.29
7	0.17	0.37	0.32	0.23	0.13	0.19	0.10	0.10	0.18	0.13	0.18	0.09	0.31	0.43
8	0.20	0.25	0.23	0.17	0.14	0.20	0.14	0.13	0.13	0.18	0.16	0.13	0.20	0.29
9	0.20	0.25	0.23	0.17	0.14	0.20	0.14	0.13	0.13	0.18	0.16	0.13	0.20	0.29

age	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
1	0.03	0.37	0.08	0.33	0.14	0.19	0.09	0.04	0	0	0.04	0.03	0.04	0.00
2	0.42	0.24	0.50	0.49	0.73	0.76	0.34	0.29	0	0	0.32	0.65	0.39	0.23
3	0.98	0.43	0.59	0.77	0.88	1.21	0.59	0.26	0	0	0.43	0.59	0.59	0.49
4	0.86	0.30	0.63	0.91	0.85	1.08	0.92	0.51	0	0	0.39	0.80	0.48	0.44
5	0.67	0.41	0.59	0.93	0.90	0.89	0.94	0.73	0	0	0.30	0.71	0.96	0.43
6	0.60	0.31	0.60	1.20	0.98	1.05	1.43	1.06	0	0	0.30	0.55	0.76	0.65
7	0.53	0.46	0.34	0.86	1.01	1.07	0.84	0.93	0	0	0.30	0.44	0.71	0.56
8	0.62	0.33	0.51	0.79	0.84	0.94	0.76	0.57	0	0	0.32	0.60	0.58	0.42
9	0.62	0.33	0.51	0.79	0.84	0.94	0.76	0.57	0	0	0.32	0.60	0.58	0.42

age	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
1	0.05	0.06	0.01	0.00	0.01	0.05	0.11	0.01	0.05	0.00	0.00	0.00	0.00	0.03
2	0.21	0.54	0.28	0.19	0.13	0.16	0.19	0.25	0.47	0.22	0.36	0.20	0.23	0.17
3	0.30	0.46	0.32	0.30	0.29	0.23	0.15	0.34	0.33	0.40	0.31	0.24	0.31	0.23
4	0.30	0.39	0.29	0.32	0.21	0.31	0.23	0.19	0.24	0.16	0.36	0.14	0.38	0.48
5	0.30	0.54	0.25	0.26	0.31	0.44	0.23	0.25	0.14	0.22	0.19	0.18	0.53	0.47
6	0.31	0.62	0.43	0.20	0.14	0.35	0.37	0.29	0.24	0.11	0.17	0.11	0.74	0.65
7	0.94	0.17	0.49	0.26	0.14	0.24	0.30	0.26	0.24	0.24	0.14	0.26	0.77	0.90
8	0.36	0.44	0.32	0.24	0.18	0.26	0.23	0.25	0.28	0.21	0.26	0.18	0.44	0.43
9	0.36	0.44	0.32	0.24	0.18	0.26	0.23	0.25	0.28	0.21	0.26	0.18	0.44	0.43

age	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
1	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	NA
2	0.27	0.12	0.14	0.15	0.14	0.12	0.08	0.16	0.23	NA
3	0.35	0.23	0.26	0.28	0.26	0.23	0.14	0.29	0.42	NA
4	0.25	0.18	0.21	0.22	0.21	0.18	0.11	0.23	0.33	NA
5	0.34	0.24	0.28	0.30	0.28	0.24	0.15	0.31	0.45	NA
6	0.24	0.21	0.24	0.26	0.24	0.21	0.13	0.27	0.38	NA
7	0.26	0.21	0.24	0.26	0.24	0.21	0.13	0.27	0.38	NA
8	0.27	0.18	0.21	0.22	0.21	0.18	0.11	0.23	0.33	NA
9	0.27	0.18	0.21	0.22	0.21	0.18	0.11	0.23	0.33	NA

Table 5.6.1.13 FITTED SELECTION PATTERN

Units : f

age \ year	2000	2001	2002	2003	2004	2005	2006	2007
1	0.00404	0.00404	0.00404	0.00404	0.00404	0.00404	0.00404	0.00404
2	0.68353	0.68353	0.68353	0.68353	0.68353	0.68353	0.68353	0.68353
3	1.25862	1.25862	1.25862	1.25862	1.25862	1.25862	1.25862	1.25862
4	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
5	1.34261	1.34261	1.34261	1.34261	1.34261	1.34261	1.34261	1.34261
6	1.14912	1.14912	1.14912	1.14912	1.14912	1.14912	1.14912	1.14912
7	1.15038	1.15038	1.15038	1.15038	1.15038	1.15038	1.15038	1.15038
8	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
9	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000

Table 5.6.1.14 PREDICTED INDEX VALUES

FLT01:West Scotland Summer Acoustic Survey (Catch:Thousands)(Effort:Unknown)

Units : NA

age \ year	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
1	743436	NA	NA	NA	125991	275811	203489	295192	227110	294220	525931
2	702306	NA	NA	NA	361698	287453	585207	485960	667495	560937	713438
3	656938	NA	NA	NA	800652	334150	259711	461413	449672	604225	525813
4	515439	NA	NA	NA	576494	589191	219506	178787	276299	315918	384134
5	854231	NA	NA	NA	703382	370227	409580	142882	122797	173453	181916
6	79797	NA	NA	NA	151527	480543	257635	322661	104751	94337	94919
7	55434	NA	NA	NA	95122	91176	303251	166631	233711	69327	48435
8	36373	NA	NA	NA	101407	58136	55622	194674	104334	159460	38882
9	67713	NA	NA	NA	71564	81007	48199	178374	139828	640159	80460

age \ year	1998	1999	2000	2001	2002	2003	2004	2005	2006
1	166019	102754	563225	342017	340025	125849	78755	76090	151547
2	1322487	390250	259773	1437046	866974	867641	324306	207881	192119
3	685968	1228579	370235	258639	1403257	852386	873428	344005	207248
4	307508	469443	827990	260285	177646	963604	599884	646304	247441
5	204470	168428	299716	536101	164583	112908	629450	415699	422534
6	89333	128618	114724	209608	365445	112254	79147	466829	297522
7	34220	47461	84418	75388	134539	235056	74092	55144	312086
8	21638	15788	30686	55129	48156	85994	153844	50921	36724
9	27816	14930	9277	17943	23500	25306	82789	46314	80024

age \ year	2007
1	NA
2	368661
3	172391
4	131873
5	142466
6	264162
7	175569
8	184942
9	46501

Table 5.6.1.15 INDEX RESIDUALS

FLT01:West Scotland Summer Acoustic Survey (Catch:Thousands)(Effort:Unknown)

Units : NA

age	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
1	-1.093	NA	NA	NA	0.9878	-1.3115	-4.3004	0.515	0.707	-1.9654
2	-0.194	NA	NA	NA	-0.2056	0.5604	0.2485	0.109	0.486	0.0273
3	-0.176	NA	NA	NA	-0.8927	-0.4598	0.9642	0.275	0.050	0.2838
4	-0.378	NA	NA	NA	-0.4493	-0.8254	1.0903	0.468	0.488	0.0409
5	-0.127	NA	NA	NA	-0.3650	0.1136	0.2838	0.764	0.220	-0.5982
6	0.335	NA	NA	NA	0.1517	-0.6938	1.2114	-0.185	0.580	-0.4426
7	-0.142	NA	NA	NA	0.0373	0.1475	-0.0652	0.893	-0.323	0.1099
8	-0.828	NA	NA	NA	-0.1212	-0.0248	1.0035	-0.114	0.819	-0.7127
9	-2.343	NA	NA	NA	-0.2094	-0.2444	1.1757	-0.302	0.365	-1.7184

age	1997	1998	1999	2000	2001	2002	2003	2004	2005
1	0.410	1.9959	1.6484	-0.2298	-0.0883	0.2224	1.2490	1.9687	-0.416
2	-0.106	-0.5094	-0.1910	0.1966	-0.3024	-0.6874	0.1806	-0.1667	0.158
3	-0.608	-0.0284	0.1220	-0.0938	-0.1723	0.0237	0.0898	-0.1388	-0.401
4	-0.833	0.4265	-0.0831	0.0828	-0.4096	0.1175	0.4236	-0.3047	-0.424
5	-1.012	-0.1328	0.6036	0.2720	-0.2032	-0.0177	0.4736	-0.0867	-0.528
6	-0.651	-0.1195	0.0755	0.7693	-0.4579	0.1493	0.1406	-0.3513	-1.117
7	-1.090	-0.1988	0.6002	0.8600	0.3101	0.1240	0.3886	-0.1814	-1.476
8	-0.294	-0.4462	0.5586	1.1301	-0.0508	0.3377	0.2845	-0.6268	-0.267
9	-1.192	0.2791	0.8634	1.9469	0.6595	0.9290	1.0891	-0.0816	-0.547

age	2006	2007
1	-0.300	NA
2	1.470	-1.0736
3	0.627	0.5352
4	0.140	0.4289
5	0.321	0.0197
6	0.332	0.2725
7	-0.318	0.3246
8	-0.526	-0.1232
9	-0.300	-0.3706

Table 5.6.1.16 PREDICTED CATCH IN NUMBER

Units : NA

age \ year	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966
1	6496	15616	53092	3561	13081	55048	11796	26546	299483	211675
2	74622	30980	67972	102124	45195	92805	78247	82611	19767	500853
3	58086	145394	35263	60290	61619	22278	53455	70076	62642	33456
4	25762	39070	116390	22781	33125	67454	11859	26680	59375	60502
5	33979	24908	24946	48881	22501	44357	40517	7283	22265	40908
6	19890	27630	17332	11631	12412	19759	26170	24227	5120	19344
7	8885	17405	16999	10347	5345	24139	8687	18637	22891	5563
8	1427	9857	7372	6346	4814	6147	13662	8797	18925	17811
9	4423	7159	8595	4617	2582	7082	6088	15103	19531	27083

age \ year	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
1	207947	220255	37706	238226	207711	534963	51170	309016	172879	69053
2	27416	94438	92561	99014	335083	621496	235627	124944	202087	319604
3	218689	20998	71907	253719	412816	175137	808267	151025	89066	101548
4	37069	159122	23314	111897	302208	54205	131484	519178	63701	35502
5	39246	13988	211243	27741	101957	66714	63071	82466	188202	25195
6	29793	23582	21011	142399	25557	25716	54642	49683	30601	76289
7	11770	15677	42762	21609	154424	10342	18242	34629	12297	10918
8	5533	6377	26031	27073	16818	55763	6506	22470	13121	3914
9	25799	10814	26207	24082	31999	16631	32223	21042	13698	12014

age \ year	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
1	34836	22525	247	2692	36740	13304	81923	2207	40794	33768	19463
2	47739	46284	142	279	77961	250010	77810	188778	68845	154963	65954
3	95834	20587	77	95	105600	72179	92743	49828	148399	86072	45463
4	22117	40692	19	51	61341	93544	29262	35001	17214	118860	32025
5	10083	6879	13	13	21473	58452	42535	14948	15211	18836	50119
6	12211	3833	8	9	12623	23580	27318	11366	6631	18000	8429
7	20992	2100	4	8	11583	11516	14709	9300	6907	2578	7307
8	2758	6278	1	1	1309	13814	8437	4427	3323	1427	3508
9	1486	1544	0	0	1326	4027	8484	1959	2189	1971	5983

age \ year	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
1	1708	6216	14294	26396	5253	17719	1728	266	1952	1193	9092
2	119376	36763	40867	23013	24469	95288	36554	82176	37854	55810	74167
3	41735	109501	40779	25229	24922	18710	40193	30398	30899	34966	34571
4	28421	18923	74279	28212	23733	10978	6007	21272	9219	31657	31905
5	19761	18109	26520	37517	21817	13269	7433	5376	7508	23118	22872
6	28555	7589	13305	13533	33869	14801	8101	4205	2501	17500	14372
7	3252	15012	9878	7581	6351	19186	10515	8805	4700	10331	8641
8	2222	1622	21456	6892	4317	4711	12158	7971	8458	5213	2825
9	2360	3505	5522	4456	5511	3740	10206	9787	31108	9883	3327

age \ year	1999	2000	2001	2002	2003	2004	2005	2006	2007
1	7635	752	517	557	190	104	64.1	261	131
2	35252	10799	67755	44369	40817	13280	5436.3	10326	28377
3	93910	18279	14500	85462	47678	42474	10653.2	13264	15888
4	25078	31823	11350	8411	41926	22711	15613.9	12306	9409
5	13364	17191	34914	11644	7337	35561	14959.0	31412	15251
6	7529	5717	11856	22447	6335	3885	14612.2	19200	24494
7	3251	4635	4698	9105	14615	4007	1901.6	22188	17936
8	1257	1646	3355	3182	5222	8130	1717.0	2549	18418
9	1089	456	1001	1423	1408	4008	1430.8	5089	4243

Table 5.6.1.17 CATCH RESIDUALS

Units : Thousands

age \ year	2000	2001	2002	2003	2004	2005	2006
1	1.5578	-1.2852	0.5768	-1.2184	-Inf	1.05e+00	-6.77e-01
2	0.5199	0.1789	-0.1424	-0.2026	-6.63e-01	5.72e-01	-4.34e-01
3	-0.0572	0.0301	0.0950	-0.0172	-6.48e-01	7.80e-01	-3.67e-01
4	0.2454	-0.1986	0.0693	0.2488	2.03e-01	2.77e-01	1.03e-01
5	-0.3377	-0.3549	0.4419	0.0171	2.53e-01	-3.79e-01	2.68e-01
6	0.2195	-0.2449	0.2216	-0.3772	7.89e-03	-4.01e-01	3.69e-01
7	-0.4077	0.3438	-0.0071	-0.1311	6.46e-01	-6.28e-01	-5.63e-02
8	-0.1256	0.3178	-0.7207	0.5649	4.23e-02	-3.62e-01	1.77e-01
9	0.0000	0.0000	0.0000	0.0000	-1.11e-16	-1.11e-16	-2.22e-16

age \ year	2007
1	7.81e-09
2	1.90e-01
3	1.11e-01
4	-3.61e-01
5	-6.69e-02
6	2.21e-01
7	1.82e-01
8	-3.04e-01
9	0.00e+00

Table 5.6.1.18 FIT PARAMETERS

	Value	CV.pct	Lower.95.pct.CL	Upper.95.pct.CL
F, 2000	1.82e-01	9.3	1.33e-01	2.48e-01
F, 2001	2.06e-01	9.8	1.52e-01	2.79e-01
F, 2002	2.23e-01	10.4	1.65e-01	3.03e-01
F, 2003	2.05e-01	10.1	1.50e-01	2.81e-01
F, 2004	1.79e-01	9.8	1.29e-01	2.50e-01
F, 2005	1.15e-01	8.2	8.09e-02	1.63e-01
F, 2006	2.34e-01	13.5	1.60e-01	3.44e-01
F, 2007	3.34e-01	22.8	2.04e-01	5.45e-01
Selectivity at age 1	4.04e-03	6.8	1.93e-03	8.45e-03
Selectivity at age 2	6.84e-01	39.0	5.11e-01	9.15e-01
Selectivity at age 3	1.26e+00	59.1	9.64e-01	1.64e+00
Selectivity at age 5	1.34e+00	42.4	1.05e+00	1.72e+00
Selectivity at age 6	1.15e+00	87.0	9.07e-01	1.46e+00
Selectivity at age 7	1.15e+00	86.9	9.06e-01	1.46e+00
Terminal year pop, age 1	1.54e+05	8.2	2.27e+04	1.04e+06
Terminal year pop, age 2	1.60e+05	2.8	8.31e+04	3.09e+05
Terminal year pop, age 3	5.08e+04	2.4	3.04e+04	8.48e+04
Terminal year pop, age 4	3.48e+04	2.3	2.16e+04	5.58e+04
Terminal year pop, age 5	4.42e+04	2.0	2.89e+04	6.76e+04
Terminal year pop, age 6	8.06e+04	1.9	5.25e+04	1.24e+05
Terminal year pop, age 7	5.89e+04	1.9	3.89e+04	8.93e+04
Terminal year pop, age 8	6.80e+04	1.9	4.48e+04	1.03e+05
Last true age pop, 2000	1.04e+04	3.1	5.88e+03	1.84e+04
Last true age pop, 2001	1.89e+04	2.3	1.21e+04	2.95e+04
Last true age pop, 2002	1.67e+04	2.1	1.12e+04	2.48e+04
Last true age pop, 2003	2.95e+04	1.9	2.02e+04	4.30e+04
Last true age pop, 2004	5.20e+04	1.8	3.56e+04	7.60e+04
Last true age pop, 2005	1.66e+04	2.0	1.14e+04	2.42e+04
Last true age pop, 2006	1.28e+04	2.0	8.88e+03	1.84e+04
Index 1, age 1 numbers, Q	6.00e-01	122.8	1.76e-01	2.05e+00
Index 1, age 2 numbers, Q	3.07e+00	17.8	2.08e+00	4.54e+00
Index 1, age 3 numbers, Q	4.76e+00	12.7	3.22e+00	7.03e+00
Index 1, age 4 numbers, Q	4.81e+00	12.7	3.26e+00	7.09e+00
Index 1, age 5 numbers, Q	4.34e+00	13.6	2.94e+00	6.42e+00
Index 1, age 6 numbers, Q	4.27e+00	13.8	2.88e+00	6.32e+00
Index 1, age 7 numbers, Q	3.88e+00	14.9	2.61e+00	5.77e+00
Index 1, age 8 numbers, Q	3.44e+00	16.6	2.31e+00	5.14e+00
Index 1, age 9 numbers, Q	3.76e+00	15.2	2.53e+00	5.58e+00

Table 5.7.1. Herring in VIa (N). Input data for short-term predictions, numbers at age from the assessment with ages 1 and 2 in 2008 replaced by geometric mean values - natural mortality (M), proportion mature (Mat), proportion of fishing mortality prior to spawning (PF), proportion of natural mortality prior to spawning (PM), mean weights at age in the stock (SWt), selection pattern (Sel), mean weights at age in the catch (CWt). All biological data are taken as mean of the last 3 years. VIa (N) herring appears to have considerable annual variability in mean weights and in fraction mature. Last years values are not applicable. N.B. In this table "age" refers to number of rings (winter rings in the otolith).

2008								
Age	N	M	Mat	PF	PM	SWt	Sel	CWt
1	596324	1	0.00	0.67	0.67	0.050	0.001	0.105
2	219080	0.3	0.88	0.67	0.67	0.144	0.228	0.152
3	94457	0.2	0.99	0.67	0.67	0.168	0.420	0.173
4	27312	0.1	1.00	0.67	0.67	0.181	0.334	0.191
5	22527	0.1	1.00	0.67	0.67	0.189	0.448	0.210
6	25567	0.1	1.00	0.67	0.67	0.197	0.383	0.224
7	49687	0.1	1.00	0.67	0.67	0.209	0.384	0.232
8	36335	0.1	1.00	0.67	0.67	0.210	0.334	0.260
9	54254	0.1	1.00	0.67	0.67	0.224	0.334	0.276

2009								
Age	N	M	Mat	PF	PM	SWt	Sel	CWt
1	596324	1	0.00	0.67	0.67	0.050	0.001	0.105
2	.	0.3	0.88	0.67	0.67	0.144	0.228	0.152
3	.	0.2	0.99	0.67	0.67	0.168	0.420	0.173
4	.	0.1	1.00	0.67	0.67	0.181	0.334	0.191
5	.	0.1	1.00	0.67	0.67	0.189	0.448	0.210
6	.	0.1	1.00	0.67	0.67	0.197	0.383	0.224
7	.	0.1	1.00	0.67	0.67	0.209	0.384	0.232
8	.	0.1	1.00	0.67	0.67	0.210	0.334	0.260
9	.	0.1	1.00	0.67	0.67	0.224	0.334	0.276

2010								
Age	N	M	Mat	PF	PM	SWt	Sel	CWt
1	596324	1	0.00	0.67	0.67	0.050	0.001	0.105
2	.	0.3	0.88	0.67	0.67	0.144	0.228	0.152
3	.	0.2	0.99	0.67	0.67	0.168	0.420	0.173
4	.	0.1	1.00	0.67	0.67	0.181	0.334	0.191
5	.	0.1	1.00	0.67	0.67	0.189	0.448	0.210
6	.	0.1	1.00	0.67	0.67	0.197	0.383	0.224
7	.	0.1	1.00	0.67	0.67	0.209	0.384	0.232
8	.	0.1	1.00	0.67	0.67	0.210	0.334	0.260
9	.	0.1	1.00	0.67	0.67	0.224	0.334	0.276

Table 5.7.1.2. Herring in VIa (N). Short-term prediction single option table, *status quo* F with the 2005 acoustic survey included in the assessment. N.B. In this table "age" refers to number of rings (winter rings in the otolith).

YEAR:	**2008**	**F MULTIPLIER:**	**1.0564**	**FBAR:**	**0.42**				
Age	F	CatchNos	Yield	StockNos	Biomass	SSNos(Jan)	SSB(Jan)	SSNos(ST)	SSB(ST)
1	0.001	536	56	596324	29836	0	0	0	0
2	0.241	40766	6215	219080	31555	193521	27873	134689	19400
3	0.444	30900	5345	94457	15831	93355	15646	60654	10166
4	0.353	7743	1482	27312	4943	27312	4943	20170	3650
5	0.473	8114	1701	22527	4260	22527	4260	15343	2901
6	0.405	8130	1822	25567	5031	25567	5031	18228	3587
7	0.406	15814	3661	49687	10361	49687	10361	35413	7385
8	0.353	10301	2675	36335	7635	36335	7635	26833	5638
9	0.353	15381	4243	54254	12175	54254	12175	40066	8991
Total		137686	27200	1125544	121626	502558	87924	351395	61717

Year:	2009	F multiplier:	1	Fbar:	0.40				
Age	F	CatchNos	Yield	StockNos	Biomass	SSNos(Jan)	SSB(Jan)	SSNos(ST)	SSB(ST)
1	0.001	508	53	596324	29836	0	0	0	0
2	0.228	38812	5918	219063	31552	193506	27871	135845	19566
3	0.420	39918	6905	127551	21378	126063	21128	83215	13947
4	0.334	13435	2571	49627	8981	49627	8981	37114	6716
5	0.448	5991	1256	17372	3285	17372	3285	12034	2276
6	0.383	3861	865	12699	2499	12699	2499	9186	1807
7	0.384	4695	1087	15429	3218	15429	3218	11158	2327
8	0.334	8114	2107	29972	6298	29972	6298	22415	4710
9	0.334	15598	4303	57620	12930	57620	12930	43092	9670
Total		130932	25064	1125658	119976	502288	86210	354058	61019

Year:	20010	F multiplier:	1	Fbar:	0.40				
Age	F	CatchNos	Yield	StockNos	Biomass	SSNos(Jan)	SSB(Jan)	SSNos(ST)	SSB(ST)
1	0.001	508	53	596324	29836	0	0	0	0
2	0.228	38815	5918	219080	31555	193521	27873	135855	19568
3	0.420	40432	6993	129193	21653	127686	21400	84287	14126
4	0.334	18577	3556	68621	12418	68621	12418	51319	9287
5	0.448	11093	2325	32165	6082	32165	6082	22282	4213
6	0.383	3053	684	10044	1976	10044	1976	7265	1430
7	0.384	2383	552	7831	1633	7831	1633	5663	1181
8	0.334	2575	669	9511	1999	9511	1999	7113	1495
9	0.334	15369	4240	56772	12740	56772	12740	42458	9528
Total		132805	24990	1129542	119892	506151	86122	356242	60827

Table 5.7.1.3. Herring in VIa (N). Short-term prediction multiple option table,. *status quo* F with the 2005 acoustic survey included in the assessment.

2008							
Biomass	SSB	FMult	FBar	Landings			
121626	61717	1.0564	0.4186	27200			
2009					2010		
Biomass	SSB	FMult	FBar	Landings	Biomass	SSB	% change
119976	76074	0	0	0	142230	96464	-100%
.	74406	0.1	0.0396	2897	139637	91959	-89%
.	72776	0.2	0.0792	5699	137132	87696	-79%
.	71184	0.3	0.1189	8409	134711	83662	-69%
.	69629	0.4	0.1585	11031	132371	79844	-59%
.	68109	0.5	0.1981	13567	130111	76229	-50%
.	66625	0.6	0.2377	16021	127926	72806	-41%
.	65174	0.7	0.2774	18394	125814	69565	-32%
.	63757	0.8	0.317	20691	123772	66494	-24%
.	62372	0.9	0.3566	22914	121799	63584	-16%
.	61019	1	0.3962	25064	119892	60827	-8%
.	59697	1.1	0.4358	27146	118048	58214	0%
.	58405	1.2	0.4755	29161	116265	55736	7%
.	57143	1.3	0.5151	31111	114541	53387	14%
.	55909	1.4	0.5547	32998	112875	51158	21%
.	54703	1.5	0.5943	34826	111263	49044	28%
.	53525	1.6	0.634	36595	109704	47038	35%
.	52374	1.7	0.6736	38308	108197	45133	41%
.	51248	1.8	0.7132	39967	106739	43325	47%
.	50149	1.9	0.7528	41574	105329	41608	53%
.	49074	2	0.7924	43130	103966	39977	59%
Values for catch option table							
119976	76074	0.00	0.00	0	142230	96464	-100%
	68444	0.48	0.20	13011	130606	77015	-52%
	66665	0.60	0.25	15954	127985	72898	-41%
	64935	0.72	0.30	18783	125468	69040	-31%
	63253	0.84	0.35	21503	123051	65424	-21%
	61616	0.96	0.40	24118	120731	62033	-11%
	61019	1.00	0.42	25064	119892	60827	-8%

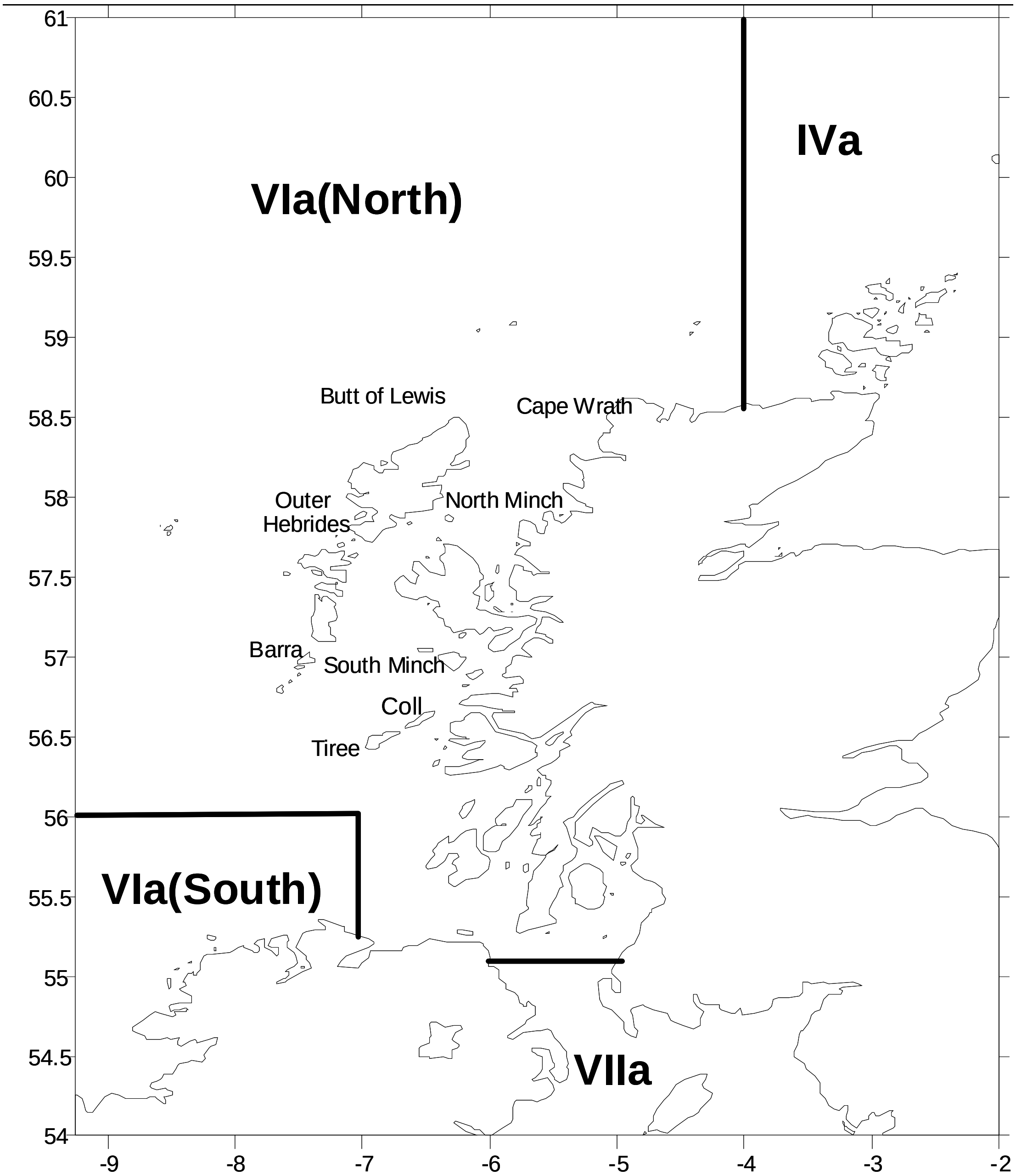


Figure 5.1 Location of ICES area VIa(North) and adjacent areas, with place names.

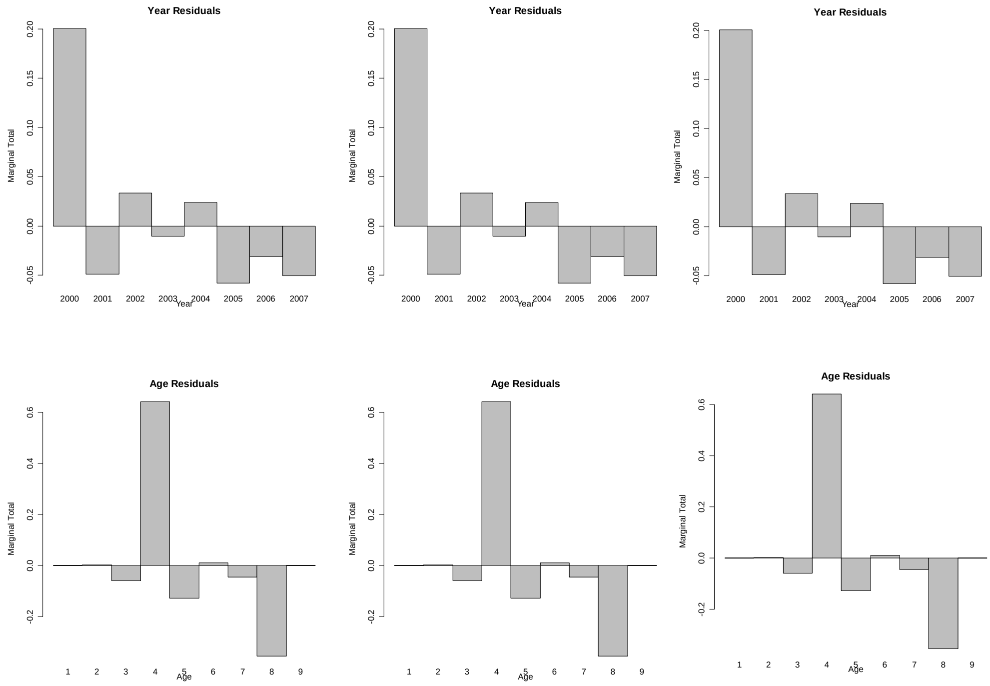
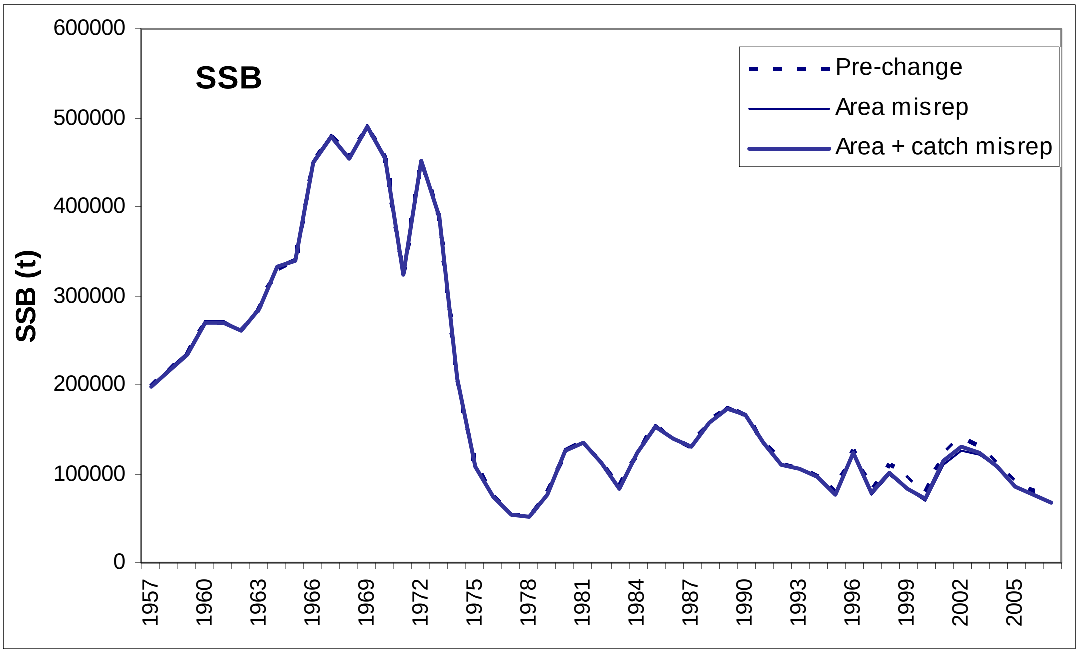


Figure 5.6.1 Herring in VIa (North). Separable model residual plots for the three exploratory assessments with data from 1957-2007. Left panels are for the original data from 2000-2005; middle panels are for intermediate revised data including area misreporting data revisions from 2000-2005; right panels are for the fully revised data set, including area misreporting and catch misreporting data revisions from 2000-2005.



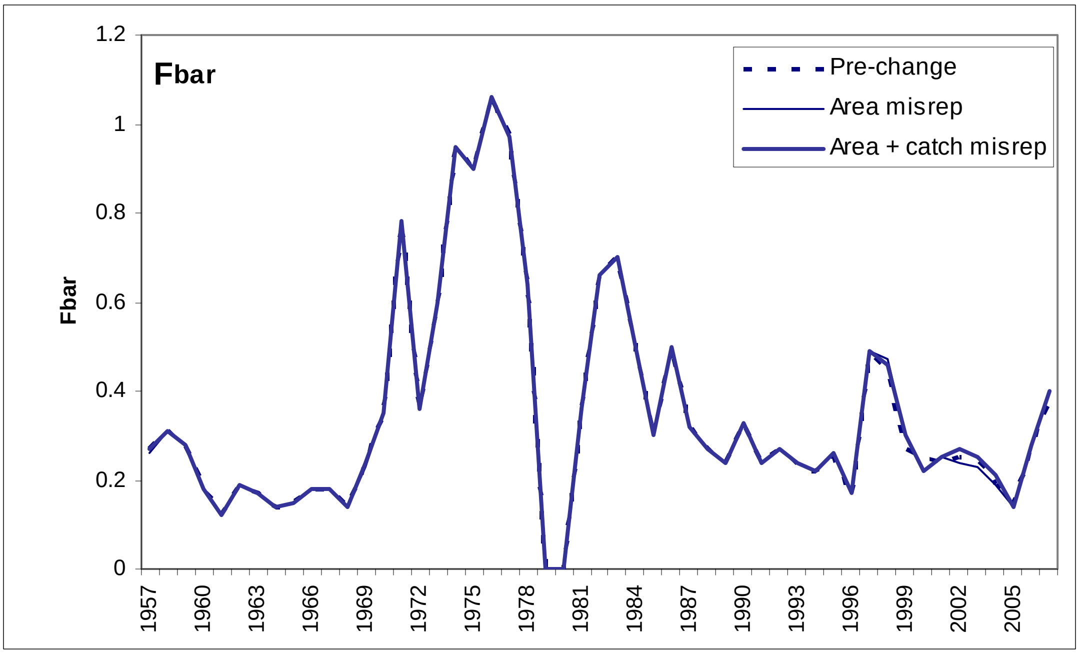


Figure 5.6.2 Herring in VIa (North). SSB and F from the three exploratory assessment with data from 1957-2007. "Pre-change" is the original data from 2000-2005; "Area misrep" is the intermediate revised data including area misreporting data revisions from 2000-2005; "Area + catch misrep" is the fully revised data set, including area misreporting and catch misreporting data revisions from 2000-2005.

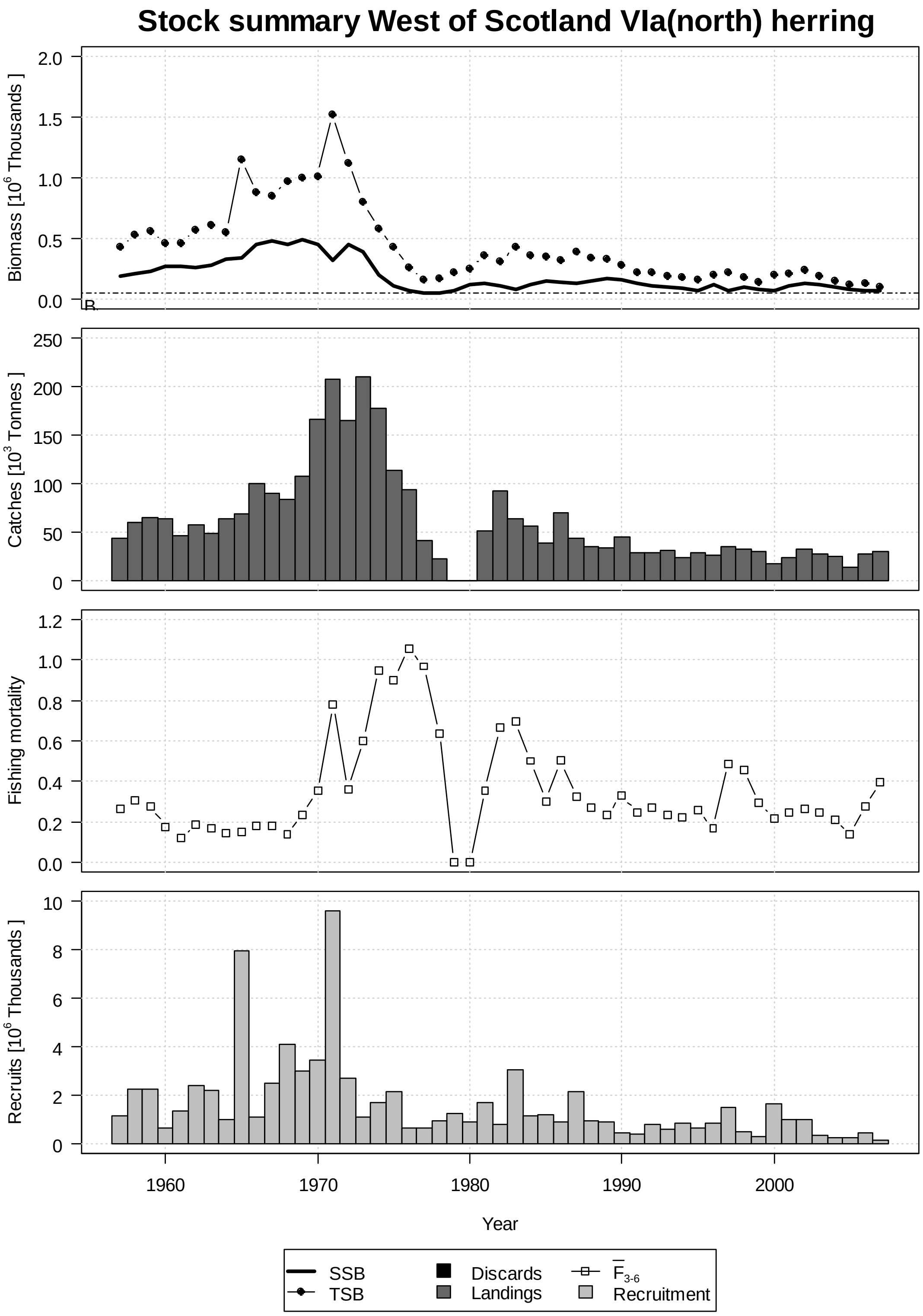


Figure 5.6.3 Herring in VIa (North). Illustration of stock trends from the assessment (8 year separable period) 1957-2007. Summary of estimates of landings, spawning stock biomass at spawning time, fishing mortality at $F_{3\text{-}6}$, recruitment at 1-ring, in the final assessment run.

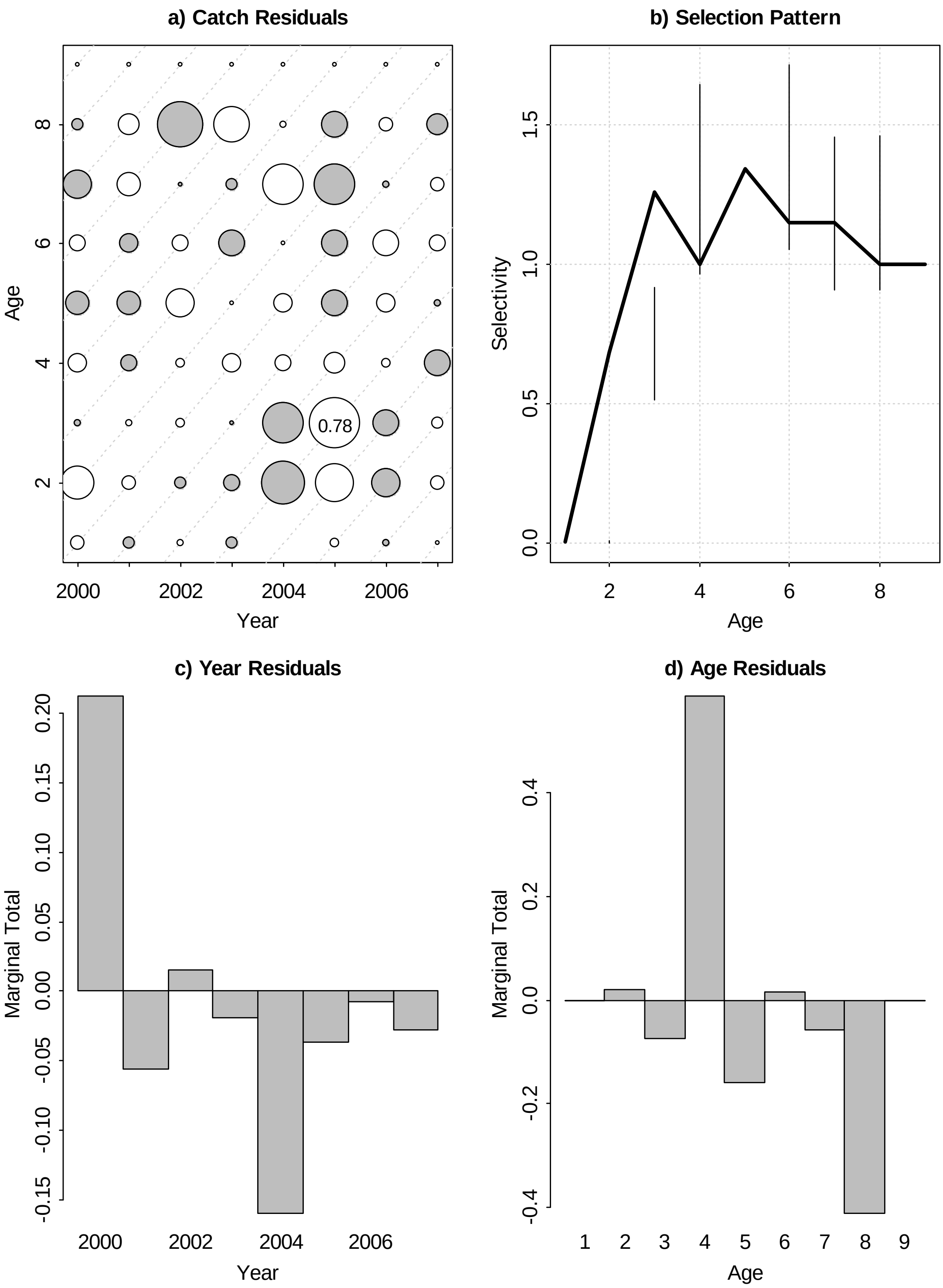


Figure 5.6.4 Herring in VIa (North). Herring in VIa (N). Illustration of selection patterns diagnostics, from deterministic calculation (8-year separable period). Top left, a bubble plot of selection pattern residuals. Top right, estimated selection (relative to 4-ringers) +/- standard deviation. Bottom, marginal totals of residuals by year and ring.

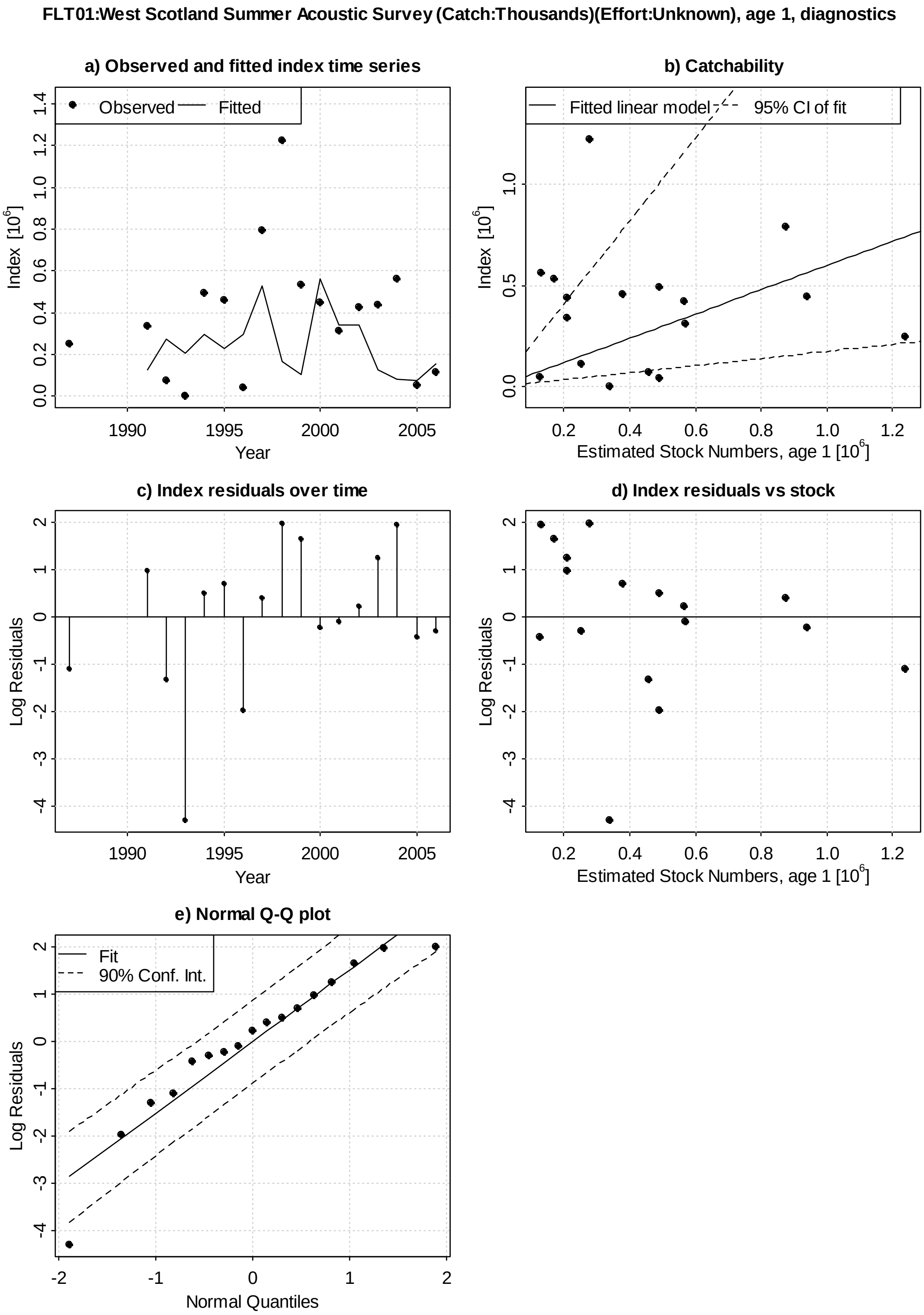


Figure 5.6.5 Herring in VIa (N), illustration of residuals from deterministic calculation (8-year separable period). Diagnostics of the fit of the 1-ring index against the acoustic surveys. Top left, fitted populations (line), and predictions of abundance in each year made from the index observations and estimated catchability (triangles +/- standard deviation), plotted by year. Top right, scatter plot and fitted relationship of abundance from fitted populations of 1-ringers in acoustic surveys. Bottom, residuals, as ln(observed index) - ln(expected index) plotted against expected values and against time. N.B. 1-ringers are down-weighted in the catch and survey in the assessment.

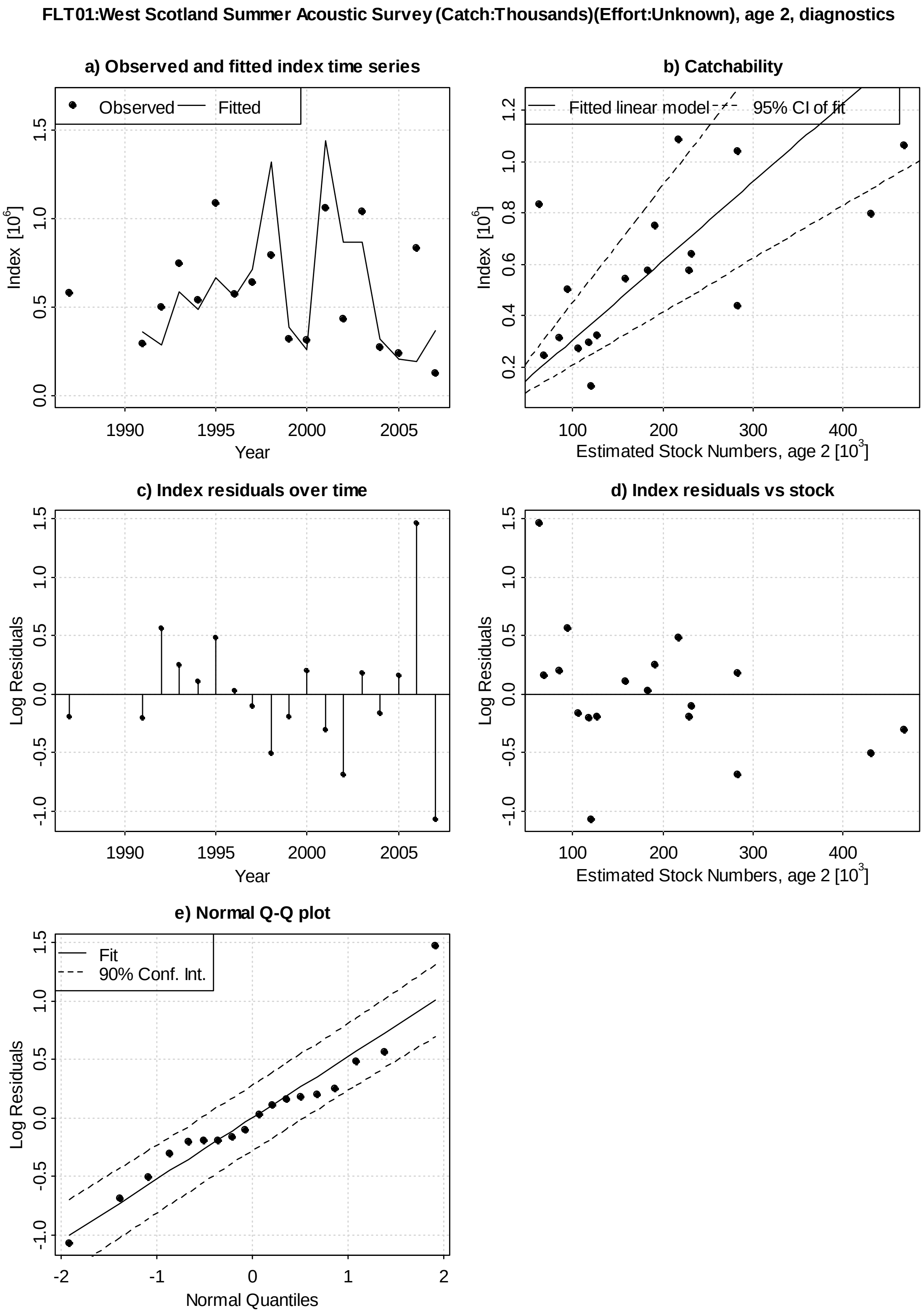


Figure 5.6.6 Herring in VIa (N), illustration of residuals from deterministic calculation (8-year separable period). Diagnostics of the fit of the 2-ring index against the acoustic surveys. Top left, fitted populations (line), and predictions of abundance in each year made from the index observations and estimated catchability (triangles +/- standard deviation), plotted by year. Top right, scatter plot and fitted relationship of abundance from fitted populations of 2-ringers in acoustic surveys. Bottom, residuals, as ln(observed index) - ln(expected index) plotted against expected values and against time.

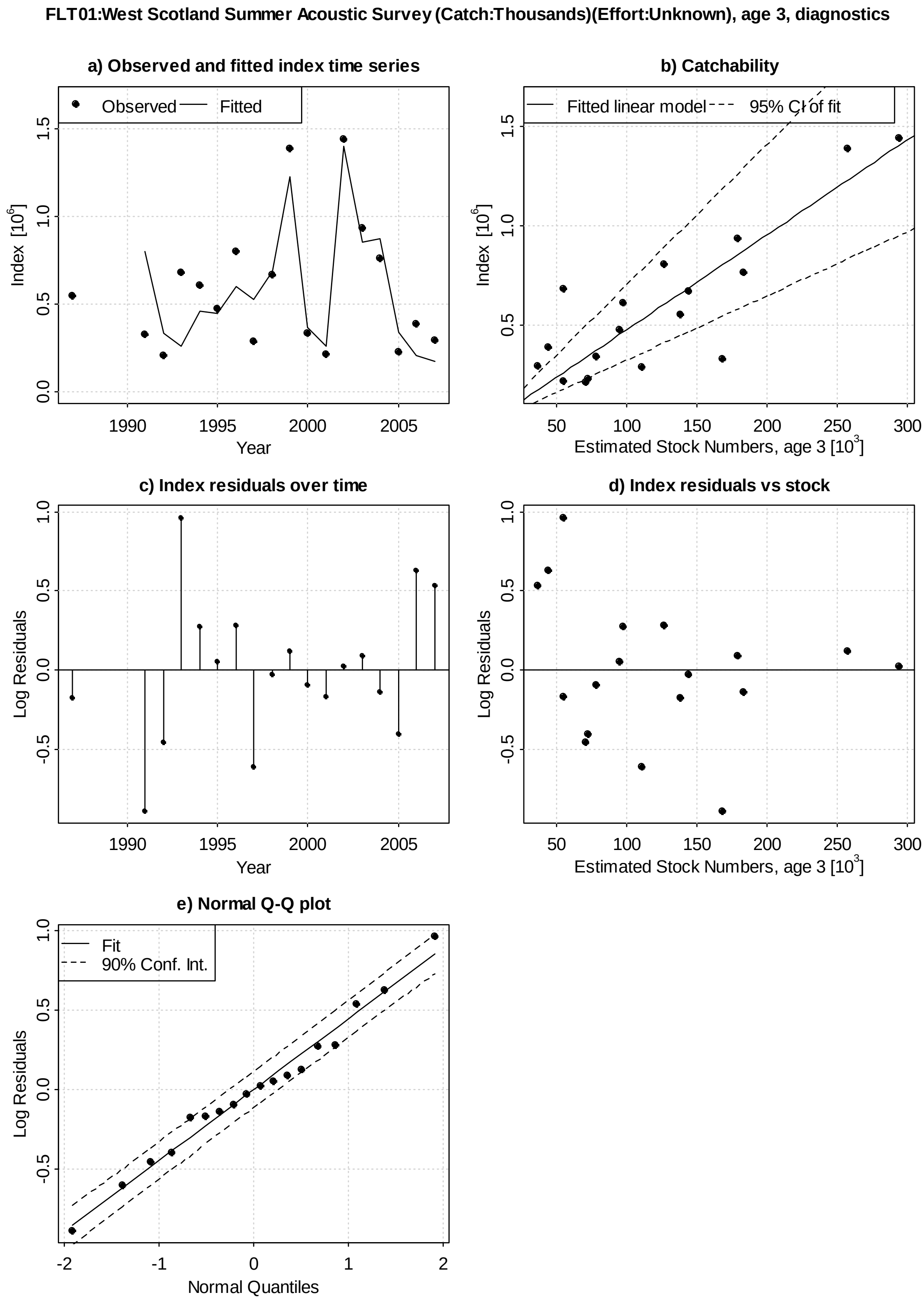


Figure 5.6.7 Herring in VIa (N), illustration of residuals from deterministic calculation (8-year separable period). Diagnostics of the fit of the 3-ring index against the acoustic surveys. Top left, fitted populations (line), and predictions of abundance in each year made from the index observations and estimated catchability (triangles +/- standard deviation), plotted by year. Top right, scatter plot and fitted relationship of abundance from fitted populations of 3-ringers in acoustic surveys. Bottom, residuals, as ln(observed index) - ln(expected index) plotted against expected values and against time.

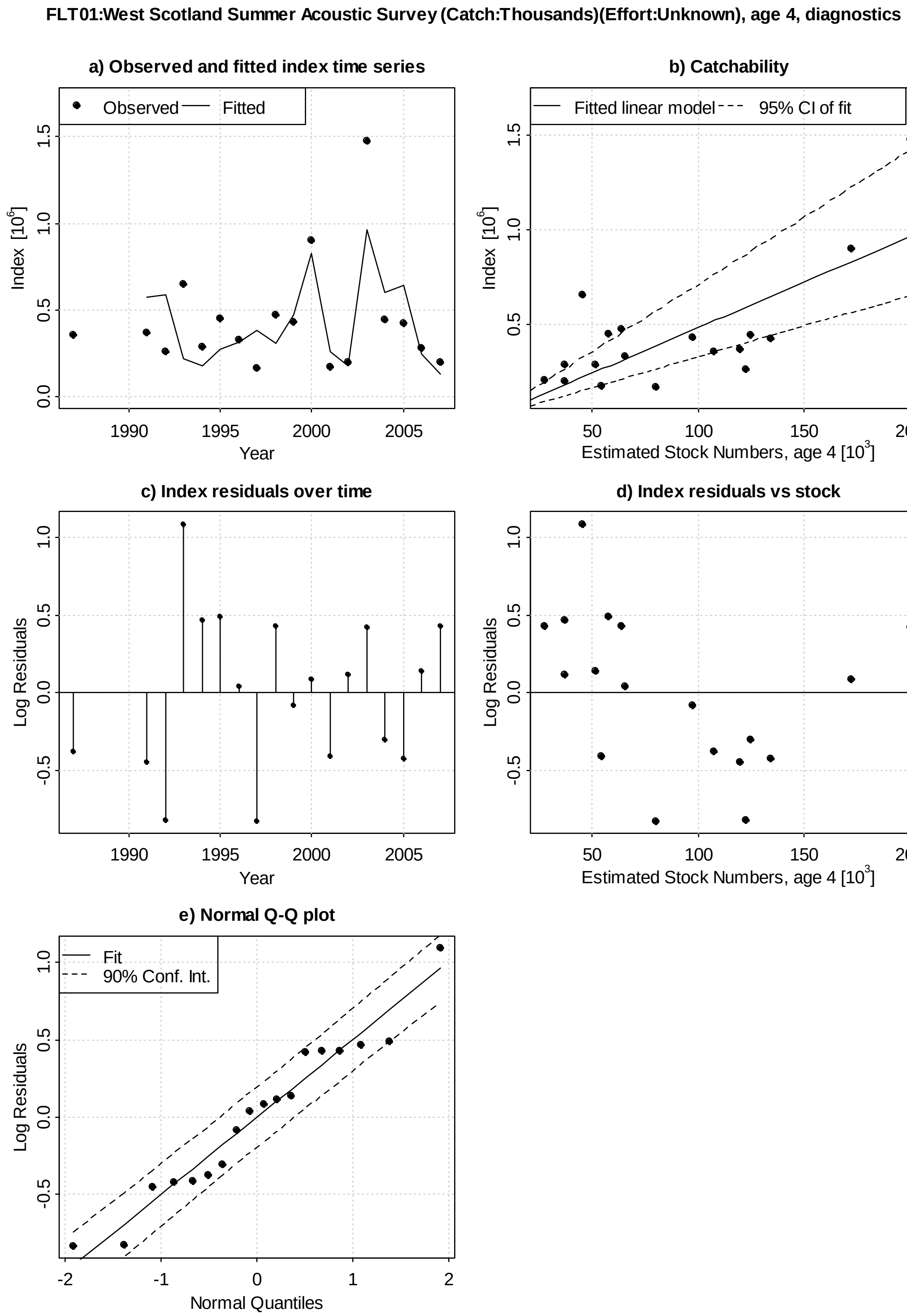


Figure 5.6.8 Herring in VIa (N), illustration of residuals from deterministic calculation (8-year separable period). Diagnostics of the fit of the 4-ring index against the acoustic surveys. Top left, fitted populations (line), and predictions of abundance in each year made from the index observations and estimated catchability (triangles +/- standard deviation), plotted by year. Top right, scatter plot and fitted relationship of abundance from fitted populations of 4-ringers in acoustic surveys. Bottom, residuals, as ln(observed index) - ln(expected index) plotted against expected values and against time.

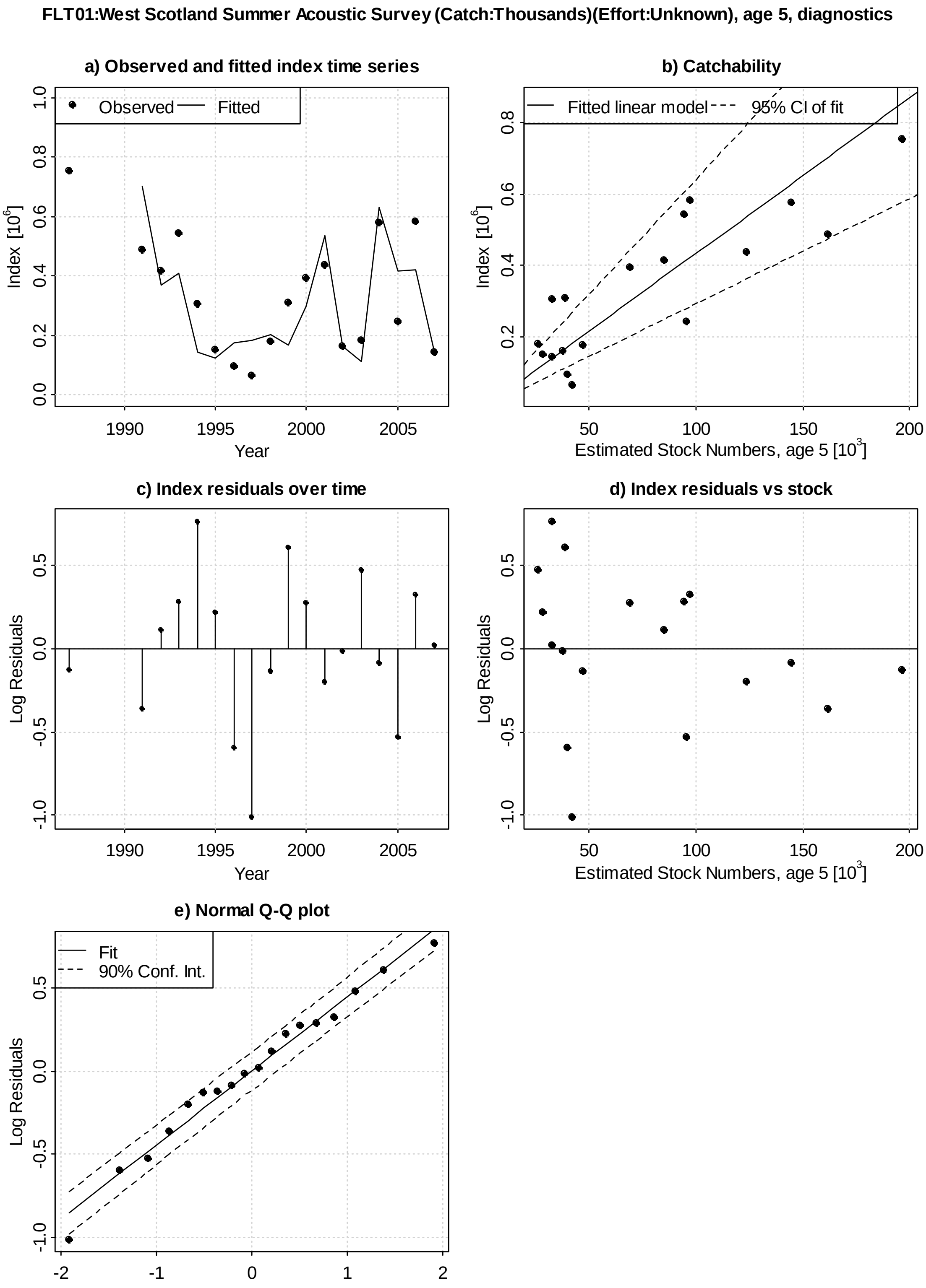


Figure 5.6.9 Herring in VIa (N), illustration of residuals from deterministic calculation (8-year separable period). Diagnostics of the fit of the 5-ring index against the acoustic surveys. Top left, fitted populations (line), and predictions of abundance in each year made from the index observations and estimated catchability (triangles +/- standard deviation), plotted by year. Top right, scatter plot and fitted relationship of abundance from fitted populations of 5 ringers in acoustic surveys. Bottom, residuals, as ln(observed index) - ln(expected index) plotted against expected values and against time.

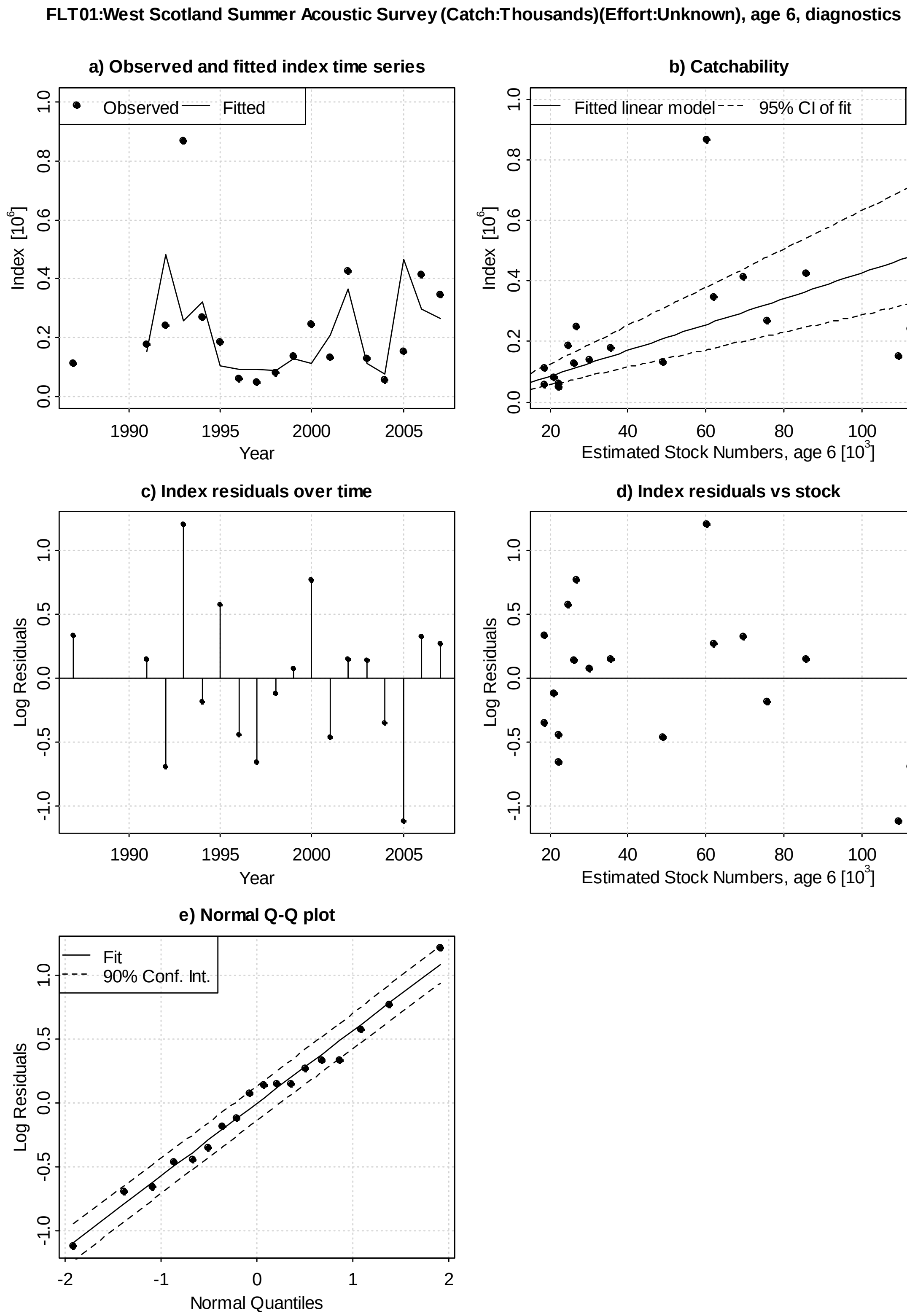


Figure 5.6.10 Herring in VIa (N), illustration of residuals from deterministic calculation (8-year separable period). Diagnostics of the fit of the 6-ring index against the acoustic surveys. Top left, fitted populations (line), and predictions of abundance in each year made from the index observations and estimated catchability (triangles +/- standard deviation), plotted by year. Top right, scatter plot and fitted relationship of abundance from fitted populations of 6 ringers in acoustic surveys. Bottom, residuals, as ln(observed index) - ln(expected index) plotted against expected values and against time.

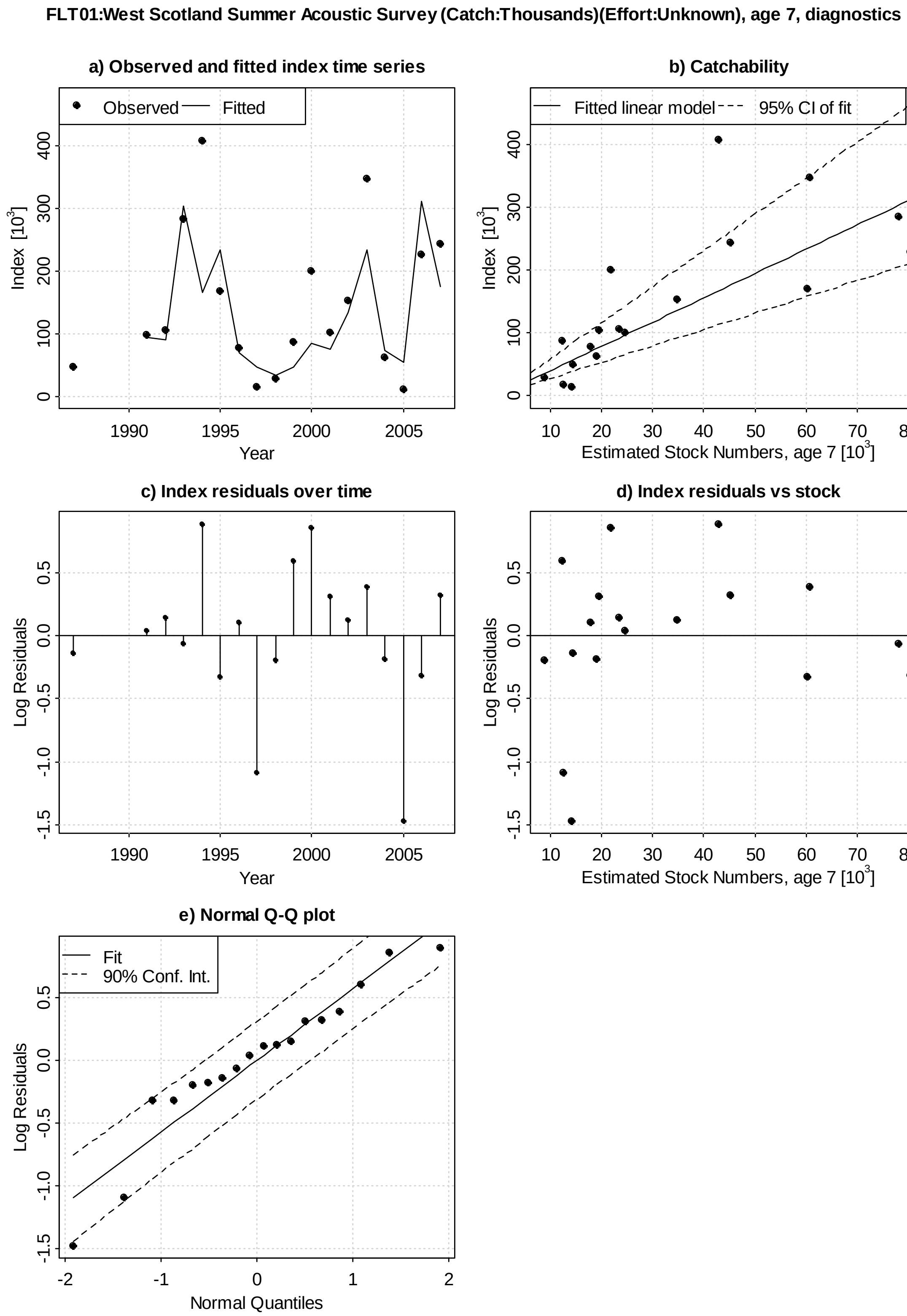


Figure 5.6.11 Herring in VIa (N), illustration of residuals from deterministic calculation (8-year separable period). Diagnostics of the fit of the 7-ring index against the acoustic surveys. Top left, fitted populations (line), and predictions of abundance in each year made from the index observations and estimated catchability (triangles +/- standard deviation), plotted by year. Top right, scatter plot and fitted relationship of abundance from fitted populations of 7 ringers in acoustic surveys. Bottom, residuals, as ln(observed index) - ln(expected index) plotted against expected values and against time.

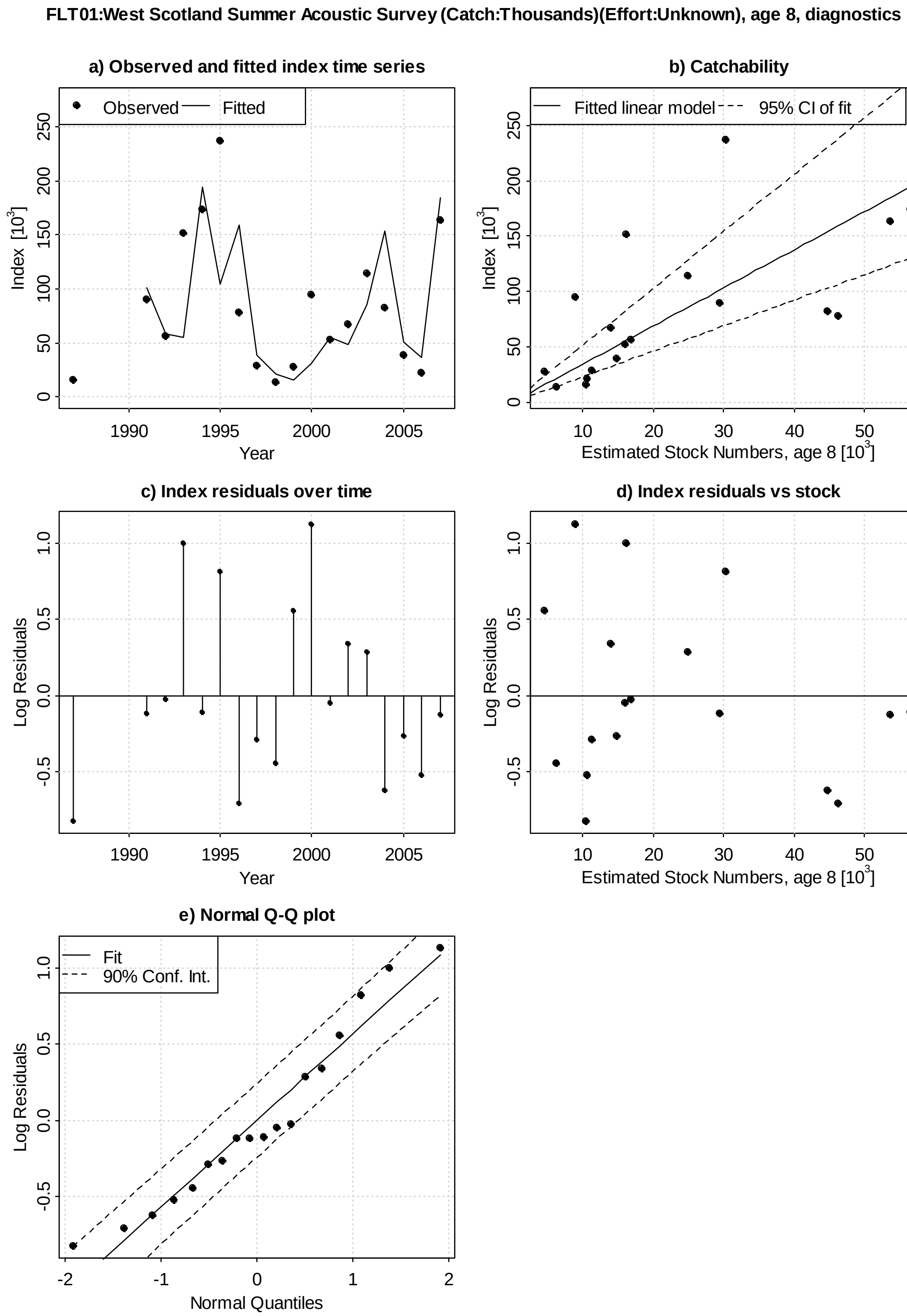


Figure 5.6.12 Herring in VIa (N), illustration of residuals from deterministic calculation (8-year separable period). Diagnostics of the fit of the 8-ring index against the acoustic surveys. Top left, fitted populations (line), and predictions of abundance in each year made from the index observations and estimated catchability (triangles +/- standard deviation), plotted by year. Top right, scatter plot and fitted relationship of abundance from fitted populations of 8 ringers in acoustic surveys. Bottom, residuals, as ln(observed index) - ln(expected index) plotted against expected values and against time.

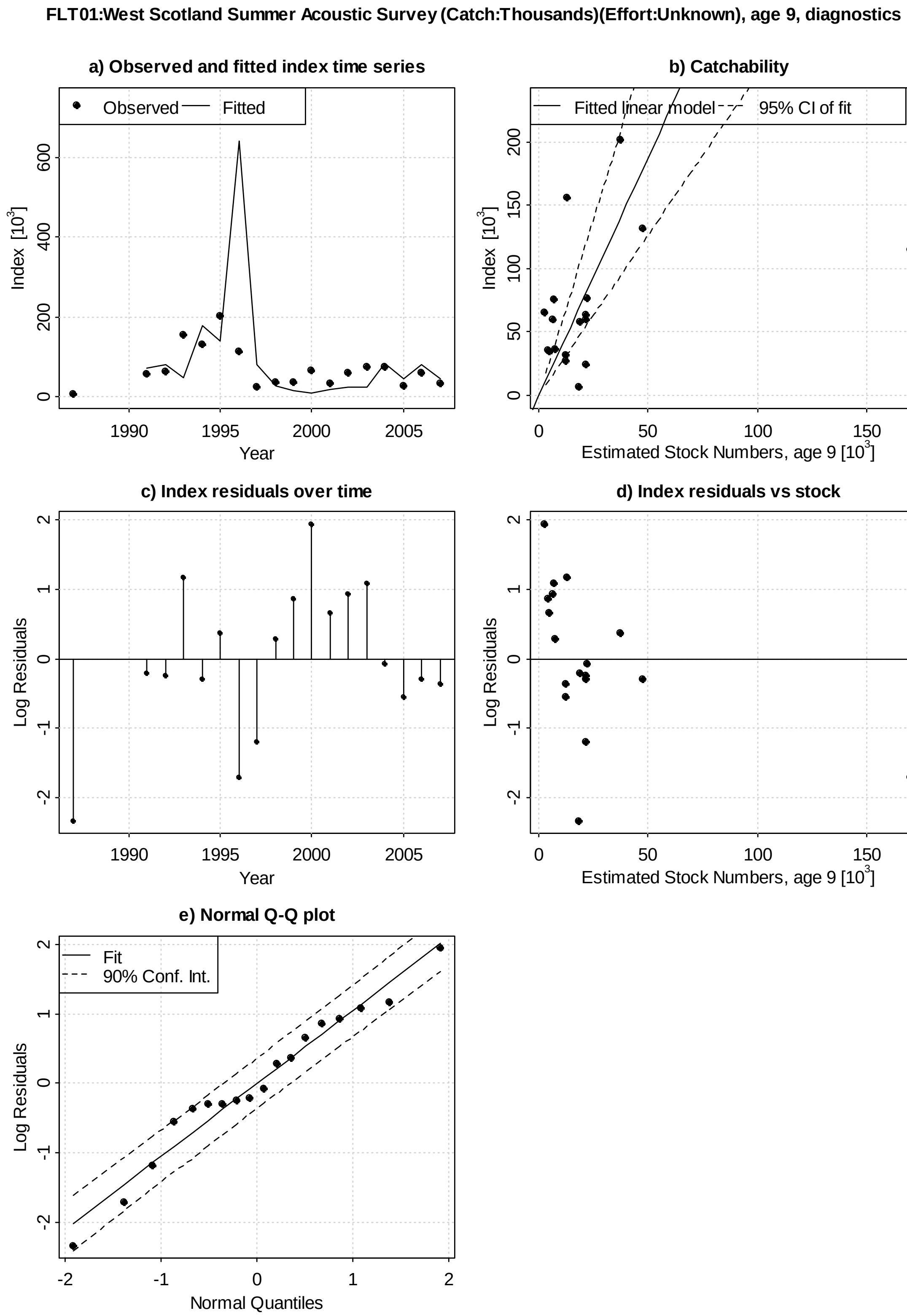


Figure 5.6.13 Herring in VIa (N), illustration of residuals from deterministic calculation (8-year separable period). Diagnostics of the fit of the 9-ring index against the acoustic surveys. Top left, fitted populations (line), and predictions of abundance in each year made from the index observations and estimated catchability (triangles +/- standard deviation), plotted by year. Top right, scatter plot and fitted relationship of abundance from fitted populations of 9 ringers in acoustic surveys. Bottom, residuals, as ln(observed index) - ln(expected index) plotted against expected values and against time.

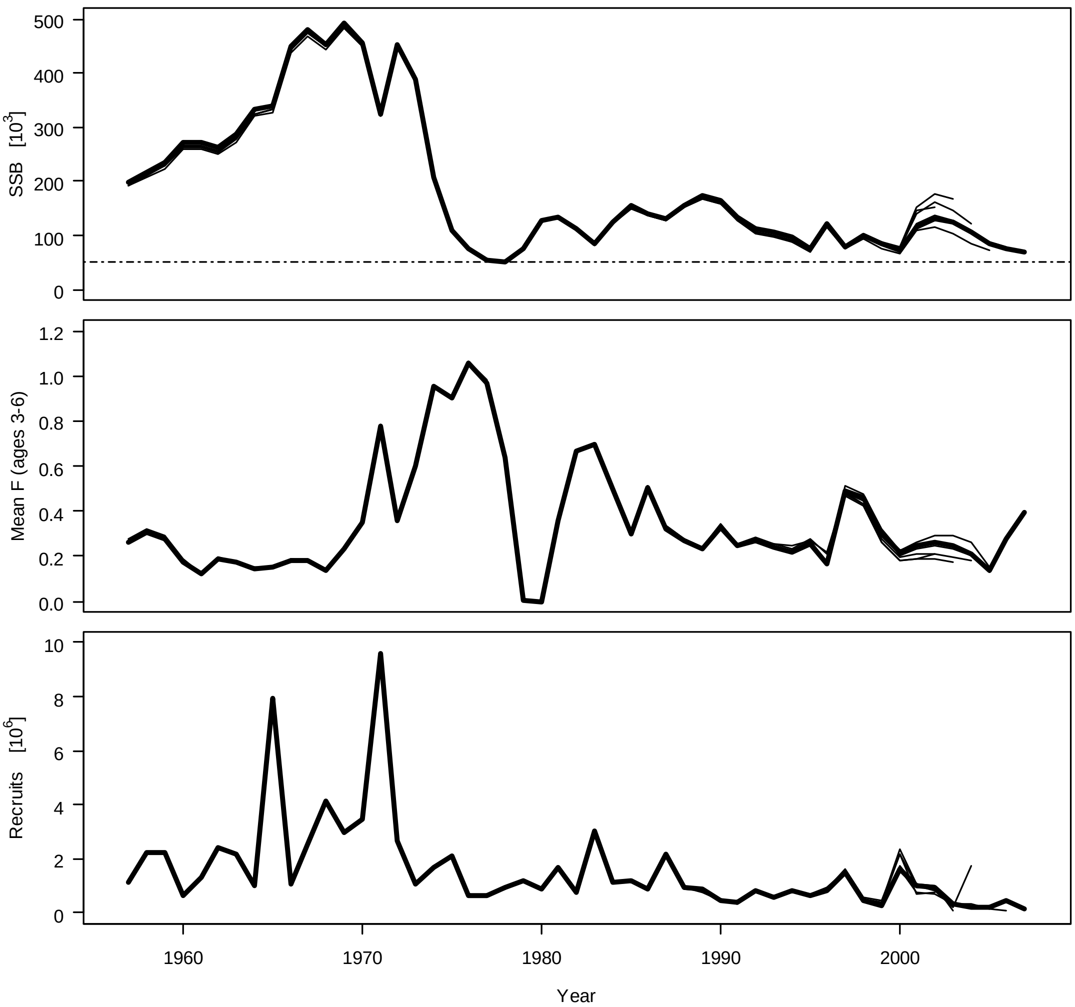
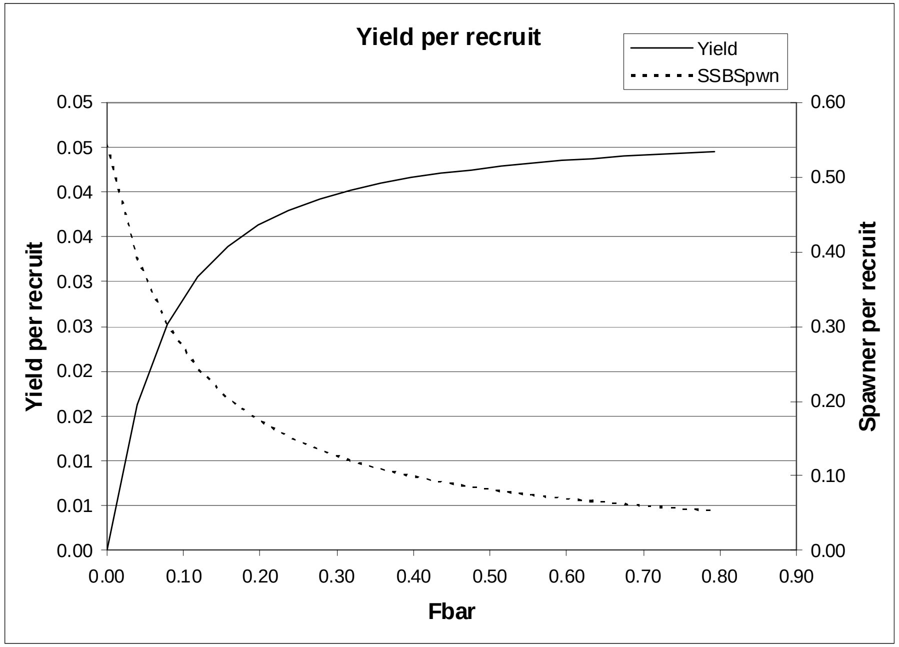
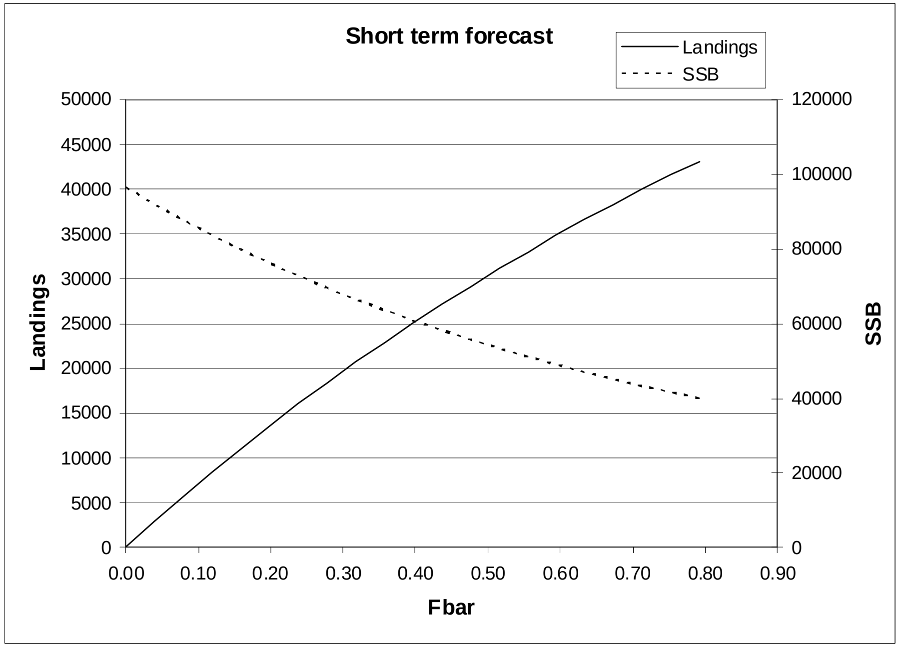


Figure 5.6.14 Herring in VIa (North). Analytical retrospective patterns (2007 to 2003) of SSB, mean F3-6 and recruitment from the final assessment.





MFYPR version 2a
Run: TAC
Time and date: 17:56 14/03/2008

Reference point	F multiplier	Absolute F
Fbar(3-6)	1.0000	0.3962
FMax	>=1000000	
F0.1	0.4592	0.1819
F35%SPR	0.4411	0.1748

Weights in kilograms

MFDP version 1a
Run: TAC
Herring VIaN
Time and date: 13:11 14/03/2008
Fbar age range: 3-6

Input units are thousands and kg - output in tonnes

Figure 5.7.1 Herring in VIa (North). Yield-per-recruit and short-term forecast.

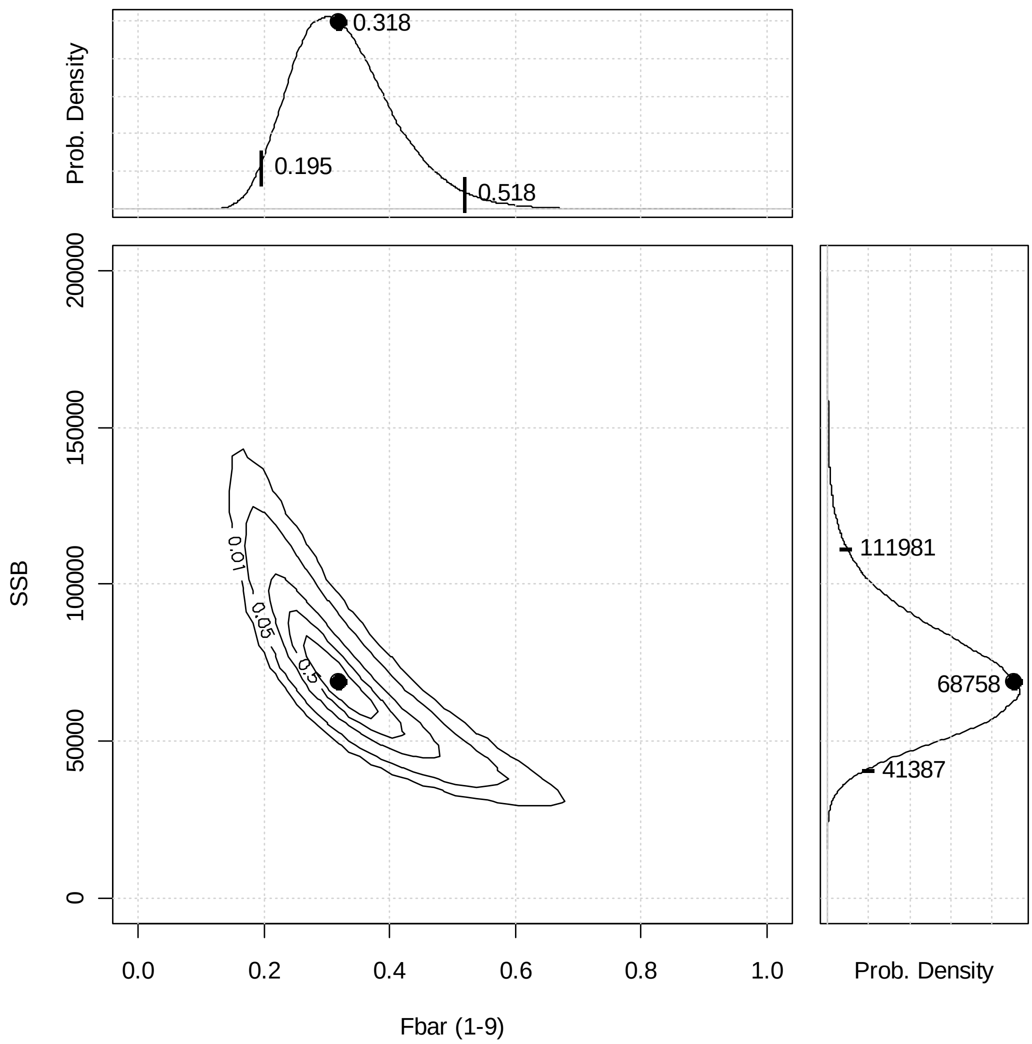


Figure 5.10.1 Model uncertainty; distribution and quantiles of estimated SSB and F in the terminal year of the assessment. Estimates of precision are based on a parametric bootstrap from the FLICA estimated variance/covariance estimates from the model.

6 Herring in Divisions VIa (South) and VIIb,c (Exploratory Assessment)

6.1 The Fishery

6.1.1 Advice and management applicable to 2007 – 2008

The TAC for this area in 2007 was 13 800 t with a decrease to over 11 600 t in 2008. For 2008, ICES advised that current SSB was unknown but likely to be below B_{lim} (81 000 t). Fishing mortality increased concomitantly with increased catch in 2006 and is likely to be above F_{pa} (0.22) and $F_{lim.}$ (0.33). ICES advised that fishing should not be allowed unless accompanied by a recovery plan. An element of this plan should include further reductions in catch. This plan should be evaluated with respect to the precautionary approach.

In 2000, the Irish North West Pelagic Management Committee was established to deal with the management of this stock. The objectives of this committee have remained unchanged and are outlined below.

- 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.

6.1.2 Catches in 2007

The working group estimates of landings recorded by each country from this fishery from 1988 – 2007 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 2007 was over 12 500 t, compared with 15 200 t in 2006. The total catches in these areas from 1970 –2007 are shown in Figure 6.1.2.1.

In 2008, as in 2007, landings data were revised with respect to reallocation of catches between area VIaS and VIaN. Prior to 2000 (1970-1999) all Irish catches reported in VIaN were reassigned to VIaS. This procedure was supported in a revision of the historical time series in VIaN presented at the HAWG in 2004. For the years 2000-2005, various procedures were used, based on consultations with stakeholders. In some years some catches were reallocated, while in others no reallocations were made. In 2007, it was decided that the most correct procedure was that used before 2000. Therefore a retrospective reallocation was conducted for the years 2000-2005, and extended to 2007. It is recognised that this procedure is not entirely correct. It is known that Irish vessels take catches of VIaN herring on an opportunistic basis, whilst fishing for mackerel or returning to Ireland, from mackerel trips. The revised reallocation does not consider this phenomenon. However, in the absence of better information on Irish directed herring fishing in VIaN, this procedure provides the best possible method. In 2007 and 2008 there have been small quantities of unallocated catches in this area.

There were no estimates of discards reported for 2007 and anecdotal reports from the industry are that discarding is not a major problem in this fishery at the present time. In September 2004 a new procedure was adopted for weighing landings and the allowance for water content was reduced from 14% to 2% therefore the catch data for 2004 are lower than previous years. It is thought that the data from 2003 and previously are directly comparable because the same water content was being adopted.

6.1.3 The fishery in 2007

The assessment period runs concurrently with the annual quota, with quotas allocated on a weekly basis. In recent years Ireland is the dominant country participating in this fishery. In 2007 all of the catches were reported from quarters 1 and 4 in VIaS with comparatively small catches reported from VIIb,c. In the first quarter the season opened on the 3rd of January and closed on the 9th February. Fishing reopened in the fourth quarter on the 21st October and closed on the 23rd of November when the quota was exhausted. The distribution of the landings from this area is presented in Figure 6.1.3.1. This corresponds with information from the fishing industry, who reported that the main herring concentrations in 2007 were in the southern part of VIaS. The industry has also observed large concentrations of herring in the northern part of VIaS in recent years.

A total of 57 boats, categorised as follows took part in the fishery in 2007:

- 22 Pelagic RSW boats with refrigerated seawater storage
- 6 polyvalent RSW boats with refrigerated seawater storage
- 4 polyvalent tank hold boats with refrigeration
- 25 polyvalent dry hold boats with no refrigeration

Polyvalent is a term used to define part of the Irish fleet licensed to catch pelagic and demersal fish.

6.1.4 Regulations and their effects

Changes to the management of this stock have influenced the way the fishery is prosecuted in space and time. The RSW vessels do not have access to the spawning grounds within a 12-mile limit. Fish on the spawning grounds are targeted largely by dry hold vessels only.

The implementation of the closed season from March to October has been successful in ensuring that the fishery mainly concentrates on the spawning component in this area. This regulation tends to confine effort to spawning components in this area, and to prevent fisheries on mixed components.

6.1.5 Changes in fishing technology and fishing pattern

There have been no significant changes in the fishing technology of the fleets in this area.

The pattern of this fishery has changed over time. In the early part of the 20th century the main spawning components were the winter spawners off the north coast, and this was where the main fishery took place. In the 1970s and 1980s the west of Ireland autumn-spawning components were dominant and the fishery was mainly distributed along the coasts of VIIb,c and VIaS. More recently the northern grounds are regaining importance.

6.2 Biological composition of the catch

6.2.1 Catch in numbers-at-age

Catch-at-age data for this fishery are available since 1970 and are shown in Table 6.2.1.1 with percentages since 1994 shown in Table 6.2.1.2. In 2007 the fishery has been dominated by 2-, 3- and 4-ringers, accounting for 22%, 39% and 21% respectively. One ringers are never well represented in the catch and normally do not show up in the catch until quarter 3. In any case, the abundance of 1-ringer in the catches has been lower in the past three years than at any time in the series. The 2007 profile shows a similar age profile to 2006 with a peak in 3-ringers. The catch numbers at age have been mean standardised and are presented in Figure 6.2.1.1. The low numbers of 1-ringers and the truncation of older ages can be clearly seen.

Three-ring fish dominate the catch in quarter 4 while in quarter 1, 2-ringers are most abundant. Overall, quarter 1 has a greater proportion of older age classes which represent the larger spring spawners. Sampling data indicates that herring are fully recruited to the fishery at 3-ringers and there is little evidence for 1-ringer fish being an important component of landings in fisheries in this area.

6.2.2 Quality of the catch and biological data

The management of the Irish fishery in recent years has tightened considerably and the accuracy of reported catches is also believed to have improved. The numbers of samples and the associated biological data are shown in Table 6.2.2.1. As Ireland is the main participant in this fishery all of the sampling is carried out by Ireland. The length distributions of the catches taken per quarter by the Irish fleet are shown in Table 6.2.2.2. The number of samples collected per tonne in VIIb was much better in 2007, though overall landings in this area are very small. In 2007, 2 samples were collected in VIIb. Sampling in this fishery relies heavily on the vessels that concentrate their effort on the inshore grounds.

6.3 Fishery Independent Information

6.3.1 Ground Fish Surveys

There are currently no recruitment indices available for this stock. However an Irish ground fish survey has been conducted in the area since the early 1990s and regularly catches herring. This survey is of little utility as a herring recruit index, because gear, timing and survey vessel changed throughout. The new time series began in 2004 and was explored as a possible recruit index. The data are highly variable from year to year and showed no clear signals. It was decided that it cannot be used at the current time (Johnston, 2008, WD 06). In particular, a strong abundance of 0-group in 2005 was not found in the acoustic survey or the catch data but it was seen in the groundfish data. The lack of signal in this data corresponds with the lack of signal in the acoustic abundance and catch numbers at age. Future work could include the possible use of Scottish groundfish survey to investigate trends in cohorts.

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 (Table 6.3.2.1). A problem with the winter acoustic survey series has been synchronising the survey with the peak spawning event to ensure containment of the stock. The winter surveys that were carried out from 2004 – 2007 varied sharply in age profile and biomass estimates, and were not considered reliable. Bad weather often affected the survey as it took place in January. Also it was recognised that synoptic coverage of a stock that spawns over a period from October to February in an area spanning all of Divisions VIaS and VIIb cannot be achieved with a winter survey. Thus the series was discontinued in 2007. The review group of the 2007 assessment highlighted that although there is an acoustic abundance estimate, the historical series is too short to consider it as a tuning survey in an analytical assessment.

The WESTHER project recommended that the survey effort along the Malin shelf area (including VIaN, VIaS, VIIb,c, Clyde and Irish Sea) should be increased or diverted to a combined survey on non-spawning herring. In 2008 PGHERS (CM 2008/LRC:01) discussed the possibility of conducting synoptic summer surveys on the Malin shelf. In 2008, the Irish survey of VIaS, VIIb,c will be conducted in July with effort concentrating on summer feeding aggregations. As this survey will be the first in a new survey time series transect resolution will be set at a high intensity throughout the survey as a means to accurately determine the distribution of summer feeding aggregations to the west and northwest of Ireland. There will be overlap between the Scottish and Irish surveys in the area around 56° N. The results of these surveys will be convened through PGHERS in 2009.

6.4 Mean weights-at-age and maturity-at-age

6.4.1 Mean Weights at Age

The mean weights (kg) at age in the catches in 2007 are based on Irish catches and are very similar to 2006 for ringers 2-7 (Figure 6.4.1.1). These mean weights display quite a stable pattern over the time series, though there appears to be a slight increase in mean weights of 1-ringers in the past four years. Fluctuations can also be seen in the oldest two ages. Generally the oldest and youngest ages are poorly represented in the catch data.

The mean weights in the stock at spawning time have been calculated from Irish samples taken during the main spawning period that extends from October to February (Figure 6.4.1.2). As in the mean weights at age there appears to be a slight decrease in oldest age and an increase in the youngest age over the last three years.

6.4.2 Maturity Ogive

One-ringers are considered to be immature and they do not contribute to the SSB. A maturity ogive has been produced from the acoustic survey data and show that northwest herring are 100% mature at 2 winter rings. This corresponds with the constant maturity ogive that is assumed for this stock and used in the assessment.

6.5 Recruitment

There is little information on recruitment in the catch at age data and there are as yet no recruitment indices from the surveys. Numbers of 1-ringers in the catches vary widely but have been consistently low in the most recent years. Further investigations on the use of the groundfish survey data as a possible index of recruitment will be carried out.

6.6 Stock Assessment

6.6.1 Data Exploration

A detailed analysis of basic data, including age composition of catches, log catch ratios and cohort catch curves was conducted in recent years and is presented in the Stock Annex (Annex 7). There has been a truncation in older age groups in recent years, and in most recent years, a paucity of recruits also. Log catch ratios show an upward trend in raw mortality on fully recruited year classes, since the mid 1990s. Catch curves show low mortality on the very large 1981, 1985 and 1988 year classes. These represent three of the biggest year classes recruited to this fishery. Low mortality was evident in the 1970s and increased mortality can be seen from 1990 on.

6.6.2 Exploratory Assessment

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 3-winter rings. This assessment is still exploratory, and no assessment has been accepted in recent years.

Three assessment runs using the separable VPA are presented, based on the three choices of terminal F. Recruitment, SSB and mean F from each run are plotted in Figure 6.6.2.1. This figure is more informative for the converged part of the VPA, but in most recent years has little information on the current stock dynamics. Outputs from separable VPAs with terminal Fs of 0.2, 0.4 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 exploratory assessments are presented in Figure 6.6.2.2. A strong negative residual pattern can be seen in 6 ringers, with other strong year effects also. A comparison with the 2007 separable VPA runs is shown in Figure 6.6.2.3.

Fishing mortality was highest in the series in 1998. Subsequent Fs have been lower but still above the long term average in each case. There was a sharp rise in F in 2006, associated with an increased catch in that year.

Recruitment appears to have remained stable at a low level with terminal F=0.4 or 0.6. A higher level of recruitment is estimated with terminal F=0.2. Each scenario shows recruitment to be at a similar level in the final year and this is calculated using the geometric mean of the recruitment index over the entire time series.

SSB 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}. Only a terminal F of 0.2 suggests some good recruitments in recent years however there is no evidence in the observed catch numbers at age to suggest that this is so.

These explorations are only useful as indicators of historic trends. These results are consistent with the preliminary data screening that shows no stronger year classes in the fishery in recent years.

A retrospective assessment was conducted for each of the F scenarios. Using a terminal F = 0.2 (Figure 6.6.2.4) overestimates SSB and underestimates F. Using a terminal F = 0.4 (Figure 6.6.2.5) displays a much more stable estimation of SSB and the overestimation of F is not as pronounced. The retrospective assessment using F=0.6

(Figure 6.6.2.6) shows SSB to be quite stable, with some tendency to underestimate in most years, and a tendency for mean F to be overestimated.

The results of the retrospective analysis suggest that using a terminal F of 0.4 produces more stable estimates of SSB and F than smaller or larger values. This suggests that recent F has been in the range of 0.4.

6.6.3 State of the Stock

The results of the non-tuned assessment suggest that the sharp decline in SSB may have stopped but the current level of SSB is uncertain but is likely to be below B_{lim}. There is no evidence that large year classes have recruited to the stock in recent years and F appears to have been reduced due to the decrease in catch. Overall F in recent years is much higher than the period prior to the mid nineties. The perception of stock trends is consistent, even though the most recent estimates of SSB and F are uncertain.

6.7 Short term projections

In the absence of an agreed assessment, it was not considered informative to carry out any predictions.

6.8 Medium term projections

Yield per recruit analyses were performed in 2006, and it is not considered necessary to update them. The results from this yield per recruit show $F_{0.1}$ = 0.17.

6.9 Precautionary and yield based reference points

As this assessment is still uncertain there was no revision of the precautionary reference points. The precautionary reference points for this stock were discussed in the 1999 Working Group Report (ICES 1999 ACFM:12). The present analysis, although uncertain, presents a similar picture of the stock as that shown in recent years. The SGPRP (ICES 2003/ACFM: 15) has reviewed the methodology for the calculation of biological reference points, and applying a segmented regression to the stock and recruit data from the 2002 HAWG assessment showed that the fit to the stock and recruit data for this stock was not significant. The stock is still likely below B_{pa} (110 000 t) but the fishing mortality has been relatively stable over the past number of years.

6.10 Quality of the Assessment

The exploratory assessment presented was based on the results from a separable VPA without a tuning index, therefore the estimates of SSB and F for recent years depend on the choice of terminal F. Although landings seem to have been stable in recent years the actual F cannot be determined. Therefore the VPA was run for a range of terminal F values and the current perception of the stock would be highly influenced by that choice. There is no information on recent recruitment levels both because the selectivity of the fishery appears to be low for the juveniles and also the lack of a recruitment index.

The retrospective analysis of the assessment suggests that an F of 0.2 underestimates mean F and SSB. Using the terminal F= 0.4 produces a more stable retrospective pattern. The highest F of 0.6 used shows an overestimation of F. Based on this information we can infer that F was in the region of 0.4

6.11 Management Considerations

Overall F in recent years is much higher than it was prior to the mid nineties. SSB may be stable at an historical low level, or even declining slightly. The peak in SSB in the 1980s may have been an isolated event. This stock should be exploited with caution. Though little information on recruitment is available, it is unlikely that it is above average and may possibly be below average. The long term catch aspiration of the local management committee is not likely to be achievable at current stock productivity.

Management objectives were reviewed by STECF in 2006 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. This management of this stock will be further discussed by SGHERWAY which are due to meet in late 2008. This group will begin to evaluate the management for this area, VIaN and VIIaN.

6.12 Environment

6.12.1 Ecosystem Considerations

Herring are an important prey species in the ecosystem and are also one of the dominant planktivorous fish. The spawning grounds for herring in this area are located in inshore areas close to the coast. These spawning grounds may contain one or more spawning beds on which herring deposit their eggs. Spawning grounds tend to be vulnerable to anthropogenic influences such as dredging and sand and gravel extraction. Similarly, trawling at or close to the bottom in known spawning areas can have the same detrimental effects.

Herring fisheries tend to be clean with little by-catch of other fish. Interactions between marine mammals and fishing vessels in this area have not been well documented.

6.12.2 Changes in the Environment

Sea surface temperature data have been collected from Malin Head on the north coast of Ireland since 1958. Since 1990 sea surface temperatures measured at stations along the northwest coast have displayed a sustained increasing trend. Winter temperatures have been >6^{o}C since 1990 with higher summer temperatures during the same period (Nolan and Lyons, 2006). There is evidence of increased salinity above the long term mean (ICES CM 2008/ ACOM:47). It is considered that this may have implications for herring. There is also evidence that productivity is currently lower than it was in the 1980s.

Table 6.1.2.1 VIa(S) and VIIb,c herring. Estimated Herring catches in tonnes, 1988–2007. 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	1998	1999
France	-	-	+	-	-	-	-	-	-	-	-	-
Germany, Fed.Rep.	-	-	-	-	250	-	-	11	-	-	-	-
Ireland	15000	18200	25000	22500	26000	27600	24400	25450	23800	24400	25200	16325
Netherlands	300	2900	2533	600	900	2500	2500	1207	1800	3400	2500	1868
UK (N.Ireland)	-	-	80	-	-	-	-	-	-	-	-	-
UK (England + Wales)	-	-	-	-	-	-	50	24	-	-	-	-
UK Scotland	-	+	-	+	-	200	-	-	-	-	-	-
Total landings	15300	21100	27613	23100	27150	30300	26950	26692	25600	27800	27700	18193
Unallocated/ area misreported	13800	7100	13826	11200	4600	6250	6250	1100	6900	-700	11200	7916
Discards	-	1000	2530	3400	100	250	700	-	-	50		
WG catch	29100	29200	43969	37700	31850	36800	33900	27792	32500	27150	38900	26109

Country	2000	2001	2002	2003	2004	2005	2006	2007
France	-	-	515	-	-	-	-	-
Germany, Fed.Rep.	-	-	-	-	-	-	-	-
Ireland	10164	11278	13072	12921	10950	13351	14840	12662
Netherlands	1234	2088	366	-	64	-	353	13
UK (N.Ireland)	-	-	-	-	-	-	-	-
UK (England + Wales)	-	-	-	-	-	-	-	-
UK Scotland	-	-	-	-	-	-	6	-
Total landings	11398	13366	13953	12921	11014	13351	15199	12675
Area misreported	8448	1390	3873	3581	2813	2880	4353	5129
Unallocated							-353	-13
Discards	-	-	-	-	-	-		
WG catch	19846	14756	17826	16502	13827	16231	19193	17791

Table 6.2.1.1 VIa(S) & VIIb,c herring. Catch in numbers-at-age (winter rings) from 1970 to 2007.

	1	2	3	4	5	6	7	8	9+
1970	135	35114	26007	13243	3895	40181	2982	1667	1911
1971	883	6177	7038	10856	8826	3938	40553	2286	2160
1972	1001	28786	20534	6191	11145	10057	4243	47182	4305
1973	6423	40390	47389	16863	7432	12383	9191	1969	50980
1974	3374	29406	41116	44579	17857	8882	10901	10272	30549
1975	7360	41308	25117	29192	23718	10703	5909	9378	32029
1976	16613	29011	37512	26544	25317	15000	5208	3596	15703
1977	4485	44512	13396	17176	12209	9924	5534	1360	4150
1978	10170	40320	27079	13308	10685	5356	4270	3638	3324
1979	5919	50071	19161	19969	9349	8422	5443	4423	4090
1980	2856	40058	64946	25140	22126	7748	6946	4344	5334
1981	1620	22265	41794	31460	12812	12746	3461	2735	5220
1982	748	18136	17004	28220	18280	8121	4089	3249	2875
1983	1517	43688	49534	25316	31782	18320	6695	3329	4251
1984	2794	81481	28660	17854	7190	12836	5974	2008	4020
1985	9606	15143	67355	12756	11241	7638	9185	7587	2168
1986	918	27110	24818	66383	14644	7988	5696	5422	2127
1987	12149	44160	80213	41504	99222	15226	12639	6082	10187
1988	0	29135	46300	41008	23381	45692	6946	2482	1964
1989	2241	6919	78842	26149	21481	15008	24917	4213	3036
1990	878	24977	19500	151978	24362	20164	16314	8184	1130
1991	675	34437	27810	12420	100444	17921	14865	11311	7660
1992	2592	15519	42532	26839	12565	73307	8535	8203	6286
1993	191	20562	22666	41967	23379	13547	67265	7671	6013
1994	11709	56156	31225	16877	21772	13644	8597	31729	10093
1995	284	34471	35414	18617	19133	16081	5749	8585	14215
1996	4776	24424	69307	31128	9842	15314	8158	12463	6472
1997	7458	56329	25946	38742	14583	5977	8351	3418	4264
1998	7437	72777	80612	38326	30165	9138	5282	3434	2942
1999	2392	51254	61329	34901	10092	5887	1880	1086	949
2000	4101	34564	38925	30706	13345	2735	1464	690	1602
2001	2316	21717	21780	17533	18450	9953	1741	1027	508
2002	4058	32640	37749	18882	11623	10215	2747	1605	644
2003	1731	32819	28714	24189	9432	5176	2525	923	303
2004	1401	15122	32992	19720	9006	4924	1547	975	323
2005	209	28123	30896	26887	10774	5452	1348	858	243
2006	598	22036	36700	30581	21956	9080	2418	832	369
2007	76	24577	43958	23399	13738	5474	1825	231	131

Table 6.2.1.2 VIa(S) & VIIb,c herring. Percentage age composition (winter rings).

	1	2	3	4	5	6	7	8	9+
1994	6	28	15	8	11	7	4	16	5
1995	0	23	23	12	13	11	4	6	9
1996	3	13	38	17	5	8	4	7	4
1997	5	34	16	23	9	4	5	2	3
1998	3	29	32	15	12	4	2	1	1
1999	1	30	36	21	6	3	1	1	1
2000	3	27	30	24	10	2	1	1	1
2001	2	23	23	18	19	10	2	1	1
2002	3	27	31	16	10	9	2	1	1
2003	2	31	27	23	9	5	2	1	0
2004	2	18	38	23	10	6	2	1	0
2005	0	27	29	26	10	5	1	1	0
2006	0	18	29	25	18	7	2	1	0
2007	0	22	39	21	12	5	2	0	0

Table 6.2.2.1 VIa(S) and VIIb,c herring. Sampling intensity of catches in 2007.

ICES area	Year	Quarter	Landings (t)	No. Samples	No. aged	No. Measured	Aged/1000 t
VIaS	2007	1	5588	17	1047	3353	187
VIaS	2007	4	6398	11	595	2141	93
VIIb	2007	1	5	0	0	0	0
VIIb	2007	4	515	2	109	322	212
VIIc	2007	4	155	0	0	0	0
Total North West			12661	30	1751	5816	492

Table 6.2.2.2 VIa(S) and VIIb,c herring. Length distribution of Irish catches/quarter (thousands) 2007.

Length cm	Quarter 1 VIa South	Quarter 4 VIIbc	Quarter 4 VIa South	Total
20				
20.5				
21				
21.5				
22	114			114
22.5	194	12	36	242
23	319	0	163	482
23.5	536	58	596	1190
24	1083	105	1192	2380
24.5	1961	233	2854	5048
25	2907	210	4625	7741
25.5	4252	384	4733	9370
26	5643	361	4697	10701
26.5	5370	431	4878	10678
27	5085	675	5329	11089
27.5	4218	431	4841	9490
28	2964	408	2674	6045
28.5	2029	245	1463	3737
29	958	163	379	1500
29.5	308	35	163	505
30	114		54	168
30.5	46			46
31	57			57
31.5	11			11
32	0			0
32.5	0			0
33	11			11
33.5	46			46
34				
Nos./t	38225	3750	38677	80653

Table 6.3.2.1 VIa(S) & VIIb,c herring. Time series of acoustic surveys since 1999. This series is now discontinued and no survey was conducted in quarter 1, 2008.

Winter rings	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
0	-	-	5	0	-	0.09	1.28	0	-	-
1	18.99	10.71	22.69	35.7	10.28		7.83	1.6	0.3	-
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 6.6.2.1 VIa(S) and VIIb,c herring. VPA run with a terminal F value of 0.2

	RECRUITS Age 1	**TOTALBIO**	**TOTSPBIO**		**YIELD/SSB**	**SOPCOFAC**	**FBAR 3- 6**
1970	403604	200778	126262	20306	0.1608	0.8968	0.1823
1971	811716	218936	110373	15044	0.1363	0.8707	0.1629
1972	730488	229116	116077	23474	0.2022	0.8975	0.2046
1973	532144	259409	147443	36719	0.249	1.0162	0.2886
1974	587134	201881	90497	36589	0.4043	0.9762	0.4539
1975	404377	197360	96533	38764	0.4016	1.1237	0.4426
1976	682473	187877	66909	32767	0.4897	1.0472	0.5072
1977	573495	178940	75890	20567	0.271	1.0778	0.3228
1978	1037282	223453	71252	19715	0.2767	1.0161	0.2657
1979	964763	261717	103003	22608	0.2195	1.0664	0.2757
1980	528121	198825	98557	30124	0.3056	0.9636	0.4
1981	672060	215101	99282	24922	0.251	1.0312	0.3204
1982	690199	225209	109768	19209	0.175	1.0301	0.2311
1983	2285722	421099	104751	32988	0.3149	1.0042	0.3703
1984	951864	340899	178715	27450	0.1536	0.9688	0.2099
1985	1218126	348852	183230	23343	0.1274	0.9846	0.1749
1986	938930	361070	217653	28785	0.1323	0.9834	0.185
1987	3211805	558801	189824	48600	0.256	0.9488	0.3523
1988	477100	422641	295910	29100	0.0983	0.9992	0.2761
1989	712664	371626	220781	29210	0.1323	1.001	0.1849
1990	809453	338119	190819	43969	0.2304	1.0006	0.2636
1991	502901	266807	165151	37700	0.2283	0.9971	0.247
1992	415932	215142	132112	31856	0.2411	0.9951	0.2766
1993	615404	231726	113565	36763	0.3237	1.006	0.357
1994	801980	212902	94656	33908	0.3582	0.998	0.3631
1995	469934	164058	83524	27792	0.3327	1.0525	0.4675
1996	833154	170018	62847	32534	0.5177	0.9955	0.5829
1997	822733	173356	64539	27225	0.4218	1.0016	0.5337
1998	528902	142747	52797	38895	0.7367	0.9988	1.0202
1999	391790	114605	45215	26109	0.5774	1.0018	0.6762
2000	450165	103967	37801	19846	0.525	1.0011	0.5002
2001	466199	95001	35509	14756	0.4156	0.9988	0.6259
2002	593719	109306	35002	17826	0.5093	0.9991	0.6837
2003	538986	111818	41233	16502	0.4002	1.002	0.6056
2004	652933	117450	46494	13727	0.2952	1.0006	0.5137
2005	802689	149830	52893	16231	0.3069	0.9986	0.465
2006	893932	167815	60908	19193	0.3151	1.0012	0.5692
2007	694464*	110771	75975	17791	0.2342	1	0.3259

*geomean

Table 6.6.2.2 VIa(S) and VIIbc herring. VPA run using a terminal F or 0.4

	RECRUITS Age 1	TOTALBIO	TOTSPBIO	LANDINGS	YIELD/SSB	SOPCOFAC	FBAR 3- 6
1970	405406	203204	128332	20306	0.1582	0.8968	0.1798
1971	815750	221363	112240	15044	0.134	0.8707	0.1605
1972	734791	231685	118031	23474	0.1989	0.8975	0.2022
1973	535671	263384	150739	36719	0.2436	1.0162	0.2856
1974	591237	204085	92113	36589	0.3972	0.9762	0.4489
1975	408159	199865	98407	38764	0.3939	1.1237	0.4359
1976	689063	190239	68345	32767	0.4794	1.0472	0.498
1977	579673	181518	77510	20567	0.2653	1.0778	0.3159
1978	1050861	226858	72843	19715	0.2706	1.0161	0.2604
1979	979832	266117	105214	22608	0.2149	1.0664	0.2696
1980	536038	202411	100953	30124	0.2984	0.9636	0.3903
1981	680782	219320	102151	24922	0.244	1.0312	0.3107
1982	699993	229744	112812	19209	0.1703	1.0301	0.2242
1983	2316783	428574	108188	32988	0.3049	1.0042	0.3596
1984	964527	347521	183307	27450	0.1497	0.9688	0.2037
1985	1231079	355017	187637	23343	0.1244	0.9846	0.1701
1986	947373	367197	222501	28785	0.1294	0.9834	0.1804
1987	3236178	566106	194519	48600	0.2498	0.9488	0.3438
1988	479966	428869	301303	29100	0.0966	0.9992	0.2696
1989	715734	376467	224841	29210	0.1299	1.001	0.1812
1990	811367	342184	194411	43969	0.2262	1.0006	0.2591
1991	503548	269757	167850	37700	0.2246	0.9971	0.2432
1992	416158	217463	134267	31856	0.2373	0.9951	0.2739
1993	615622	233641	115357	36763	0.3187	1.006	0.3542
1994	802219	214411	96063	33908	0.353	0.998	0.361
1995	468988	164527	84060	27792	0.3306	1.0525	0.4654
1996	831804	170161	63107	32534	0.5155	0.9955	0.5816
1997	820042	173194	64639	27225	0.4212	1.0016	0.533
1998	525736	142286	52665	38895	0.7385	0.9988	1.0199
1999	386841	113750	44917	26109	0.5813	1.0018	0.6788
2000	441196	102529	37323	19846	0.5317	1.0011	0.5065
2001	445741	92236	34709	14756	0.4251	0.9988	0.6395
2002	543231	102860	33413	17826	0.5335	0.9991	0.7105
2003	452196	99525	37668	16502	0.4381	1.002	0.6489
2004	483458	95810	39660	13727	0.3461	1.0006	0.5815
2005	505367	106845	40085	16231	0.4049	0.9986	0.5721
2006	451995	100547	37732	19193	0.5087	1.0012	0.842
2007	665029*	60034	36648	17791	0.4855	1	0.6411
	*geomean						

Table 6.6.2.3 VIa(S) and VIIb,c herring. VPA run using a terminal F or 0.6

	RECRUITS Age 1	TOTALBIO	TOTSPBIO	LANDINGS	YIELD/SSB	SOPCOFAC	FBAR 3- 6
1970	406475	204610	129529	20306	0.1568	0.8968	0.1783
1971	818153	222775	113321	15044	0.1328	0.8707	0.1591
1972	737343	233184	119167	23474	0.197	0.8975	0.2009
1973	537757	265711	152666	36719	0.2405	1.0162	0.2839
1974	593667	205382	93062	36589	0.3932	0.9762	0.4459
1975	410406	201345	99511	38764	0.3895	1.1237	0.4321
1976	692974	191640	69196	32767	0.4735	1.0472	0.4927
1977	583325	183047	78471	20567	0.2621	1.0778	0.312
1978	1058890	228875	73786	19715	0.2672	1.0161	0.2574
1979	988678	268712	106522	22608	0.2122	1.0664	0.2661
1980	540666	204522	102366	30124	0.2943	0.9636	0.3847
1981	685874	221803	103844	24922	0.24	1.0312	0.3052
1982	705718	232409	114605	19209	0.1676	1.0301	0.2203
1983	2334839	432945	110209	32988	0.2993	1.0042	0.3537
1984	971843	351387	185996	27450	0.1476	0.9688	0.2003
1985	1238557	358607	190210	23343	0.1227	0.9846	0.1675
1986	952234	370757	225322	28785	0.1278	0.9834	0.1779
1987	3250158	570333	197245	48600	0.2464	0.9488	0.3391
1988	481611	432472	304425	29100	0.0956	0.9992	0.2659
1989	717497	379265	227189	29210	0.1286	1.001	0.1791
1990	812467	344531	196485	43969	0.2238	1.0006	0.2565
1991	503932	271457	169404	37700	0.2225	0.9971	0.241
1992	416303	218800	135507	31856	0.2351	0.9951	0.2723
1993	615777	234747	116387	36763	0.3159	1.006	0.3527
1994	802425	215288	96872	33908	0.35	0.998	0.3598
1995	468695	164828	84374	27792	0.3294	1.0525	0.4642
1996	831349	170288	63271	32534	0.5142	0.9955	0.5808
1997	819141	173196	64726	27225	0.4206	1.0016	0.5324
1998	524690	142154	52642	38895	0.7389	0.9988	1.0188
1999	385176	113477	44832	26109	0.5824	1.0018	0.679
2000	438228	102066	37178	19846	0.5338	1.0011	0.5086
2001	439526	91376	34448	14756	0.4284	0.9988	0.6441
2002	527824	100871	32907	17826	0.5417	0.9991	0.72
2003	423926	95584	36558	16502	0.4514	1.002	0.6646
2004	426210	88650	37480	13727	0.3662	1.0006	0.6077
2005	405275	92494	35871	16231	0.4525	0.9986	0.618
2006	311751	78798	29950	19193	0.6408	1.0012	0.9975
2007	652107*	43772	23641	17791	0.7525	1	0.95
	*geomean						

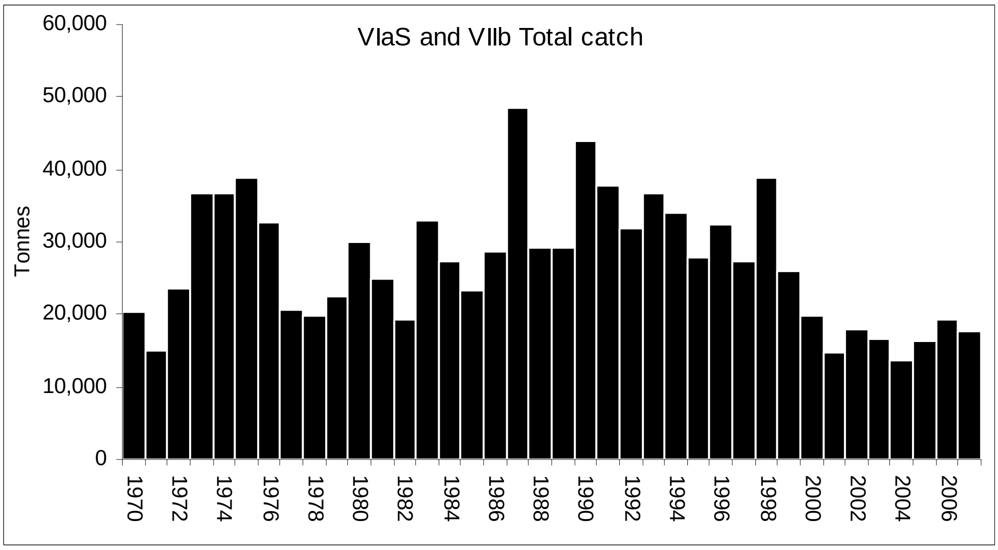


Figure 6.1.2.1 VIa(S) & VIIb,c herring. Working group estimate of catches from 1970-2007.

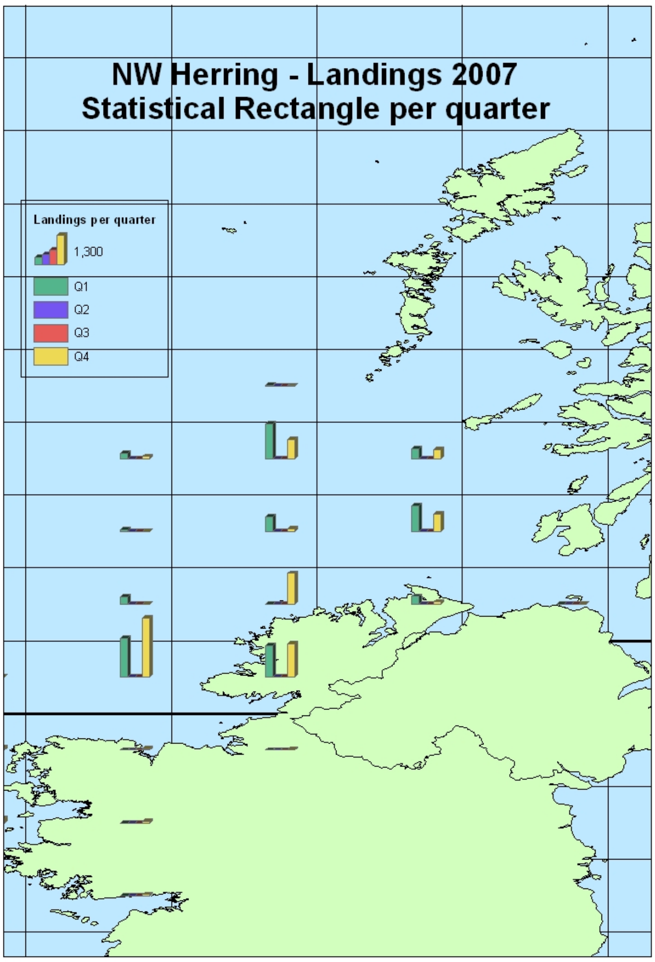


Figure 6.1.3.1 VIa(S) & VIIb,c herring. Distribution of Northwest herring landings in 2007.

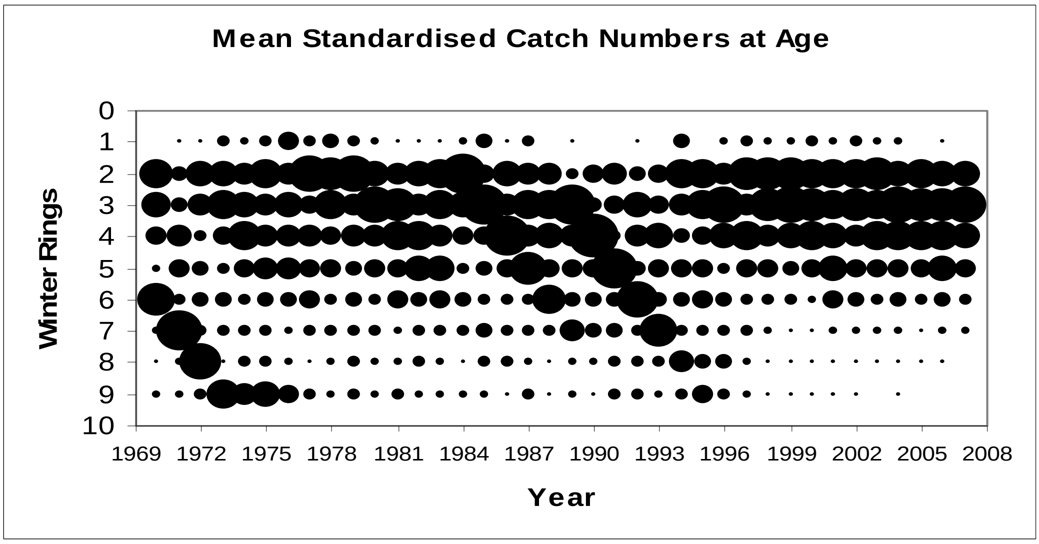


Figure 6.2.1.1 VIa(S) & Division VIIb,c herring. Mean standardised catch numbers at age standardised by year for the fishery.

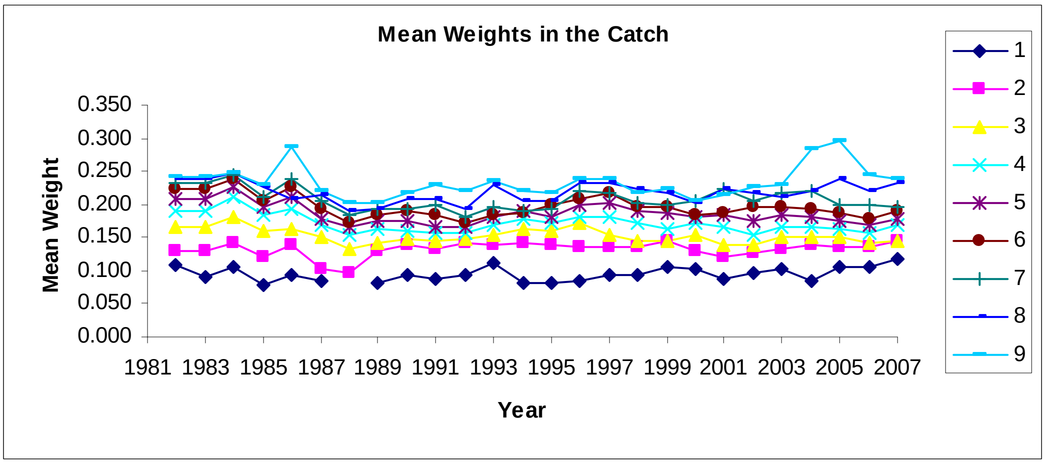


Figure 6.4.1.1 VIa(S) & Division VIIb,c herring. Mean Weights in the Catch.

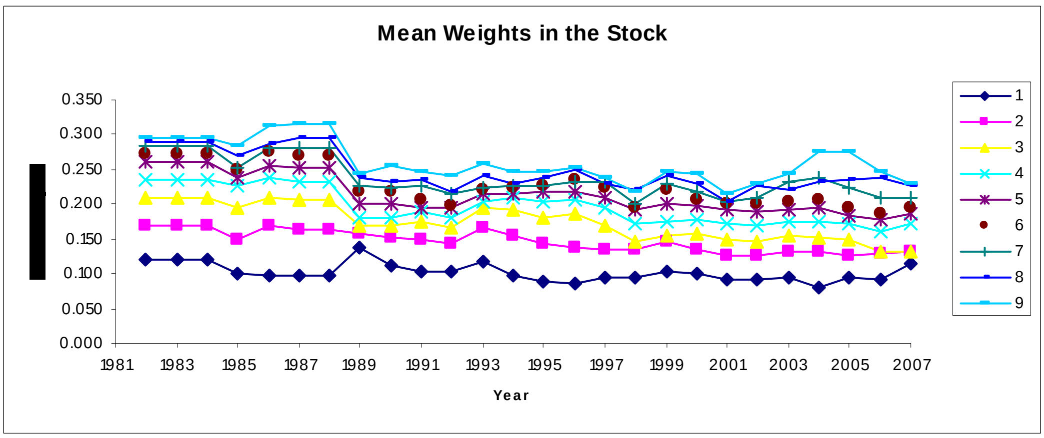


Figure 6.4.1.2 VIa(S) & Division VIIb,c herring. Mean weights in the stock.

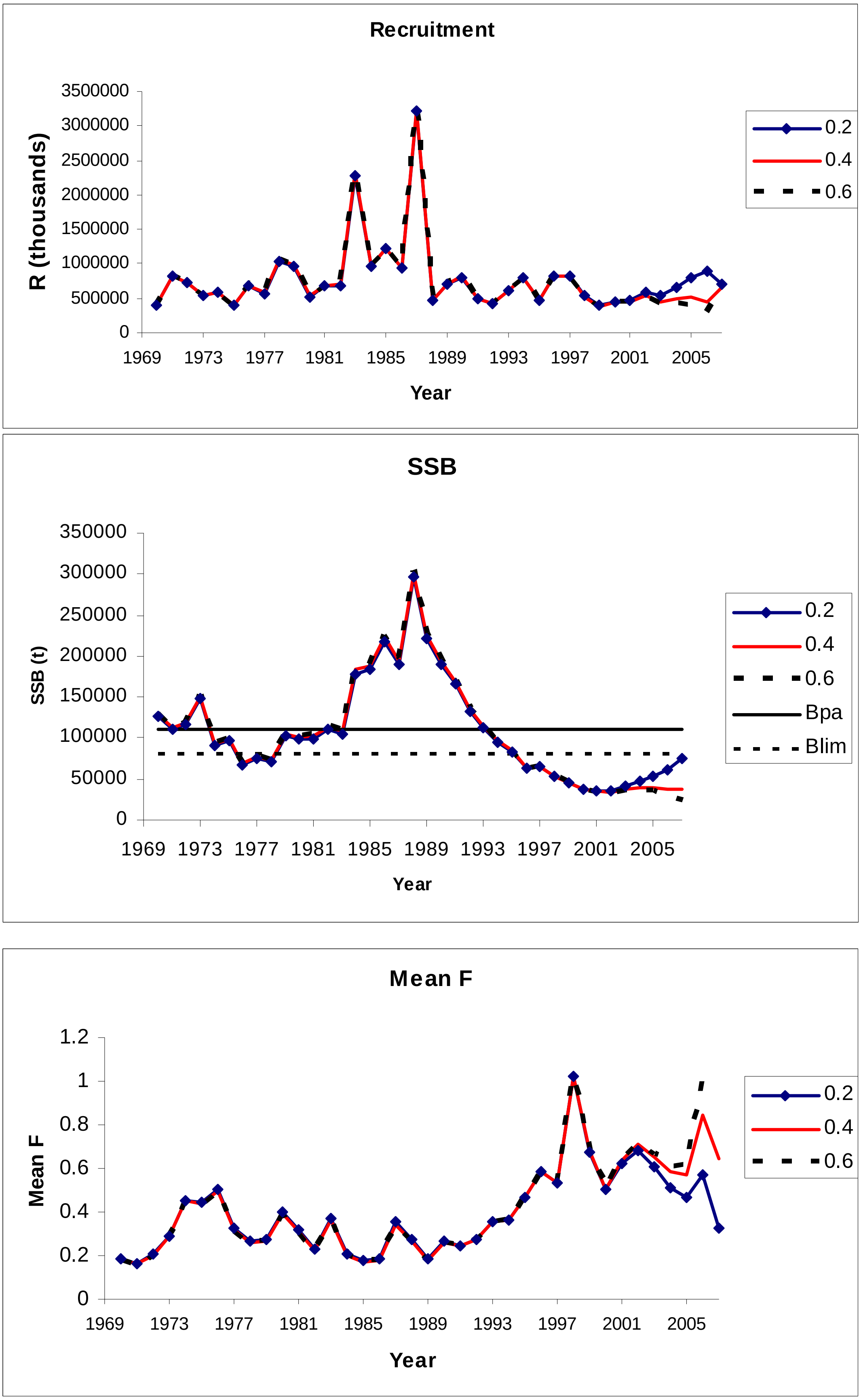


Figure 6.6.2.1 VIa(S) and VIIb,c herring. Three separable VPA runs using values of 0.2, 0.4 and 0.6 for terminal F.

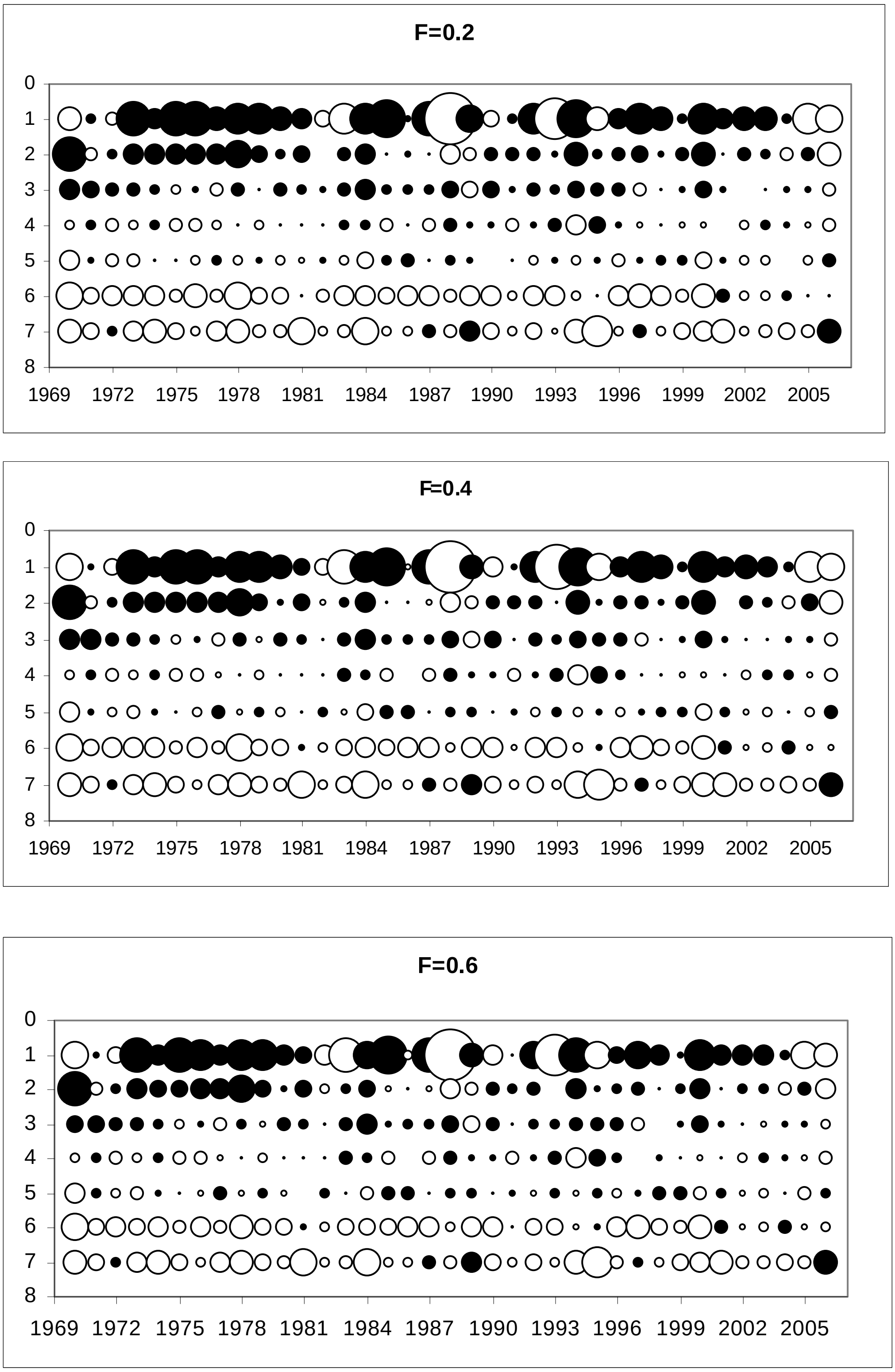


Figure 6.6.2.2 VIa(S) and VIIb,c herring. Residuals from three separable VPA runs using terminal F values of 0.2 (upper), 0.4 (middle) and 0.6 (lower). Black indicates positive residuals and white indicates negative.

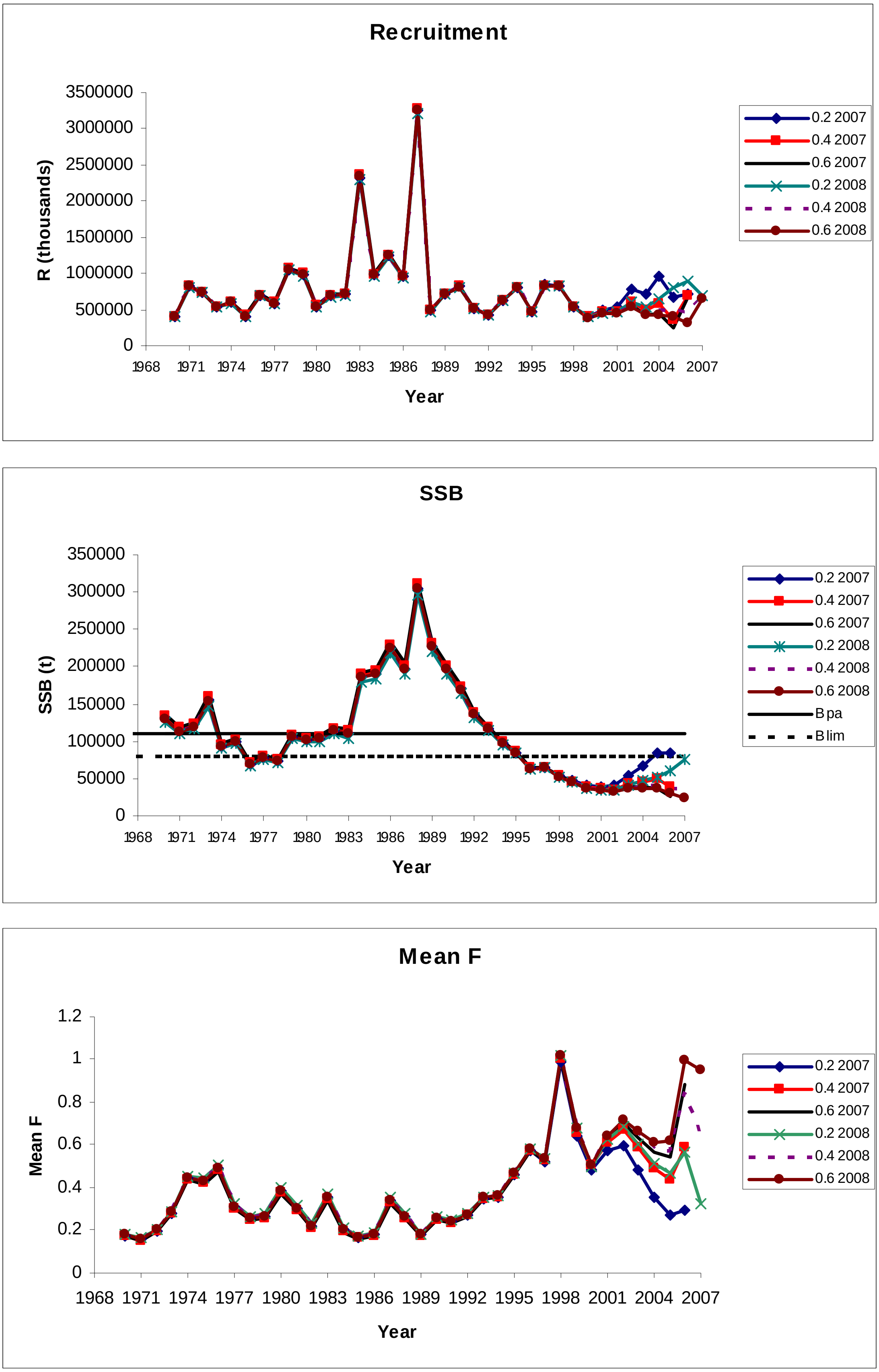
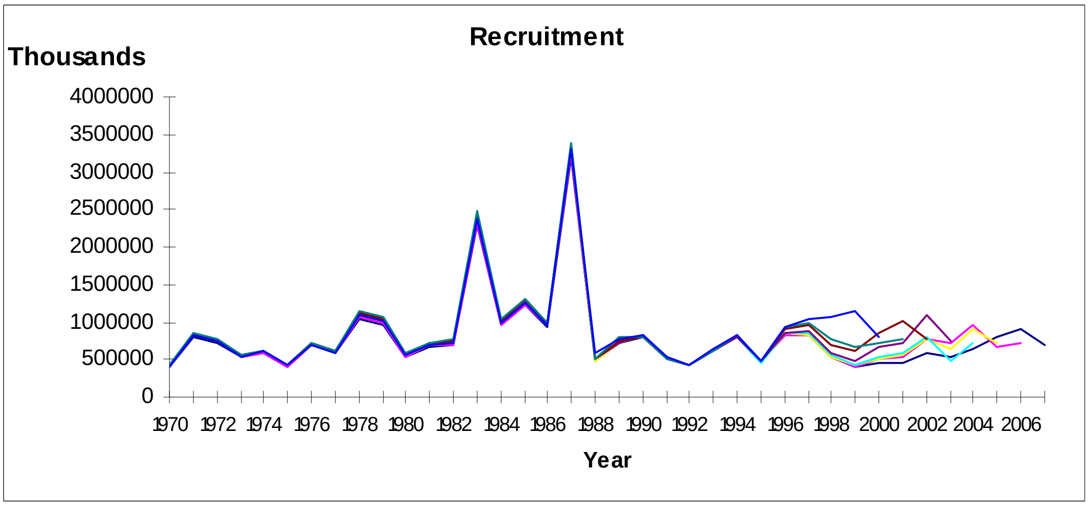
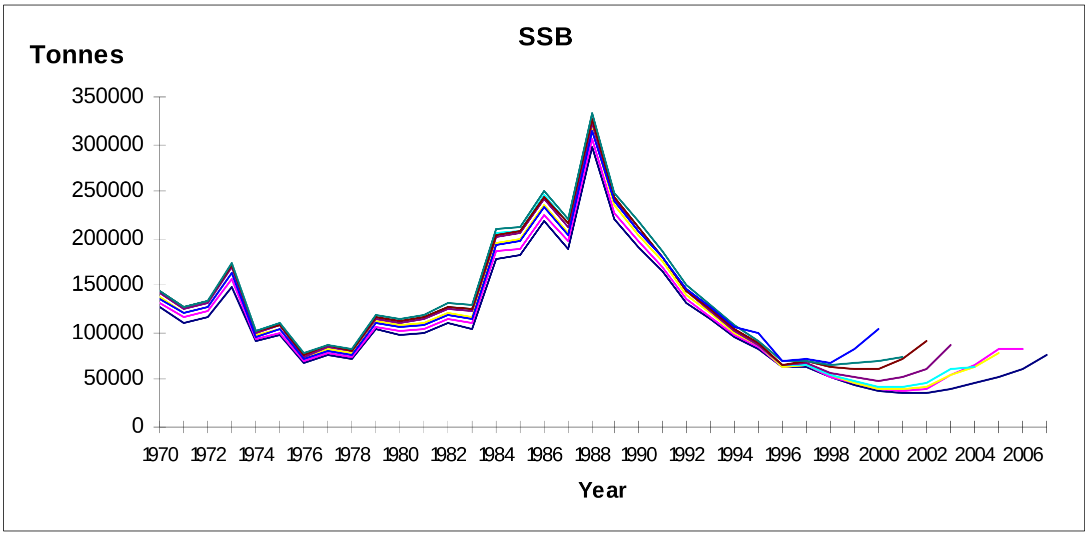


Figure 6.6.2.3 VIa(S) and VIIb,c herring. Comparison of three separable VPA runs of the current working group and the 2007 working group, using values of 0.2, 0.4 and 0.6 for terminal F.





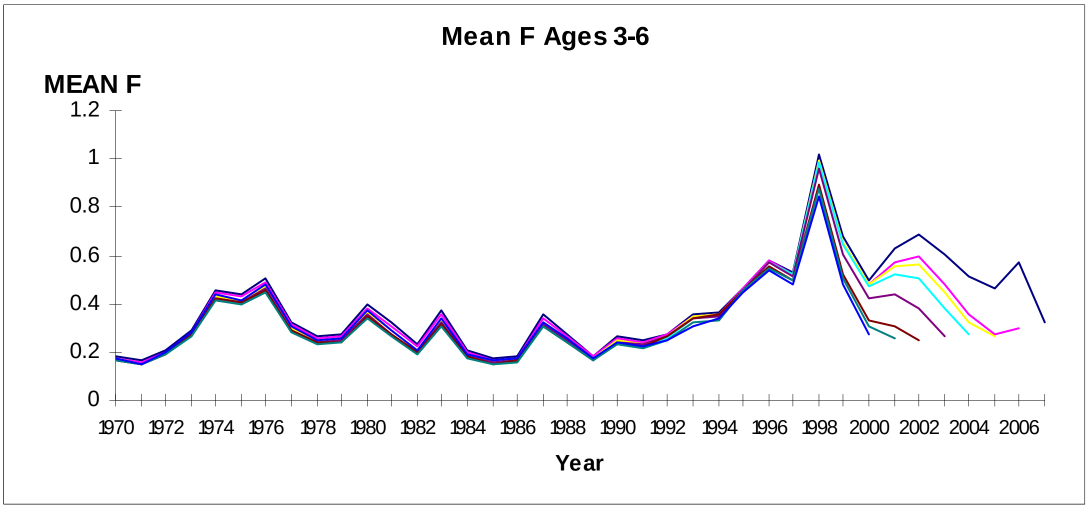


Figure 6.6.2.4 VIa(S) and VIIb,c herring. Retrospective assessment using F=0.2

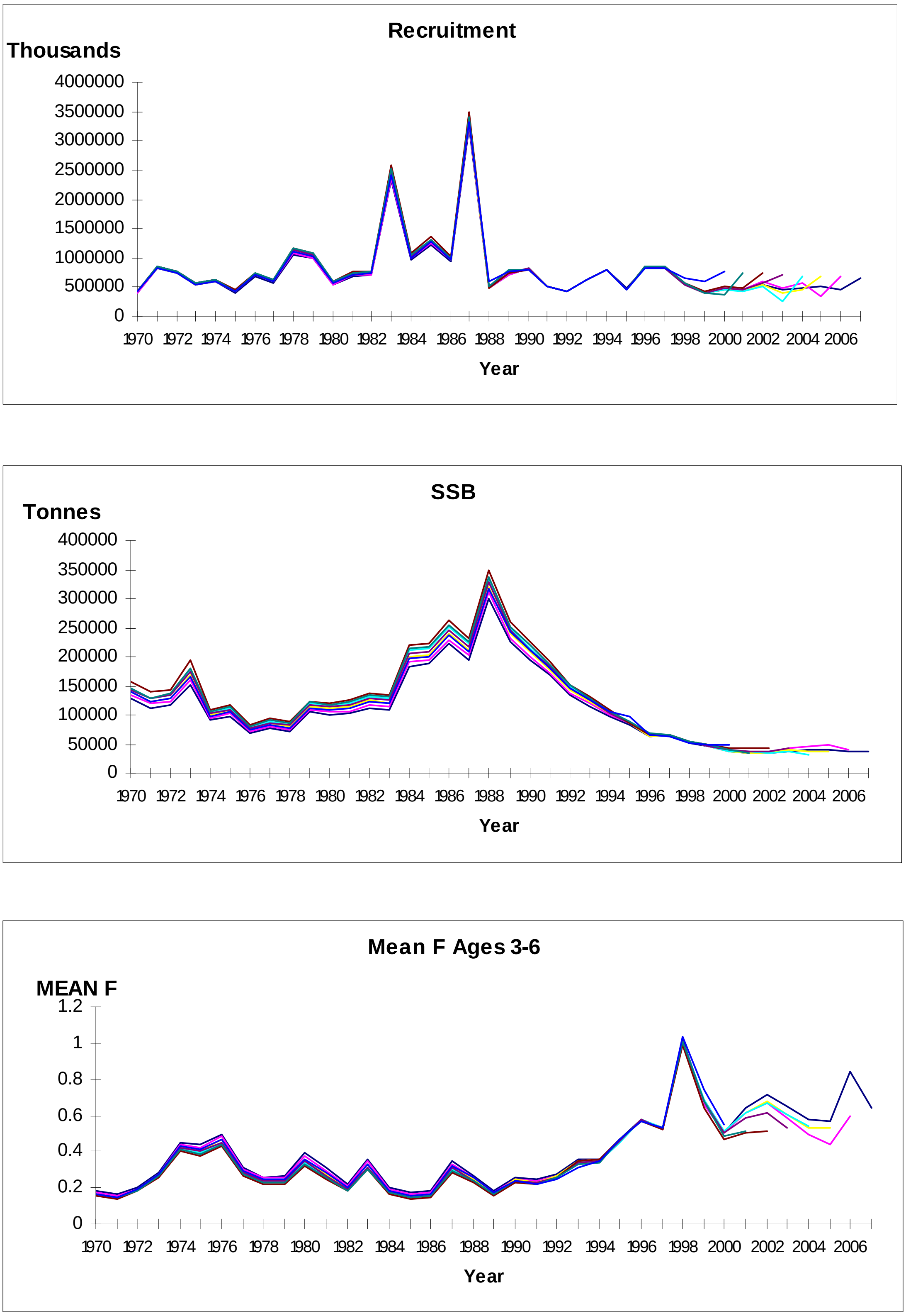
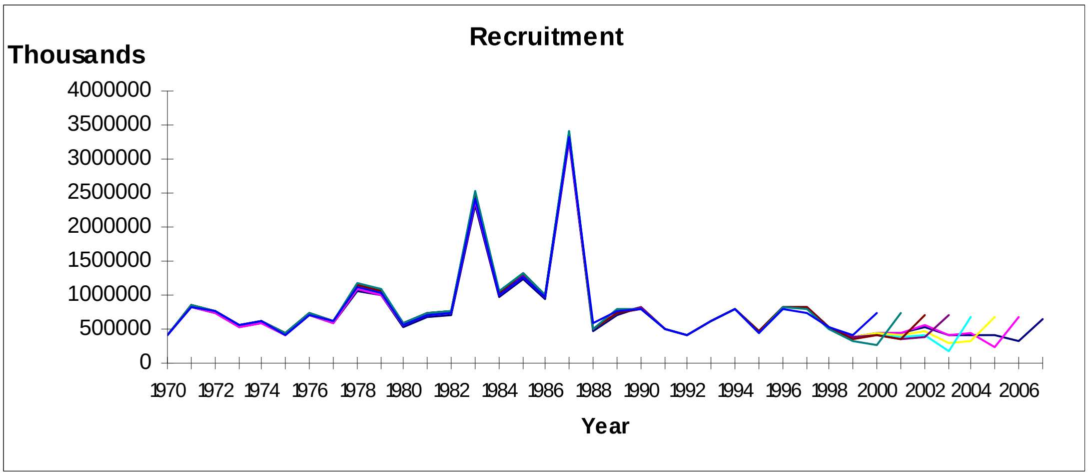
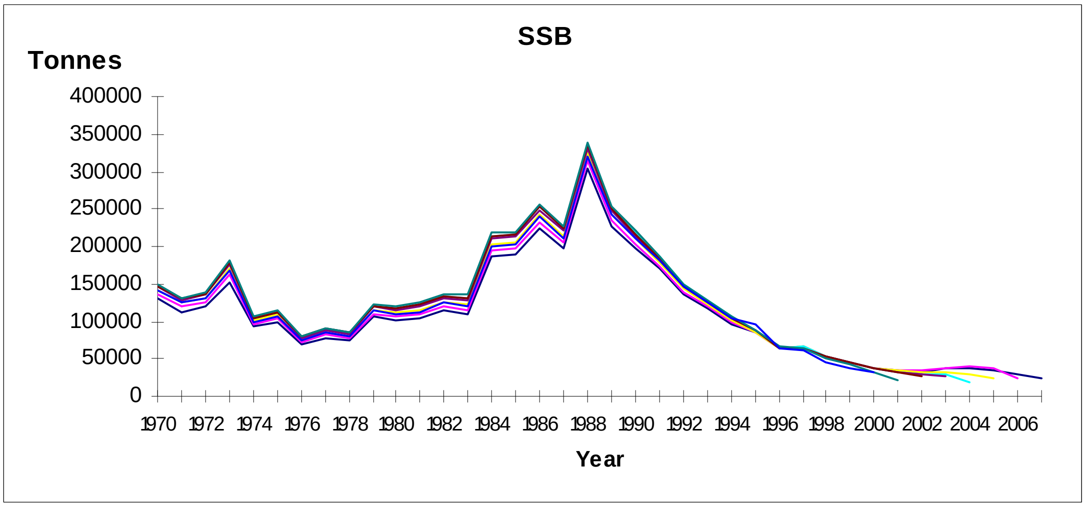


Figure 6.6.2.5 VIa(S) and VIIb,c herring. Retrospective assessment using F=0.4





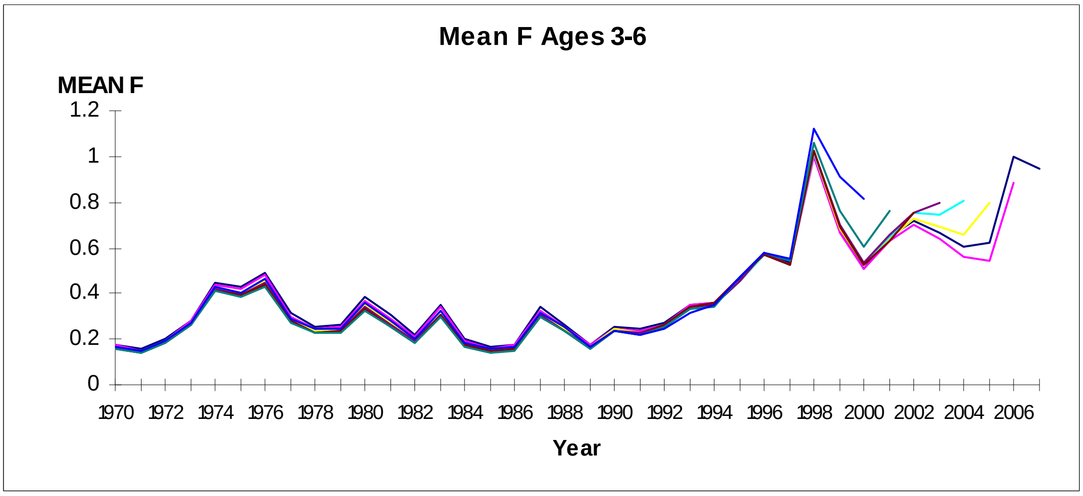


Figure 6.6.2.6 VIa(S) and VIIb,c herring. Retrospective assessment using F=0.6

7 Irish Sea Herring [Division VIIA(North)]

7.1 The Fishery

7.1.1 Advice and management applicable to 2007 and 2008

The WG did not present the results of a final assessment to ACFM in 2007 due to the findings of preliminary data explorations. Exploration of proportion at age data suggested that conflicting year effects were present in the acoustic and catch-at-age data, particularly since 2000/2001. These conflicting signals were shown to be contributing to the poor model fit in the separable period, as shown by the year residual patterns. Despite these problems the exploratory analysis suggested that SSB and fishing mortality had been relatively stable for the last 10 years.

ACFM subsequently advised that a TAC of 4 400 t, based on recent catches, be adopted for 2008. This advice was rejected in favour of a *status quo* TAC of 4 800 t, partitioned as 3 500 t to the UK and 1 250 t to the Republic of Ireland.

7.1.2 The fishery in 2007

The catches reported from each country for the period 1986 to 2007 are given in Table 7.1.1, and total catches from 1961 to 2007 in Figure 7.1.1. Reported international landings in 2007 for the Irish Sea amounted to 4 629 t with UK vessels acquiring extra quota through swaps with the Republic of Ireland. Catches in 2007 were taken evenly over the 3rd and 4th quarters.

The 2007 VIIa(N) herring fishery opened in August, the majority of catches taken during August and September were by a pair of UK pair trawlers. October saw activity of the Mourne fishery, limited to boats under 40ft. This fishery saw catches of herring in 2006 landing catches of ~20 t during October and November. In 2007 17 vessels recorded landings of ~33.5 t during October to December. Fishing by the UK pair trawlers recommenced in October and continued through to November.

7.1.3 Regulations and their effects

Closed areas for herring fishing in the Irish Sea along the east coast of Ireland and within 12 nautical miles of the west coast of Britain were maintained throughout the year. The traditional gillnet fishery on the Mourne herring, which has a derogation to fish within the Irish closed box, operated successfully again in 2007, 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.

The arrangement of closed areas in Division VIIa(N) prior to 1999 are discussed in detail in ICES (1996/ACFM:10) with a change to the closed area to the east of the Isle of Man being altered in 1999 (ICES 2001/ACFM:10). The closed areas consist of: all year juvenile closures along part of the east coast of Ireland, and the west coast of Scotland, England and Wales; spawning closures along the east coast of the Isle of Man from 21st September- 15th November, and along the east coast of Ireland all year round. The WG recommends that any alterations to the present closures be considered carefully, in the context of this report, to ensure protection for all components of this stock.

The TAC for VIIa(N) is partitioned as 3 500 t to the UK and 1 250 t to the Republic of Ireland.

7.1.4 Changes in fishing technology and fishing patterns

The fishery in area VIIa(N) has not changed in recent years. A pair of UK pair trawlers takes the majority of catches during the 3rd and 4th quarters. A small local fishery has recently recorded landings on the traditional Mourne herring grounds.

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 2007 and a graphical representation is given in Figure 7.2.1. The predominant year class in 2007 landings was the 1-ringers followed by the 2-ringers. The majority of 1-ringers were taken in the 4th quarter landings. The catch in 1-ringers was the highest seen in this fishery since the late 1970s. The catch in numbers at length is given in Table 7.2.2 for 1992 to 2007.

7.2.2 Quality of catch and biological data

There are no estimates of discarding or slippage in the Irish Sea fisheries that target herring. Discarding however is not thought to be a feature of this fishery. Biological sampling remains high for this fishery with all data in 2007 arising from AFBI, Northern Ireland. It should be noted however that the majority of samples are taken from only one fishing unit, the pair of UK vessels operating in the Irish Sea. 29 samples were processed for 2007 with 18 from the 3rd quarter fishery and 11 from the 4th quarter. Further details of sampling are given in Table 7.2.3.

7.2.3 Acoustic surveys

The information on the time-series of acoustic surveys in the Irish Sea is given in Table 7.2.4. As in the last years assessment, the SSB estimates from the survey are calculated using the (annually varying) maturity ogives from the commercial catch data.

The acoustic survey in 2007 was carried out over the period 29th August to 13th 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., (ICES 2005 WD 23). Sampling intensity was high during the 2007 survey with 33 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). However in recent years the ratio of sprat to herring has been seen to increase in favour of the 0-group herring. As in previous years 0-group herring were found to be abundant to the west of the Isle of Man and in the north eastern Irish Sea. Of note was the very low abundance of 0-group herring to the west of the Isle of Man and throughout the western Irish Sea (Figure 7.2.3.B). 1+ herring targets were mostly distributed to the west and north of the Isle of Man, with scattered targets to the south east. Approximately 50% of the total 1+ herring biomass estimate in 2007 was attributed to an area known locally as the "herring peaks". This area is thought to be a migratory stopping point for herring entering the Irish Sea to spawn. Due to randomisation of the transect positions in this area and the variation in timing of herring migration, herring in this area are not often observed (Figure 7.2.3.A).

As in previous years, no herring schools were detected in the area immediately north of the Isle of Man, despite an abundance of early-stage larvae in this area in November (Figure 7.2.5). It is possible that spawning in this area only commences after the acoustic survey.

The estimate of herring SSB of 51 819 t for 2007 is the highest estimate in the time series (Table 7.2.4). The approximate coefficient of variation (CV) of 0.42 is within the estimates associated with this survey. The biomass estimate of 120 878 t for 1+ ringers is also the highest estimate in the time series, whilst the approximate CV of 0.53 is within the limits of this survey. 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 1 and 2-ringers.

7.2.4 Larvae surveys

Northern Ireland undertook a herring larvae survey over the period 6th to 15th November 2007. The survey followed the methods and designs of previous surveys in the time-series (Annex 8). The production estimate for 2007 in the NE Irish Sea was a reduction on the previous year and below the time series average (Table 7.2.6). As in previous years herring larvae were found to be most abundant to the southeast and northeast of the Isle of Man and less abundant in the western Irish Sea. Of note was the occurrence of larvae in the area of the traditional Mourne spawning ground where previous to last year no larvae had been caught in considerable numbers (Figure 7.2.5).

7.3 Mean weight, maturity and natural mortality-at-age

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 (Table 7.3.2). Maturity-at-age (in the catches) for each year (1961 to 2007) are given in Table 7.3.3. As in previous years, natural mortality per year was assumed to be 1.0 on 1-ringers, 0.3 for 2-ringers, 0.2 for 3-ringers and 0.1 for all older age classes (Annex 8).

Mean weights-at-age have shown a general downward trend in the last 22 years. The 2007 weights-at-age are higher than 2006 values at all ages.

7.4 Recruitment

An estimate of total abundance of 0-ringers and 1-ringers is provided by the Northern Ireland acoustic survey. However, there is evidence that a proportion of these are of Celtic Sea origin. Separation of the trawl catches of 0-groups into autumn and winter spawning components, based on otolith microstructure and shape analysis was presented to the working group by Beggs et al. (ICES 2008 WD4). It is hoped that repeating this procedure annually could result in a survey index of recruitment for the Irish Sea stock that could be used directly in the assessment. Such an index may also be of use in the Celtic Sea assessment, as it would provide an estimate of juveniles resident in the Irish Sea originating from this management area.

7.5 Stock Assessment

7.5.1 Data exploration and preliminary modelling

2007 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.

In 2008 comparisons between total mortality rates estimated from the acoustic (Figure 7.5.1) and catch-at-age data (Figure 7.5.2) highlighted a divergence in estimates beginning in 1999 (1996 year class) (Figure 7.5.3). The acoustic survey was shown to have higher estimates of total mortality due to the large year effects in the LnCatch ratios at ages 2-7. This divergence was found to be associated with the variation in migration of herring enter the spawning area of the Irish Sea.

In light of the results of data exploration carried out in 2007 and further exploration in 2008 the working group decided not to attempt an assessment with ICA. This exploratory analysis revealed a contrast in the proportion catch-at-age between the acoustic and catch-at -age data (Figure 7.5.4). Evidence suggested that the inter-annual variation in the migration and distribution of herring surrounding the Isle of Man had an inter-annual effect on the age class selectivity of this spawning stock fishery (Figure 7.5.5). This effect was shown to be significantly associated with 2-ringers, the most abundant in numbers-at-age in the stock (Table 7.2.1). This inter-annual variation in the selectivity of the fishery therefore violated the separable assumption of ICA and confounds the estimation of reference F.

In lieu of a separable period assessment model information on the recent trends in the stock were explored using a two-stage biomass model Roel and De Oliveira (ICES 2005 WD10). Information on the current status of the stock was inferred from the recent survey and catch-at-age data. 2007 acoustic survey estimates suggest that SSB and 1+ ringer biomass are at higher levels than anytime in the 13 year time-series. Numbers-at-age in the acoustic survey suggest a strong 2005 year class (1-ringers in 2007). This year class was also observed in the acoustic survey as a high abundance of 0-groups in 2006. Microstructure analysis of the 0-group otoliths classified approx. 90% of these juveniles in the eastern Irish Sea as “autumn” spawners Beggs *et al.*, (ICES 2008 WD4). This may suggest that a strong year class has entered the fishery.

Catch-at-age data from the 2007 fishery also highlighted the strong 2005 year class with the highest numbers of 1-ringers present in the catch since the late 1970s. High numbers of 2-ringers were also present in the catch-at-age data.

7.5.2 Two-stage biomass model

In 2005 a Two-Stage Biomass model for the assessment of Irish Sea VIIa(N) herring given additional variance in the recruitment index was presented by Roel and De Oliveira (ICES 2005 WD10). In 2008 it was decided to run the model as an alternative to ICA.

The model addresses the problem of the high uncertainty in the assessment of Irish Sea herring which, to some extent may be related to the presence of juvenile Celtic Sea herring in both the fishery and the survey area. In the absence of a Celtic Sea herring recruitment index, the biomass model presented addressed the problem by limiting recruitment variability in Irish Sea herring on the basis of information available for other herring stocks. The total variability in the recruitment data was divided into two components: the one related to Irish Sea herring recruitment variability and the rest which was likely to represent variability related to the presence of Celtic Sea juveniles.

The model was fitted to biomass indices of 1-ringer fish and to aggregated biomass indices for the 2-rings and older herring from Northern Ireland acoustic surveys. The survey age composition data and the weights-at-age from the catch were used to calculate the proportion of 1-ring fish in the survey. The proportion was then applied to the total acoustic biomass to compute the 1-ring biomass index while the 2^{+} index was obtained by subtraction. The catch in weight was split in a similar manner but based on commercial catch samples. Both the survey and the catch data correspond to the period 1994 – 2007.

7.5.2.1 The model

The dynamics take into account only two stages in the population: the recruits, 1-ringer fish, and the fully recruited that comprise 2-ringer and older fish. The biomass dynamics is represented by the following:

$$B_{y+1} = B_{1,y+1} + \left[(B_{2+,y} + B_{1,y}) e^{-3g/4} - C_y \right] e^{-g/4}$$

[1]

where

$B_{1,y}$	is the biomass of recruitment (tons) at the start of year *y*;
$B_{2+,y}$	is the biomass of 2+ aged fish (tons) at the start of year *y*;
C_y	is the biomass of fish caught (tons) during year *y*, assumed to be taken in a pulse fishery 3/4 of the way into year *y*; and
g	is a composite parameter, treated as an annual rate, which accounts for natural mortality and growth.

Maximum likelihood estimation is used, assuming survey indices are log-normally distributed about their expected values. Standard errors of the log-distributions are approximated by the sampling CVs of the untransformed distributions.

The estimable parameters are g, $B_{2+,1994}$, $B_{1,1994}$,...,$B_{1,2004}$, λ^2 and q

where q corresponds to the catchability associated with the survey indices $I_{1,y}$ and $I_{2+,y}$ and λ^2 is the additional variance.

7.5.2.2 Results

The data were explored for values of recruitment variability (σ_R) = 0.4 and 0.8. The value 0.4 corresponds to the variability in recruitment age 1 as estimated by ICA for the period used in this analysis, but excluding the most recent estimate (1994 – 2006). The two parameters, *g* and *q*, may be confounded in the model indicating that fixing *g* was appropriate. This parameter was fixed to 0.2 following a similar approach as in Roel and De Oliveira (ICES 2005 WD10).

Fits to the index data (Figure 7.5.6), normalised residuals from the model fit (Figure 7.5.7) and time-series of estimated biomass and confidence intervals (Figure 7.5.8) are presented for σ_R = 0.4 for which a better fit to the data was achieved. Estimates of key parameters with associated CVs are shown in Table 7.5.1 for the two runs performed. The estimates are not particularly sensitive to the value of σ_R assumed. The additional variance parameter which is an indication of the incidence of Celtic

Sea recruitment in the survey index (B1), is high compared to the recruitment variability.

The model estimates median recruitment around 6400 tons for the period considered and a relatively stable adult stock. Although the model suggests a slight increase in biomass in the recent year this is not as pronounced as indicated by the survey index. Sensitivity to the value of the parameter *g* was tested by running the model for *g* = 0.4. Results for the key parameter estimates are shown on Table 7.5.1. The results are sensitive to the value of g, which appears to scale the biomass. This is reflected in the values of B_{init} and R_{med}. The trend in biomass (B_1 and B_{2+}, not shown) remained the same.

7.5.3 Conclusion to explorations

The exploratory analysis completed in 2007 and continued in 2008 suggests that ICA is unsuitable as an assessment method for the Irish Sea stock. Recent estimates of SSB and F are unreliable, although trends in SSB and F during the diverged period of the VPA are considered reliable. Exploration of proportion-at-age data in 2007 suggests that conflicting year effects were present in the acoustic and catch-at-age data. These conflicting signals were contributing to the poor model fit in the separable period as shown by the large year residuals. In 2008 comparisons of the total mortality rates estimated from the acoustic and catch-at-age data suggested a conflicting signal with divergence in the estimates.

Catch-at-age data and the number-at-age both reveal the high portions of 1-and 2-ringers in the stock. The presence of the high numbers of 1-ringers currently in the stock can be substantiated by the strong recruitment event observed in 2005. This evidence suggests that a large year class is present in the fishery.

The output from the two-stage biomass model also provides useful information on recent trends in the stock, suggesting that the biomass has been relatively stable over recent years.

7.5.4 Stock assessment

From the exploratory analysis it was considered that ICA was unsuitable for the assessment of this stock and therefore no runs are presented. In lieu of a separable period assessment model information on the recent trends in the stock were explored using a two-stage biomass model Roel and De Oliveira (ICES 2005 WD10).

7.6 Stock and Catch Projection

7.6.1 Deterministic short-term predictions

The Working Group decided that there was no basis for undertaking short-term predictions of stock size.

7.6.2 Yield-per-recruit

The Working Group decided that there was no basis for yield-per-recruit analysis.

7.7 Medium-term predictions of stock size

The Working Group decided that there was no basis for undertaking medium-term projections of stock size.

7.8 Reference points

The estimation of $\mathbf{B}_{pa}$ (9 500 t) and $\mathbf{B}_{lim}$ (6 000 t) were not revisited this year. There were no new points to add to the discussions and deliberations presented in 2000 (ICES 2000/ACFM:12). There is no precautionary F value for this stock.

7.9 Quality of the assessment

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 numbers-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. Otolith microstructure analysis in 2006 classified 0-group herring to seasonal origin providing estimates of mixing between Celtic and Irish Sea juveniles. These results suggest that there was extensive mixing of the two components in the Irish Sea management area with the majority of eastern Irish Sea juveniles classified as the autumn spawner component (Beggs *et al.*, ICES 2008 WD4). Further research is required to investigate the mixing of juveniles in the Irish Sea.

In past years the assessment for this stock has not been accepted by the WG. Both the catches and survey data are seen to contain large year residuals. From the exploratory analysis in 2007 and 2008 it can be seen that the majority of this variation may arise from the inter-annual variation in herring migration patterns and their effect on the selectivity of both the fishery and acoustic survey.

Given the inter-annual variation in the catch-at-age and survey data it is difficult to detect abrupt changes in the stock dynamics. In 2008 ICA was not considered appropriate for the assessment of this stock due to the variation in the selectivity of the fishery during the separable period. In lieu of a separable period assessment model information on the recent trends in the stock were explored using a two-stage biomass model Roel and De Oliveira (ICES 2005 WD10).

Given the historical landings from this stock and the knowledge that fishing pressure is mostly confined to one pair of UK vessels it can be assumed that fishing pressure and activity has not varied considerably in recent years. Evidence from the acoustic survey and catch-at-age data indicate a strong recruitment event, observed through the 0-group and 1-ringers. Microstructure analysis confirms that the Irish Sea autumn spawning component represents a considerable proportion of this strong year class (ICES 2008 WD4). Evidence from landings data and the herring larvae surveys suggest that the Mourne spawning component in the western Irish Sea has witnessed a recent expansion. The output from the two-stage biomass model suggests the stock has been at a relatively stable level in recent years. Moreover, this model, which takes into account the variability introduced in the data by the presence of Celtic Sea juveniles, suggests some increase in adult biomass probably linked to good recruitment in 2006. From these sources of information it can be inferred that the Irish Sea stock is relatively stable with indications of strong recruitment and signs of stock expansion in recent years. Fishing mortality has also been relatively stable since the late 1990's.

7.10 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). Though the exact level of the stock is unclear from the current analysis, the trends from the two-stage biomass model suggest that the stock remains relatively stable. Acoustic and catch-at-age data both show indications that a strong year class has entered the stock, while microstructure analysis confirms that a large proportion of these are of autumn spawning origin. The expansion of the Mourne fishery suggests that this stock or sub-component is under a state of recovery. 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. The management and assessment of this stock will be reviewed in SGHERWAY.

7.11 Environment

7.11.1 Ecosystem Considerations

There are irregular cycles in the productivity of herring stocks (weights-at-age and recruitment). There are many hypotheses as to the cause of these changes in productivity, but in most cases it is thought that the environment plays an important role (through transport, prey, and predation). Coincident periods of high and low production have been seen in the herring in VIaN and Irish Sea herring. Exploitation and management strategies must account for the likelihood of productivity changing. The Irish Sea herring stock has shown a marked decline in productivity during the late 70's and remained on a low level since then.

7.11.2 Changes in Environment

There has been an increase in water temperatures in this area (ICES, 2006) which is likely to affect the distribution area of some fish species, and some changes of distribution have already been noted. Temperature increase is likely to affect stock recruitment of some species. In addition, the combined effects of over exploitation and environmental variability might lead to a higher risk of recruitment failure and decrease in productivity (ICES, 2007).

Table 7.1.1 Irish Sea Herring Division VIIa(N). Working group catch estimates in tonnes by country, 1987-2007. The total catch does not in all cases correspond to the official statistics and cannot be used for management purposes.

COUNTRY	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**
Ireland	1 200	2 579	1 430	1 699	80	406	0	0	0
UK	3 290	7 593	3 532	4 613	4 318	4 864	4 408	4 828	5 076
Unallocated	1 333	-	-	-	-	-	-	-	-
Total	5 823	10 172	4 962	6 312	4 398	5 270	4 408	4 828	5 076

Country	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**
Ireland	100	0	0	0	0	862	286	0	749
UK	5 180	6 651	4 905	4 127	2 002	4 599	2 107	2 399	1 782
Unallocated	22	-	-	-	-	-		-	-
Total	5 302	6 651	4 905	4 127	2 002	5 461	2 393	2 399	2 531

Country	**2005**	**2006**	**2007**
Ireland	1 153	581	0
UK	3 234	3821	4 629
Unallocated	-	-	
Total	4 387	4 402	4 629

Table 7.2.1 Irish Sea Herring Division VIIa(N). Catch-at-age (thousands) by year.

	Age (rings)							
Year	1	2	3	4	5	6	7	8+
1972	40640	46660	26950	13180	13750	6760	2660	1670
1973	42150	32740	38240	11490	6920	5070	2590	2600
1974	43250	109550	39750	24510	10650	4990	5150	1630
1975	33330	48240	39410	10840	7870	4210	2090	1640
1976	34740	56160	20780	15220	4580	2810	2420	1270
1977	30280	39040	22690	6750	4520	1460	910	1120
1978	15540	36950	13410	6780	1740	1340	670	350
1979	11770	38270	23490	4250	2200	1050	400	290
1980	5840	25760	19510	8520	1980	910	360	230
1981	5050	15790	3200	2790	2300	330	290	240
1982	5100	16030	5670	2150	330	1110	140	380
1983	1305	12162	5598	2820	445	484	255	59
1984	1168	8424	7237	3841	2221	380	229	479
1985	2429	10050	17336	13287	7206	2651	667	724
1986	4491	15266	7462	8550	4528	3198	1464	877
1987	2225	12981	6146	2998	4180	2777	2328	1671
1988	2607	21250	13343	7159	4610	5084	3232	4213
1989	1156	6385	12039	4708	1876	1255	1559	1956
1990	2313	12835	5726	9697	3598	1661	1042	1615
1991	1999	9754	6743	2833	5068	1493	719	815
1992	12145	6885	6744	6690	3256	5122	1036	392
1993	646	14636	3008	3017	2903	1606	2181	848
1994	1970	7002	12165	1826	2566	2104	1278	1991
1995	3204	21330	3391	5269	1199	1154	926	1452
1996	5335	17529	9761	1160	3603	780	961	1364
1997	9551	21387	7562	7341	1641	2281	840	1432
1998	3069	11879	3875	4450	6674	1030	2049	451
1999	1810	16929	5936	1566	1477	1989	444	622
2000	1221	3743	5873	2065	558	347	251	147
2001	2713	11473	7151	13050	3386	936	650	803
2002	179	9021	1894	1866	2395	953	474	343
2003	694	4694	3345	2559	882	2945	872	605
2004	3225	8833	5405	2161	623	213	673	127
2005	8692	13980	10555	3287	1422	415	292	368
2006	5669	15253	8198	6318	1325	605	262	246
2007	20290	18291	4980	1655	1062	325	122	111

Table 7.2.2 Irish Sea Herring Division VIIa(N). Catch at length data 1992-2007. Numbers of fish in thousands. Table amended with 1990-1991 year-classes removed (see Annex 8).

Length	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
14																
14.5																
15	95															
15.5	169							10								16
16	343			21	21	17		19	12	9					2	
16.5	275			55	51	94		53	49	27			13	1	44	33
17	779		84	139	127	281	26	97	67	53			25	39	140	69
17.5	1106		59	148	200	525	30	82	97	105			84	117	211	286
18	1263		69	300	173	1022	123	145	115	229			102	291	586	852
18.5	1662		89	280	415	1066	206	135	134	240	36		114	521	726	2088
19	1767	39	226	310	554	1720	317	234	164	385	18		203	758	895	2979
19.5	1189	75	241	305	652	1263	277	82	97	439	0	29	269	933	1246	3527
20	1268	75	253	326	749	1366	427	218	109	523	0	73	368	943	984	3516
20.5	705	57	270	404	867	1029	297	242	85	608	18	215	444	923	1443	2852
21	705	130	400	468	886	1510	522	449	115	1086	307	272	862	1256	1521	3451
21.5	597	263	308	782	1258	1192	549	362	138	1201	433	290	1007	1380	1621	2929
22	664	610	700	1509	1530	2607	1354	1261	289	1748	1750	463	1495	1361	2748	3821
22.5	927	1224	785	2541	2190	2482	1099	2305	418	1763	1949	600	2140	1448	3629	3503
23	1653	2016	1035	4198	2362	3508	2493	4784	607	2670	2490	1158	2089	1035	4358	4196
23.5	1156	2368	1473	4547	2917	3902	2041	4183	951	2254	1552	1380	2214	1256	2920	3697
24	1575	2895	2126	4416	3649	4714	3695	4165	1436	3489	1029	1273	2054	1276	3679	3178
24.5	2412	2616	2564	3391	4077	4138	2769	3397	1783	4098	758	1249	2269	1083	2431	2136
25	2792	2207	3315	3100	4015	5031	2625	2620	2144	5566	776	1163	1749	1086	3438	1503
25.5	3268	2198	3382	2358	3668	3971	2797	1817	1791	4785	1335	1211	1206	584	2198	952
26	3865	2216	3480	2334	2480	3871	3115	1694	1349	3814	1570	1140	823	438	1714	643
26.5	3908	2176	2617	1807	2177	2455	2641	1547	840	2243	1552	1573	587	203	605	330
27	3389	2299	2391	1622	1949	1711	2992	1475	616	1489	776	1607	510	165	445	147
27.5	2203	2047	1777	990	1267	1131	1747	867	479	644	433	1189	383	60	155	72
28	1440	1538	1294	834	906	638	1235	276	212	496	162	726	198	45	104	33
28.5	569	944	900	123	564	440	170	169	58	179	108	569	51	18	9	26
29	278	473	417	248	210	280	111	61	42	10	36	163		12	46	
29.5	96	160	165	56	79	59	92		12	0	36	129				7
30	70	83	9	40	32	8	84		6	9		43				
30.5	36	15	27	5	0	5	3					43				
31	2	4		1	2							43				
31.5																
32																
32.5																
33																
33.5																
34																

Table 7.2.3 Irish Sea Herring Division VIIa(N). Sampling intensity of commercial landings in 2007.

Quarter	Country	Landings (t)	No. samples	No. fish measured	No. fish aged
1	Ireland	0	-	-	-
	UK (N. Ireland)	0.003	0	0	0
	UK (Isle of Man)	0	-	-	-
	UK (Scotland)	0	-	-	-
	UK (England & Wales)	0	-	-	-
2	Ireland	0	-	-	-
	UK (N. Ireland)	0	-	-	-
	UK (Isle of Man)	*	-	-	-
	UK (Scotland)	0	-	-	-
	UK (England & Wales)	0	-	-	-
3	Ireland	0	-	-	-
	UK (N. Ireland)	2 552	18	3406	892
	UK (Isle of Man)	*	-	-	-
	UK (Scotland)	0	-	-	-
	UK (England & Wales)	0	-	-	-
4	Ireland	0	-	-	-
	UK (N. Ireland)	2 078	11	2 482	550
	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 1989-2007. Small clupeoids include sprat and 0-ring herring unless otherwise stated. CVs are approximate. Biomass in t. All surveys carried out at 38kHz except December 1996, which was at 120kHz.

YEAR	AREA	DATES	HERRING BIOMASS	CV	HERRING BIOMASS	CV	SMALL CLUPEOIDS	CV
			(1+years)		(SSB)		biomass	
1989	Douglas Bank	25/09-26/09			18,000	-	-	-
1990	Douglas Bank	26/09-27/09			26,600	-	-	-
1991	W. Irish Sea	26/07- 8/08	12,760	0.23			66,000[1]	0.20
1992	W. Irish Sea + IOM E. coast	20/07-31/07	17,490	0.19			43,200	0.25
1994	Area VIIa(N)	28/08 – 8/09	31,400	0.36	25,133	-	68,600	0.10
	Douglas Bank	22/09-26/09			28,200	-	-	-
1995	Area VIIa(N)	11/09-22/09	38,400	0.29	20,167	-	348,600	0.13
	Douglas Bank	10/10-11/10		-	9,840	-	-	-
	Douglas Bank	23/10-24/10			1,750	0.51	-	-
1996	Area VIIa(N)	2/09-12/09	24,500	0.25	21,426	0.25	-[2]	-
1997	Area VIIa(N)-reduced	8/09-12/09	20,100	0.28	10,702	0.35	46,600	0.20
1998	Area VIIa(N)	8/09-14/09	14,500	0.20	9,157	0.18	228,000	0.11
1999	Area VIIa(N)	6/09-17/09	31,600	0.59	21,040	0.75	272,200	0.10
2000	Area VIIa(N)	11/09-21/09	40,200	0.26	33,144	0.32	234,700	0.11
2001	Area VIIa(N)	10/09-18/09	35,400	0.40	13,647	0.42	299,700	0.08
2002	Area VIIa(N)	9/09-20/09	41,400	0.56	25,102	0.83	413,900	0.09
2003	Area VIIa(N)	7/09-20/09	49,500	0.22	24,390	0.24	265,900	0.10
2004	Area VIIa(N)	6/09-10/09, 15/09-16/09, 28/09-29/09	34,437	0.41	21,593	0.41	281,000	0.07
2005	Area VIIa(N)	29/08 -14/09	36,866	0.37	31,445	0.42	141,900	0.10
2006	Area VIIa(N)	30/08 – 9/09	33,136	0.24	16,332	0.22	143,200	0.09
2007	Area VIIa(N)	29/08 - 13/09	120,878	0.53	51,819	0.42	204,700	0.09

[1] sprat only; [2]Data can be made available for the IoM waters only

Table 7.2.5 Irish Sea Herring Division VIIa(N). Age-disaggregated acoustic estimates (thousands) of herring abundance from the Northern Ireland surveys in September (ACAGE).

AGE (RINGS)	1	2	3	4	5	6	7	8+
1994	66.8	68.3	73.5	11.9	9.3	7.6	3.9	10.1
1995	319.1	82.3	11.9	29.2	4.6	3.5	4.9	6.9
1996	11.3	42.4	67.5	9	26.5	4.2	5.9	5.8
1997	134.1	50	14.8	11	7.8	4.6	0.6	1.9
1998	110.4	27.3	8.1	9.3	6.5	1.8	2.3	0.8
1999	157.8	77.7	34	5.1	10.3	13.5	1.6	6.3
2000	78.5	103.4	105.3	27.5	8.1	5.4	4.9	2.4
2001	387.6	93.4	10.1	17.5	7.7	1.4	0.6	2.2
2002	391	71.9	31.7	24.8	31.3	14.8	2.8	4.5
2003	349.2	220	32	4.7	3.9	4.1	1	0.9
2004	241	115.5	29.6	15.4	2.1	2.3	0.2	0.2
2005	94.3	109.9	97.1	17	8	0.8	0.6	5.8
2006	374.7	96.6	15.6	10.0	0.5	0.4	0.5	0.5
2007	1316.7	251.3	46.6	21.1	20.8	1.2	0.7	0.6

Table 7.2.6 Irish Sea Herring Division VIIa(N). Larval production (10^{11}) indices for the Manx component. Table amended with Douglas Bank time series removed (see Annex 8).

YEAR	NORTHEAST IRISH SEA					
		Isle of Man			Northern Ireland	
	Date	Production	SE	Date	Production	CV
1989	-	-	-	-	-	-
1990	-	-	-	-	-	-
1991	-	-	-	-	-	-
1992	20 Nov	128.9	-	-	-	-
1993	22 Nov	1.1	-	17 Nov	38.3	0.48
1994	24 Nov	12.5	-	16 Nov	71.2	0.12
1995	-	-	-	28 Nov	15.1	0.62
1996	26 Nov	0.3	-	19 Nov	4.7	0.30
1997	1 Dec	35.9	-	4 Nov	29.1	0.11
1998	1 Dec	3.5	-	3 Nov	5.8	1.02
1999	-	-	-	9 Nov	16.7	0.57
2000	-	-	-	11 Nov	35.5	0.12
2001	11 Dec	198.6	-	7 Nov	55.3	0.55
2002	6 Dec	19.8	-	4 Nov	31.5	0.47
2003	-	-	-	9 Nov	15.8	0.58
2004	-	-	-	30 Oct	22.7	0.48
2005	-	-	-	6 Nov	26.4*	0.57
2006	-	-	-	6 Nov	43.8	0.70
2007	-	-	-	6 Nov	12.6	0.67

SE = Standard Error

***2005 Index value amended**

Table 7.3.2 Irish Sea Herring Division VIIa(N). Mean weights-at-age in the catch.

Year	Weights-at-age (g) Age (rings)							
	1	2	3	4	5	6	7	8+
1985	87	125	157	186	202	209	222	258
1986	68	143	167	188	215	229	239	254
1987	58	130	160	175	194	210	218	229
1988	70	124	160	170	180	198	212	232
1989	81	128	155	174	184	195	205	218
1990	77	135	163	175	188	196	207	217
1991	70	121	153	167	180	189	195	214
1992	61	111	136	151	159	171	179	191
1993	88	126	157	171	183	191	198	214
1994	73	126	154	174	181	190	203	214
1995	72	120	147	168	180	185	197	212
1996	67	116	148	162	177	199	200	214
1997	64	118	146	165	176	188	204	216
1998	80	123	148	163	181	177	188	222
1999	69	120	145	167	176	188	190	210
2000	64	120	148	168	188	204	200	213
2001	67	106	139	156	168	185	198	205
2002	85	113	144	167	180	184	191	217
2003*	81	116	136	160	167	172	186	199
2004	73	107	130	157	165	187	200	205
2005	67	103	136	156	166	180	191	209
2006	64	105	131	149	164	177	184	211
2007	67	112	135	158	173	183	199	227

*** Average for the preceding five years**

Table 7.3.3 **Irish Sea Herring Division VIIa(N). Maturity ogive (maturity in the catch).** *Average for the preceding nine years.

YEAR	AGE (RINGS)							
	1	2	3	4	5	6	7	8+
1961	0.00	0.22	0.63	1.00	1.00	1.00	1.00	1.00
1962	0.00	0.24	0.83	0.92	1.00	1.00	1.00	1.00
1963	0.00	0.34	0.88	0.89	1.00	1.00	1.00	1.00
1964	0.00	0.53	0.81	1.00	1.00	1.00	1.00	1.00
1965	0.00	0.61	0.90	1.00	1.00	1.00	1.00	1.00
1966	0.00	0.47	0.91	1.00	1.00	1.00	1.00	1.00
1967	0.02	0.37	0.75	0.83	1.00	1.00	1.00	1.00
1968	0.00	0.88	0.94	0.94	1.00	1.00	1.00	1.00
1969	0.00	0.71	0.92	0.94	1.00	1.00	1.00	1.00
1970	0.02	0.92	0.94	0.96	1.00	1.00	1.00	1.00
1971	0.15	0.87	0.97	0.98	1.00	1.00	1.00	1.00
1972	0.11	0.88	0.90	1.00	1.00	1.00	1.00	1.00
1973	0.12	0.77	0.89	0.97	1.00	1.00	1.00	1.00
1974	0.36	0.99	0.96	1.00	1.00	1.00	1.00	1.00
1975	0.40	0.99	1.00	0.94	1.00	1.00	1.00	1.00
1976	0.07	0.96	0.98	1.00	1.00	1.00	1.00	1.00
1977	0.03	0.92	0.96	1.00	1.00	1.00	1.00	1.00
1978	0.04	0.81	0.88	0.91	1.00	1.00	1.00	1.00
1979	0.00	0.84	0.81	0.78	1.00	1.00	1.00	1.00
1980	0.20	0.88	0.95	0.95	1.00	1.00	1.00	1.00
1981	0.19	0.89	0.90	0.94	1.00	1.00	1.00	1.00
1982	0.10	0.80	0.89	0.91	1.00	1.00	1.00	1.00
1983	0.02	0.73	0.88	0.90	1.00	1.00	1.00	1.00
1984	0.00	0.69	0.83	0.93	1.00	1.00	1.00	1.00
1985	0.14	0.62	0.71	0.88	1.00	1.00	1.00	1.00
1986	0.31	0.73	0.66	0.81	1.00	1.00	1.00	1.00
1987	0.00	0.85	0.91	0.87	1.00	1.00	1.00	1.00
1988	0.00	0.90	0.96	0.99	1.00	1.00	1.00	1.00
1989	0.07	0.63	0.93	0.95	1.00	1.00	1.00	1.00
1990	0.06	0.66	0.90	0.95	1.00	1.00	1.00	1.00
1991	0.04	0.30	0.74	0.82	1.00	1.00	1.00	1.00
1992	0.28	0.48	0.72	0.81	1.00	1.00	1.00	1.00
1993	0.00	0.46	0.99	1.00	1.00	1.00	1.00	1.00
1994	0.19	0.68	0.99	0.97	1.00	1.00	1.00	1.00
1995	0.10	0.86	0.94	0.99	1.00	1.00	1.00	1.00
1996	0.02	0.60	0.96	0.83	1.00	1.00	1.00	1.00
1997	0.04	0.82	0.95	1.00	1.00	1.00	1.00	1.00
1998	0.30	0.83	0.97	0.99	1.00	1.00	1.00	1.00
1999	0.02	0.84	0.95	0.97	1.00	1.00	1.00	1.00
2000	0.14	0.79	0.99	1.00	1.00	1.00	1.00	1.00
2001	0.15	0.54	0.88	0.97	1.00	1.00	1.00	1.00
2002	0.02	0.92	0.95	0.98	1.00	1.00	1.00	1.00
2003*	0.11	0.76	0.95	0.97	1.00	1.00	1.00	1.00
2004	0.11	1.00	0.97	1.00	1.00	1.00	1.00	1.00
2005	0.20	0.97	0.99	1.00	1.00	1.00	1.00	1.00
2006	0.19	0.89	1.00	1.00	1.00	1.00	1.00	1.00
2007	0.16	0.94	0.98	1.00	1.00	1.00	1.00	1.00

Table 7.5.1 Irish Sea herring VIIa(N). Model estimates (point value and CV) for the additional variance (*addv*), median recruitment (*Rmed*), initial biomass (*Binit*) and survey catchability (*q*) for two scenarios of recruitment variability (σ_R = 0.4 and 0.8) and for *g* = 0.2 and 0.4.

	Recruitment variability (σ_R					
	0.4				0.8	
	g = 0.2		g=0.4		g = 0.2	
Model paramete	Point estimate	CV	Point Estimate	CV	Point Estimate	CV
addv	0.75	51%	0.75	54%	0.41	84%
Rmed	6342.50	12%	11057.5	21%	6006.10	15%
Binit	12711.0	33%	18812.7	42%	13860.0	32%
q	2.33	29%	1.87	38%	2.27	29%

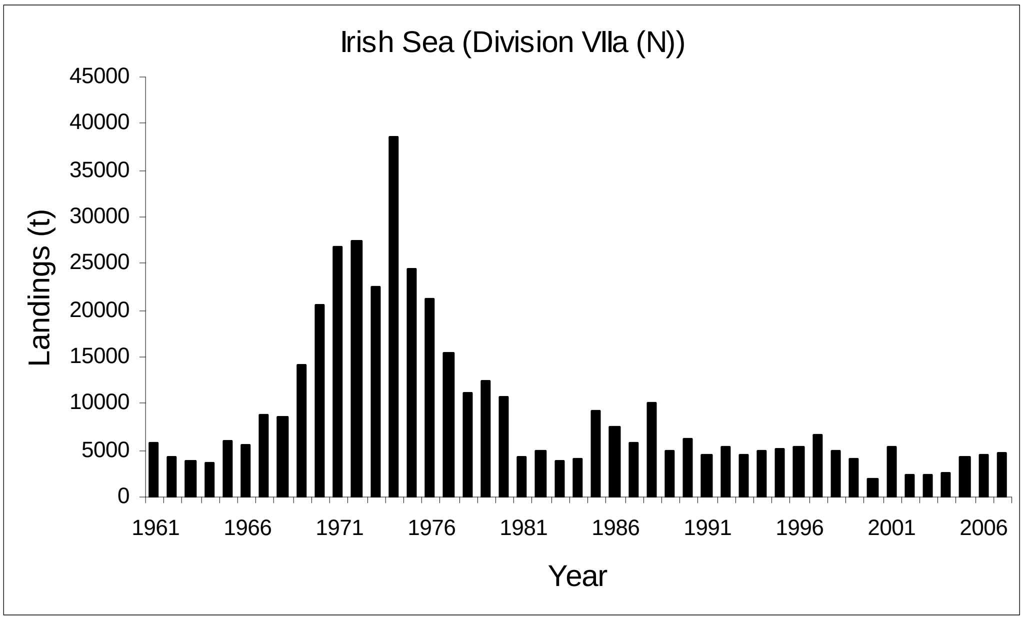


Figure 7.1.1 **Irish Sea herring VIIa(N). Landings of herring from VIIa(N) from 1961 to 2007.**

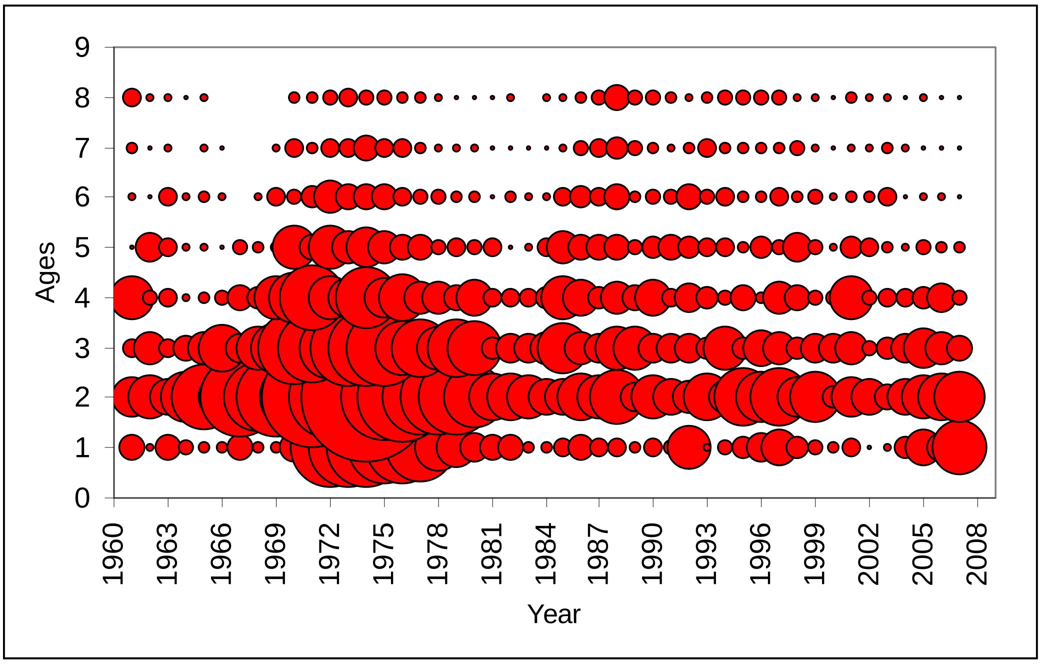


Figure 7.2.1 **Irish Sea herring VIIa(N). Landings (catch-at-age) of herring from VIIa(N) from 1961 to 2007.**

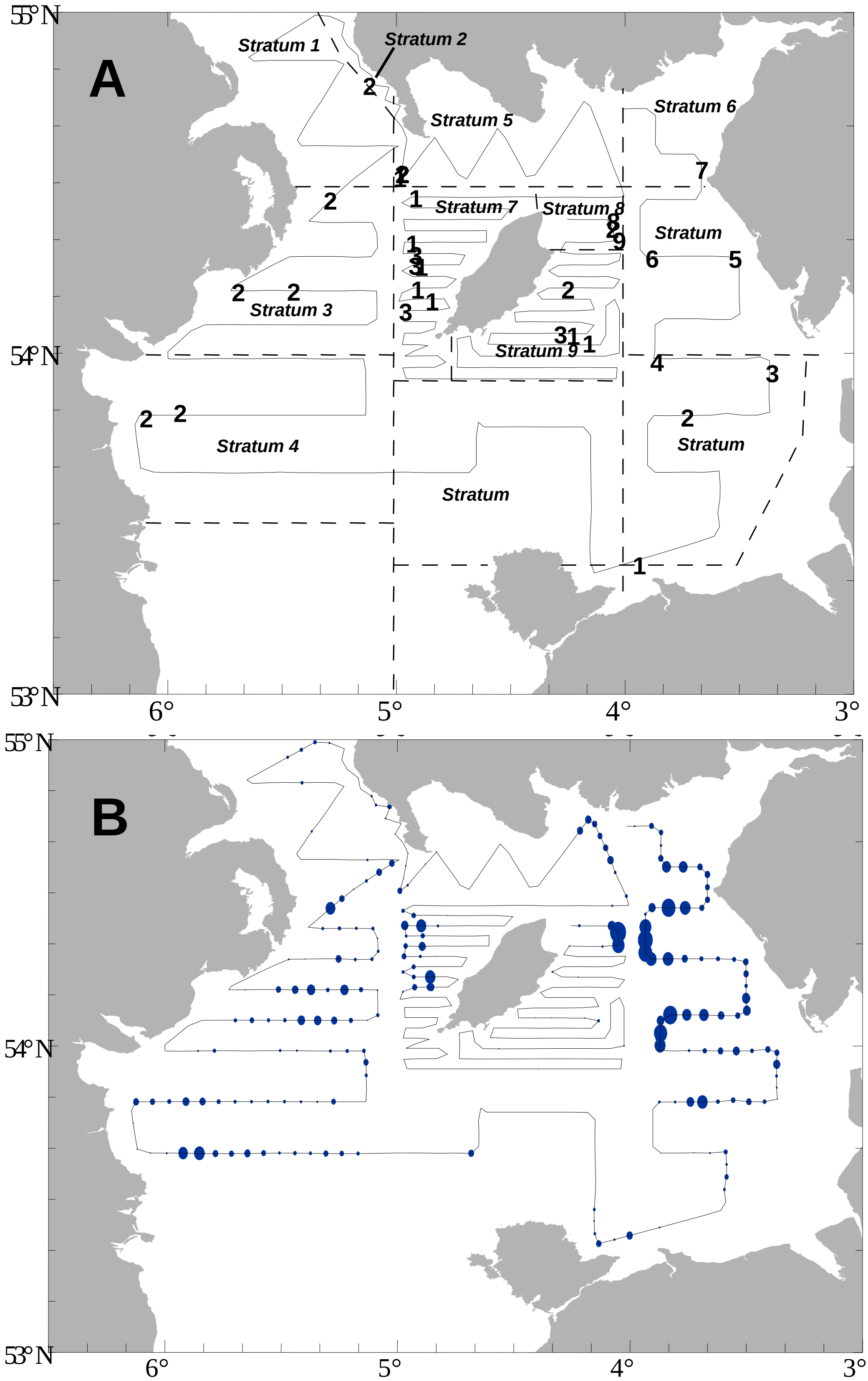
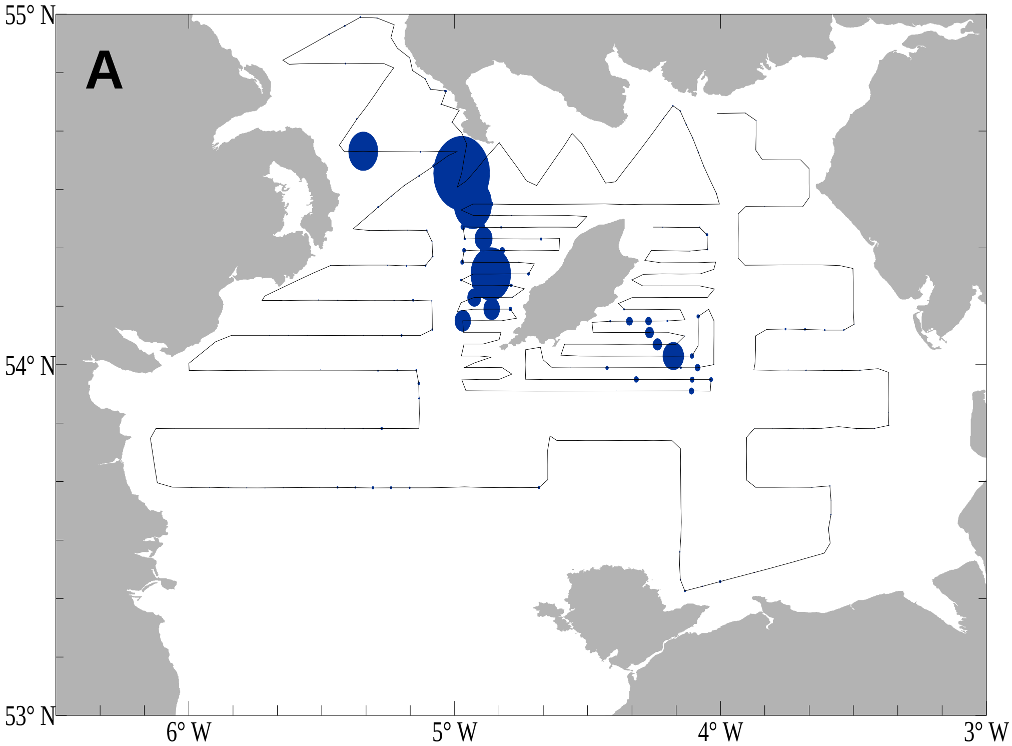


Figure 7.2.2 Irish Sea herring VIIa(N). (A) Transects, stratum boundaries and trawl positions for the 2007 acoustic survey; (B) Density distribution of sprats (size of ellipses is proportional to square root of the fish density (t $n.mile^{-2}$) per 15-minute interval). Maximum density was 500 t $n.mile^{-2}$.



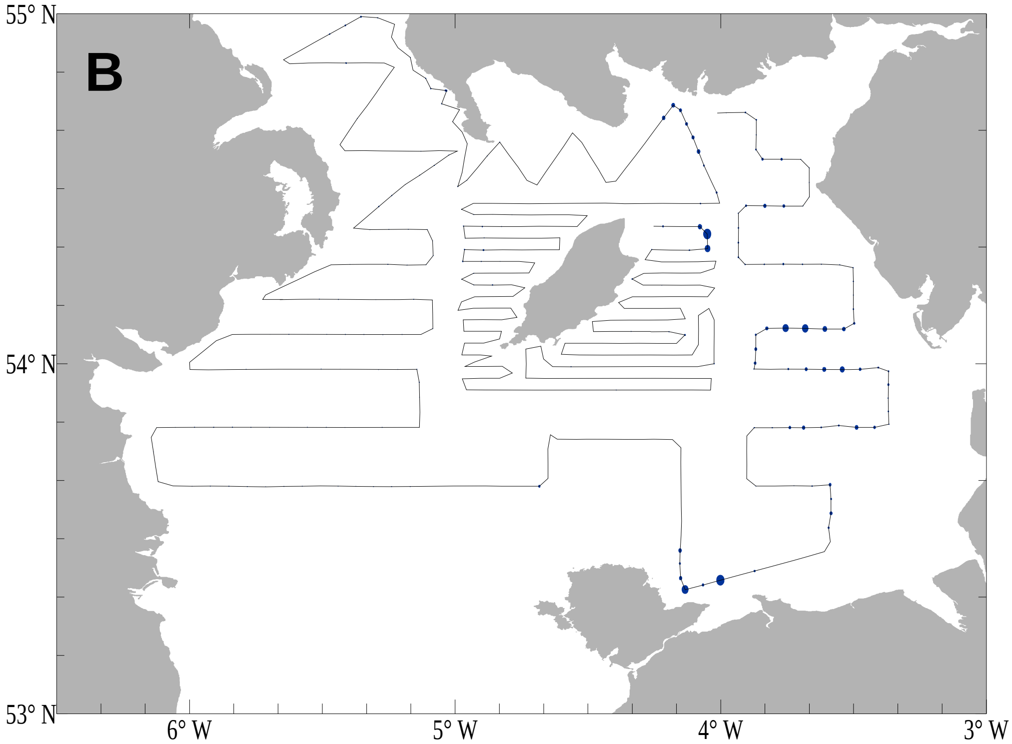


Figure 7.2.3 Irish Sea herring VIIa(N). (A) Density distribution of 1-ring and older herring (size of ellipses is proportional to square root of the fish density (t n.mile^{-2}) per 15-minute interval). Maximum density was 4 900 t n.mile^{-2}. (B) Density distribution of 0-ring herring. Maximum density was 90 t n.mile^{-2}. Note: same scaling of ellipse sizes on above figures.

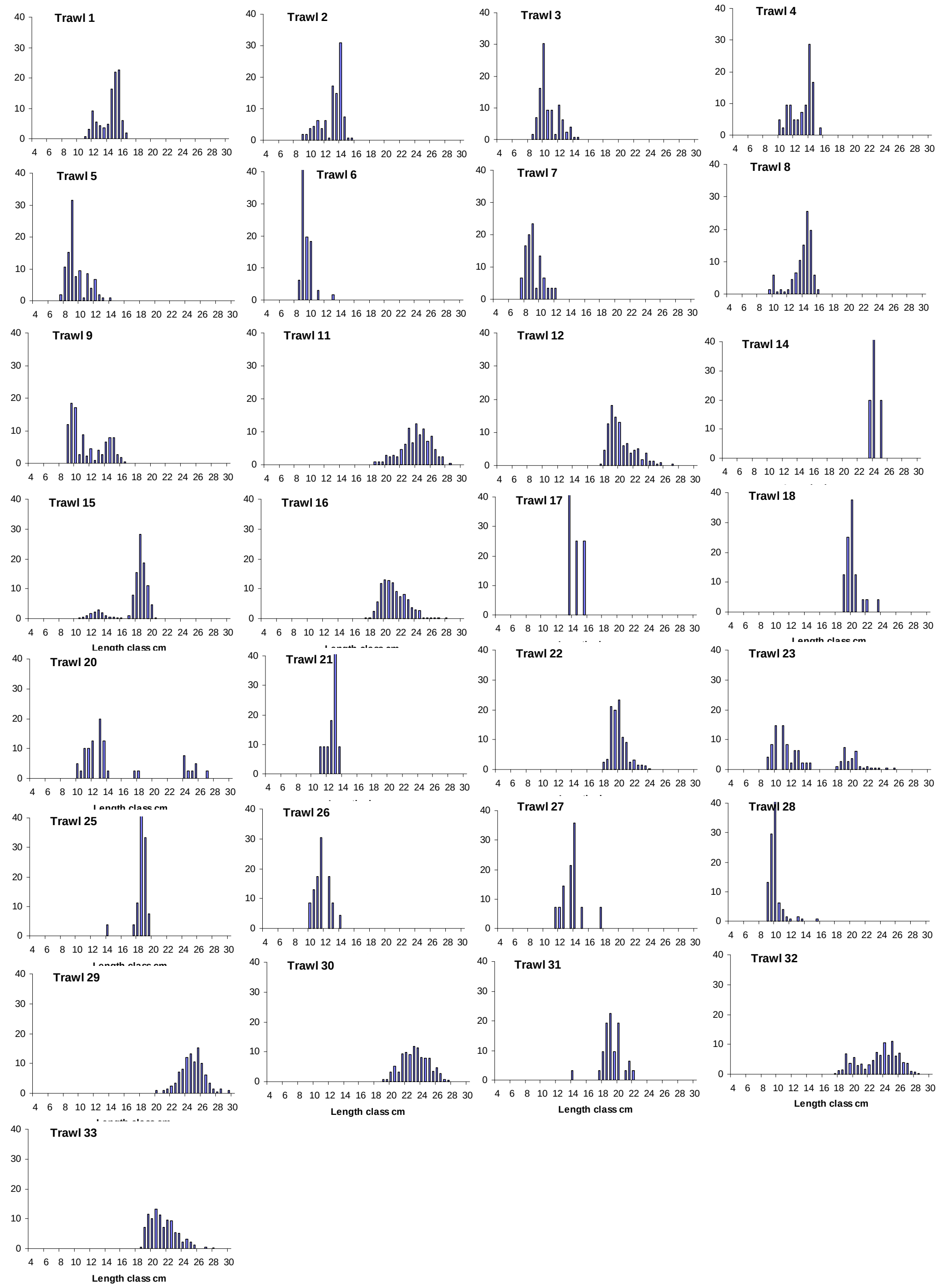


Figure 7.2.4 Irish Sea herring VIIa(N). Percentage length compositions of herring in each trawl sample in the September 2007 acoustic survey.

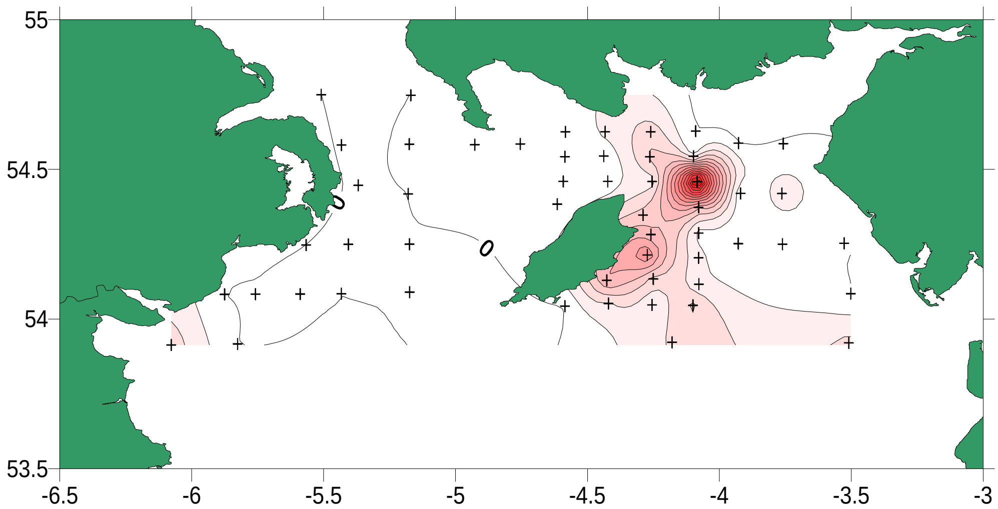


Figure 7.2.5 Irish Sea herring VIIa(N). Estimates of larval herring abundance in the Northern Irish Sea, 6th to 15th November 2007. (maximum abundance = 340.41 per m²).

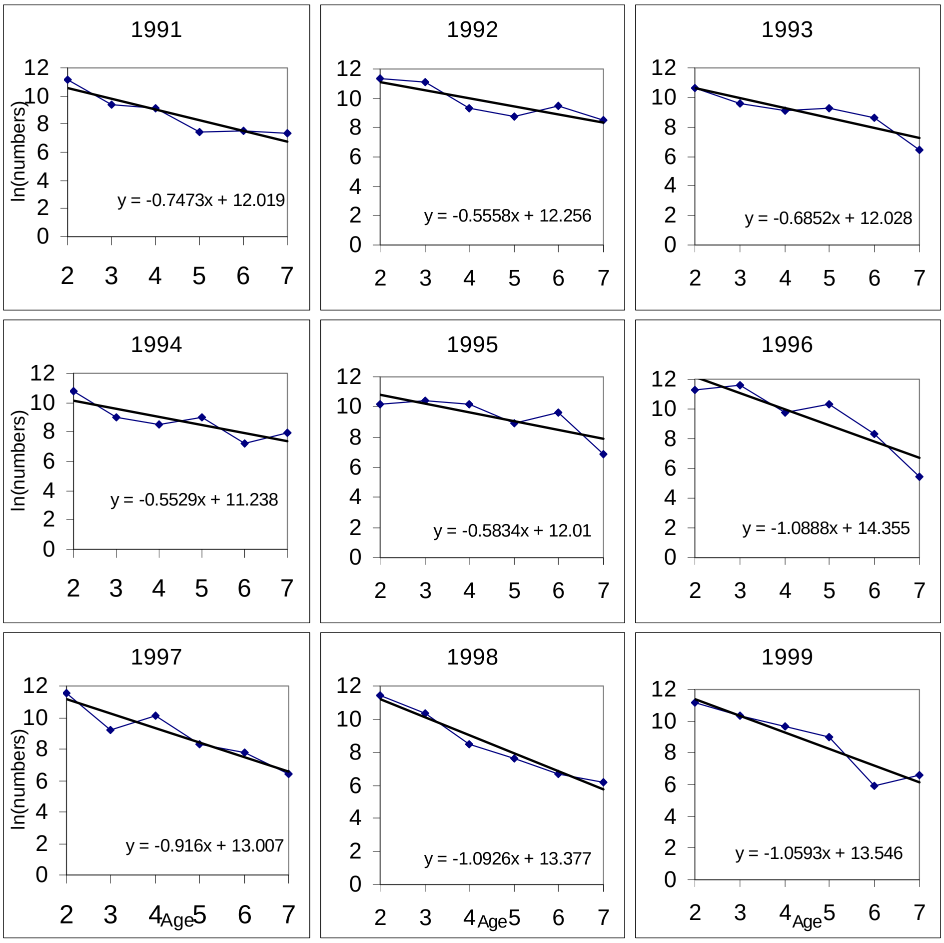


Figure 7.5.1 Irish Sea herring VIIa(N). Regressions of decline in ln numbers at ages 2 to 7 from the acoustic survey for year classes 1991 to 1999. Slope of regression (y) is estimate of total mortality Z.

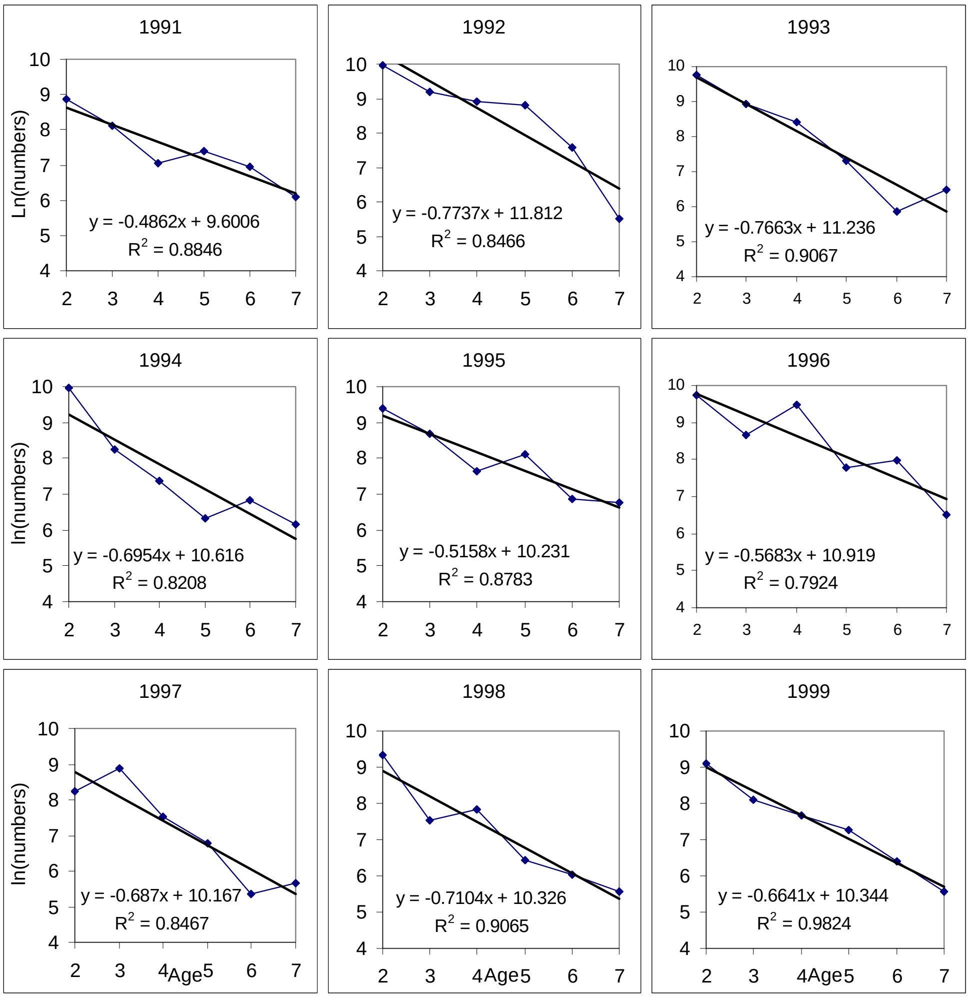


Figure 7.5.2 Irish Sea herring VIIa(N). Regressions of decline in (ln) numbers at ages 2 to 7 from the landings for year classes 1991 to 1999. Slope of regression (y) is estimate of total mortality Z.

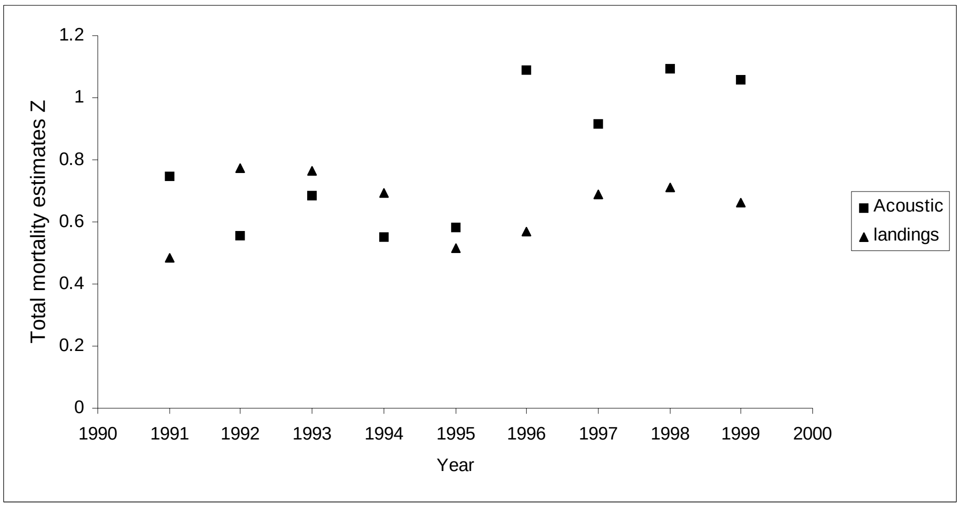


Figure 7.5.3 Irish Sea herring VIIa(N). Comparison of annual total mortality rates as estimated from the landings and acoustic survey for year 1991 to 1999. Totality mortality is slope of regression of decline in numbers-at-age.

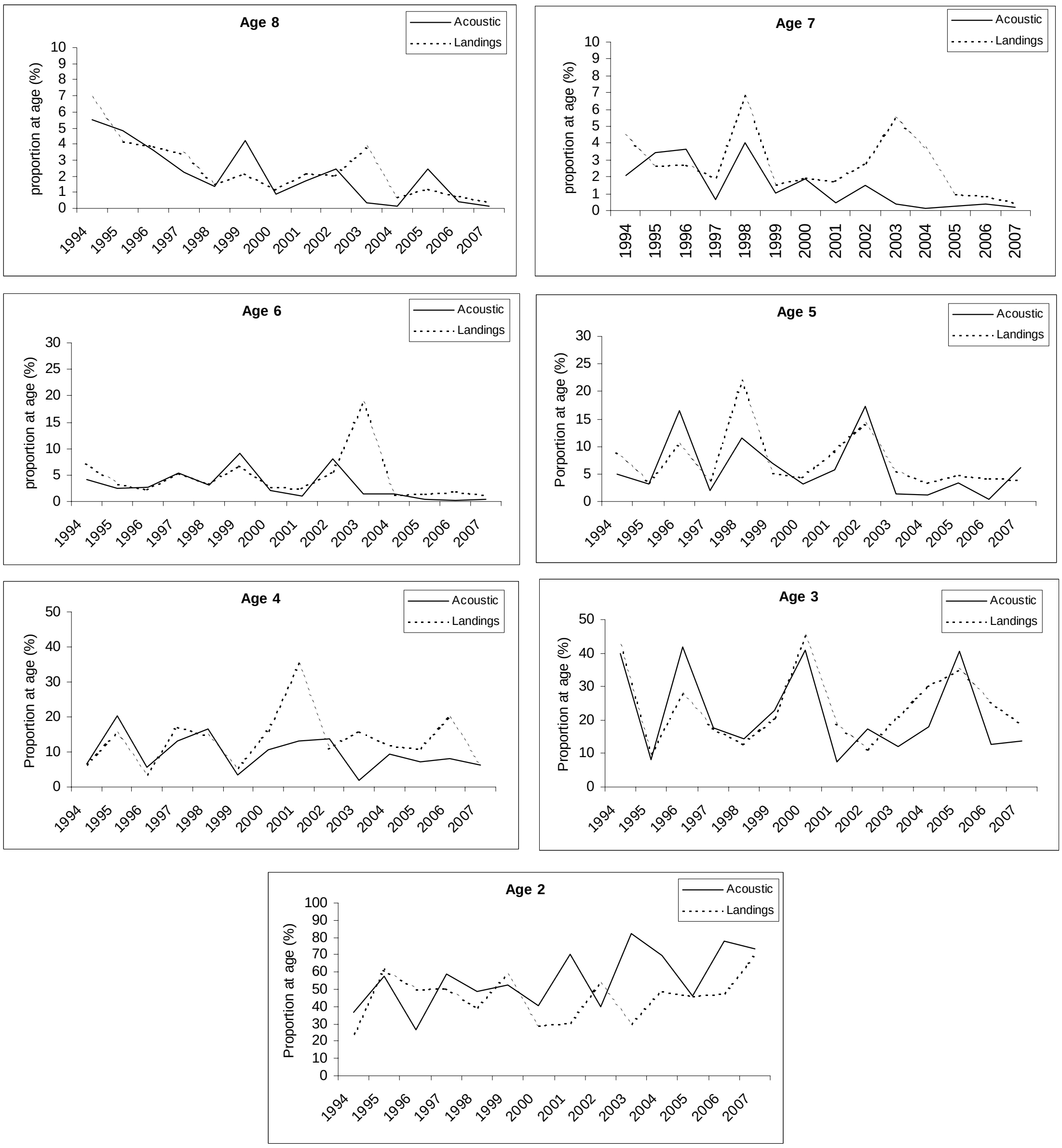


Figure 7.5.4 **Irish Sea herring VIIa(N). Inter-annual comparison of proportion catch-at-age between acoustic and catch at age data for ages 2 to 7.**

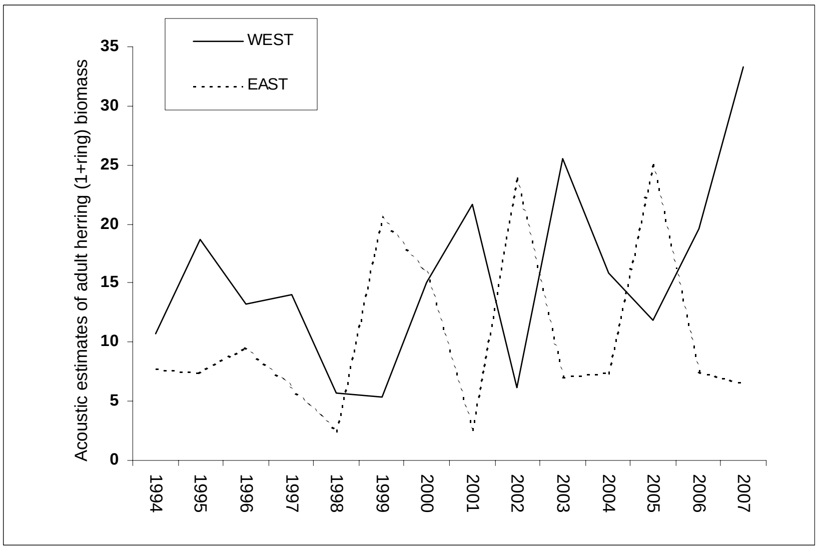


Figure 7.5.5 Irish Sea herring VIIa(N). Time-series of shifts in adult herring (1+ring) biomass distribution between the west and east Isle of Man coasts estimated from acoustic surveys 1994-2007.

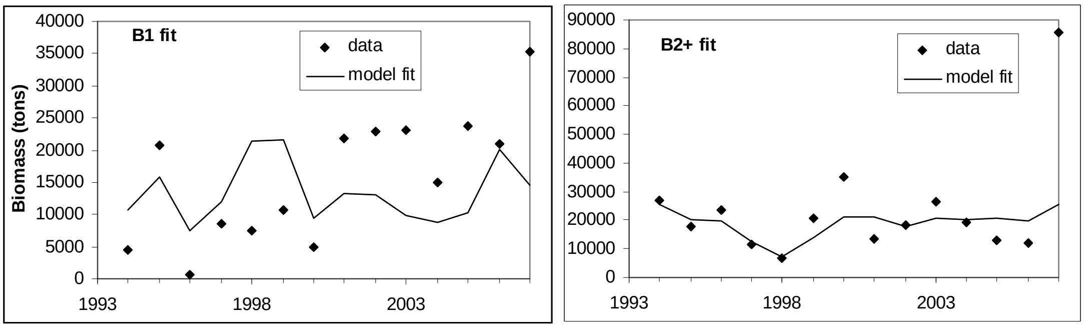


Figure 7.5.6 Irish Sea herring VIIa(N).Observed and model estimated survey indices for 1 and 2^{+}- ringers. Recruitment variability is 0.4, g = 0.2.

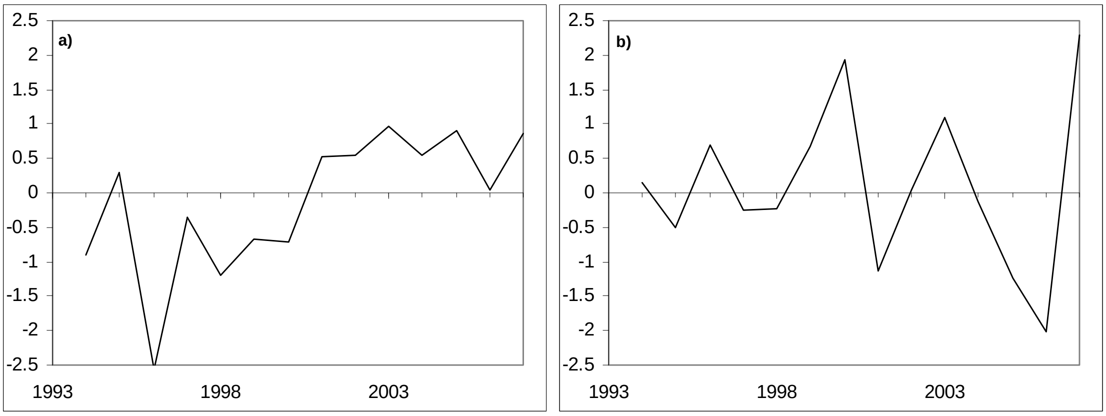


Figure 7.5.7 Irish Sea herring VIIa(N). Normalised residuals from the model fit to 1 (a) and 2+-ringers (b) survey indices for recruitment variability equal 0.4.

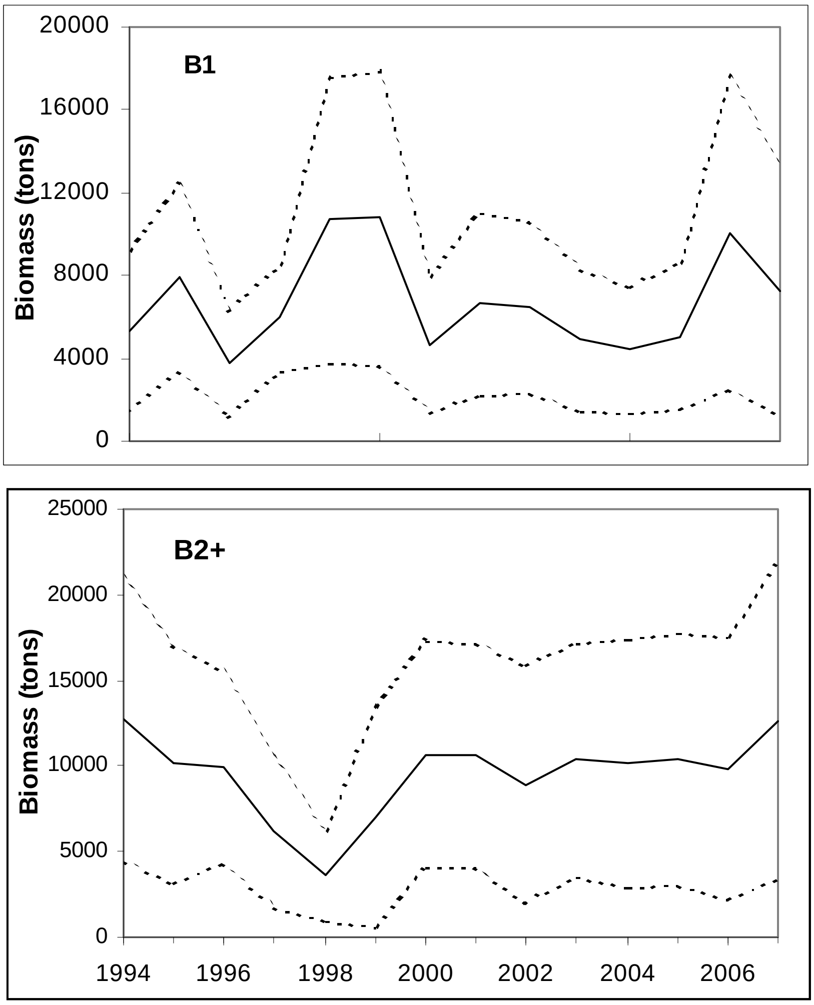


Figure 7.5.8 Irish Sea herring VIIa(N). Biomass trajectories for model fitted biomass of 1 and 2+ ringers. Recruitment variability equal to 0.4. Dotted lines correspond to +/- 2 standard deviations.

8 Sprat in the North Sea

This is an exploratory assessment.

8.1 The Fishery

8.1.1 ACFM Advice Applicable to 2007 and 2008

There have never been any explicit management objectives for this stock. The TAC set for 2006 was 282 700 t but a mid-year revision of the TAC resulted in a final TAC of 175 000 t. This was also kept as TAC in 2007. For 2008 a preliminary TAC is set at 175 000 t and a revised mid-year advice is expected. For 2008, the by-catch quota of herring (EU fleet) was set at 18 806 t.

8.1.2 Catches in 2007

Catch statistics for 1996–2007 for sprat in the North Sea by area and country are presented in Table 8.1.1. Catch data prior to 1996 are considered unreliable. As in previous years sprat from the fjords of western Norway are not included in the catches for the North Sea, due to uncertainties in stock identity. Annual catches of Norwegian fjord sprat have ranged between 400 t (2004) and 3 300 t (1996, 1999) in this period. Total catches for the North Sea in 2007 were 83 826 t, the lowest for the entire time series. The Danish catches represent more than 90% of the total catches. The Norwegian sprat fishery caught nearly 7 000 t of sprat. As an interesting note, biological sampling of Norwegian sprat catches in January revealed that these contained only minor proportions of sprat (11.8% on average), whereas sardines and anchovies made up most of the catches.

The catches by year, quarter, and area show the same picture as last year, with the largest amount taken in IVbE and in IVc, though only small catches were landed in the first quarter in 2007 (Table 8.1.2). Any inconsistency in total catches is due to rounding errors.

Quarterly and annual distribution of catches per rectangle for Subarea IV show a fishery more to the west in the first and second quarter, while the central-eastern areas are targeted in the second half of the year (Figures 8.1.1a-d and Figure 8.1.2).

8.1.3 Regulations and their effects

The Norwegian vessels are not allowed to fish in the Norwegian zone until the quota in the EU-zone has been taken. They are not allowed to fish in the 2nd and 3rd quarters in the EU and the Norwegian zone.

Sprat cannot be fished without by-catches of herring except in years with high sprat abundance or low herring recruitment. Management of this stock should consider management advice given for herring in Subarea IV, Division VIId, and Division IIIa. A decrease in recruitment for the North Sea herring autumn spawners and a probable high incoming sprat year class may potentially result in a fishery for sprat with less by-catch of herring.

Most sprat catches are taken in an industrial fishery where catches are limited by herring by-catch restrictions.

8.1.4 Changes in fishing technology and fishing patterns

No changes in fishing technology and fishing patterns of importance for the sprat fisheries in the North Sea have been reported.

8.2 Biological composition of the catch

Only data on by-catch from the Danish fishery were available to the Working Group (Table 8.2.1). The Danish sprat fishery has in general been conducted with minor by-catch of herring. The total amount of herring caught as by-catch in the sprat fishery has been less than 10 % of the total landings in the period, representing about 8 % in 2007.

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. One-year-old sprat has dominated the landings in all years (51-96%) except in 2004. In 2006, a large part of the landings (47%) consisted of 2-year-olds (2004 year class). In 2007, sprat of the 2006 year class (1-year-olds) made up about 70% of the total numbers landed.

Mean weights-at-age (g) in the landings in 2007 were in general higher than the ones in previous years (Table 8.2.3). In 2006 the mean weights-at-age for 1 and 2 group indicate ageing problems.

Denmark and Norway provided age data of commercial landings in 2007 for all quarters fished (Table 8.2.4). These data were used to raise the landings data from the North Sea. The landings by UK (England and Scotland) were minor and unsampled. The sampling level in 2007 improved compared to 2006 considering number of samples and number measured, but decreased considering the number aged. In 2007 18 sprat per 1000 t were aged compared to 33 per 1000 t in 2006. In Denmark the provisions in the EU regulation 1639/2001 and the amendment 1581/2004 have been implemented. This provision requires 1 sample per 2000 t landed. This sampling level is lower than the guidelines (1 sample per 1000 t) previously used by the HAWG but as the main fishery was carried out in a limited area and a limited season, the recommended sampling level can be regarded as adequate.

8.3 Fishery Independent Information

8.3.1 IBTS (February)

The 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. The data series from 1984 onwards are considered as comparable (Table 8.3.1). The indices from 2004-2007 are updated. It is, however, unclear how the calculations are made and if the same method has been used for the whole times series (see WD8 Jansen and Payne 2008).

Sprat of age 1 and 2 were found in the south-east, with the highest concentrations in the more central parts of the distribution area (Figure 8.3.1a-c) and Division IVc.

8.3.2 Acoustic Survey

The acoustic surveys for the North Sea herring in June-July have estimated sprat abundance since 1996 (ICES 2008/LRC:01) (see table below). In this period no sprat has been recorded in the northern part of the North Sea. The sprat was in 2007 almost exclusively found in the eastern and southern parts of the North Sea, with highest abundances off the coast of Lowestoft and in the inner German Bight (Figure 8.3.2). The age-disaggregated time series of sprat abundance and biomass from the acoustic series (ICES areas IVa-c), have been re-calculated using FishFrame for the years 2003-2007 (ICES CM 2008/LRC:01). The surveyed area has increased over the years, thus only figures for the last 5 years are roughly comparable.

Total abundance was estimated to 44 631 million individuals and total biomass 352 700 t which is a reduction by 20 % in terms of biomass when compared to last year. In most recent years the majority of the stock consists of mature sprat, but in 2007 roughly 1/3 of the sprat biomass was immature fish. The strength of the 2006 year class is above average. The sprat stock is dominated by 1- and 2-year old fish representing more than 90% of the biomass.

	ABUNDANCE (millions)					BIOMASS (1000 t)				
Year/Age	0	1	2	3+	sum	0	1	2	3+	sum
2007*	0	37250	5513	1869	44631	0.0	258.0	66.2	28.5	352.7
2006*	0	21862	19916	760	42537	0.0	158.9	265.2	11.8	435.9
2005*	0	69798	2526	350	72674	0.0	474.6	32.8	5.9	513.3
2004*	17401	28940	5312	367	52019	19.3	266.6	73.3	6.3	365.5
2003*	0	25294	3983	338	29615	0.0	198.4	61.1	6.0	265.5
2002	0	15769	3687	207	19664	0.0	166.8	55.1	3.7	225.6
2001	0	12639	1812	110	14561	0.0	96.5	23.5	1.8	121.8
2000	0	11569	6407	180	18156	0.0	100.4	92.4	2.8	195.6
1999	0	353	5	0	358	0.0	3.3	0.0	0.0	3.3
1998	17	5365	960	37	6379	0.1	48.2	14.1	0.8	63.2

***Re-calculated by the means of FishFrame (ICES 2008/LRC:01)**

8.4 Mean weights-at-age and maturity-at-age

Data on maturity by age, mean weight- and length-at-age during the 2007 summer acoustic survey are presented in the PGHERS report (ICES 2008/LRC:01).

8.5 Recruitment

The IBTS (February) 1-group index is used as a recruitment index for this stock.

The 2005 index of 1-group (2004 year class) was the highest for the 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 a few single hauls. This year class was abundant as 3-group in 2007, and in 2008 it was above, but near the average for the 4-group. In 2008 the incoming 1-group (2007 year class) is estimated to be higher than the abundance of the 1-group last year, but this estimate should be considered as preliminary.

8.6 Assessment of sprat in the North Sea

8.6.1 Data Exploration

The ICES North Sea Sprat assessment utilizes one fishery independent index namely the IBTS Q1 index (ICES, 2008). In order to prepare an analysis of the high variability of this index a raising script was developed according to the published specifications. The output suggests that the raising algorithm implemented in DATRAS differ from the documentation and have changed through time. The size of the difference is small and is not likely to have major impact on the assessment. For more details, see WD 8 (Jansen and Payne 2008).

Survey Index Comparison

Two out of three available surveys are not used in the assessment, namely IBTS Q3 and HERAS (acoustic survey). The internal consistencies of the surveys through time are depicted in Figures 8.6.1-8.6.3. Comparisons between the age structures estimated by each survey are seen on Figures 8.6.4-8.6.6. Comparison with the acoustic survey could only be done for five years, because area IVc was not covered before 2003.

All three surveys have poor internal consistencies. One possible factor adding to the noise would be the age reading problems (Torstensen 1994, 1996, 2002; Torstensen *et. al.* 2004). The HERAS consistency is appreciably better than either of the IBTS surveys (Figures 8.6.7) but is limited by the short time series.

The between survey consistency is somewhat better, indicating that the noise from the aging problems does not dominate over the signal from the true age structured population size.

8.6.2 Stock 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. 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. 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 CSA V3 software obtained through the ICES website (http://www.ices.dk/committe/acom/wg/asoft/CSA/) with catch and IBTS q1 survey indices from 1996 onwards.

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 8.6.8; note the logarithmic scale for biomass). The SSQ surface appeared to be very flat, and no clear minimum was apparent. An optimal value of around 1.16 was estimated internally by the CSA software and used as the basis for further exploration. Critically, the terminal year biomass is scaled strongly by this parameter (Figure 8.6.8). This particular effect is discussed at length in this same section in the 2007 Report (ICES CM 2007 / ACFM:11). Thus, given the inability to fix the *s* value independently of the model, 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 8.6.1 and 8.6.2, respectively. The CSA model generated a time series of the estimated recruits, stock biomass and of fishing mortality (F) which are shown in Figure 8.6.9. From the size of each individual age-group it is then possible to calculate a time series of the total stock biomass. The stock biomass in recent years decreased by approximately 50% from the ten-year high observed in 2005 but in 2008 the model estimated a slight increase. 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 8.6.9). 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 strongly with the catchability ratio, *s*. The discrepancy between the CSA and MSVPA F values can be explained in terms of this scaling. It should also be noted that the stock biomass estimated in 2008 by this method is 1 406 000 tonnes, which conflicts strongly with the value estimated from the acoustic survey (see 8.3).

The log-residuals from the CSA fit to the recruits and age 2+ are shown in Figure 8.6.10. The diagram shows some temporal patterns in both age groups although the sizes of the residuals are relatively small.

Bootstrap estimates of the stock biomass confidence intervals are shown in Figure 8.6.11 together with the point estimates. The illustration highlights the uncertainty of the estimates.

A retrospective analysis of the stock using the CSA model was limited by the relatively short time series of reliable catch data and only four retrospective runs were feasible (Figure 8.6.12). A strong retrospective bias is noted in the two most recent years. This is likely due to unrepresentative values of the 2007 IBTS indices (see analysis in 2007 WG Report, ICES CM 2007/ACFM:11).

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 additional 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 2008 total stock biomass shows a slight increase compared to 2007, which had undergone a 50% reduction from the 10-year high in 2005.

8.7 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 2008 (Figure 8.7.1) indicate a catch in the coming year of about 170 000 t. The preliminary TAC for 2008 is 175 000 t. Although such a method has been common in previous years the approach is less than ideal. The TAC is not always taken in this fishery. Using a linear regression is thus not an adequate tool for managing the stock.

8.8 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. Investigations of the structure of these metrics performed by HAWG in 2007 (ICES CM 2007/ACFM:11) revealed significant questions about their reliability; specifically, 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. Furthermore the SSB in 2008 (1 406 000 t) estimated via this method conflicts strongly with that estimated from the acoustic survey (approximately 350 000 t).

HAWG is not aware of any method to estimate the *s* 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.

8.9 State of the Stock

Precautionary reference points have not been defined for this stock and the available information is inadequate to estimate the absolute stock size. However, relative trends in biomass from an exploratory assessment indicate that the stock is at a median level for the last 10-years. The recruitment of the 2007 year class is estimated to be higher than that of the 2006 year class.

8.10 Management Considerations

The sprat stock in the North Sea is dominated by young fish and the size of the 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 previous years has been dominated by the very strong 2004 year class. The 2006 and 2007 year classes, as indicated by the 2008 IBTS q1 age 1 index, is below the average for the period. There are indications that larvae from autumn spawning will over-winter as larvae and metamorphose the year after. Requirements for a better understanding of the sprat stock in the North Sea are knowledge about stock structure, spatial distribution in the North Sea, the spawning seasons and recruitment from a possible autumn spawning.

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.

8.11 Ecosystem Considerations

Multispecies investigations have demonstrated that sprat is one of the important prey species in the North Sea ecosystem. Many of the plankton-feeding fish have recruited poorly in recent years (e.g. herring, sandeel, Norway pout). The implications of the environmental change for sprat and the influence of the sprat fishery for other fish species and sea birds, are at present unknown.

The zooplankton community structure that is sustaining the sprat stocks appears to be changing, and there has been a long-term decrease in total zooplankton abundance in the northern North Sea (Reid et al., 2003; Beaugrand, 2003; ICES, 2006). However, sprat is mainly distributed in the southern North Sea where these trends have not been observed (ICES, 2006).

8.12 Changes in the environment

Temperatures in this area have been increasing over the last number of decades. It is considered that this may have implications for sprat. The high incidence of anchovy and sardine in the Norwegian catches is probably related to increased water temperature.

Table 8.1.1. Sprat in the North Sea. Catches (' 000 t) 1996-2007. 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	2007
Division IVa												
Denmark	0.3			0.7		0.1	1.1		0.0		0.0	0.8
Norway												
Sweden						0.1						
Total	0.3	0.0	0.0	0.7	0.0	0.2	1.1	0.0	0.0	0.0	0.0	0.8
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	2.3
Norway	1.9	2.3				0.9	0.0					
UK(Engl.&Wales)												
UK(Scotland)				0.8								0.1
Total	3.7	84.5	21.1	14.0	18.8	12.0	16.3	22.0	53.8	53.3	8.0	2.4
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	53.2
Germany												
Norway	50.9	0.8	15.3	13.1	0.9	5.0			0.1		0.8	3.7
Sweden	0.5		1.7	2.1		1.4				0.0		
UK(Scotland)				0.6								
Total	126.1	11.7	115.2	162.9	145.0	139.3	109.8	130.9	122.2	150.7	72.3	56.9
Division IVc												
Denmark	3.9	5.7	11.8	3.3	28.2	13.1	14.8	22.3	16.8	2.0	23.8	20.6
France												
Netherlands				0.2								
Norway		0.1	16.0	5.7	1.8	3.6					9.0	2.9
UK(Engl.&Wales)	2.6	1.4	0.2	1.6	2.0	2.0	1.6	1.3	1.5	1.6	0.5	0.3
Total	6.5	7.2	28.0	10.8	32.0	18.7	16.4	23.6	18.3	3.6	33.4	23.8
Total North Sea												
Denmark	80.7	98.8	131.1	164.3	191.1	157.1	142.0	175.2	192.7	206.0	103.4	76.8
France	0.0	0.0	0.0	0.0	0.0	0.0	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	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	0.0	0.0	0.0	0.0	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	6.7
Sweden	0.5	0.0	1.7	2.1	0.0	1.5	0.0	0.0	0.0	0.0	0.0	0.0
UK(Engl.&Wales)	2.6	1.4	0.2	1.6	2.0	2.0	1.6	1.3	1.5	1.6	0.5	0.3
UK(Scotland)	0.0	0.0	0.0	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Total	136.6	103.4	164.3	187.8	195.9	170.2	143.6	176.5	194.3	207.7	113.7	83.8

Table 8.1.2. Sprat in the North Sea. Catches (tonnes) by quarter. Catches in fjords of Western Norway excluded. Data for 1996-1999 in ICES CM 2007/ACFM :11

Year	Quarter	Area					Total
		IVaW	IVaE	IVbW	IVbE	IVc	
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
2007	1			582		247	829
	2			230	11	3	244
	3			1,165	15,438		16,603
	4	769		4,135	37,715	23,531	66,150
	Total	769	0	6,112	53,164	23,781	83,826

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 1998-2007.

	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
Tonnes	2007	76,828	6,596	168	900	6	126	18	6	253	84,902
Percent	1998	88.6	8.1	0.4	0.5	0.0	0.2	0.0	1.5	0.8	100.0
Percent	1999	91.4	4.2	0.2	0.6	0.0	0.2	0.0	2.9	0.4	100.0
Percent	2000	90.3	5.6	1.6	1.0	0.0	0.4	0.0	0.2	0.9	100.0
Percent	2001	79.9	8.2	0.0	1.0	0.1	0.2	0.0	10.0	0.7	100.0
Percent	2002	83.9	9.9	1.2	1.5	0.0	0.4	0.0	2.4	0.5	100.0
Percent	2003	88.8	5.3	0.4	0.6	0.0	0.4	0.0	2.8	1.8	100.0
Percent	2004	89.6	5.0	0.2	0.2	0.0	2.2	0.0	1.9	0.9	100.0
Percent	2005	85.9	9.0	1.1	0.2	0.0	0.4	0.0	2.9	0.4	100.0
Percent	2006	86.0	7.5	0.5	0.3	0.0	0.8	0.0	4.5	0.5	100.0
Percent	2007	90.5	7.8	0.2	1.1	0.0	0.1	0.0	0.0	0.3	100.0

Table 8.2.2 North Sea Sprat. Catch in numbers (millions) by quarter and by age 1997-2007.

Year	Quarter	Age						
		0	1	2	3	4	5+	Total
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
2007	1	0.0	12.1	57.4	17.3			86.8
	2	0.0	3.9	18.5	5.6			28.0
	3	0.0	1,025.3	194.5	17.7	25.3		1,262.7
	4	858.6	4,047.6	1,066.0	150.9			6,123.1
	Total	858.6	5,088.8	1,336.5	191.4	25.3	0.0	7,500.6

Table 8.2.3. North Sea Sprat. Mean weight (g) by quarter and by age for 1996 - 2007.

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
2007	1		4.0	9.0	12.0			829
	2		4.0	9.0	12.0			244
	3		12.0	17.0	13.0	17.0		16,603
	4	5.1	10.9	13.5	16.3			66,150
Weighted mean		5.1	11.1	13.8	15.5	17.0		83,826

Table 8.2.4. North Sea Sprat. Sampling for biological parameters in 2007.

Country	Quarter	Landings ('000 tonnes)	No. samples	No. measured	No. aged
Denmark	1	0.1	0	0	0
	2	0.2	0	0	0
	3	16.6	5	642	200
	4	59.9	24	3568	984
	Total	76.8	29	4210	1184
UK(England)	1	0.2	0	0	0
	2				
	3				
	4	0.0	0	0	0
	Total	0.3	0	0	0
UK(Scotland)	1	0.1	0	0	0
	2				
	3	0.0	0	0	0
	4				
	Total	0.1	0	0	0
Norway	1	0.4	2	149	99
	2				
	3				
	4	6.3	4	400	200
	Total	6.7	6	549	299
Total North Sea		83.8	35	4759	1483

Table 8.3.1 North Sea sprat. Abundance indices (no. per hour) by age from IBTS (February) from 1984-2008.

Year	Age					
	1	2	3	4	5+	Total
1984	233.76	329.00	39.61	6.20	0.29	608.86
1985	376.10	195.48	26.76	3.80	0.35	602.49
1986	44.19	73.54	22.01	1.23	0.24	141.21
1987	542.24	66.28	19.14	1.92	0.24	629.82
1988	98.61	884.07	61.80	6.99	0.00	1051.46
1989	2314.22	476.29	271.85	5.47	1.65	3069.48
1990	234.94	451.98	102.16	28.06	2.22	819.37
1991	676.78	93.38	23.33	2.63	0.12	796.24
1992	1060.78	297.69	43.25	7.23	0.53	1409.48
1993	1066.83	568.53	118.42	6.07	0.34	1760.19
1994	2428.36	938.16	92.16	3.59	0.50	3462.77
1995	1224.89	1036.40	87.33	2.52	0.76	2351.90
1996	186.13	383.53	146.84	18.28	0.74	735.53
1997	591.86	411.95	179.55	15.52	2.24	1201.13
1998	1171.05	1456.51	305.91	15.75	3.38	2952.60
1999	2534.53	562.10	80.35	4.83	0.45	3182.25
2000	1058.20	851.58	274.71	43.89	0.88	2229.27
2001	883.06	1057.00	185.47	17.55	0.35	2143.42
2002	1152.33	812.45	91.63	11.93	0.38	2068.72
2003	1842.26	309.92	44.49	2.21	0.04	2198.92
2004	1593.89	495.70	78.24	3.50	1.54	2172.87
2005	3053.46	267.89	36.39	0.87	0.00	3358.60
2006	421.80	1212.87	92.38	8.26	0.07	1735.39
2007	1053.68	1339.83	274.81	11.18	0.01	2679.52
2008*	1598.78	666.52	83.58	11.02	0.00	2359.91

*: Preliminary

Table 8.6.1. North Sea sprat. Input data to the CSA model. Catch in numbers, IBTS q1 abundance indices for age 1 (Irec) and age 2+ (Ifull), mean weights (g) in the stock of recruits and mature individuals, the catchability ratio (Srat) and the natural mortality per year, (M). Catches for the 2007 year are set to zero, as they are not used by the model. The 2008 Ifull index is used as a fitting parameter in this method but the Irec index for 2008 is not.

	Catch no.		IBTS indices (Feb)		Weights (g)			
Year	Age 1	Age 2+	Age 1	Age 2+	Age 1	Age 2+	Srat	M
1996	2118	9393	186	549	4.5	9.67	1	0.75
1997	5675	1865	592	609	4.5	9.67	1	0.75
1998	8933	4124	1171	1782	4.5	9.67	1	0.75
1999	15829	3206	2535	648	4.5	9.67	1	0.75
2000	11649	5803	1058	1171	4.5	9.67	1	0.75
2001	8280	6420	883	1260	4.5	9.67	1	0.75
2002	10442	1850	1152	916	4.5	9.67	1	0.75
2003	12529	3449	1842	357	4.5	9.67	1	0.75
2004	9283	1542	1594	579	4.5	9.67	1	0.75
2005	22364	708	3053	305	4.5	9.67	1	0.75
2006	6691	6495	422	1314	4.5	9.67	1	0.75
2007	5089	1553	1054	1625	4.5	9.67	1	0.75
2008			1599	761	4.5	9.67	1	0.75

Table 8.6.2 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	17948	98971	1037816	0.155	0.118	0.095	2118	9393	1.164	0.75
1997	105662	47317	933035	0.074	0.054	0.039	5675	1865	1.164	0.75
1998	98757	67080	1093068	0.122	0.090	0.061	8933	4124	1.164	0.75
1999	229853	69362	1705066	0.097	0.069	0.046	15829	3206	1.164	0.75
2000	101973	128257	1699119	0.117	0.114	0.045	11649	5803	1.164	0.75
2001	72970	96758	1264014	0.135	0.113	0.066	8280	6420	1.164	0.75
2002	68866	70071	987481	0.138	0.152	0.026	10442	1850	1.164	0.75
2003	109635	57181	1046298	0.150	0.114	0.060	12529	3449	1.164	0.75
2004	88083	67817	1052162	0.107	0.105	0.023	9283	1542	1.164	0.75
2005	330247	66202	2126285	0.088	0.068	0.011	22364	708	1.164	0.75
2006	41318	171412	1843488	0.095	0.162	0.038	6691	6495	1.164	0.75
2007	89267	91424	1285774	0.055	0.057	0.017	5089	1553	1.164	0.75
2008	138924	80788	1406372	-	-	-	-	-	1.164	0.75

q = 0.98916E-02

SSQ = 0.387E+01
RMS = 0.322E+00

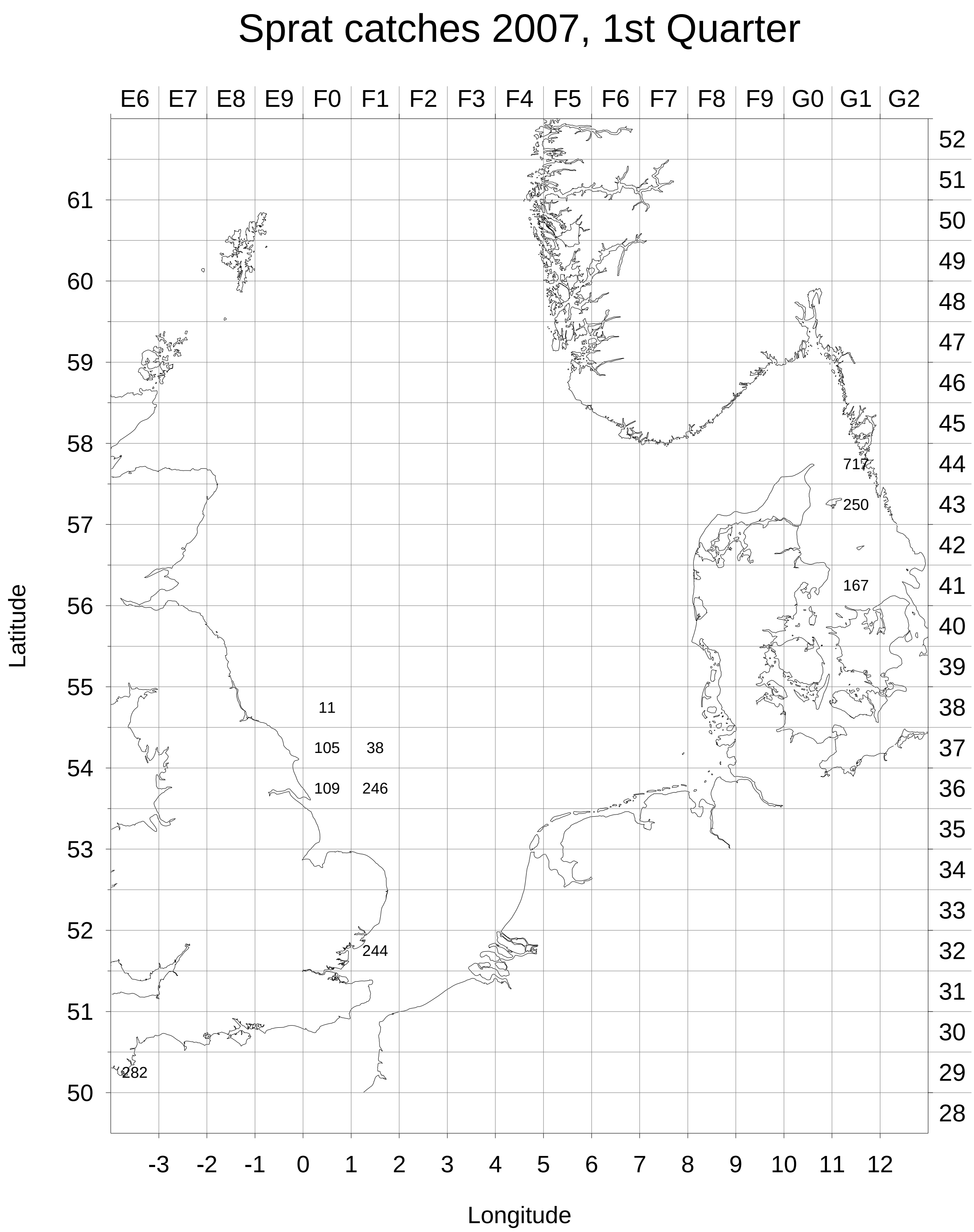


Figure 8.1.1a Sprat catches in the North Sea (in tonnes) in 2007 by statistical rectangle. Working group estimates (if available). a.: 1st quarter

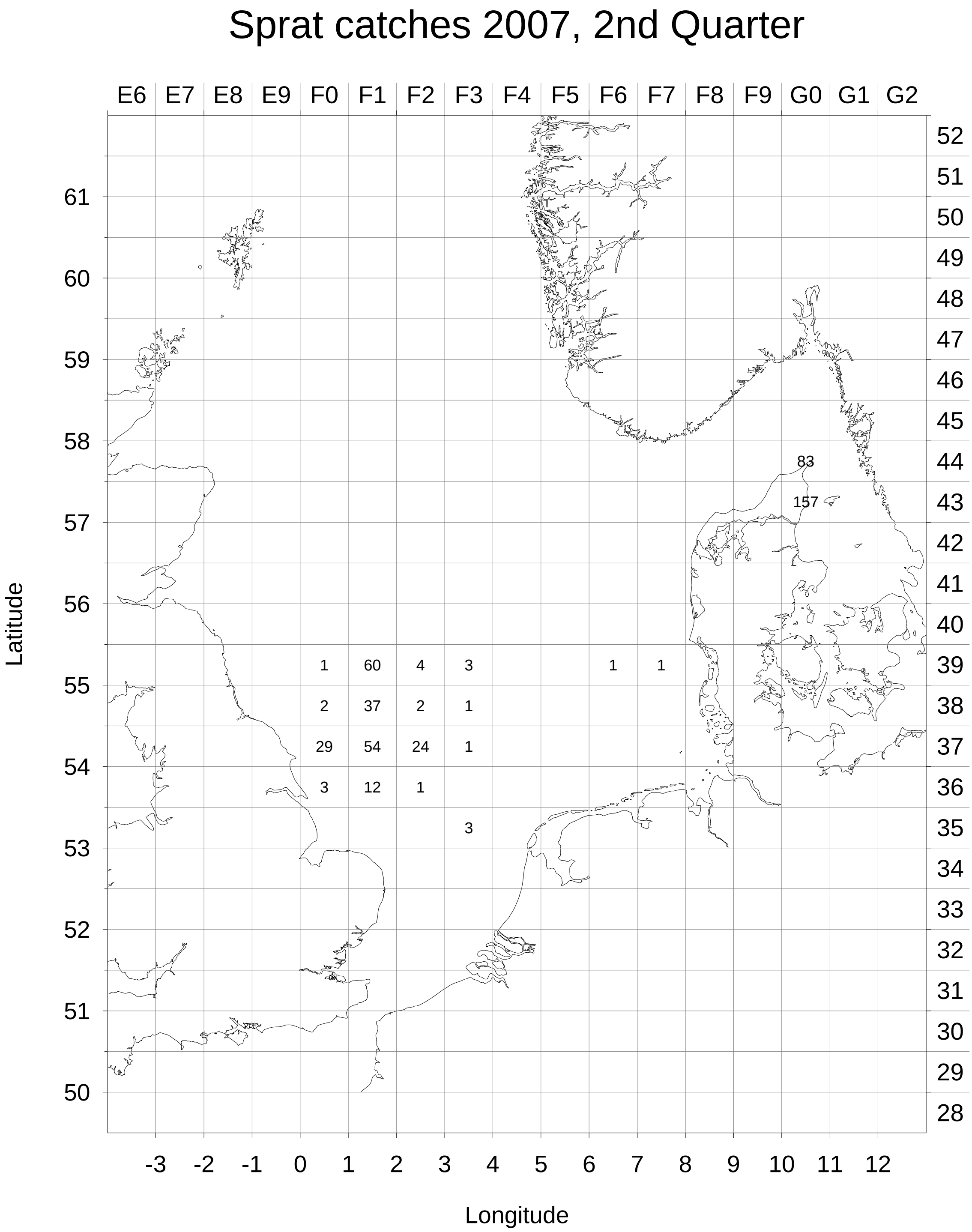


Figure 8.1.1b Sprat catches in the North Sea (in tonnes) in 2007 by statistical rectangle. Working group estimates (if available). b.: 2nd quarter

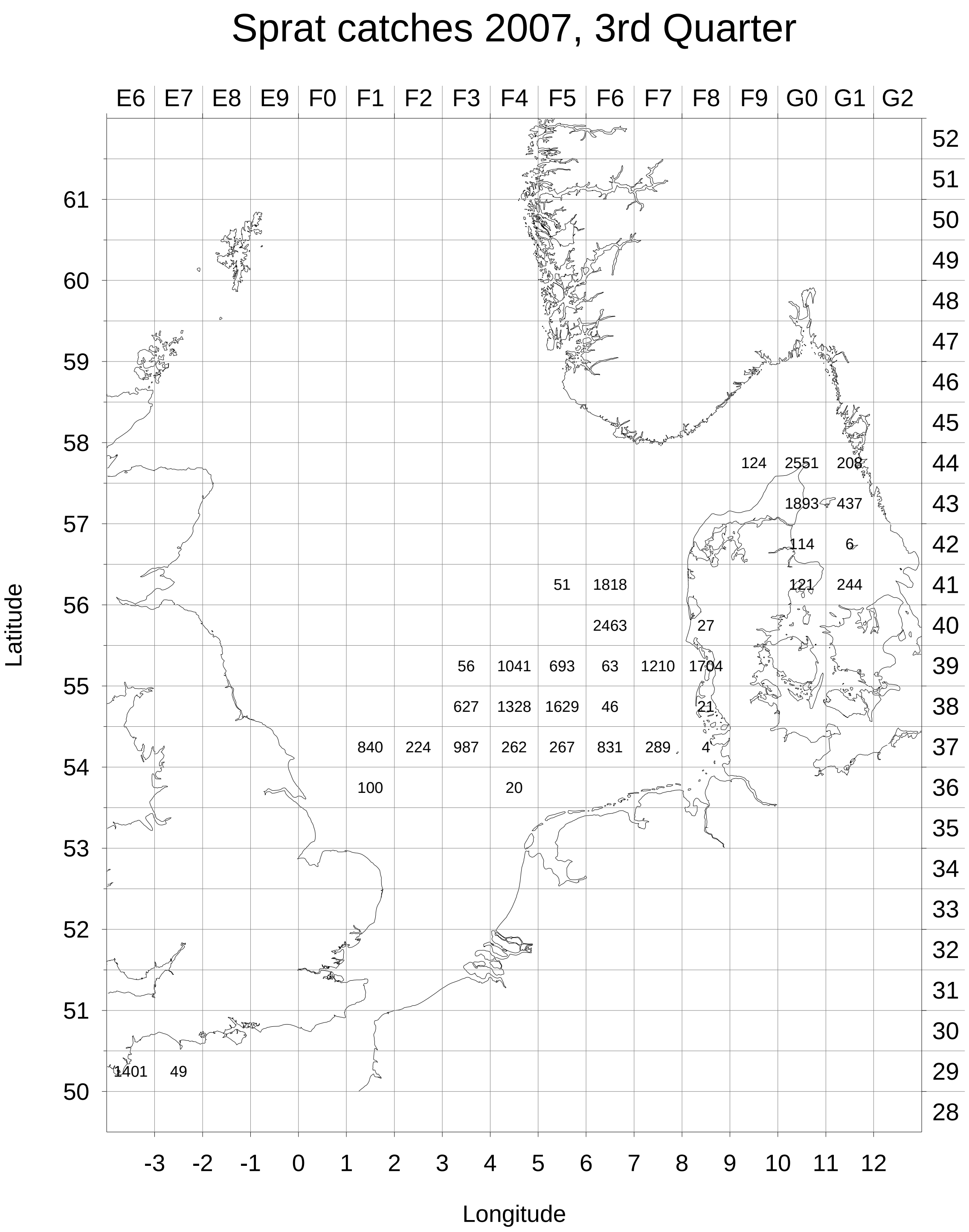


Figure 8.1.1c **Sprat catches in the North Sea (in tonnes) in 2007 by statistical rectangle. Working group estimates (if available). c.: 3rd quarter**

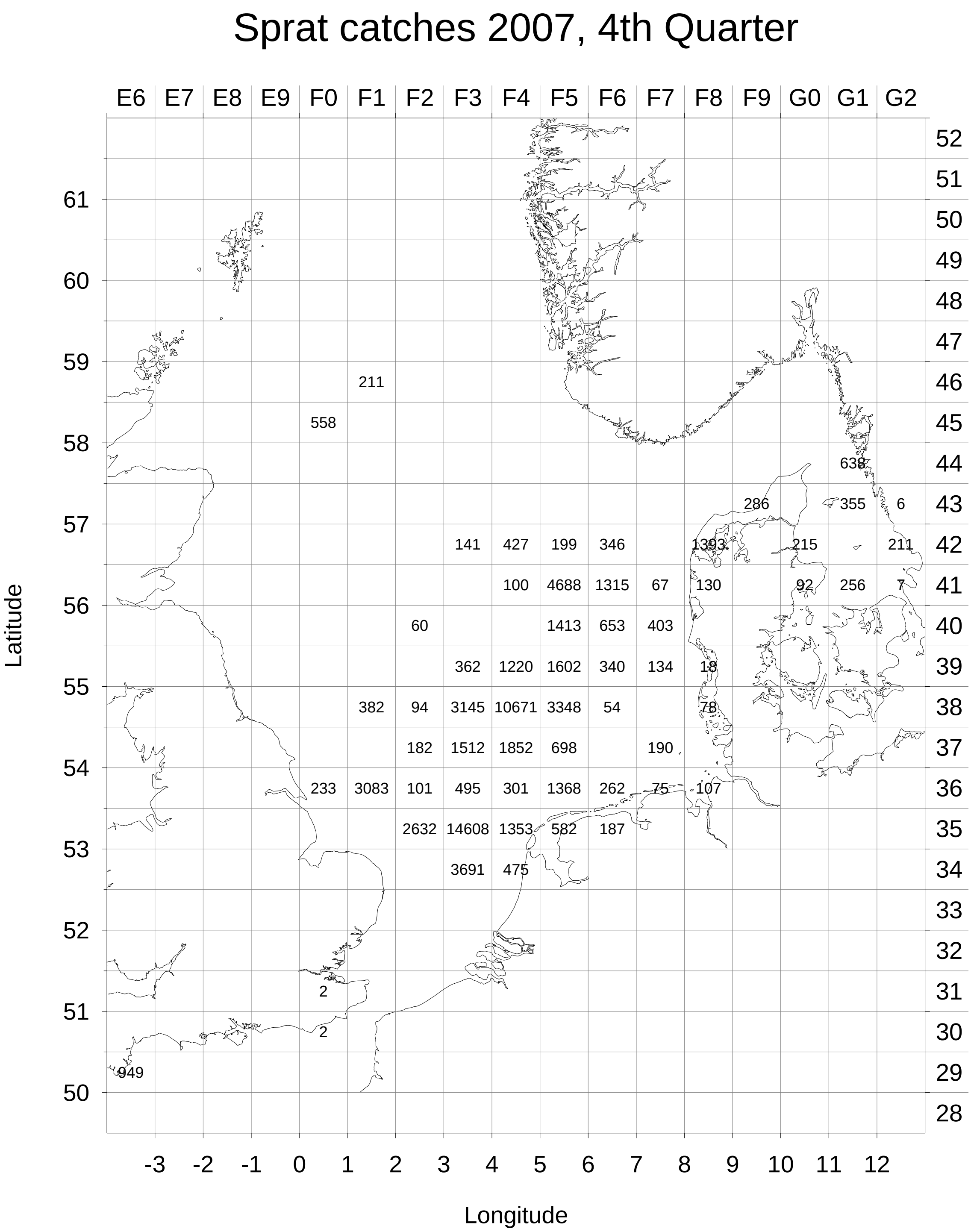


Figure 8.1.1d Sprat catches in the North Sea (in tonnes) in 2007 by statistical rectangle. Working group estimates (if available). d.: 4th quarter

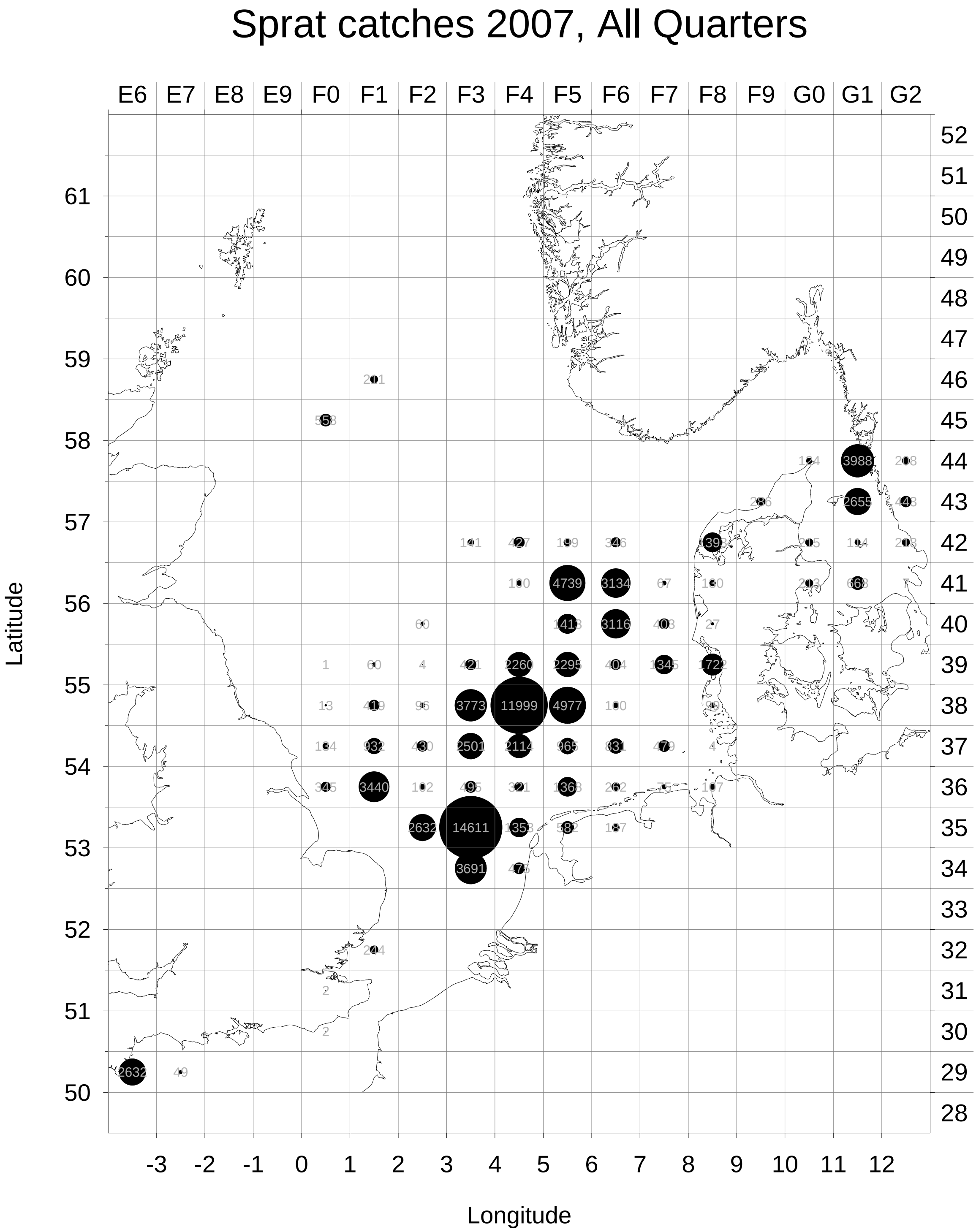


Figure 8.1.2 **Sprat catches in the North Sea (in tonnes) in 2007 by statistical rectangle. Working group estimates (if available). e: all quarters**

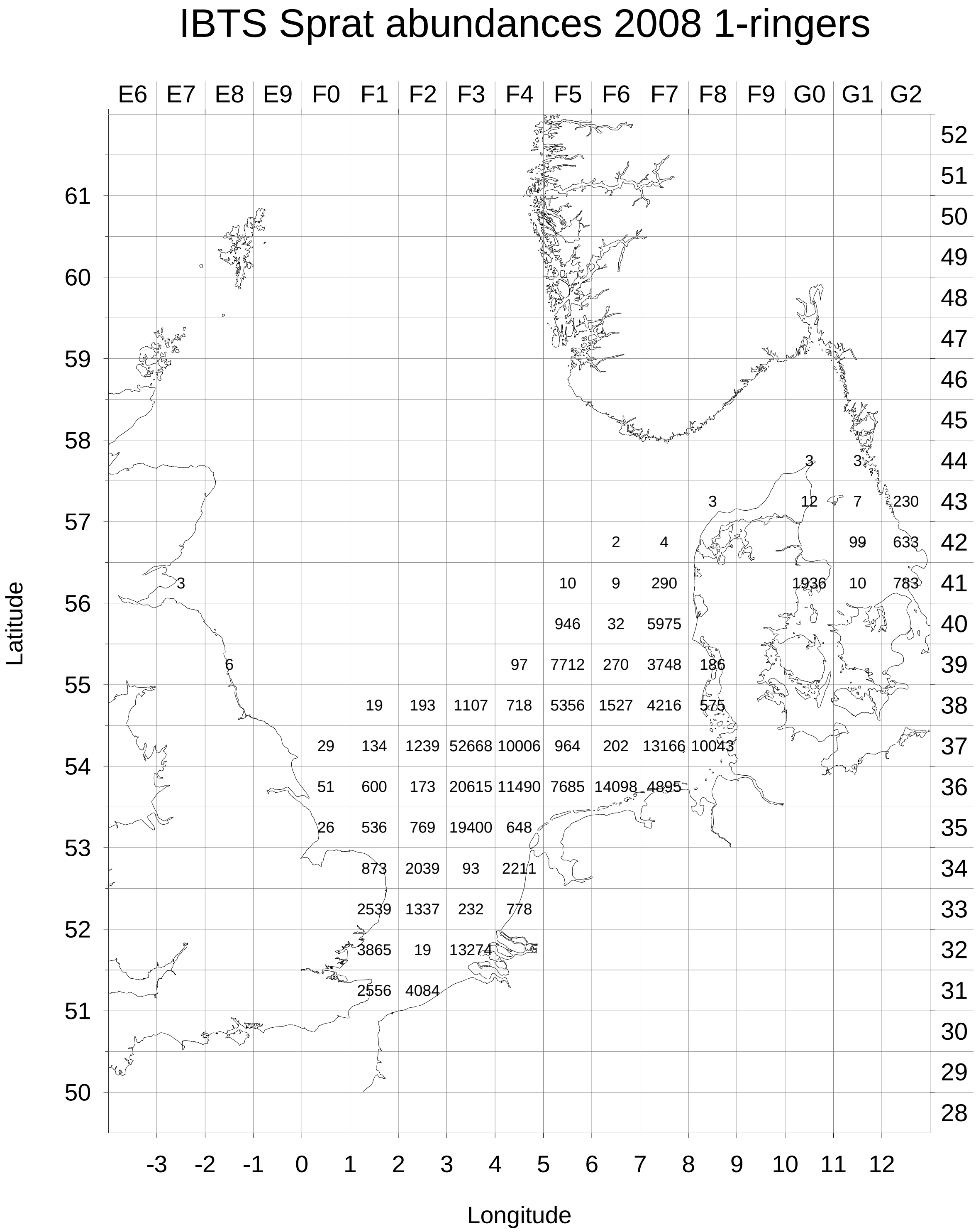


Figure 8.3.1a. Distribution of 1-ringers in the IBTS (February) 2008 in the North Sea and Division IIIa (Mean number per hour per rectangle).

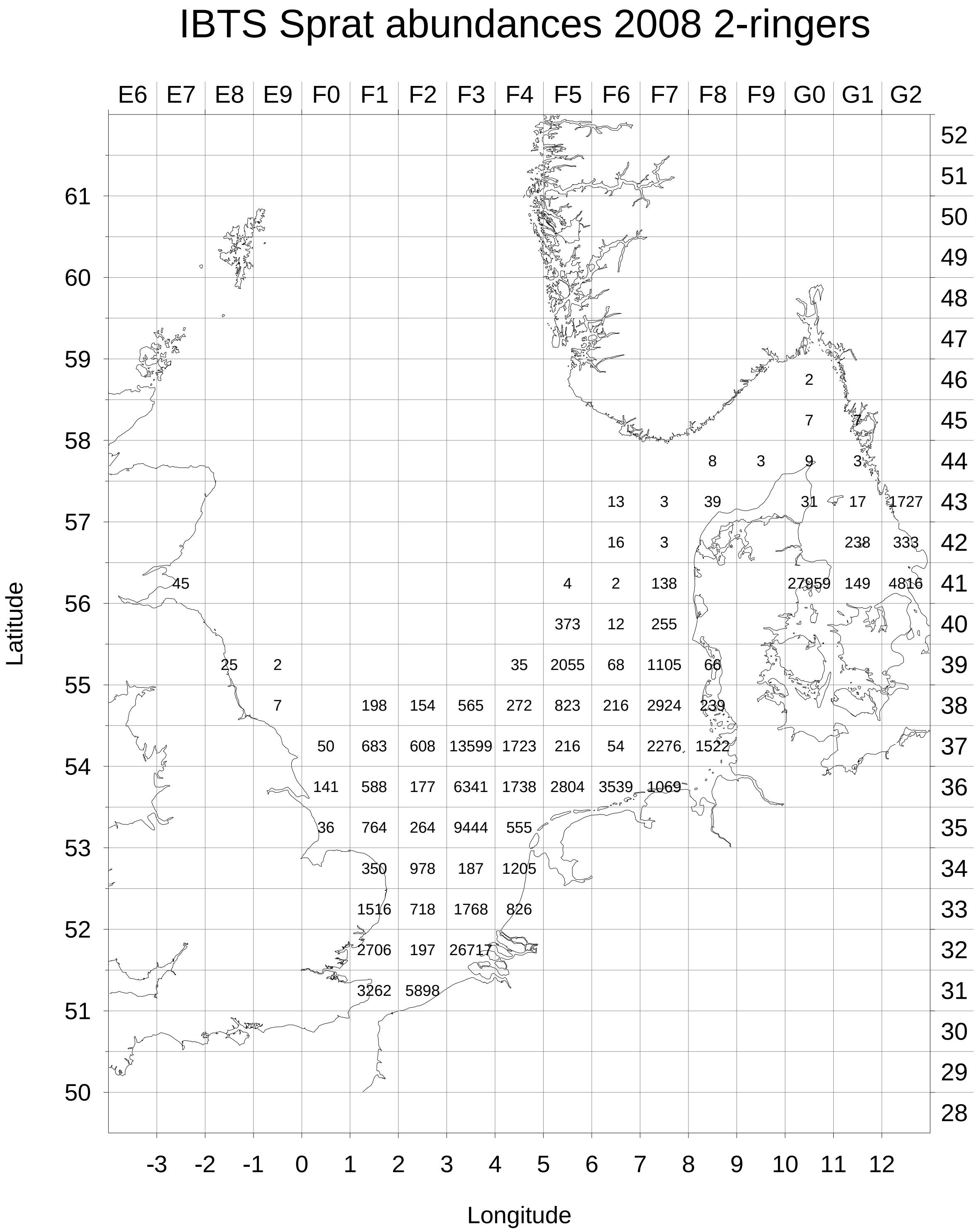


Figure 8.3.1b. Distribution of 2-ringers in the IBTS (February) 2008 in the North Sea and Division IIIa (Mean number per hour per rectangle).

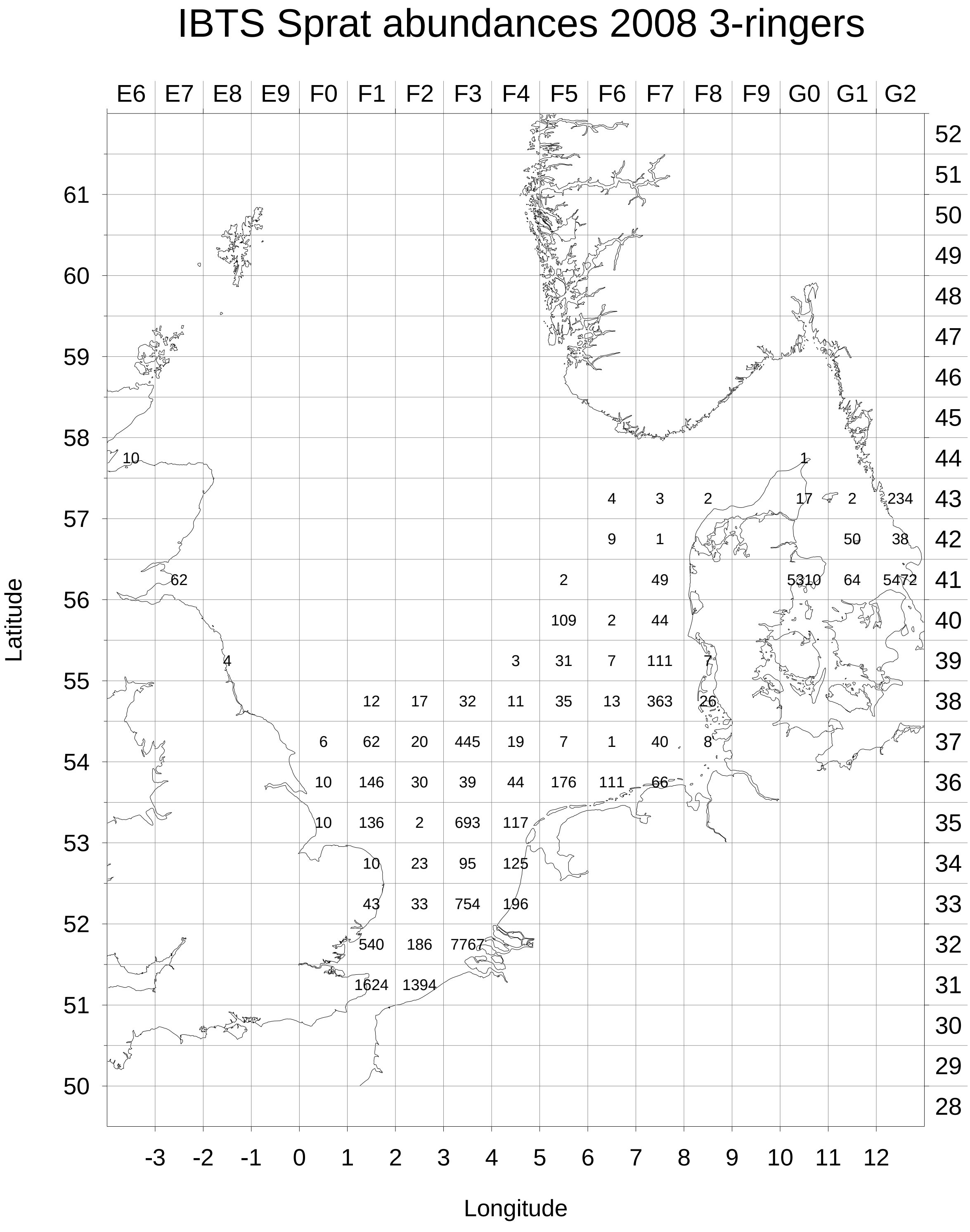


Figure 8.3.1c. Distribution of 3-ringers in the IBTS (February) 2008 in the North Sea and Division IIIa (Mean number per hour per rectangle).

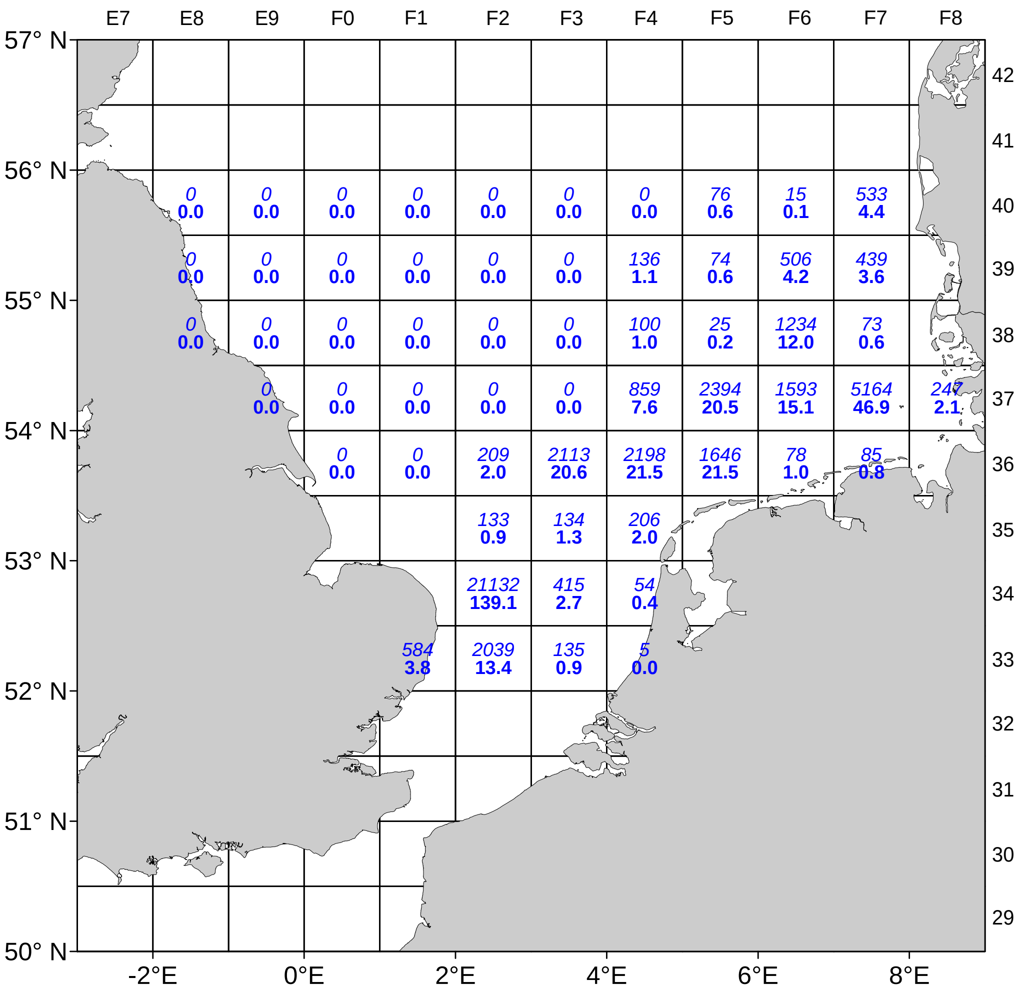


Figure 8.3.2: North Sea Sprat. Abundance (upper figure, in millions) and biomass (lower figure, in 1000 t) per statistical rectangle as obtained by the herring acoustic survey 2007.

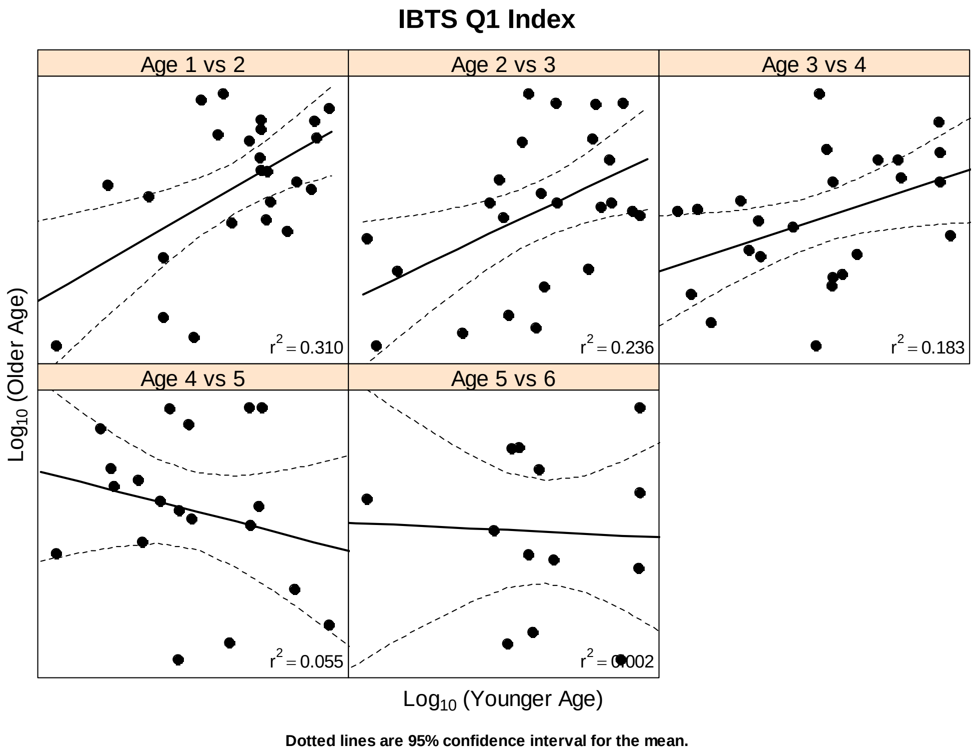


Figure 8.6.1. IBTS Q1 internal consistency plot of cohort size for all available years

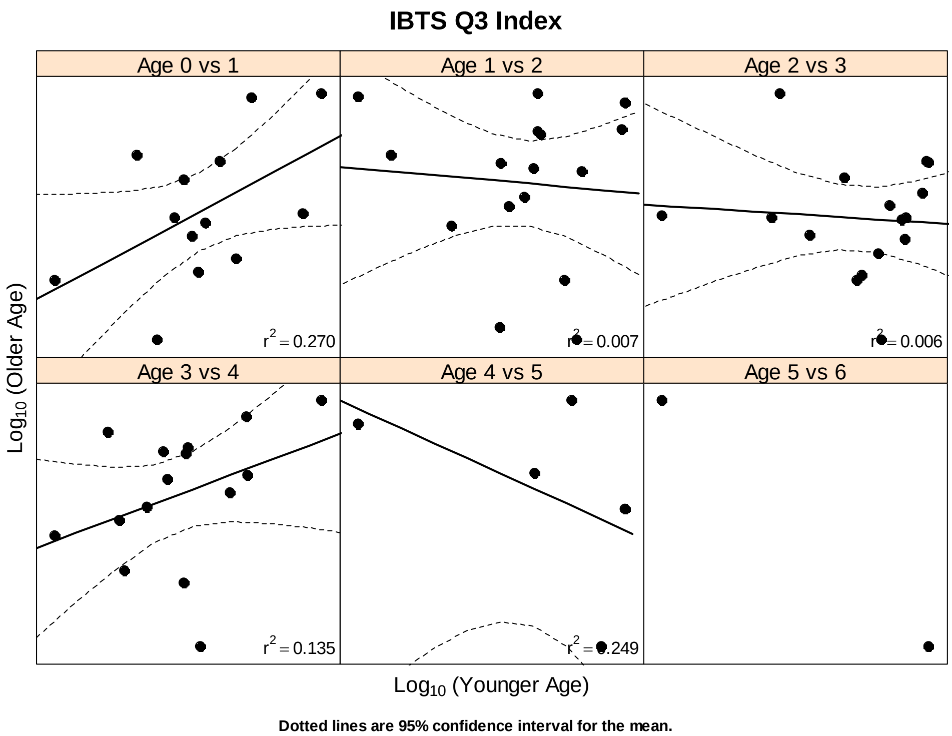


Figure 8.6.2. IBTS Q3 internal consistency plot of cohort size. All years included.

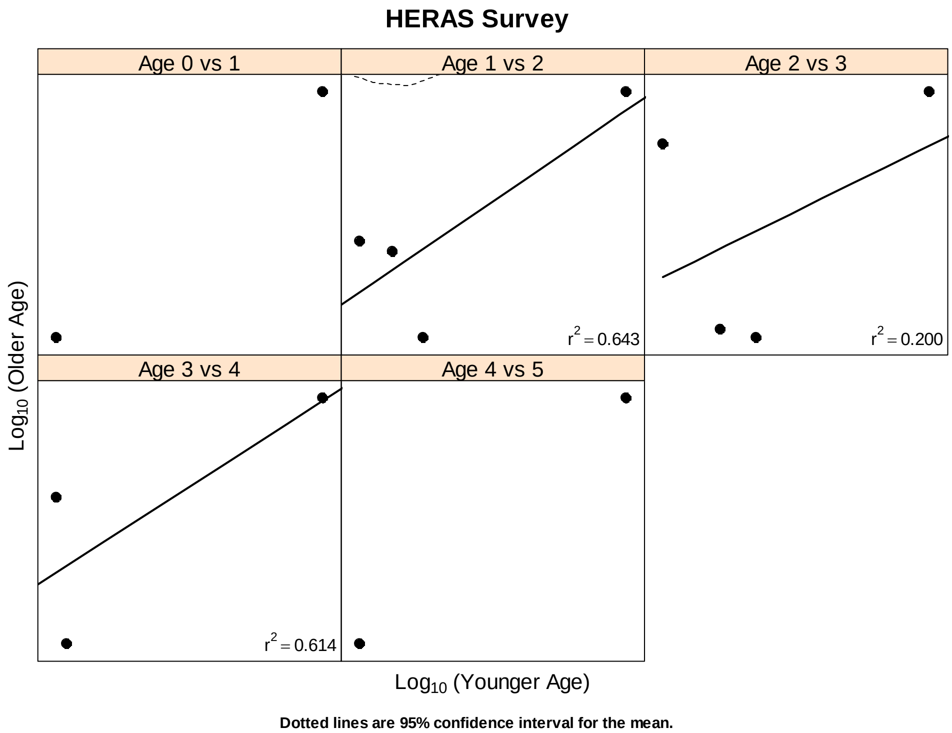


Figure 8.6.3. HERAS internal consistency plot of cohort size. All years included.

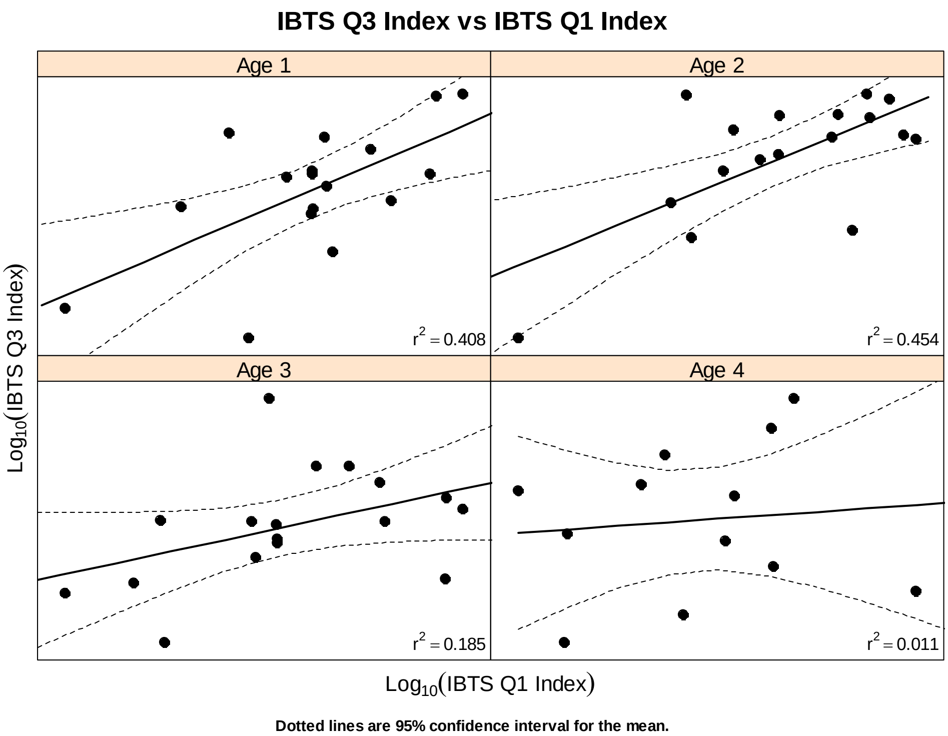


Figure 8.6.4. Comparison between surveys: IBTS Q1 vs. IBTS Q3

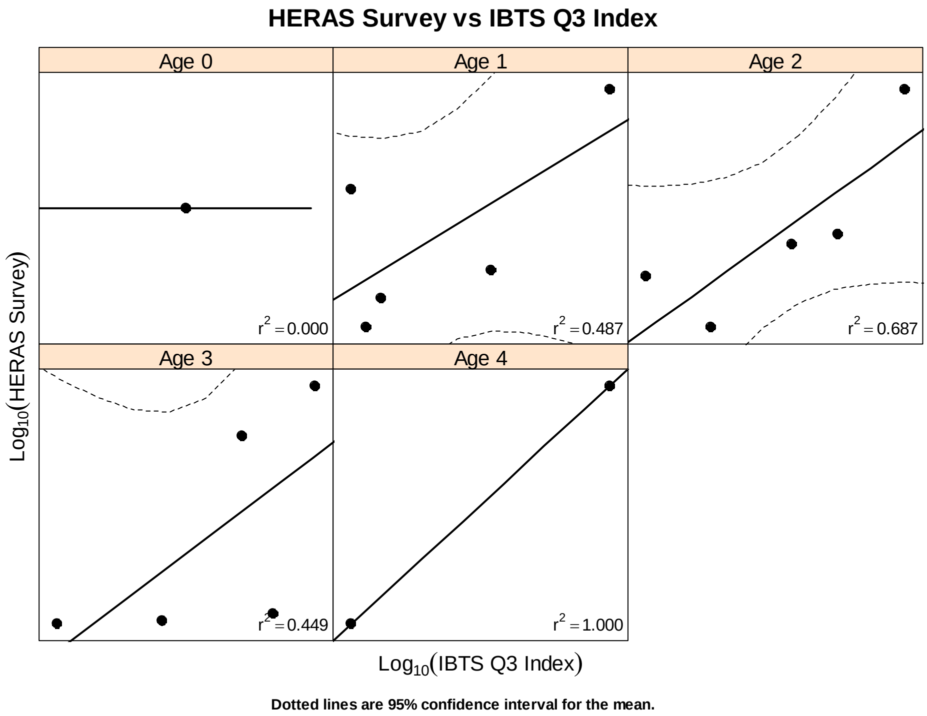


Figure 8.6.5. Comparison between surveys: IBTS Q3 vs. HERAS

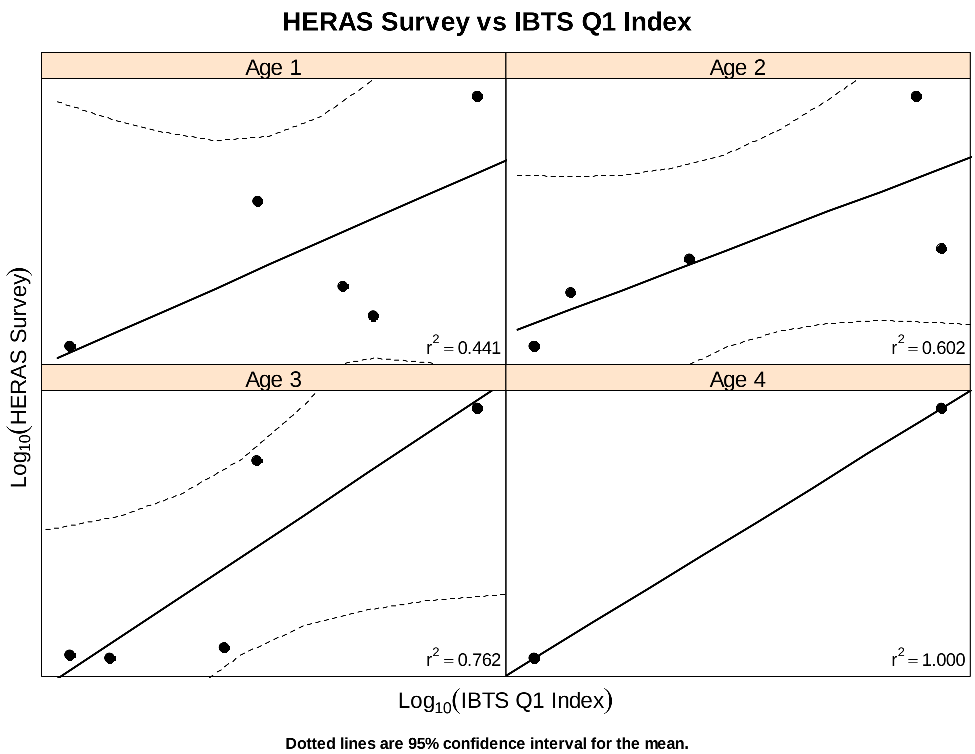


Figure 8.6.6. Comparison between surveys: IBTS Q1 vs. HERAS

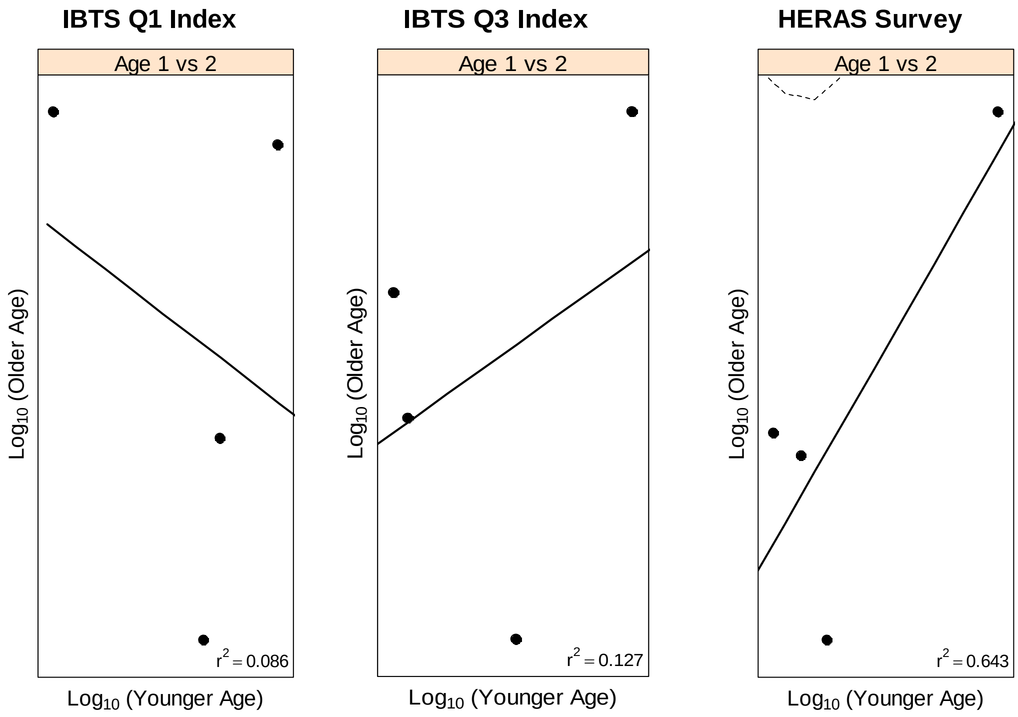


Figure 8.6.7. Internal consistency plot of age 1 vs. age 2 for IBTS Q1, Q3 and HERAS

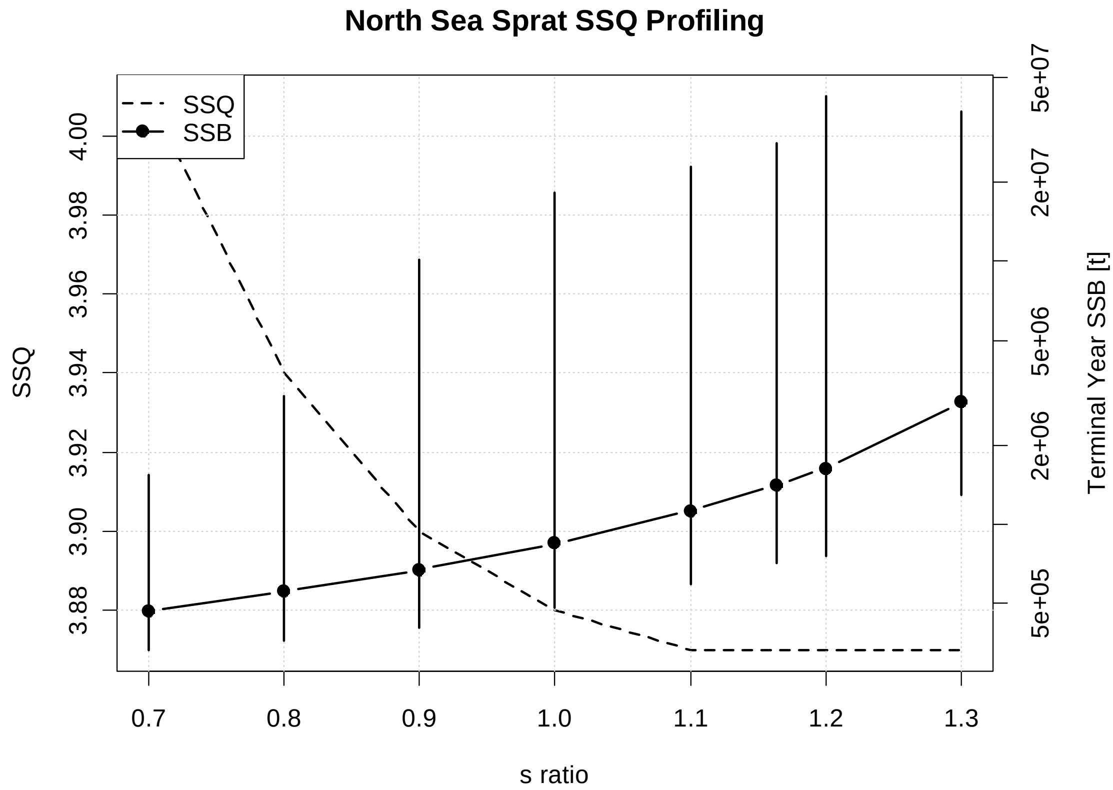


Figure 8.6.8 North Sea sprat. Fit of the CSA model (as described by the sum of squares of the fit error, SSQ) and estimated 2007 total stock biomass for a range of values of the catchability ratio s = q1/q2+. Note that the estimated 2007 biomass is plotted on a logarithmic scale. Error bars represent a 90% confidence interval in the biomass, estimated using the non-parametric bootstrapping algorithm in the CSA software.

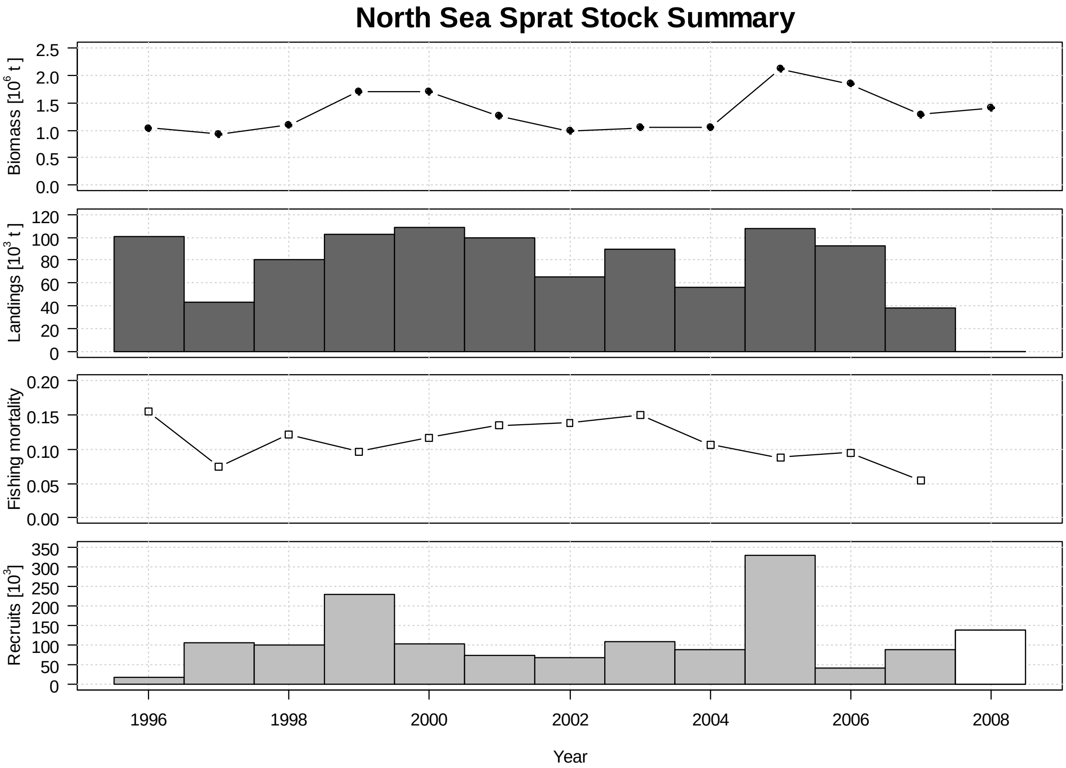


Figure 8.6.9 North Sea sprat. Stock summary. Time-series of biomass, landings, fishing mortality and recruits as estimated by CSA for the period 1996 – 2008.

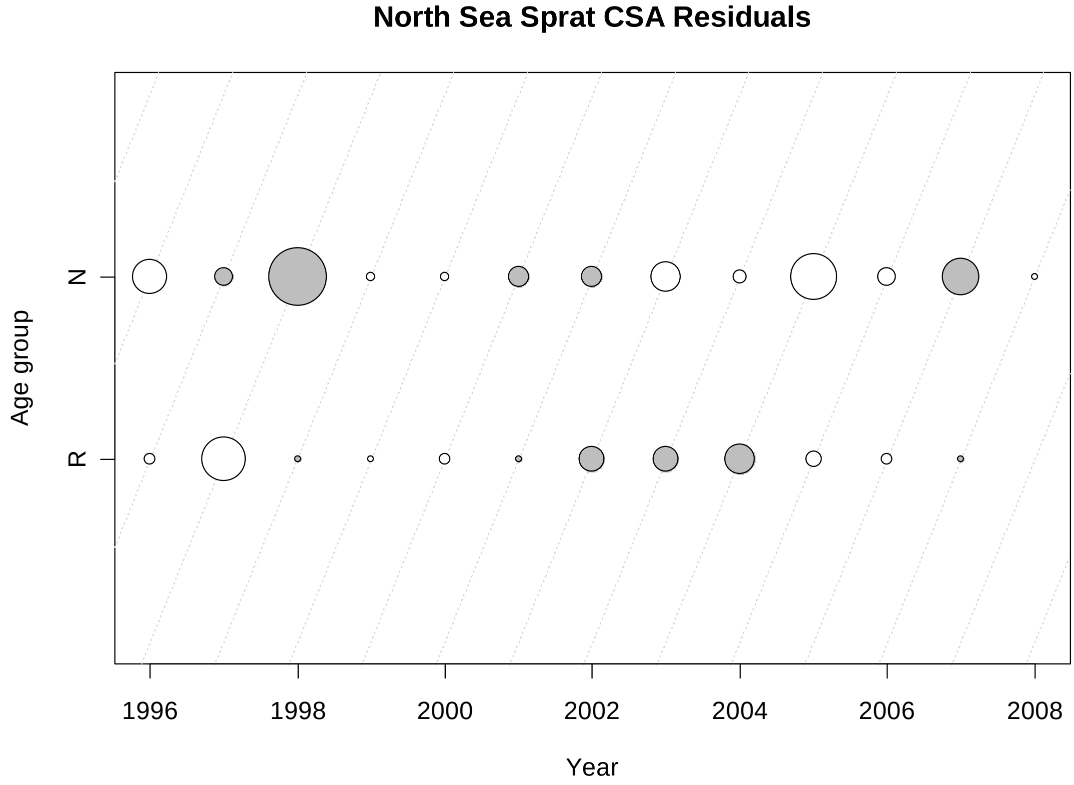


Figure 8.6.10 North Sea sprat. Residuals from the CSA fit to the IBTS survey indices. The largest residual occurs in 1998 for the N age group, and has a value of -0.98. R = recruits, age 1, and N = age 2+.

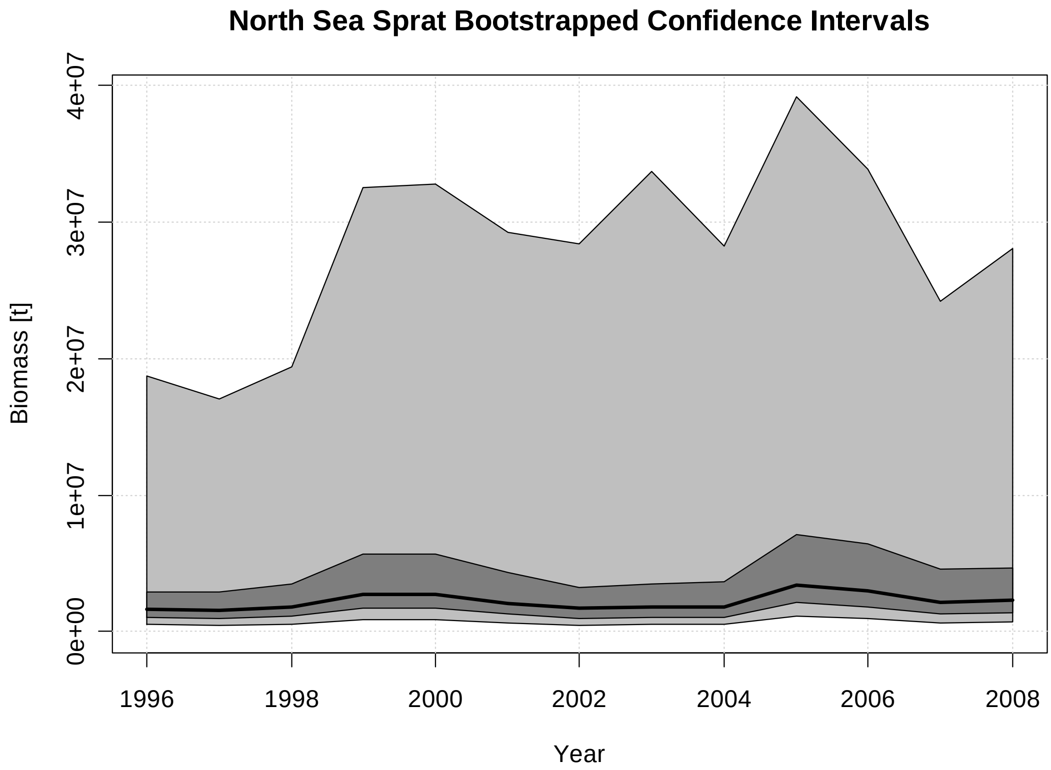


Figure 8.6.11 North Sea sprat. Biomass and associated confidence intervals for the time period 1996-2008 as estimated by CSA for a catchability ratio of 1.16 and a natural mortality of 0.75.

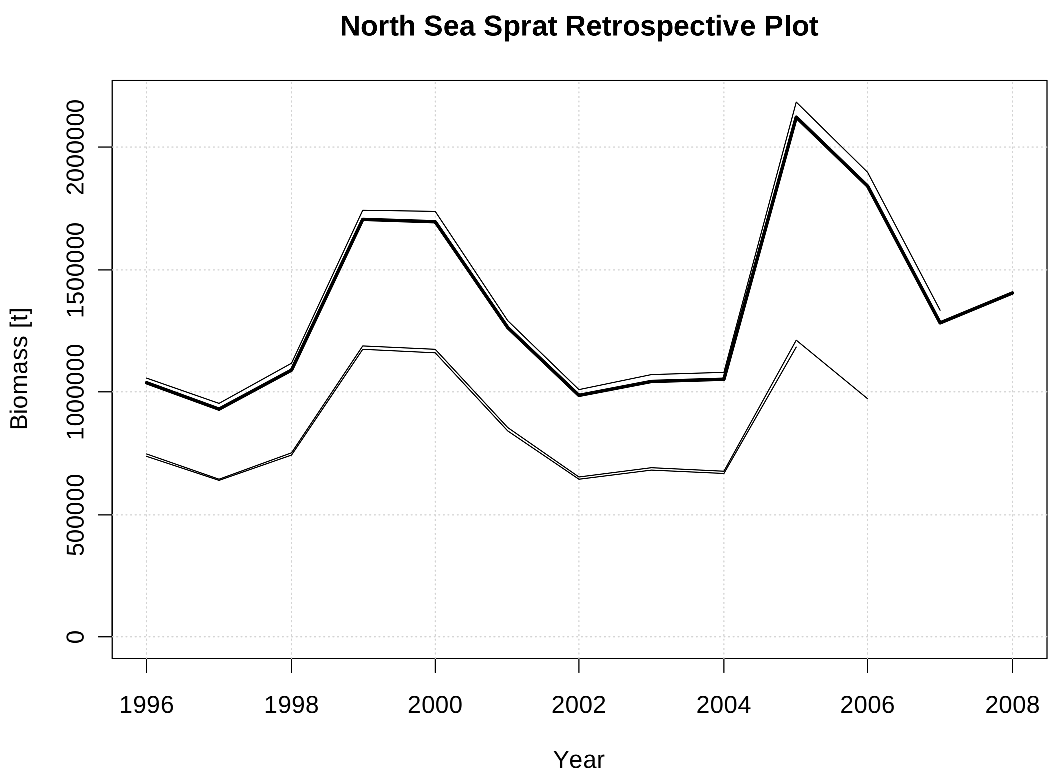


Figure 8.6.12 North Sea sprat. Retrospective analysis of biomass using the CSA model with a natural mortality of 0.75 and catchability ratio, s = 1.16.

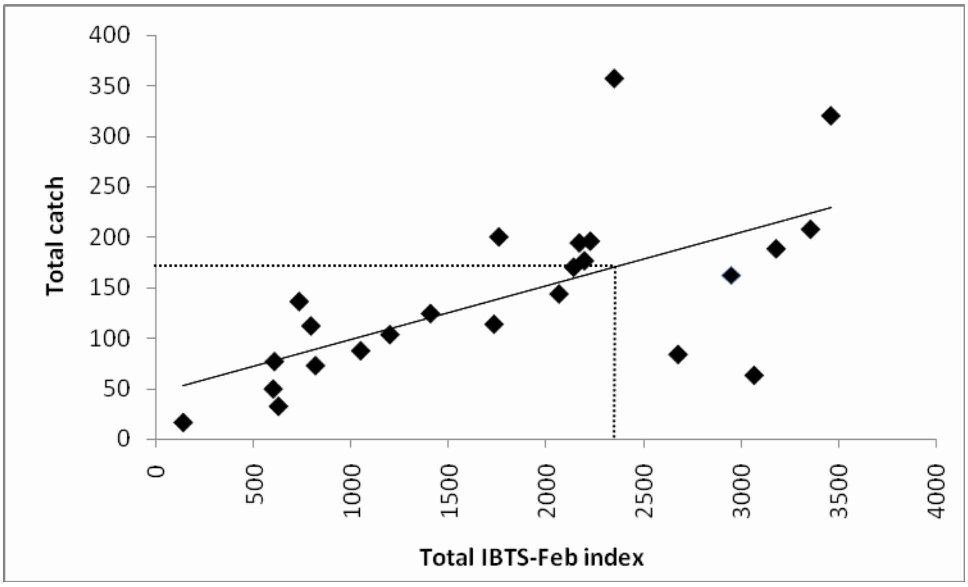


Figure 8.7.1 North Sea sprat. IBTS q1 indices vs total catch (1984-2007). A fitted regression line results in an R^2 coefficient of 0.412. The dotted line indicates the IBTS q1 index from 2008 (2360 no. per hour) and gives an estimated 2008 catch of 170 000 t.

9 Sprat in Division IIIa

9.1 The Fishery

9.1.1 ICES advice applicable for 2007 and 2008

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. For 2007 the sprat TAC was set at 52 000 t. The by-catch of herring for the EU fleet was 15 396 t. For 2008, the TAC for sprat is set at 52 000 t and the by-catch quota of herring at 11 470 t.

9.1.2 Landings

The total landings increased from 12 200 tonnes in 2006 to 15 700 tonnes in 2007 (Table 9.1.1). The table presents the landings from 1996 onwards. The data from 1996 and onwards are considered reliable in this context due to the implementation of the new Danish monitoring scheme. The data prior to 1996 can be found in the HAWG report from 2006 (ICES 2006/ACFM:20), and for 1996-1999 in ICES 2007/ACFM:11. In 2007 total landings increased. This was mainly due to an increase in the Danish fishery in Kattegat, and in the Norwegian fishery. The Norwegian and Swedish landings include the coastal and fjord fisheries.

In general, there were sprat landings in all quarters (Table 9.1.2, see Figures 8.1.1–8.1.2). In 2007 more than 70% of the total landings were taken in the second part of the year. In the Norwegian fishery landings were taken in the 1st, 3rd and 4th quarter, all as part of the fishery for "anchovy"-production (large sprat).

9.1.3 Fleets

Fleets from Denmark, Norway and Sweden carry out the sprat fishery in Division IIIa.

The Danish sprat fishery consists of trawlers using a 16 mm mesh size codend, and all landings are used for fishmeal and oil production. Some of the sprat landings from Denmark and Sweden are by-catches from the herring fishery using 32 mm mesh size codends. There is a Swedish fishery directed at herring for human consumption, with by-catches of sprat.

The Norwegian sprat fishery in Division IIIa is a coastal/fjord purse seine fishery for human consumption.

9.1.4 Regulations and their effects

Sprat cannot be fished without by-catches of herring except in years with high sprat abundance or low herring recruitment. Management of this stock should consider management advice given for herring in Subarea IV, Division VIId, and Division IIIa. A decrease in recruitment for the North Sea herring autumn spawners and a probable high incoming sprat year class may potentially result in a fishery for sprat with less by-catches of herring.

Most sprat catches are taken in an industrial fishery where catches are limited by herring by-catch restrictions.

9.1.5 Changes in fishing technology and fishing patterns

No changes in fishing technology and fishing patterns of importance for the sprat fisheries in IIIa have been reported.

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 2007, were of the lowest for the period 1996-2006 (Table 9.2.1). Data for 1996-2003 is presented in ICES CM 2007/ACFM:11. Sprat of the 2006-year class (age 1) made more than 60% of the total numbers. The strong 2004-year class were seen as a relative strong 3 age-group in the landings throughout the year. 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 3-group in 2007 were higher than in the previous year (Table 9.2.2).

Denmark and Sweden provided biological samples from three of the quarters. No Norwegian samples were collected. Landings in 2007, 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 Division IIIa since 1996. At the time of the surveys, sprat has mainly been recorded in the Kattegat (ICES CM 2008/LRC:01).

In 2007 sprat was observed both in the Kattegat (ICES squares 41G1-G2, 42G0-G2, 43G0-G1 and 44G1) and, on a much lower level, in the Skagerrak area (43F8-F9, 44F8-F9). The total abundance was estimated to 6 319 million individuals - an increase from 2 242 million sprat in 2006. The biomass was estimated to 59 000 t. Most sprat were immature, one-year old fish (> 95 %).

The IBTS (February) sprat indices for 1984-2007 are presented in Table 9.3.1. The data for 2006 has been updated. The IBTS data are provided by rectangle in Figure 8.3.1 for age groups 1, 2 and 3+. The indices are calculated as mean numbers per hour (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 Study Group on the Evaluation of the quarterly IBTS surveys in ICES 1998, implemented in the IBTS manual rev VII (ICES CM 2006/RAC:03) as well as in DATRAS (ICES 2008). Area weighting has also been added to the DATRAS algorithm (ICES 2008). The full documentation of the current index calculation algorithm is available by combining ICES (2008) and ICES CM 2006/RAC:03. However, it is unclear if the available time series has been revised according to the updated methods (WD 8: Jansen and Payne).

The preliminary total IBTS index for 2008 increased compared to the 2007 index, but is still one of the lowest for the period. The 1-group index is the second lowest seen.

9.4 Mean weight-at-age

Mean weight-at-age (g) in the catches are presented by quarter in Table 9.2.2. Mean weights-at-age for 1996-1999 are presented in ICES CM 2007/ACFM:11. The mean weights have been very variable over time. Whether this is due to actual variation in mean weight-at-age or difficulties in ageing of sprat or due to the allocation procedure, 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 (Table 9.3.1). The 1-group index for 2007 is well below the average for the time series. The procedure for the survey did not differ from previous years. However, the index does not fully reflect strong and weak cohorts seen in the catch. This has also been expressed in a previous working group report (ICES 1998 ACFM:14), and may be linked to difficulties in age determination and/or methodological issues related to the way the indices are estimated (see 3.1.7).

9.6 State of the Stock

No assessment of the sprat stock in Division IIIa has been presented since mid-1980ies and this year is no exception. Various methods have been explored without success - see the WG report from last year (ICES CM 2007/ACFM:11). No new input data was available for the HAWG, thus no exploratory runs were made this year.

The signal in the IBTS (February) index for 2007 indicates a sprat stock at the same level as last year, which appears to be one of the lowest for the time series 1984-2007.

9.7 Projection of Catch and Stock

There is no relationship between the IBTS (February) index (numbers per hour) and the total catch in the same year. Thus, this index is not considered useful for management of sprat in Division IIIa.

9.8 Reference Points

There is no scientific basis to define reference points for this stock.

9.9 Management Considerations

Sprat in Division IIIa is a short-lived species with large inter-annual fluctuations in stock biomass. The natural inter-annual variability in stock abundance, mainly driven by recruitment variability, is high and does not appear to be strongly influenced by the observed levels of fishing effort.

The sprat has mainly been fished together with herring. The human consumption fishery takes only a minor proportion of the total catch. Within the current management regime, where there is a by-catch ceiling limitation of herring as well as by-catch percentage limits, the sprat fishery is controlled by these factors. In the last years the sprat fishery was limited by quota restriction on sprat and not by by-catch restrictions on herring. The same situation may occur in 2008.

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.

9.10 Ecosystem Considerations

Multispecies investigations have demonstrated that sprat is one of the important prey species in the North Sea ecosystem, as a prey species for both fish and seabirds. Many of the plankton feeding fish have recruited poorly in recent years (eg. herring, sandeel, Norway pout). The implications for sprat are at present unknown.

The zooplankton community structure that is sustaining the sprat stocks appears to be changing and there has been a long-term decrease in total zooplankton abundance in the northern North Sea (Reid et al., 2003; Beaugrand 2003; ICES CM 2006/LRC:03)

9.11 Changes in the environment

Temperatures in the area have increased over the last years. It is considered that this may have implications for sprat. Incidents of anchovies and sardines in catches in the area are probably related to increased water temperature.

Table 9.1.1 Division IIIa sprat. Landings in ('000 t) 1996-2007.
(Data provided by Working Group members). These figures do not in all cases correspond to the official statistics and cannot be used for management purposes.

	Skagerrak				Kattegat			Div. IIIa total
Year	Denmark	Sweden	Norway	**Total**	Denmark	Sweden	**Total**	
1996	7.0	3.5	1.0	11.5	3.4	3.1	6.5	18.0
1997	7.0	3.1	0.4	10.5	4.6	0.7	5.3	15.8
1998	3.9	5.2	1.0	10.1	7.3	1.0	8.3	18.4
1999	6.8	6.4	0.2	13.4	10.4	2.9	13.3	26.7
2000	5.1	4.3	0.9	10.3	7.7	2.1	9.8	20.1
2001	5.2	4.5	1.4	11.2	14.9	3.0	18.0	29.1
2002	3.5	2.8	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
2007	1.4	2.8	1.6	5.9	8.5	1.3	9.8	15.7

Table 9.1.2. Division IIIa sprat. Landings of sprat ('000 t) by quarter by countries, 2000-2007. Data for 1996-1999 in ICES CM 2007/ACFM:11 (Data provided by the Working Group members)

	Quarter	Denmark	Norway	Sweden	Total
2000	1	4.1	0.1	2.3	6.5
	2	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
2007	1	2.3	0.4	0.4	3.1
	2	0.7		0.6	1.3
	3	5.1	0.0	0.2	5.4
	4	1.8	1.2	3.0	5.9
	Total	9.9	1.6	4.2	15.7

Table 9.2.1 **Division IIIa sprat**. Landed numbers (millions) of sprat by age groups in 2004-2007. The landed numbers in 1996-2003 can be found in the ICES CM 2007/ACFM:11.

	Quarter	Age						Total
		0	1	2	3	4	5+	
2004	1		539.6	39.3	47.2	20.7	8.0	654.8
	2		36.7	22.3	44.9	11.8	1.1	116.8
	3	10.0	254.4	19.4	4.1	2.4		290.3
	4	874.0	366.8	33.0	24.9	3.4	0.3	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
2007	1	0.0	61.2	47.5	120.9	12.5	1.8	243.9
	2	0.0	26.1	17.8	53.5	4.9	0.5	102.9
	3	0.0	401.1	22.8	12.3	3.2	0.0	439.3
	4	33.4	248.6	57.0	50.5	6.6	1.1	397.1
	Total	33.4	737.0	145.1	237.2	27.2	3.4	1,183.3

Table 9.2.2. **Division IIIa Sprat.** Quarterly mean weight-at-age (g) in the

Year		Age					
	Quarter	0	1	2	3	4	5+
2004	1		4.6	14.6	17.8	17.3	17.3
	2		7.0	13.6	16.7	17.0	19.5
	3	3.0	14.1	16.7	20.0	21.4	
	4	3.5	16.8	19.9	22.2	20.9	28.0
Weighted mean		3.5	10.4	16.3	18.4	17.8	17.9
2005	1		3.0	14.6	16.3	20.3	21.1
	2		5.4	11.7	26.8	0.0	
	3	2.9	11.9	14.6	15.4	11.0	
	4	3.3	13.1	19.1	20.1	21.1	23.1
Weighted mean		5.0	7.6	15.4	17.1	17.2	21.5
2006	1		5.0	12.2	15.4	15.2	18.5
	2		7.0	13.3	16.3	22.0	
	3		11.2	17.4	20.3	18.6	22.8
	4	4.3	16.1	19.6	21.4	23.8	26.6
Weighted mean		4.3	6.8	13.6	16.8	16.1	19.4
2007	1		2.3	12.3	16.3	17.0	25.2
	2		6.1	17.1	20.6	21.9	20.4
	3		12.0	13.0	17.0	17.6	
	4	7.9	14.1	20.3	23.4	22.6	26.2
Weighted mean		7.9	11.5	15.9	18.4	19.3	25.2

Table 9.2.3 **Division IIIa sprat.** Sampling commercial landings for biological samples in 2007.

Country Area	**Quarter**	**Landings (tonnes)**	**No. samples**	**No. meas.**	**No. aged**
Denmark	1	2,264	10	837	197
	2	699			
	3	5,147	30	3,545	521
	4	1,785	11	119	237
	Total	9,895	51	4,501	955
Norway	1	445	0	0	0
	2	-			
	3	42	0	0	0
	4	1,155	0	0	0
	Total	1,642	0	0	0
Sweden	1	382	6	443	443
	2	592	2	273	273
	3	210	0	0	0
	4	2,976	10	510	509
	Total	4,160	18	1,226	1,225
Denmark		9,895	51	4,501	955
Norway		1,642	0	0	0
Sweden		4,160	18	1,226	1,225
	Total	15,697	69	5,727	2,180

Table 9.3.1. Division IIIa sprat. IBTS(February) indices of sprat per age group 1984-2007.

Year	No Rect	No hauls	Age Group					
			1	2	3	4	5+	Total
1984	15	38	5,675.45	868.88	205.10	79.08	63.57	6,892.08
1985	14	38	2,157.76	2,347.02	392.78	139.74	51.24	5,088.54
1986	15	38	628.64	1,979.24	2,034.98	144.19	37.53	4,824.58
1987	16	38	2,735.92	2,845.93	3,003.22	2,582.24	156.64	11,323.95
1988	13	38	914.47	5,262.55	1,485.07	2,088.05	453.13	10,203.26
1989	14	38	413.94	911.28	988.95	554.53	135.79	3,004.48
1990	15	38	481.02	223.89	64.93	61.11	45.69	876.65
1991	14	38	492.50	726.82	698.11	128.36	375.44	2,421.23
1992	16	38	5,993.64	598.71	263.97	202.90	76.04	7,135.25
1993	16	38	1,589.92	4,168.61	907.43	199.32	239.64	7,104.92
1994	16	38	1,788.86	715.84	1,050.87	312.65	70.11	3,938.32
1995	17	38	2,204.07	1,769.53	35.19	44.96	4.23	4,057.98
1996	15	38	199.30	5,515.42	692.78	111.98	173.75	6,693.23
1997	16	41	232.65	391.23	1,239.13	139.14	134.51	2,136.67
1998	15	39	72.25	1,585.22	619.76	1,617.71	521.52	4,416.46
1999	16	42	4,534.96	355.24	249.86	44.25	313.52	5,497.83
2000	16	41	292.32	737.80	59.69	51.79	23.21	1,164.80
2001	16	42	6,539.48	1,144.34	676.71	92.37	45.87	8,498.77
2002	16	42	1,180.52	1,035.71	89.96	58.85	12.93	2,241.90
2003	17	46	462.64	1,247.49	1,172.13	382.29	123.17	3,387.72
2004	16	41	402.87	49.00	156.62	86.57	27.48	722.54
2005	17	50	3,314.17	1,563.16	470.84	837.09	452.17	6,637.43
2006	17	45	1,323.59	11,855.76	1,753.92	299.05	0.00	15,232.32
2007	17	46	774.11	306.63	250.81	42.08	0.00	1,373.63
2008*	17	46	149.26	1,000.95	112.17	232.51	103.87	1,598.76

* Preliminary

10 Stocks with insufficient data

Two stocks with very low research intensity were poorly described in previous reports in devoted sections or chapters. These were Clyde herring (Section 5.11 in ICES 2005a) and sprat in VIId,e (Section 9 in ICES 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 the HAWG report (ICES CM 2005/ACFM:18).

There was no sampling of the catch in 2007 for both Clyde herring and sprat in VIId,e. The catch of Clyde herring in 2007 was low (Table 10.1), as was the catch of sprat in VIId,e (Table 10.2). However, the 2007 Clyde herring catch was slightly higher than in recent years.

Table 10.1 Herring from the Firth of Clyde. Catch in tonnes by country, 1955–2007. Spring and autumn-spawners combined.

Year	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968
All Catches														
Total	4 050	4 848	5 915	4 926	10 530	15 680	10 848	3 989	7 073	14 509	15 096	9 807	7 929	9 433

Year	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
All Catches													
Total	10 594	7 763	4 088	4 226	4 715	4 061	3 664	4 139	4 847	3 862	1 951	2 081	2 135

Year	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Scotland	2 506	2 530	2 991	3 001	3 395	2 895	1 568	2 135	2 184	713	929	852	608	392
Other UK	-	273	247	22	-	-	-	-	-	-	-	1	-	194
Unallocated[1]	262	293	224	433	576	278	110	208	75	18	-	-	-	-
Discards	1 253	1 265	2 308[3]	1 344[3]	679[3]	439[4]	245[4]	-[2]	-[2]	-[2]	-[2]	-[2]	-[2]	-[2]
Agreed TAC			3 000	3 000	3 100	3 500	3 200	3 200	2 600	2 900	2 300	1 000	1 000	1 000
Total	4 021	4 361	5 770	4 800	4 650	3 612	1 923	2 343	2 259	731	929	853	608	586

Year	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Scotland	598	371	779	16	1	78	46	88	-	-	+	163
Other UK	127	475	310	240	0	392	335	240	-	318	512	458
Unallocated[1]	-	-	-	-	-	-	-	-	-	-	-	-
Discards	-	-	-	-	-	-	-	-	-	-	-	-
Agreed TAC	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	800
Total	725	846	1089	256	1	480	381	328	0	318	512	621

[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 1985-2007

	1985	1986	1987	1988	1989	1990	1991	1992
Denmark		15	250	2 529	2 092	608		
France	14		23	2	10			35
Netherlands								
UK (Engl.&Wales)	3 771	1 163	2 441	2 944	1 319	1 508	2 567	1 790
Total	3 785	1 178	2 714	5 475	3 421	2 116	2 567	1 825
Country	**1993**	**1994**	**1995**	**1996**	**1997**	**1998***	**1999***	**2000***
Denmark								
France	2	1	0					18
Netherlands							1	1
UK (Engl.&Wales)	1 798	3 177	1 515	1 789	1 621	2 024	3 559	1 692
Total	1 800	3 178	1 515	1 789	1 621	2 024	3 560	1 711
Country	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	
Denmark								
France								
Netherlands								
UK (Engl.&Wales)	1 349	1 196	1 377	836	1 635	1 974	1819	
Total	1 349	1 196	1 377	836	1 635	1 974	1819	
* Preliminary								

11 Working Documents

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WD 2 Gröhsler, T.. German herring fisheries and stock assessment data in the western Baltic in 2007. vTI-OSF, Rostock, Germany.

WD 3 Schmidt, J.O., Rohlf, N., Gröger, J. Report of the herring larvae surveys in the North Sea in 2007/2008 IFM-GEOMAR, Kiel, Germany.

WD 4 Beggs, S.E., Allen, M., Schön, P-J. Stock Identification of 0-group Herring in the Irish Sea (VIIaN) using Otolith Microstructure and Shape Analysis. AFBI, Belfast, N. Ireland, UK.

WD 5 Hatfield, E.M.C., Clarke, S..L. West of Scotland Herring in 2007: data update, fishery, data exploration and update assessment. FRS, Aberdeen, Scotland, UK.

WD 6 Johnston, G.A Preliminary Recruitment Index for North-West of Ireland Herring. Marine Institute, Rinville, Oranmore, Galway, Ireland.

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Annex 1: List of Participants

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11 - 19 March 2008

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Annex 2: - Recommendations

HAWG 2008 makes the following recommendations:

RECOMMENDATION	ACTION
HAWG experienced significant problems this year with the software packages employed to do the stock assessment. HAWG recommends that ICES takes an active and central role in the coordination of the development of the tools necessary for working groups to perform their tasks, including the archiving, storage and quality control of such tools. Workings groups should also be actively involved in the development, maintenance, recording of changes and documentation of the tools they require. Active involvement of all parties in collaborative projects such as FLR is strongly encouraged.	ACOM, ICES Secretariat
HAWG recommends further that the use of the ICA tool as a primary assessment should be discontinued. All work that was previously done with ICA can and should be done using the FLICA tool. All such efforts previously directed towards ICA should be redirected towards FLICA.	ACOM, ICES Secretariat
HAWG recommends that all metiers with substantial catch should be sampled (including by-catches in the small meshed fishery). (see Section 2.2.2).	National labs, PGCCDBS
Since 2007, the extension of the IBTS 1st quarter survey area in the Eastern English Channel is implemented. Due to the findings of the survey in the eastern part of the Channel, an increase in survey effort (MIK and GOV) and in area coverage is recommended. (see Section 2.11).	IBTS WG, IFREMER
HAWG requests that in 2009, 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. (see Section 2.3.2).	IMR
HAWG recommends to describe the methods, parameters and settings underlying the IBTS sprat indices; furthermore, all sprat IBTS indices need to be revised by focussing on 10 to 150 m depth.	ICES Secretariat
A benchmark assessment on North Sea sprat should be performed.	ACOM
Fleet definitions of the fishery in Div. IIIa (see Section 3.1.2): HAWG recommends an exploration of whether the discrepancy identified between the Swedish and Danish fleet definition of vessels operating in Div. IIIa have any effect on the raising of the input data during HAWG and in the end have a clear definition of the fleets exploiting the stock and in particular the samples taken from these fleets.	National laboratories
HAWG encourages further examination of the observed internannual variability in maturity ogive using appropriate scientific methodology (see Section 3.4).	National laboratories, PGCCDBS
HAWG recommends a workshop on the identification of clupeid fish larvae to ensure data quality. This WS should especially deal with possible sources of misidentification of sprat, herring and other clupeid larvae	PGCCDBS, PGHERS

Annex 3: – Stock Annex North Sea Herring

Quality Handbook ANNEX: hawg-her47d3

Stock specific documentation of standard assessment procedures used by ICES.

Stock: North Sea Autumn Spawning Herring (NSAS)

Working Group: Herring Assessment WG for the Area south of 62°N

Date: 19 March 2008

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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 2^{nd} and 3^{rd} quarter, and in the English Channel (Division VIId) in the 4^{th} quarter. Juveniles are caught in Division IIIa and as by-catch in the industrial fishery in the central North Sea. For management purposes, 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 lows of less than 100 000 tonnes in the late 1970s. The species has demonstrated robustness in relation to recovery from such low levels once fishing mortality is curtailed in spite of recruitment levels being adversely affected.

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 to 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 study by Pierce *et al.* (2002) investigated incidental catch from commercial pelagic trawlers over the period January to August 2001. The target species, herring, accounted for 98% by weight of the overall catch with an overall incidental catch of 2.3%. 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 3rd 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 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 specific 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 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 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. Pierce (2002) also reports that no by-catches of marine mammals were observed over 69 studies hauls and considers that the underlying rate for marine mammals in the pelagic fisheries studies (pelagic trawls in IVa and VIa) is no more than 0.05 (i.e. five events per 100 hauls) and may well be considerably lower than this. Consequently, the cetacean by-catch by the pelagic trawl fishery can be regarded as negligible. This was also confirmed by an UK observer programme ended in 2003 (Northridge, pers. Comm.).

Other than the above, there are no reliable estimates of by-catch for pelagic trawl fisheries, though observations have been made and by-catch rates have been established for several fisheries. Kuklik and Skóra (2003) refer to a single record of a harbour porpoise (*Phocoena phocoena*) by-caught in a herring trawl in the Baltic. Observations in several other pelagic trawl fisheries were reported by Morizur et al. (1999) and Couperus (1997). All appear to agree that incidental catches of cetaceans in the Dutch pelagic trawl fishery are largely restricted to late-winter/early-spring in an area along the continental slope southwest of Ireland.

Seal by-catch: The by-catch of seals in directed pelagic herring fishery in the North Sea is reported to be "very rare" (Aad Jonker, pers. comm.). Independent verification also confirms this to be so, with perhaps one animal being caught by the whole North Sea fleet a year (Bram Couperus (IMARES, pers. comm.). Northridge (2003) observed 49 seals taken in 312 pelagic trawl tows throughout UK waters and reports that the fishery in North-western Scotland has the highest observed seal by-catch levels of UK pelagic trawl fisheries, possible amounting to dozens per year. Although not confirmed, it was assumed that the majority were grey seal *Halichoerus grypus*. This species is mainly distributed around the Orkneys and Outer Hebrides – out of a UK population of 129 000, only around 7 000 and 5 900 are distributed off the Scottish and English North Sea coasts respectively (SCOS, 2002), and so by-catch rates in the North Sea are likely to be substantially less than off the NW Scottish coast. The eastern Atlantic population of the Grey seal is not considered to be threatened.

Other by-catch: Sharks are occasionally caught by pelagic trawlers in the North Sea, although this is rare with a maximum of two fish per trip (Aad Jonker, pers. comm.). Survival rates are apparently high, sharks are released during or after the cod-end is being emptied. The species are unknown, although blue shark *Prionace glauca*, which preys primarily upon schooling fishes such as anchovies, sardines and herring, are known to have been caught by pelagic trawls off the SW English coast (Bram Couperus (IMARES), pers. comm.). Gannets (*Morus bassanus*), which frequently dive at and around nets, were observed by Napier *et al.* (2002) entangled in the nets but were not present in samples. Actual mortality rates of caught gannets have not been assessed in detail, and some have been observed alive after release from the gear. An extrapolation from observed mortalities corresponds to around 560 gannet deaths per year, although this is based on a relatively low sample frame. Seabird by-catch in the North Sea is considered to be comparatively rare. In the NW Scotland, 1-3 birds may be caught, especially in grounds off St. Kilda (Aad Jonker (former freezer trawler skipper), pers. comm.). IMARES observers in the North Sea only recorded one incident of seabird by-catch over 10 trips (Bram Couperus, pers. comm.).

B. Data

B.1. Commercial catch:

Commercial catch is obtained from national laboratories of nations exploiting herring in the North Sea. Since 1999 (catch data 1998), these labs have used a spreadsheet to provide all necessary landing and sampling data, which was developed originally for the Mackerel Working Group (WGMHSA) and further adapted to the special needs of the Herring Assessment Working Group. The current version used for reporting the 2007 catch data was v1.6.4. 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.

In addition, commercial catch and sampling data were stored and processed using the Intercatch-software for the first time during the WG in 2007. While at that time larger discrepancies up to 5 % between the SALLOCL routines and Intercatch did occur, Intercatch performed quite well in 2008. The estimates of CANON, CATON and WECA were highly comparable.

The "wonderful table". The following figure explains were the estimates in the wonderful table are derived from:

Year		2007	2008	
Sub-Area IV and Division VIId: TAC (IV and VIId)				
Recommended Divisions IVa, b [1]	22			
Recommended Divisions IVc, VIId	14			
Expected catch of spring spawners				
Agreed Divisions IVa,b [2]	TAC human consumption in IVa and b	303.5	174.6	Total TAC for human consumption in North Sea
Agreed Div. IVc, VIId	TAC human consumption in IVc and VIId	37.5	26.7	
Bycatch ceiling in the small mesh fishery	TAC industrial fishery	31.9	18.8	
CATCH (IV and VIId)				
National landings Divisions IVa,b [3]		326.8		
Unallocated landings Divisions IVa,b		21.9		
Discard/slipping Divisions IVa,b [4]		0.1		
Total catch Divisions IVa,b [5]		348.8		
National landings Divisions IVc, VIId [3]		34.3		
Unallocated landings Divisions IVc,VIId		4.7		
Discard/slipping Divisions IVc, VIId [4]		-		
Total catch Divisions IVc, VIId		39.0		
Total catch IV and VIId as used by ACFM [5]		**387.8**		Herring caught in the North Sea
CATCH BY FLEET/STOCK (IV and VIId) [10]				
North Sea autumn spawners directed fisheries (Fleet A)		379.6		NS catch human consumption
North Sea autumn spawners industrial (Fleet B)		7.1		NS catch industrial fishery
North Sea autumn spawners in IV and VIId total		**386.7**		
Baltic-IIIa-type spring spawners in IV		1.1		Catch of WBSS in IV, estimated by splitting
Coastal-type spring spawners		0.0		e.g. spring spawner in river estuaries (Thames, Wash)
Norw. Spring Spawners caught under a separate quota in IV [20]		0.7		direct information from Norway
Division IIIa: TAC (IIIa)				
Predicted catch of autumn spawners	22			
Recommended spring spawners	22			
Recommended mixed clupeoids				
Agreed herring TAC		69.4	51.7	
Agreed mixed clupeoid TAC				
Bycatch ceiling in the small mesh fishery		15.4	11.5	
CATCH (IIIa)				
National landings		47.3		
Catch as used by ACFM		47.4		
CATCH BY FLEET/STOCK (IIIa) [10]				
Autumn spawners human consumption (Fleet C)		16.4		
Autumn spawners mixed clupeoid (Fleet D) [19]		3.4		
Autumn spawners other industrial landings (Fleet E)				
Autumn spawners in IIIa total		**19.8**		Catch of NSAS in IIIa, estimated by splitting
Spring spawners human consumption (Fleet C)		25.3		
Spring spawners mixed clupeoid (Fleet D) [19]		2.3		
Spring spawners other industrial landings (Fleet E)				
Spring spawners in IIIa total		**27.6**		
North Sea autumn spawners Total as used by ACFM		**406.5**		

Transparency of data handling by the Working Group. The current practice of data handling by the Working Group is that the data received by the co-ordinators is available in a folder called "archive". These high-resolution data are not reproduced in the report. The archived data contains the disaggregated dataset (disfad), the allocations of samples to unsampled catches (alloc), the aggregated dataset (sam.out) and (in some cases) a document describing any problems with the data in that year. Since 2007, the corresponding datasets are also stored in Intercatch, where they are accessable to the stock coordinators only.

Current methods of compiling fisheries assessment data. The stock co-ordinator is responsible for compiling the national data to produce the input data for the assessments. In addition to checking the major task involved is to allocate samples of catch numbers, mean length and mean weight-at-age to unsampled catches. There are at present no defined criteria on how this should be done, but the following general process is implemented by the species co-ordinators. Searches are made for appropriate samples by gear (fleet), area and quarter. If an exact match is not available the search will move to a neighbouring area if the fishery extends to this area in the same quarter. More than one sample may be allocated to an unsampled catch, in this case a straight mean or weighted mean of the observations may be used. If there are no samples available the search will move to the closest non-adjacent area by gear (fleet) and quarter, but not in all cases.

The Working Group acknowledges the effort some members have made to provide "corrected" data, which in some cases differ significantly from the officially reported catches. Most of this valuable information is gathered on the basis of personal knowledge of the fishery and good relations between the scientist responsible and the fishermen. 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.

The WG considered the need of 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. Since 2007, national landings, allocations schemes and output files are also stored in Intercatch which was used in that year for the first time and compared with the SALLOC results. While differences does occur for some reason in 2007, the Intercatch and Salloc outputs were highly comparable in the 2008 assessment.

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). Since 1991, this survey 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 (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 coast, 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 38 kHz sounder echo-integrator with transducers mounted on the hull, drop keel or towed bodies. Prior to 2006, Simrad EK500 and EY500 were also used. Further data analysis is carried out using either BI500, Echoview or Echoann software. The survey track is selected to cover the area giving a basic sampling intensity over the whole area based on the limits of herring densities found in previous years. A transect spacing of 15 nautical miles is used in most parts of the area with the exception of some relatively high density sections, east and west of Shetland, in the Skagerrak where short additional transects were carried out at 7.5 nautical miles spacing, and in the southern area, where a 30 nautical miles transect spacing is used.

The following target strength to fish length relationships have been used to analyse the data:

herring	TS = 20 log L - 71.2 dB
sprat	TS = 20 log L -71.2 dB
gadoids	TS = 20 log L - 67.5 dB
mackerel	TS = 21.7 log L - 84.9 dB

Data is reported through standardised data exchange format and uploaded into the FishFrame database, currently held at DTU Aqua, Charlottenlund, Denmark. National estimates are aggregated trough Fishframe during PGHERS to calculate global estimates for the North Sea, the West of Scotland and the western Baltic Sea. The exchange format currently holds information on the ICES statistical rectangle level, with at least one entry for each rectangle covered, but more flexible strata are accommodated by allowing multiple entries for abundance belonging to different strata. Data submitted consists of the ICES rectangle definition, biological stratum, herring abundance by proportion of autumn spawners (North Sea and VIa North) and Spring spawners (Western Baltic, age and maturity, and survey weight (survey track length). Data are presented according to the following age/maturity classes: 1 immature (maturity stage 1 or 2), 1 mature (maturity stage 3+), 2 immature, 2 mature, 3 immature, 3 mature, 4, 5, 6, 7, 8, 9+. In addition to proportions at age data on mean weights and mean length are reported at age/maturity by biological strata. Data 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 2007 the IBTS was extended into English Channel. In addition, historical IBTS indices have been updated from 2004 onwards (in 2007).

In 1977 sampling for late stage herring larvae was introduced at the IBTS 1st quarter, using Isaccs-Kidd Midwater trawls. These catches appeared as a good indicator of herring recruitment, however examination of IKMT performance showed deficiencies in its catchability for herring larvae, and a more applicable gear, a ring net (MIK) was suggested as an alternative gear. Hence, gear type was changed in the mid 90'ies, and the MIK has been the standard gear of the 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. Catches in Division IIIa are 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 are used to calculate an 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 or GULF VII sampler. 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 & Popp-Madsen, 1996) enables an accurate and precise split between three groups, autumn, winter and spring-spawners. However, different populations with similar spawning periods are not resolved with the present level of analysis. Different stock components that are not easily distinguished by their otolith microstructure (OM), are considered to have different mean vertebral counts (vs) as, e.g., winter-spawning Downs herring: 56.6 (Hulme, 1995), and the small local stocks, the Skagerrak winter/spring-spawners: 57 (Rosenberg and Palmén, 1982). Further, the estimated stock specific mean vs count varies somewhat among different studies; North Sea: 56.5, Western Baltic Sea: 55.6 (Gröger & Gröhsler, 2001) and North Sea: 56.5, Western Baltic Sea: 55.8 (ICES 1992/H:5). Comparison between separation methods using frequency distributions of vertebral counts and otolith microstructure showed reasonable correspondence. Using this information the years from 1991 to 1996 was reworked in 2001, applying common splitting keys for all years by using a combination of the vertebral count and otolith microstructure methods (ICES, 2001/ACFM:12). From 2001 and onwards, the otolith-based method only has been used for the Division IIIa.

Different methods of identifying herring stocks in the Division IIIa and Subdivisions 22-24 were evaluated in EU CFP study project (EC study 98/026). The study involved several inter-calibration sessions between microstructure readers in the different laboratories involved with the WBSS herring. After the study was finished a close collaboration concerning reader interpretations has been kept between the Danish and Swedish laboratories. Sub-samples of the 2002 and 2003 Danish, Swedish, and German microstructure analyses were double-checked by the same Danish expert reader for consistency in interpretation. The overall impression is an increasingly good agreement among readers.

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:

A benchmark assessment for North Sea herring was carried out in 2006. North Sea herring was on the AFCM observation list, but was classed as an update assessment in 2008 by ACFM. The choice of assessment model, catch and survey weightings and the length of separable period were not explored in 2008, and for justification of the approach refer to the benchmark assessment (HAWG 2006) and Simmonds (2003). Following the benchmark investigation in 2006, the tool for the assessment of North Sea herring is ICA. However, the environment to execute the ICA has changed from the original ICA software into FLR (now called FLICA). This change in software has been tested with the new relaise of FLICA, and no differences were found. Therefore the WG assumes there are no differences between the old ICA and FLICA. Thus FLICA was used in the 2008 update assessment.

Details on input parameters and model setup for the final FLICA assessment are presented in Table 2.6.2.1.in 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:

$$\sum_{a=0,y=1997}^{a=8,y=2002} \lambda_a (\ln(\hat{C}_{a,y}) - \ln(C_{a,y}))^2 +$$
$$\sum_{y=1979}^{y=2002} \lambda_{mlai} \cdot (\ln(q_{mlai}.S\hat{S}B_y^K) - \ln(MLAI_y))^2 +$$
$$\sum_{a=1,y=1983**}^{a=5+,y=2003} \lambda_{a,ibtsa} (\ln(q_{a,ibtsa} \cdot \hat{N}_{a,y}) - \ln(IBTS_{a,y}))^2 +$$
$$\sum_{a=1,y=1989}^{a=9+,y=2002} \lambda_{a,acoust} (\ln(q_{a,acoust} \cdot \hat{N}_{a,y}) - \ln(ACOUST_{a,y}))^2 +$$
$$\sum_{y=1977}^{y=2003} \lambda_{mik} (\ln(q_{mik} \cdot \hat{N}_{0,y}) - \ln(MIK_y))^2 +$$
$$\sum_{y=1960}^{y=2002} \lambda_{ssr} (\ln(\hat{N}_{0,y+1}) - \ln\left(\frac{\alpha\, S\hat{S}B_y}{\beta + S\hat{S}B_y}\right))^2$$

** 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
$S\hat{S}B$	Estimated spawning stock size
MLAI	MLAI index (biomass index)
ACOUST	Acoustic index (age disaggregated)
IBTS	IBTS index (1-5+ ringers)
MIK	MIK index (0-ringers)
q	Catchability
k	power of catchability model
α, β	parameters to the Beverton stock-recruit model
λ	Weighting factor

Software used: FLICA, based on ICA (Patterson, 1998; Needle, 2000)

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	1960-2007	1-9+	Yes
Weca	Weight at age in the commercial catch	1960-2007	1-9+	Yes
West	Weight at age of the spawning stock at spawning time.	1960-2007	1-9+	Yes (smoothed)
Mprop	Proportion of natural mortality before spawning	1960-2007	1-9+	No
Fprop	Proportion of fishing mortality before spawning	1960-2007	1-9+	No
Matprop	Proportion mature at age	1960-2007	1-9+	Yes (smoothed)
Natmor	Natural mortality	1960-2007	1-9+	No

Tuning data:

Type	Name	Year range	Age range (wr)
Tuning fleet 1	IBTS Q1	1984-2008	1-5
Tuning fleet 2	MIK	1992-2008	0
Tuning fleet 3	Acoustic	1989-2007	1-9+
Tuning fleet 4	MLAI	1973-2007	SSB

Variance and weighting factors for ICA

In the ICA model a fixed set of inverse variance weights for surveys and catch at age have been used. In the benchmark assessment in 2006 (ICES 2006/ACFM:20) the weighting factors of the indices used in ICA were fixed and have been used with the same values since. This reflects a slight change from a major investigation in 2001 carried out by the Study Group on Evaluation of Current Assessment Procedures for North Sea herring (SGEHAP, ICES 2001/ACFM:22). The original weighting factors were derived from the survey and catch data by methods given in ICES 2001/ACFM:22 and Simmonds (2003). The variance used is the variance of the natural logarithm of the estimates of the index based on a 2 stage bootstrap procedure. The choice matches the use of a maximum log likelihood method with a lognormal error distribution used within the ICA model. All indices are treated in the same manner. The individual station estimates at all ages are bootstrapped using a simple resampling with replacement procedure. This provides a variance covariance estimate of estimates of indices at age for each index assuming identically independently distributed samples. (iid)

As the spatial distributions are correlated and the sampling on the surveys are non-random in space, the spatial autocorrelation was taken into account using geostatistics. The methodology is described in Rivoirard et al. (2000), who provide the formulae and methods required to estimate variograms and calculate the estimation variance. Petitgas and Lafont (1997) provide the free software (EVA2) that has been used here for calculating the estimation variance for all the surveys. The iid estimates are corrected to provide overall estimates of variance covariance estimates across ages for each survey. The mean variance covariance estimate for the survey timeseries was calculated to provide one average variance/covariance matrix per survey.

ICA does not explicitly deal with covariance (in common with many assessment models) but it does allow modification of weights at age to account for this in a general way. The concept is to reduce the inverse variance factor by an amount that accommodates the covariance. The limits are: for zero correlation a factor of unity; for 100% covariance over n ages weights of 1/n. In both surveys the 1 to 2 group estimates are effectively independent and can be given weighting due to the full inverse variance weight, for subsequent ages the weighting has been implemented here for intermediate values of covariance to give the *W*age weighting factors at age:

$$W_{age} = \frac{1}{\mathrm{var}_{age}}\{n - \sum \mathrm{cov}_{age,age-1}\}/\{\mathrm{cov}_{age,age-1}/\sum 1/\mathrm{cov}_{age,age-1}\}$$

Where var_{age} is the variance of ln(estimate at age)

cov is covariance (age, age-1)

n is the number of ages in the correlated sequence

The resulting correlation correction factors are given in Table 2.6.7.3 in HAWG Report 2008.

The weighting factors used since 2006 (ICES 2006/ACFM:20) are given in Table 1 and can be compared with the old weighting factors derived under SGEHAP (ICES 2001/ACFM:22). The major difference is a slight general reduction in survey weights relative to the catch. Among the surveys the resulting spread of weights is generally similar to the earlier values, reducing with age, more steeply with the IBTS than the acoustic. The major difference is the MIK weighting which is reduced to about 1/3 of the previous value. The change is caused by the recent extended analysis. The difference between the previous analysis and this one was that in the earlier work the geostatistical analysis of spatial variance was limited to only a few recent years in each series. This resulted quite accidentally and unknowingly in selecting years from the MIK index that were very precise.

Table 1: North Sea herring. New weighting factors (ICES 2006 /ACFM:20) based on bootstrap of survey data. Old weights are included for comparison

	CATCH		ACOUSTIC		IBTS		MIK		MLAI	
Age	Old	New	Old	New	Old	New	Old	New	Old	New
0	0.10	0.10					2.05	0.63		
1	0.10	0.10	0.74	0.63	0.67	0.47				
2	3.17	3.67	0.75	0.62	0.24	0.28				
3	2.65	2.87	0.64	0.17	0.06	0.01				
4	1.94	2.23	0.27	0.10	0.03	0.01				
5	1.31	1.74	0.14	0.09	0.03	0.01				
6	0.97	1.37	0.13	0.08						
7	0.75	1.04	0.12	0.07						
8	0.55	0.94	0.07	0.07						
9	0.54	0.91	0.07	0.05						
SSB									0.65	0.60

D. Short-Term Projection

The short-term prediction method was substantially modified in 2002. Following the review by SGEHAP (ICES 2001/ACFM:22), which recommended that a simple multi-fleet method would be preferable, the complex split-factor method used for a number of years prior to 2002 has not been used since. The multi-fleet, multi-option, deterministic short-term prediction programme (MFSP) was accepted by ACFM in 2002 and further refined in 2003. It has been used routinely to perform short term predictions for this stock since then.. The good agreement between predicted biomass for the 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. Since 2004, the Working Group has included prediction of low maturation into the projections. Model used: Age-structured model, by fleet and area fished

Software used: MFSP

Initial stock size: output from ICA

Maturity: average of the three most recent years used

F and M before spawning: 0.67 for both (assumes spawning starts around September)

Weight at age in the stock: Mean over the last three years of unsmoothed weights, excluding the slow growing 2000 year class from the means. The weights of the 2000 year class are predicted using a von Bertalanffy growth model. Weight at age in the catch: average of last three years BY FLEET. For the A-fleet, mean over the last three years of catch weights, excluding the slow growing 2000 year class from the means were used. The weights for the 2000 year class are reduced according to the recent discrepancy between that year class and the mean weights at age.

Exploitation pattern:

Intermediate year assumptions: Catch constraint: TAC adjusted for experienced deviation of the actual catch from the TAC. For the A-fleet, an overfishing of 10-15 has been assumed in the recent years. For the other fleets, catches have been well below the TAC.

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)

E. Medium-Term Projections – *–are made as needed.*

Model used: 10 year stochastic prediction Software used: STPR3 has been used as a standard in the past, as it allows for independent regulations of two 'flles' (fisheries)

Initial stock size: As for the short term prediction, but with random variation according the variance-covariance matrix taken from the ICA assessment

Natural mortality: Constant as in the assessment

Maturity: As in the short term prediction

F and M before spawning: Constant values : 0.67 for both.

Weight at age in the stock: Obtained each projection year by drawing a historical year randomly and using the weights from that year.

Weight at age in the catch: As weight at age in the stock.

Exploitation pattern: As for short term forecast. Fleet A separately, fleets B-C-D merged.

Intermediate year assumptions: As for short term prediction

Stock recruitment model used: Beverton Holt or Hockey stick

Uncertainty models used:

Initial stock size: See above

Natural mortality: Constant

Maturity: Constant

F and M before spawning: Constant

Weight at age in the stock: See above

Weight at age in the catch: See above

Exploitation pattern: Constant

Intermediate year assumptions: Constant

Stock recruitment model used: Log-normal variation around a stock-recruit function with fixed parameters. Opportunity to truncate the distribution.

F. Long-Term Projections – *–not done since 1996(?)*

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 6 mm to 9 mm 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 are found in the Baltic, Skagerrak and Kattegat, and may also be found in the North Sea as well as Norwegian coastal spring spawners.

The main autumn spawning begins in the northern North Sea in August and progresses steadily southwards through September and October in the central North Sea to November and as late as January in the southern North Sea and eastern English Channel. The widespread but discrete location of the herring spawning grounds throughout the western North Sea has been well known and described since the 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.

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 83 500 t, 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 52 000 t. By 1981 the SSB had increased to over 200 000 t. Prior to the moratorium there had been no control, other than market forces, on catches in the North Sea directed herring fishery. Once the fishery 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 long-term average over this period. The 1985 year class was the biggest recorded since 1960 and the third highest in the records dating back to 1946. Landings also steadily increased over this period reaching a peak of 876 000 tonnes in 1988. This resulted from a steady increase in fishing mortality to $F_{ages\ 2\text{-}6}$ = 0.6 (ca. 45%) in 1985 and a high by-catch of juveniles in the industrial fisheries for sprat. Following a period of four years of below average recruitment (year classes 1987-91), SSB fell rapidly to below 500 000 tonnes in 1993. Fishing mortality increased rapidly averaging $F_{ages\ 2\text{-}6}$=0.75 (ca. 52%) over the period 1992–95 and recorded landings regularly exceeded the TAC. The North Sea industrial fishery for sprat developed rapidly over this period with the annual catch increasing from 33 000 tonnes in 1987 to 357 000 tonnes by 1995. With the 10% by-catch limit as the only control on the catch of immature herring, there was a consequent high mortality on juvenile herring which averaged 76% of the total catch in numbers of North Sea autumn spawners over this period.

During the summer of 1991 the presence of the parasitic fungus *Ichthyophonus* spp was noted in the North Sea herring stock. All the evidence suggested that the parasite was lethal to herring and that its occurrence could have a significant effect on natural mortality in the stock and ultimately on spawning stock biomass. High levels of infection were recorded in the northern North Sea north of latitude 60°N whilst infection rates in the southern North Sea and English Channel were very low. Efforts were made to estimate the prevalence of the disease in the stock through a 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 the TAC of the preceding year.*
7. *By-catches of herring may only be landed in ports where adequate sampling schemes to effectively monitor the landings have been set up. All catches landed shall be deducted from the respective quotas set, and the fisheries shall be stopped immediately in the event that the quotas are exhausted*

8. *The allocation of 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.*

Meanwhile, the management agreement was reviewed and is still valid (status March 2008).

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;

H.5 Terminology

The WG uses “rings” rather than “age” or “winter rings” throughout the report to denominate the age of herring, with the intention to avoid confusion. It should be observed that, for autumn spawning stocks, there is a difference of one year between “age” and “rings”. HAWG in 1992 (ICES 1992/Assess:11) stated that

“The convention of defining herring age rings instead of years was introduced in various ICES working groups around 1970. The main argument to do so was the uncertainty about the racial identity of the herring in some areas. A herring with one winter ring is classified as 2-years-old if it is an autumn spawner, and one-year-old if it is a spring spawner. Recording the age of the herring in rings instead of in years allowed scientists to postpone the decision on year of birth until a later date when they might have obtained more information on the racial identity of the herring.

The use of winter rings in ICES working groups has introduced a certain amount of confusion and errors. In specifying the age of the herring, people always have to state explicitly whether they are talking about rings or years, and whether the herring are autumn- or spring spawners. These details tend to get lost in working group reports, which can make these reports confusing for outsiders, and even for herring experts themselves. As the age of all other fish species (and of herring in other parts of the world) is expressed in years, one could question the justification of treating West-European herring in a special way. Especially with the present trend towards multispecies assessment and integration of ICES working groups, there might be a case for a uniform system of age definition throughout all ICES working groups.

However, the change from rings to years would create a number of practical problems. Data files in national laboratories and at ICES would have to be adapted, which would involve extra costs and manpower. People that had not been aware of the change might be confused when comparing new data with data from old working group reports. Finally, in some areas (notably Division IIIa), the distinction between spring- and autumn spawners is still hard to make, and scientists preferred to continue using rings instead of years.

The Working Group discussed at length the various consequences of a change from rings to years. The majority of the Group felt that the advantages of such a change did not outweigh the disadvantages, and it was decided to stick to the present system for the time being.”

The text table below gives an example for the correlation between age, rings and year class for the different spawning types in late 2002:

Year class (autumn spawners)	2001/2002	2000/2001	1999/2000	1998/1999
Rings	**0**	**1**	**2**	**3**
Age (autumn spawners)	1	2	3	4
Year class (spring spawners)	**2002**	**2001**	**2000**	**1999**
Rings	**0**	**1**	**2**	**3**
Age (spring spawners)	0	1	2	3

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Annex 4: - Stock Annexes- Herring in Division IIIa and Subdivisions 22-24

Quality Handbook ANNEX: HAWG-herring WBSS

Stock specific documentation of standard assessment procedures used by ICES and relevant knowledge of the biology.

Stock	Western Baltic Spring spawning herring (WBSS)
Working Group: Area	Herring Assessment Working Group for the South of 62º N
Date:	14.03.2008
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.

The contribution of Downs-herring to the mix-area of Division IIIa is likely to be relatively small (un-published data from otolith readings, DIFRES), and Downs-herring are therefore included under NSAS for the stock assessment of herring in Division IIIa and 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, 2007).

In the Kattegat and the eastern Skagerrak, mainly 2+ ringers of the WBSS and 0 to 2-ringers from the NSAS are being caught (ICES, 2004; ICES WD, 2006). The area provides a nursery habitat for juvenile NSAS (also 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 seem to appear along the southern edge of the Norwegian Trench and in the area to the east of Læsø, in Kattegat (ICES, 2005; ICES, 2006). In 3rd quarter large concentrations of 2+ ringers of the WBSS are found in the southern Kattegat and Subdivision 23 as they aggregate for the over-wintering, which mainly takes place in Subdivision 23 (Nielsen et al., 2001; Clausen et al., 2006).

In the eastern North Sea and the western Skagerrak mainly 2+ ringers from WBSS and 1 to 2-ringer NSAS are being caught (Clausen et al., 2006). Peak catches of WBSS occur in quarter 3, during which the spawning stock of WBSS feed in these areas (ICES, 2002). According to the herring acoustic survey (ICES, 2006) the largest concentrations of herring in this area occur along the transition zone between the Skagerrak and the North Sea (ICES, 2006). Some 2+ ringer NSAS are caught in 1st and 4th quarter, since part of the NSAS spawning stock over-winter in the Norwegian trench in this area. (Burd, 1978; Cushing and Bridger, 1966; Clausen et al., 2006).

In historic time several local 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 German herring catches were caught in the passive fishery by gillnets and trapnets around the Rügen Island. Since 2001 the activities in the trawl fishery increased. Recently the landings by trawl reached a level of more than 50 % of the total landings (2003: 63 %, 2004: 52 %, 2005: 57 % and 2006: 64 %). The change in fishing pattern was caused by requirements for a fish factory on Rügen Island established in 2003 which can process 50 000 t per year.

Investigation of new Danish fleet/metier description and the possibilities of improving the advice for the mixed stocks in IIIa (The IMHERSKA EU-project (Clausen et al., 2006))

An ecosystem approach to fisheries management should consider conservation of intra-specific variation due to population structure and life history variation. Knowledge of stock integrity is of unequivocal importance for sustainable fisheries management, since variable compositions in mixed areas together with asynchronous population dynamics may lead to over-fishing of individual stocks if not all components are managed to ensure (or achieve) sustainable exploitation.

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

For the descriptive analysis of the Danish fleet dynamics during the last decade, the fisheries identified in Ulrich and Andersen (2004) was modified accordingly, to get as much consistency with the previous HAWG work. Fisheries were identified using a 3-steps method using multivariate analysis of landings profile (target species) and trips descriptors (mesh size, season, and area). The data were based on logbook data and though considerable misreporting is suspected to take place between Division IIIa and the North Sea, the geographical patterns described below is believed to illustrate the fishery behaviour in general terms.

Figure A.2.1 illustrates the distribution of Danish herring landings in Division IIIa by vessel type and homeport (fleet) in 2004. From this 4 fleets were identified and Figure 3.1.2 shows the distribution of herring landings by fleet over selected years:

(1) OTB_NSSK: trawlers from North Sea and Skagerrak harbours (Skagen included). This fleet is referred to as the Northern fleet.
(2) PSB_NSSK: purse-seines from North Sea and Skagerrak harbours.
(3) OTB_KAWB: trawlers from North Sjælland and Western Baltic (Subdivisions 22-24) harbours. This fleet is referred to as the Southern fleet.
(4) OTH: all other vessels recorded for having caught herring in Division IIIa at least once a year. Given its low importance, this fleet is not kept further in the analysis.

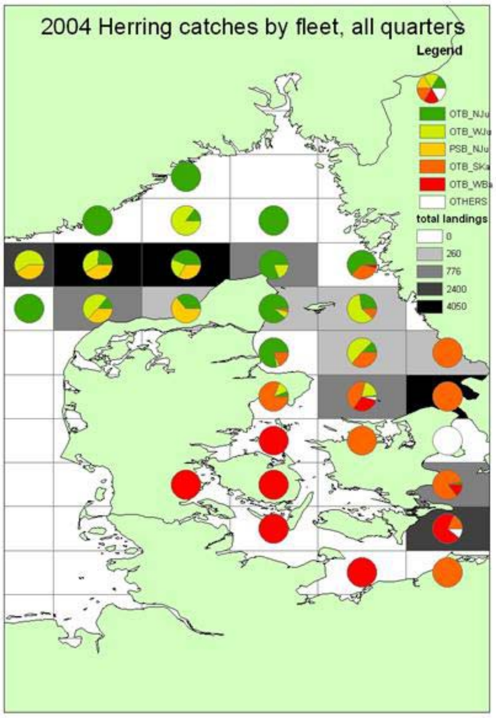

Figure A.2.1 Danish landings in IIIa by vessel and homeport.

The spatial and temporal distribution of the two main stocks (NSAS and WBSS respectively) in the SubDivisions IVaE, IIIaN, IIIaS and SubDivisions 22-24 based on analysis of herring catch compositions from both commercial and scientific sampling in the period from 1999 to 2004 appear to be following certain patterns in terms of seasonality which in turn allow predictions of the mix of herring in the area. Furthermore, by using the above four fleets/metiers and disaggregating those further into industrial or commercial activities and looking at the stock composition in their catches within different seasons, stock selective metiers was identified (a stock selective metier was defined as: a metier with 80% or more of its landings constituting the same stock). Identifying such patterns, both in terms of the life-stage spatiality of WBSS and NSAS in division IIIa and adjacent areas, and in terms of fleets activity and inter-stock selectivity was a necessary prerequisite for any use of improved fleet- and stock-based management objectives. We have thus demonstrated that a more precise advice for the mixed stock in IIIa using elaborate fleet- and stock-based 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.

The Swedish fleet definition is based on mesh size of the gear as for the Danish fleet. However, a recent change in the Swedish industrial fishery has occurred, as the Swedish industrial fishery has rapidly declined during the 1990´s and it is currently no longer operating in the area. Therefore, there is no difference in age structure of the Swedish landings between vessel using different mesh sizes since both are basically targeting herring for human consumption.

A.3. Ecosystem aspects

Recent results from the HERGEN research-project on herring (HERGEN, EU project QLRT 200-01370, final report) reveals an increase in genetic distance between herring populations in the Baltic and successive populations in subdivisions 24, 22, 21, and 20 and finally the North Sea where genetic distance reach a maximum constant difference to the Baltic. Further, genetic differences are larger among populations within the Division IIIa and Western Baltic than among populations in the North Sea. The results also suggests that the herring spawning in spring on local spawning areas in the fjords of both the Western Baltic, the Kattegat, and the Skagerrak should be regarded as distinct spawning populations (or sub-populations) rather than as "strayers" from the Rügen-herring population. Furthermore, the contribution of these local spring spawning populations are considerable (Bekkevold et al., 2005; HERGEN, EU project QLRT 200-01370, final report).

By comparing five different Baltic herring stocks, temperature and SSB was shown as a te main predictors contributing to explain recruitment in the whole Baltic Sea, (Cardinale et al. 2008) except for Western Baltic herring where the Baltic Sea Index was the selected proxy in the final model. However, Baltic Sea Index is known to be a proxy for SST in the area.

B. Data

B.1. Commercial catch

Misreporting to fishing area still occurs. There is uncertainty about where the Danish landings for human consumption, reported from Division IIIa were actually taken. There is a high probability that these catches have been taken in the North Sea. Therefore, some of these catches have been transferred to the North Sea. Lastly, some landings reported as taken in the Triangle (Gilleleje, DK - Kullen, S - Helsingborg, S - Helsingør, DK), may have been taken outside this area and listed under the Kattegat.

There is at present no information about the relevance of local herring stocks/populations in relation to the fisheries and their possible influence on the stock assessment. Recent evidence from genetic differentiation among spawning aggregations in the Skagerrak suggests a potential high representation of these local spawning stocks (Bekkevold et al., 2005). Other results suggest that at least the mature proportion of the different stock components to a large extent shares migration patterns and feeding areas (Ruzzante et al., 2006; van Deurs and Ramkaer, 2006).

B.2. Biological parameters for assessment

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. The survey has been revised in 2007 and it now includes also SD 21 Used in the final assessment.

The IBTS 3rd quarter survey in Div. IIIa is part of the North Sea and Div. IIIa bottom trawl survey carried out in the 1st and 3rd quarter. The IBTS has been conducted annually in the 1st quarter since 1977 and 3rd quarters from 1991. From 1983 and onwards the survey was standardised according to the IBTS manual (ICES 2002/D:03). During the HAWG 2002 the IBTS survey data (both quarter) were revised from 1991 to 2002. Historical catch rates are heavily skewed and therefore the survey indices by winter rings 1-5 were calculated as geometric means from observed abundances ($n \cdot h^{-1}$) at age at trawl stations. However, inspections of the distributions of CPUE ($n \cdot h^{-1}$) reveals that they are characterized by a relatively large number of low values, including true zeroes, but also occasional catches comprising large number of individuals. Statistical inference based on such data is likely to be inefficient or wrong unless an appropriate distribution is carefully chosen Generally, a quasi-Poisson distribution (with a log-link function in order to constraint the estimates of CPUE to be positive) and a so called zero inflated models (Minami et al. 2006; Martin et al., 2005) are used. While quasi-Poisson can treat zeroes and non-zeroes in the same models, zero-inflated models are expressed in two parts: the probability of being in a 'perfect-state' (e.g., no catch), and the probability of being in an 'imperfect-state' where positive events (e.g., catch) may occur (Minami et al. 2006). The perfect-state is usually modeled with a logistic, and a quasi-Poisson or a negative binomial distribution is assumed for the imperfect state. Those models are usually referred to as zero-inflated (ZIP and ZINB) models. Zero-inflated models are also attractive because they make a distinction between covariates associated with the perfect state (no catch) and covariates associated with the imperfect state in which catch can occur, but is not certain. Analysis is ongoing to test the use of ZIP and ZINB for estimating catch at age from IBTS dataset to be included in the next benchmark assessment. Thus, the IBTS indeces were not used in the final assessment in 2008.

The German herring larvae monitoring started in 1977 and takes place every year from March/April to June in the main spawning grounds of the spring spawning herring in the Western Baltic. These are the Greifswalder Bodden and adjacent waters. For the calculation of the number of larvae per station and area unit, the methods of Smith and Richardson (1977) and Klenz (1993) were used and projected to length-classes. Further details concerning the surveys and the treatment of the samples are given in Brielmann (1989), Müller and Klenz (1994) and Klenz (2002). Data revision was made in 2007 with a new method in calculating number at 20mm. There was a high correlation between the indices N20 and HA_1 which are based on significantly different methods, areas and periods. Thus, results suggest that the index N20 is a suitable estimator of the new year-class of the spring spawning herring in ICES subdivision 22 – 24 (Oeberst et al, 2007, WD 7 in HAWG 2008 report). The time series now cover the period 1992-2007. Used in the final assessment.

B.4. Commercial CPUE

None

B.5. Other relevant data

None

C. Historical Stock Development

Model used: ICA
Software used: FLICA

Model Options chosen:
No of years for separable constraint: 5
Reference age for separable constraint: 4
Constant selection pattern model: yes
S to be fixed on last age: 1.0
First age for calculation of reference F: 3
Last age for calculation of reference F: 6
Relative weights-at-age: 0.1 for 0-group, all others 1
Relative weights by year: all 1
Catchability model used: for all indices linear
Survey weighting: Manual all 1
Estimates of the extent to which errors in the age-structured indices are correlated across ages: all 1
No shrinkage applied

Input data types and characteristics:

Type	Name	Year range	Age range	Variable from year to year Yes/No
Caton	Catch in tonnes	1991- last data year	0-8+	Yes
Canum	Catch-at-age in numbers	1991- last data year	0-8+	Yes
Weca	Weight-at-age in the commercial catch	1991- last data year	0-8+	Yes
West	Weight-at-age of the spawning stock at spawning time.	1991- last data year	0-8+	Yes, assumed as the Mw in the catch first quarter
Mprop	Proportion of natural mortality before spawning	1991- last data year	0-8+	No, set to 0.25 for all ages in all years
Fprop	Proportion of fishing mortality before spawning	1991- last data year	0-8+	No, set to 0.1 for all ages in all years
Matprop	Proportion mature at age	1991- last data year	0-8+	No, constant for all years
Natmor	Natural mortality	1991- last data year	0-8+	No, constant for all years

Presently used Tuning data:

Type	Name	Year range	Age range
Tuning fleet 1	Danish Acoustic Survey Div. IIIa	1989 – last year data	3-6
Tuning fleet 2	German Acoustic Survey SDs 22-24	1989 – last year data	1-3
Tuning fleet 3	N20 larval survey, Greifswalder Botten	1992 – last year data	0

D. Short-Term Projection

Model used: Age structured

Software used: MFDP 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

Natural mortality: The same values as in the assessment is used for all years

Maturity: The same values as in the assessment is used for all years

F and M before spawning: The same 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: HCS

Software used: HCS

Initial stock size: ICA estimates of population numbers were used

Natural mortality: The same values as in the assessment is used for all years

Maturity: The same values as in the assessment is used for all years

F and M before spawning: The same values as in the assessment is used for all years

Weight-at-age in the stock: Average weight of the three last years

Weight-at-age in the catch: Average weight of the three last years

Exploitation pattern: Average weight of the three last years

Intermediate year assumptions: Status quo fishing mortality

Stock recruitment model used: Hockey stick

Uncertainty models used:

1) Initial stock size:
2) Natural mortality:
3) Maturity:
4) F and M before spawning:
5) Weight-at-age in the stock:
6) Weight-at-age in the catch:
7) Exploitation pattern:
8) Intermediate year assumptions:
9) Stock recruitment model used:

F. Long-Term Projections

Model used: none

Software used:

Maturity:

F and M before spawning:

Weight-at-age in the stock:

Weight-at-age in the catch:

Exploitation pattern:

Procedures used for splitting projected catches:

G. Biological Reference Points

There are no precautionary approach reference points for this stock. Based on yield per recruit analysis and simulation carried out during HAWG (2007) and WKHMP (2008), a proxy for long term maximum sustainable exploitation rate should be a level of fishing mortality should not exceed F = 0.25.

Risk assessment performed in 2007

To address the issue of risk assessment with respect to simulation based optimizations carried out for IIIa herring in section 3.8 we implemented the following risk definition as given in the SGRAMA report of 2006 (ICES 2006/RMC:04) which is risk in a juridical sense:

$$\begin{aligned}\text{Risk} &= \text{P(harmful event)} \times \text{severity of harmful event} \\ &= \text{P(lower SSB limit undercut)} \times \text{EL}\end{aligned} \quad (1)$$

with expected loss (EL) being defined as

$$\text{EL} = \text{E}[\text{SSB}_{\text{lower limit}} - \text{SSB}_{\text{estimated}} \mid \text{SSB}_{\text{estimated}} < \text{SSB}_{\text{lower limit}}] \ . (2)$$

While this definition of risk is not only implemented as part of many national constitutions (for instance, of the German constitution; Schuldt 1997, Schulte 1999, Schulz *et al.* 2001) but is also commonly used in engineering, in natural or environmental sciences or in medicine (see, for instance, Burgmann 2004), in mathematical sciences however P (harmful event) is often solely used as a definition for risk. As we aim at specifying costs or loss from a political and economic perspective, Eq. (1) turns out to be the appropriate risk measure, as it contains a probability term specifying the chance or likelihood of a harmful event and a severity term quantifying the magnitude of the loss. Further information on the theory underlying risk assessment and risk management can be found in Burgmann (2004), Francis and Shotton (1997) and Lane and Stephenson (1997). For a formal treatment of quantitative risk assessment and management see McNeil (2005).

H. Other Issues

None

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Annex 5 Quality Handbook Herring in Celtic Sea and VIIj

Stock specific documentation of standard assessment procedures used by ICES.

Stock:	Herring in the Celtic Sea and VIIj
Working Group:	Herring Assessment Working Group for the area south of 62^0
Date:	
Authors:	Afra Egan and Maurice Clarke

A.1 General

The herring to the south of Ireland in the Celtic Sea and in Division VIIj comprise both autumn and winter spawning components. For the purpose of stock assessment and management. The inclusion, in 1982, of VIIj was to deal with misreporting of catches from VIIg. The same fleet exploited these stocks and it was considered more realistic to assess and manage the two areas together. This decision was backed up by work by ICES HAWG in 1982 that showed similarities in age profiles between the two areas. In addition, larvae from the spawning grounds in the western part of the Celtic Sea were shown to be transported into VIIj (ICES, 1982).

It was concluded that recruitment to the Celtic Sea stock includes herring from VIIj (Molloy, 1968). A study group examined stock boundaries in 1994 and recommended that the boundary line separating this stock from the herring stock of VIaS and VIIb be moved southwards from latitude 52°30′N to 52°00′N (ICES, 1994b). However, a recent study (Hatfield et al. 2007) examined the stock identity of this and other stocks around Ireland. It concluded that the Celtic Sea stock area should remain unchanged.

Some juveniles of this stock are present in the Irish Sea for their first year or two of life. Juveniles, which are believed to have originated in the Celtic Sea move to nursery areas in the Irish Sea before returning to the spawn in the Celtic Sea (Ref). This has been verified through herring tagging surveys, conducted in the early 1990s, (Molloy, *et al* 1993) and studies examining otolith microstructure (Brophy and Danilowicz, 2002). Age distribution of the stock suggests that recruitment in the Celtic Sea occurs first in the eastern area and follows a westward movement. After spawning herring move to the feeding grounds offshore (Ref). In VIIj herring congregate for spawning in autumn but little is known about where they reside in winter (ICES, 1994). A schematic representation of the movements and migrations is presented in Figure V.1. Figure V.2 shows areas mentioned in the text.

The management area for this stock comprises VIIaS, VIIg, VIIj, VIIk and VIIh. Catches in VIIk and VIIh have been negligible in recent years. The linkages between this stock and herring populations in VIIe and VIIf are unknown. The latter are managed by a separate precautionary TAC. A small herring spawning component is known to exist in VIIIa, though its linkage with the Celtic Sea stock is also unknown.

A.2. Fishery

Historical fishery development

Coastal herring fisheries off the south coast of Ireland have been in existence from at least the seventeenth century (Burd and Bracken, 1965). These fisheries have been an important source of income for many coastal communities in Ireland. There have been considerable fluctuations in herring landings since the early 1900s.

In the Celtic Sea, historically, the main fishery was the early summer drift net fishery and the Smalls fishery which also took place in the summer. In 1933 several British vessels, mainly from Milford Haven, began to fish off the coast of Dunmore East and the winter fishery gained importance. The occurrence of the world war changed the pattern of the herring fishery further with little effort spent exploiting herring in the immediate post war years (Burd and Bracken, 1965). Landings of herring off the south west coast increased during the 1950s.

In 1956 Dunmore East was considered as the top herring port in Ireland with over 3,000 t landed. This was mainly sold to the UK or cured and sent to the Netherlands (Molloy, 2006). During this time many boats from other European countries began to exploit herring in this area during the spawning period. This continued until the 1960s when catches began to fall. In 1961 the Irish fishery limits changed whereby non-Irish vessels were prohibited from fishing in the inshore spawning grounds (Molloy, 1980). Consequently, continental fleets could no longer exploit herring on the Irish spawning grounds. They had to purchase herring from Irish vessels in order to meet requirements (Molloy, 2006).

During the period from 1950-1968 the fleet exploiting the stock changed from mainly drift and ring nets to trawls. Further fluctuations in the landings were evident during this time with high quantities of herring landed from 1958 – 1960 and from 1966 – 1971 (Molloy, 1972). In the mid-sixties, the introduction of mid-water pair trawling led to greater efficiency in catching herring and this method is still employed today. Overall the 1960s saw a rise in herring landings with 1969 seeing a rise to 48,000t. The North Sea herring fisheries were becoming depleted and several countries were turning to Ireland to supply their markets. Prices also increased and additional vessels entered the fleet (Molloy, 1995). Increases in effort led to increased catches initially but this did not continue and the decline of the fishery began.

Modern Fishery

In the past, fleets from the UK, Belgium, The Netherlands and Germany as well as Ireland exploited Celtic Sea herring. In recent years however this fishery has been prosecuted entirely by Ireland. This fishery is managed by the Irish "Celtic Sea Herring Management Advisory Committee", established in 2000 and constituted in law in 2005.

The Irish quota is managed by allocating individual quotas to vessels on a weekly basis. Participation in the fishery is restricted to licensed vessels. The licensing requirements have been changed. Previously, vessels had to participate in the fishery each year to maintain their licence. Since 2004 this requirement has been lifted. This has been one of the contributing factors to the reduction in number of vessels participating in the fishery in recent seasons (ICES, 2005b). Fishing is restricted to the period Monday to Friday each week, and vessels must apply a week in advance before they are allowed to fish in the following week. Triennial spawning box closures are enshrined in EU legislation (Figure V.2).

The stock is exploited by two types of vessels, larger boats with RSW storage and smaller dry hold vessels. The smaller vessels are confined to the spawning grounds (VIIaS and VIIg) during the winter period. The refrigerated seawater (RSW) tank vessels target the stock inshore in winter and offshore during the summer feeding phase (VIIg). There has been less fishing in VIIj in recent seasons.

The fleet can be classified into four categories of vessels:

Category 1: "Pelagic Segment".	Refrigerated seawater trawlers
Category 2: "Polyvalent Segment".	Refrigerated seawater or slush ice trawlers
Category 3: "Polyvalent Segment".	Varying number of dry hold pair trawlers,
Category 4: Drift netters.	A negligible component in recent years, very small vessels

Since 2002 fishing has taken place in quarter 3, targeting fish during the feeding phase on the offshore grounds around the Kinsale Gas Fields. These fish tend to be fatter and in better condition than winter-caught fish. In 2003 the fishery opened in July on the Labadie Bank. In 2004-2006 it opened in August and in 2007 in September. The July 2003 fishery caught larger fish were caught than are normally found in the fishery. Only RSW and bulk storage vessels can prosecute this fishery. Traditional dry-hold boats are unable to participate.

In recent years, the targeting fleet has changed. The fleet size has reduced but an increasing proportion of the catch is taken by RSW and bulk storage vessels and less by dry-hold vessels. There has been considerable efficiency creep in the fishery since the 1980s with greater ability to locate fish.

The collapse of the market for herring roe means that there is no longer the same incentive to discard (slip) catches.

A.3. Ecosystem aspects

The ecosystem of the Celtic Sea is described in ICES WGRED (2007). The main hydrographic features of this area as they pertain to herring are presented in Figire V.3.

Temperatures in this area have been increasing over the last number of decades. There are indications that salinity is also increasing (ICES 2006). Herring are found to be more abundant when the water is cooler while pilchards favour warmer water and tend to extend further east under these conditions (Pinnegar, *et al* 2002).

However, studies have been unable to demonstrate that changes in the environmental regime in the Celtic Sea have had any effect on productivity of this stock.

Herring larval drift occurs between the Celtic Sea and the Irish Sea. The larvae remain for a period as juveniles before returning to the Celtic Sea. Catches of herring in the Irish Sea may therefore impact on recruitment into the Celtic Sea stock (Molloy, 1989). Distinct patterns were evident in the microstructure and it is thought that this is caused by environmental variations. Variations in growth rates between the two areas were found with Celtic Sea fish displaying fastest growth in the first year of life. These variations in growth rates between nursery areas are likely to impact recruitment (Brophy and Danilowicz, 2002). Larval dispersal can further influence maturity at age. In the Celtic Sea faster growing individuals mature in their second year (1 w. ring) while slower growing individuals spawn for the first time in their third year (2 w. winter ring). The dispersal into the Irish Sea which occurs before recruitment and subsequent decrease in growth rates could thus determine whether juveniles are recruited to the adult population in the second or third year (Brophy and Danilowicz, 2003).

The spawning grounds for herring in the Celtic Sea are well known and are located inshore close to the coast. These spawning grounds may contain one or more spawning beds on which herring deposit their eggs. Individual spawning beds within the spawning grounds have been mapped and consist of either gravel or flat stone (Breslin, 1998). Spawning grounds tend to be vulnerable to anthropogenic influences such as dredging and sand and gravel extraction. The main spawning grounds are displayed in Figure V.4, whilst the distributions of spawning and non-spawning fish are presented in Figure V.5.

By Catch

By catch is defined as the incidental catch of non target species. There are few documented reports of by catch in the Celtic Sea herring fishery. A European study was undertaken to quantify incidental catches of marine mammals from a number of fisheries including the Celtic Sea herring fishery. Small quantities of non target whitefish species were caught in the nets. Of the non target species caught whiting was most frequent (84% of tows) followed by mackerel (32%) and cod (30%). The only marine mammals recorded were grey seals (*Halichoerus grypus*). The seals were observed on a number of occasions feeding on herring when the net was being hauled and during towing. They appear to be able to avoid becoming entangled in the nets. It was considered unlikely by Berrow, *et al* 1998, that this rate of incidental catch in the Celtic Sea would cause any decline in the Irish grey seal population. Results from this project also suggested that there was little interaction between the fishing vessels and the cetaceans in this area. Occasional entanglement may occur but overall incidental catches of cetaceans are thought to be minimal (Berrow, *et al* 1998). The absence of any other by caught mammals does not imply that by catch is not a problem, only that it did not occur during this study period (Morizur, *et al* 1999).

Discards

Catch is divided into landings (retained catch) and discards (rejected catch). Discards are the portion of the catch returned to the sea as a result of economic, legal, or personal considerations (Alverson *et al* 1994). In the 1980s a roe (ovary) market developed in Japan and the Irish fishery became dependent on this market. This market required a specific type of herring whose ovaries were just at the point of spawning. A process developed whereby large quantities of herring were slipped at sea. This type of discarding usually took place in the early stages of spawning and was reduced by the introduction of experimental fishing (Molloy, 1995). This market peaked in 1997 and has been in decline since with no roe exported in recent years. Markets have changed with the majority of herring going to the European fillet market.

Presently there are no estimates of discards for this fishery used in assessments. Berrow, *et al* 1998 also looked at the issue of discarding during the study on by catch. The discard rate was found to be 4.7% and this compares favourably with other trawl fisheries. Possible reasons for discarding were thought to be the market requirements for high roe content and high proportions of small herring in the catch. Overall this study indicated that the Celtic Sea herring fishery is very selective and that discard rates are well within the figures estimated for fishery models.

Since the demise of the roe fishery, it is considered that the incentive to discard is less. However it is known that discarding still takes place, in response to a constrained market situation.

B. Data

B.1. Commercial Catch

The commercial catch data are provided by national laboratories belonging to the nations that have quota/fisheries for this stock. In recent years, only Ireland has been catching herring in this area, and the data are derived entirely from Irish logbook data. Figure V. 6 shows the trends in catches over the time series.

B.2. Biological

Sampling is performed as part of commitments under the EU Council Regulation 1639/2001. Ireland acts as stock coordinator for this stock. Commercial catch at age data are submitted in Exchange sheet v 1.6.4. These data are processed either using SALLOCL (Patterson, 1998b), or using *ad hoc* spreadsheets, usually the latter. The relevant files are placed on the ICES archive each year.

The InterCatch database was developed by ICES and first tested by the herring assessment working group in 2007. In 2007 and 2008 all data for this stock has been uploaded to intercatch.

Sampling Protocol

Sampling (of the Irish catches) is conducted using the following protocol

Collect a sample from each pair of boats that lands. Depending on the size range a half to a full fish box (depending on size range) is sufficient. If collecting from processor make sure sample is ungraded and random.

Record the boat name, ICES area, fishing ground, date landed for each sample. If possible find out roughly how much the boat landed.

Randomly take 75 fish for ageing. Record length in 0.5cm, weight, sex, maturity (use maturity scale for guideline). Extract otolith taking care not to break tip, store it in otolith tray. Make sure the tray is clean and dry.

Record a tally for the 75 aged fish under "Aged Tally" on datasheet.

Measure the remaining fish and record a tally on the measured component of datasheet

Ageing Protocol

Celtic Sea herring otoliths are read using a stereoscopic microscope, using reflected light. The minimum level of magnification (15x) is used initially and is then increased to resolve the features of the otolith. Herring otoliths are read within the range of 20x – 25x. The pattern of opaque (summer) and translucent (winter) zones is viewed. The winter (translucent) ring at the otolith edge is counted only in otoliths from fish caught after the 1st April. This "birth date" is used because the assessment year for Celtic Sea and Division VIIj herring runs from this date to the 31st March of the following year (ICES, 2007). This ageing and assessment procedure is unique in ICES, to this herring stock. The first winter ring that is counted is that which corresponds to the second "birth date" of the fish. For this stock, the birth date is the 1st April. This is unique to this stock, within the ICES area (Lynch, *in prep*).

A fish of 2 winter rings is a 3 year old. This naming convention applies to all ICES herring stocks where autumn spawning is significant.

Age composition in the catch

In recent years there is a decreasing proportion of older fish present in the catch. Figure V.7 shows the age composition of the catches over the time series. It is clear that there is a truncation of older age classes in recent years.

Precision in Ageing

Precision estimates from the ageing data were carried out in the HAWG in 2007, for the 2006/2007 season (ICES, 2007). Results found that CVs are highest on youngest and oldest ages that are poorly represented in the fishery. The main ages present in the fishery had low cvs, of between 5% and 13%, which is considered a very good level of precision. In the third and the fourth quarter, estimates of 1 wr on CS herring were also remarkably precise.

Mean Weights and Natural Mortality

An extensive data set on landings is available from 1958. Mean weights at age in the catch in the 4th and 1st quarter are used as stock weights. Trends in mean weights at age in the catches are presented in Figure V.8, and for weights in the spawning stock in Figure V.9. Clearly there has been a decline in mean weights since the early 1980s, to the lowest values observed.

The natural mortality is based on the results of the MSVPA for North Sea herring. Natural mortality is assumed to be as follows:

1 ringer	1
2 ringer	0.3
3	0.2
4 and and subsequent ringer	0.1

Maturity Ogive

Clupea harengus is a determinate one-batch spawner. In this stock, the assessment considers that 50% of 1 ringers are mature and 100% of two ringers mature. The maturity ogive calculated from acoustic survey data in 2007 shows that 58% of 1 ringers are mature and 99% of 2 ringers. Lynch (*in prep*) has also shown that more than 50% of 1 ringers are mature.

It is to be noted that the fish that recruit to the fishery as 1-ringers are probably precocious and late maturing 1-ringers may not be recruited. Thus maturity at 1-ringer in the population as a whole may be different to that observed in the fishery.

B.3. Surveys

Acoustic

Acoustic surveys have been carried out on this stock from 1990-1996, and again from 1998-2007. During the first period, two surveys were carried out each year. The series was interrupted in 1997 due to the absence of a survey vessel. Until 1996 mostly two surveys were conducted each season, using RV *Lough Foyle*. A uniform design, randomised survey track, timing and the same research vessel have been employed since 2005. A summary of the acoustic surveys is presented in Table V.1.

Revision of acoustic time series

A review of the acoustic survey programme was conducted to check the internal consistency of the previous surveys and produce a new refined series for tuning the assessment (Doonan, unpublished). The old survey abundance at age series is presented in Table V.2 and the revised survey time series is shown in the Table V.3 (ICES, 2006).

The surveys were divided into two series, early and late, based on how far from the south coast of Ireland the transects extended. The early group, 1990-91 to 1994-95, extended to about 15 nautical miles offshore with two surveys, one in autumn (before Christmas) and another in winter (after Christmas). This design aimed to survey spawning fish close inshore with two surveys, the results of which could be added, the two legs covering the two main spawning seasons. The off shore limits were extended in 1995 and some of these surveys had more fish off shore than close inshore. This changed the catchability, suggesting the later series should be separated from the earlier one. Consequently the years before 1995 were removed. This is not considered to be a problem because the earlier series would contribute little to the ICA anyway. Winter surveys were not always conducted in the later series, not being done in 1998 and not at all after 2000 so these were dropped too.

The autumn surveys did not cover the southwest Irish coast of VIIj in all years (3 years missing). In order to correct for this, the missing values were substituted with the mean of the available western bays SSB estimates, 7 800 t (11 values, range from 0 to 16 000 t). Numbers-at-age in these surveys were adjusted upwards by the ratio of the adjusted SSB in the SW to the south coast SSB.

Analysis errors were found in the surveys from 1998 onwards. The 2003 biomass (SSB, 85 500 t) was re-analysed after the discovery of errors in the spreadsheets used to estimate biomass. The errors affected the calculation of the weighted mean of the integrated backscatter when positive samples had lengths shorter than the base one (here, 15 minutes) and the partitioning of the backscatter for a mixture of species. Also, no account was taken of different sampling frequencies within a 10x20 minute cell (the analysis unit). The 2003 SSB came mainly from two cells that included an intensive survey in Waterford Harbour and these cells had an SSB of about 68 000 t, which was reduced to 7 300 t when all errors were corrected. There were some minor corrections in three other cells. The revised total biomass was 24 000 t and the revised spawning biomass was 22 700 t.

In addition, the cell means took no account of the implicit sampling area of transects so that the biomass coming from a large sample value depended on the number of transects passing through the cell. The data were re-analysed using mean herring density by transect as the sample unit and dividing the area into strata based on transect spacing. Areas with no positive samples were excluded from the analysis (since they have zero estimates). Zigzags in bays were analysed as before. For each stratum, a mean density was obtained from the transect data (weighted by transect length) and this was multiplied by the stratum area to obtain a biomass and numbers-at-age. The overall total was the sum of the strata estimates. The same haul assignments as in the original analysis were used. At the same time, a CV was obtained based on the transect mean densities, i.e. a survey sample error. For surveys before 1998 and the western part survey in 2002, a cv was estimated using;

$$\sqrt{\log(1.3^2)/n}$$

where n is the number of positive sample values (15 minute of survey track) from Definite and Probably Herring categories. This was based on the data from the autumn surveys in 1998, 2000, 2001, 2002, and 2005.

Current acoustic survey implementation

The acoustic data are collected using the Simrad ER60 scientific echosounder. The Simrad ES-38B (38 KHz) split-beam transducer is mounted within the vessels drop keel or in the case of a commercial vessel mounted within a towed body. The survey area is selected to cover area VIIj, and the Celtic Sea (areas VIIg and VIIaS). Transect spacing in these surveys has varied between 1 to 4 nmi. For bays and inlets in the southwest region (VIIj) a combined zigzag and parallel transect approach was used to best optimise coverage. Offshore transect extension reached a maximum of 12 nmi, with further extension where necessary to contain fish echotraces within the survey area.

The data collected is scrutinised using Echoview® post processing software. The allocated echo integrator counts (S_a values) from these categories were used to estimate the herring numbers according to the method of Dalen and Nakken (1983). The following target strength to fish length relationships is used for herring.

$$TS = 20\log L - 71.2 \text{ dB per individual (L = length in cm)}$$

Irish Groundfish Survey

The IGFS is part of the western IBTS survey and has been carried out on the *RV Celtic Explorer* since 2003. In 2005 Johnston and Clarke (2005 WD), investigated the utility of the IGFS as a tuning series. Strong year effects were evident. Herring were either caught in large aggregations or not at all. The signals from this survey were very noisy, but when a longer time series is developed, it will at least provide qualitative information. The absence of the 2001 year class was supported in the survey data in 2004.

French EVHOE Survey

The Herring Assessment Working group in 2006 had access to data from the French EVHOE quarter 4 western IBTS survey (GOV trawl). The French survey series is from 1997 to 2005 and displayed very variable observed numbers at age between years. Consequently, further exploration of the series was not performed.

UK Quarter 1 survey

The UK quarter 1 survey was also explored and strong year and age effects, particularly at 2- and 5-ringers were found. Due to strong year and age effects and because it was discontinued in 2002 this survey is considered unsuitable as a recruit index (ICES 2006:ACFM 20).

While these data are useful for comparisons between surveys, as with the Irish data, at the moment it is difficult to see how these data can be used in an assessment. The data, particularly towards the end of the time series are very noisy and the absence of very small (juvenile) fish, particularly 1 ringers for the majority of time series is not encouraging (Johnston and Clarke, 2005).

Irish and Dutch juvenile herring trawl surveys

Juvenile herring surveys were carried out from 1972 – 1974 by Dutch and Irish scientists. These surveys aimed to get information on the location and distribution of young herring. They were also used to examine if young herring surveys in the Irish Sea could provide abundance indices for either the Irish Sea or Celtic Sea stocks. Further young fish surveys were carried out in the Irish Sea from 1979 – 1988. They were discontinued when it was decided that it was not possible to use the information as recruitment indices for the Celtic Sea or Irish Sea stocks despite earlier beliefs (Molloy, 2006).

Northern Ireland GFS surveys

These surveys take place in quarters 1 and 3 each year. Armstrong et al (2004) presented a review of these surveys. They are likely to be useful if the natal origin can be established.

Larval Surveys

Herring larval surveys were conducted in the Celtic Sea between October and February from 1978 to 1985 with one further survey carried out in 1989. These surveys provided information on the timing of spawning and on the location of the main spawning events as well as on the size of autumn and winter spawning components of the stock. The larval surveys carried out after the fishery reopened in 1982 showed an increase in the spawning stock (Molloy, 1995).

The surveys covered the south coast and stations were positioned 8 nautical miles apart in a grid formation. A Gulf III sampler, with 275 µm mesh was used to collect the samples. The total abundance of <10mm larvae (prior to December 15th) or <11mm (after December 15th) was calculated by raising the numbers per m^2 by the area represented by each station. The mean abundance of <11mm larvae in December – February gave the winter index which when multiplied by 1.465 and added to the Autumn index to give a single index of the whole series (Grainger *et al* 1982).

Larval surveys have not been undertaken in this area since 1989 and until the acoustic survey became established, no survey was available to tune the assessment.

B.4. Commercial CPUE

In the 1960s and 1970s CPUE (Catch per unit effort) data from commercial herring vessels were used as indices of stock abundance because there were no survey data available. These data provided an index of changes that were occurring in the fishery at the time. CPUE data were used to tune the assessment (Molloy, 2006). However it is likely that the decline in the stock in the 1970s was not picked up in the CPUE until it was at an advanced stage. It is now demonstrated that CPUE data does not provide an accurate index of herring abundance, as they are a shoaling fish.

C. Historical Stock Development

Time Periods in the Fishery

This fishery can be divided into time periods. A number of factors have changed in this fishery overtime such as the markets, discards, water allowance. These changes have implications for the trustworthiness of the catch data used in the assessment. The time periods are presented in the Table V.3.

The recent biological history of the stock is presented in Table V.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 was rather strong.

Exploration of basic data

Data exploration consisted of examining a number of features of the basic data. These analyses included log catch ratios, cohort catch curves in survey and catch at age series. Log catch ratios were constructed for the time series of catch at age data, as follows:

$\log[C(a,y)/C(a+1,y+1)]$

These are presented in Figure V.11. 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 V.12.). 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 V.5, and the Z estimated over 2-7 ringer is shown in Table V.11. Total mortality was low for cohorts 1956 to 1964 (Figure V.12). 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 V.13) and for the acoustic survey (Figure V.14). 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.

Recent Assessments

In recent years, ICA (Patterson, 1998) has been used for this stock. In 2007,a benchmark assessment used a variety of models viz. ICA, separable VPA, XSA, CSA and Bayesian catch at age methods. In addition an analysis of long term dynamics of recruitment was conducted. Simulations of various fishing mortalities were conducted, based on stock productivity. The separability assumption may not be valid, and future benchmark work should consider models that allow for changes in selection pattern. Though no final model formulation was settled upon, ICA continues to be treated as the base case run for tracking stock development. It was preferred to XSA because it is more influenced by younger ages that dominate the stock and fishery, and because of consistency.

In recent years much attention was paid to ICA settings, but the base case settings have remained unchanged. They are shown below:

Separable constraint over the last 6 years (weighting = 1.0 for each year)

Reference ages for separable constraint: 3

Constant selection pattern model: Yes

Selectivity on oldest age: 1.0

First age for calculation of mean F: 2

Last age for calculation of mean F: 7

Weighting on 1 ringers: 0.01 Other age classes: 1.0

Lowest feasible F: 0.05

Highest feasible F: 1.05

Ages for acoustic abundance estimates: 2-5

Plus group: 9

Shrinkage: No

The 2007 benchmark found slightly better diagnostics when the plus group was reduced to 7 ringer and this may be considered as base case for future ICA assessment.

Based on ICA base case exploratory run, the stock history is presented in Figure V. 15. It can be seen that there has been an overall downward trend in SSB in recent years. 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.

It can be seen that SSB was high in the 1960s and declined in the 1970s as F increased in recruitment was poor. The stock rebuilt in the 1980s but not to quite the same level. This rebuilding was due to good recruitments, and was not associated with large reductions in F.

The stock recruitment relationship from ICA base case runs is presented in Figure V.16. Estimates of recruitment at given SSB sizes were classified according to the quality of the basic data. It can be seen that the form of the relationship is different, depending on which data quality categories are considered. However this is a simplistic treatment of stock and recruitment, as these estimates are not based on data that relate to one year, but to observations of cohorts.

Analysis of productivity over time

To account for the influence of the ecosystem on the productivity of this herring stocks (ICES, 2007, Chapter 1) the methods of Nash and Dickey-Collas (2005) were applied. The recruit per spawner ratio was calculated. These calculations formed the basis for the detection of periods of high and low production of the stock (Figure V.17).

The next step was to calculate the net and surplus production of the whole stock, including the recruits and the growth of all non-recruits, the natural and the fishing mortality. To subtract the influence of the spawning stock biomass a hockey stick and a Ricker stock recruitment relationship were fitted to the data to obtain the residuals of the recruits of a given year. The residuals were used to remove the year effect from the estimation of the stock size and to gain the net production and the surplus production respectively without the effect of the SSB on the number of recruits. Contrary to ICES (2007, Technical Minutes) the stock recruit model is not presented. This is because the model is not considered a good fit to the data and because the aim of this analysis is to examine recruitment, having removed the effect of SSB.

The data used in this analysis was derived from the assessment outputs from the HAWG in 2006 (ICES HAWG, 2006, Table 1.8.3.1).

Calculation of the surplus production

$Ps = Br + Bg - M$

where Br is the biomass of the recruits, Bg the gain of biomass due to growth of all fish excluding the recruits and M the natural mortality. The net production equals the surplus production minus the fishing mortality (F).

The Celtic Sea herring stock had a low productivity throughout the whole time series, compared to other stocks (ICES, 2007). The net and surplus production is very noisy displaying neither clear trend. The impact of a varying F was tested using the Hockey Stick stock recruitment relationship. The stock showed variable production over time (Figure V.18). It can be seen that $F_{0.1}$ is associated with high though variable surplus production over the series, whilst F's greater than 0.4 are associated with reduced productivity in the most recent years. This analysis demonstrates the benefits of harvesting at F around $F_{0.1}$. Exploitation in the range of recent F (~0.7-1.2) is detrimental to stock productivity.

D. Short-Term Projection

Short term forecasts are not usually used for advice for this stock, but were routinely performed until 2004. The most recent method used the "Multi fleet Deterministic Projection" software (Smith, 2000). A short-term projection is carried out under the following assumptions. Recruitment was set at geometric mean of all but the most recent one or two (poorly estimated) years. This value was usually around 406 million fish. Mean weights in the catch and in the stock were calculated as means over the entire time series. Population numbers of 2-ringers in the intermediate season were calculated by the degradation of geometric mean recruitment (1958-2001) using the equation, following the same procedure as last year.

$$N_{t+1} = N_t * e^{-F+M}$$

Two forecasts were usually preformed one based on F_{sq} (=$F_{assessment\ year}$), the other on a catch constraint of using the TAC for that particular year. However, the sharp observed changes in F from year to year, suggest that a TAC constraint is more meaningful.

Short term forecasts are not considered reliable at present because:

There is no reliable estimate of recruitment.

GM recruitment is not a good proxy for recruitment because observed values have fluctuated widely

The terminal population estimate is not reliable.

A stochastic short term forecast was attempted (Clarke and Egan, 2007). This used STPR (Skagen Ref). However the large degree of noise in the variance covariance matrix made the forecast unstable.

E. Medium-Term Projections

Yield per recruit analyses have been conducted for this stock since the mid 1960s, though not necessarily every year. Recent analyses have used the "Multi Fleet Yield Per Recruit" software (reference).

Yield per recruit analysis requires input values for F_{low}, F_{med} and F_{high}. These are calculated by plotting the stock recruit relationship. YPR have been carried out for a number of years for this stock. A comparison of the results is shown in the table below. Based on the most recent estimate $F_{0.1}$ is estimated at 0.19 (Figure V.19).

Table V. 6 presents estimates of Fmax, F0.1 and other parameters of yield per recruit analyses conducted over time.

F. Long-Term Projections

A number of possible management scenarios were tested using the stochastic simulation tool Fpress (Codling and Kelly, 2005). This tool is used to test the robustness of harvest control rules. The following scenarios were tested:

Zero catch in 2007

3,000 t TAC in 2007, the highest catch consistent with the median SSB simulated in 2007 >$B_{pa.}$

A TAC of 9,350 t, a 15% reduction on 2006

A simple harvest control rule was applied for all years after 2007 with the following condition for TAC adjustment:

TAC multiplier: $SSB_{estimated}/SSB_{changepoint}$

The simulations showed that none of the scenarios tested were low risk. In all cases the risk that SSB will be below B_{pa} in 2008 is high. The highest risk tactic for 2007 was a TAC reduction of 15%. This is because SSB is at a low level, below the changepoint, in 2006. The trigger point used during these simulations is unsatisfactory because it is too close to the point of recruitment impairment (STECF, 2006).

In 2008, preliminary simulations of a simple HCR using FPRESS suggested that initial TACs of greater than 5 000 t were associated with unacceptable risk of SSB<B_{lim}.

G. Biological Reference Points

B_{pa} is set at 44 000 t and B_{lim} at 26 000 t. F reference points are not defined for this stock.

B_{pa} is based on a low probability of low recruitment and B_{lim} set at $B_{loss.}$ (Reference).

There is still considerable instability in the assessment, so there is no basis for a revision of reference points at this point.

A recent management strategy simulation (STECF, 2006; Kelly and Campbell, 2006) estimated 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 too low, and that B_{lim} = 44 000 t, and that an HCR should be devised with a trigger biomass far enough above B_{lim} 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 (ICES, 2007).

H.1. Biology of the species in the distribution area

Herring shoals migrate to inshore water to spawn. Their spawning grounds are located in shallow waters close to the coast and are well known and well defined. This stock can be divided into autumn and winter spawning components. Spawning begins in October and can continue until February. A number of spawning grounds are located along the South coast, extending from the Saltee Islands to the Old Head of Kinsale. These grounds include Baginbun Bay, Dunmore East Co Waterford, around Capel and Ballycotton Islands and around the entrance to Cork Harbour (Molloy, 2006). The areas surrounding the Daunt Rock and old Head of Kinsale have also been recognised as spawning grounds (Breslin, 1998). These spawning grounds are shown in figure V.2 and V.5.

Herring are benthic spawners and deposit their eggs on the sea bed usually on gravel or course sediments. The yolk sac larvae hatch and adopt a pelagic mode of life.

When referring to spawning locations the following terminology is used (Molloy, 2006)

A <u>spawning bed</u> is the area over which the eggs are deposited

- • A <u>spawning ground</u> consists of one or more spawning beds located in a small area.
- •A <u>spawning area</u> is comprised of a number of spawning grounds in a larger area

Spawning grounds are typically located in high energy environments such as the mouth of large rivers and areas where the tidal currents are strong. Herring shoals return to the same spawning grounds each year (Molloy, 2006).

Herring produce benthic eggs that are adhered to the bottom substrate where they remain until hatching. Hatching takes place after XXX degree days (ref), check a manuscriupt that John made for a symposium in Alaska). A study conducted in the 1920s found that the eggs produced by spring spawners were 25% bigger than those autumn spawners but were less numerous (Farran, 1938).

The larval phase is an important period in the herring life cycle. Larvae use their oil globule for food and to provide buoyancy. Currents transport the newly hatched larvae to areas in the Celtic Sea or to the Irish Sea (Molloy, 2006). The conditions experienced during the larval phase as well as during juvenile phase are likely to have some influence on the maturation of Celtic Sea herring. Fast growing juveniles can recruit to the population a year earlier than slow growing juveniles. Faster growth may also lead to increased fecundity (Brophy and Danilowich, 2003). Fluctuating environmental conditions play an important role in the growth and survival of herring in this area.

The juveniles tend to remain close inshore, in shallow waters for the first two years of their lives, in nursery areas. There are many of these nursery areas around the coast. The minimum landing size for herring is 20cm and therefore these juvenile herring are not caught by the fishery in the early stages of their life cycle (Molloy, 2006).

Celtic Sea herring have undergone changes in growth patterns and a declining trend in mean weights and lengths can be seen over time. It is important to detect these changes from a management perspective because changes can have an impact on the estimation of stock size. Growth has an impact on factors such as maturity and recruitment (Molloy, 2006). Trends in mean weights and lengths are currently being examined over the time series and possible links to environmental factors investigated (Lynch *in prep*).

The locations of spawning and non spawning fish in the Celtic Sea as shown in Figure V.5. This is based on the knowledge of fishermen and shows spawning herring are found close inshore and non spawning fish found in areas further off shore.

H.2. Management and ACFM Advice

The assessment year is from 1st April to 31st March. However for management purposes, the TAC year is from 1st January to 31st December.

The first time that management measures were applied to this fishery was during the late 1960s. This was in response to the increasing catches particularly off Dunmore East. The industry became concerned and certain restrictions were put in place in order to prevent a glut of herring in the market and a reduction in prices. Boat quotas were introduced restricting the nightly catches and the number of boats fishing. Fishing times were specified with no weekend fishing and herring could not be landed for the production of fishmeal. A minimum landing size was also introduced (Molloy, 1995).

The TAC (total allowable catch) system was introduced in 1972, which meant that yearly quotas were allocated. This continued until 1977 until the fishery was closed. During the closure a precautionary TAC was set for Division VIIj. This division was not assessed analytically (ICES, 1994). After the closure of this fishery a new management structure was implemented with catches controlled on a seasonal basis and individual boat quotas were put in place (Molloy 1995).

This fishery is still managed by a TAC system with quotas allocated to boats on a weekly basis. Participation in the fishery is restricted to licensed vessels. A series of closed areas have been implemented to protect the spawning grounds, when herring are particularly vulnerable. These spawning box closures were implemented under EU legislation. The committee set up to manage the stock has the following objectives.

To build the stock to a level whereby it can sustain annual catches of around 20,000 t.

In the event of the stock falling below the level at which these catches can be sustained the Committee will take appropriate rebuilding measures.

To introduce measures to prevent landings of small and juvenile herring, including closed areas and/or appropriate time closures.

To ensure that all landings of herring should contain at least 50% of individual fish above 23 cm.

To maintain, and if necessary expand the spawning box closures in time and area.

To ensure that adequate scientific resources are available to assess the state of the stock.

To participate in the collection of data and to play an active part in the stock assessment procedure.

This committee has also developed a management plan that envisages fixing the 2008 TAC at 85% of that in 2007, and implementing a closure of VIIaS to all but small boats, see ICES HAWG (2008).

Management advice

Table V.7 shows the history of the ICES advice, implemented TACs and ICES' estimates of removals from the stock. It can be seen that the implemented TAC has been set higher than the advice in about 50% of years since the re-opening of the fishery in 1983.

H.4. Terminology

The WG uses "rings" rather than "age" or "winter rings" throughout the report to denominate the age of herring, with the intention to avoid confusion. It should be observed that, for autumn spawning stocks, there is a difference of one year between "age" and "rings". HAWG in 1992 (ICES 1992/Assess:11) stated that

"The convention of defining herring age rings instead of years was introduced in various ICES working groups around 1970. The main argument to do so was the uncertainty about the racial identity of the herring in some areas. A herring with one winter ring is classified as 2-years-old if it is an autumn spawner, and one-year-old if it is a spring spawner. Recording the age of the herring in rings instead of in years allowed scientists to postpone the decision on year of birth until a later date when they might have obtained more information on the racial identity of the herring.

The use of winter rings in ICES working groups has introduced a certain amount of confusion and errors. In specifying the age of the herring, people always have to state explicitly whether they are talking about rings or years, and whether the herring are autumn- or spring spawners. These details tend to get lost in working group reports, which can make these reports confusion for outsiders, and even for herring experts themselves. As the age of all other fish species (and of herring in other parts of the world) is expressed in years, one could question the justification of treating West-European herring in a special way. Especially with the present trend towards multispecies assessment and integration of ICES working groups, there might be a case for a uniform system of age definition throughout all ICES working groups.

However, the change from rings to years would create a number of practical problems. Data files in national laboratories and at ICES would have to be adapted, which would involve extra costs and manpower. People that had not been aware of the change might be confused when comparing new data with data from old working group reports. Finally, in some areas (notably Division IIIa), the distinction between spring- and autumn spawners is still hard to make, and scientists preferred to continue using rings instead of years.

The Working Group discussed at length the various consequences of a change from rings to years. The majority of the Group felt that the advantages of such a change did not outweigh the disadvantages, and it was decided to stick to the present system for the time being."

The text table below gives an example for the correlation between age, rings and year class for the different spawning types in late 2002:

YEAR CLASS (AUTUMN SPAWNERS)	2001/2002	2000/2001	1999/2000	1998/1999
Rings	0	1	2	3
Age (autumn spawners)	1	2	3	4
Year class (spring spawners)	2002	2001	2000	1999
Rings	0	1	2	3
Age (spring spawners)	0	1	2	3

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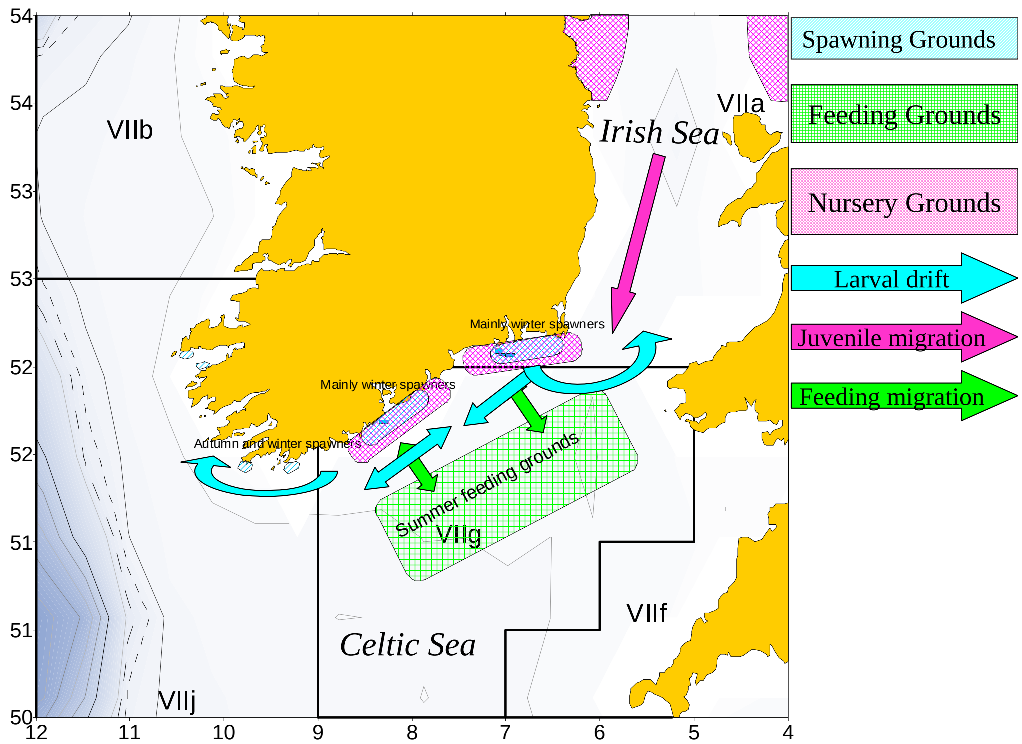


Figure V.1. Celtic Sea and VIIj herring. Schematic presentation of the life cycle of Celtic Sea and VIIj Herring (ICES, 2005c, SGRESP).

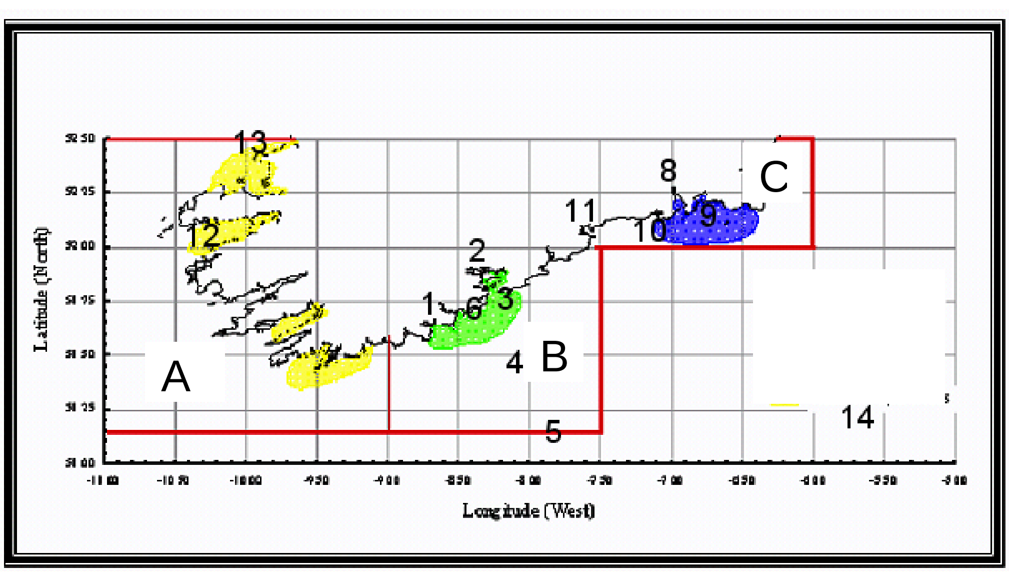


Figure V.2. Herring in the Celtic Sea and VIIj. Areas mentioned in the text and spawning boxes A, B and C, south of Ireland. One of these boxes is closed each season, under EU legislation. 1 Courtmacsherry, 2 Cork Harbour, 3 Daunt Rock, 4 Kinsale Gas Field (Rigs), 5 Labadie Bank, 6 Kinsale, 8 Waterford Harbour, 9, Baginbun Bay, 10, Tramore Bay/ Dunmore East, 11, Ballycotton Bay, 12, Valentia Island, 13 Kerry Head to Loop Head, 14, The Smalls. The spawning boxes A-C correspond to ICES Divisions VIIj, VIIg and VIIaS respectively.

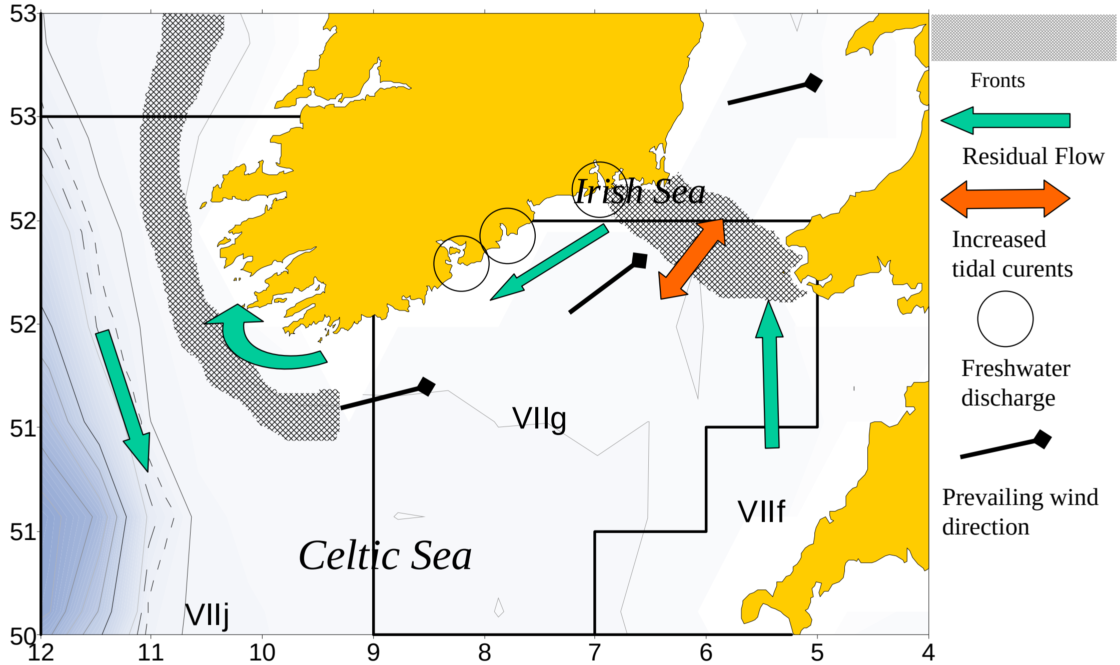


Figure V.3. Herring in the Celtic Sea and VIIj. Schematic presentation of prevailing oceanographic conditions in the Celtic Sea and VIIj (ICES, 2005c, SGRESP).

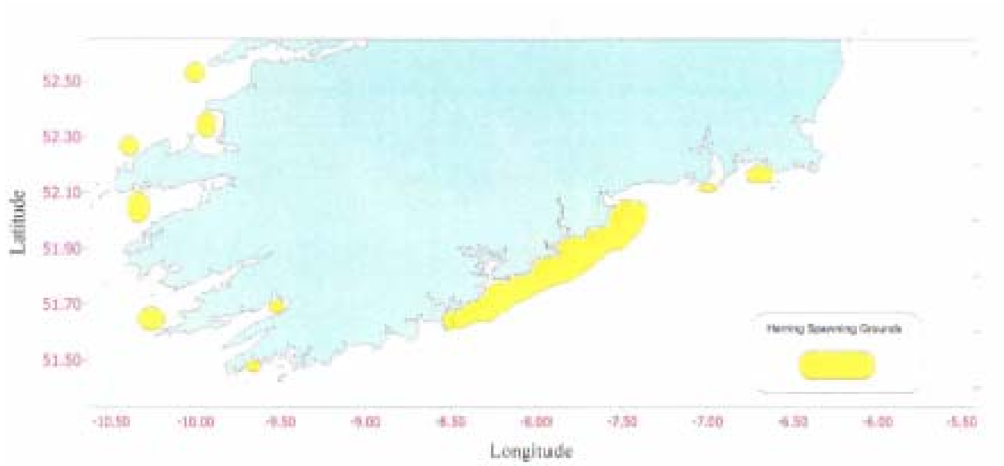


Figure V.4. Herring in the Celtic Sea and VIIj. Spawning ground of herring along the south coast of Ireland, inferred from information on the Irish herring fishery (Breslin, 1998).

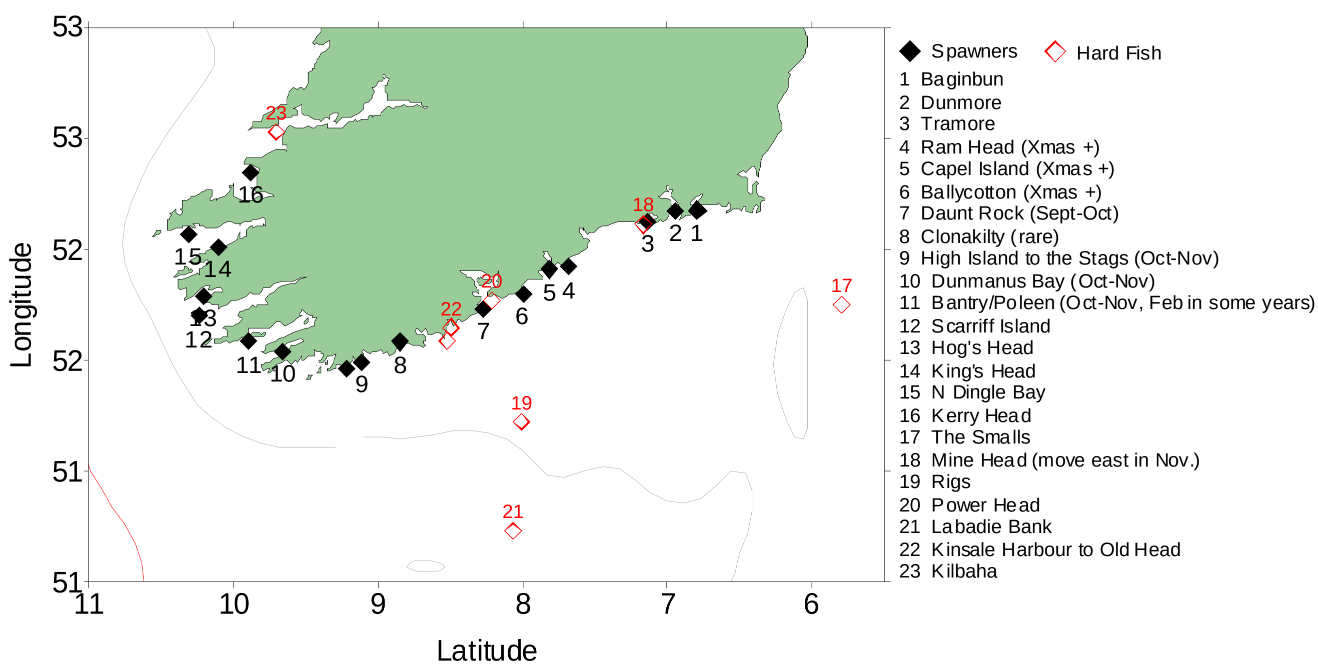


Figure V.5. Herring in the Celtic Sea and VIIj. Location of spawning (closed symbol) and non spawning (open symbol) herring in the Celtic Sea and SW of Ireland.

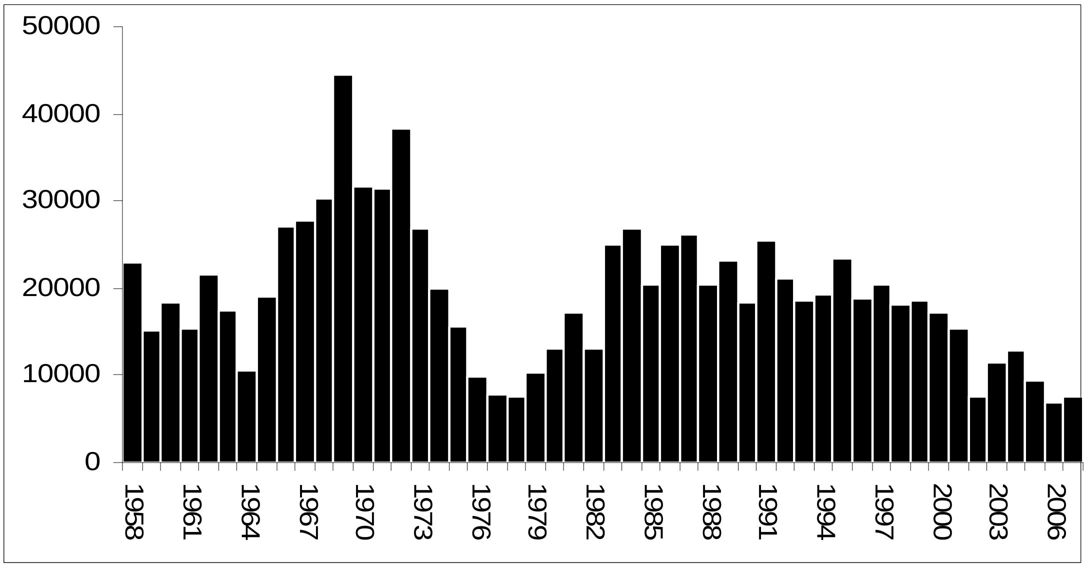


Figure V.6. **Herring in the Celtic Sea and VIIj.** **ICES estimates of herring catches (tonnes) per season 1958/1959 to 2006/2007.**

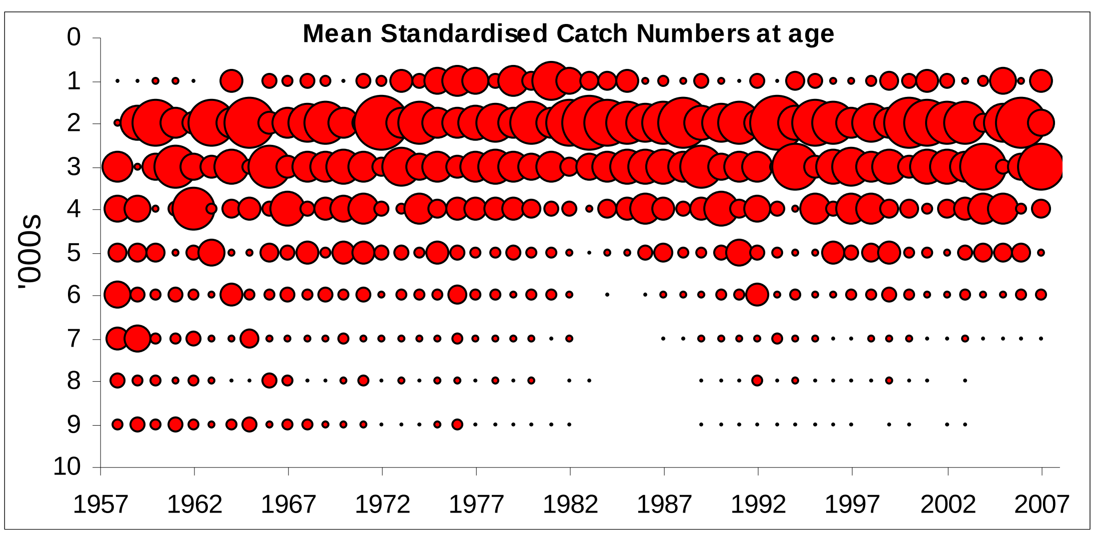


Figure V.7. **Herring in the Celtic Sea and VIIj.** **Catch numbers at age standardised by yearly mean.**

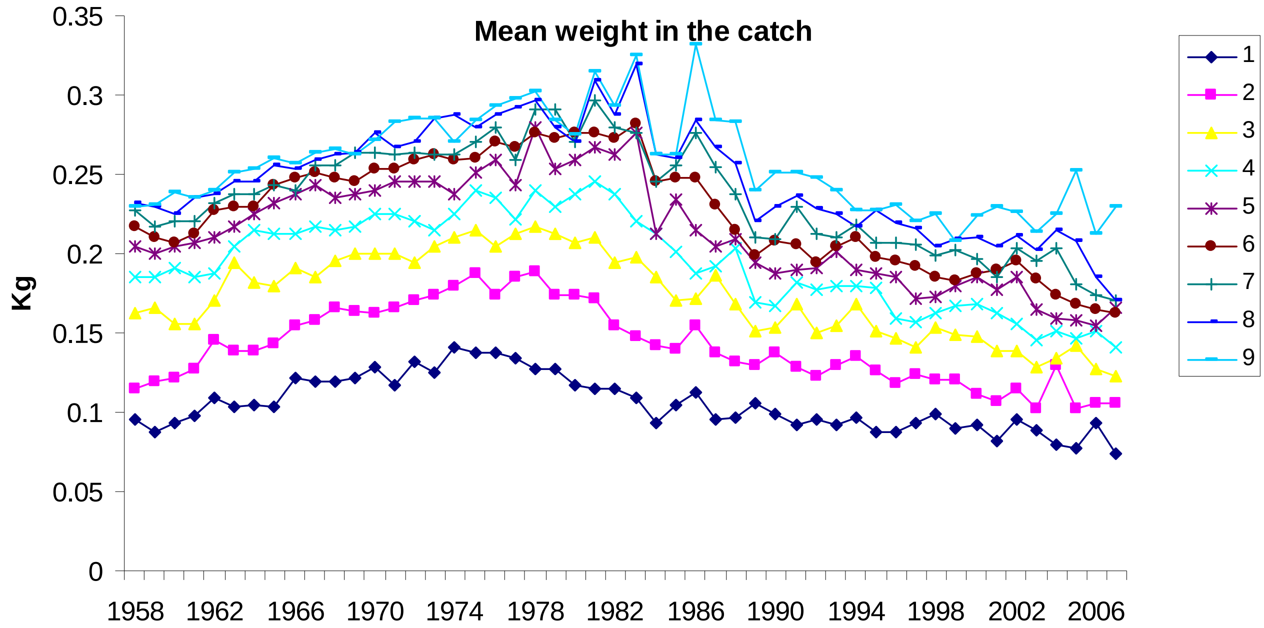


Figure V.8. Herring in the Celtic Sea and VIIj. Trends over time in mean weights in the catch.

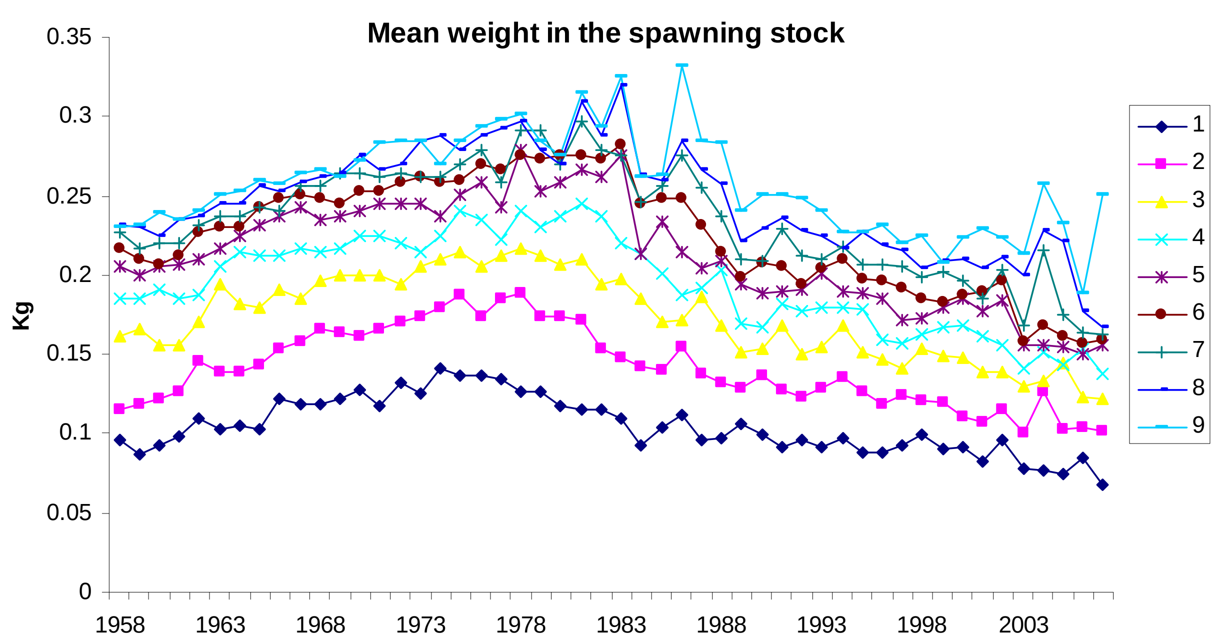
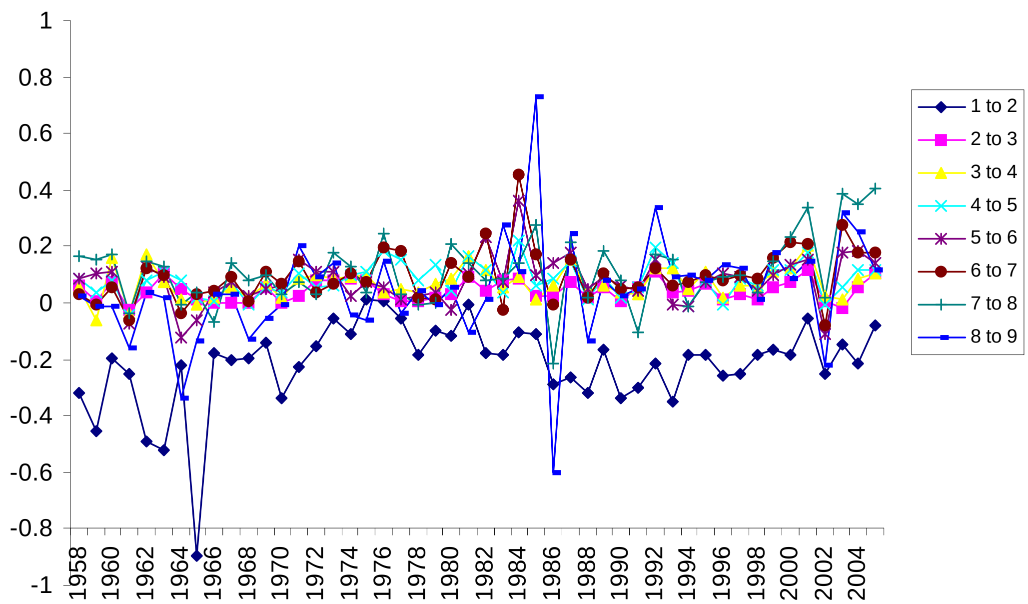


Figure V.9. Herring in the Celtic Sea and VIIj. Trends over time in mean weights in the stock at spawning time.



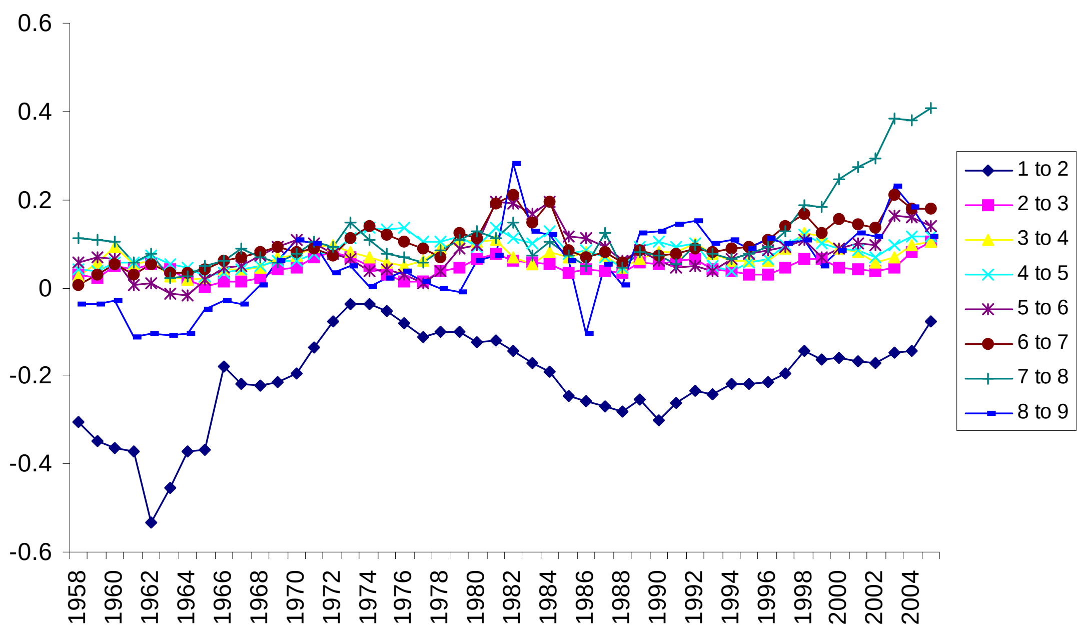


Figure V.10. Herring in the Celtic Sea and VIIj. Log catch ratios (above) and log catch ratios smoothed with a 4 year moving average for each age group for the time series 1958-2006.

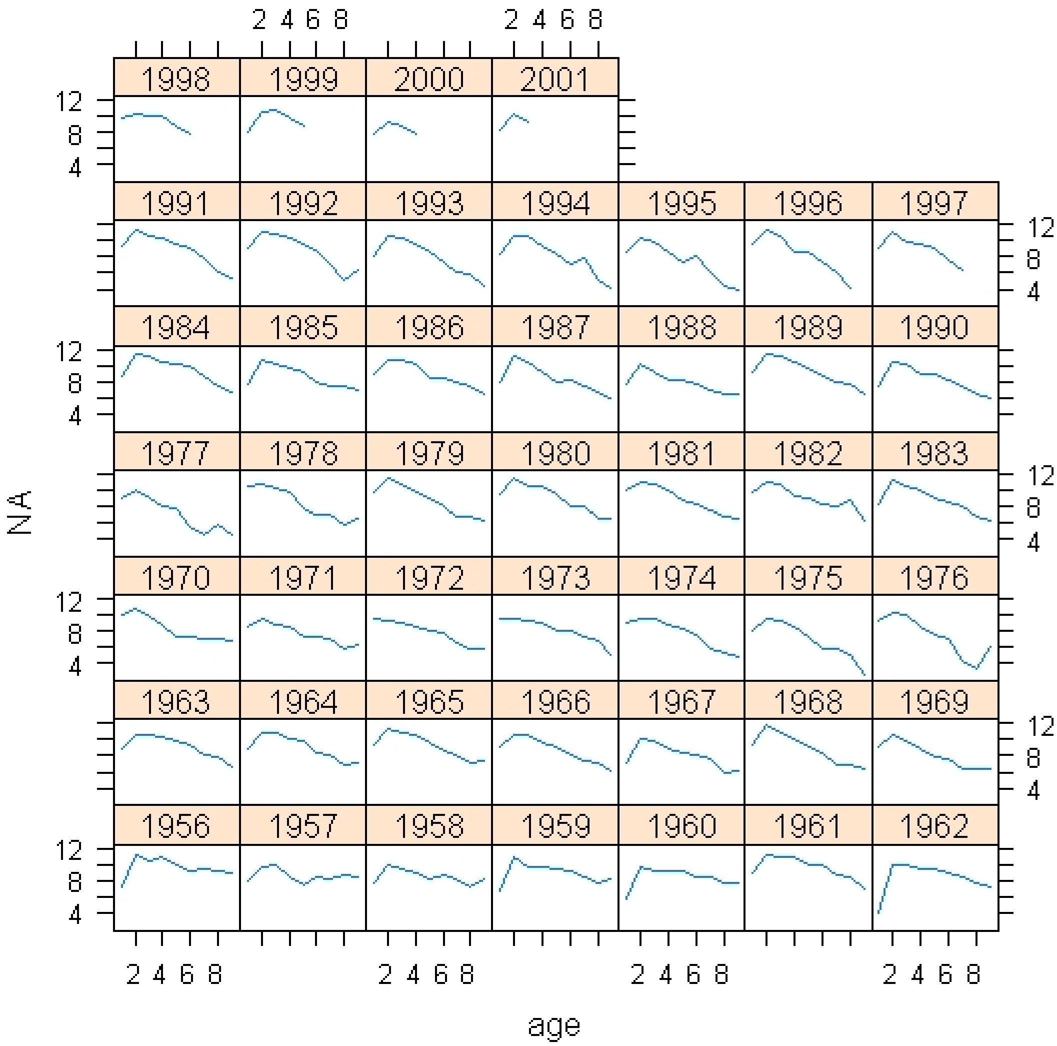


Figure V.11. Herring in the Celtic Sea and VIIj. Cohort catch curves for the time series of catch at age data. Age in winter rings on the horizontal axis and log transformed catch numbers at age on the vertical axis.

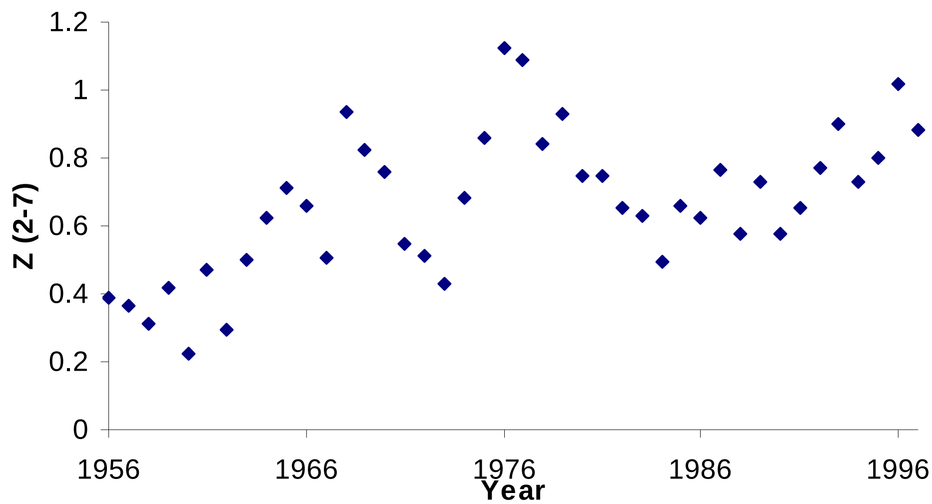


Figure V.12. Herring in the Celtic Sea and VIIj. Total mortality (Z) estimated from cohort catch curves (2-7 ringer) for cohorts 1958 to 1997.

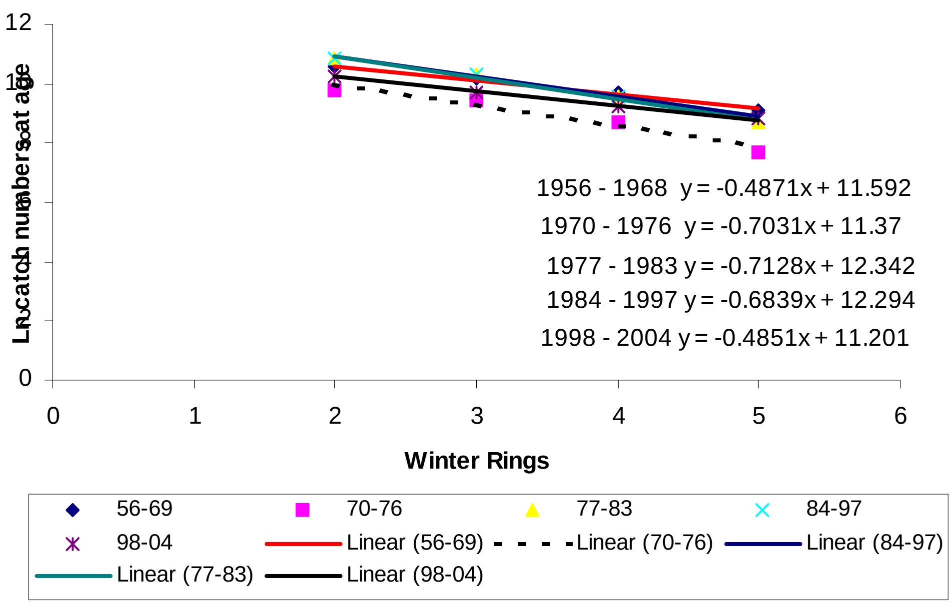


Figure V.13. Herring in the Celtic Sea and VIIj. Cohort catch curves (2-5 ringer), averaged over several year classes, from catch at age data.

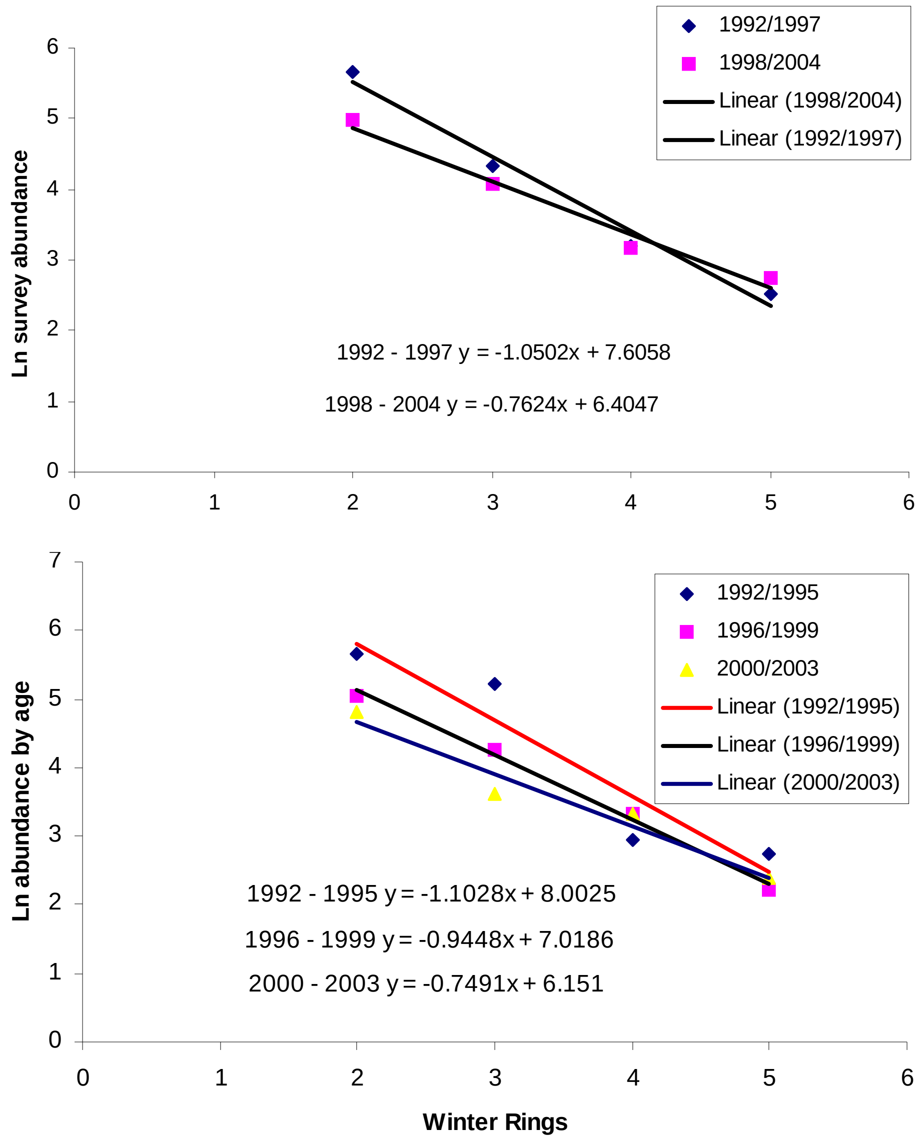


Figure V.14. Herring in the Celtic Sea and VIIj. Cohort catch curves (2-5 ring) based on acoustic survey abundance. Upper panel shows means for two periods, and below for three time periods, over the same series of surveys.

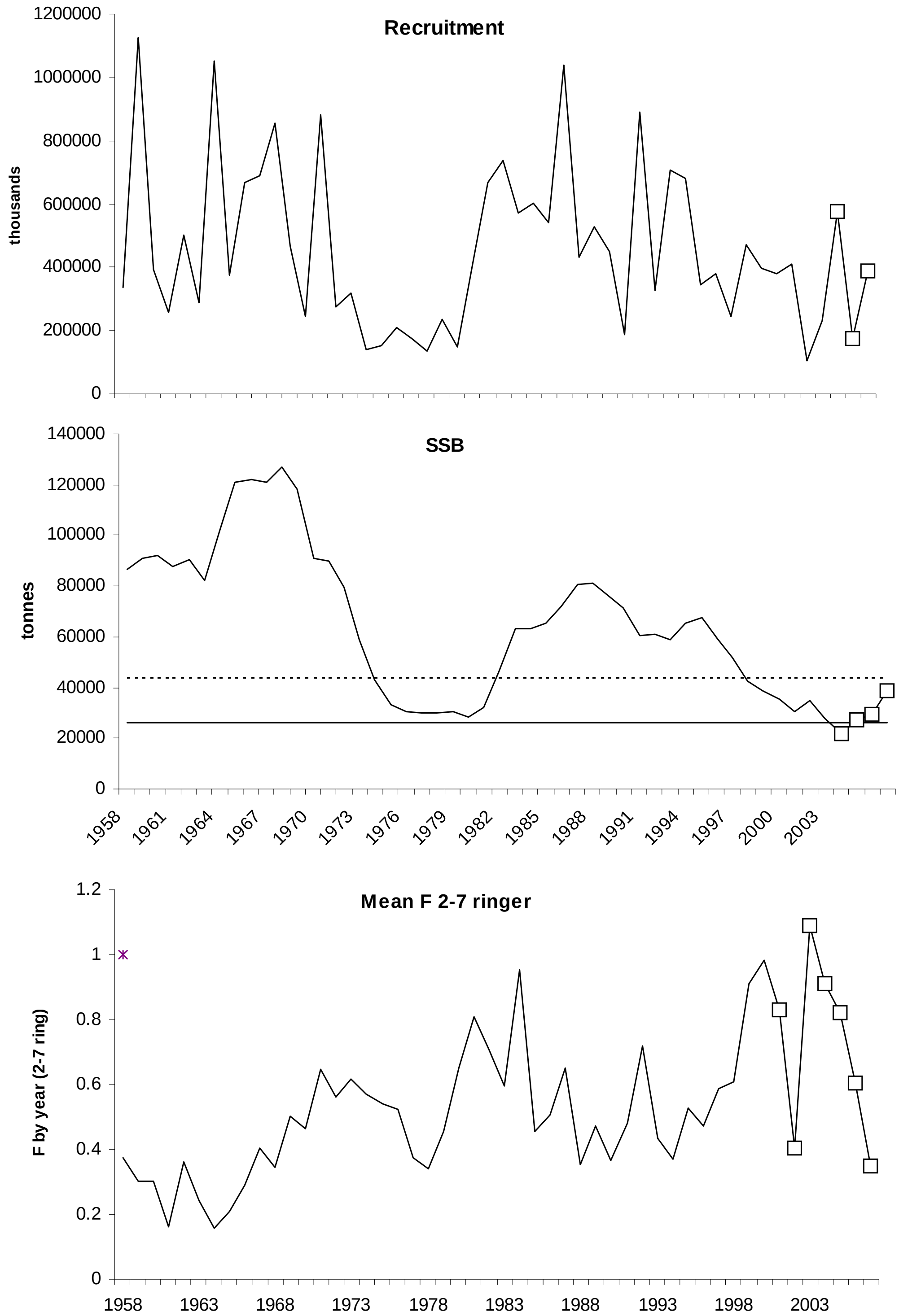


Figure V.15. Herring in the Celtic Sea and VIIj. SSB, F and recruitment (1-ringer) from ICA base case run in 2008. Non-converged estimates indicated in open circles.

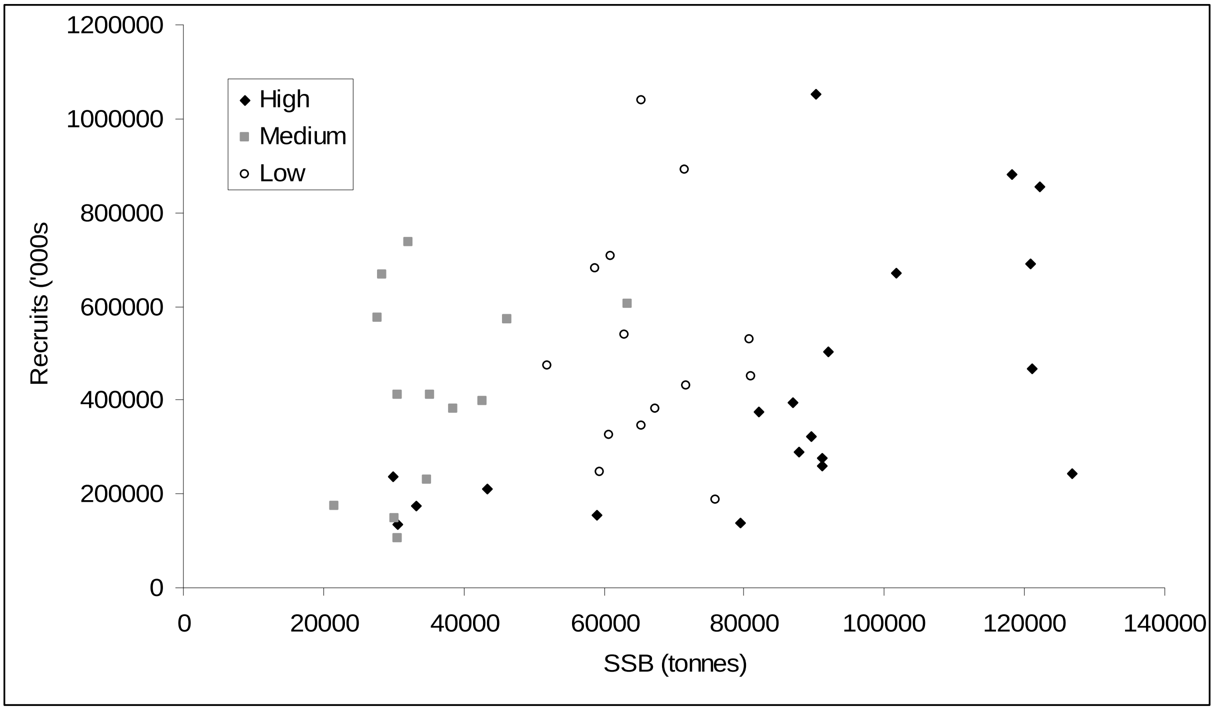


Figure V.16. Herring in the Celtic Sea and VIIj. Stock recruit relationship from ICA base case runs. Data classified according to quality of input data, see Table V.3.

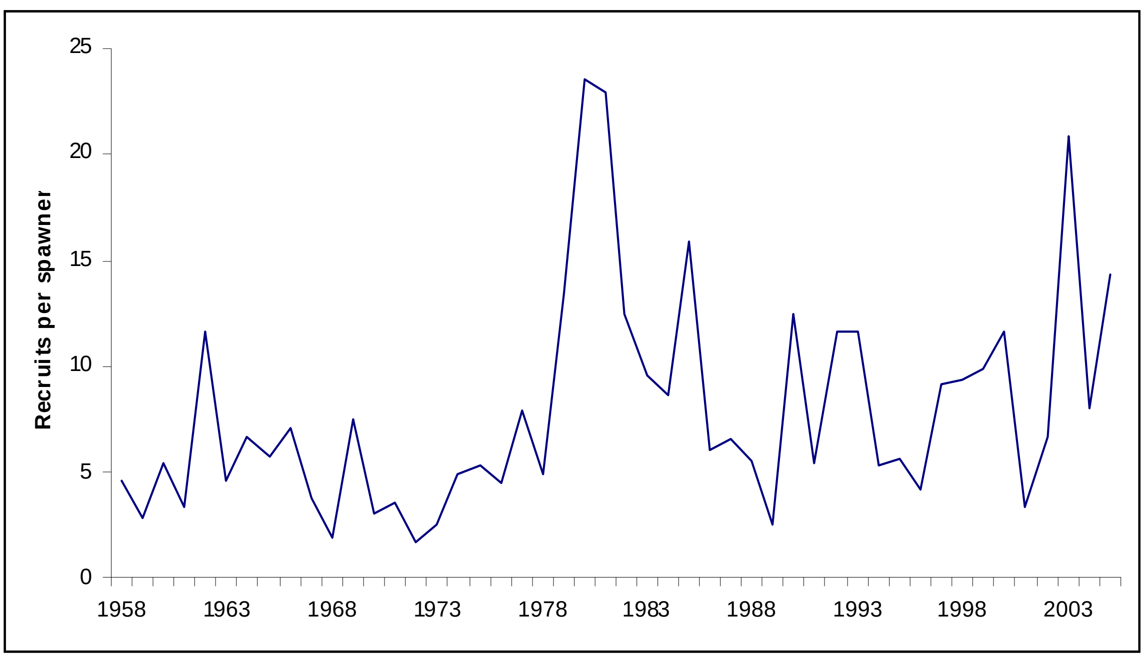


Figure V.17. Herring in the Celtic Sea and VIIj. Recruits per spawener, in '000s/tonnes.

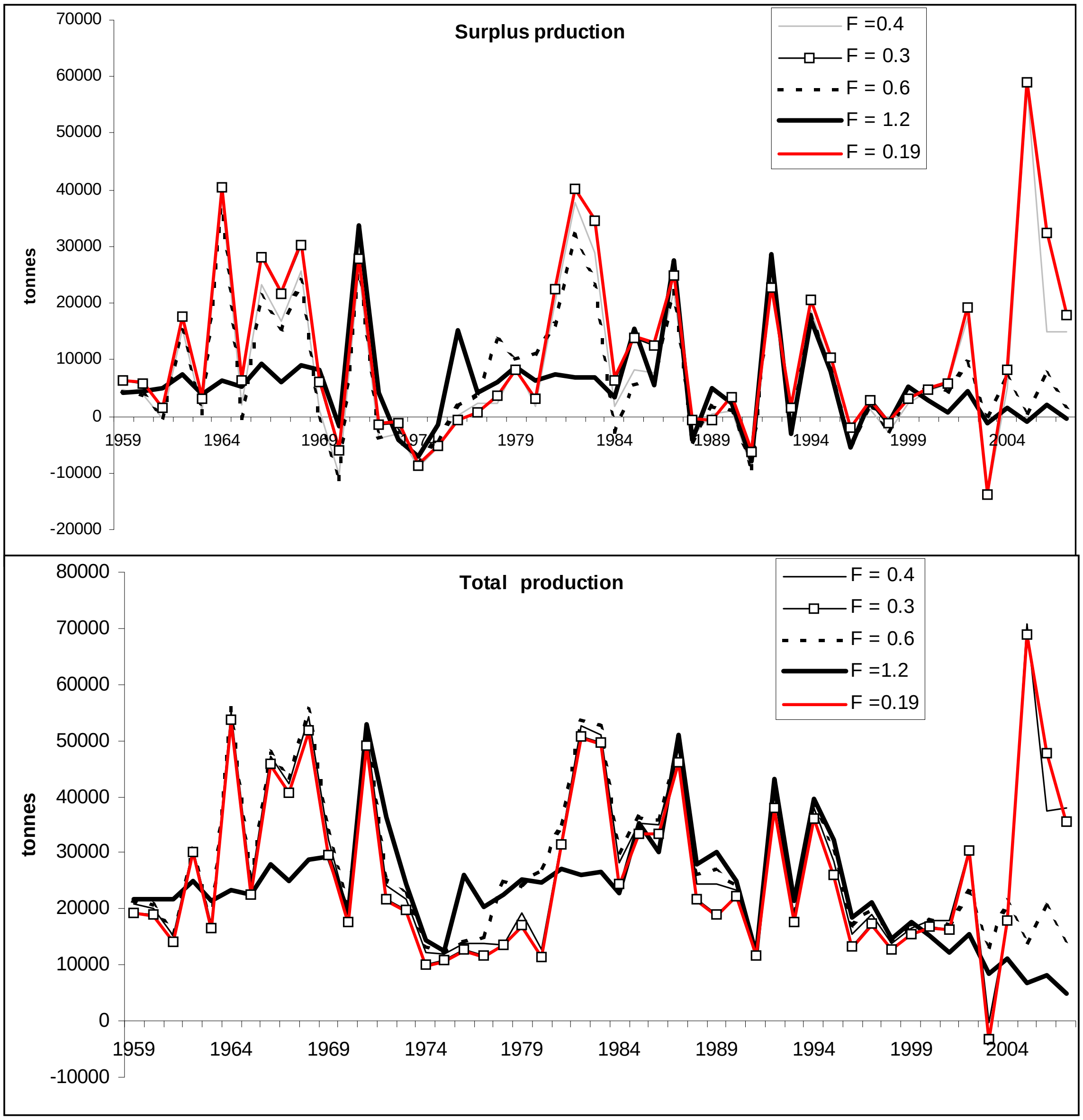
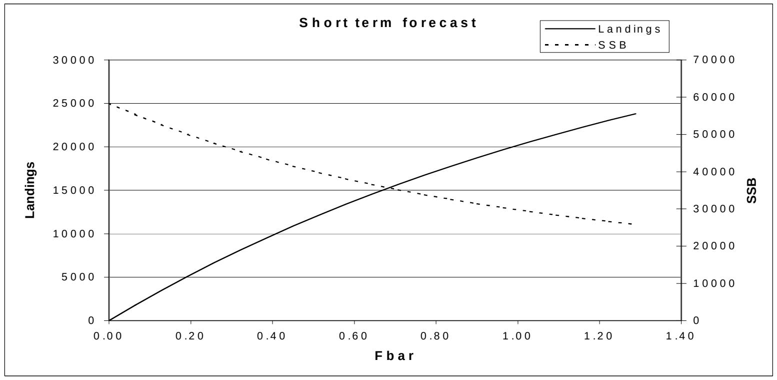


Figure V.18. Herring in the Celtic Sea and VIIj. Total and surplus production in the time series over a range of fishing mortalities.



MFYPR version 2a
Run: Run 1
Time and date: 08:46 22/03/2007

Reference point	F multiplier	Absolute F
Fbar(2-7)	1.0000	0.4196
FMax	>=1000000	
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

Weights in kilograms

MFDP version 1a
Run: Run 1
Herring "VIIg" "VIIj" "VIIaS(run:" 1 "2007)"
Time and date: 08:41 22/03/2007
Fbar age range: 2-7

Input units are thousands and kg - output in tonnes

Figure V.19. Herring in the Celtic Sea and VIIj. Yield per recruit and spawners per recruit analysis.

Table V.1. Herring in the Celtic Sea & Division VIIj. Acoustic surveys of Celtic Sea and VIIj herring, by season. Number of surveys per season and type indicated along with biomass and SSB estimates. Shaded sections show surveys not used in tuning.

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**
2007/2008	**1**	**Pre-spawning**	**-**	**46**

Table V.2. Herring in the Celtic Sea & Division VIIj. Original acoustic survey abundance at age as used by ICES until HAWG 2006.

	1990	1991	1992	1993	1994	1995	1996*	1997	1998*	1999**	1999	2000	2001	2002	2003	2004	2005	2006
	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2000	2001	2002	2003	2004	2005	2005	2007
0	205	214	142	259	41	5	3	-	-	13	-	23	19	0	25	26	13	-
1	132	63	427	217	38	280	134	-	21	398	23	18	30	41	73	13	54	21
2	249	195	117	438	127	551	757	-	157	208	97	143	160	176	323	29	125	211
3	109	95	88	59	160	138	250	-	150	48	85	36	176	142	253	32	26	48
4	153	54	50	63	11	94	51	-	201	8	16	19	40	27	61	16	50	14
5	32	85	22	26	11	8	42	-	109	1	21	7	44	6	16	3	20	11
6	15	22	24	16	7	9	1	-	32	1	8	3	23	8	5	1	5	1
7	6	5	10	25	2	8	14	-	30	0	2	2	17	3	2	0	1	-
8	3	6	2	2	3	9	1	-	4	0	1	0	11	0	0	0	-	-
9+	2	-	1	2	1	5	2	-	1	0	0	1	23	0	0	0	-	-
Total	904	739	882	1107	399	1107	1253		705	677	252	250	542	404	758	119	292	305
Biomass (000't)	103	84	89	104	52	135	151		111	58	30	33	80	49	89	13	33	37
SSB (000't)	91	77	71	90	51	114	146		111	23	26	32	74	39	86	10	30	36

*** Autumn survey**

**** Summer survey**

Table V.2. Herring in the Celtic Sea & Division VIIj. Revised acoustic series as used by HAWG 2006 and subsequent HAWGs.

	1995 1996	1996 1997	1997 1998	1998 1999	1999 2000	2000 2001	2001 2002	2002 2003	2003 2004	2004 2005	2005 2006	2006 2007	2007 2008
0	202	3	-	0	-	25	40	0	24	-	2	-	1
1	25	164	-	30	-	102	28	42	13	-	65	21	106
2	157	795	-	186	-	112	187	185	62	-	137	211	70
3	38	262	-	133	-	13	213	151	60	-	28	48	220
4	34	53	-	165	-	2	42	30	17	-	54	14	31
5	5	43	-	87	-	1	47	7	5	-	22	11	9
6	3	1	-	25	-	0	33	7	1	-	5	1	13
7	1	15	-	24	-	0	24	3	0	-	1	-	4
8	2	0	-	4	-	0	15	0	0	-	0	-	1
9+	2	2	-	2	-	0	52	0	0	-	0	-	0
Abundance	469	1338	-	656		256	681	423	183	-	312	305	454
SSB	36	151		100		20	95	41	20	-	33	36	46
CV	53	26		36		100	88	49	34	-	48	35	25

Table V.3. Herring in the Celtic Sea & Division VIIj. Rudimentary history of the Irish fishery since 1958.

Time period	1958-1977	1977-1983	1983-1997	1998-2004	2004-2007
Type of fishery	**Cured fish**	**Closure**	**Herring roe**	**Fillet/whole fish**	**Fillet/whole fish**
Quality of catch data	**High**	**Medium**	**Low**	**Medium/low**	**High**
Source of catch data	**Auction data**	**Auction data**	**Skipper logbook estimate**	**Skipper logbook estimate**	**Weighbridge landings**
Discard Levels	**Low**	**Low**	**High**	**Medium**	**Medium**
Incentive to discard	**None**	**None**	**Maturity stage**	**Size grade, market**	**vs. quota**
Alloowance for water*	**na**	**na**	**na**	**20%***	**2%***

* RSW only. These vessels are more dominant in recent years.

Table V.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**	**?**

Table V.5. Celtic Sea and VIIj herring. Total mortality Z estimated from cohort catch curves.

Cohort	**Z (2-7 ring)**	**Cohort**	**Z (2-7 ring)**
1956	**0.39**	**1977**	**1.09**
1957	**0.37**	**1978**	**0.84**
1958	**0.31**	**1979**	**0.93**
1959	**0.42**	**1980**	**0.75**
1960	**0.22**	**1981**	**0.75**
1961	**0.47**	**1982**	**0.65**
1962	**0.30**	**1983**	**0.63**
1963	**0.50**	**1984**	**0.50**
1964	**0.62**	**1985**	**0.66**
1965	**0.71**	**1986**	**0.62**
1966	**0.66**	**1987**	**0.76**
1967	**0.51**	**1988**	**0.58**
1968	**0.93**	**1989**	**0.73**
1969	**0.82**	**1990**	**0.57**
1970	**0.76**	**1991**	**0.65**
1971	**0.55**	**1992**	**0.77**
1972	**0.51**	**1993**	**0.90**
1973	**0.43**	**1994**	**0.73**
1974	**0.68**	**1995**	**0.80**
1975	**0.86**	**1996**	**1.02**
1976	**1.12**	**1997**	**0.88**

Table V.6. Celtic Sea and VIIj herring. Total mortality Z estimated from cohort catch curves.

Cohort	Z (2-7 ring)	Cohort	Z (2-7 ring)
1956	0.39	1977	1.09
1957	0.37	1978	0.84
1958	0.31	1979	0.93
1959	0.42	1980	0.75
1960	0.22	1981	0.75
1961	0.47	1982	0.65
1962	0.30	1983	0.63
1963	0.50	1984	0.50
1964	0.62	1985	0.66
1965	0.71	1986	0.62
1966	0.66	1987	0.76
1967	0.51	1988	0.58
1968	0.93	1989	0.73
1969	0.82	1990	0.57
1970	0.76	1991	0.65
1971	0.55	1992	0.77
1972	0.51	1993	0.90
1973	0.43	1994	0.73
1974	0.68	1995	0.80
1975	0.86	1996	1.02
1976	1.12	1997	0.88

Table V.7. Celtic Sea and VIIj herring. Advice history.

Year	ICES Advice	Predicted catch corresp. to advice	Agreed TAC	Official Landings	Discards	Estimated Catch[1]
1974	NEAFC TAC		32	20	-	19.74
1975	Reduce F, TAC ≤ 25,000		25	16	-	15.13
1976	TAC between 10,000 and 12,000		10.8	10	-	8.2
1977	No Fishing	0	0	8	-	3.0
1978	No Fishing	0	0	8	-	7.1
1979	TAC set for VIIj only, No fishing in Celtic Sea	0	6	10	-	12.1
1980	TAC set for VIIj only, No fishing in Celtic Sea		6	9	-	9.2
1981	TAC set for VIIj only, No fishing in Celtic Sea		6	17	-	16.8
1982	TAC		8*	10	-	9.5
1983	TAC		8*	22	4.0	22.18
1984	TAC	13	13	20	3.6	19.7
1985	TAC	13	13	16	3.1	16.23
1986	No specific TAC, preferred overall catch 17,000t		17	13	3.9	23.3
1987	Precautionary TAC	18	18	18	4.2	27.3
1988	TAC	13	18	17	2.4	19.2
1989	TAC	20	20	18	3.5	22.7
1990	TAC	15	17.5	17	2.5	20.2
1991	TAC (TAC excluding discards)	15 (12.5)	21	21	1.9	23.6
1992	TAC	27	21	19	2.1	23
1993	Precautionary TAC (including discards)	20–24	21	20	1.9	21.1
1994	Precautionary TAC (including discards)	20–24	21	19	1.7	19.1
1995	No specific advice	-	21	18	0.7	19
1996	TAC	9.8	16.5–21	21	3	21.8
1997	If required, precautionary TAC	< 25	22	20.7	0.7	18.8
1998	Catches below 25	< 25	22	20.5	0	20.3
1999	F = 0.4	19	21	19.4	0	18.1
2000	F < 0.3	20	21	18.8	0	18.3
2001	F < 0.34	17.9	20	19	0	17.7
2002	F<0.35	11	11	11.5	0	10.5
2003	Substantially less than recent catches	-	13	12	0	11
2004	60% of average catch 1997–2000	11	13	12	-	11
2005	60% of average catch 1997–2000	11	13	10	-	8
2006	Further reduction 60% avg catch 2002–2004	6.7	11	9	-	8.5
2007	No fishing without rebuilding plan	--	9.3	9.6	-	8.2
2008	No targeted fishing without rebuilding plan	--	7.8			
2009	No targeted fishing without rebuilding plan	--				

Annex 6: Quality Handbook ANNEX: Her VIaN

Stock specific documentation of standard assessment procedures used by ICES.

Stock:	Herring in VIa (North)
Working Group:	Herring Assessment WG for the Area south of 62°N
Date:	25 March 2008
Authors:	E.M.C. Hatfield, E.J. Simmonds and A. Edridge

A. General

A.1. Stock definition

The stock is distributed over ICES Division VIa (N). Some of the larger adults typically found close to the shelf break may be caught in division Vb.

A.2. Fishery

The dominant fleet fishing in VIa (N) since 1957 has been the Scottish fleet. In the early years the Scottish fishery was prosecuted using a mixture of vessel size and gear, including gill nets, ring-nets and trawls. The boats were small, and targeted the coastal stock, primarily fishing in the winter. Until 1970 the only other nations fishing in this area on a regular basis were the former German Federal Republic, and to a much lesser extend the Netherlands. These fleets operated in deeper water near the shelf edge.

In 1970 a large increase in exploitation occurred with the entry of fleets from Norway and the Faroes, and an increased Netherlands catch. In addition, considerably smaller catches were taken by France and Iceland.

Throughout this period juvenile herring catches from the Moray Firth, in the north-east of Scotland, were included in the VIa catch figures, as tagging programs showed there to be some links between herring spawning to the west of Scotland and the Moray Firth juveniles.

Prior to 1982 herring stocks in ICES Area VIa were assessed as one stock, along with the herring by-catch from the sprat fishery in the Moray Firth. In the 1982 herring assessment working group report, and in subsequent years, Area VIa was split into a northern and a southern area at 56°N (ICES, 1982).

In 1979 and 1981 the fishery was closed. After re-opening the nature of the fishery changed to an extent, with fewer Scottish boats targeting the coastal stock than before the closure. The Scottish domestic pair trawl fleet and the Northern Irish fleet operated in shallower, coastal areas, principally fishing in the Minches and around the Island of Barra in the south; younger herring are found in these areas. Since 1986 Irish trawlers have operated in the south of the area, from the VIa (S) line up to the south-western Hebrides. The Scottish and Norwegian purse seine fleets targeted herring mostly in the northern North Sea, but also operated in the northern part of VIa (N). An international freezer-trawler fishery operated in deeper water near the shelf edge where older fish are distributed. These vessels are mostly registered in the

Netherlands, Germany, France and England. In recent years the catch of these fleets has become more similar and has been dominated by younger adults resulting from increased recruitment into the stock.

In recent years the Scottish fleet has changed to a predominantly purse-seine fleet to a trawl fleet. Norwegian vessels fish less in the area than in the past. Scottish catches still comprise around half of the total, the rest is dominated by the offshore, international fishery.

A recent EU-funded programme WESTHER has elucidated stock structures of herring throughout the western seaboard of the British Isles using a combination of morphometric measurements, otolith structure, genetics and parasite loads. The results provide information on mixing of stocks within and beyond VIa (N).

A.3. Ecosystem aspects

Herring are an important prey species in the ecosystem and also one of the dominant planktivorous fish.

Herring fisheries tend to be clean with little bycatch of other fish. Scottish discard observer programs since 1999 indicate that discarding of herring in these directed fisheries are at a low level. These discard observer programs have recorded occasional catches of seals and zero catches of cetaceans.

B. Data

B.1. Commercial catch

Commercial catch is obtained from national laboratories of nations exploiting herring in VIa (N). Since 1999 (catch data 1998), these labs have used a spreadsheet to provide all necessary landing and sampling data, which was developed originally for the Mackerel Working Group (WGMHSA) and further adapted to the special needs of the Herring Assessment Working Group. The current version used for reporting the 2002 catch data was v1.6.4. The majority of commercial catch data of multinational fleets was provided on these spreadsheets and further processed with the SALLOCL-application (Patterson, 1998a). This program gives the needed standard outputs on sampling status and biological parameters. It also clearly documents any decisions made by the species co-ordinators for filling in missing data and raising the catch information of one nation/quarter/area with information from another data set.

Transparency of data handling by the Working Group. The current practice of data handling by the Working Group is that the data received by the co-ordinators is available in a folder called "archive". These high-resolution data are not reproduced in the report. The archived data contains the disaggregated dataset (disfad), the allocations of samples to unsampled catches (alloc), the aggregated dataset (sam.out) and (in some cases) a document describing any problems with the data in that year.

Current methods of compiling fisheries assessment data. The species co-ordinator is responsible for compiling the national data to produce the input data for the assessments. In addition to checking the major task involved is to allocate samples of catch numbers, mean length and mean weight-at-age to unsampled catches. There are at present no defined criteria on how this should be done, but the following general process is implemented by the species co-ordinators. Searches are made for appropriate samples by gear (fleet) area quarter, if an exact match is not available the search will move to a neighbouring area if the fishery extends to this area in the same quarter. More than one sample may be allocated to an unsampled catch, in this case a straight mean or weighted mean of the observations may be used. If there are no samples available the search will move to the closest non-adjacent area by gear (fleet) and quarter, but not in all cases.

Until 2003 the VIa(N) catch data extended back to the early 1970s; since 1986 the series has run from 1976 to present. In 2004 the data set was extended back to 1957. Details are given below.

Historic Catches from 1957 to 1975

The working group has obtained preliminary estimates of catch and catch-at-age for the period 1957 to 1975. These have been estimated from records of catch presented in HAWG reports from 1973, 1974, 1981 and 1982. Intervening reports were also consulted to check for changes or updates during the period. Catch-at-age data were available from 1970 to 1975 from the 1982 Working Group report, and catches-at-age for the period 1957 to 1972 were estimated from paper records of catch-at-age by national fleets for 1957 to 1972, held at FRS Marine Laboratory Aberdeen. The fishing practices of national fleets were established for the period 1970 to 1980 from catches in VIa and VIa (N) recorded in the 1981 and 1982 Working Group reports respectively. This procedure suggested that, on average, more than 90% of catch by national fleet could be fully assigned to either VIa (N) or VIa (S). The remaining catch was assigned assuming historic proportions. During this period catches were split into autumn and spring spawning components; anecdotal information on trials to verify this separation suggests it was not a robust procedure. Currently about 5% of herring in VIa (N) is found to be spent at the time of the acoustic surveys in July, and thought to be spring spawning herring. However, at present the Working Group assesses VIa (N) herring as one stock, regardless of spawning stock affiliation. In the earlier period higher proportions were allocated as spring spawners. The Working Group considered that it was preferable to combine all catch in the earlier period as VIa (N) catch, as the spawning components are currently mixed and the historic separation was uncertain. Similarly, a small Moray Firth juvenile fishery was also included in VIa (N) catch in earlier years because it was thought that these juveniles were part of the VIa (N) stock. Separating this component in the historic data was difficult, and as the fishery ceased in the very early 70s this has no implications for current allocation of these fish. The Moray Firth is, geographically, part of IVa (ICES stat. rectangles 44E6, 44E7, 45E6) and is now managed as part of that area. Currently there are no juvenile herring catches from the Moray Firth. Full details of the analysis carried out is provided as an appendix (Appendix 11) to the 2004 Working Group report.

Allocation of catch and misreporting

This fishery has had a strong tradition of misreporting before 2000, though this has reduced in recent years. It is believed that the shortfall between the TAC and the catch was used to misreport catches from other areas (from IVa to the east and from VIa (S) to the south). In the past, fishery-independent information confirmed that large catches were being reported from areas with low abundances of fish, and informal information from the fishery and from other sources confirmed that most catches of fish recorded between 4°W and 5°W were most probably misreported North Sea catches. The problem was detailed in the Working Group report in 2002 (ICES 2002/ACFM:12). Improved information from the fishery in 1998 - 2002 allowed for re-allocation of many catches due to area misreporting (principally from VIa (N) to IVa (W)). This information was obtained from only some of the fleets

As a result of perceived problems of area misreporting of catch from IVa into VIa (N), Scotland introduced a fishery regulation in 1997 with the aim to improve reporting accuracy. Under this regulation, Scottish vessels fishing for herring were required to hold a license either to fish in the North Sea or in the west of Scotland area (VIa (N)). Only one licensed option could be held at any one time. However in 2004, the requirement to carry only a single licence was rescinded. Area misreporting of catch taken in area IVa into area VIa (N) then increased in 2004 and continued in 2005. It is possible, therefore, that the relaxation of this single area licence contributed to a resurgence in area misreporting. In 2007, as in 2006, there was no misreporting from IVa into VIa (N). New sources of information on catch misreporting from the UK became available in 2006 (see the 2007 HAWG report). This information was associated with a stricter enforcement regime that may be responsible for the lack of that area misreporting since 2006.

The Butt of Lewis box, (a seasonal closure to pelagic fishing of the spawning ground in the north west of the continental shelf in area VIa(North) since the late 1970s was opened to fishing in 2008 following a STECF review in 2007. It has not been possible to show either beneficial or deleterious effects from this closure.

Catches are included in the assessment. Biases and sampling designs are not documented. Discards are not included. Slippage and high grading are not recorded.

B.2. Biological

Catch-at-age data (catch numbers-at-age, mean weights-at-age in the catch, mean length-at-age) are derived from the raised national figures received from the national laboratories. The data are obtained either by market sampling or by onboard observers, and processed as described in Section B.1 above. For information on recent sampling levels and nations providing samples, see Section 2.2. in the most recent HAWG report.

Proportions mature (maturity ogive) and mean weights-at-age in the stock derived from the acoustic survey (see next section) have been used since 1992 and 1993, respectively. Prior to these years, time-invariant values derived from ??? were used.

Biological sampling of the catches was extremely poor in recent history (particularly in 1999). This was particularly the case for the freezer trawler fishery that takes the larger component of the stock based around the shelf break. The lack of samples was due in part to the fact that national vessels tend to land in foreign ports, avoiding national sampling programs. The same fleet is thought to high grade. The long length of fishing trips makes observer programs difficult. Even when samples are taken, age determination is limited for most nations.

Sampling has improved over the last few years. The number of age readings per 1,000 t of catch increased from the low in 1999 of 52 to a high in 2001 of 93. Numbers have decreased again since then to 57 per 1,000 t in 2003. From 1999 to 2003 the sampling has been dominated by Scotland (ranging between 70 and 98% of the age readings), except in 2001, when only 43% of the age determination was on Scottish landings in VIa (N).

Natural mortality (M) varies with age (expressed in number of winter rings) according to the following:

Rings	M
1	1
2	0.3
3	0.2
4+	0.1

Those values have been held constant from 1957 to date. Those values correspond to estimates for North Sea herring based on recommendations by the Multi-species WG (Anon. 1987a) that were applied to adjacent areas (Anon. 1987b).

B.3. Surveys

B.3.1 Acoustic survey

An acoustic survey has been carried out for VIa (N) herring in the years 1987, 1991-2003

Biomass estimated from the acoustic survey tends to be variable. Herring are found in similar area each year, namely south of the Hebrides off Barra Head, west of the Hebrides and along the shelf edge.

The stock is highly contagious in its spatial distribution, which explains some of the high variability in the time series. Effort stratification has improved with knowledge of the distribution and this may be less of a problem in more recent years. The survey uses the same target strength as for the North Sea surveys and there is no reason to suppose why this should be any different. Species identification is generally not a great problem.

B.3.2 Larvae survey

Larvae surveys for this stock were carried out from 1973 to 1993. Larval production estimates (LPE) and a larval abundance index (LAI) were produced for the time series. These values were used in the assessment, the LPE until 2001. However, in 2002 it was decided that the LAI had no influence on the assessment and has not been used since. Documentation of this survey time-series is given in ICES CM 1990/H:40.

B.4. Commercial CPUE

Not used for pelagic stocks

B.5. Other relevant data

C. Historical Stock Development

An experimental survey-data-at-age model was formulated at the 2000 HAWG. In 1999 and 1998 a Bayesian modification to ICA was used to account for the uncertainty in misreporting.

Model used: FLICA Software R / ICA (Patterson 1998b)

Model Options chosen:

- Separable constraint over last 8 years (weighting = 1.0 for each year)
- Reference age = 4
- Constant selection pattern model
- Selectivity on oldest age = 1.0
- First age for calculation of mean F = 3
- Last age for calculation of mean F = 6
- Weighting on 1-rings = 0.1; all other age classes = 1.0
- Weighting for all years = 1.0
- All indices treated as linear

- No S/R relationship fitted
- Lowest and highest feasible F = 0.02 and 0.5
- All survey weights fitted by hand i.e., 1.0 with the 1 ringers in the acoustic survey weighted to 0.1.
- Correlated errors assumed i.e., = 1.0
- No shrinkage applied

Input data types and characteristics:

Type	Name	Year range	Age range	Variable from year to year Yes/No
Caton	Catch in tones	1957 - last data year	NA	Yes
Canum	Catch at age in Numbers	1957 - last data year	1-9+	Yes
Weca	Weight at age in the commercial catch	1957-1972 1973-1981 1982-1984 1985-last data year	1-9+ 1-9+ 1-9+ 1-9+	No No No Yes
West	Weight at age of the spawning stock at spawning time.	1957 - 1992 1993-last data year	1-9+ 1-9+	No Yes
Mprop	Proportion of natural mortality before spawning	1957-last data year	NA	No
Fprop	Proportion of fishing mortality before spawning	1957-last data year	NA	No
Matprop	Proportion mature at age	1957 - 1991 1992-last data year	1-9+ 1-9+	No Yes
Natmor	Natural mortality	1957 - last year	1-9+	No

Tuning data:

Type	Name	Year Range	Age Range
Tuning fleet 1	VIa (N) Acoustic Survey	1987,	1-9+
		1991- last data year	1-9+

D. Short-Term Projection

Model used: Age structured Software used: MFDP ver 1a

Initial stock size: Taken from the last year of the assessment. 1- and 2-ring recruits taken from a geometric mean for the years 1976 to one year prior to the last year.

Maturity: Mean of the last three years of the maturity ogive used in the assessment.

F and M before spawning: Set to 0.67 for all years.

Weight at age in the stock: Mean of the last three years in the assessment.

Weight at age in the catch: Mean of the last three years in the assessment.

Exploitation pattern: Mean of the previous three years, scaled by the Fbar (3-6) to the level of the last year.

Intermediate year assumptions: **TAC** constraint. Stock recruitment model used: None used

Procedures used for splitting projected catches: Not relevant

E. Medium-Term Projections (done intermittently)

Model used: ICP as described in ICES 1996/ACFM:10 Software used: ICP (Patterson 1999)?

Initial stock size: Population parameters (vector of abundance at age in 2003, fishing mortality at reference age in 2003, selection at age) are drawn from a multivariate normal distribution with mean equal to the values estimated in the stock assessment model, and with covariance as estimated in the same model fit. Geometric mean recruitment for 1- and 2-ringers is used to replace the values in the assessment for the first projected year, however, the covariance values produced by ICA are retained.

Natural mortality: Mean of the last three years in the assessment.

Maturity: Mean of the last three years of the maturity ogive used in the assessment.

F and M before spawning: Set to 0.67 for all years.

Weight at age in the stock: Mean of the last three years in the assessment.

Weight at age in the catch: Mean of the last three years in the assessment.

Exploitation pattern: ???

Intermediate year assumptions: F or TAC constraint

Stock recruitment model used: Ockham option using the converged VPA 1972 to three years prior to last year in the assessment.

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

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

The report of SGPRP (ICES 2003/ACFM:15) proposed a Blim of 50,000 t for VIa (N) herring. This is calculated from the values in the converged part of the VPA (1976-1999) and the Working Group endorsed this value in 2003 (ICES 2003/ACFM:17).

Suggested Precautionary Approach reference points:

B_{LIM} is 50,000 t	B_{PA} be set at 75,000 t

Technical basis:

B_{LIM}: B_{LOSS} Estimated SSB for sustained recruitment	Bpa: 1.5 * Blim

H. Other Issues

H.1 Biology of the species in the distribution area

The Atlantic herring, *Clupea harengus,* is numerically one of the most important pelagic species in North Atlantic ecosystems with widespread distribution around the Scottish coast. Within the Northeast Atlantic they are encountered from the north of Biscay to Greenland, and east into the Barents Sea. It is thought that herring stocks comprise many reproductively isolated subpopulations through specific spawning grounds and seasons (e.g. autumn and spring spawners), but the taxonomic status of these subpopulations remains unclear.

Herring are demersal spawners and produce dense beds of benthic eggs deposited on gravelly substrates. This behaviour is considered to be an evolutionary remnant of herrings' river spawning past. Each female produces a single batch of eggs per year, releasing a ribbon of eggs that adheres to the benthos; the male sheds milt while swimming a few centimetres above the female. This particular behaviour renders herring vulnerable to anthropogenic activity such as offshore oil and gas industries and gravel extraction.

The eggs take about three weeks to hatch, dependant on the temperature. The larvae on hatching are 6-9mm long and are immediately planktonic. Their yolk sac lasts for about a week during which time they will begin to feed on phytoplankton and crustacean larvae. Their planktonic development lasts around three to four months during which time they are passively subjected to the residual drift which takes them to coastal nurseries. The habitats of juveniles are primarily pelagic, and hydrographical features such as temperature and the depth of thermocline, as well as abundance of zooplankton affect their distribution. Adult fish are pelagic and found mostly in continental shelf seas to depths up to 200m. They form large shoals with diurnal migration patterns through the water column which can be associated with the availability of prey and stage of maturity. In the winter the feeding activity and growth are very slow. Herring can reach 40cm in length and have a maximum lifespan of 10 years although most herring range between 20-30cm and are less than 7 years.

Assessing age and year class for herring can be problematic due to the extended spawning season of autumn spawners from September to January. Using the convention of January 1st as the birthday, 0-group refer to fish born between 3 and 18 months ago but 0-group autumn spawners belong to a different class from 0-group spring spawners. Time series of a stock's age structure helps its management and it is vital that they are extended for all the '*West of Scotland*' herring components in the VIaN (North), VIaS (South) and VIb areas. The stock identity of herring west of the British Isles was reviewed by the EU-funded project WESTHER, which identified VIaN as an area where catches comprise a mixture of fish from Areas VIaN, VIaS, and VIIaN. ICES current advice is that herring components should be managed separately to afford maximum protection, but a study group will be convened in 2008 (SGHERWAY) to evaluate the WESTHER recommendations.

There are many hypotheses as to the cause of the irregular cycles shown in the productivity of herring stocks (weights-at-age and recruitment), but in most cases it is thought that the environment plays a key role (through prey, predation and transport). The VIaN herring stock has shown a marked decline in productivity during the late 1970s and has remained at a low level since then. ICES identifies that the VIaN stock is currently fluctuating at low levels and is being exploited above F_{msy} .

Historically, the stock in this area has been affected by three fisheries:

i) A Scottish domestic pair trawl fleet and the North Irish fleet operated in shallower, coastal areas, principally fishing in the Minches and around the Island of Barra in the South where younger herring are encountered. This fleet has reduced in the last years.

ii) The Scottish single-boat trawl and purse-seine fleets, with refrigerated seawater tanks, targeting herring mostly in the northern North Sea, but also operating in the northern part of VIaN. This fleet now operates mostly with trawls but many vessels can deploy either gear.

iii) An international freezer-trawler fishery has historically operated in deeper water near the shelf edge where older fish are distributed. These vessels are mainly registered in the Netherlands, Germany, France, and England but most are Dutch owned.

In recent years the age structure of the catch of these last two fleets has become more similar.

In addition to being a valuable protein resource for humans, herring represent an important prey item for many predators including cod and other large gadoids, dogfish and sharks, marine mammals and sea birds. Because the trophic importance of herring puts its stocks under immense pressure from constant exploitation, it is important that management takes into account all anthropogenic, environmental and biological variables.

H.2 Terminology

The WG uses "rings" rather than "age" or "winter rings" throughout the report to denominate the age of herring, with the intention to avoid confusion. It should be observed that, for autumn spawning stocks, there is a difference of one year between "age" and "rings". HAWG in 1992 (ICES 1992/Assess:11) stated that

"The convention of defining herring age rings instead of years was introduced in various ICES working groups around 1970. The main argument to do so was the uncertainty about the racial identity of the herring in some areas. A herring with one winter ring is classified as 2-years-old if it is an autumn spawner, and one-year-old if it is a spring spawner. Recording the age of the herring in rings instead of in years allowed scientists to postpone the decision on

year of birth until a later date when they might have obtained more information on the racial identity of the herring.

The use of winter rings in ICES working groups has introduced a certain amount of confusion and errors. In specifying the age of the herring, people always have to state explicitly whether they are talking about rings or years, and whether the herring are autumn- or spring spawners. These details tend to get lost in working group reports, which can make these reports confusing for outsiders, and even for herring experts themselves. As the age of all other fish species (and of herring in other parts of the world) is expressed in years, one could question the justification of treating West-European herring in a special way. Especially with the present trend towards multispecies assessment and integration of ICES working groups, there might be a case for a uniform system of age definition throughout all ICES working groups.

However, the change from rings to years would create a number of practical problems. Data files in national laboratories and at ICES would have to be adapted, which would involve extra costs and manpower. People that had not been aware of the change might be confused when comparing new data with data from old working group reports. Finally, in some areas (notably Division IIIa), the distinction between spring- and autumn spawners is still hard to make, and scientists preferred to continue using rings instead of years.

The Working Group discussed at length the various consequences of a change from rings to years. The majority of the Group felt that the advantages of such a change did not outweigh the disadvantages, and it was decided to stick to the present system for the time being. "

The text table below gives an example for the correlation between age, rings and year class for the different spawning types in late 2002:

Year class (autumn spawners)	**2001/2002**	**2000/2001**	**1999/2000**	**1998/1999**
Rings	0	1	2	3
Age (autumn spawners)	1	2	3	4
Year class (spring spawners)	2002	2001	2000	1999
Rings	0	1	2	3
Age (spring spawners)	0	1	2	3

I. References

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Annex 7: Stock Annex – Herring in Division VIa South and VIIbc

Quality Handbook ANNEX: Herring VIaS and VIIb, c

Stock specific documentation of standard assessment procedures used by ICES.

Stock:	Herring in VIaS and VIIb, c
Working Group:	Herring Assessment Working Group for the area south of 62^0 N
Date:	March 2008
Authors:	Afra Egan and Maurice Clarke

A. General

The herring to the northwest of Ireland comprise both autumn and winter/spring spawning components. The age distribution of the catch and vertebral counts were used to distinguish these components (Bracken, 1964, Kennedy, 1970). Spawning takes place from September until March and may continue until April (Molloy and Kelly, 2000). Spawning in VIIb has traditionally taken place in the autumn and in VIaS, later in the autumn and in the winter.

For the purpose of stock assessment and management, these areas have been separated from VIaN since 1982 and are split at 56° N. This split is based on work carried out by working groups in the late 1970s and early 1980s which found that the stocks exploited off the west coast of Scotland were biologically different from those off the north coast of Ireland. A second new assessment area was also recommended by the 1981 Working Group (ICES CM 1981). The Irish landings were taken mainly in the southern part of VIa and in VIIb, c. These catches were found to be biologically very similar with respect to age composition and spawning. It was decided at the 1981 working group to combine the areas and conduct a joint assessment (Molloy, 2006).

A herring tagging experiment was carried out in 1992 in order to investigate the movements and annual migrations of herring around the Irish Coast. 20,000 herring were tagged in total with 10,000 of these off the west coast. Some fish moved northwards and were recaptured along the north coast between July and February, in the main fishing areas. 90% of the fish tagged along the west coast were recovered from the Donegal Bay area. The maturity stages of the recaptured fish, suggests that the fish were migrating inshore towards spawning grounds (Molloy, *et al* 1993). There were no returns from north of Donegal although it is possible that there may not have been much fishing activity in the area at this time (Molloy and Kelly, 2000).

Assessment and biology

A study group on herring assessment and biology in the Irish Sea and adjacent areas met in 1994 (ICES, 1994). This meeting highlighted the problems associated with the assessment of herring stocks around Ireland. This group recommended that the boundary line separating this stock from the herring stock of VIaS and VIIb be moved southwards from latitude 52°30'N to 52°00'N (ICES, 1994). A Schematic presentation of the life cycle of herring to the west and northwest of Ireland is shown in Figure A.1. The spawning, nursery and feeding grounds are shown as well as the direction of larval drift and migration.

WESTHER

WESTHER was an EU-funded project, to review, the stock identity of herring west of the British Isles. A number of factors were examined including.

- Morphometrics and meristic characteristics
- Internal parasites
- Otolith microstructure and microchemistry
- Genetics

Results from this project identified distinct spawning grounds and spawning components. It was recommended that the stocks to the west of the British Isles should be managed as two stocks, the Malin Shelf stock and the Celtic Sea stock. Management plans should be fleet and area based in order to prevent the local depletion of any population unit in the areas (WESTHER, Q5RS-2002-01056). Further work on the management of these stocks will be conducted by SGHERWAY which are due to meet in late 2008.

A.2. Fishery

Development of this fishery

In the early 1900s the main herring fisheries in Ireland were located off the Donegal coast. Donegal matje herring was important in supplying the German markets. Herring fisheries, which took place every spring and summer off the coast of Donegal, have been under scientific observation since 1921, with very little scientific work carried out prior to this. The fishing grounds were well known and were located between ten and forty miles offshore. Fishing during this time was split into three well defined time periods.

1) December/January
2) May (main fishing took place)
3) September/October

During the 1930s many of the major herring markets disappeared (Molloy, 1995). In contrast to the rapid expansion experienced in the Celtic Sea the revival of the northwest fishery occurred at a slower pace (Molloy, 2006). The revival first became evident in the 1950s when many Scottish ring netters took part in this fishery with many of the Irish boats also using this gear. Then several boats changed to pelagic midwater trawls. The herring fleet continued to expand throughout the 1960s with many skippers becoming experts in pelagic pair trawling (Molloy, 2006).

In the 1970s and 1980s the autumn spawners became more significant and accounted for the majority of the landings. Galway and Rossaveal gained increasing importance as herring ports in the 1970s. In the 1974/75 season landings decreased dramatically and it was the first indication that the stock might have started to decline. The North Sea stock was already in decline and many Dutch boats were fishing off the Irish west coast. TACs were reduced and the stock continued to decline. In 1978 it was advised that the fishery be closed (Molloy, 2006). This closure lasted until 1981 and was reopened with new management units. VIaS and VIIb, c were joined and were assessed separately from VIaN.

In recent years the northern grounds have regained importance with catch also coming from the west coast close to the VIa boundary line (ICES, 2005). Very little fishing now takes place on previously important grounds in Galway Bay and along the Mayo coast (Molloy and Kelly, 2000).

Since the late 1970s considerable changes have taken place in the type of pelagic fishing carried out by Irish boats off the North West Coast, with directed herring fishing having been largely replaced by mackerel fishing (Breslin, 1998).

Recent

The TAC is taken mainly by Ireland, which has over 90% of the quota. In recent years, only Ireland has exploited herring in this area. The fishery is concentrated in quarters one and four. Landings have decreased markedly from about 44,000 t in 1990 to around 13,800t in 2004. Working group catches in the last two years have decreased from 19,000 t in 2006 and over 17,000 t in 2007. Total catch over the complete time series are shown in the Figure A.3. The number of boats participating in this fishery remained constant for a number of years at around 30 vessels. Increases were seen in the last two years with 57 vessels landing northwest herring in 2007. The number of vessels engaged in fishing for herring depends very much on the availability of mackerel or horse mackerel. Many of the larger vessels target these species primarily.

The majority of the landings in recent years are taken in quarters one and four with small quantities landed in quarter three. The main age groups are 2, 3, 4 and 5 with older age groups accounting for small proportions of the catch. The proportions of older age groups have been decreasing over the last number of years.

A.3. Ecosystem aspects

Divisions VIaS and VIIb, c are located to the North West and west of Ireland respectively. This area is limited to the southwest by the Rockall Trough, where the transition between the Porcupine Bank and the trough is a steep and rocky slope with reefs of deepwater corals; further north, the slope of the Rockall Trough is closer to the coast line; west of the shelf break is the Rockall Plateau with depths of less than 200m. The shelf area consists of mixed substrates, with soft sediments (sand and mud) in the west and more rocky, pinnacle areas to the east. The area has several seamounts: the Rosemary Bank, the Anton Dohrn sea mount and the Hebrides, which have soft sediments on top and rocky slopes (ICES, 2007b).

The shelf circulation is influenced by the poleward flowing 'slope current', which persists throughout the year north of the Porcupine Bank, but is stronger in the summer. A schematic representation of the oceanographic conditions in this area is presented in Figure A.2. Over the Rockall plateau, domes of cold water are associated with retentive circulation. Thermal stratification and tidal mixing generate a northwards running coastal current known as the Irish coastal current which runs northwards along the west coast (ICES, 2007). The main oceanographic features in these areas are the Islay and the Irish Shelf fronts. The waters to the west of Ireland are separated by the Irish shelf front. This front causes turbulence and this may bring nutrients from deep waters to the surface. This promotes the growth of phytoplankton and dinoflagellates where there is increased stratification. Associated with this is increased growth of zooplankton and aggregations of fish. The Islay front persists throughout the winter due to the stratification of water masses of different salinities (ICES, 2006). The ability to quantify any variability in frontal location and strength is an important element in understanding fisheries recruitment (Nolan and Lyons, 2006).

In the North, most of the continental shelf is exposed to prevailing sothwesterly winds and saline oceanic waters cross the shelf edge between Malin head off the north coast of Ireland and Barra head in the Outer Hebrides. The Irish shelf current flows northwards and then eastwards along the north coast of Ireland (Reid *et al*, 2003). Freshwater discharges from rivers such as the Shannon and Corrib interact with the Eastern North Atlantic water on the Irish shelf front to produce the observed circulation pattern (ICES, 2006).

Sea surface temperature data have been collected from Malin head on the North coast of Ireland since 1958. During periods of low winter temperatures, there is less pronounced heating during the summer. This can be seen in 1963, 1978 and 1985-1986. During these years there were also stormy conditions. This is concurrent with the lower winter temperatures (ICES, 2007). There is considerable variability over the complete time series. A definite trend can be identified from the early 1990s. Since 1990 sea surface temperatures measured at stations along the northwest coast of Ireland have displayed a sustained increasing trend, with winter temperatures $>6^{\circ}$ and higher summer temperatures during the same period (Figure A.4), (Nolan and Lyons, 2006).

Environmental conditions can cause significant fluctuations in abundance in a variety of marine species including fish. A study conducted in 1980 found that west coast herring catches showed strong correlations with temperature and salinity at a constant lag of three or four years. Oceanographic variation associated with temperature and salinity fluctuations appears to affect herring in the first year of life, probably during the winter larval drift (Grainger 1980a).

Productivity in this region is reasonably high on the shelf but drops rapidly west of the shelf break. This area is important for many pelagic fish species. The shelf edge is a spawning area for mackerel *Scomber scombrus* and blue whiting *Micromesistius potassou*. Historically, there were important commercial fisheries for many demersals species also. On the shelf, the main resident pelagic species is herring *Clupea harengus* (ICES, 2007b). Preliminary examination of productivity shows that overall productivity in this area is currently lower than it was in the 1980s. Further information on this can be found in the HAWG report 2007 (ICES CM 2007).

Larvae that were spawned on the west and northwest coast follow a northwards drift. Larvae spawned further north off the Donegal coast were found to drift towards the Scottish west coast (Grainger and McArdle, 1985; Molloy and Barnwall, 1988) Studies have shown that the maximum larval depth is below the surface between 5-15m and there has been no evidence of diel migration, or variation in the distribution of different larval size categories (Grainger 1980b). Galway Bay and Donegal Bay, several inshore lochs and also Stanton Bank, an offshore area northwest of the Irish north coast are important nursery areas (ICES, 1994; Anon., 2000).

The spawning grounds for herring along the northwest coast are located in inshore areas close to the coast. These spawning grounds may contain one or more spawning beds on which herring deposit their eggs. The timing of spawning is not the same on each spawning ground. Spawning grounds tend to be vulnerable to anthropogenic influences such as dredging and sand and gravel extraction.

Discards

The main market for Irish herring in the late 1980s and early 1990s was the Japanese roe market. The development of this market coincided with a decline in a number of other herring markets. It was therefore only favourable to catch roe herring, whose ovaries are just at the point of spawning. This led to discarding of non roe herring due to the lack of a suitable market. The roe market is no longer the main market for Irish herring. It is not known what the level of discarding is in this stock area and if it is a problem in this fishery.

By Catch

Overall there is a paucity of data relating to by catch and discarding in this area. Interactions between cetaceans and fishing vessels have not been well documented and therefore no information is available. It is not possible therefore to make assumptions regarding implications for the marine ecosystem in area VIaS and VIIb, c.

B. Data

B.1. Commercial Catch

The commercial catch data are provided by national laboratories belonging to the nations that have quota for this stock. In recent years, only Ireland has been catching herring in this area, and the data are derived entirely from Irish sampling. Sampling is performed as part of commitments under the EU Council Regulation 1639/2001.

Commercial catch at age data are submitted in Exchange sheet v 1.6.4. These data are usually processed using SALLOCL (Patterson, 1998b). However, since only one country participates in this fishery this system is not required. Ireland acts as stock coordinator for this stock.

InterCatch

In 2007 and 2008, InterCatch, which is a web-based system for handling fish stock assessment data was used. National fish stock catches are imported into InterCatch. Stock coordinators then allocate sampled catches to unsampled catches, aggregate them to stock level and download the output. The InterCatch stock output can then be used as input for the assessment models. It is envisaged that this system will replace SALLOCL and other previously used systems.

Reallocation of Catches

In 2008, as in 2007 landings data were revised with respect to reallocation of catches between area VIaS and VIaN, for the years 2000-2005. Before 2000, a comprehensive reallocation was used. For 2000-2005, various procedures were used. These attempted to deal with the increasing Irish catches along the 56° line and opportunistic Irish catches of herring in VIaN during the 4th and 1st quarter mackerel fishery. In some years some catches were reallocated, while in others no reallocations were made. In 2007, it was considered that the most correct procedure was that used before 2000. Therefore a retrospective reallocation has been conducted. It does not adequately consider the Irish herring catches in VIaN, nor does the reallocation consider fishing along the 56°line. However, in the absence of better information on Irish directed herring fishing in VIaN, this procedure provides the best possible method.

B.2. Biological

Sampling Protocol

Landings data are available for this area from 1970. Data on catch numbers at age, mean weights at age and mean lengths at age are derived from Irish data. Sampling is conducted by area and by quarter. Landings from this fishery, at present, are mainly into the port of Killybegs with lesser amounts landed into Rossaveal. Irish samples are collected from these commercial landings. Length frequency and age data is collected by ICES division by quarter. The length frequency data is added together for each division and quarter and raised to the landings for that area and quarter. The sample weight is divided into the catch weight to get the raising factor. The sum of the length frequencies per quarter is multiplied by the raising factor. An age length key is applied to this data and catch numbers at age calculated.

Age Reading Protocol

Northwest herring are currently aged using otoliths and are read using a stereoscopic microscope, with reflected light. The minimum level of magnification (15x) is used initially. It is then increased to resolve the features of the otolith. Herring otoliths are generally read in the magnification range of 20x – 25x. The patterns of opaque (summer) and translucent (winter) zones are viewed. The winter (translucent) ring at the otolith edge is counted only in otoliths from fish caught after the 1st January. The first winter ring that is counted is that which corresponds to the second "birth date" of the fish. Therefore a fish of 2 winter rings is a 3 year old. This convention applies to all ICES herring stocks with autumn spawning (Lynch, *in prep*).

Age composition in the catch

Scales were used in the past for ageing and on average 4 and 5 ringers counted for 46% of the total catch. In 1929 however strong year classes were evident with 4 and 5 ringers making up 85% of the total (Farran, 1928). Currently the catch is mainly composed of ages 2 ,3, 4 and 5 ringers. In recent years there have been decreasing proportions of older fish in the catch. This stock is different from the Celtic Sea in that there is no recruitment failure and the Northwest stock is less reliant on incoming recruitment. The decrease in the proportions of older ages can be seen in Figure B.1.

Precision Estimates

The precision estimates on 2006 ageing data were worked up using a bootstrap technique. The results of the method found that the relative error is below 20% over the age range 2-6wr. At older ages, estimates of NW herring show higher CVs which is likely to be due to the relative paucity in the catch.

Mean Weights

Mean weights in the stock (West) are calculated using samples taken from Q1 and Q4. A mean weight at age is then calculated. Mean weights in the catch (Weca) are calculated using samples from all quarters of the fishery and a mean weight per age derived.

Trends in mean weights over time

The mean weights in the catch display quite a stable pattern over the time series, although variable weights are only available from the early 1980s. Younger ages (1-6 ring) show an overall downward trend with more fluctuations evident in older ages (7-9 ring). The mean weights in the stock at spawning time have been calculated from Irish samples taken during the main spawning period and show similar patterns to the mean weight in the catch.

Maturity ogive

A maturity ogive has been produced from the 2007 acoustic survey shows that 58% are mature at 1-ring, 99% at 2-ring and 100% mature at 3-ring. The maturity ogive used in the assessment considers 1-ringers to be all immature and all subsequent age groups as fully mature.

Log Catch Ratios

The log catch ratios ($\ln C_{a,y}/ C_{a+1,y+1}$) are presented below and are smoothed with a 4-year running average to show the main trends (Figure B.2). Data for 1-ringers are noisy because this group is not fully selected by the fishery. The data for older fish are also noisy, particularly in later years, reflecting their relative paucity in the catches and suggest high variability in the exploitation rates of these age groups. These show an upward trend for all fully recruited year classes since the mid nineties. Overall, the catch data show a diminishing range of ages in the catches and older fish are at their lowest levels in the time series.

Catch Curves

Cohort catch curves, were constructed for each year class in the catch at age data (Figure B.3). These catch curves show signals in total mortality over the time series. Low mortality seems evident on the very large 1981,1985 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.

B.3. Surveys

Acoustic Surveys

Acoustic surveys have been carried out in this area since 1994. The timing of these surveys has changed over this period. Initially the surveys were undertaken in the summer in order to coincide with international herring surveys and with the summer feeding period of this stock. In 1997, a research vessel was not available and the survey was not carried out. From 1998 -2001 surveys were undertaken in October in order to survey the autumn spawning component. This was changed in 2002 with surveys carried out in January targeting the winter spawning components of this stock.

Since 2004 the surveys have been carried out on the *R.V. Celtic Explorer*. A parallel transect design was adopted with transects running perpendicular to the coastline and extending up to 54 nmi (nautical miles) offshore. Transect spacing was set at 2 nmi throughout the survey. In bays a single zigzag transect approach was used to optimise coverage. The survey area was divided into strata based on the timing of spawning in each area. The first strata to be covered was chosen in order to contain the earliest spawning components of the stock. The second strata is characterised as containing a mixture of early and mid spawning stock components. The third strata covered the area where the latest spawning is known to occur. Strata were subdivided in order to concentrate on known spawning grounds.

The acoustic data were collected using the Simrad ER60 scientific echosounder. The Simrad ES-38B (38 KHz) split-beam transducer is mounted within the vessels drop keel and lowered to the working depth of 3.3m below the vessels hull or 8.8m below the sea surface.

Acoustic data analysis was carried out using Sonar data's Echoview® (V 3.2) post processing software and was backed up every 24 hrs. Partitioning of data was viewed and agreed upon by 2 scientists experienced in viewing echograms. Where no directed trawling had taken place, biological data from the nearest neighbour was used to determine the size classification of the echotrace.

The following TS/length relationships were used to analyse the data.

Herring	TS = 20logL – 71.2 dB per individual (L = length in cm)
Sprat	TS = 20logL – 71.2 dB per individual (L = length in cm)
Mackerel	TS = 20logL – 84.9 dB per individual (L = length in cm)
Horse mackerel	TS = 20logL – 67.5 dB per individual (L = length in cm)

The current acoustic survey time series is split and runs from 1999-2003 and 2004-2007 because of the timing. Earlier survey series were carried out in Q4 and the more recent surveys were in Q1. The acoustic survey time series is shown in the text table below.

Year	Type	Biomass	SSB
1994	Feeding phase	-	353,772
1995	Feeding phase	137,670	125,800
1996	Feeding phase	34,290	12,550
1997	-	-	-
1998	-	-	-
1999	Autumn spawners	23,762	22,788
2000	Autumn spawners	21,000	20,500
2001	Autumn spawners	11,100	9,800
2002	Winter spawners	8,900	7,200
2003	Winter spawners	10,300	9,500
2004	Winter spawners	41,700	41,399
2005	Winter spawners	71,253	66,138
2006	Winter spawners	27,770	27,200
2007	Winter spawners	14,222	13,974

Larval Surveys

Assessment of this stock was largely based on the results of larval surveys in the 1980s. Herring Larval surveys were first carried out on this stock, by Ireland, in 1981 and continued until 1986. Prior to this the surveys were carried out by the Scottish but only had limited coverage of the assessment area. The survey grid consisted of sampling stations about 18km apart. A gulf III plankton sampler with 275 µm mesh was towed at each station. The samples collected were preserved in 4% formalin. Herring larvae were identified and measured. Only larvae of less than 10mm were used for the assessment. The number of larvae below each square meter was calculated and then multiplied by the area of the sea at each station (Grainger and McArdle, 1981). These surveys did not produce a satisfactory index of stock size because of two very low values in 1984 and 1985 (Molloy, 1989). However these surveys did provide valuable information on the distribution of very small larvae and on the location of the spawning grounds (Molloy and Kelly, 2000).

Ground Fish Survey

The IGFS is part of the western IBTS survey and has been carried out on the *RV Celtic Explorer* since 2003. The gear used on the survey is a GOV 36/47 demersal trawl with a 20mm cod end liner to retain juvenile and small fish, including small herring. This survey has been conducted since the early 1990s but is of little utility as a herring recruit index, because the gear, timing and survey vessel changed throughout. Once a sufficient time series becomes available it will be investigated as a possible tuning fleet. The Scottish groundfish survey, which has some coverage of VIaS will also be investigated as an additional tuning fleet.

B.4. Commercial CPUE

Research surveys were not started in Ireland until the mid 1960s and in the absence of this information commercial catch per unit effort (CPUE) data was used as an index of stock size. It is known that CPUE data may not give an accurate index of stock size due to the shoaling nature of pelagic stocks. Fish can aggregate in dense shoals in a small area and CPUE may remain high even though the stock size is low. However the CPUE data collected in the 1960s and 1970s did provide an index of changes that were occurring in the fisheries around Ireland. F was calculated for the Northwest herring stock using this data during this time and showed an increasing trend in F. This CPUE data was used to show the dramatic decline that took place in this stock in the 1970s (Molloy, 2006).

C. Historical Stock Development

Time periods in the fishery

This fishery peaked in the late 1980s, largely as a result of two strong year classes in 1981 and 1985. This corresponded to the highest SSB and a medium level of F. In the late 1980s changes also took place with regard to the location and timing of the fishery. The North and West coast fisheries in December and January were now the most important with smaller amounts taken during the autumn fishery (Molloy, 2006). Since then there has been a downward trend in SSB and recruitment with no evidence of strong year classes entering the fishery. Mean F has been fluctuating but is though to be at a high level.

Spawning stock size peaked in 1988 and has followed a steady decline since then. Landings have drastically fallen since 1999 (ICES, 2004). Long term changes in the spawning component have occurred in the area and time of spawning. In 1920-1930s there was a north coast fishery that spawned in the North in spring and an autumn fishery that spawned in the west of Donegal. Sligo and Galway had no important fishery. In the ‘40-50 herring all over Ireland declined and the recovery in the 1960s occurred mainly in Mayo, Sligo and Galway as autumn spawners. Recently there has been a shift to the northern fishery, while little fishing occurs on the west coast of Ireland. The northwest herring fishery was based on hard (stage V) herring but towards the late 1980s the focus shifted to spawning herring.

Assessment

In 1930, Farran made his first attempt to quantify the abundance of the herring stock in this area. In the 1930s many of the previous herring markets disappeared and there was widescale discarding of herring along the Donegal coast. It is thought that during this time that the herring population was at a very low level (Molloy, 1995).

Recent Assessments

In recent years the model used for this stock was a separable VPA. This was used to screen over three terminal fishing mortalities, 0.2, 0.4 and 0.6. This was achieved using the Lowestoft VPA software (Darby and Flatman, 1994). Reference age for calculation of fishing mortality was 3-6 and terminal selection was fixed at 1, relative to age 3 winter rings. ICA was used in exploratory assessments with the acoustic surveys as a tuning fleet.

Model used: ICA and VPA

No final assessment has been accepted for this stock by the working group. However several scenarios are run, screening over a range of terminal F’s (0.2, 0.4 and 0.6). In 2006 and 2007 exploratory runs using the ICA model (Patterson, 1998) were performed. In the absence of a sufficient time series in this area the use of the ICA model has discontinued.

Software used: **VPA**
A separable VPA is used to track the historic development of this stock.
Software used: Lowestoft VPA Package (Darby and Flatman, 1994).

VPA SETTINGS
Reference Age = 3
Selection in the terminal year = 1.0
Terminal F = 0.2, 0.4, 0.6
1 Ringers: downweighted to 0.1
Reference ages for calculation of Mean F= 3-6

Software used: **ICA**
Model Options chosen:

- Separable constraint over the last 6 years (weighting = 1.0 for each year)
- Reference ages: 3
- Constant selection pattern model
- Selectivity on oldest age: 1.0
- First age for calculation of mean F: 3
- Last age for calculation of mean F: 6
- Weighting on 1 ringers: 0.01 Other age classes: 1.0
- Lowest feasible F: 0.05
- Highest feasible F: 2.0
- Ages for acoustic abundance estimates: 3-4
- Plus group: 9

Input data types and characteristics:

TYPE	NAME	YEAR RANGE	AGE RANGE	VARIABLE FROM YEAR TO YEAR YES/NO
Caton	Catch in tonnes	1970-2007	1-9 +	Yes
Canum	Catch at age in numbers	1970-2007	1-9 +	Yes
Weca	Weight at age in the commercial catch	1970-2007	1-9 +	Yes
West	Weight at age of the spawning stock at spawning time.	1970-2007	1-9 +	Yes
Mprop	Proportion of natural mortality before spawning	1970-2007	1-9 +	No
Fprop	Proportion of fishing mortality before spawning	1970-2007	1-9 +	No
Matprop	Proportion mature at age	1970-2007	1-9 +	No
Natmor	Natural mortality	1970-2007	1-9 +	No

Tuning data:

TYPE	NAME	YEAR RANGE	AGE RANGE
Tuning fleet 1	NWHAS	1999-2003	3-4
Tuning fleet 2	NWHAS	2004-2007	3-4

D. Short-Term Projection

Due to the absence of information on recruitment and the uncertainty about the current stock size short term predictions have not been routinely carried out for this stock.

E. Medium-Term Projections

Model Used: Multi Fleet Yield Per Recruit

Software Used: MFYPR Software

Yield-per-recruit analysis was carried out using MFYPR to provide yield-per-recruit plots for the data produced in the assessment. The values for $\mathbf{F}_{0.1}$ and $\mathbf{F}_{med}$ are 0.17 and 0.31. F_{max} is undefined and this is consistent with many other pelagic species (ICES, 2006).

F. Long-Term Projections

Not performed

G. Biological Reference Points

In 2007 the technical basis for the selection of the precautionary reference points was examined based on methods used by SGPRP (ICES CM 2001). No alternative biomass and fishing mortality reference points are available. It is clear that recruitment does not show any clear dependence on the SSB and that apart from the very high year classes in the 1980s is showing a decline.

The SGPRP (ICES CM 2003) has reviewed the methodology for the calculation of biological reference points, and applying a segmented regression to the stock and recruit data from the 2002 HAWG assessments. This showed that the fit to the stock and recruit data for this stock was not significant. There was no well defined change point and there was no reason to refine the reference points at that time.

Current reference points

B_{pa} = 81,000 t = the lowest reliable estimate of SSB

B_{llim}= 110,000 t = 1.4 x B_{pa}

F_{pa} = 0.22 = F_{med} (1998)

F_{lim} = 0.33 = lowest observed F

H: Other Issues

H.1. Biology of the species in the distribution area

The herring (*Clupea harengus*) is a widely distributed pelagic species in this area. This stock is comprised of different spawning components. Off the west coast the majority of the stock, are autumn spawners. Off the northwest coast distinct spawning units have also been identified. Autumn spawners, that spawn in the Donegal Bay area and winter/spring spawners, that spawn further north off the Donegal coast (Breslin, 1998). Autumn and winter spawners were distinguished by vertebral counts and timing of maturity.

Herring are benthic spawners and deposit their eggs on the sea bed usually on gravel or course sediments. The yolk sac larvae hatch and adopt a pelagic mode of life.

When referring to spawning locations the following terminology is used (Molloy, 2006)

- A spawning bed is the area over which the eggs are deposited
- A spawning ground consists of one or more spawning beds located in a small area.
- A spawning area is comprised of a number of spawning grounds in a larger area

Spawning grounds are typically located in high energy environments such as the mouth of large rivers and areas where the tidal currents are strong. Herring shoals return to the same spawning grounds each year (Molloy, 2006).

The spawning grounds for northwest herring are located in shallow waters close to the coast and are well known and well defined. Spawning begins in October and can continue until February. Fecundity is the number of eggs produced by the female and is proportional to the length of the fish (Molloy, 2006). Several studies were carried out in the early 1980s to analyse the fecundity of winter and autumn spawning components of the North West herring stock and considerable differences were found. Donegal winter spawners produce significantly fewer eggs than autumn spawners. When compared to the Celtic Sea herring stock, Donegal herring have a higher fecundity and begin to spawn earlier (McArdle, 1983). A study conducted in the 1920s found that the eggs produced by winter/spring spawners were 25% bigger than those autumn spawners but were less numerous (Farran, 1938).

Herring produce benthic eggs that are adhered to the bottom substrate where they remain until the larvae hatch. The larvae are carried by the currents and drift towards the west coast of Scotland (Grainger and McArdle, 1985). Several important nursery grounds for juveniles have been identified in this area.

The larval phase is an important period in the herring life cycle. Larvae use their oil globule for food and to provide buoyancy. Their movements and survival are determined by favourable environmental conditions. Larvae originating from spawning grounds off the west coast are carried by currents to the northwest coast of Donegal and may even travel as far as Scotland (Molloy, 2006). Figure A.1 shows a schematic presentation of the life cycle of Herring west and northwest of Ireland.

The juveniles tend to remain close inshore, in shallow waters for the first two years of their lives, in nursery areas. There are many of these nursery areas around the coast, for example St. Johns point in Donegal Bay. The minimum landing size for herring is 20cm and therefore these juvenile herring are not caught by the fishery in the early stages of their life cycle (Molloy, 2006).

Changes in the growth rate of this stock can be seen over time. In the late 1980s a sudden and unexplained drop in mean weights was observed. This had an impact on the estimate of SSB and the advised TAC. The growth rate of this stock has never recovered to the levels before this decline (Molloy, 2006).

Adult herring are found offshore until spawning time, when they move inshore. Occasionally very large herring are found off the Irish coast. Theses herring appear off the north coast and are usually in a spawning or pre spawning condition (Molloy, 2006).

H.2. Management and ACFM advice

Local Management

Various management measures have been introduced to control the exploitation of this stock. From 1972-1978 TACs were set by NEAFC and covered all of area VIa. The TAC decreased rapidly and the stock was thought to be in decline. This continued until the fishery was closed in 1979 and 1980. During the closure because there was no analytical assessment of VIIb fishing was allowed to continue on a precautionary basis (ICES, 1994). When the fishery was reopened it was decided to split the area into VIaS and VIaN. Landings from this area increased due to the increased efficiency of the Irish vessels and the participation in this fishery by Dutch vessels (Anon, 2000).

Management measures were slowly introduced into this fishery with by-laws restricting fishing in certain areas off the coast in the early 1900s. This type of management continued until the 1930s when fishing was prohibited during April and May, in order to improve the quality of the herring being landed. In the 1970s management measured became more defined. Direct fishing of herring for fishmeal was banned. A minimum landing size of 20cm was implemented and also minimum mesh sizes. TACs were introduced in order to control the amount of herring landing each year from each ICES area (Molloy, 1995).

The management of the fishery has improved in recent years and catches have been considerably reduced since 1999. In 2000 the Irish North West Pelagic Management Committee was established to deal with the management of this stock. The assessment period runs concurrently with the annual quota. Quotas are allocated on a fortnightly basis and there is some capacity to carry unused allocation into the following fortnight with overruns being deducted.
In 2000, the Irish North West Pelagic Management Committee was established to deal with the management of this stock. The committee has the following objectives:

- To rebuild this stock to above the B_{pa} level of 110 000 t.
- In the event of the stock remaining below this level, additional conservation measures will need to be implemented.
- In the longer term it is the policy of the committee to further rebuild the stock to the level at which it can sustain annual catches of around 25 000 t.

- Implement a closed season from March to October.
- Regulate effort further through boat quotas allocated on a weekly basis in the open season.

This committee manages the whole fishery for this stock at present, given that Ireland currently accounts for the entire catch.

The current state of the stock is uncertain. Preliminary assessments suggest that SSB may be stable at a low level. The current level of SSB is uncertain but likely to be below B_{lim}. There is no evidence that large year classes have recruited to the stock in recent years. F appears to have increased concomitantly with increases in the catch. F is likely to be above F_{pa} and also likely above F_{lim}.

There is no explicit management plan for this stock. The local Irish management committee developed the objective to rebuild the stock to above B_{pa} and to maintain catches of 25 000 t per year. The implementation of the closed season from March to October has been successful in ensuring that the fishery mainly concentrates on the spawning component in this area. ICES have recommended that a rebuilding plan be put in place that will reduce catches. If no rebuilding plan is established, there should be no fishing. The rebuilding plan should be evaluated with respect to the precautionary approach.

H.4 Terminology

The WG uses "rings" rather than "age" or "winter rings" throughout the report to denominate the age of herring, with the intention to avoid confusion. It should be observed that, for autumn spawning stocks, there is a difference of one year between "age" and "rings". HAWG in 1992 (ICES 1992/Assess:11) stated that

"The convention of defining herring age rings instead of years was introduced in various ICES working groups around 1970. The main argument to do so was the uncertainty about the racial identity of the herring in some areas. A herring with one winter ring is classified as 2-years-old if it is an autumn spawner, and one-year-old if it is a spring spawner. Recording the age of the herring in rings instead of in years allowed scientists to postpone the decision on year of birth until a later date when they might have obtained more information on the racial identity of the herring.

The use of winter rings in ICES working groups has introduced a certain amount of confusion and errors. In specifying the age of the herring, people always have to state explicitly whether they are talking about rings or years, and whether the herring are autumn or spring spawners. These details tend to get lost in working group reports, which can make these reports confusion for outsiders, and even for herring experts themselves. As the age of all other fish species (and of herring in other parts of the world) is expressed in years, one could question the justification of treating West-European herring in a special way. Especially with the present trend towards multispecies assessment and integration of ICES working groups, there might be a case for a uniform system of age definition throughout all ICES working groups.

However, the change from rings to years would create a number of practical problems. Data files in national laboratories and at ICES would have to be adapted, which would involve extra costs and manpower. People that had not been aware of the change might be confused when comparing new data with data from old working group reports. Finally, in some areas (notably Division IIIa), the distinction between spring and autumn spawners is still hard to make, and scientists preferred to continue using rings instead of years.

The Working Group discussed at length the various consequences of a change from rings to years. The majority of the Group felt that the advantages of such a change did not outweigh the disadvantages, and it was decided to stick to the present system for the time being."

The text table below gives an example for the correlation between age, rings and year class for the different spawning types in late 2002:

YEAR CLASS (AUTUMN SPAWNERS)	2001/2002	2000/2001	1999/2000	1998/1999
Rings	0	1	2	3
Age (autumn spawners)	1	2	3	4
Year class (spring spawners)	2002	2001	2000	1999
Rings	0	1	2	3
Age (spring spawners)	0	1	2	3

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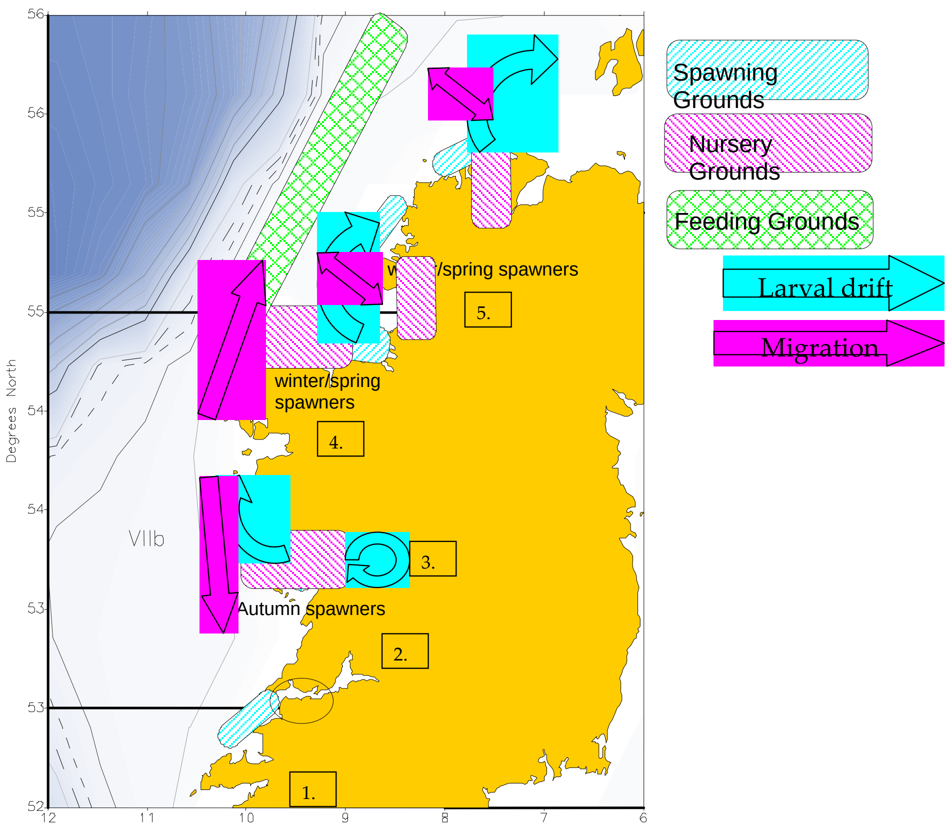


Figure A.1 Schematic presentation of the life cycle of Herring west and northwest of Ireland. Numbers represent locations mentioned in the text:1 – Dingle Peninsula, 2 – Shannon River, 3 – Galway Bay, 4 – Mayo, 5 – Donegal Bay (ICES, 2005b, SGRESP)

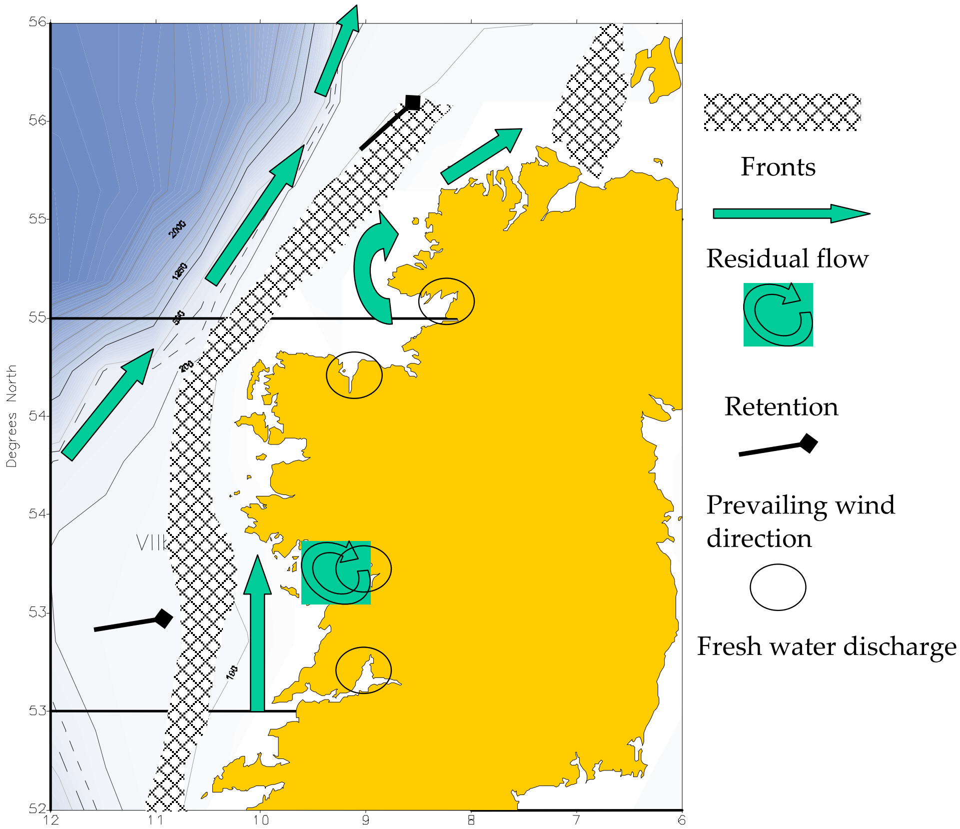


Figure A.2 Schematic presentation of prevailing oceanographic conditions in the west and northwest of Ireland. Fronts are 1.) the Islay front northeast of Ireland and 2.) the Irish shelf front to the west of the Celtic Sea, both fronts are a thermohaline fronts persisting throughout the year with an additional tidal mixing front developing near Islay during summer stratification. Residual currents are the Irish coastal current, a clockwise density current and the Atlantic shelf edge current. Circulation is mainly wind driven with prevailing south-easterly winds from October to May and density driven from May to October (ICES, 2005b, SGRESP).

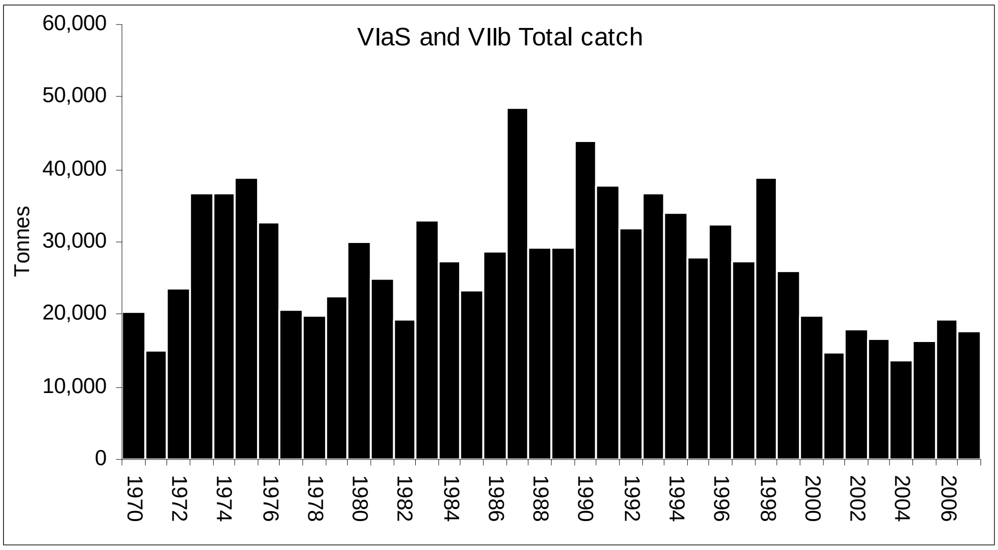


Figure A.3: Total landings from VIaS, VIIb,c

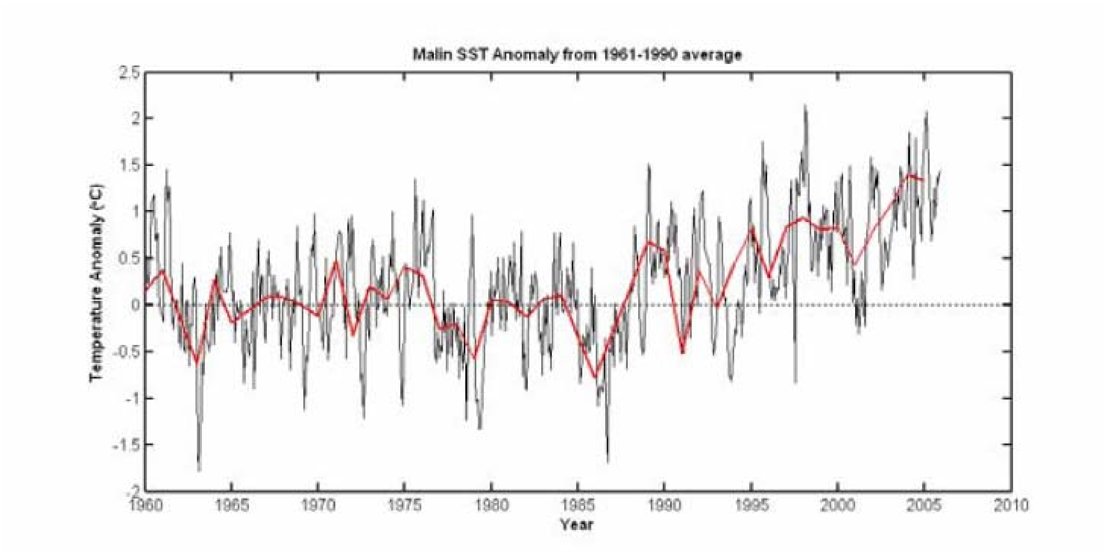


Figure A.4: Sea surface temperature anomaly at Malin Head (1960-2005) (Nolan and Lyons, 2006)

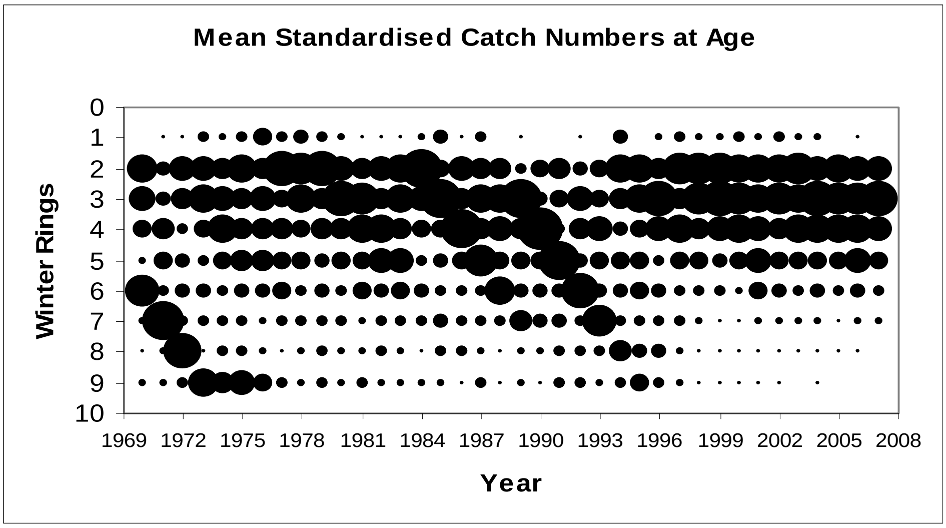
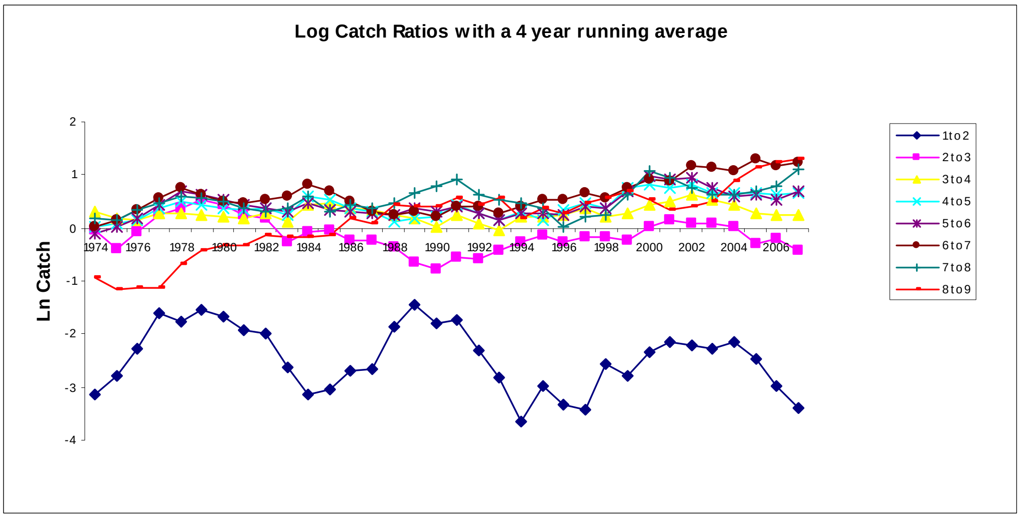


Figure B.1: Mean Standardised Catch Numbers at Age



B.2: Log Catch Ratios with a four year running average

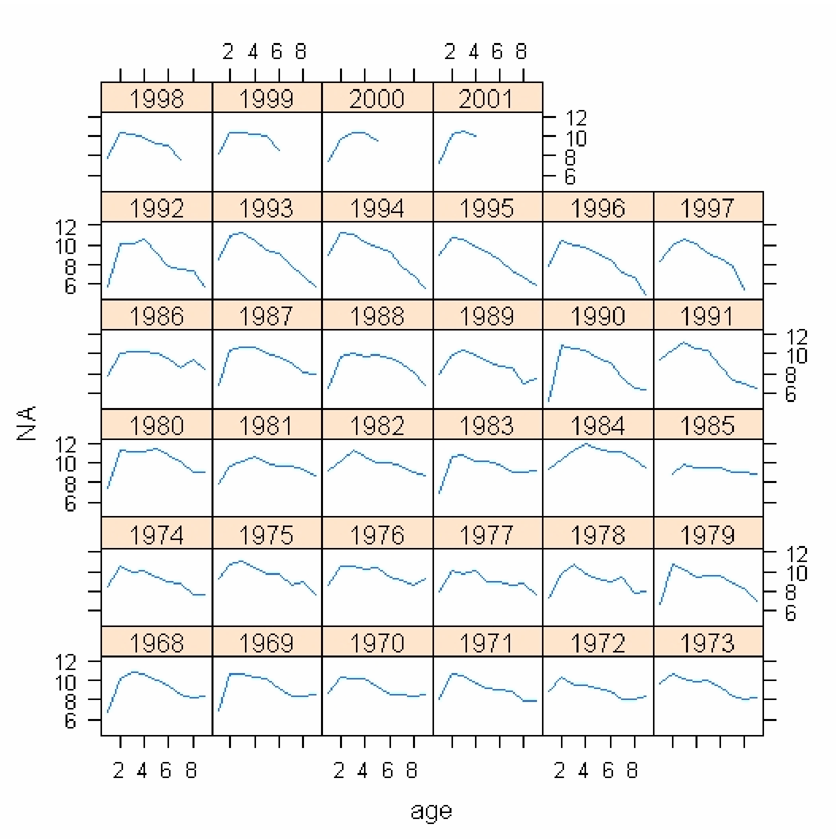


Figure B.3: Catch Curves by cohort

Annex 8: Stock Annex – Irish Sea Herring VIIa (N)

Quality Handbook ANNEX:_hawg-nirs

Stock specific documentation of standard assessment procedures used by ICES.

Stock:	Irish Sea herring (VIIa(N)
Working Group	Herring Assessment Working Group (HAWG)
Date:	17 March 2004

A. General

A.1. Stock definition

Herring spawning grounds in the Irish Sea are found in coastal waters to the west and north of the Isle of Man and on the Irish Coast at around 54°N (ICES, 1994; Dickey-Collas *et al.*, 2001). Spawning takes place from September to November in both areas, occurring slightly later on average on the Irish Coast than off the Isle of Man. ICES Herring Assessment Working Groups from 19XX to 1983 used vertebral counts to separate catches into Manx and Mourne stocks associated with these spawning grounds. However, taking account of inaccuracies in this method and the results of biochemical analyses, the 1984 WG combined the data from the two components to provide a "more meaningful and accurate estimate of the total stock biomass in the N. Irish Sea." All subsequent assessments have treated the VIIa(N) data as coming from a single stock. During the 1970s, catches from the Manx component were about three times larger than those from the Mourne component. By the early 1980s, following the collapse of the stock, the catches were of similar magnitude. The fishery off the Mourne coast declined substantially in the 1990s then ceased, whilst acoustic and larva surveys in this period indicate that the spawning population in this area has been very small compared to the biomass off the Isle of Man.

The occurrence in the Irish Sea of juvenile herring from a winter-spring spawning stock has been recognized since the 1960s based on vertebral counts (ICES, 1994). More recently, Brophy and Danilowicz (2002) used otolith microstructure to show that nursery grounds in the western Irish Sea were generally dominated by winter-spawned fish. Samples from the eastern Irish Sea were mainly autumn-spawned fish. Recaptures from 10,000 herring tagged off the SW of the Isle of Man in July 1991 occurred both on the Manx spawning grounds and along the Irish Coast with increasing proportions from the Celtic Sea in subsequent years (Molloy *et al.*, 1993). The pattern of recaptures indicated a movement towards spawning grounds in the Celtic Sea as the fish matured.

A proportion of the Irish Sea herring stocks may occur to the north of the Irish Sea outside of the spawning period. This was indicated by the recapture on the Manx spawning grounds of 3-6 ring herring tagged during summer in the Firth of Clyde (Morrison and Bruce, 1981). Aggregations of post-spawning adult herring were detected along the west coast of England during an acoustic survey in December 1996

(Department of Agriculture and Rural Development for Northern Ireland, unpublished data), showing that a component of the stock may remain within the Irish Sea.

The results of WESTHER, a recent EU-funded programme aiming to elucidate stock structures of herring throughout the western seaboard of the British Isles have recently been published. Using a combination of morphometric measurements, otolith structure, genetics and parasite loads the conductivity of stocks within and beyond the Irish Sea have been examined. The results of this programme are due to be discussed at SGHERWAY in light of the future assessment and management of stocks to the western British Isles.

A.2. Fishery

There have been three types of fishery on herring in the Irish Sea in the last 40 years:

i) Isle of Man- aimed at adult fish that spawn around the Isle of Man.

ii) Mourne- aimed at adult fish that spawn off the Northern Irish eastern coast.

iii) Mornington- a mixed industrial fishery that caught juveniles in the western Irish Sea.

The Mornington fishery started in 1969 and at its peak it caught 10,000 tonnes per year. It took place throughout the year. The fishery was closed due to management concerns in 1978 (ICES, 1994). In the 1970s the catch of fish from the Mourne fishery made up over a third of the total Irish Sea catch. The fishery was carried out by UK and Republic of Ireland vessels using trawls, seines and drift nets in the autumn. However the fishery declined and ceased in the early 1990s (ICES, 1994). The biomass of Mourne herring, determined from larval production estimates is now 2-4% of the total Irish Sea stock (Dickey-Collas *et al*., 2001).

The main herring fishery in the Irish Sea has been on the fish that spawn in the vicinity of the Isle of Man. The fish are caught as they enter the North Channel, down the Scottish coast, and around the Isle of Man. Traditionally this fishery supplied the Manx Kipper Industry, which requires fish in June and July. However the fish appeared to spawn slightly later in the year in the 1990s and this lead to problems of supply for the Manx Kipper Industry. In 1998 the Kipper companies decided to buy in fish from other areas. Generally the fishery has occurred from June to November, but is highly dependent on the migratory behaviour of the herring.

The fishery has been prosecuted mainly by UK and Irish vessels. TACs were first introduced in 1972, and vessels from France, Netherlands and the USSR also reported catches from the Irish Sea during the 1970s before the closure of the fisheries from 1978 to 1981. By the 1990s only the fishery on the Manx fish remained, and by the late 1990s this was dominated by Northern Irish boats. The number of Northern Irish vessels landing herring declined from 24 in 1995-96 to 6-10 in 1997-99 and to 4 in 2000. Only two vessels operated in 2002 and 2003. However, total landings have remained relatively stable since the 1980s whilst the mean amount of fish landed per fishing trip has increased, reflecting the increase in average vessel size

A.3. Ecosystem aspects

The main fish predators on herring in the Irish Sea include whiting (*Merlangius merlangus*), hake (*Merluccius merluccius*) and spurdogfish (*Squalus acanthias*). The size composition of herring in the stomach contents indicates that predation by whiting is mainly on 0-ring and 1-ring herring whilst adult hake and spurdogfish also eat older herring (Armstrong, 1979; Newton, 2000; Patterson, 1983). Sampling since the 1980s has shown cod (*Gadus morhua*), taken by both pelagic and demersal trawls in the Irish

Sea, to be minor predators on herring. Small clupeids are an important source of food for piscivorous seabirds including gannets, guillemots and razorbills (ref…) which nest at several locations in and around the Irish Sea. Marine mammal predators include grey and harbour seals (ref.) and possibly pilot whales, which occur seasonally in areas where herring aggregate.

Whilst small juvenile herring occur throughout the coastal waters of the western and eastern Irish Sea, their distribution overlaps extensively with sprats (*Sprattus sprattus*). The biomass of small herring has typically been less than 5% of the combined biomass of small clupeids estimated by acoustics (ICES, 2008 ACOM:02).

B. Data

B.1. Commercial catch

National landings estimates

The current ICES assessment of Irish Sea herring extends back to 1961, and is based on landings only. ICES WG reports (ICES 1981, 1986 and 1991) highlight the occurrence of discarding and slippage of catches, which can occur in areas where adult and juvenile herring co-occur. Discarding has been practised on an increasing scale since 1980 (ICES, 1986). This increase is primarily related to the onset of slippage of catches that coincided with the cessation of the industrial fishery in early 1979 (ICES, 1980). As a result of sorting practices, slippage has led to marked changes in the age composition of the catch since 1979 and considerable change in the mean weights at age in the catch of the three youngest age groups (ICES 1981). Estimates of discarding were sporadically performed in the 1980s (ICES, 1981, 1982, 1985 and 1986), but there are no estimates of discarding or slippage of herring in the Irish Sea fisheries since 1986. Highly variable annual discard rates are evident from the 1980s surveys. For example, discards estimates of juvenile herring (0-group) for the Mourne stock taken in the 1981 *Nephrops* fishery was estimated at 1.9×10^{6} of vessels landing in Northern Ireland, which amounts to approximately 20% of the Mourne fishery (ICES 1982). In 1982, at least 50% of 1-group herring caught were discarded at sea by vessels participating in the Isle of Man fishery (ICES, 1983). A more comprehensive survey programme to determine the rate of discarding in 1985 revealed discard estimates of 82% by numbers of 1-ring fish, 30% of 2-ring and 6% of 3-ring fish, with the dominant age group in the landed catch being 3 ring (ICES, 1986). A similar survey in 1986, however, found the discarding of young fish fell to a very low level (ICES, 1987). The 1991 WG discussed the discard problem in herring fisheries in general and suggested possible measures to reduce discarding. No quantitative estimates were given, but reports of fishermen suggesting discards of up to 50% of catch as a result of sorting practices by using sorting machines (ICES, 1991). The variation in discard rates since 1980, as a result of changes in discard practices, can probably be attributed to several changes in the management of the fishery. These include the availability of different fishing areas, the change to fortnightly catch quotas per boat (ICES, 1987) and level of TAC, where lower discard rates are observed with a higher TAC (ICES, 1989). The level of slippage is also related to the fishing season, since slippage is often at a high level in the early months (ICES, 1987). Due to the variable nature of discard estimates and the lack of a continuous data series, it has not been included in the annual catch at age estimates (with the exception of the 1983 assessment when the catch in numbers of 1-ringers was doubled based on a 50% discard estimate of this age group).

Landings data for herring in Division VIIa(N) are generally collated from all participating countries providing official statistics to ICES, namely UK (England &

Wales, Northern Ireland, Scotland and the Isle of Man), Ireland, France, the Netherlands and what was formally the USSR. The data for the period 1971 to 2002 are reported in the various Herring Assessment Working Group Reports and are reproduced in Table 1. The official Statistics for Irish landings from VIIa have been processed to remove data from the Dunmore East fishery in area VIIa(S), and represent landings from VIIa(N) only.

Over the past three decades, the WG highlighted the under- or misreporting of catches as the major problem with regards to the accuracy of the landing data. Related to this are the problems of illegal landings during closed periods and paper landings. Area misreporting was also recognised (ICES, 1999), although a less prominent problem that is mostly corrected for.

The 1980 WG first identified the problem of misreporting of landings based on the results of a 3-year sampling programme, which was initiated after 1975 when herring were being landed in metric units at ports bordering the Irish Sea (1 unit = 100 kg nominal weight). The study showed the weight of a unit to be very variable, but was usually well in excess of 100 kg. An initial attempt to allow for misreporting using adjusted catches made very little difference to any of the values of fishing mortality (ICES, 1980). Subsequently, despite serious concerns about considerable under-reporting being raised (ICES 1990, 1994, 2000 and 2001), the WG made no attempts to examination the extent of the problem. This uncertainty signifies no estimates of under-reporting and consequently no allowance for under-reporting of landings has been made. Considerable doubt was raised as to the accuracy of landing data over the period 1981-87 (ICES, 1994). However, after apparent re-examination all WG landing statistics are assumed to be accurate up to 1997 (ICES, 2000), but with no reliable estimates of landings from 1998-2000 (ICES, 2001). The WG acknowledged that poor quality landing data bring the catch in numbers at age data into question and hence the accuracy of any assessment using data from such periods (ICES, 1994).

In 2002 the ICES assessment was extended back to include data for 1961-1970 with the intention of showing the stock development prior to the large expansion in fishing effort and stock size in the early 1970s. This has now been extended further back to 1955. Landings data for this period were extracted from the UK fisheries data bases (England & Wales, Scotland and Northern Ireland: Table 1, columns 8-10) and publications by Bowers and Brand (1973) for Isle of Man landings (column 11). Landings data for Ireland and France were not available.

To estimate the VIIa(N) herring landings for Ireland and France during 1955-1970, the NE Atlantic herring catches for each country were obtained from the FAO database (column 16). Using the ICES landings data for each country (column 17) the mean proportion of the VIIa(N) catch to the NE Atlantic catch during 1971 to 1981 was estimated (column 18). This was applied to the NE Atlantic catches from each country, for the period 1955 to 1970, to give an estimated landing for both France and Ireland (column 19). These landings were added to the known catches from the CEFAS database to give the total landings. The landings data (tonnes) used in the assessment are given in Table 1, column 14. It is anticipated that landings data for VIIa(N) for years prior to 1971 can be extracted from the Irish databases. However, the French landings will remain as estimates. As yet there has been no analysis of magnitude of errors in the old data. Need discussion on errors due to misreporting

Catch at age data

Age classes in the ICES Canum file refer to numbers of winter rings in otoliths. As the Irish Sea stock comprises autumn spawners, *i*-ring fish taken in year *y* will comprise fish in their i_{th} year of life if caught prior to the spawning season and $(i+1)_{th}$ year if caught after the spawning period. An *i*-ring fish will belong to year-class *y*-2. As spawning stock is estimated at spawning time (autumn), spawning stock and recruitment relationships require estimates of recruitment of *i*-ring fish in year *y* and estimates of SSB in year *i*-2. The current assessment estimates recruitment as numbers of 1-ring fish.

The most recent description of sampling and raising methods for estimating catch at age of herring stocks is in ICES (1996). This includes sampling by UK(E&W) and Ireland, but not UK(NI) and Isle of Man

UK(NI): A random sample of 10-20kg of herring is taken from each landing into the main landing port (Ardglass) by the NI Department of Agriculture and Rural Development. Samples are also collected from any catches landed into Londonderry. Prior to the 1990s, the samples were mostly processed fresh. During the 1990s, there was an increasing tendency for samples to be frozen for a period of weeks before processing. No corrections have been applied to weight measurements to allow for changes due to freezing and defrosting. The length frequency (total length) of each sample is recorded to the nearest 0.5cm below. A sample of herring is then taken for biological analysis as follows: one fish per 0.5 cm length class, followed by a random sample to make the sample up to 50 fish.

Otoliths are removed from each fish, mounted in resin on a black slide and read by reflected light. Ages are assigned according to number of winter rings.

Length frequencies (LFDs) for VIIa(N) catches are aggregated by quarter. The weight of the aggregate LFD is calculated using a length-weight relationship derived from the biological samples. The LFD is then raised to the total quarterly landings of herring by the NI fleets. A quarterly age-length key, derived from commercial catch samples only, is applied to the raised LFD to give numbers at age and mean weight at age.

IOM: IOM sampling covers the period 1923 – 1997. Samples are collected from any landings into Peel, by staff of the Port Erin Marine Laboratory (Liverpool University). The sampling and raising procedures are the same as described for UK(NI) with the following exceptions: i) the weight of the aggregate quarterly LFD is obtained from the original sample weights rather than using a length-weight relationship, and ii) the biological samples are random rather than stratified by length. The 1993 ICES herring assessment WGs noted a potential under-estimation by one ring, of herring sampled in the IOM. This was caused by a change in materials used for mounting otoliths and appears to have been a problem for ageing older herring in 1990-92. This was since rectified. However, the bias for the 1990-92 period has not yet been quantified and will be examined in the near future.

Ireland: Irish sampling of VIIa(N) herring covers the period 19xx – 2001. Some samples are from landings into NI but transported to factories in southern Ireland. Irish sampling schemes for herring in Div. VIa(S), VIIb, Celtic Sea and VIIj are described in ICES (1996). Methods for sampling catches in VIIa(N) are similar. The procedure is the same as described above for UK(NI) except that the biological samples are random rather than length stratified. ICES (1996) notes that a length-stratified scheme should be adopted to ensure proper coverage at the extremes of the LFDs.

Quality control of herring ageing has fallen under the remit of EU funded programmes EFAN and TACADAR, to which the laboratories sampling VIIa(N) herring contribute. An otolith exchange exercise was initiated in 2002 and is currently being completed.

B.2. Biological

Natural Mortality

Natural mortality (M) varies with age (expressed in number of winter rings) according to the following:

Rings	M
1	1
2	0.3
3	0.2
4+	0.1

Those values have been held constant from 1972 to date. Those values correspond to estimates for North Sea herring based on recommendations by the Multi-species WG (Anon. 1987a). which were applied to adjacent areas (Anon. 1987b).

Maturity at age

Combined, year-specific maturity ogives were used in the 2003 Assessment (ICES 2003). The way those values were derived is documented on Dickey-Collas *et al.* (2003). Prior to 2003 annually invariant estimates of the proportion of fish mature by age were used. Those were based on estimates from the 1970s (ICES, 1994). The use of the variable maturity ogive in 2003 did not change greatly the perception of the stock state (Dickey-Collas *et al., op cit*). Due to inconsistencies in the maturity data collected in 2003, the WG used a mean maturity ogive for the preceding nine years for 2003. The rationale for the 9 years was that there appeared to be a shift in the maturity ogive around 1993. After 2003 all weights and maturity-at-age data were based on corresponding annual biological samples.

SSB in September is estimated in the assessment. The survey larvae estimate is used as a relative index of SSB. The proportions of M and F before spawning are held constant over time in the assessment.

Stock weights

Stock weights at age have been derived from the age samples of the 3rd quarter landings since 1984 (R. Nash *pers comm.*). The stock mean weights for 1975-83 are time invariant and were re-examined in 1985 (Anon. 1985). They result from combining Manx and Mourne data sets. The weights at age of those stocks were considered relatively stable over time.

Mean weights

Mean weights-at-age in the catch (1985 to 2007) are given in Table 3. Mean weights-at-age of all ages remained low. There has been a change in mean weight over the time period 1961 to the present (ICES, 2003 ACFM:17). Mean weights-at-age increased between the early 1960s and the late 1970s whereupon there has been a steady decline to the early 1990s, where they remained low. In the assessment, mean weights-at-age for the period 1972 to 1984 are taken as unchanging. In extending the data series back from 1971 to 1961, mean weights-at-age in the catch were taken from samples recorded by the Port Erin Marine Laboratory (ICES, 2003 ACFM:17).

There was some uncertainty in the mean weights-at-age for 2003 presented to the WG, and consequently the WG replaced these with the average mean stock weights-at-age for the preceding five years (1998 to 2002).

Mean Lengths

Mean lengths-at-age are calculated using the catch data and are given for the years 1985 to 2006 in Table 4. In general, mean lengths have been relatively stable over the last few years and this trend has continued in 2006.

Catch at length

Catch at length are listed for the years 1990-2004 (Table 5)

B.3. Surveys

The following surveys provide data for the VIIa(N) assessment:

SURVEY ACRONYM	TYPE	ABUNDANCE DATA	AREA AND MONTH	PERIOD
AC(VIIaN)	Acoustic survey	Numbers at age (1-ring and older); SSB	VIIa(N) from 53⁰20'N – 55ºN; September	1994 – present
NINEL	Larva survey	Production of larvae at 6mm TL	VIIa(N) from 53º 50'N – 54º 50'N; November	1993 – present
DBL	Larva survey	Production of larvae at 6mm TL	East coast of Isle of Man; October	1989 – 1999 (1996 missing)
GFS-oct	Groundfis h survey	Mean nos. caught per 3 n.miles (1&2 ringers), by region	VIIa(N) from 53⁰20'N – 54º50'N (stratified); October	1993 - present
GFS-mar	Groundfis h survey	Mean nos. caught per 3 n.miles (1&2 ringers), by region	VIIa(N) from 53⁰20'N – 54º50'N (stratified); March	1993 - present

Data from a number of earlier surveys have been documented in the ICES WG reports. These include:

NW Irish Sea young herring surveys (Irish otter trawl survey using commercial trawler; 1980 – 1988)

Douglas Bank (East Isle of Man) larva surveys (ring net surveys; 1974 – 1988) (Port Erin Marine Lab)

Douglas Bank spawning aggregation acoustic surveys (1989, 1990, 1994, 1995) (Port Erin Marine Lab)

Western Irish Sea acoustic survey (July 1991, 1992) (UK(NI))

Eastern Irish Sea acoustic survey (December 1996)

Surveys used in recent assessments are described below.

AC(VIIaN) acoustic survey

This survey uses a stratified design with systematic transects, during the first two weeks of September. Vessel currently used is the R.V. Corystes (UK(NI)) replacing the R.V. *Lough Foyle* (UK(NI)). Starting positions are randomized each year (see recent HAWG reports for transect design and survey results). The survey is most intense around the Isle of Man (2 to 4 n.mile transect spacing) where highest densities of adult herring are expected based on previous surveys and fishery data. Transect spacing of 6 to 10 n.miles are used elsewhere. A sphere-calibrated EK-500 38kHz sounder is employed, and data are archived and analysed using Echoview (SonarData, Tasmania). Targets are identified by midwater trawling. Acoustic records are manually partitioned to species by scrutinising the echograms and using trawl compositions where appropriate. ICES-recommended target strengths are used for herring, sprat, mackerel, horse mackerel and gadoids. The survey design and implementation follows, where possible, the guidelines for ICES herring acoustic surveys in the North Sea and West of Scotland. The survey data are analysed in 15-minute elementary distance sampling units (approx. 2.5 n.miles). An estimate of density by age class, and spawning stock biomass, is obtained for each EDSU and a distance-weighted average calculated for each stratum. These are raised by stratum area to give population numbers and SSB by stratum.

NINEL larva survey

The DARD herring larva survey has been carried out in November each year since 1993. Sampling is carried out on a systematic grid of stations covering the spawning grounds and surrounding regions in the NE and NW Irish Sea (Figure 1). Larvae are sampled using a Gulf-VII high-speed plankton sampler with 280 μm net. Double-oblique tows are made to within 2m of the seabed at each station. Internal and external flow rates, and temperature and salinity profiles, were recorded during each tow. Lengths of all herring larva captured are recorded.

Mean catch-rates (nos.m^{-2}) are calculated over stations to give separate indices of abundance for the NE and NW Irish Sea. Larval production rates (standardised to a larva of 6mm), and birth-date distributions, are computed based on the mean density of larvae by length class. A growth rate of 0.35mm day^{-1} and instantaneous mortality of 0.14 day^{-1} are assumed based on estimates made in 1993 - 1997. More recent studies have indicated a mortality rate of 0.09, and this value is also applied to examine the effect on trends in estimates of larval production

DBL larva survey

Herring larvae were sampled on the east side of the Isle of Man in September or October each year. Double oblique tows with a 60 cm Gulf VII/PRO-NET high-speed plankton sampler with a 40cm aperture nose cone were undertaken on a 5 Nm square grid. The tow profile was followed with a FURUNO net sonde attached to the top of the equipment. The volume of water filtered was calculated from the nose cone mouth flow meter. The samples were preserved in 4% seawater buffered formalin and stored in 70% alcohol.

All herring larvae were sorted from the samples. The numbers of larvae per m^3 were calculated from the volume of water filtered and the number of larvae per tow. Up to 100 larvae from each tow were measured with an ocular graticule in a stereo microscope. Each sample was assigned to a sampling square and the total number of larvae per 0.5mm size class calculated from the average depth of the square and the surface area.

The total production and time of larvae hatch was calculated using an instantaneous mortality coefficient (k) of 0.14 and a growth rate of 0.35 mm d^{-1} in the formula:

$$N_t = N_o e^{-(kt)}$$

Production was calculated as the sum of all size classes/hatching dates. Spawning dates were taken as 10 days prior to the hatching date (Bowers 1952).

The Douglas Bank Larva survey has not been updated since 1999. Examination of the sum of squares surface from SPALY in 2005 indicated that the Douglas Bank larvae index (DBL) was having no influence in the assessment estimates for the current year. Therefore, the WG agreed on removing DBL from the analysis (ICES, 2005). The DBL time series is listed in Table 6

GFS-oct and –mar groundfish surveys

The DARD groundfish survey of ICES Division VIIaN are carried out in March and October 2003 at standard stations between 53° 20'N and 54° 45'N (Figure 2). Data from additional stations fished in the St George's Channel since October 2001 have not been used in calculating herring indices of abundance. As in previous surveys, the area was divided into strata according to depth contour and sediment type, with fixed station positions (note that the strata in Fig. 2 differ from those in the September acoustic survey shown in Fig. 1). The sampling gear was a Rockhopper otter trawl fitted with non-rotating rubber discs of approximately 15 cm diameter on the footrope. The trawl fishes with an average headline height of 3.0 m and door spread of 30 - 40 m depending on depth and tide. A 20mm stretched-mesh codend liner was fitted. During March, trawling was carried out at an average speed of 3 knots across the ground, over a standard distance of 3 nautical miles at standard stations and 1 nautical mile in the St. George's Channel. Since 2002, all survey stations in the October survey have been of 1-mile distance. Comparative trawling exercises during the October surveys and during an independent exercise in February 2003 indicate roughly similar catch-rates per mile between 1-mile and 3-mile tows. It is planned to continue with some comparative trawling experiments during future surveys to improve the statistical power of significance tests between the 1-mile and 3-mile tows.

As the surveys are targeted at gadoids, ages were not recorded for herring. The length frequencies in each survey were sliced into length ranges corresponding to 0-ring and 1-ring herring according to the appearance of modes in the overall weighted mean length frequency for each survey. Some imprecision will have resulted because of the overlap in length-at-age distributions of 1-ring and 2-ring herring. The error is considered to be comparatively small for most of the surveys where clear modes are apparent. There was no clear division between 1-ring and 2-ring herring in the March 2003 groundfish survey, and the estimate for 1-ringers may include a significant component of small 2-ringers. The arithmetic mean catch-rate and approximate variance of the mean was computed for each age-class in each survey stratum, and averaged over strata using the areas of the strata as weighting factors.

Groundfish surveys were used by the 1996 to 1999 HAWG to obtain indices for 0- and 1-ring herring in the Irish Sea. These indices have performed poorly in the assessment and have not been used since 1999. The time-series is listed in Table 7.

B.4. Commercial CPUE

Commercial CPUE's are not used for this stock.

B.5. Other relevant data

C. Historical Stock Development

Model used: ICA
Software used: ICA (Patterson 1998)

Model Options chosen:

- Separable constraint over last 6 years (weighting = 1.0 for each year)
- Reference age = 4
- Constant selection pattern model
- Selectivity on oldest age = 1.0
- First age for calculation of mean F = 2
- Last age for calculation of mean F = 6
- Weighting on 1-rings = 0.1; all other age classes = 1.0
- Weighting for all years = 1.0
- All indices treated as linear
- No S/R relationship fitted
- Lowest and highest feasible F = 0.05 and 2.0
- All survey weights fitted by hand i.e., 1.0 with the 1 ringers in the acoustic survey weighted to 0.1.
- Correlated errors assumed i.e., = 1.0
- No shrinkage applied

Input data types and characteristics:

TYPE	NAME	YEAR RANGE	AGE RANGE	VARIABLE FROM YEAR TO YEAR YES/NO
Caton	Catch in tonnes	1961-last data year	NA	Yes
Canum	Catch at age in numbers	1961-last data year	1-8+	Yes
Weca	Weight at age in the commercial catch	1961-1971 1972-1983 1984-last data year	1-8+ 1-8+ 1-8+	Yes No Yes
West	Weight at age of the spawning stock at spawning time.	1961-1971 1972-1983 1984-last data year	1-8+ 1-8+ 1-8+	Yes No Yes
Mprop	Proportion of natural mortality before spawning	1961-last data year	NA	No
Fprop	Proportion of fishing mortality before spawning	11961-last data year	NA	No
Matprop	Proportion mature at age	1961-last data year	1-8+	Yes
Natmor	Natural mortality	1961-last data year	1-8+	No

Tuning data:

TYPE	NAME	YEAR RANGE	AGE RANGE
Tuning fleet 1	NINEL	1993-2003	SSB
Tuning fleet 2	DBL	1989-1999	SSB
Tuning fleet 3	GFS-octtot	1993-2005	1 & 2
Tuning fleet 4	GFS-martot	1992-2003	1
Tuning fleet 5	ACAGE	1994-2003	1-8+
Tuning fleet 6	AC_VIIa(N)	1994-2003	SSB
Tuning fleet 7	AC_1+	1994-2003	SSB/Total biomass

D. Short-Term Projection

NOT USED IN 2004

Model used: Age structured

Software used: MFDP ver 1a

Initial stock size: Taken from the last year of the assessment. 1-ring recruits taken from a geometric mean for the years 1983 to two years prior to the current year. Where 1-ringers are absurdly estimated in the assessment 2-ringers are estimated as a geometric mean of the previous 10 year period.

Maturity: Mean of the previous three years of the maturity ogive used in the assessment.

F and M before spawning: Set to 0.9 and 0.75 respectively for all years.

Weight at age in the stock: Mean of the previous three years in the assessment.

Weight at age in the catch: Mean of the previous three years in the assessment.

Exploitation pattern: Mean of the previous three years, scaled by the Fbar (2-6) to the level of the last year.

Intermediate year assumptions: TAC constraint.

Stock recruitment model used: None used

Procedures used for splitting projected catches: Not relevant

E. Medium-Term Projections

F. Long-Term Projections

Not done

G. Biological Reference Points

Until there is confidence in the assessment the Working Group decided not to revisit the estimation of $\mathbf{B}_{pa}$ (9,500 t) and $\mathbf{B}_{lim}$ (6,000 t). There were no new points to add to the discussions and deliberations presented in 2000 (ICES 2000/ACFM:10).

H. Other Issues

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Table 1. Biological sampling of Irish Sea (VIIa(N)) landings. Country denotes sampling nation.

	COVERAGE	% OF LANDINGS SAMPLED	NO OF SAMPLES	TOTAL LANDINGS	LANDINGS BY Q?	IRELAND				NORTHERN IRELAND				ISLE OF MAN				OTHERR UK/UK OFFSHORE				TOTAL			
Year						Landings	Sample	Length	Ages	Landings	Sample	Length	Ages	Landings	Sample	Length	Ages	Landings	Samples	Length	Ages	Landings	Sample	Length	Ages
1988	(4)					**2579																	0	0	0
1989	(3) temp		88	4962	NO	1430	21	1843	555		45	11464	2249		21	5173	1057		1	96	0	4962	88	18576	3861
1990	p(1,2)	68%	100	6312	YES	1699	44	5176	1022	2322	38	9310	1900	542	18	5276	897	179/1570	0	0	0	6312	100	19762	3819
1991	g	90%	138	4398	YES	80	5	1255	247	3298	105	16724	2484	629	28	8280	1392	0/391	0	0	0	4398	138	26259	4123
1992	g	98%	32	5270	YES	406	3	593	99	4120	16	1588	770	741	13	3488	680	3	0	0	0	5270	32	5669	1549
1993	p (1)	65%	48	4408	YES	0	5	1378	245	3632	34	3744	832	776	9	1560	448	0	0	0	0	4408	48	6682	1525
1994	v.g	95%	59	4828	YES	0	2[1]	569	100	3956	43	3691	1175	716	14	3724	614	156	0	0	0	4828	59	7984	1889
1995	g (1)	87%	85	5076	YES	0	2[1]	569	100	3860	75	8282	2545	615	8	2182	400	601	0	0	0	5076	85	11033	3045
1996	g (1,5)	70%	51	5301	YES	100	1	537	55	4335	45	4813	1050	537	5	997	228	329	0	0	0	5301	51	6347	1333
1997	g (1,2)	91%	34	6649	YES	0	2	473	50	5679	25	2900	1199	765	7	2246	340	205	0	234	76	6649	34	5853	1665
1998	g (2)	84%	31	4904	YES	0	2	150	50	4131	29	2979	1450	0	0	0	0	773[2]	0	0	0	4904	31	3129	1500
1999	g (2)	72%	32	4127	YES	0	4	0	200	2967	28	2518	1400	0	0	0	0	1160[2]	0	0	0	4127	32	2518	1600
2000	v.g	97%	28	2002	YES	0	5	932	0	2002	23	1915	1150	0	0	0	0	0	0	0	0	2002	28	2847	1150
2001	p (2)	70%	31	5461	YES	862	8	1031	222	3786	23	2915	1149	86	0	0	0	727[2]	0	0	0	5461	31	3946	1371
2002	p (1)	62%	9	2392	YES	286	0	0	0	2051	9	949	450	4	0	0	0	51	0	0	0	2392	9	949	450
2003																									
2004																									
2005																									
2006																									
2007																									

COVERAGE: Sum of the landings (by Q and Nation(UK disaggregated))/total landings. From 1993 (possibly from 1990) to date landings and sampling levels are presented by quarter so coverage is related to this level of detail:

VERY GOOD (v.g) : all landings which individually are >10% of the total were sampled, all Q for which there were landings were sampled

GOOD (g) : landings that constitute the majority of the catch (adding to approx 70% or more of total) were sampled

POOR (p) : some of the large landings not sampled

(1): unsampled quarters

(2): large landings with few samples or unsampled. High level of sampling corresponds to 1 sample per 100t landed (WG rep 1997)

(3): Comment from WG rep. From 1990 going back, Report landings and sampling levels are shown aggregated for the whole year. UK landings lumped in one figure.

(4): no information in the WGrep of level of sampling prior to 1988. Sampling levels believed to be good. Actual figures to be provided by R. Nash, M Armstrong and CEFAS after going back to their labs.
(5): NO samples for NI landings in 4th Q, there is a suspicion that the figures correspond to 'paper landings'.

[1]Samples applied to NI landings: [2]Large unsampled landings.

Table ??: Data and method used to estimate landings from Division VIIa(N) herring.

																Estimates of maximum likely catch for VIIa(N) incl. of French and ROI catches							
Column No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	**16**		**17**		**18**		**19**	
	ICES table							British Isles catches						**CATCH IN ASSESS-MENT**		NE Atlantic catch		ICES 7a catch		% of NE atlantic		max likely catch	
	Ireland	UK	France	Netherlands	USSR/ Russia	Unallocated	Total	England	Northern Ireland	Wales	Manx	Irish	Total			France	Ireland	France	Ireland	France	Ireland	France	Ireland
1955								0	0	72	3815		3887	**8056**		60500	4900					3630	539
1956								5	0	20	4762		4787	**8743**		52000	7600					3120	836
1957								21	0	1638	2832		4491	**7966**		36100	11900					2166	1309
1958								31	0	12	2482		2525	**6261**		38800	12800					2328	1408
1959								20	0	96	3577		3693	**7833**		40400	15600					2424	1716
1960								1	0	9	2093		2103	**6607**		36200	21200					2172	2332
1961								32	0	144	1941		2117	**5710**		36600	12700					2196	1397
1962								4	0	21	1528		1552	**4343**		29100	9500					1746	1045
1963								5	0	34	974		1013	**3947**		33500	8400					2010	924
1964								2	0	0	556		558	**3593**		35000	8500					2100	935
1965								1629	0	398	1135		3162	**5923**		26400	10700					1584	1177
1966								2041	0	46	596		2683	**5666**		22400	14900					1344	1639
1967								2911	0	8	1959		4878	**8721**		20600	23700					1236	2607
1968								1504	0	5	3253		4762	**8660**		22800	23000					1368	2530
1969								3591	0	63	5044		8698	**14141**		27100	34700					1626	3817
1970								4662	0	16	9782		14461	**20622**		24400	42700					1464	4697
1971	3131	21861	1815				26807							**26807**		23500	31200	1815	3131	0.08	0.10		
1972	2529	23337	1224	260			27350							**27350**		29900	47800	1224	2529	0.04	0.05		
1973	3614	18587	254	143			22598							**22598**		30800	38900	254	3614	0.01	0.09		
1974	5894	27489	3194	1116	945		38638							**38638**		21199	39608	3194	5894	0.15	0.15		
1975	4790	18244	813	630	26		24503							**24503**		25645	29752	813	4790	0.03	0.16		
1976	3205	16401	651	989			21246							**21246**		20466	22227	651	3205	0.03	0.14		

1977	3331	11498	85	500			15414							**15414**		4164	23436	85	3331	0.02	0.14		
1978	2371	8432	174	98			11075							**11075**		4201	27717	174	2371	0.04	0.09		
1979	1805	10078	455				12338							**12338**		3596	27454	455	1805	0.13	0.07		
1980	1340	9272	1				10613							**10613**		6126	36917	1	1340	0.00	0.04		
1981	283	4094					4377							**4377**		6952	29926			0.00	0.00		
1982	300	3375				1180	4855							**4855**									
1983	860	3025	48				3933							**3933**						0.06	0.11		
1984	1084	2982					4066							**4066**									
1985	1000	4077				4110	9187							**9187**									
1986	1640	4376				1424	7440							**7440**									
1987	1200	3290				1333	5823							**5823**									
1988	2579	7593					10172							**10172**									
1989	1430	3532					4962							**4962**									
1990	1699	4613					6312							**6312**									
1991	80	4318					4398							**4398**									
1992	406	4864					5270							**5270**									
1993	0	4408					4408							**4408**									
1994	0	4828					4828							**4828**									
1995	0	5076					5076							**5076**									
1996	100	5180				22	5302							**5302**									
1997	0	6651					6651							**6651**									
1998	0	4905					4905							**4905**									
1999	0	4127					4127							**4127**									
2000	0	2002					2002							**2002**									
2001	862	4599					5461							**5461**									
2002	286	2107					2393							**2393**									
2003	0	2399					2399							**2399**									
2004	749	1782					2531							**2531**									
2005	1153	3234					4387							**4387**									
2006	581	3821					4402							**4402**									
2007	0	4629					4629							**4629**									
2008																							

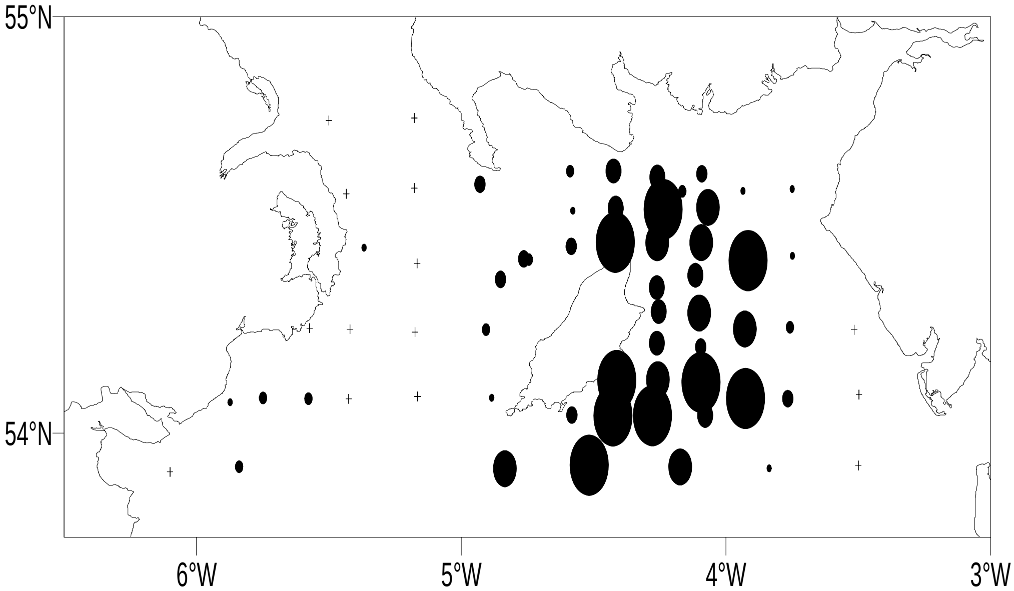
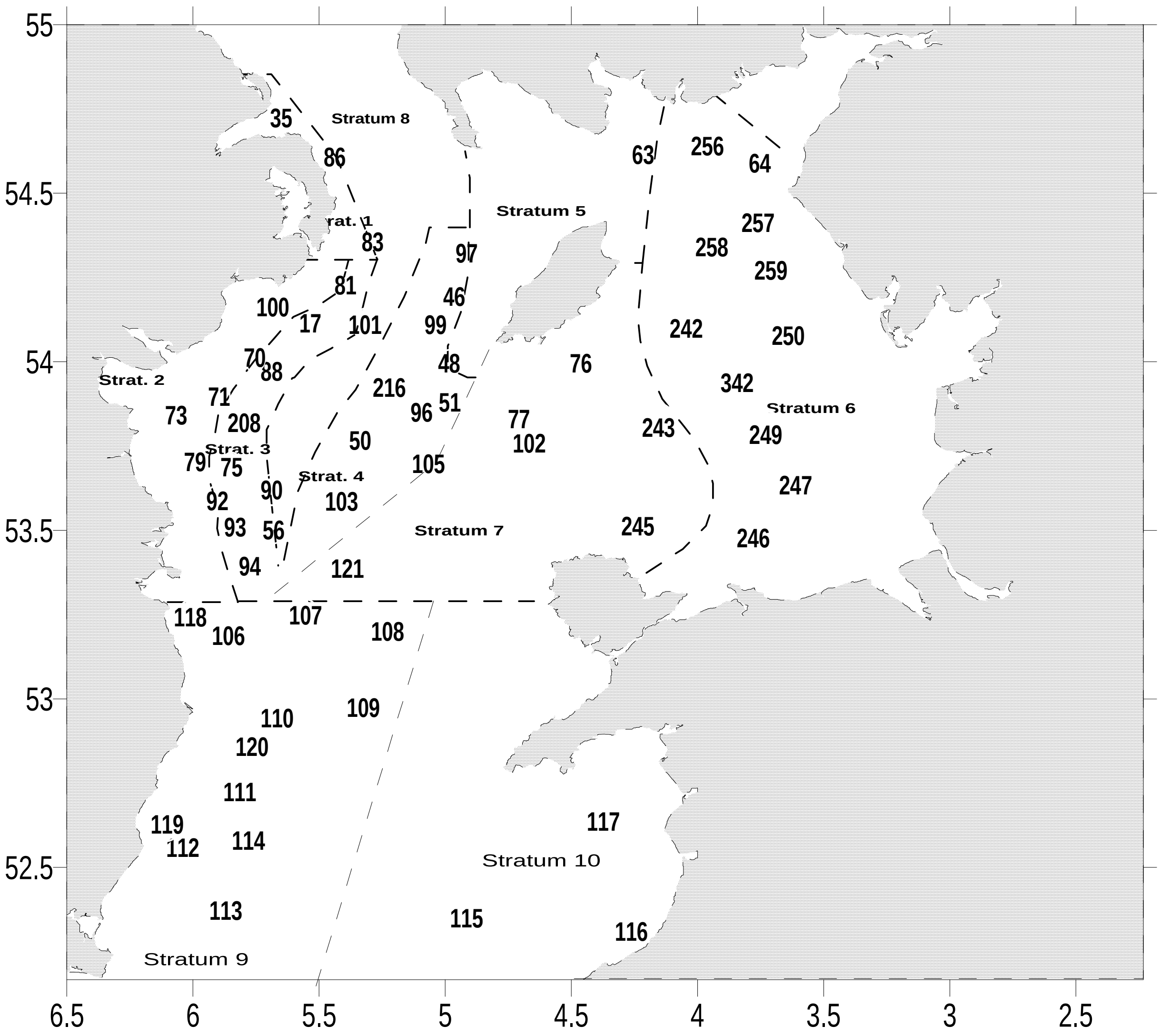


Figure 1. Sampling stations for larvae in the North Irish Sea (NINEL). Sampling is undertaken in November each year.



Key to strata:
1. Irish Coast (N), <100m, Mixed sediments
2. Irish Coast, < 50m, sand and finer sediments
3. Irish Coast, 50 - 100m, Muddy sediments
4. W and SW Isle of Man, 50 - 100m, mud and muddy sand
5. N Isle of Man, <50m, gravel sediments
6. Eastern Irish Sea, <50m, sand and finer sediments
7. S. Isle of Man, <100m, gravel sediments
8. Deep western channel and North Channel >100m
9. St George's Channel west; sandy/mixed sediments; <100m
10. St George's Channel east; sandy/mixed sediments; <100m

Figure 2. Standard station positions for DARD groundfish survey of the Irish Sea in March and October. Boundaries of survey strata are shown. Indices for the "Western Irish Sea" use data from strata 2 - 4. Indices for the "Eastern Irish Sea" use data from stratum 6 only (few juvenile herring are found in stratum 7). (Note different stratification to Fig. 1.). New stations fished in the St Georges Channel (strata 9 and 10) since October 2001 are not included in the survey indices. Stratum 5 (1 station only in recent years) is also excluded from the index. There are no stations in stratum 8 due to difficult trawling conditions for the gear used in the survey. Station 121 in stratum 7 has been fished only once and is excluded from the index.

Table 3. Irish Sea Herring Division VIIa(N). Mean weights-at-age in the catch.

Year	Weights-at-age (g) Age (rings)							
	1	2	3	4	5	6	7	8+
1985	87	125	157	186	202	209	222	258
1986	68	143	167	188	215	229	239	254
1987	58	130	160	175	194	210	218	229
1988	70	124	160	170	180	198	212	232
1989	81	128	155	174	184	195	205	218
1990	77	135	163	175	188	196	207	217
1991	70	121	153	167	180	189	195	214
1992	61	111	136	151	159	171	179	191
1993	88	126	157	171	183	191	198	214
1994	73	126	154	174	181	190	203	214
1995	72	120	147	168	180	185	197	212
1996	67	116	148	162	177	199	200	214
1997	64	118	146	165	176	188	204	216
1998	80	123	148	163	181	177	188	222
1999	69	120	145	167	176	188	190	210
2000	64	120	148	168	188	204	200	213
2001	67	106	139	156	168	185	198	205
2002	85	113	144	167	180	184	191	217
2003*	81	116	136	160	167	172	186	199
2004	73	107	130	157	165	187	200	205
2005	67	103	136	156	166	180	191	209
2006	64	105	131	149	164	177	184	211
2007	67	112	135	158	173	183	199	227

*** Average for the preceding five years**

Table 4. Irish Sea Herring Division VIIa(N). Mean length-at-age in the catch.

Year	Lengths-at-age (cm) Age (rings)							
	1	2	3	4	5	6	7	8+
1985	22.1	24.3	26.1	27.6	28.3	28.6	29.5	30.1
1986	19.7	24.3	25.8	26.9	28.0	28.8	28.8	29.8
1987	20.0	24.1	26.3	27.3	28.0	29.2	29.4	30.1
1988	20.2	23.5	25.7	26.3	27.2	27.7	28.7	29.6
1989	20.9	23.8	25.8	26.8	27.8	28.2	28.0	29.5
1990	20.1	24.2	25.6	26.2	27.7	28.3	28.3	29.0
1991	20.5	23.8	25.4	26.1	26.8	27.3	27.7	28.7
1992	19.0	23.7	25.3	26.2	26.7	27.2	27.9	29.4
1993	21.6	24.1	25.9	26.7	27.2	27.6	28.0	28.7
1994	20.1	23.9	25.5	26.5	27.0	27.4	27.9	28.4
1995	20.4	23.6	25.2	26.3	26.8	27.0	27.6	28.3
1996	19.8	23.5	25.3	26.0	26.6	27.6	27.6	28.2
1997	19.6	23.6	25.1	26.0	26.5	27.1	27.7	28.2
1998	20.8	23.8	25.2	26.1	27.0	26.8	27.2	28.7
1999	19.8	23.6	25.0	26.1	26.5	27.1	27.2	28.0
2000	19.7	23.8	25.3	26.3	27.1	27.7	27.7	28.1
2001	20.0	22.9	24.8	25.7	26.2	26.9	27.5	27.8
2002	21.1	23.1	24.8	26.0	26.6	26.7	27.0	28.1
2003	21.1	23.7	25.0	26.5	26.9	27.1	27.8	28.5
2004	20.7	23.1	24.6	25.8	26.1	27.1	27.6	28.3
2005	20.0	22.6	24.5	25.5	26.0	26.6	27.1	27.8
2006	19.5	22.7	24.3	25.3	26.0	26.6	26.9	28.0
2007	20.1	23.0	24.1	25.1	25.8	26.2	26.7	27.8

Table 5. Irish Sea Herring Division VIIa (N). Catch-at-length for 1990-2004. Numbers of fish in thousands.

Length	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
14															
.5															
15			95												
.5			169							10					
16	6		343			21	21	17		19	12	9			
.5	6	2	275			55	51	94		53	49	27			13
17	50	1	779		84	139	127	281	26	97	67	53			25
.5	7	4	1106		59	148	200	525	30	82	97	105			84
18	224	31	1263		69	300	173	1022	123	145	115	229			102
.5	165	56	1662		89	280	415	1066	206	135	134	240	36		114
19	656	168	1767	39	226	310	554	1720	317	234	164	385	18		203
.5	318	174	1189	75	241	305	652	1263	277	82	97	439	0	29	269
20	791	454	1268	75	253	326	749	1366	427	218	109	523	0	73	368
.5	472	341	705	57	270	404	867	1029	297	242	85	608	18	215	444
21	735	469	705	130	400	468	886	1510	522	449	115	1086	307	272	862
.5	447	296	597	263	308	782	1258	1192	549	362	138	1201	433	290	1007
22	935	438	664	610	700	1509	1530	2607	1354	1261	289	1748	1750	463	1495
.5	581	782	927	1224	785	2541	2190	2482	1099	2305	418	1763	1949	600	2140
23	2400	1790	1653	2016	1035	4198	2362	3508	2493	4784	607	2670	2490	1158	2089
.5	1908	1974	1156	2368	1473	4547	2917	3902	2041	4183	951	2254	1552	1380	2214
24	3474	2842	1575	2895	2126	4416	3649	4714	3695	4165	1436	3489	1029	1273	2054
.5	2818	2311	2412	2616	2564	3391	4077	4138	2769	3397	1783	4098	758	1249	2269
25	4803	2734	2792	2207	3315	3100	4015	5031	2625	2620	2144	5566	776	1163	1749
.5	3688	2596	3268	2198	3382	2358	3668	3971	2797	1817	1791	4785	1335	1211	1206
26	4845	3278	3865	2216	3480	2334	2480	3871	3115	1694	1349	3814	1570	1140	823
.5	3015	2862	3908	2176	2617	1807	2177	2455	2641	1547	840	2243	1552	1573	587
27	3014	2412	3389	2299	2391	1622	1949	1711	2992	1475	616	1489	776	1607	510
.5	1134	1449	2203	2047	1777	990	1267	1131	1747	867	479	644	433	1189	383
28	993	922	1440	1538	1294	834	906	638	1235	276	212	496	162	726	198
.5	582	423	569	944	900	123	564	440	170	169	58	179	108	569	51
29	302	293	278	473	417	248	210	280	111	61	42	10	36	163	
.5	144	129	96	160	165	56	79	59	92		12	0	36	129	
30	146	82	70	83	9	40	32	8	84		6	9		43	
.5	57	36	36	15	27	5	0	5	3					43	
31	54	12	2	4		1	2							43	
.5	31	3													
32	29														
.5															
33															
.5															
34															

Table 6. Irish Sea herring Division VIIa(N). Northern Ireland groundfish survey indices for herring (Nos. per 3 miles).

(a) 0-ring herring: October survey

	Western Irish Sea			Eastern Irish Sea			Total Irish Sea		
Survey	Mean	N.obs	SE	Mean	N.obs.	SE	Mean	N. obs	SE
1991	54	34	22						
1992	210	31	99	240	8	149	177	46	68
1993	633	26	331	498	10	270	412	44	155
1994	548	26	159	8	7	5	194	41	55
1995	67	22	23	35	9	18	37	35	11
1996	90	26	58	131	9	79	117	42	50
1997	281	26	192	68	9	42	138	43	70
1998	980	26	417	12	9	10	347	43	144
1999	389	26	271	90	9	29	186	43	96
2000	202	24	144	367	9	190	212	38	89
2001	553	26	244	236	11	104	284	45	93
2002	132	26	84	18	11	10	63	45	31
2003	1203	26	855	75	11	47	446	45	296
2004	838	26	292	447	11	191	469	45	125
2005	1516	26	1036	256	11	152	627	45	363
2006	4677	26	2190	2140	11	829	2468	45	822

(b) 1-ring herring: March Surveys.

	Western Irish Sea			Eastern Irish Sea			Total Irish Sea		
Survey	Mean	N.obs	SE	Mean	N.obs.	SE	Mean	N.obs	SE
1992	392	20	198	115	10	73	190	34	77
1993	1755	27	620	175	10	66	681	45	216
1994	2472	25	1852	106	9	51	923	39	641
1995	1299	26	679	73	8	32	480	42	235
1996	1055	22	638	285	9	164	487	39	230
1997	1473	26	382	260	9	96	612	43	137
1998	3953	26	1331	250	9	184	1472	43	466
1999	5845	26	1860	736	9	321	2308	42	655
2000	2303	26	853	546	10	217	1009	44	306
2001	3518	26	916	1265	11	531	1763	45	381
2002[a]	2255	25	845	185	11	84	852	44	294
2002[b]	7870	26	5667	185	11	84	2794	45	1960
2003	2103	26	876	896	11	604	1079	45	382
2004	6611	25	2726	491	11	163	2486	44	945
2005	7274	26	3097	1240	8	375	3001	42	1121
2006	4249	26	1687	2630	11	813	2496	45	662

a. Unusually large catch removed, b. unusually large catch retained.

Table 6. (Continued) Irish Sea herring Division VIIa(N). Northern Ireland groundfish survey indices for herring (Nos. per 3 miles.).

(c) 1-ring herring: October Surveys

	Western Irish Sea			Eastern Irish Sea			Total Irish Sea		
Survey	Mean	N.obs	SE	Mean	N.obs.	SE	Mean	N.obs	SE
1991	102	34	34	n/a	n/a	n/a	n/a	n/a	n/a
1992	36	31	18	20	8	11	21	46	8
1993	122	26	66	4	10	2	44	44	23
1994	490	26	137	17	6	10	176	40	47
1995	153	22	61	3	9	1	55	35	21
1996	30	26	13	2	9	1	11	42	5
1997	612	26	369	0.2	9	0.2	302	43	156
1998	39	26	15	13	9	10	53	43	35
1999	81	26	41	104	9	95	74	43	40
2000	455	24	250	74	9	52	579	38	403
2001	1412	26	641	5	11	3	513	45	223
2002	370	26	111	4	11	2	291	45	158
2003	314	26	143	410	11	350	267	45	144
2004	710	26	298	103	11	74	299	45	108
2005	3217	25	1467	18	11	12	1121	44	507
2006	1458	26	669	40	11	18	523	45	231

Table 7. Irish Sea Herring Division VIIa (N). Larval production (10^{11}) indices for the Manx component.

Year	Douglas Bank		
		Isle of Man	
	Date	Production	SE
1989	26 Oct	3.39	1.54
1990	19 Oct	1.92	0.78
1991	15 Oct	1.56	0.73
1992	16 Oct	15.64	2.32
1993	19 Oct	4.81	0.77
1994	13 Oct	7.26	2.26
1995	19 Oct	1.58	1.68
1996			
1997	15 Oct	5.59	1.25
1998	6 Nov	2.27	1.43
1999	25 Oct	3.87	0.88

Annex 9: Stock Annex – Sprat in the North Sea

Quality Handbook ANNEX: Sprat in the North Sea

Stock specific documentation of standard assessment procedures used by ICES.

Stock:	Sprat in the North Sea
Working Group	Herring Assessment Working Group (HAWG)
Date:	29TH March 2008

A. General

A.1. Stock definition

Sprat in ICES area IV.

A.2. Fishery

The Danish small meshed fishery is responsible for the majority of the landings. A study undertaken in 2000 showed that the species composition in the Danish sprat fishery has changed towards a fishery with low by-catches of other species (ICES CM 2001/ACFM:12). The Norwegian sprat fishery is carried out by purse-seiners. A closure of the Norwegian fishery was introduced for the second and third quarter in 1999 and this management regime is still in force. On top of this management regime, a maximum quota (900 t) per vessel is set for the Norwegian vessels; and they are not allowed to fish in the Norwegian Economic Zone until the Norwegian quota in EU waters has been taken. The majority of the catches in both fisheries is taken in the 4th quarter, though some fishery takes place during January and February.

There was a considerable increase in landings from about 10,000 t in 1986 to a peak of 357,000 t in 1995. In 1996 total landings declined to abt 135.000 t and have since been in the range of 84.000 t (2007) to 206.000 t (2005).

A.3. Ecosystem aspects

Multispecies investigations have demonstrated that sprat is one of the important prey species in the North Sea ecosystem. Many of the plankton-feeding fish have recruited poorly in recent years (e.g. herring, sandeel, Norway pout) changing availability of prey. The influence of the sprat fishery for other fish species and sea birds, are at present unknown.

Sprat 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 other fish and for sea birds.

The zooplankton community structure that is sustaining the sprat stocks appears to be changing, and there has been a long-term decrease in total zooplankton abundance in the northern North Sea (Reid *et al.*, 2003; Beaugrand, 2003; ICES, 2006). However, sprat is mainly distributed in the southern North Sea where these trends have not been observed (ICES, 2006). The implications of the environmental change for sprat are unknown

Sprat spawn in the upper water layers. The main spawning season is April-June, but eggs and larvae have been recorded more or less during the whole year. Spawning and nursery areas, being near the coasts, are particularly sensitive and vulnerable to anthropogenic influences.

B. Data

B.1. Commercial catch

The commercial catch data is provided by the national laboratories belonging to nations exploiting the sprat in the North Sea. The sampling intensity for biological samples, i.e., age and weight-at-age is mainly performed following the EU regulation 1639/2001 as the country landing most of the catches follows this regulation. This provision requires 1 sample per 2000 tonnes landed. This sampling level is lower than the guidelines (1 sample per 1000 tonnes) previously used by the HAWG. As the fishery is carried out in a limited area, the recommended sampling level can be regarded as adequate.

The majority of commercial catch and sampling data are submitted in the Exchange sheet v. 1.6.4 and further processed with the SALLOCL-application (Patterson 1998). This program 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

Mean weights at age in the catch in the 1st quarter are used as stock weights.

Natural mortality. Results from the multi-species VPA (.Report from the ICES Workshop on Multi-species VPA in the North Sea, Charlottenlund, Denmark 8th-12th April 2002: ICES CM 2002/D:04) are used as a basis to fix the value of M in the CSA model. The estimated values presented in table XX correspond to predation mortality. To estimate total natural mortality a value of 0.2 to account for other sources of natural mortality should be added to the predation mortality.

B.3. Surveys

The acoustic surveys for the North Sea herring in June-July have estimated sprat abundance since 1996 (ICES 2008/LRC:01) (see table below). In this period no sprat has been recorded in the northern part of the North Sea. The sprat was in 2007 almost exclusively found in the eastern and southern parts of the North Sea, with highest abundances off the coast of Lowestoft and in the inner German Bight (Figure 8.3.2). The age-disaggregated time series of sprat abundance and biomass from the acoustic series (ICES areas IVa-c), have been re-calculated using FishFrame for the years 2003-2007 (ICES CM 2008/LRC:01). The surveyed area has increased over the years, thus only figures for the last 5 years are roughly comparable.

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. The fishing method (gear) in the IBTS-survey was standardised in 1983 and the data series from 1984, are comparable. The indices from 2004-2007 were updated in 2008. It is, however, unclear how the calculations are made and if the same method has been used for the whole times series (see WD8 Jansen and Payne 2008).

Old IBTS-indices are available in ICES 2001/ACFM:12.

B.4. Commercial CPUE

Not used for this stock.

B.5. Other relevant data

C. Historical Stock Development

Model used:

Sprat is a relatively short-lived species, the stock and the catches, consisting mostly of 1 and 2 year-olds. In addition, there are difficulties in age reading resulting in unreliable estimates of numbers at age both from the surveys and the commercial catch. Given those limitations a data exploration using Catch-Survey Analysis (CSA), an assessment method designed for cases where full age-structured data are missing, has been undertaken by the WG since 2003. The method is described 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. 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. The model assumes that the population consists of two stages: the recruits (age 1) and the fully recruited ages (ages 2+). The model is fitted to survey indices for the two age groups. The assessment was carried out using the CSA V3 software obtained through the ICES website (http://www.ices.dk/committe/acom/wg/asoft/CSA/) with catch and IBTS q1 survey indices from 1996 onwards.

Software used:

http://www.ices.dk/committe/acom/wg/asoft/CSA/)

Model Options chosen:

Input data types and characteristics:

Model input data consisting of the time-series of catch numbers for each stage, mean weight for each stage in the stock at the start of the year and the 1st quarter IBTS index of abundance for the 1 year-old sprat and older (2+ age). Given low sampling levels in years previous to 1995, constant weight at age based on commercial data from the 1st quarter was assumed for the whole period. Reservations regarding the ability of the IBTS 1-year-old index to fully reflect strong and weak cohorts for sprat were expressed in previous WG reports (see ICES 1998 ACFM:14). Those were linked to difficulties in age reading and/or a possible prolonged spawning and recruitment season. Another problem identified in some surveys was related to large catches in small areas which could have been very influential on the results. Examination of the biomass and the 1 year-old index trajectories by the WG in 2003, suggested that the observed fluctuations in overall biomass are related to a large extent to observed fluctuations in the 1 year-old index. This is to be expected in a population where the recruits account for a large proportion of the stock. A unique value for the instantaneous rate of natural mortality ($M = 0.4$) and a parameter corresponding to the ratio of the survey catchability of the recruits to the fully recruited ages (s = 1) were fixed externally.

D. Short-Term Projection

Model used:

The SHOT- approach (Shepherd, 1991) was used in the past by the WG to estimate the landings in the assessment year. The 2003 WG considered that approach inappropriate for a short-lived stock like sprat therefore the projection was based on the results from CSA.

A catch prediction for the assessment year is based on a linear regression of annual catch versus IBTS estimated biomass for the period starting in 1987.

Software used:

Initial stock size:

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:

Procedures used for splitting projected catches:

E. Medium-Term Projections

Not performed

F. Long-Term Projections

Not performed

G. Biological Reference Points

Not set.

H. Other Issues

Only in-year catch forecasts are available. The stock consists of only a few year classes, with a predominance of 1-year-old fish in the catch.

I. References

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Shepherd, J.G. 1991. Simple Methods for Short Term Forecasting of Catch and Biomass. ICES J. Mar. Sci., 48: 67–78.

WD 8 Jansen, T., Payne, M. 2008. IBTS Q1 Sprat (*Sprattus sprattus*) index calculation algorithm. Implementation in R and comparison with the index used in assessment. DTU-Aqua, Copenhagen, Denmark.

Annex 10: Stock Annex – Sprat in Division IIIa

Quality Handbook ANNEX: Sprat IIIa

Stock specific documentation of standard assessment procedures used by ICES.

Stock:	Sprat in Division IIIa
Working Group:	Herring Assessment Working Group (HAWG)
Date:	29th March 2008
Authors:	Torstensen, E.; Clausen, L.W.

A. General

A.1. Stock definition

Sprat in ICES area IIIa

A.2. Fishery

Fleets from Denmark, Norway and Sweden carry out the sprat fishery in Division IIIa. The Danish sprat fishery consists of trawlers using a 16 mm-mesh size codend and all landings are used for fishmeal and oil production. Some of the sprat landings from Denmark and Sweden are by-catches in the herring fishery using 32 mm mesh-size cod ends. The Swedish fishery is directed at sprat with by-catches of herring but also includes 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 an inshore purse seine fishery for human consumption.

The majority of the landings are made by the Danish fleet. In 1997 a mixed-clupeoid fishery management regime was changed to a new agreement between the EU and Norway that resulted in a TAC for sprat as well as a by-catch ceiling for herring. Catches are taken in all quarters, though with the bulk of catches in the first and fourth quarter. Denmark has a total ban on the sprat fishery in Division IIIa from May to September.

There was a considerable increase in landings from about 10,000 t in 1993 to a peak of 96,000 t in 1994. From 1996 the landings have varied between 13,000 t (2006) and 40,000t (2005).

A.3. Ecosystem aspects

B. Data

B.1. Commercial catch

The commercial catch is provided by the national laboratories belonging to nations exploiting the sprat in Division IIIa. The sampling intensity for biological samples, i.e., age and weight-at-age is mainly performed following the EU regulation 1639/2001 as Denmark landing most of the catches follows this regulation. This provision requires 1 sample per 2000 tonnes landed.

The majority of commercial catch and sampling data are submitted in the Exchange sheet v. 1.6.4 and further processed with the SALLOCL-application (Patterson 1998). This program 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

Mean weights-at-age (g) in the catches 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.

No estimation of natural mortality is made for this stock.

B.3. Surveys

Acoustic estimates of sprat have been available from the ICES co-ordinated Herring Acoustic surveys since 1996. The estimated biomass of sprat has been very variable with low values in the period from 1997 to 2002, but recently the biomass has increased. The majority of the biomass during the acoustic survey is recorded in the Kattegat area.

The IBTS (February) sprat indices (no per hour) in Division IIIa are used as an index of abundance, however, the index has not been considered useful for management of sprat in Division IIIa. The indices are calculated as mean no./hr (CPUE) weighted by area where water depths are between 10 and 150 m (ICES 1995/Assess:13). The indices were revised in 2002 (ICES 2002/ACFM:12) based on an agreement in the IBTS WG in 1999, where it was decided to calculate the sprat index as an area weighted mean over means by rectangles for the IIIa (ICES 1999/D:2). The old time-series of IBTS indices (from 1984-2001) is shown in ICES 2001/ACFM:10.

B.4. Commercial CPUE

Not used for this stock.

B.5. Other relevant data

C. Historical Stock Development

Not performed

D. Short-Term Projection

Not perfomed

E. Medium-Term Projections

Not performed

F. Long-Term Projections

Not performed

G. Biological Reference Points

Not set.

H. Other Issues

I. References

Patterson, K.R. 1998: A programme for calculating total international catch-at-age and weight-at-age. Working Document to Herring Assessment Working Group South of 62oN. ICES CM 1998/ACFM:14.

Annex 11: Stock Annex – Sprat in Division VIIde

Quality Handbook ANNEX:_Sprat VIIde

Stock specific documentation of standard assessment procedures used by ICES.

Stock:	Sprat in Division VIId,e
Working Group:	Herring Assessment Working Group (HAWG)
Date:	29^{TH} March 2008
Author:	Torstensen, E; Clausen, L.W.

A. General

A.1. Stock definition

Sprat in ICES area VIId, VIIe,f.

A.2. Fishery

Vessels from UK (England and Wales) are currently responsible for the catches. The landings in this area are small and have never been above 6,000 t since 1985. Since 2000 the landings have been in the range of 840 t (2004) and 2 000 t (2006)

A.3. Ecosystem aspects

B. Data

B.1. Commercial catch

The commercial catch is provided by the national laboratories belonging to nations exploiting the sprat in the Division VIId and VIIe,f. The sampling intensity for biological samples, i.e., age and weight-at-age has not been performed since 1999, but as the fishery is so small, this is not considered to be a problem.

B.2. Biological

B.3. Surveys

There are no surveys targeting sprat in this area.

B.4. Commercial CPUE

Not used for this stock.

B.5. Other relevant data

C. Historical Stock Development

Not performed for this stock.

D. Short-Term Projection

Not performed for this stock.

E. Medium-Term Projections

Not performed

F. Long-Term Projections

Not performed

G. Biological Reference Points

Not set.

H. Other Issues

I. References

Annex 12: Technical Minutes from the Celtic Seas Review Group

Review of ICES Herring Assessment Working Group for the Area South of 62° N Report 2008

Reviewers:	Mark Dickey-Collas (chair, The Netherlands)
	Gary Melvin (Canada)
	Krzysztof Radtke (Poland)
	Tore Jakobsen (Norway)
Chairs WG:	Tomas Gröhsler (Germany) & Emma Hatfield (UK)
Secretariat:	Cristina Morgado / Henrik Sparholt

General

This working group was one of four reviewed by the Celtic Seas Review Group 2008. The review considered the following stocks

Celtic Sea and Division VIIj herring	advice
Herring in Divisions VIa (South) and VIIb,c	advice
Irish Sea herring (Division VIIa)	advice
Herring in Division VIa (North)	advice
Sprat in Divisions VIId,e	no advice

The review group also considered the general sections. The review group acknowledges the intense effort expended by the working group to produce the report and the work required to produce the stock assessments under a time of reform at ICES.

The review group found the introductory chapter and summary very useful in setting the scene for the assessments that followed in the later chapters. The working group carried out the requested plan for the introduction given by ICES at the time, and the review group found this section (1.10) too long and repetitive. This was not the fault of the working group, but due to the interpretation of the request of ACOM by the ICES secretariat. At a time when the reports should be shortened, this structure of the introduction has resulted in unnecessary repetition and this repetition of the draft stock summary sheets was not constructive.

The rest of the report was clear and transparent.

Benchmark assessment proposal

Benchmarks to be performed before the next assessment.

Stock	Problem	Last benchmark

Stock: Sprat in Divisions VIId,e

Assessment type: No Assessment due to insufficient data.

Assessment: N/A

Forecast:: N/A

Assessment model: N/A

Consistency: same as last year

Stock status: Unknown

Man. Plan.: N

General comments:

- Virtually no research
- Catches low and below long term average of 2,194t since 1999.

Technical comments:

Improvements for next year: do some research

Conclusions:

RG agrees with WG on stock

Stock: West of Scotland herring (Division VIa(N))

Assessment type: Update assessment

Assessment: presented (Y), agreed (Y)

Forecast: presented (Y), agreed (Y)

Assessment model: ICA (FLICA)

Consistency: same as last year

Stock status: B vs Blim (50,000t) and B_{trig} (75 000 t), Bpa (not set), F (0.4) vs Flim and Fpa, R comments

- SSB for 2007 of 68 764 t and a mean fishing mortality (3 to 6-ringers) of 0.40
- Poor recruitment in recent years
- The SSB half of 2002, likely a result of lower recruitment and an increased catch since 2005.
- SSB will decrease over next 3 years if F (0.40) status quo followed.
- SSB will increase over next 3 years if F (0.20) in plan followed.

Man. Plan.: Y, but not implemented

- In 2006 management based on status quo TAC, in 2007 the advice was based on the proposed management plan.
- Management plan developed 2005, but to date this agreement has not been implemented.
- If TAC of 27,200t for 2008 taken the stock will continue to decline. Significant reduction in F required to improve this stock's status.
- The agreed TAC for 2008 is 27 200 t, which is not in accordance with the HCR and is therefore not precautionary. The TAC in 2007 was 34 000 t.

General comments:

- Poor sampling of catch especially from the Dutch fleet. Total of 25 samples overall.
- Acoustic survey declined from 501,500 tonnes to 298,880 tonnes in 2006 vs 2007 with truncated size distribution for small and larger fish.
- Unusual to have 2008 population numbers estimated the same as 2007 (Table 5.6.1.11)
- Single age structure index from acoustic survey.

Technical comments:

- Data revisions in 2006 resulted in small positive changes to stock perception (SSB> and F<). Three scenarios tested for effects. Revision to input data from 2000 evaluated with minimal (<10%) changes to output.
- 100% of each age class >1 mature. This is different from other years. Negligible in the context of the final estimate of SSB.

- Conflicting information on recent recruitment between catch and survey with the survey. Survey suggests a slightly better recruitment of the 2003 year class (3-ringers in 2007) and the catch suggesting it is the 2004 year class (2-ringers in 2007) that is better.

- There is a noticeable lack of difference in mean wt at age in 2007. A difference of only 21gm between age 4 and age 9 is difficult to explain.

- Tested effect of 0 age 1 fish on assessment. Effect minimal at -2 to +1% change in SSB and F compared with defining as unknown

Improvements for next year:

- Improved sampling of catch to represent the fishery

Things that need update before ADG: none

Conclusions

RG agrees with WG on stock

Stock: Herring in Divisions VIa (South) and VIIb,c

Assessment type: Exploratory Assessment, separable VPA

Assessment: presented (Y), agreed (Y)

Forecast: presented (N), agreed (Y)

Assessment model: Lowestoft VPA

Consistency: Different from last year as no index of abundance

Stock status: B(unknown) vs Blim(90,000t) and Bpa(110 000 t) , F (unknown) vs Flim. (0.33) and Fpa(0.22)

- Current level of SSB is uncertain but is likely to be below B_{lim}.

Man. Plan.: Y but not evaluated by ICES

- Overall F in recent years is much higher .
- SSB may be stable at an historical low level, or even declining slightly
- WG concluded that rebuilding the stock to levels above B_{pa} and maintaining annual catches of 25 000 t would not be achievable.

General comments

- The TAC for this area in 2007 was 13 800 t with a decrease to over 11,600 t in 2008.
- Irish catches reported in VIaN were reassigned to VIaS.
- Catches have increased slightly since 2004.
- No sign of good recruitment.
- 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.

Technical comments:

- In September 2004 a new procedure was adopted for weighing landings and the allowance for water content was reduced from 14% to 2% therefore the catch data for 2004 are lower than previous years. Has this been evaluated or just assumed to have no effect?
- No recruitment index available for this stock.
- The timing of acoustic surveys changed in 1999 with the surveys being carried out in the winter instead of summer. Survey discontinued.
- Three terminal fishing mortalities: 0.2, 0.4 and 0.6 evaluated in exploratory assessment.
- Retrospective pattern for F=0.2 and F=0.6, but F=0.4 is more stable.

Improvements for next year:

- Decision on the best approach to develop an index of abundance for the spawning stock and recruits.

Things that need update before ADG: none

Conclusions

RG agrees WG on stock

Stock:	Irish Sea Herring (VIIa)
Assessment type:	Exploratory
Assessment:	presented (Y), agreed (Y)
Forecast:	presented (N)
Assessment model:	Two-Stage Biomass model
Consistency:	Different from previous years. Separable condition violated so ICA not used.
Stock status:	B vs Blim(6 000 t) and Bpa(9 500 t) , F vs Flim and Fpa, R comments.

- No recruitment Index
- Acoustic index based on ability to separate herring and sprat.
- Catch of 4 629 t

Man. Plan.: N

- Catches similar over past 3 years.
- Stock level is unclear from the current analysis, but stock remains relatively stable.
- Evidence suggests that a large year class is presently in the fishery from 2005 year class.
- TAC of 4 400 t recommended for 2008 but rejected for current levels 4 800 t.

General comments

- WG suggests that ICA is unsuitable as an assessment method for the Irish Sea stock.
- Fishing mortality has been relatively stable since the late 1990's.
- Catches in 2007 strongly dependent upon 1 and 2 ringers. Other numbers at age are down.
- SSB and 1+ from acoustic survey highest in the series and represent a major jump from the previous couple of years.
- Curious that 2007 represents the largest estimate in SSB but one of the lowest in larval production.

Technical comments:

- Possible presence of juvenile Celtic Sea herring in both the Irish Sea fishery and the survey area.
- Conflicting year effects were present in the acoustic and catch-at-age data. Majority of this variation may arise from the inter-annual variation in herring migration patterns and their effect on the selectivity of both the fishery and acoustic survey.
- Two staged biomass model has year effect in normalised residuals for 1 ringer in figure7.5.7.and noisy for 2+.

Improvements for next year:

- Explore methods to separate juveniles from adjacent stocks, or assessment methods that can account for this uncertainty.
- Review of the model (ICA) for the assessment of this stock.

Things that need update before ADG: none

Conclusions

RG agrees with WG on stock, but further justification is required for dismissing an assessment model that has been used for a number of years without exploring mechanisms to resolve the problem.

Stock:	**Celtic Sea and Division VIIj**
Assessment type:	exploratory update assessment
Assessment:	presented (Y), agreed (Y)
Forecast:	presented (N)
Assessment model:	ICA

- Recommend FLICA will be used rather than ICA in future exploratory work.

Consistency:	same as last year, plus a reduced plus group and non-inclusion of the 2007 survey.
Stock status:	B vs Blim(26 000 t) and Bpa(44 000t), F vs Flim(undefined) and Fpa(undefined), R comments

- Current level of SSB considered to be a risk for reduced recruitment.
- Currently F is uncertain but high. probably above $F_{0.1}$.
- Exploratory runs suggest that the stock is just below B_{pa}.
- Yield-per-recruit studies in 2007 suggest $F_{0.1}$ = 0.19.
- Real dependency on single year class
- 100% of each age class >1 are considered mature.

Man. Plan.:	Yes but not evaluated by ICES

- Plan in place that defines objectives to move toward a sustained annual catches of around 20 000 t.
- Rebuilding Plan needed.
- Closure of VIIaS, except for a sentinel fishery.
- Poor recruitment, truncation of age classes and lowest observed mean weights at age are cause for concern . A further reduction in F is required for the stock to rebuild

General comments:

- The TAC in 2007 was 9 393 t, and in 2008 is 7 890 t. The catch for 2007/2008 season was over 7 600 t, an increase from 6 944t the previous year.
- A rotational "spawning box" closure in place, but timing of the closures may not coincides with peak spawning at present.
- In recent years, the targeting fleet has changed along with the demand for roe.
- Some unknown amount of discarding still occurs, particularly of smaller fish.
- Section 4.11. F0.1 defined as =0.18 not as 0.19 elsewhere in text.

Technical comments:

-The change in water content, changes in control and the demise of the roe fishery may bias the data, and need to be considered when examining long term stock dynamics.

- Revised acoustic survey only available since 1995. A longer time series may be needed.

- Acoustic Survey and catch at age data similar except for 1 ringer

- No other surveys available although a pair trawl was conducted in 2008 to explore juveniles

Improvements for next year:

- Develop Index of recruitment.

- A number of changes have occurred in this fishery which I don't believe have been fully investigated by the WG (eg the change from a roe market and the affect on mean weight at age).

Things that need update before ADG: none

Conclusions

RG agrees with WG on stock, but would like to stress the uncertainty of parameter estimates and the fact that the fishery in 2007 was dependent primarily on a single year class, with no signs or index of good recruitment coming.

Annex 13: Technical Minutes from the North Sea Review Group

REVIEW OF PARTS OF THE ICES HAWG REPORT 2008

Reviewers:	Asgeir Aglen (chair, Norway)
	Norman Graham (Ireland) Valentin Tryjillo (Spain) Eero Aro (Finland)
Chair WG:	Tomas Gröhsler, Emma Hatfield
Secretariat:	Barbara Schoute / Henrik Sparholt

General

The Working Group is complimented for a clearly structured and understandable report.

Concerns raised about decline in market sampling. Missing samples from some fleet segments (métiers).

Benchmark assessment proposal

Benchmarks to be performed **before the next assessment**

Stock	Problem	Last benchmark

Herring in Division IIIa and Subdivisions 22–24

Assessment type	Benchmark assessment
Assessment:	presented (Y), agreed (Y)
Forecast:	presented (Y), agreed (Y)
Assessment model:	FLICA
Consistency:	changes in tuning feets, moderate revisions of stock size. Retrospective analysis ok
Stock status:	No ref.points, low and possibly declining ssb, rather high and stable F, R low
Man. Plan.:	at an early stage

General comments:

The stock is composed of several rather distinct spring spawning populations and probably different sub-stocks. In addition it mix with the North Sea autumn spawners in IIIa and IVa(east). Therefore, both for the research and management there is a balance between the focus on the total yield of herring from the merged complex and focus on the specific components (biodiversity). Some minimum level of monitoring of local spawning areas seems to be important.

The main changes in tuning fleets are:

Revised larvae index used as 0-gr index.

Revised German Acoustic survey

IBTS not used in this assessment

Technical comments (referring to sections in the report)

3.1: Are fishing Fleets C and D the same as C and D in the fishery for North Sea herring?

Sub-divisions 20 and 21 are not on the official map of ICES-areas.

3.2: Precision of otolith classification is described. What about the precision for the vertebral count method?

3.4: Status-quo raising method should be explained

The discussion on using quarter 1 weca as west is unclear. Plotting or tabulating the results would be helpful. (It seems trivial that first quarter is closer to spawning time than other years, but the critical question is the potential size selection in the fishery). The discussion on variation in maturation would also be more meaningful by presenting the data considered.

3.6.1.2.1 The paragraph on mortality signal should be elaborated and documented

How serious is the lack of stock split in the added data from southern Kattegat in the German acoustic survey?

Figures 3.6.1.3b, c and d must be Log (Survey Index) not Log Catch.

Choice of tuning data and models and Exploratory runs seem reasonable. The RG agrees to the WG conclusion: “There are some issues which require more detailed examination: specifically the incomplete understanding of the way the model responds to the choice of reference age, the issues relating to the choice of catchability model for the N20 index, and the weak trends in catchability all require further investigation". In spite of this the overall diagnostics for the final choice of model settings seem acceptable. The single fleet runs are fairly close, bearing in mind that the N20 fleet only has information for the 0-gr. The retrospective runs also seem reasonable.

The RG consider the final assessment to be acceptable. Technically it may also be used for predictions. Catch forecasts for this stock is complicated by uncertainty in the mixture of spring spawners and autumn spawners in the fishery both in the current year and the advice year.

Improvements for next year:

Lack of surveys covering the total spatial distribution might be critical. Hope for further progress in combining German and Danish acoustic surveys?

The stock complex?

Things that need update before ADG:

Answer of the ad hoc request on management of North Sea herring and Western Baltic herring. To be taken from HAWG-report section 1.3 (based on the WKHMP-report).

Conclusions

RG agrees with WG on stock

Herring in Subarea IV, Divisions VIId and IIIa (autumn spawners)

Assessment type	Update assessment
Assessment:	presented (Y), agreed (Y)
Forecast:	presented (Y), agreed (Y)
Assessment model:	FLICA
Consistency:	close to last year / upward revision (75%) of the still weak 2006 ycl
Stock status:	SSB above Blim, below HCR trigger point (used as Bpa), F above the HCR target F (used as Fpa), R low; all year classes since 2001 below average, 2007 ycl lowest since the 1977 ycl
Man. Plan.:	Y, evaluated by ICES Y, New evaluation and proposal this year (special request?)

General comments:

A rather consistent pattern of overshooting TAC. F(2-6) is generally higher than intended in the HCR, not the case for F(0-1). Last benchmark in 2006 documented a reliable assessment. Retrospective pattern is fine (Figures 2.6.19-20), remarkably good for R. This is further reflected in a good retrospective pattern for individual cohorts (Figure 2.10.2).

Technical comments

The plots of the ICA diagnostics (Figures 2.6.1-2.6.16) reveal some periodic residuals in the tuning fleets. In the acoustic survey the ages 4 and older show positive residuals in the late 90-ies and negative in the five most recent years. The SSB-index from MLAI has a somewhat opposite pattern. The IBTS is more noisy than the other surveys, but the residuals show less obvious time periods. Some high residuals are observed in IBTS for ages 3-5. (These ages are heavily down weighted by prior weightings in the analysis). In view of these observed residual patterns the retrospective performance is surprisingly good. The wg has commented: "*In the 2006 benchmark assessment it was concluded that one of the reasons for the relatively stable assessment was the balance of the major sources of information, with each potentially delivering short periods with bias but in combination providing a balance of errors*." There could be an inherent risk (now, and in the future) for the "periodic" bias to occur in the same direction for the main tuning fleets. This may not be easily detected in the first few years of such a period.

The bubble plots in Figures 2.6.17 and 18 should be better explained (scaled by prior weighting?).

Improvements for next year:

Things that need update before ADG:

Answer of the ad hoc request on management of North Sea herring and Western Baltic herring. This is dealt with in the HAWG-report section 1.3 (based on the WKHMP-report).

Conclusions

RG agrees with WG on the assessment and prediction. The RG supports the proposed revisions of the management plan. This is mainly based on having a low risk of ssb<Blim.

Sprat in the North Sea (Subarea IV)

Assessment:	presented (Y), agreed (Y)
Forecast:	In-year forecast presented and agreed
Assessment model:	CSA, and catch/survey regression
Consistency:	SPALY, results close to last year
Stock status:	No reference points. SSB and R intermediate, F declining
Man. Plan.:	No

General comments

No available information on the recruitment to the fishery in next year. Therefore only in-year forecast.

Technical comments

Absolute level of CSA-estimates is sensitive to the assumed ratio between survey catchability of recruits (age 1) and older fish (2+). Trends are rather robust against this assumption.

Improvements for next year:

For in-year catch forecast: Investigate alternative IBTS-index that are less driven by some few large trawl catches.

Things that need update before ADG:

Conclusions

RG agrees with WG on stock